Aerated Wastewater Lagoon Troubleshooting

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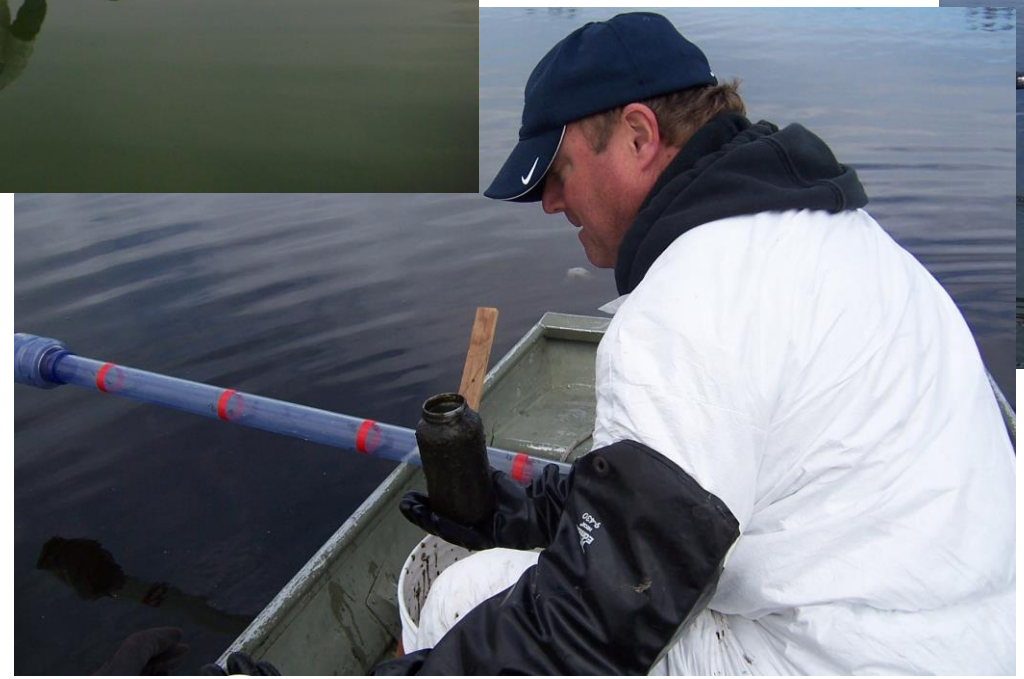
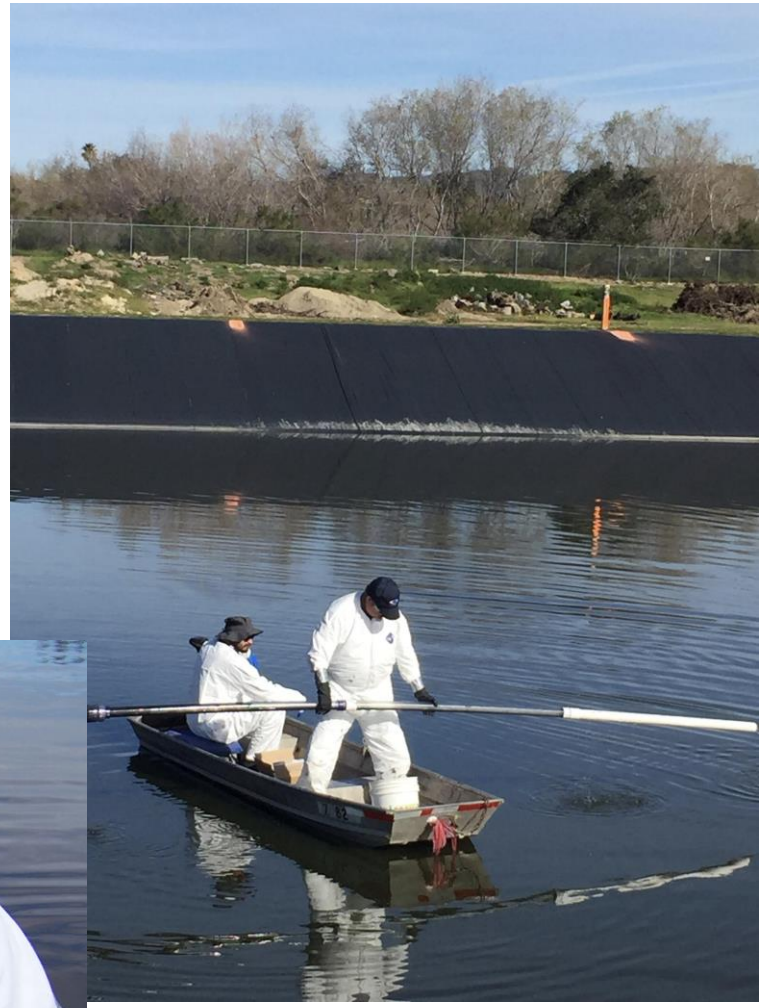
What we will do today:

- Make introductions
- Describe the general principals behind aerated lagoon troubleshooting
- Go through case studies






AZ6829K


HQ40d
multi

Objectives

Introduce you to our protocol for optimizing and troubleshooting aerated wastewater lagoon systems

- This Protocol Starts with Understanding the Following:
  - There is a where, a when, and a why to solving problems and optimizing wastewater lagoon systems
  - Algae cause BOD problems because they respire for five (5) days in the BOD_5 test bottle
  - Intra-Pond Testing is CRITICAL to solving lagoon problems
  - Cell # 1 should remove at least 80% of the influent BOD_5. Cell # 2 Should be for removing nutrients and the other cells are for killing pathogens and settling (clarifying) effluent water
  - You can do little to solve problems without data!

- Wastewater lagoons fail for about six (6) main reasons, but they fail largely fail because of two (2) main reasons;

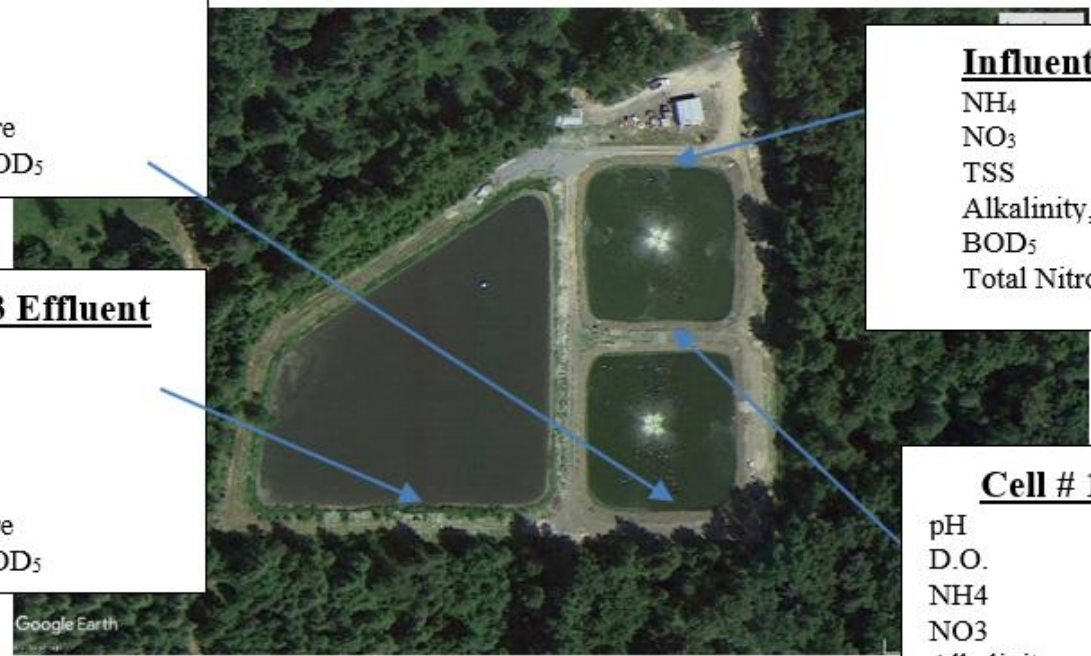
1) Sort-circuiting, and
2) Sludge accumulation

- When and how you test is very important. Composite sampling is the best
- The collection system should be considered as part of your pond system

The Protocol

Your Town WWTP

Cell # 2 Effluent
pH
D.O.
NH_4
NO_3
Alkalinity
Temperature
BOD_5, $CBOD_5$



Influent
NH_4
NO_3
TSS
Alkalinity, pH
BOD_5
Total Nitrogen

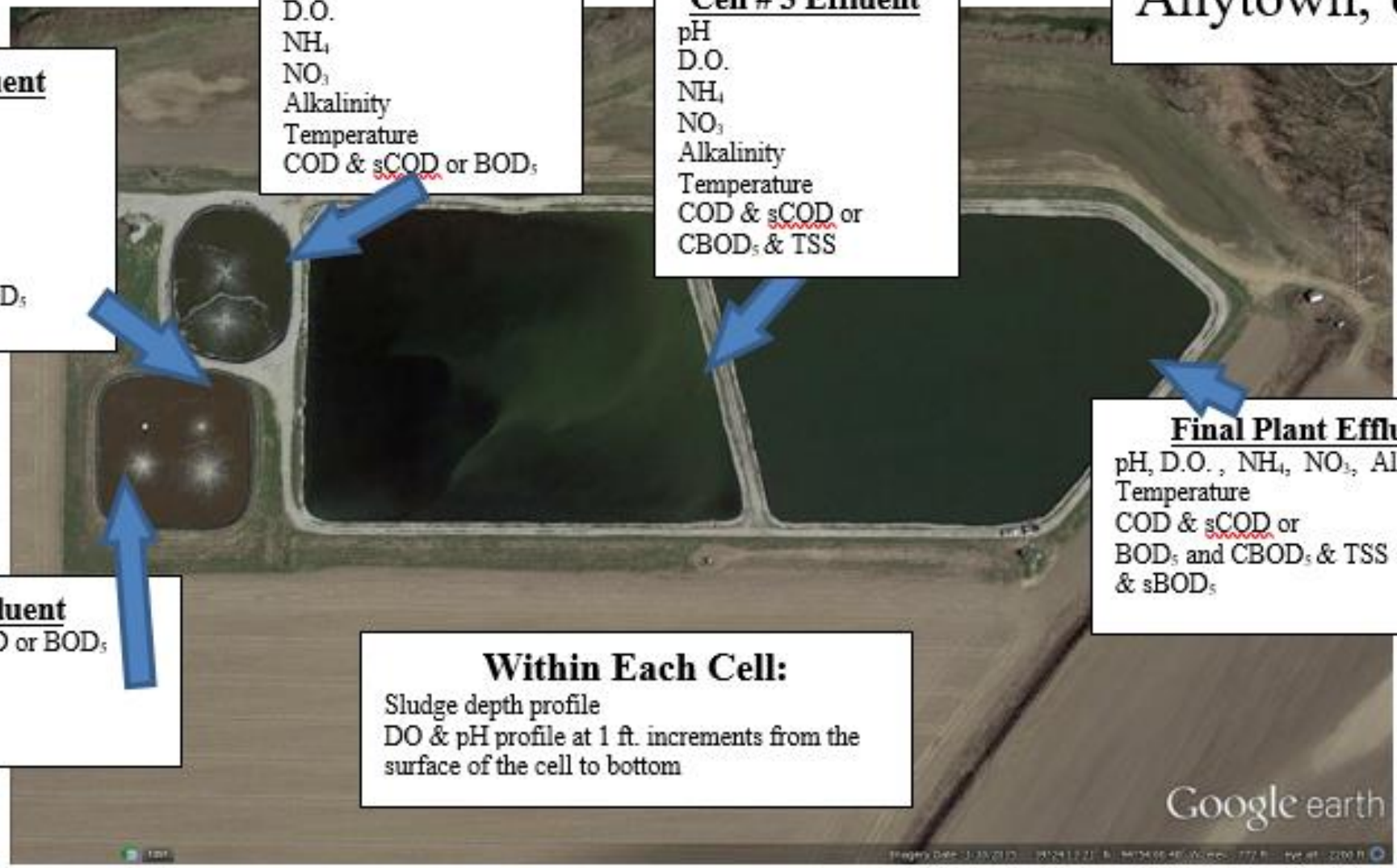
Cell # 3 Effluent
pH
D.O.
NH_4
NO_3
Alkalinity
Temperature
BOD_5, $CBOD_5$

Cell # 1 Effluent
pH
D.O.
NH4
NO3
Alkalinity
Temperature
BOD_5, $CBOD_5$

Within Each Cell:
Sludge depth profile
DO & pH profile at 1 ft. increments from the surface of the cell to bottom

Final Plant Effluent Post Disinfection

pH, D.O. , NH_4, NO_3, Alkalinity
Temperature
Total Nitrogen,
BOD_5, $CBOD_5$, $SCBOD_5$,
TSS


Anytown, USA
Cell # 1 Effluent
pH
D.O.
NH4
NO3
Alkalinity
Temperature
COD & sCOD or BOD5
CBOD5 & TSS
Cell # 2 Effluent
pH
D.O.
NH4
NO3
Alkalinity
Temperature
COD & sCOD or BOD5
Cell # 3 Effluent
pH
D.O.
NH4
NO3
Alkalinity
Temperature
COD & sCOD or
CBOD5 & TSS
Final Plant Effluent
pH, D.O. , NH4, NO3, Alkalinity
Temperature
COD & sCOD or
BOD5 and CBOD5 & TSS
& sBOD5
Influent
COD or BOD5
NH4
NO3
TSS
Within Each Cell:
Sludge depth profile
DO & pH profile at 1 ft. increments from the surface of the cell to bottom
Google earth

1) This testing protocol is the basis for understanding what is happening biologically and biochemically in your lagoon, so you can make decisions to optimize a system to meet permit limits.

2) Pinpointing the source ***and location*** of a lagoon system's inefficiencies saves time and money by selecting the right troubleshooting or optimization course of action. It also provides a greater understanding of how and **where** lagoon systems work and why a system performs the way it does.

3) We combine at least five (5) years of historical data with field grab sample data taken onsite and perform statistical analysis on DMR and system data sets to find correlations leading to the direction optimization and or troubleshooting should take.
4) Field data and historical data are then combined to understand why things are happening in the system, where things are happening, and when it is happening. In this way, we can pinpoint the source of the problem or find the place to focus optimization efforts to meet treatment objectives.

Here is how the optimization/troubleshooting process works; the primary treatment cell is responsible for removing up to eighty percent (80%) of a system's influent BOD. If the Primary treatment cell is not accomplishing this goal, it tells us that there is:

- Short-circuiting
- Too much sludge accumulation
- Too little air for the load
- A need for pre-treatment (toxicity / loading control)
- A need for headworks modification or maintenance
- Too great of a load (septage waste, portable toilet waste, vault waste, illegal drug waste or industrial waste)

If the primary treatment cell can remove 80% of the influent $BOD_{5,}$ then other cells are free to effectively remove **nitrogen**, settle solids, and kill pathogens.

Not removing 80% of the influent BOD "pushes" the job of BOD removal to subsequent treatment cells. Getting the primary treatment cell to do its job, for example, is critical to successful ammonia removal in wastewater lagoon systems.

This allows the lagoon system to accomplish what the engineer designed the system to do

Cases

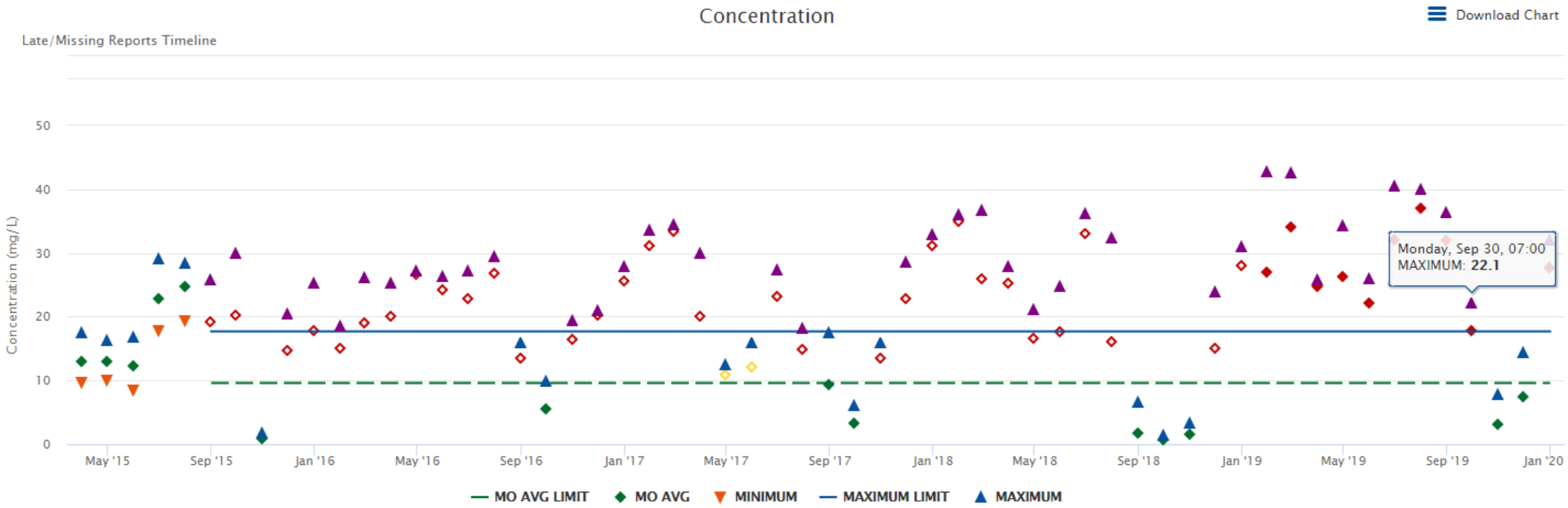
Diffused Air System With Too Much Sludge and Too Little Ammonia Removal

Case 1

Show/Hide Table

Discharge Point:	001 - External Outfall
Pollutant:	Nitrogen, ammonia total [as N]
Monitoring Location:	Effluent Gross

Download Data Chart Legend Help



Show/Hide Table

Discharge Point:	001 - External Outfall
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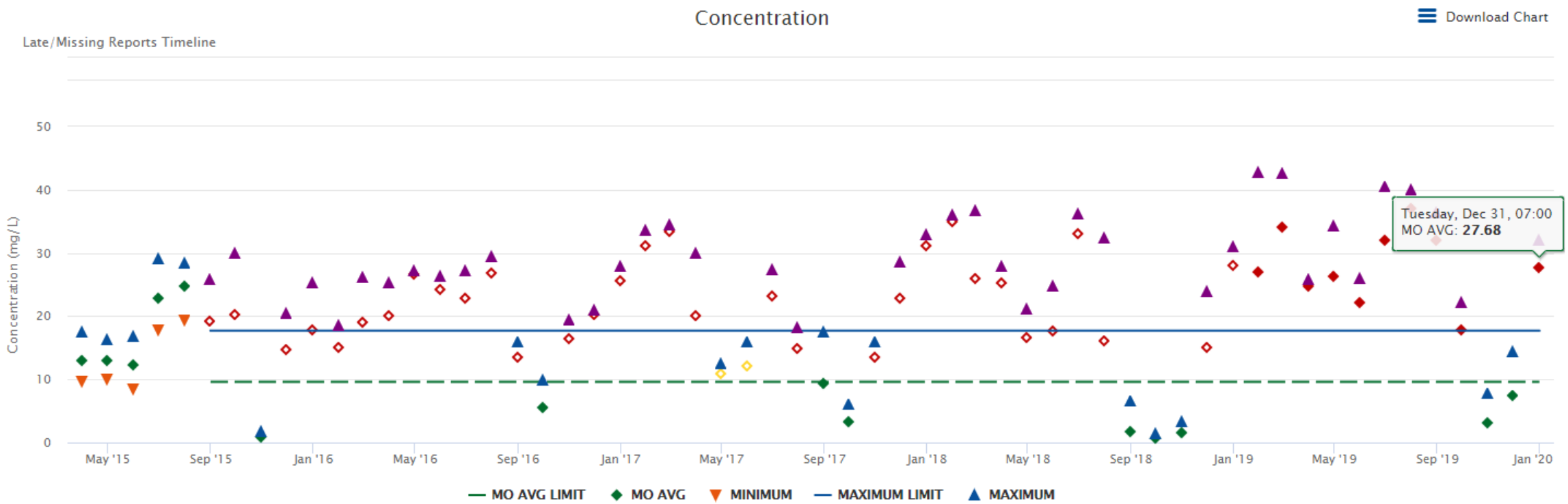
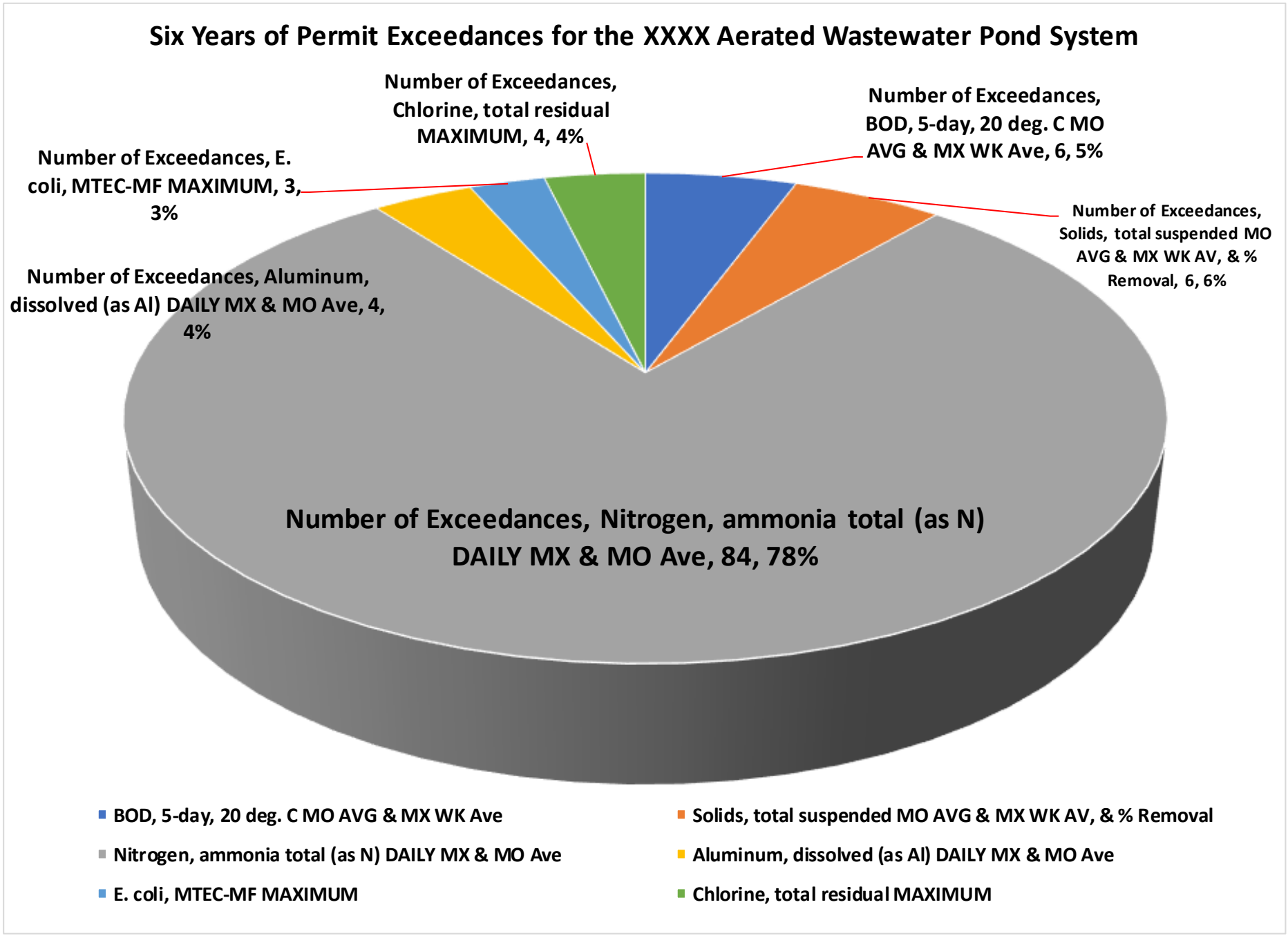
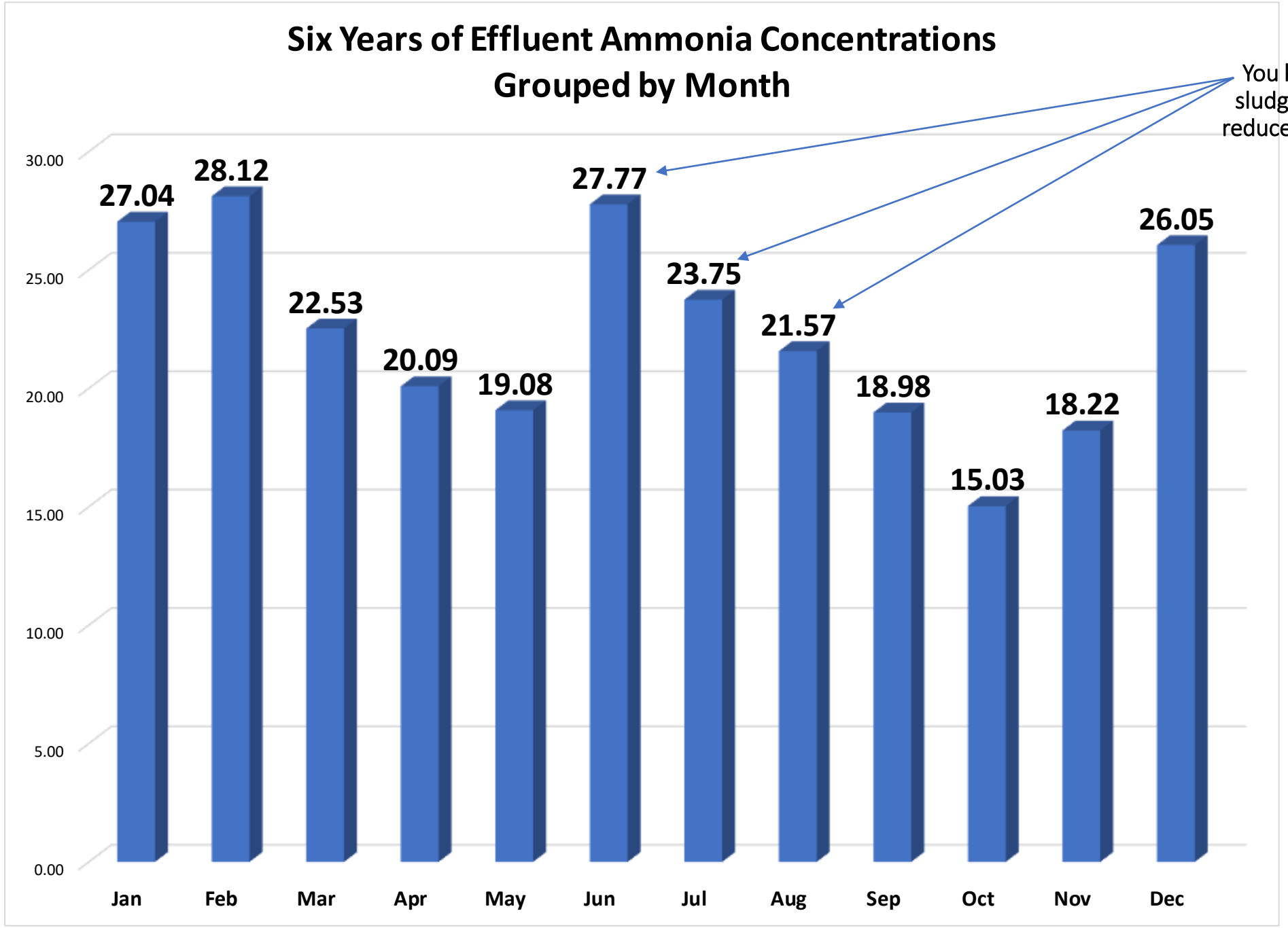
Download Data Chart Legend Help




Six Years of Permit Exceedances for the XXXX Aerated Wastewater Pond System
Number of Exceedances, Chlorine, total residual MAXIMUM, 4, 4%
Number of Exceedances, BOD, 5-day, 20 deg. C MO AVG & MX WK Ave, 6, 5%
Number of Exceedances, E. coli, MTEC-MF MAXIMUM, 3, 3%
Number of Exceedances, Solids, total suspended MO AVG & MX WK AV, & % Removal, 6, 6%
Number of Exceedances, Aluminum, dissolved (as Al) DAILY MX & MO Ave, 4, 4%
Number of Exceedances, Nitrogen, ammonia total (as N) DAILY MX & MO Ave, 84, 78%
BOD, 5-day, 20 deg. C MO AVG & MX WK Ave
Solids, total suspended MO AVG & MX WK AV, & % Removal
Nitrogen, ammonia total (as N) DAILY MX & MO Ave
Aluminum, dissolved (as Al) DAILY MX & MO Ave
E. coli, MTEC-MF MAXIMUM
Chlorine, total residual MAXIMUM

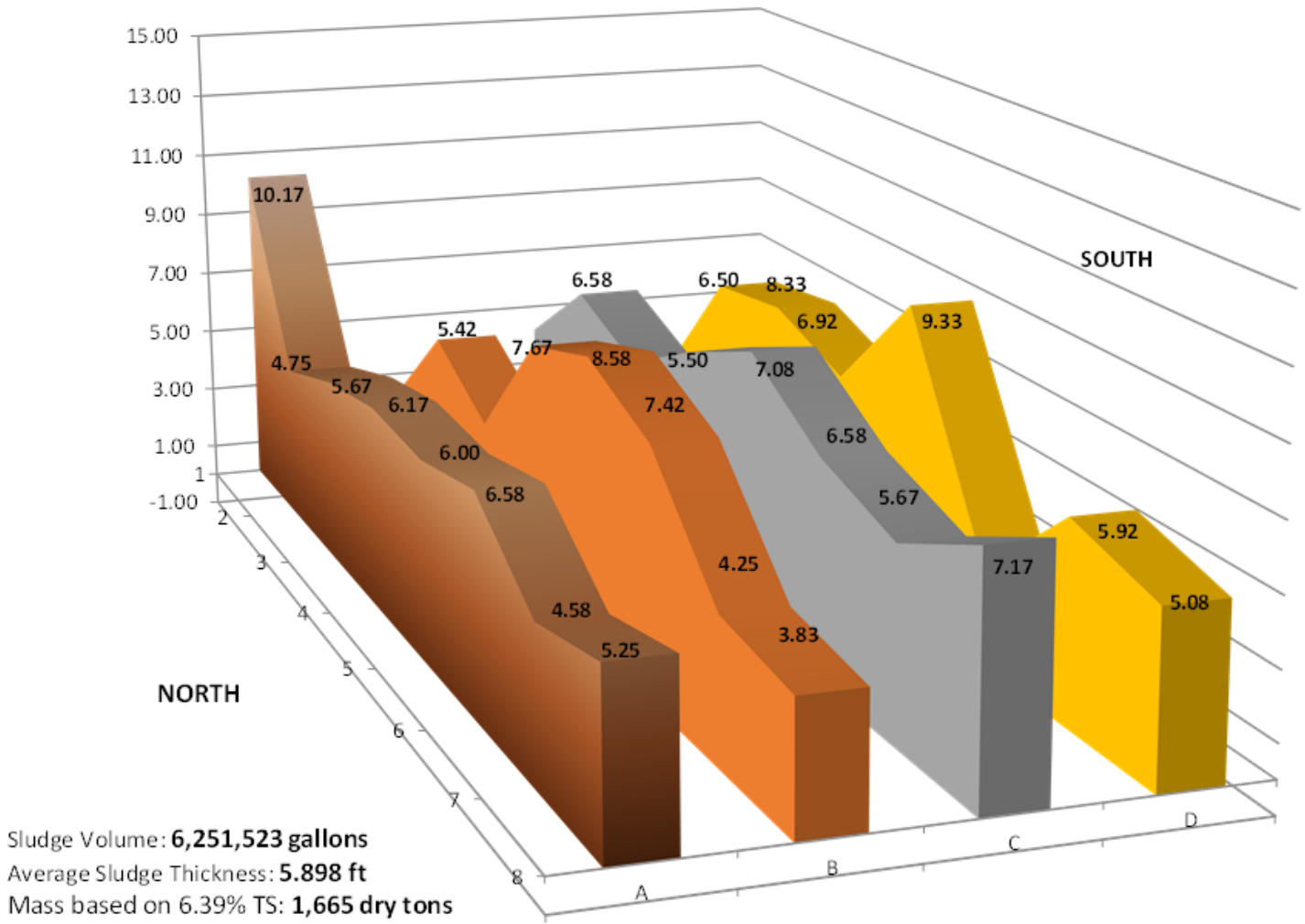

Six Years of Effluent Ammonia Concentrations
Grouped by Month
30.00
25.00
20.00
15.00
10.00
5.00
0.00
27.04
28.12
22.53
20.09
19.08
27.77
23.75
21.57
18.98
15.03
18.22
26.05
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
You know you have too much sludge when your system can't reduce ammonia to below 1 mg/l during the summer


0.5

Cell # 1 Sludge Blanket Thickness Locations

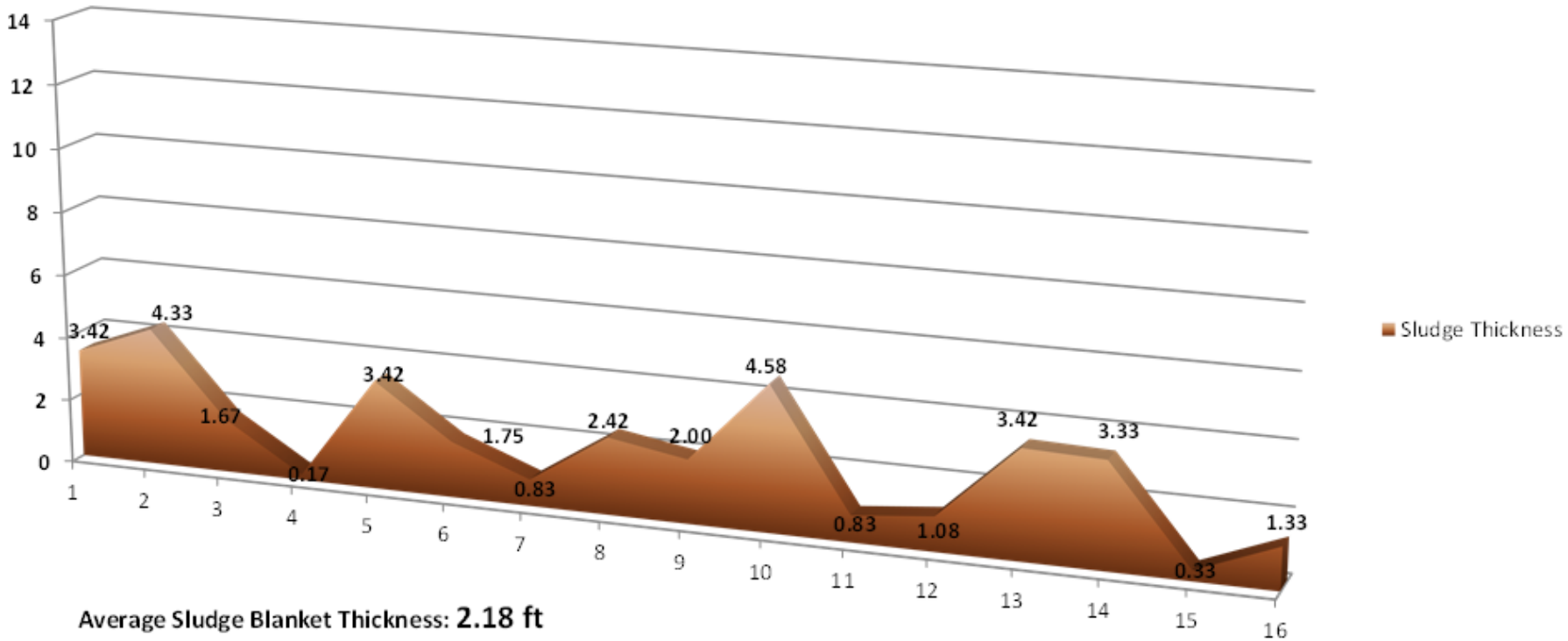
	1	2	3	4	5	6	7	8
A	10.17	4.75	5.67	6.17	6.00	6.58	4.58	5.25
B	2.33	5.42	3.92	7.67	8.58	7.42	4.25	3.83
C	4.17	6.58	5.50	7.08	8.33	6.58	5.67	7.17
D	2.50	6.50	6.92	5.92	9.33	2.92	5.92	5.08

Cell # 1 Sludge Blanket Profile for the [redacted] Wastewater Pond System



Sludge Volume: **6,251,523 gallons**
Average Sludge Thickness: **5.898 ft**
Mass based on 6.39% TS: **1,665 dry tons**
Average Water Depth: **14.5 ft**

Cell # 2 Sludge Blanket Thickness Profile for [redacted]
Wastewater Pond System



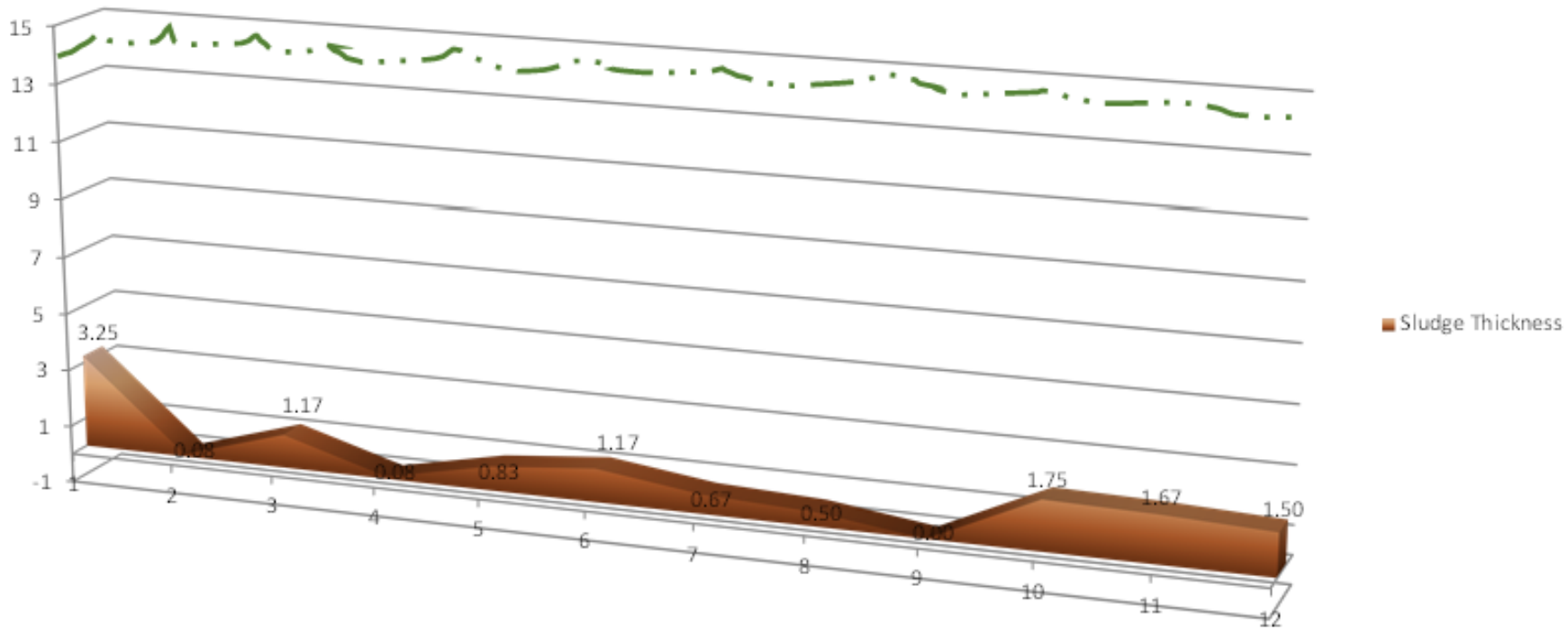
Average Sludge Blanket Thickness: **2.18 ft**

Sludge Volume: **1,024,383 gallons**

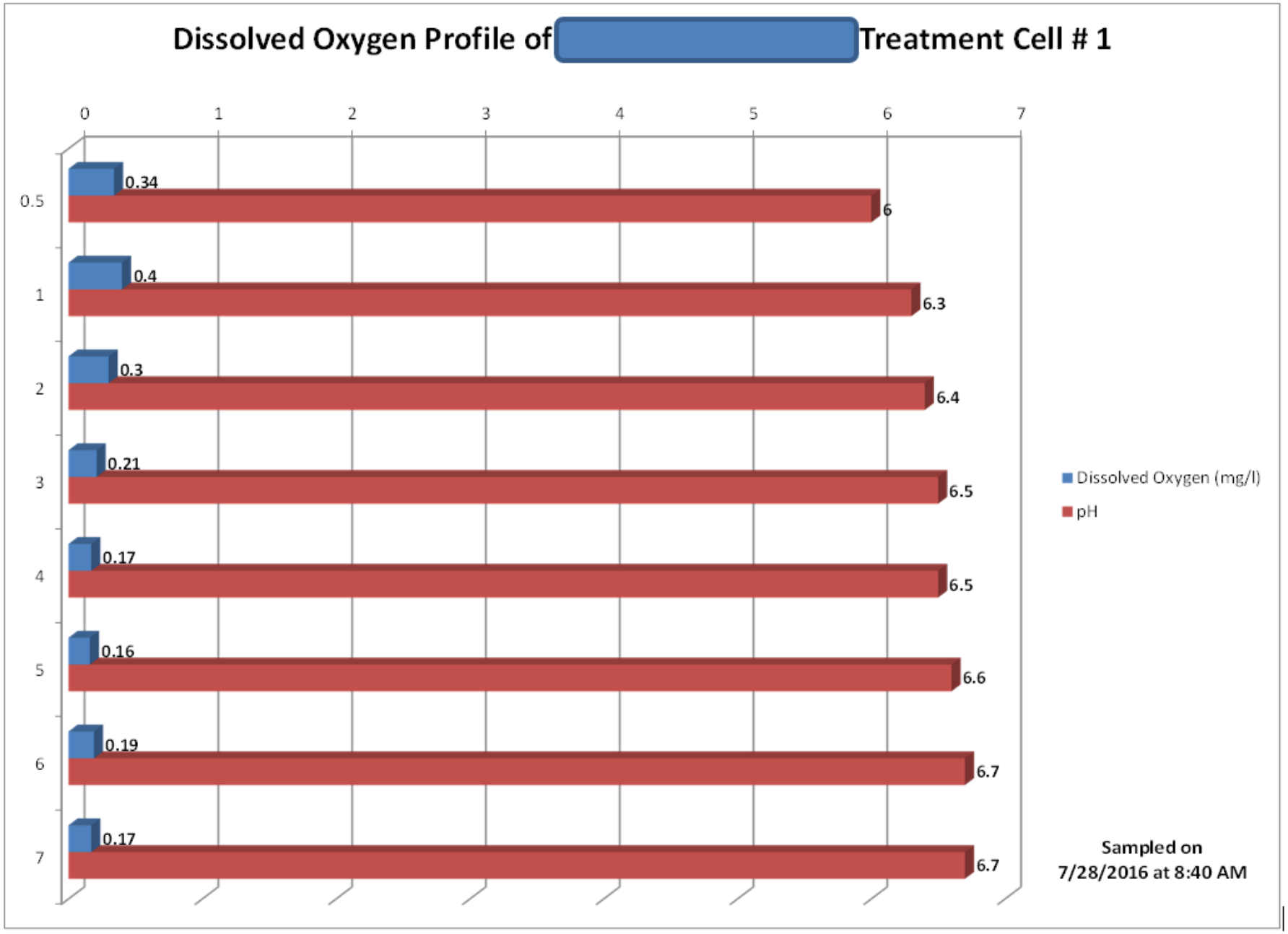
Mass based on **17.03** Ave TS: **727 dry tons**

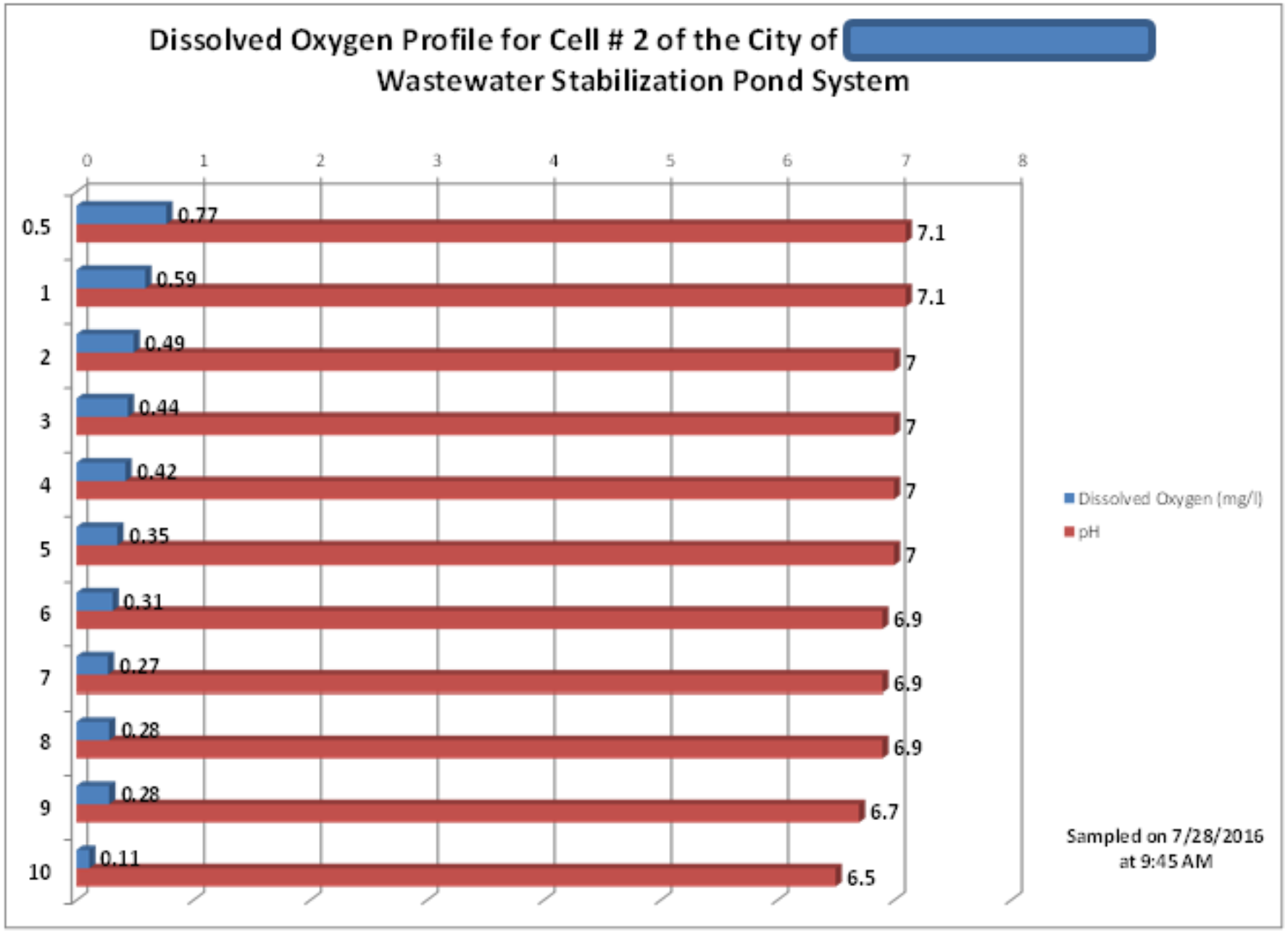
Average Water Depth: **13.23 ft**

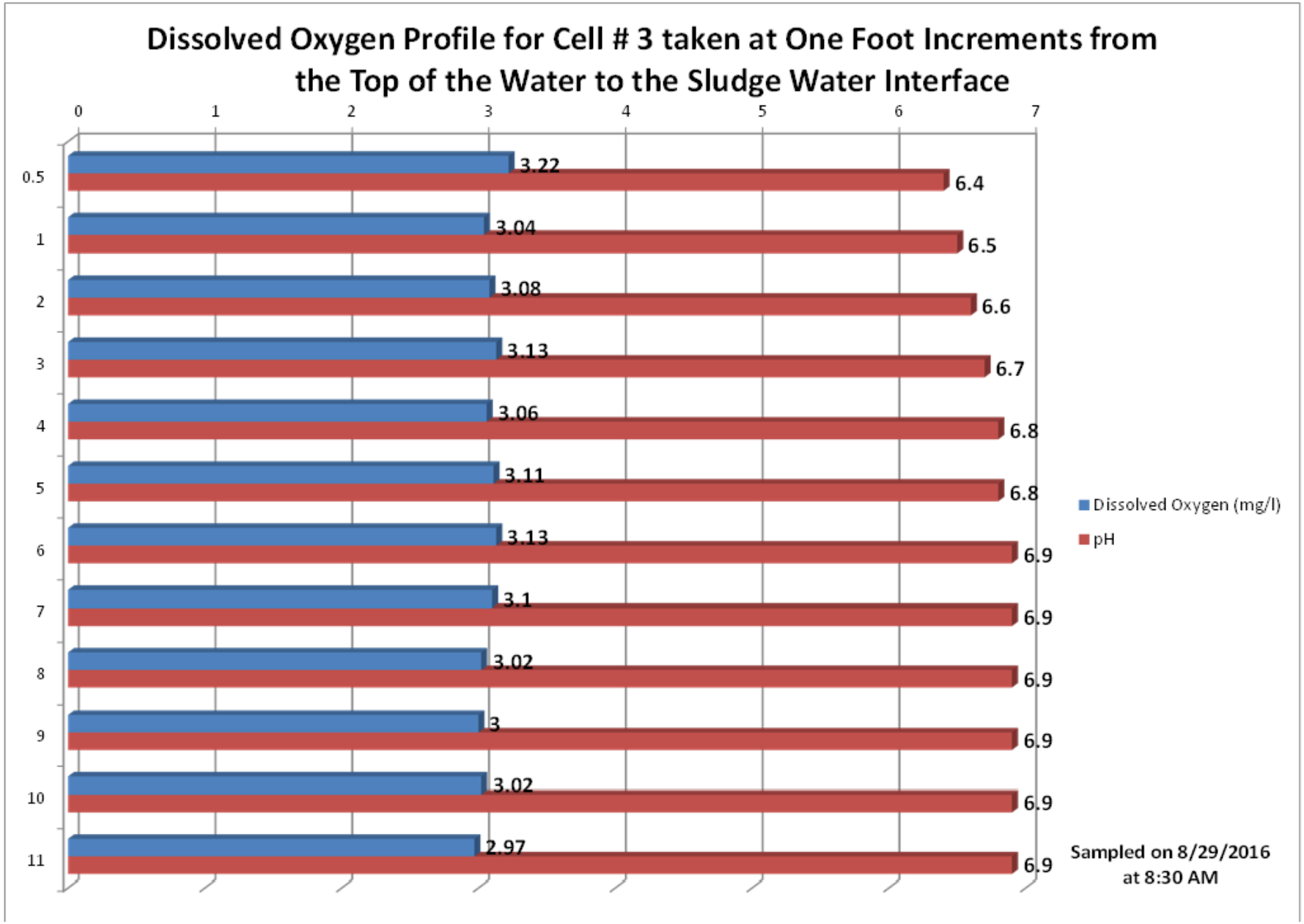
Cell # 3 Sludge Blanket Thickness Profile for the [redacted] Wastewater Pond System



Average Sludge Blanket Thickness: 1.055 ft
Sludge Volume: 480,880 gallons
Average Water Depth: 14.37 ft

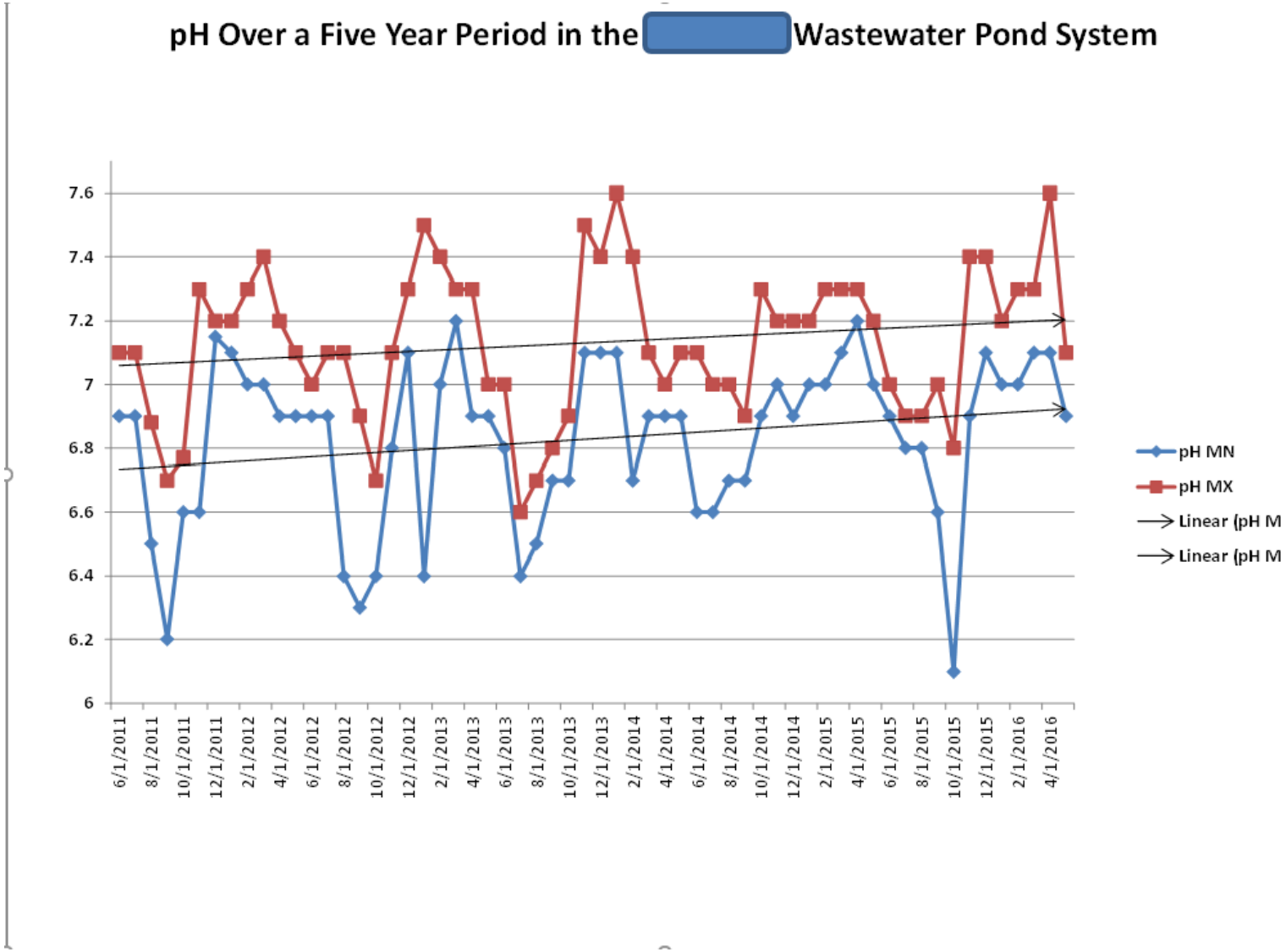

Dissolved Oxygen Profile of [redacted] Treatment Cell # 1
0
1
2
3
4
5
6
7
0.5
1
2
3
4
5
6
7
0.34
6
0.4
6.3
0.3
6.4
0.21
6.5
0.17
6.5
0.16
6.6
0.19
6.7
0.17
6.7
Dissolved Oxygen (mg/l)
pH
Sampled on
7/28/2016 at 8:40 AM


Dissolved Oxygen Profile for Cell # 2 of the City of
Wastewater Stabilization Pond System
0
1
2
3
4
5
6
7
8
0.5
1
2
3
4
5
6
7
8
9
10
0.77
0.59
0.49
0.44
0.42
0.35
0.31
0.27
0.28
0.28
0.11
7.1
7.1
7
7
7
7
6.9
6.9
6.9
6.7
6.5
Dissolved Oxygen (mg/l)
pH
Sampled on 7/28/2016
at 9:45 AM

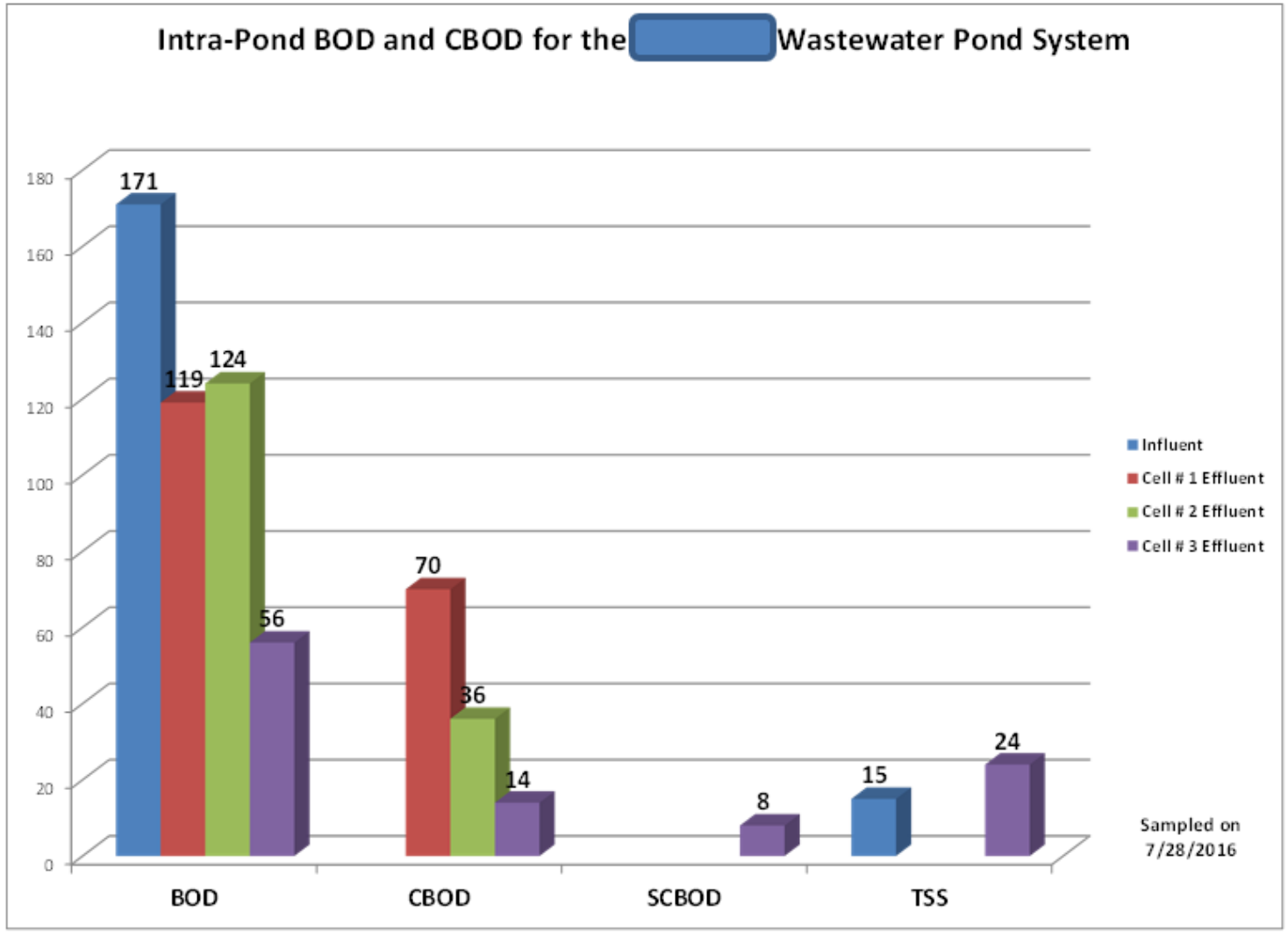

Dissolved Oxygen Profile for Cell # 3 taken at One Foot Increments from the Top of the Water to the Sludge Water Interface
0
1
2
3
4
5
6
7
0.5
1
2
3
4
5
6
7
8
9
10
11
3.22
6.4
3.04
6.5
3.08
6.6
3.13
6.7
3.06
6.8
3.11
6.8
3.13
6.9
3.1
6.9
3.02
6.9
3
6.9
3.02
6.9
2.97
6.9
Dissolved Oxygen (mg/l)
pH
Sampled on 8/29/2016 at 8:30 AM


HQ40d
0.4

Effluent pH is Around Neutral



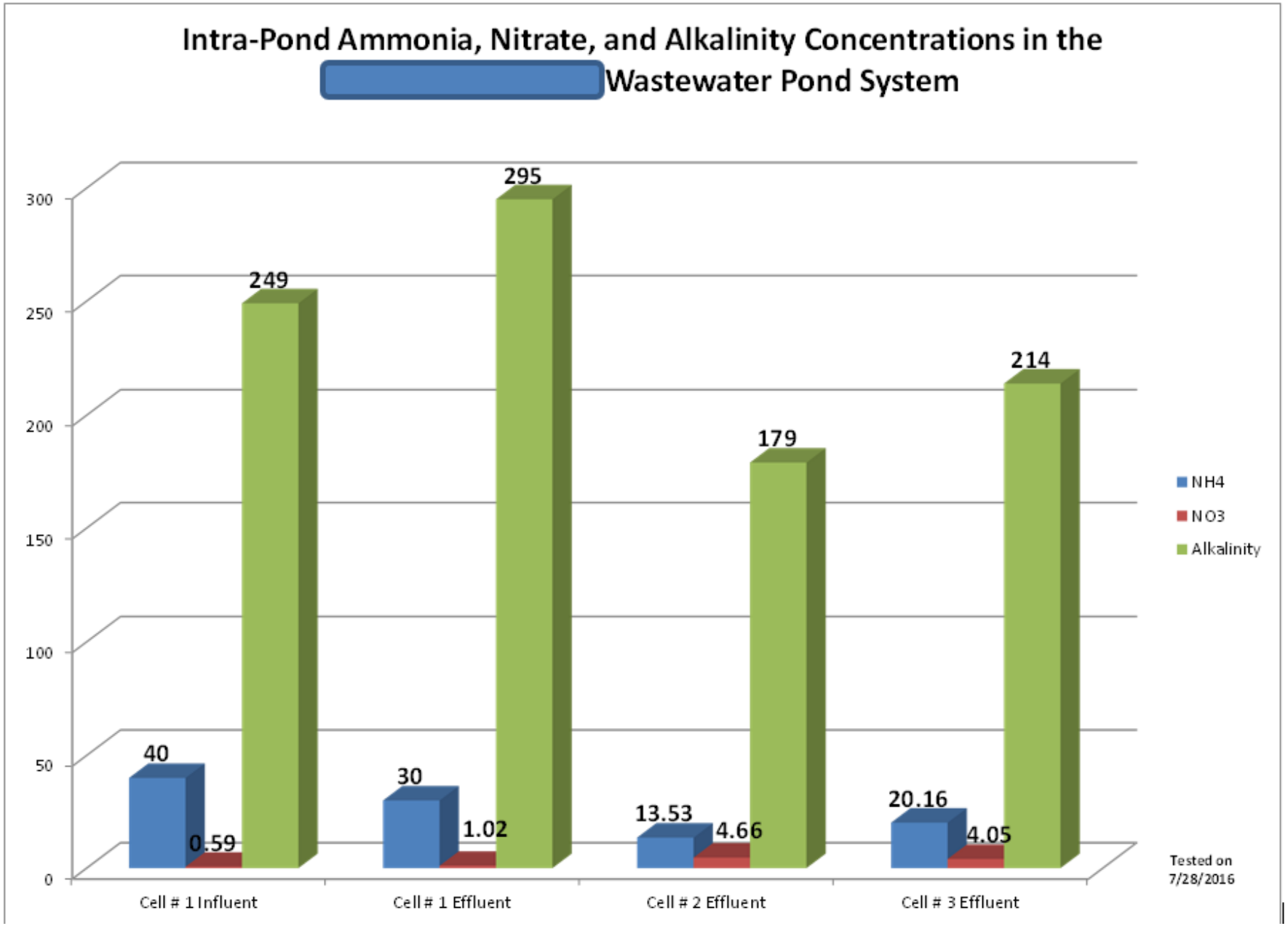
Poor BOD5 Removal…too Much Ammonia is Leaving the Plant

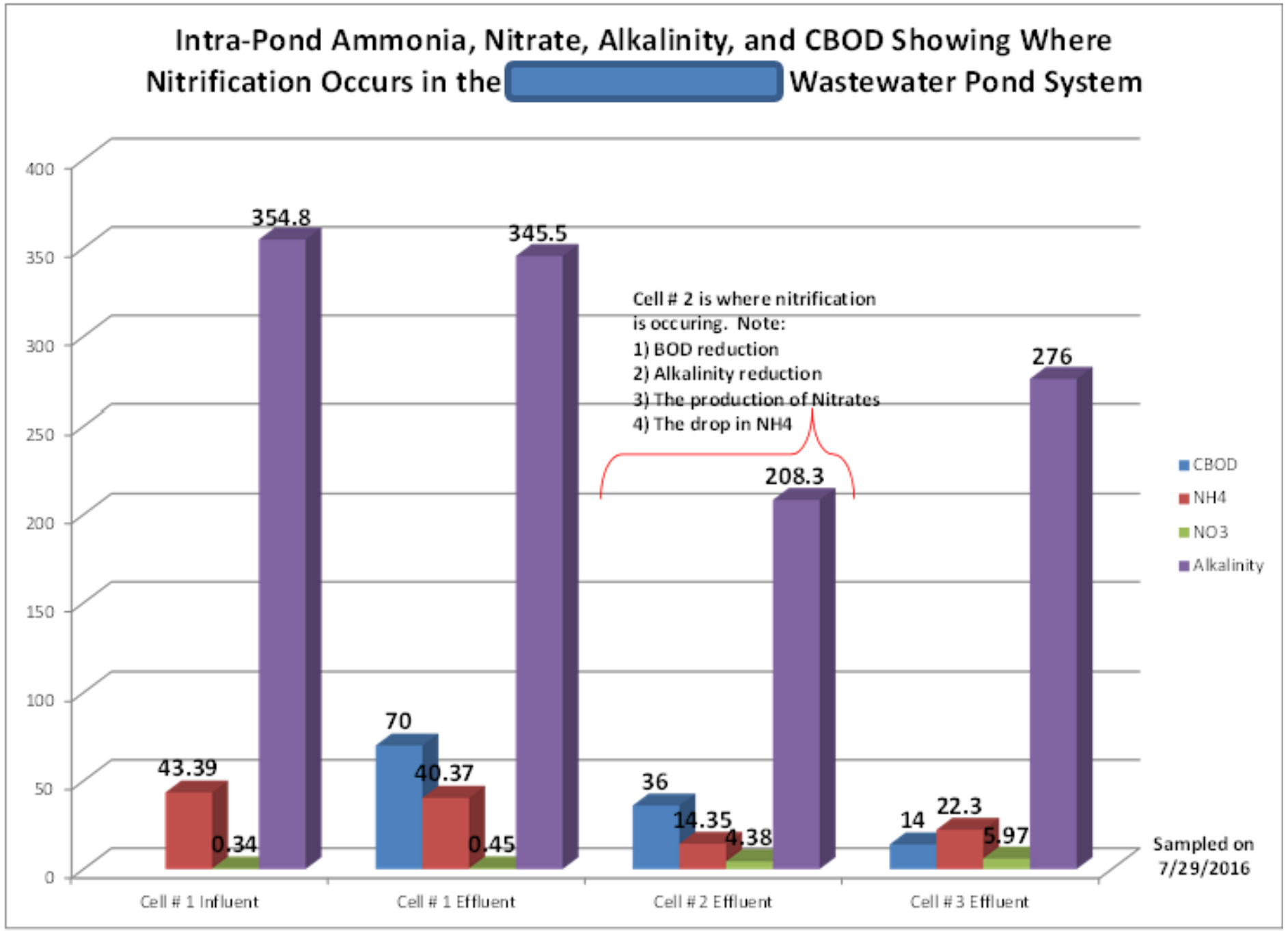


30.6 % BOD Removal in Cell # 1 (Should be 80%)
67.3% BOD Removal by the Final Cell

42% of the final effluent BOD is caused by nitrification in the BOD_5 test bottle

This means more air must be added up front to removal ammonia in the pond system itself. Too much ammonia is getting into the BOD_5 test bottle


Intra-Pond Ammonia, Nitrate, and Alkalinity Concentrations in the
Wastewater Pond System
300
250
200
150
100
50
0
249
295
179
214
40
0.59
30
1.02
13.53
4.66
20.16
4.05
NH4
NO3
Alkalinity
Tested on
7/28/2016
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent

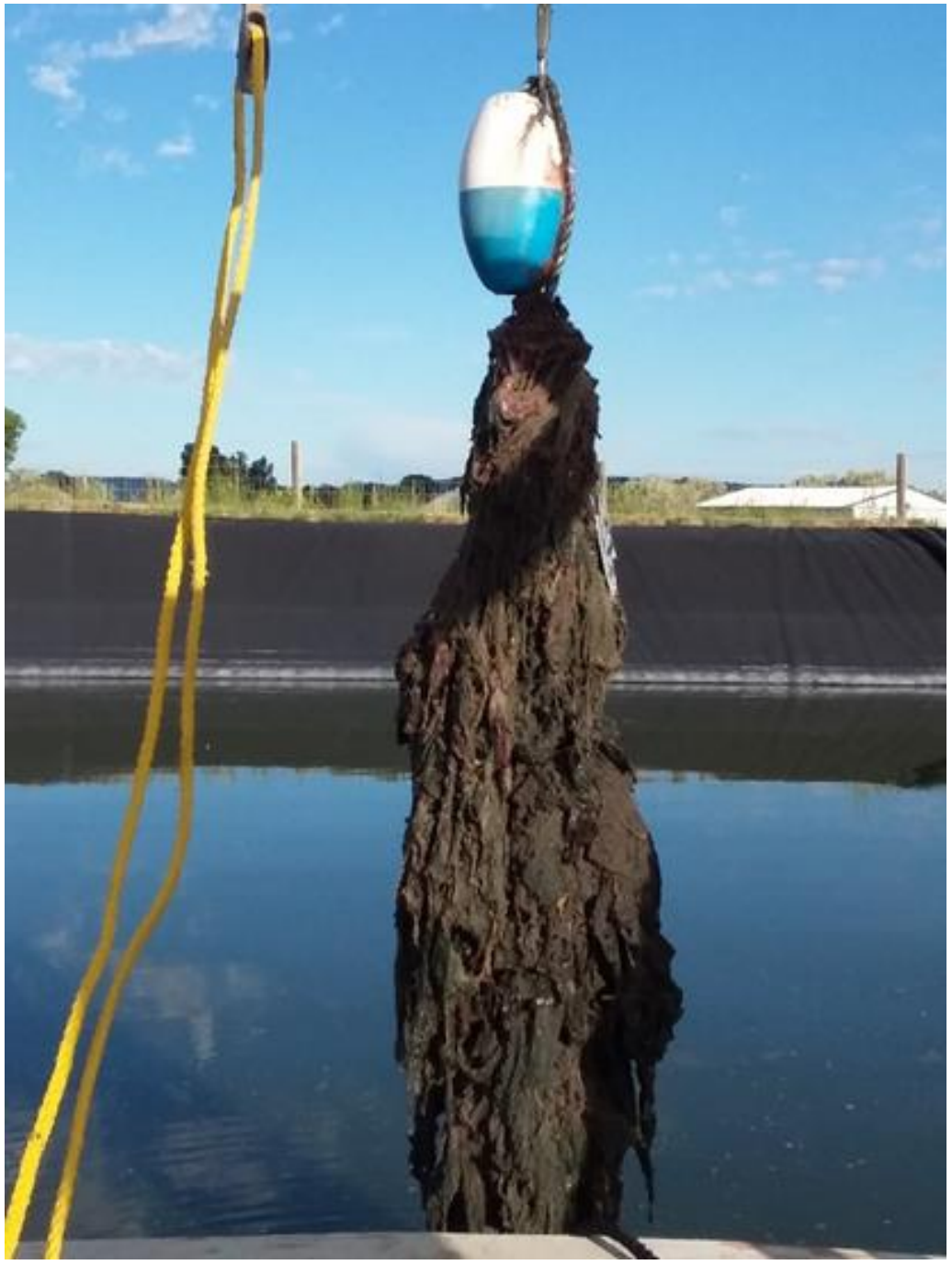

Intra-Pond Ammonia, Nitrate, Alkalinity, and CBOD Showing Where Nitrification Occurs in the [redacted] Wastewater Pond System
400
350
300
250
200
150
100
50
0
354.8
345.5
276
208.3
70
43.39
40.37
36
22.3
14.35
14
5.97
4.38
0.34
0.45
Cell # 2 is where nitrification is occuring. Note:
1) BOD reduction
2) Alkalinity reduction
3) The production of Nitrates
4) The drop in NH4
CBOD
NH4
NO3
Alkalinity
Sampled on 7/29/2016
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent

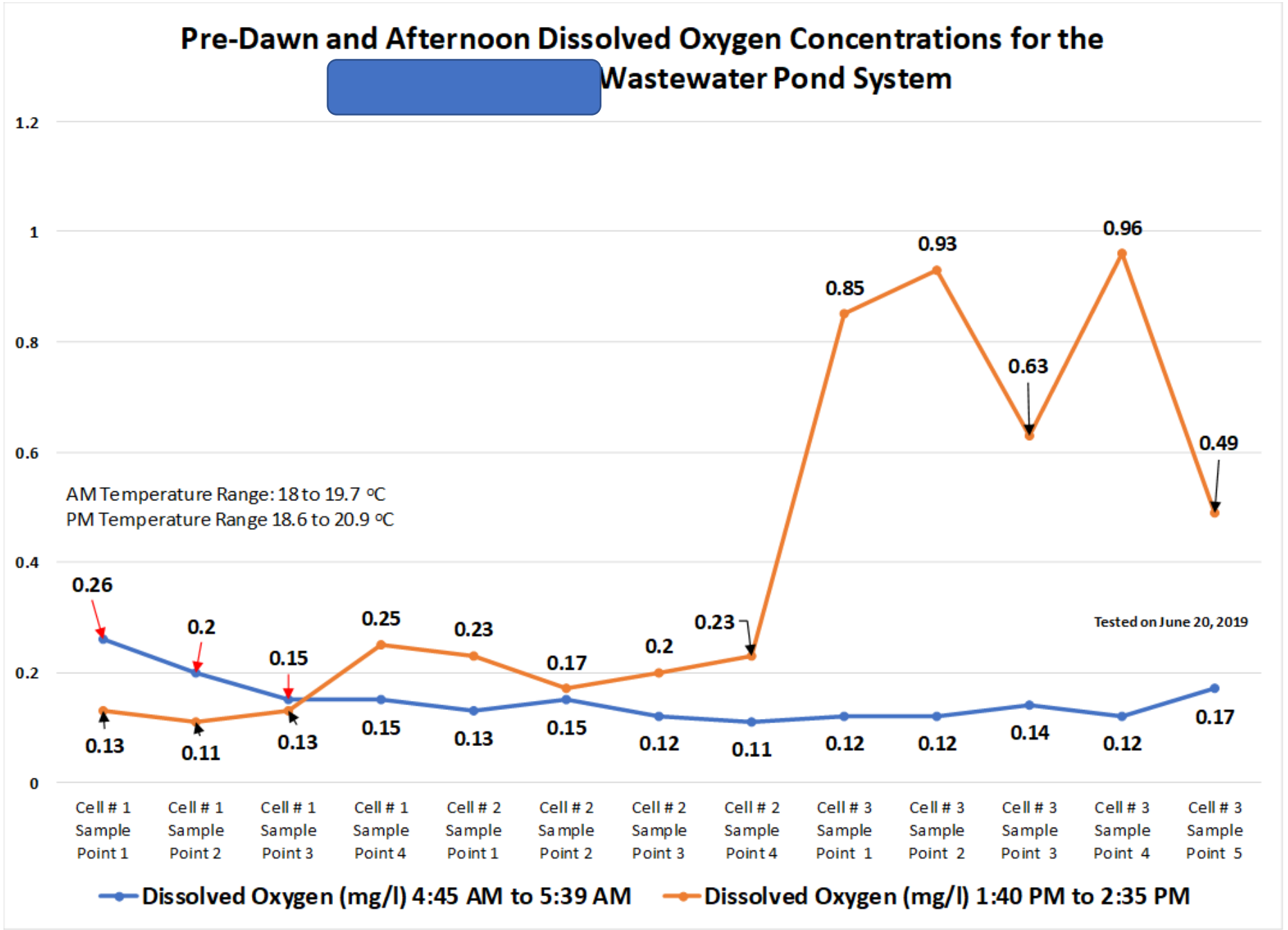
The saving grace for this system. A clarifier. This is why TSS and even BOD is so low

Low Dissolved Oxygen

This lagoon system runs anoxic both day and night, has very poor ammonia removal, poor Cell # 1 BOD_5 removal efficiency, smells, and pops sludge in the final treatment cell.

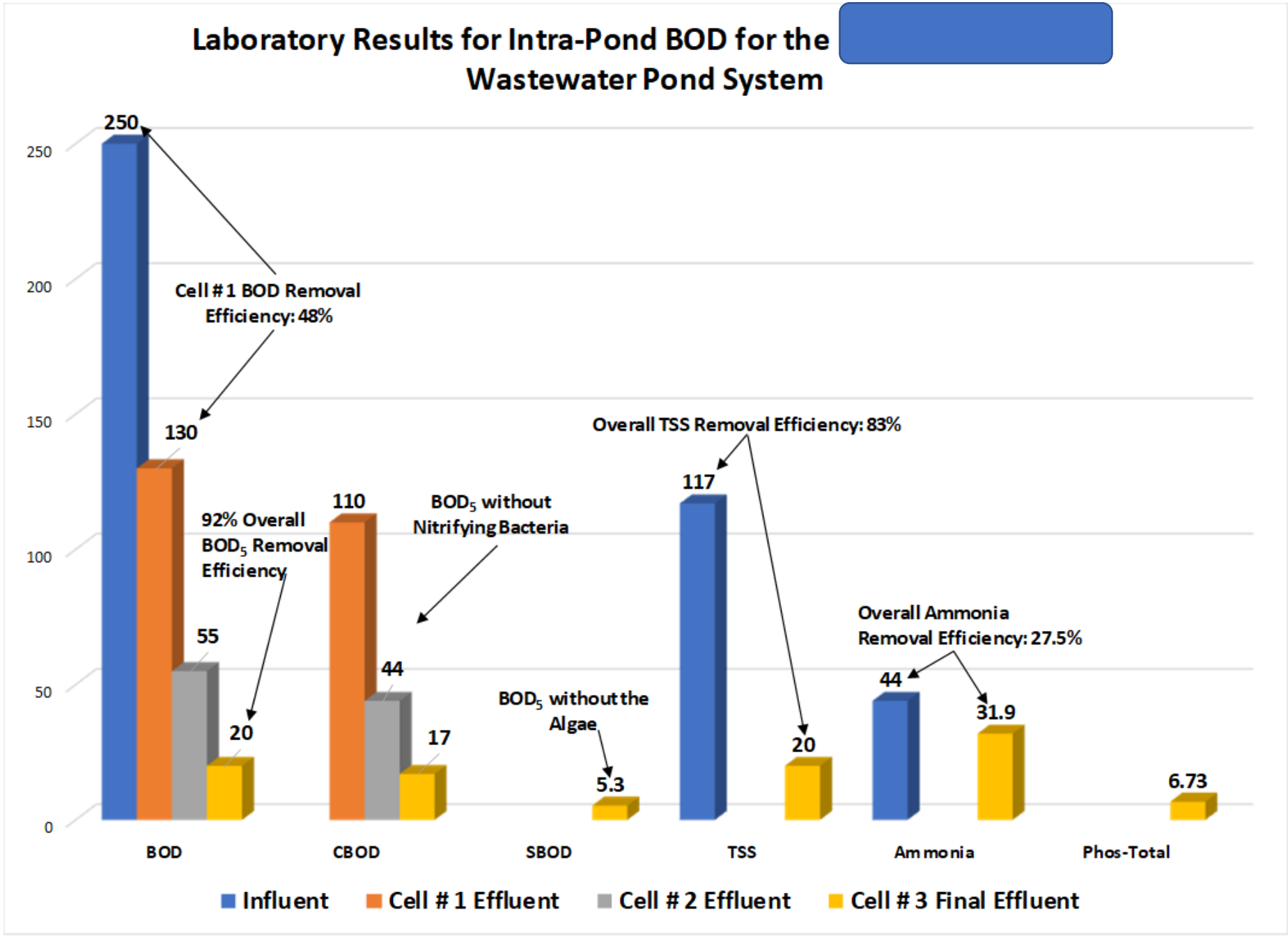
Case # 2

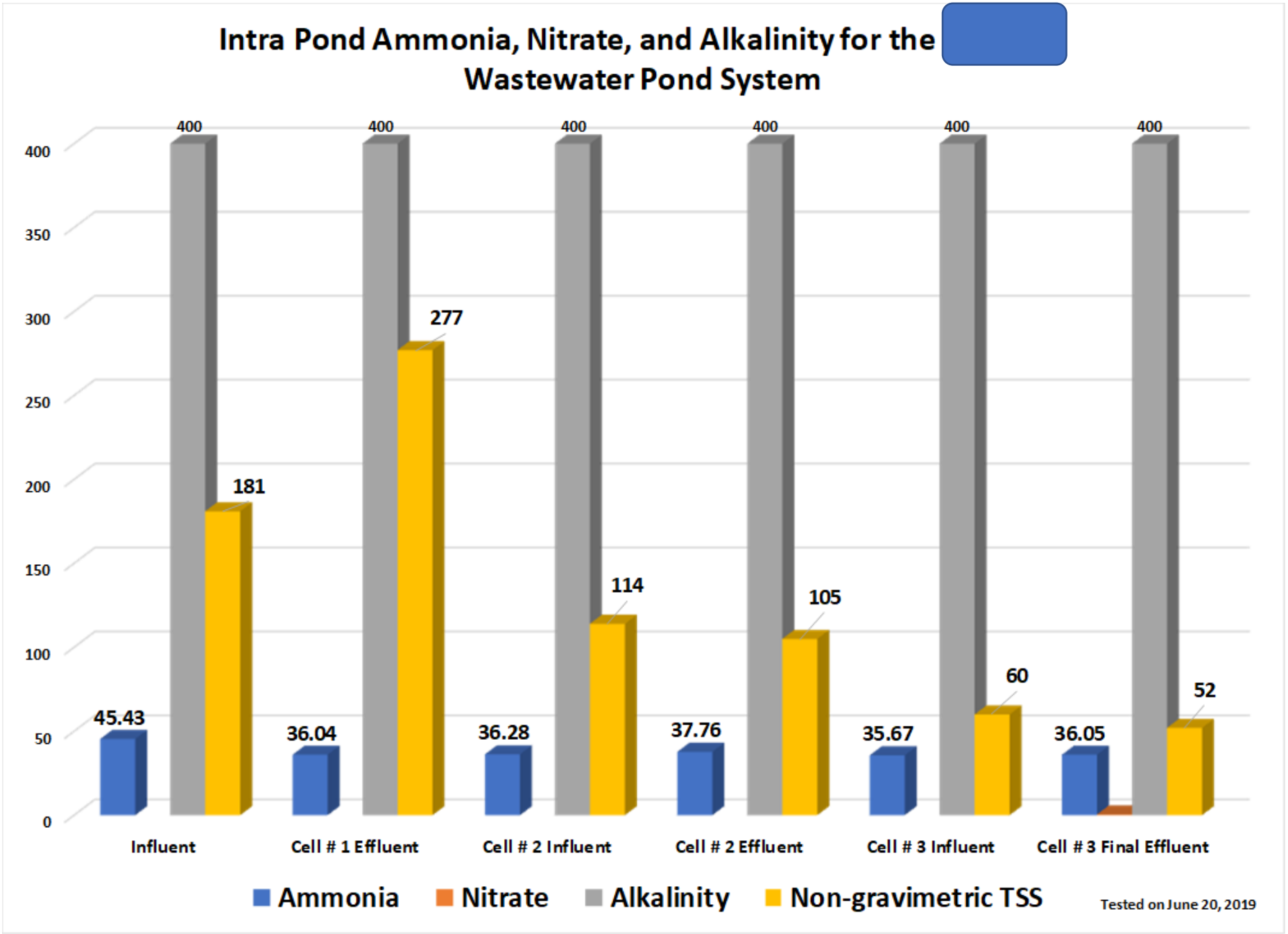


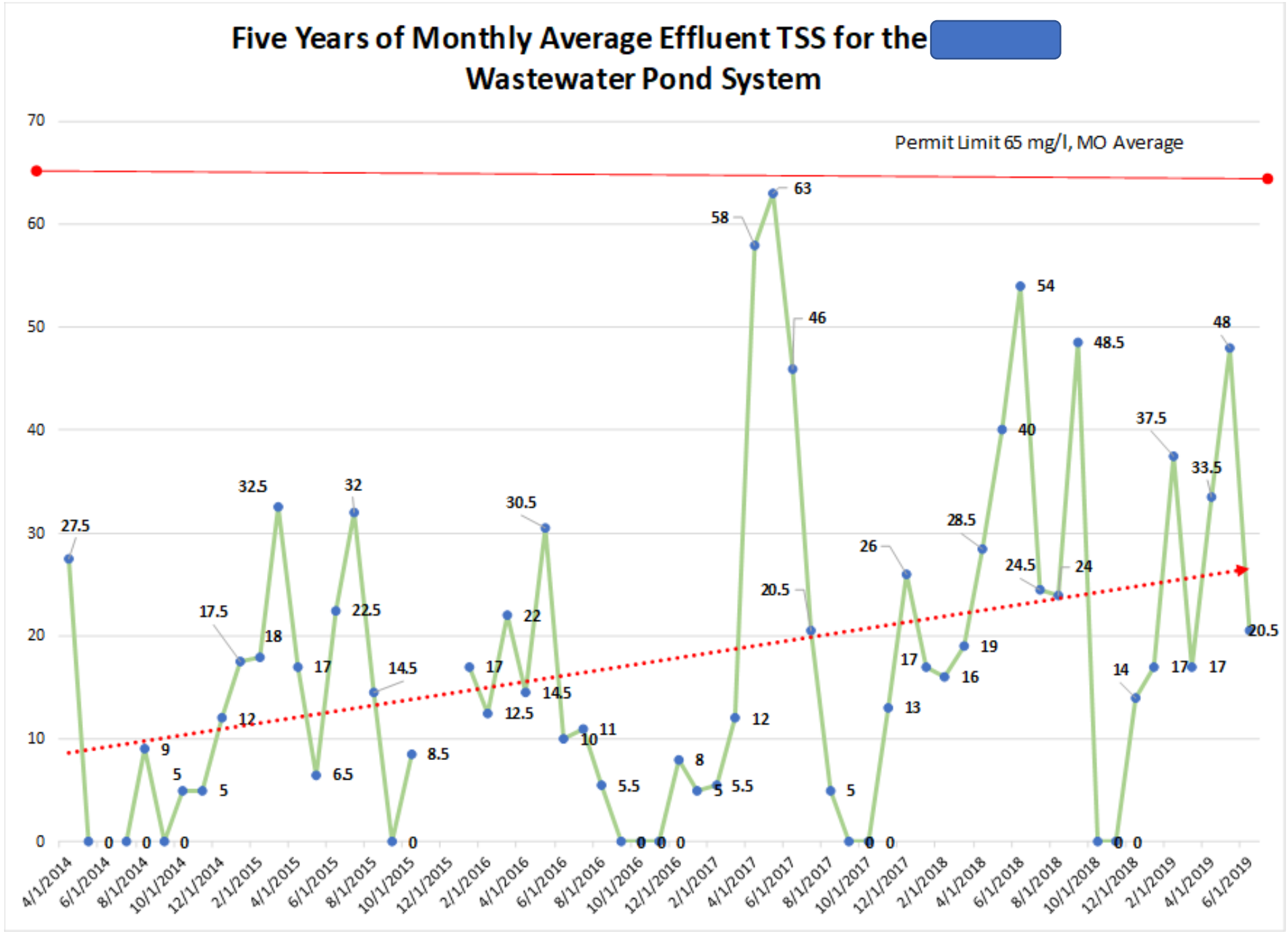

Pre-Dawn and Afternoon Dissolved Oxygen Concentrations for the
Wastewater Pond System
1.2
1
0.8
0.6
0.4
0.2
0
AM Temperature Range: 18 to 19.7 °C
PM Temperature Range 18.6 to 20.9 °C
Tested on June 20, 2019
0.26
0.2
0.15
0.13
0.11
0.13
0.25
0.23
0.17
0.15
0.13
0.15
0.2
0.23
0.12
0.11
0.85
0.93
0.63
0.12
0.12
0.96
0.49
0.14
0.12
0.17
Cell # 1 Sample Point 1
Cell # 1 Sample Point 2
Cell # 1 Sample Point 3
Cell # 1 Sample Point 4
Cell # 2 Sample Point 1
Cell # 2 Sample Point 2
Cell # 2 Sample Point 3
Cell # 2 Sample Point 4
Cell # 3 Sample Point 1
Cell # 3 Sample Point 2
Cell # 3 Sample Point 3
Cell # 3 Sample Point 4
Cell # 3 Sample Point 5
Dissolved Oxygen (mg/l) 4:45 AM to 5:39 AM
Dissolved Oxygen (mg/l) 1:40 PM to 2:35 PM

Poor BOD_5 and Ammonia removal can be seen to occur in the XXX system. Poor Cell # 1 BOD_5 and effluent ammonia removal efficiency result from too little dissolved oxygen delivered to the microbes required to remove these pollutants.

Lesser treatment facilities across the USA remove ammonia down to 0.5 mg/l during the summer.




Intra Pond Ammonia, Nitrate, and Alkalinity for the Wastewater Pond System
400
350
300
250
200
150
100
50
0
400
400
400
400
400
400
277
181
114
105
60
52
45.43
36.04
36.28
37.76
35.67
36.05
Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 Effluent
Cell # 3 Influent
Cell # 3 Final Effluent
Ammonia
Nitrate
Alkalinity
Non-gravimetric TSS
Tested on June 20, 2019


Five Years of Monthly Average Effluent TSS for the [redacted] Wastewater Pond System
Permit Limit 65 mg/l, MO Average
70
60
50
40
30
20
10
0
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
12/1/2015
2/1/2016
4/1/2016
6/1/2016
8/1/2016
10/1/2016
12/1/2016
2/1/2017
4/1/2017
6/1/2017
8/1/2017
10/1/2017
12/1/2017
2/1/2018
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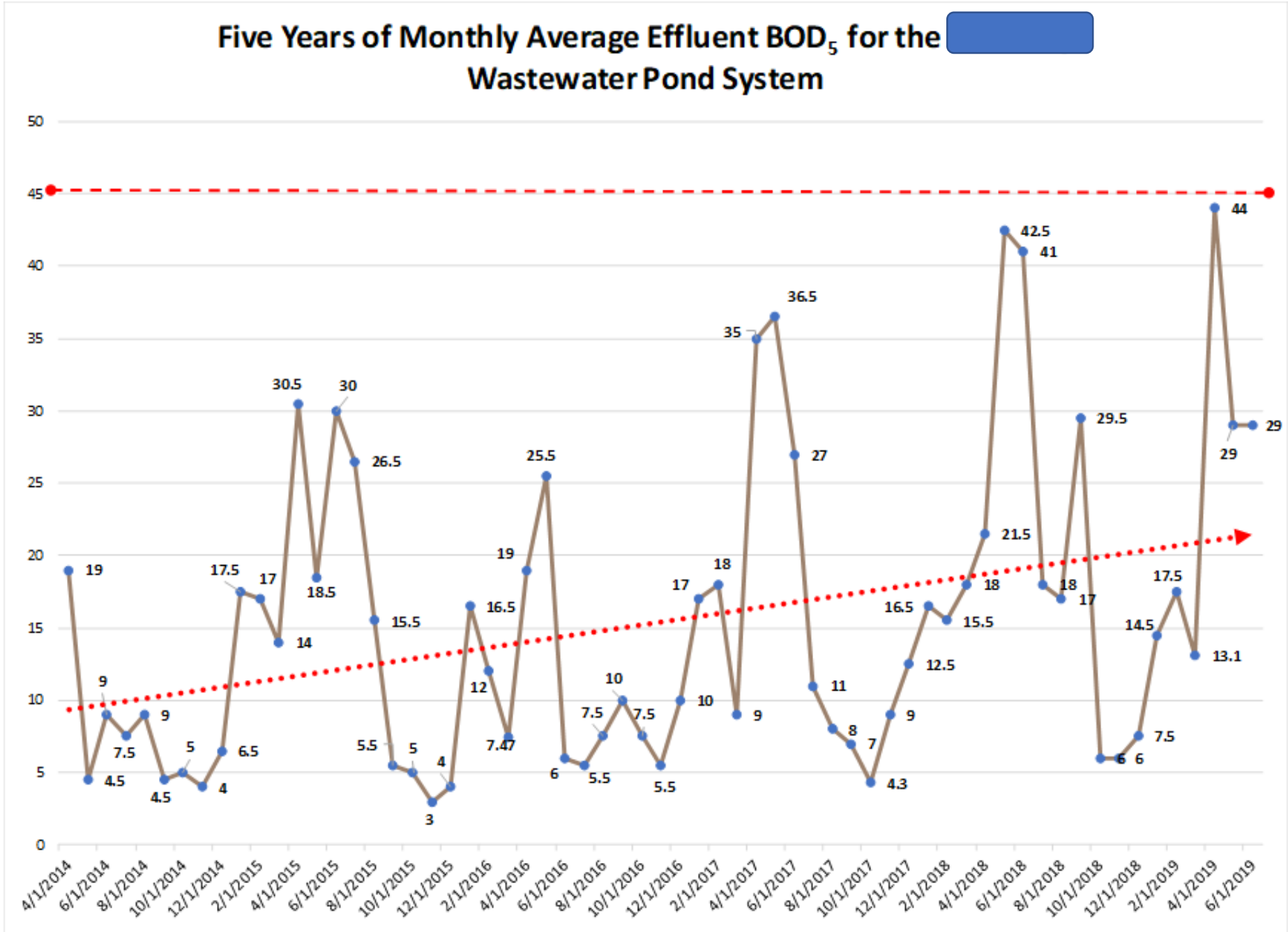
12/1/2018
2/1/2019
4/1/2019
6/1/2019


Five Years of Monthly Average Effluent BOD5 for the
Wastewater Pond System
50
45
40
35
30
25
20
15
10
5
0
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
12/1/2015
2/1/2016
4/1/2016
6/1/2016
8/1/2016
10/1/2016
12/1/2016
2/1/2017
4/1/2017
6/1/2017
8/1/2017
10/1/2017
12/1/2017
2/1/2018
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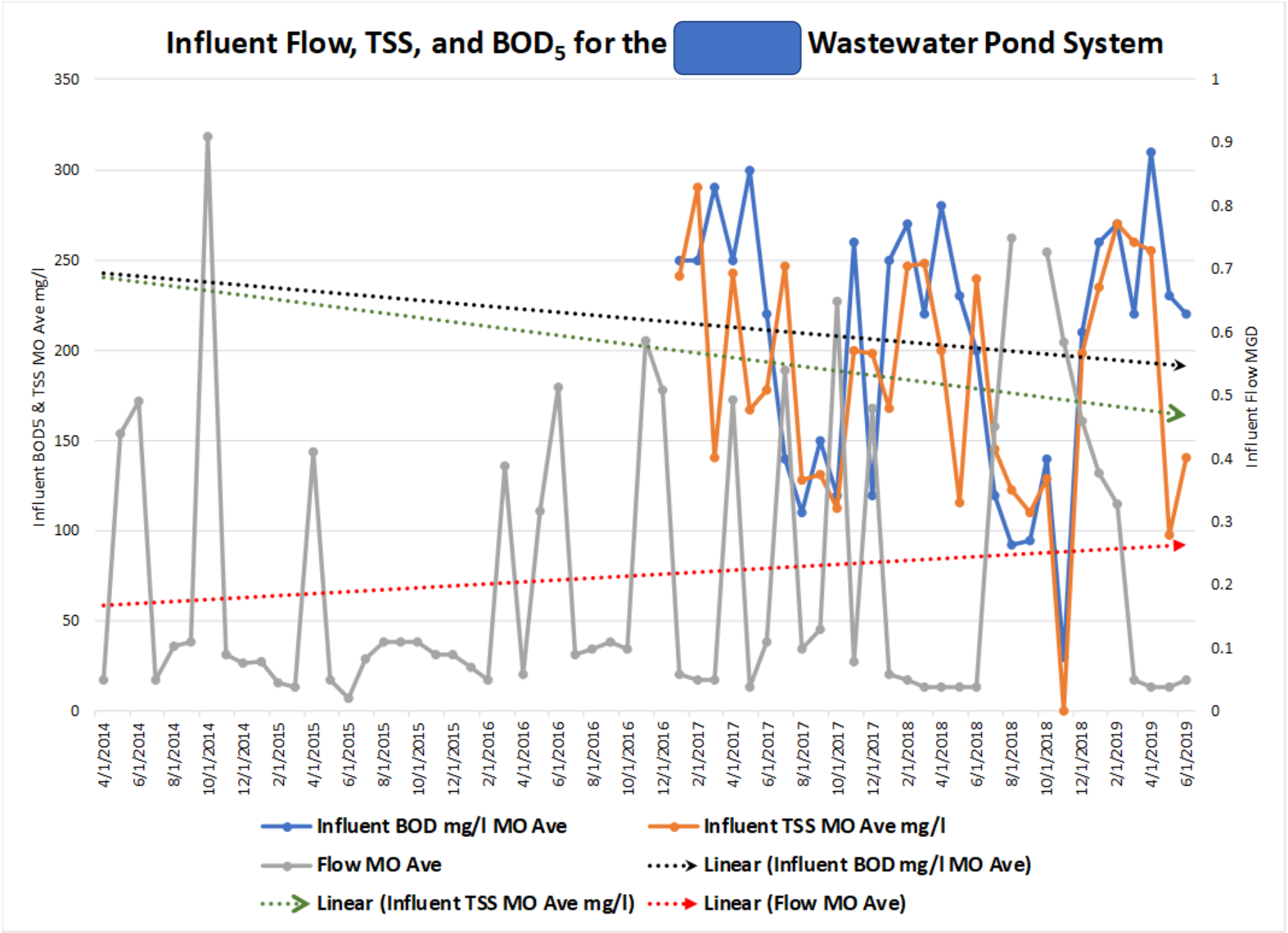
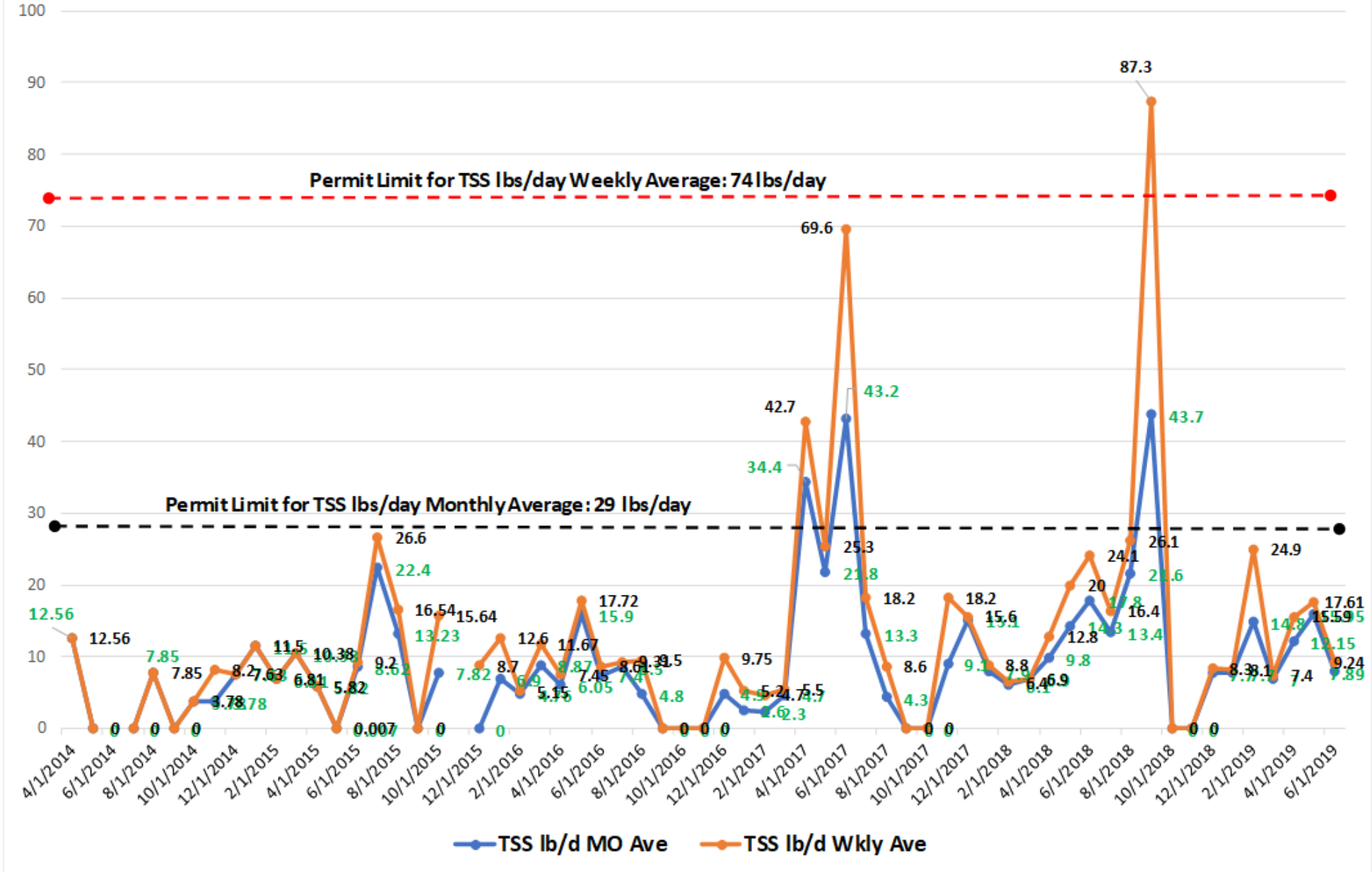
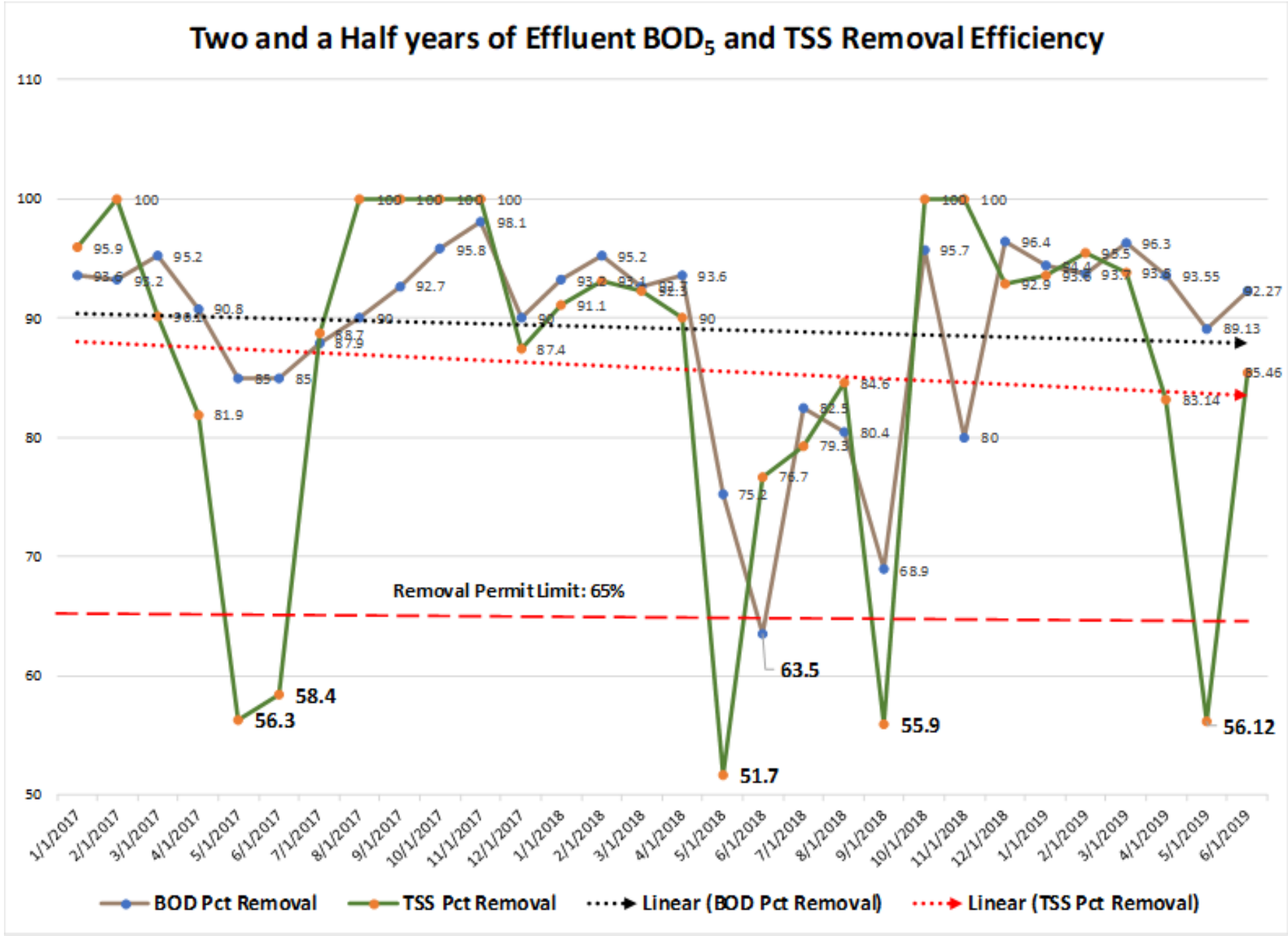
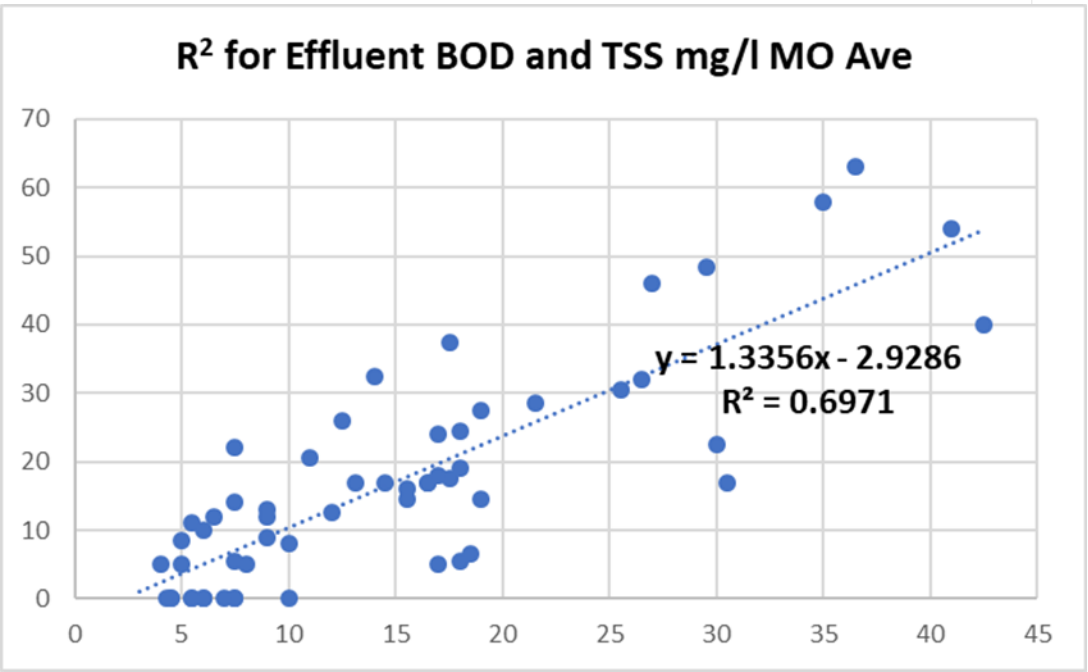
12/1/2018
2/1/2019
4/1/2019
6/1/2019

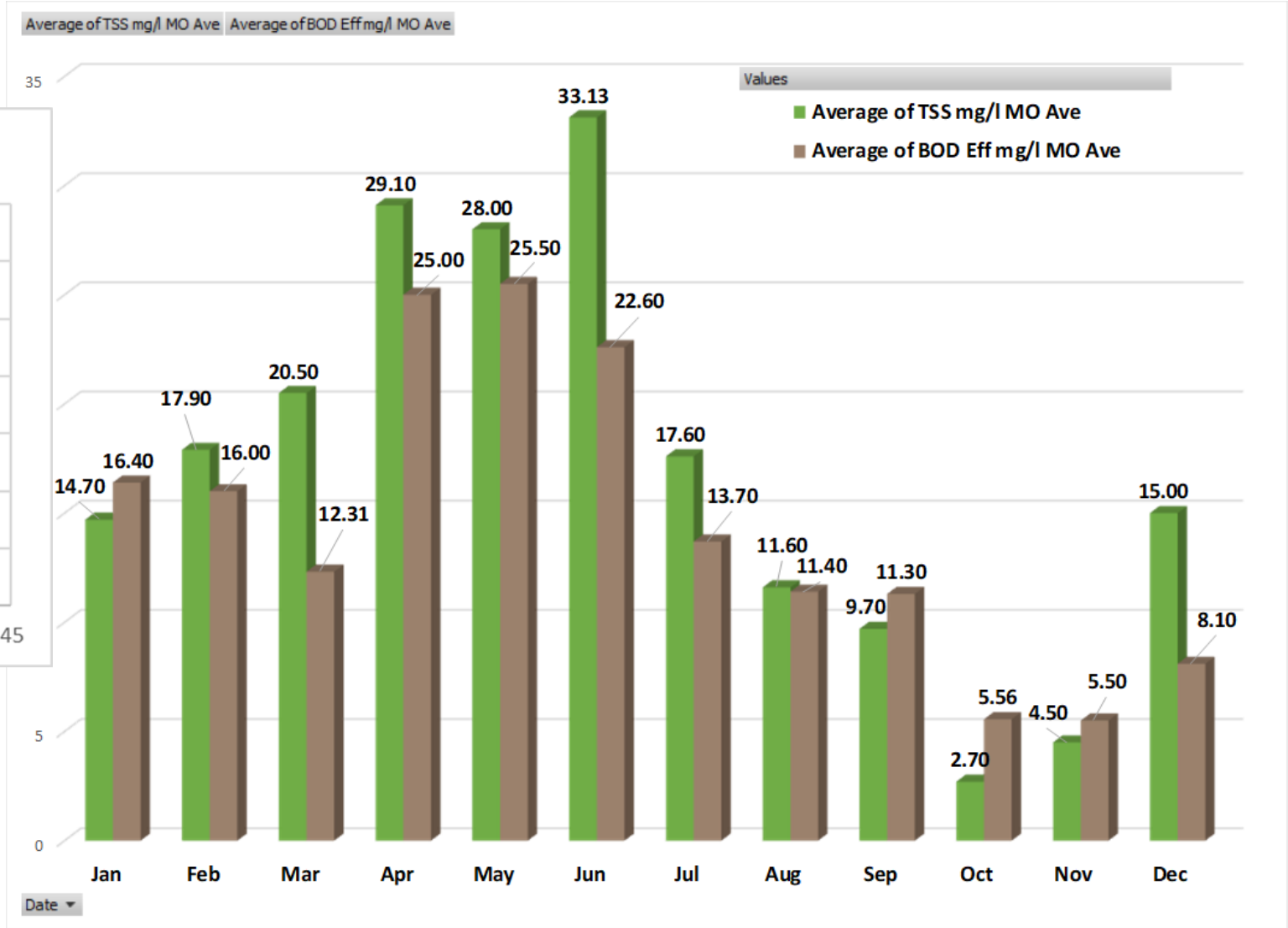

Influent Flow, TSS, and BOD5 for the [redacted] Wastewater Pond System
Influent BOD5 & TSS MO Ave mg/l
Influent Flow MGD
350
300
250
200
150
100
50
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
12/1/2015
2/1/2016
4/1/2016
6/1/2016
8/1/2016
10/1/2016
12/1/2016
2/1/2017
4/1/2017
6/1/2017
8/1/2017
10/1/2017
12/1/2017
2/1/2018
4/1/2018
6/1/2018
8/1/2018
10/1/2018
12/1/2018
2/1/2019
4/1/2019
6/1/2019
Influent BOD mg/l MO Ave
Influent TSS MO Ave mg/l
Flow MO Ave
Linear (Influent BOD mg/l MO Ave)
Linear (Influent TSS MO Ave mg/l)
Linear (Flow MO Ave)

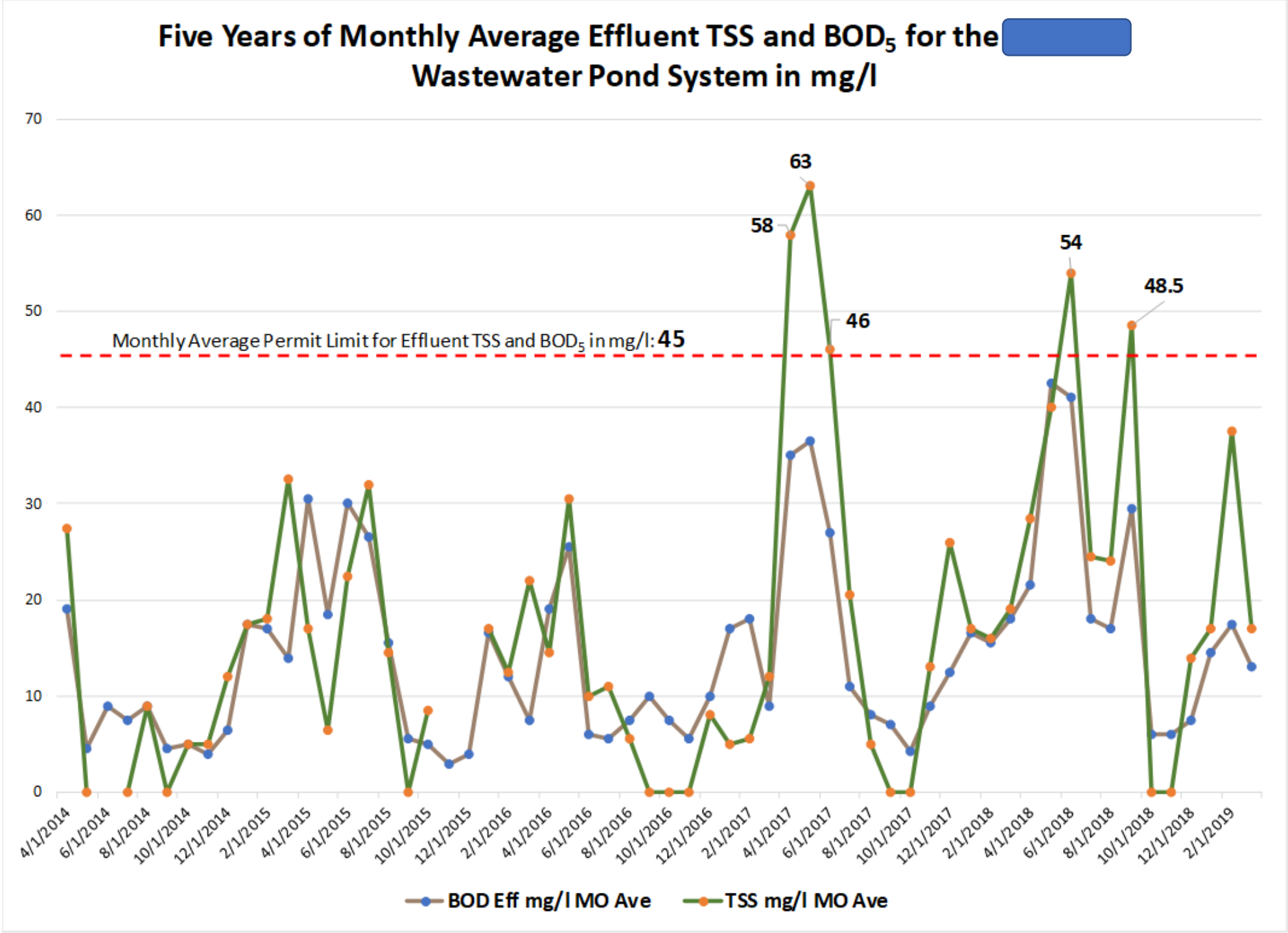
Effluent TSS in Pounds Per Day Over the Past Five Years for the Wastewater Pond System




Two and a Half years of Effluent BOD5 and TSS Removal Efficiency
Removal Permit Limit: 65%
BOD Pct Removal
TSS Pct Removal
Linear (BOD Pct Removal)
Linear (TSS Pct Removal)


R² for Effluent BOD and TSS mg/l MO Ave
y = 1.3356x - 2.9286
R² = 0.6971
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45


Average of TSS mg/l MO Ave
Average of BOD Eff mg/l MO Ave
Values
Average of TSS mg/l MO Ave
Average of BOD Eff mg/l MO Ave
35
5
0
14.70
16.40
17.90
16.00
20.50
12.31
29.10
25.00
28.00
25.50
33.13
22.60
17.60
13.70
11.60
11.40
9.70
11.30
2.70
5.56
4.50
5.50
15.00
8.10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date


Five Years of Monthly Average Effluent TSS and BOD5 for the
Wastewater Pond System in mg/l
70
60
50
40
30
20
10
0
63
58
54
48.5
46
Monthly Average Permit Limit for Effluent TSS and BOD5 in mg/l: 45
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
12/1/2015
2/1/2016
4/1/2016
6/1/2016
8/1/2016
10/1/2016
12/1/2016
2/1/2017
4/1/2017
6/1/2017
8/1/2017
10/1/2017
12/1/2017
2/1/2018
4/1/2018
6/1/2018
8/1/2018
10/1/2018
12/1/2018
2/1/2019
BOD Eff mg/l MO Ave
TSS mg/l MO Ave

1. Strive to maintain a two (2) mg/l dissolved oxygen level in each treatment cell at all times.
2. Continue to clean and replace diffuser sleeves for better oxygen transfer from the diffusers
3. Consider adding a headworks to the system to remove the profound amount of trash entering the pond system every day
4. Consider adding an effluent multiple-level draw-off to pull fewer algae cells and popped up floating sludge into the effluent
5. Add about five (5) horsepower of mixing to Cell # 3 to drive off CO_2 for reduced algae growth
6. Smoke test the collection system to discover the sources of infiltration and inflow due to storm events and runoff. Controlling I&I can be one of the best lagoon upgrades
7. Quarterly perform diagnostic BOD and TSS sampling to understand the nature of the TSS in the effluent. Focus maximizing BOD and ammonia removal from the effluent of Cell # 1

This is why it is important to take samples, record the data and then trend the data to see if things are getting better or worse after making changes

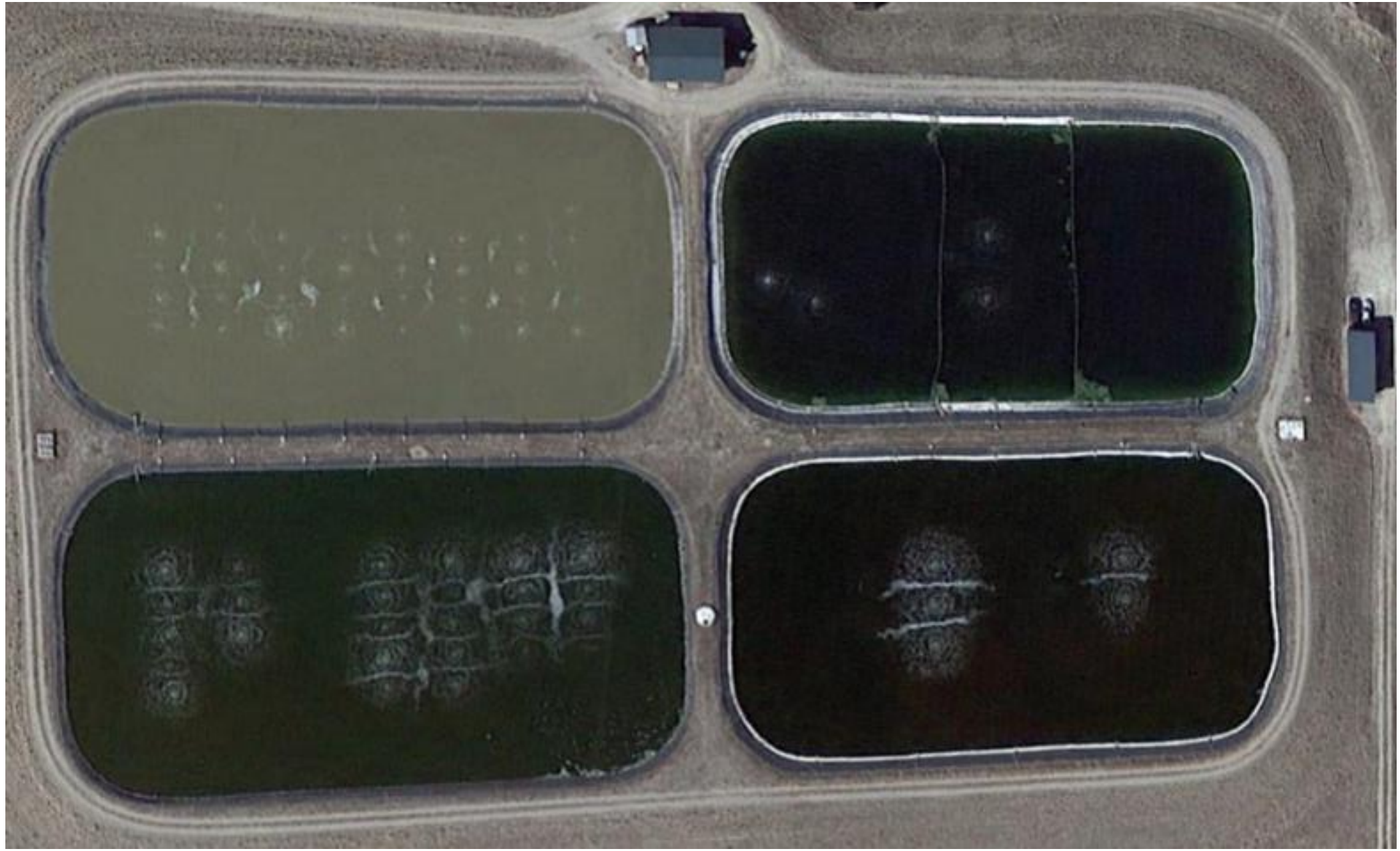
Case # 3

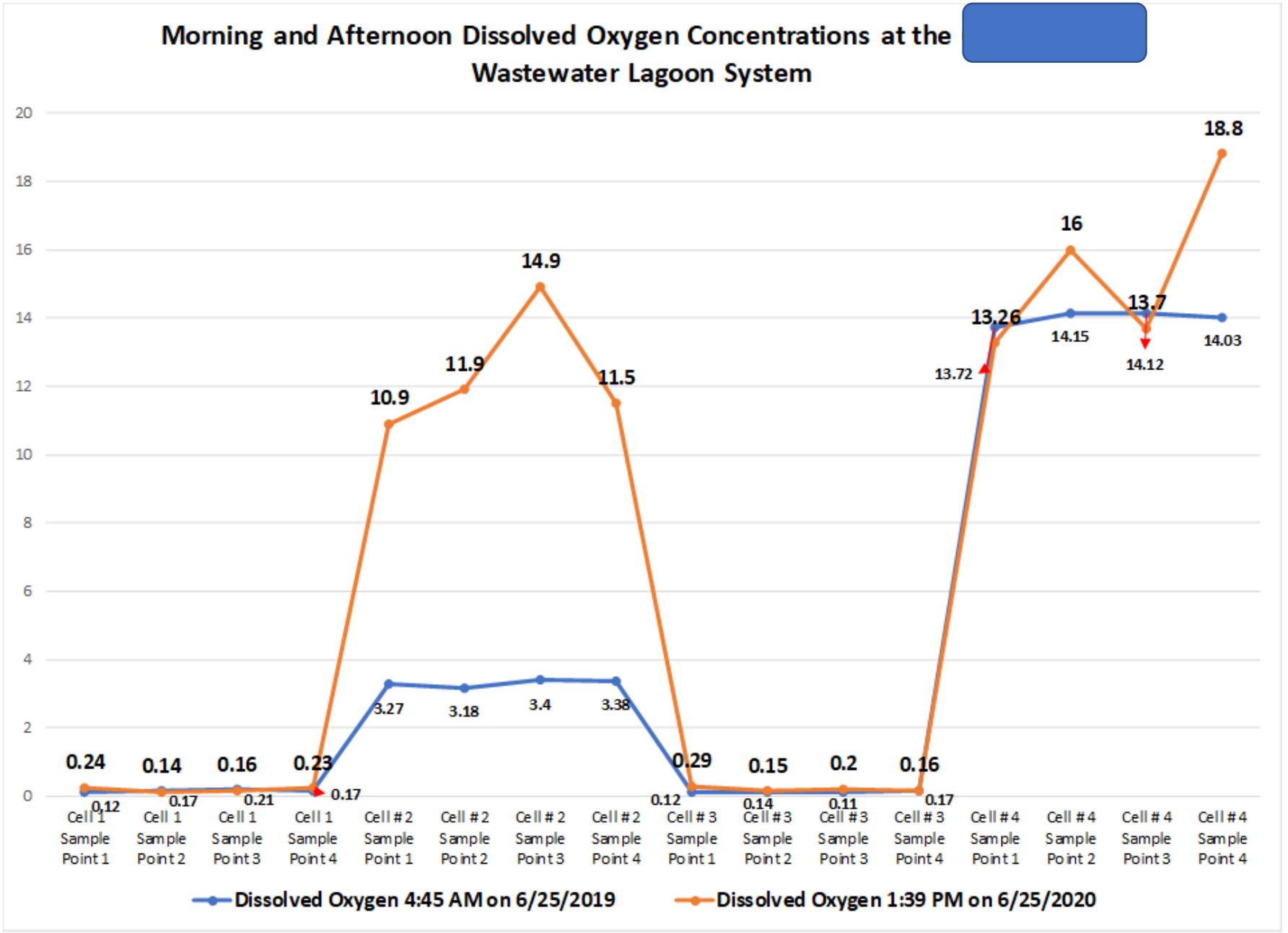
Balancing Aeration Cells

Final Effluent that Has Been allowed to Sit Fallow for Months

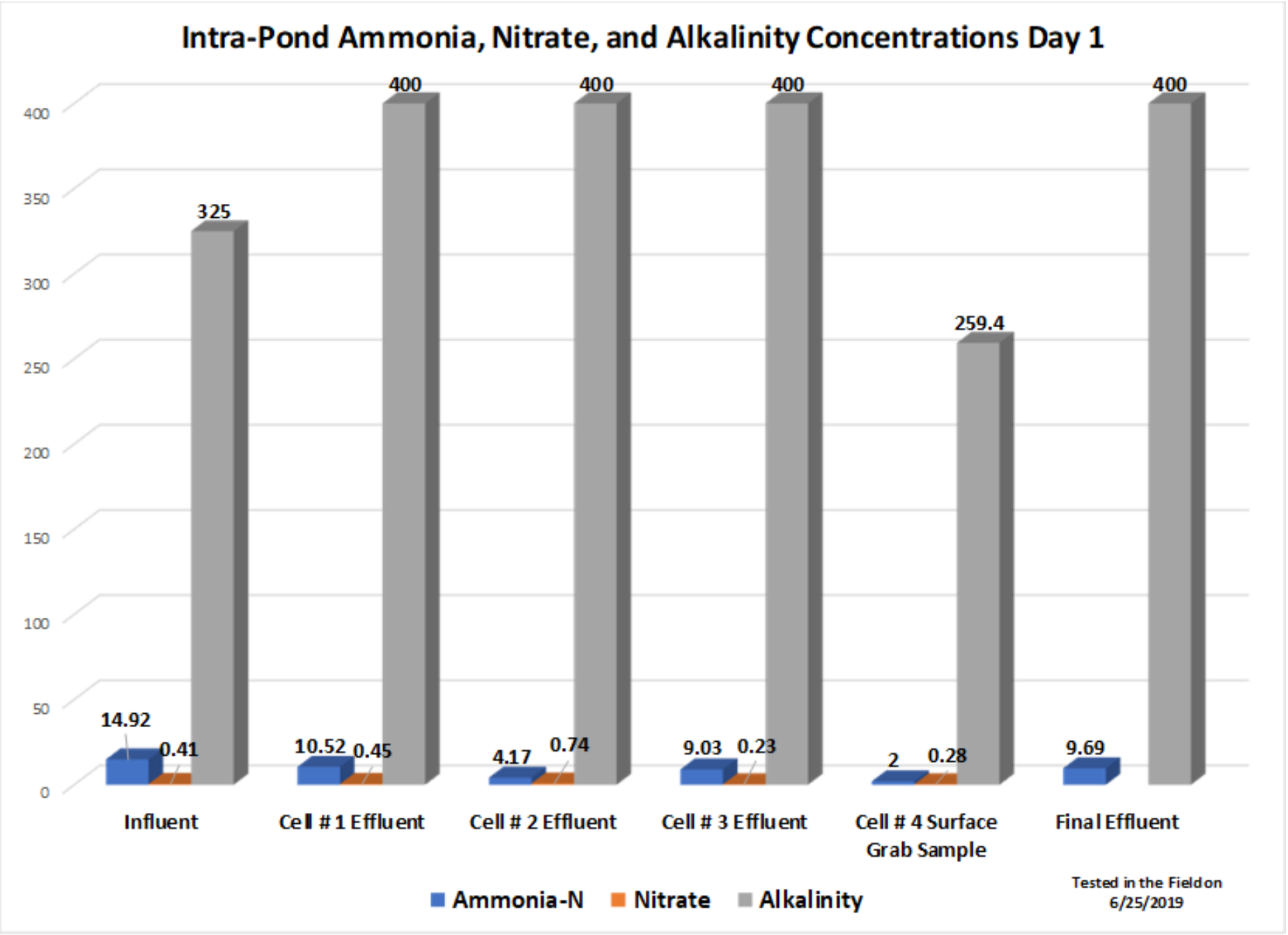
Pulling Samples Between Treatment Cells to Isolate the Problem

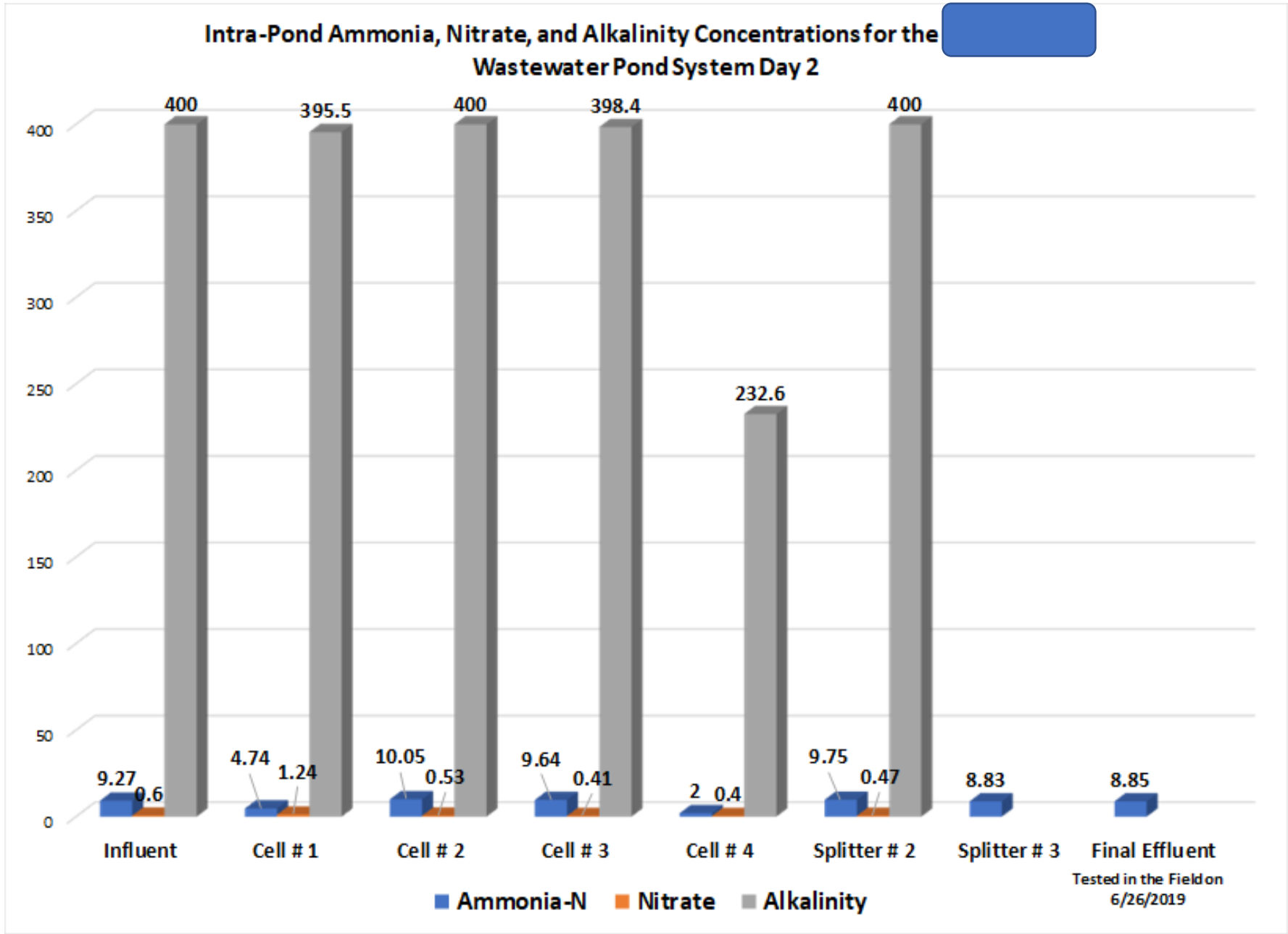
Lots of Sludge Trapped in the Effluent Wet Well

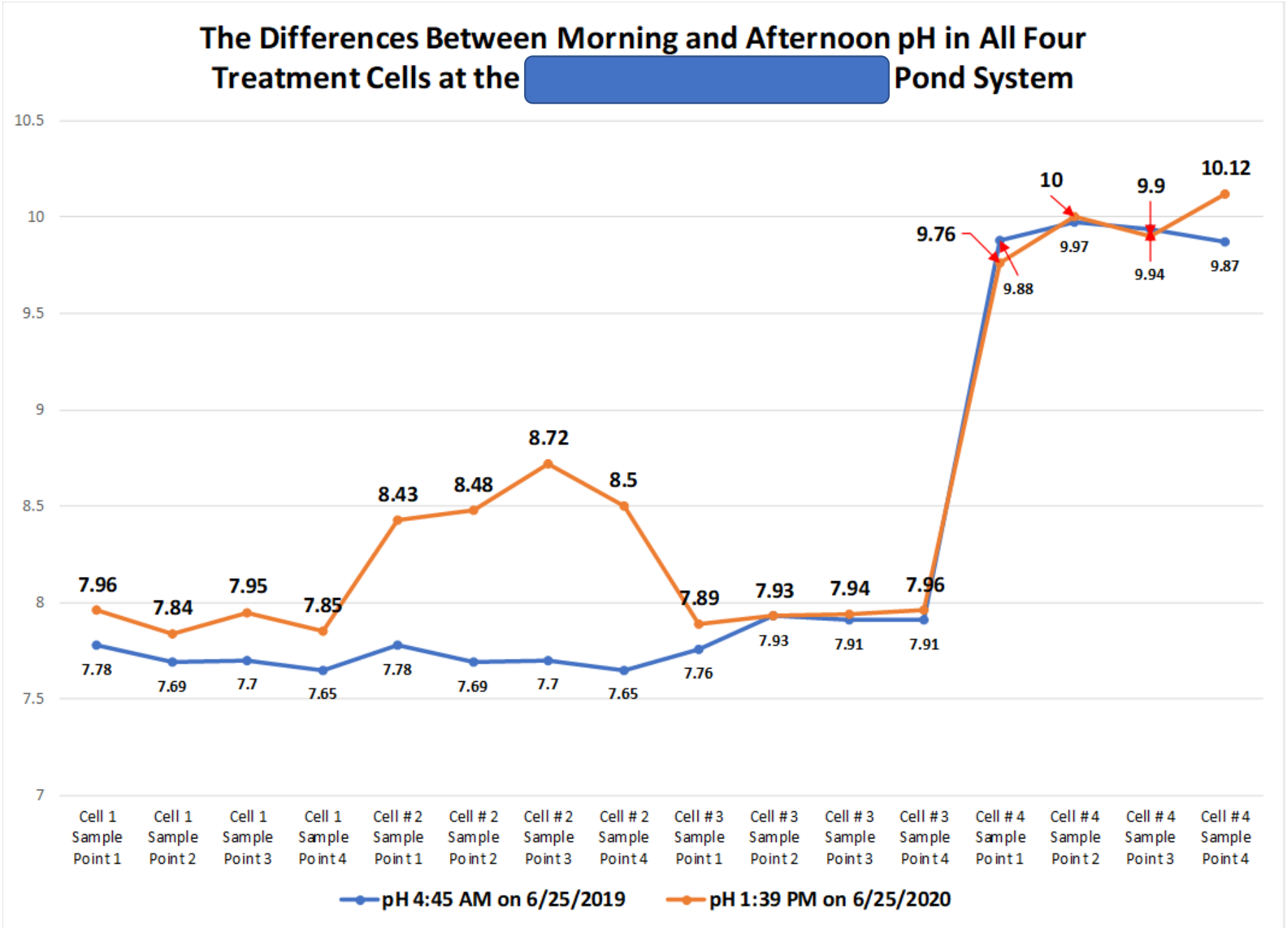


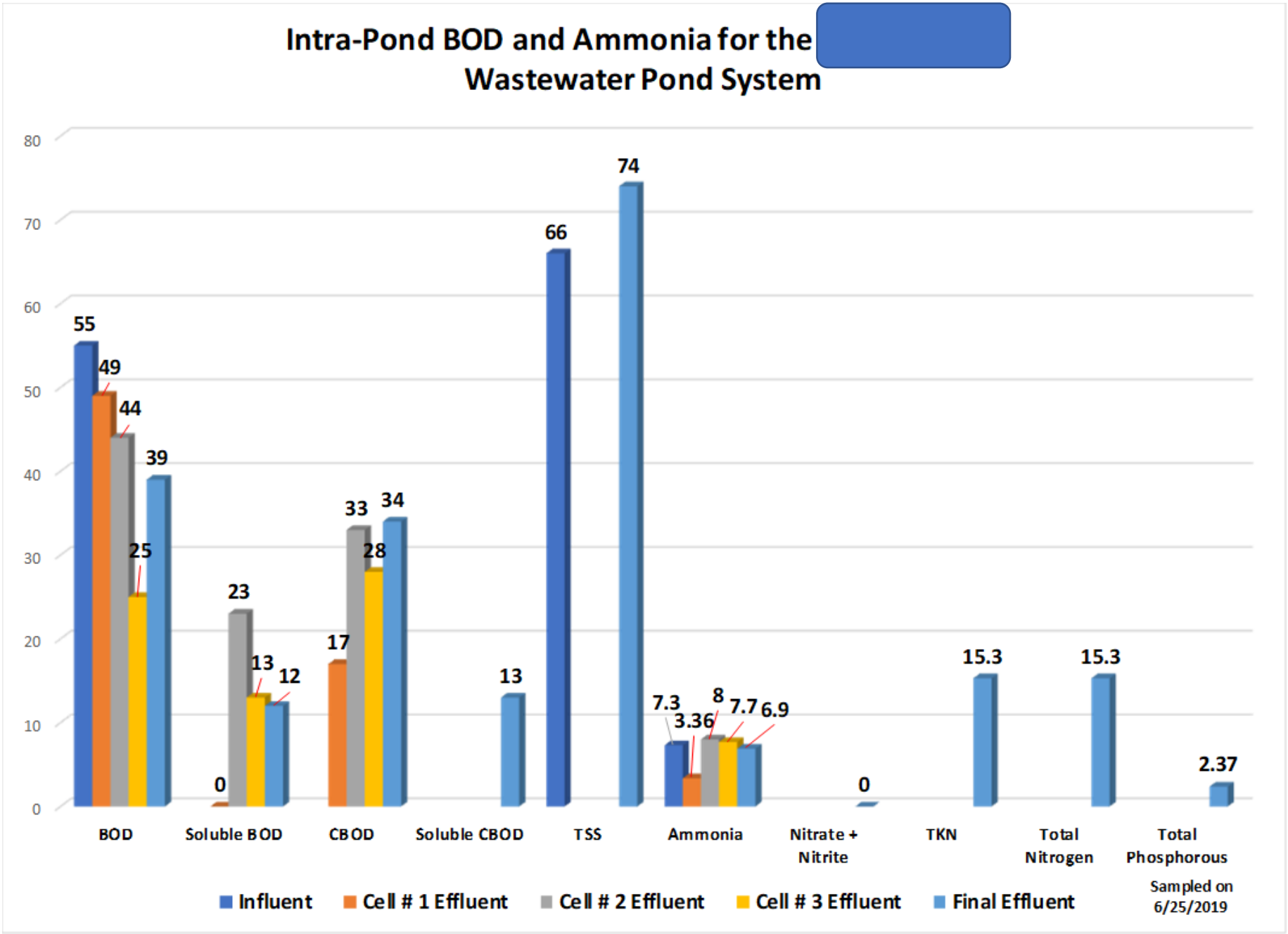

Morning and Afternoon Dissolved Oxygen Concentrations at the Wastewater Lagoon System
20
18
16
14
12
10
8
6
4
2
0
0.24
0.14
0.16
0.23
0.12
0.17
0.21
0.17
10.9
11.9
14.9
11.5
3.27
3.18
3.4
3.38
0.29
0.15
0.2
0.16
0.12
0.14
0.11
0.17
13.72
13.26
16
14.15
13.7
14.12
18.8
14.03
Cell 1 Sample Point 1
Cell 1 Sample Point 2
Cell 1 Sample Point 3
Cell 1 Sample Point 4
Cell # 2 Sample Point 1
Cell # 2 Sample Point 2
Cell # 2 Sample Point 3
Cell # 2 Sample Point 4
Cell # 3 Sample Point 1
Cell # 3 Sample Point 2
Cell # 3 Sample Point 3
Cell # 3 Sample Point 4
Cell # 4 Sample Point 1
Cell # 4 Sample Point 2
Cell # 4 Sample Point 3
Cell # 4 Sample Point 4
Dissolved Oxygen 4:45 AM on 6/25/2019
Dissolved Oxygen 1:39 PM on 6/25/2020

Intra-Pond Testing




Intra-Pond Ammonia, Nitrate, and Alkalinity Concentrations for the
Wastewater Pond System Day 2
400
350
300
250
200
150
100
50
0
400
395.5
400
398.4
400
232.6
9.27
0.6
4.74
1.24
10.05
0.53
9.64
0.41
2
0.4
9.75
0.47
8.83
8.85
Influent
Cell # 1
Cell # 2
Cell # 3
Cell # 4
Splitter # 2
Splitter # 3
Final Effluent
Tested in the Field on
6/26/2019
Ammonia-N
Nitrate
Alkalinity

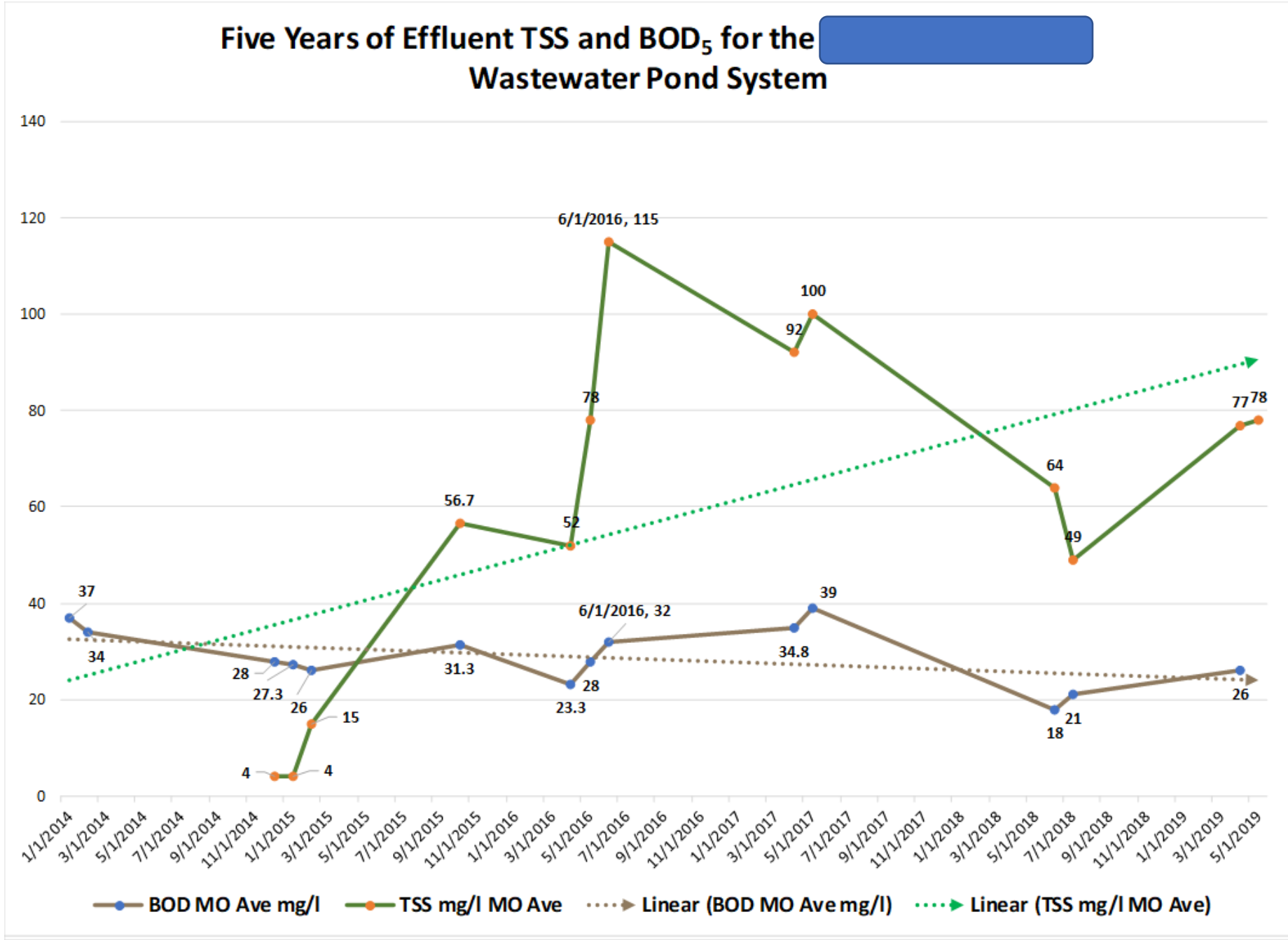

The Differences Between Morning and Afternoon pH in All Four Treatment Cells at the [redacted] Pond System
10.5
10
9.5
9
8.5
8
7.5
7
7.96
7.84
7.95
7.85
8.43
8.48
8.72
8.5
7.89
7.93
7.94
7.96
9.76
10
9.9
10.12
7.78
7.69
7.7
7.65
7.78
7.69
7.7
7.65
7.76
7.93
7.91
7.91
9.88
9.97
9.94
9.87
Cell 1 Sample Point 1
Cell 1 Sample Point 2
Cell 1 Sample Point 3
Cell 1 Sample Point 4
Cell # 2 Sample Point 1
Cell # 2 Sample Point 2
Cell # 2 Sample Point 3
Cell # 2 Sample Point 4
Cell # 3 Sample Point 1
Cell # 3 Sample Point 2
Cell # 3 Sample Point 3
Cell # 3 Sample Point 4
Cell # 4 Sample Point 1
Cell # 4 Sample Point 2
Cell # 4 Sample Point 3
Cell # 4 Sample Point 4
pH 4:45 AM on 6/25/2019
pH 1:39 PM on 6/25/2020


Intra-Pond BOD and Ammonia for the
Wastewater Pond System
80
70
60
50
40
30
20
10
0
55
49
44
39
25
0
23
13
12
17
33
28
34
13
66
74
7.3
3.36
8
7.7
6.9
0
15.3
15.3
2.37
BOD
Soluble BOD
CBOD
Soluble CBOD
TSS
Ammonia
Nitrate + Nitrite
TKN
Total Nitrogen
Total Phosphorous
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent
Final Effluent
Sampled on 6/25/2019

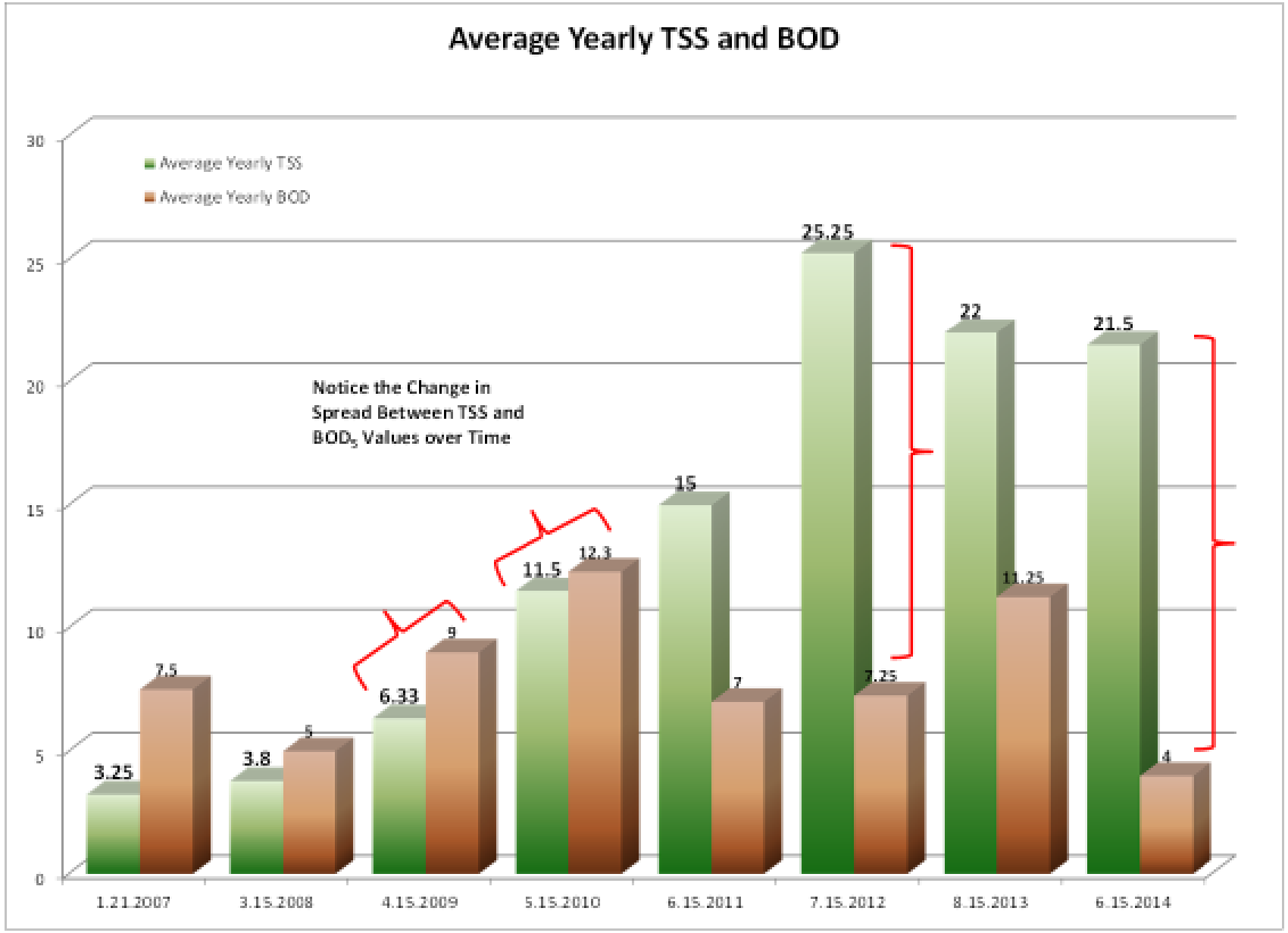
Maintenance and operational items that need to be addressed as listed below:

- 1) Replace or repair blowers and motors. Completely replace the control panel
- 2) Replace UV bulbs
- 3) Repair diffusers after blowers are replaced or repaired to correctly assess the magnitude of diffuser failure
- 4) Adjust Cell # 4 discharge piping to draw effluent from the lowest to the middle discharge pipe. Cease discharging from Cell # 3 to the effluent and direct all effluent flow to Cell # 4.
- 5) Purchase a DO/pH meter. A dissolved oxygen/pH meter is essential to running the xxxx pond system. A DO meter will help balance air delivery to the system and help Tanner know from which pipe to discharge. A pH meter will help meet pH permit limits as adjustments are made to the valving of the effluent discharge
- 6) Run all treatment cells at a uniform depth…fifteen (15) feet or greater.
- 7) Adjust valving to split flow evenly when running Cells 1 & 2 in parallel. Stop discharge to the effluent of Cell # 3 water! Discharge through Cell # 4 exclusively! Cell # 4 is where the water quality can be controlled through the multiple level piping configurations.
- 8) Begin recording lift station run times to calculate influent flow and loading.
- 9) Begin to sample routinely as outlined in the XXXXX discharge permit
- 10) Test again after ninety (90) days to measure the success of operational changes that have been made

Sludge at the Effluent Structure


Five Years of Effluent TSS and BOD5 for the [redacted] Wastewater Pond System
140
120
100
80
60
40
20
0
6/1/2016, 115
100
92
78
77
78
64
56.7
52
49
37
34
28
27.3
26
15
4
4
31.3
6/1/2016, 32
39
34.8
28
23.3
18
21
26
1/1/2014
3/1/2014
5/1/2014
7/1/2014
9/1/2014
11/1/2014
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
1/1/2017
3/1/2017
5/1/2017
7/1/2017
9/1/2017
11/1/2017
1/1/2018
3/1/2018
5/1/2018
7/1/2018
9/1/2018
11/1/2018
1/1/2019
3/1/2019
5/1/2019
BOD MO Ave mg/l
TSS mg/l MO Ave
Linear (BOD MO Ave mg/l)
Linear (TSS mg/l MO Ave)

This is what 30-year-old sludge looks like



Sludge at the Effluent Structure

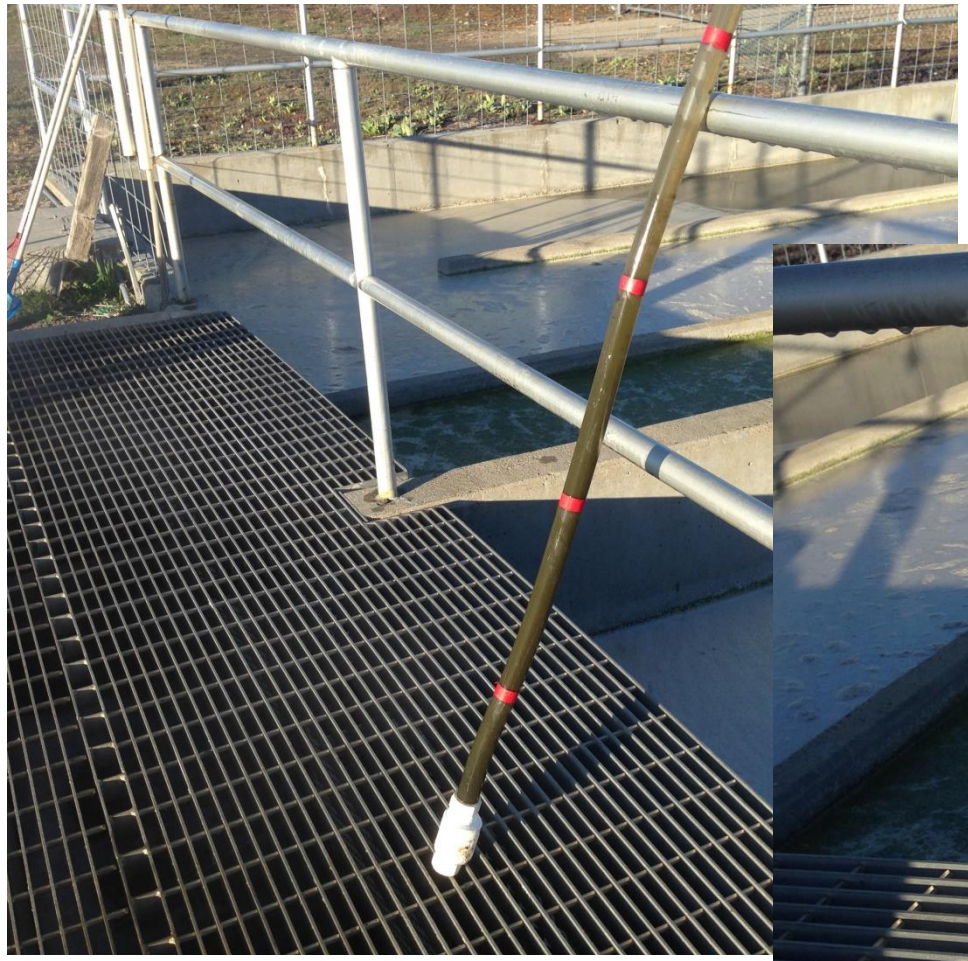
Sludge Accumulation in the chlorine contact chamber at a Small Plant in Indiana

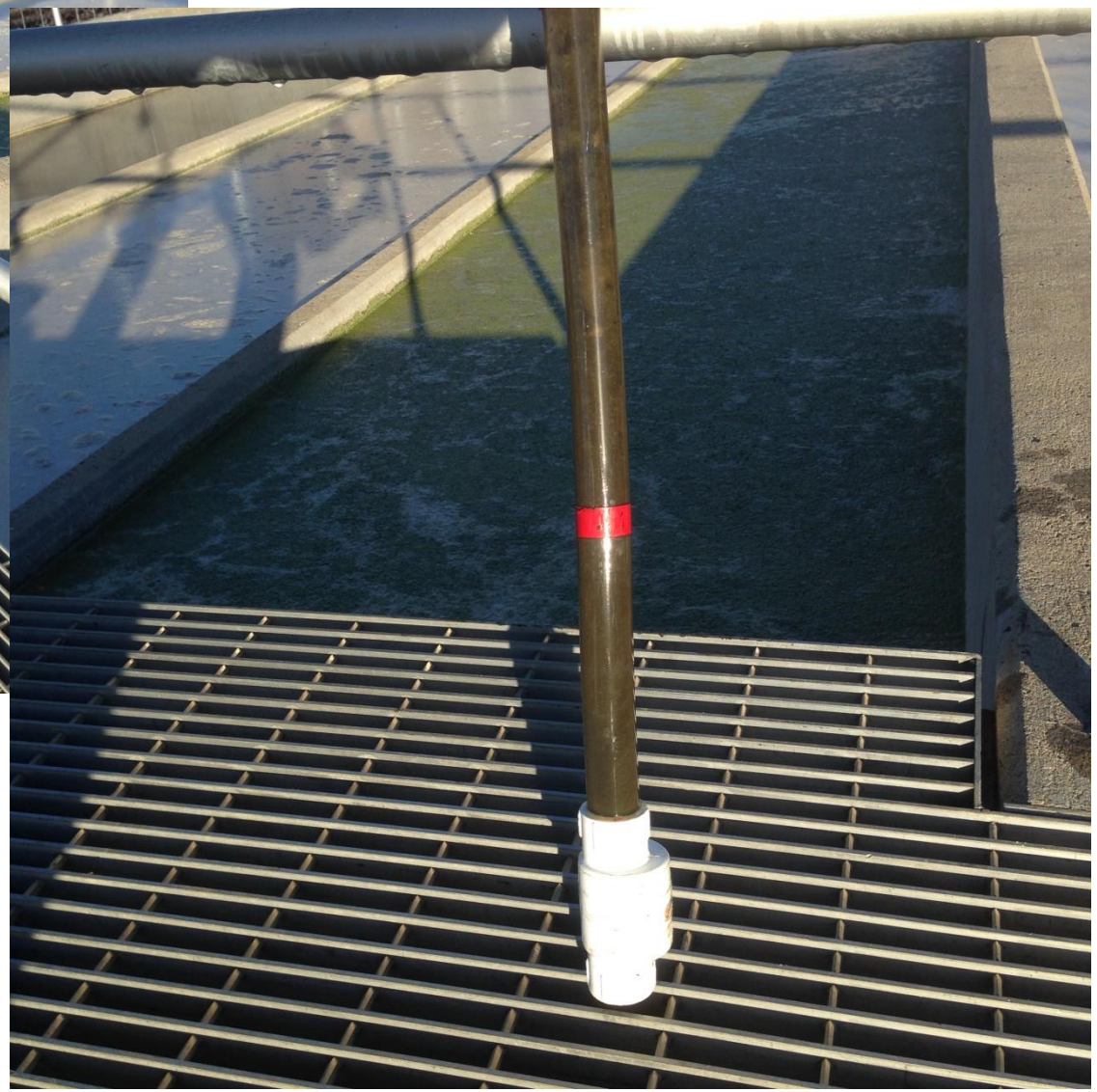
The Jar to the left is from the final treatment cell. The jar to the right is from the chlorine contact chamber after the chamber was mixed

Three Feet of Sludge at the Effluent Structure

sludge accumulation at the effluent structure

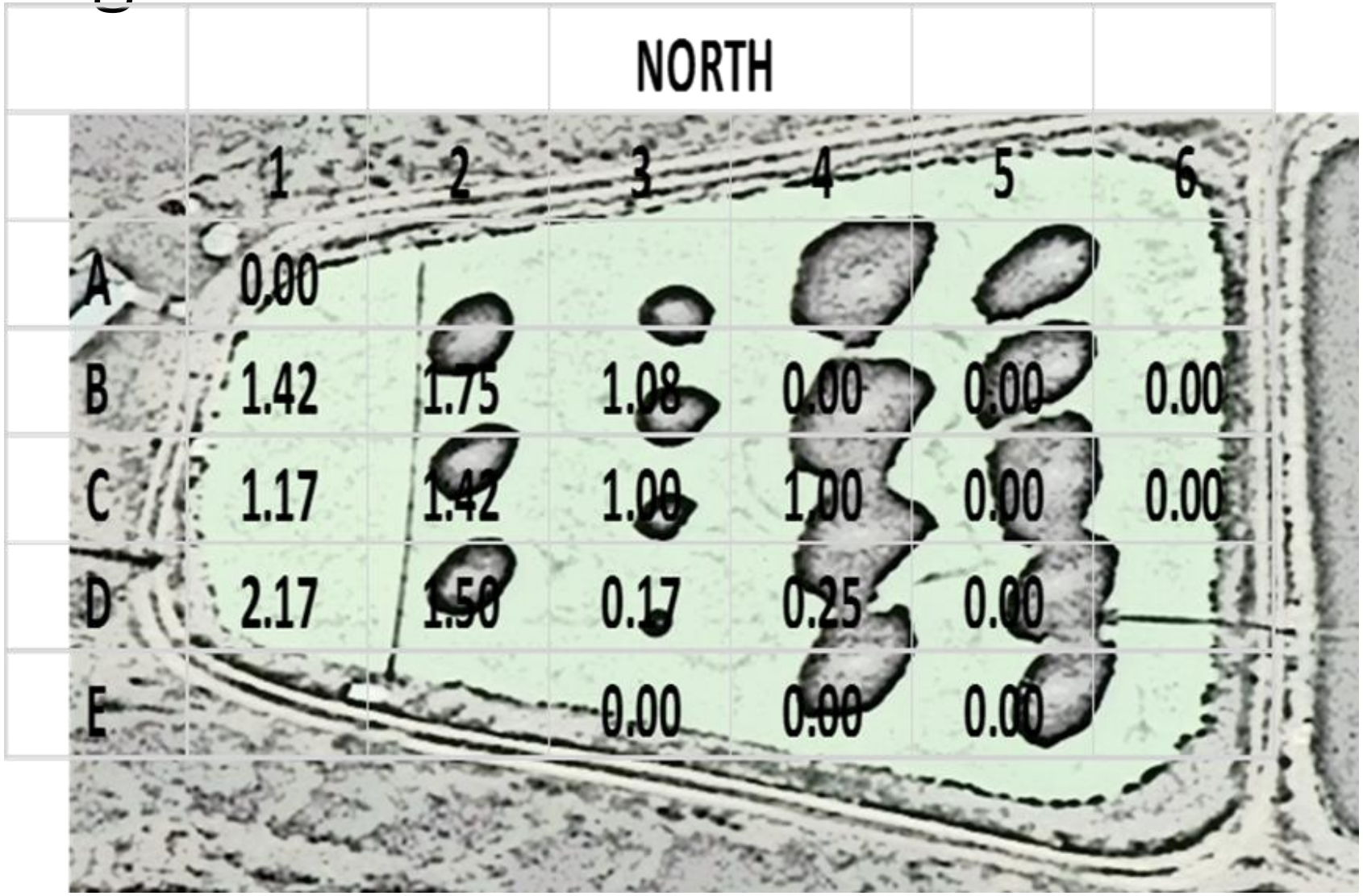
These accumulated Solids Can Affect Permit Results





Solids at the effluent can cause sporadic test results as sludge “burps” up whenever

Discharge Cell

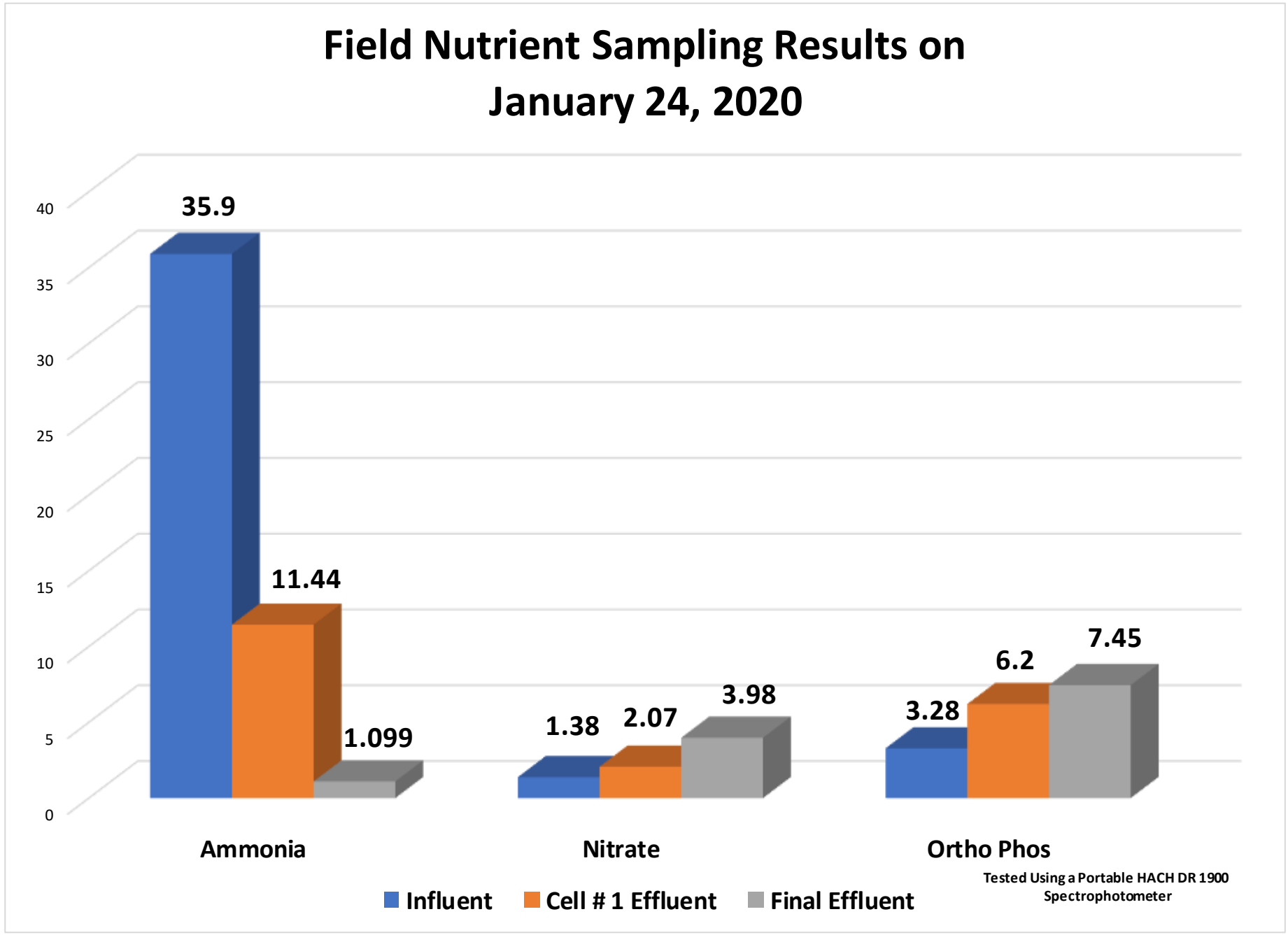


Sludge in the Discharge Well

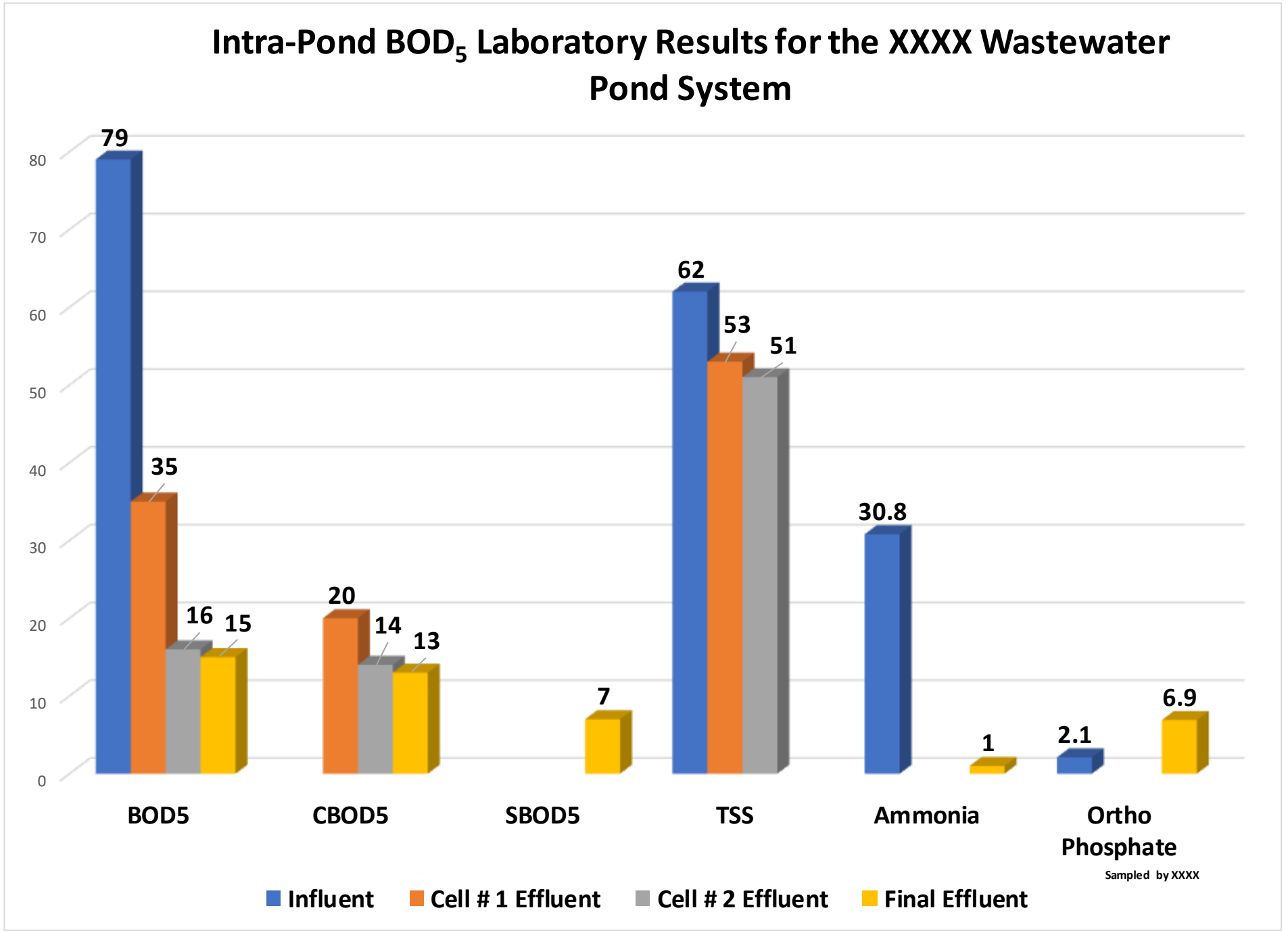
Sludge in the UV Tank

A Word About Sludge

Its impact on pond systems



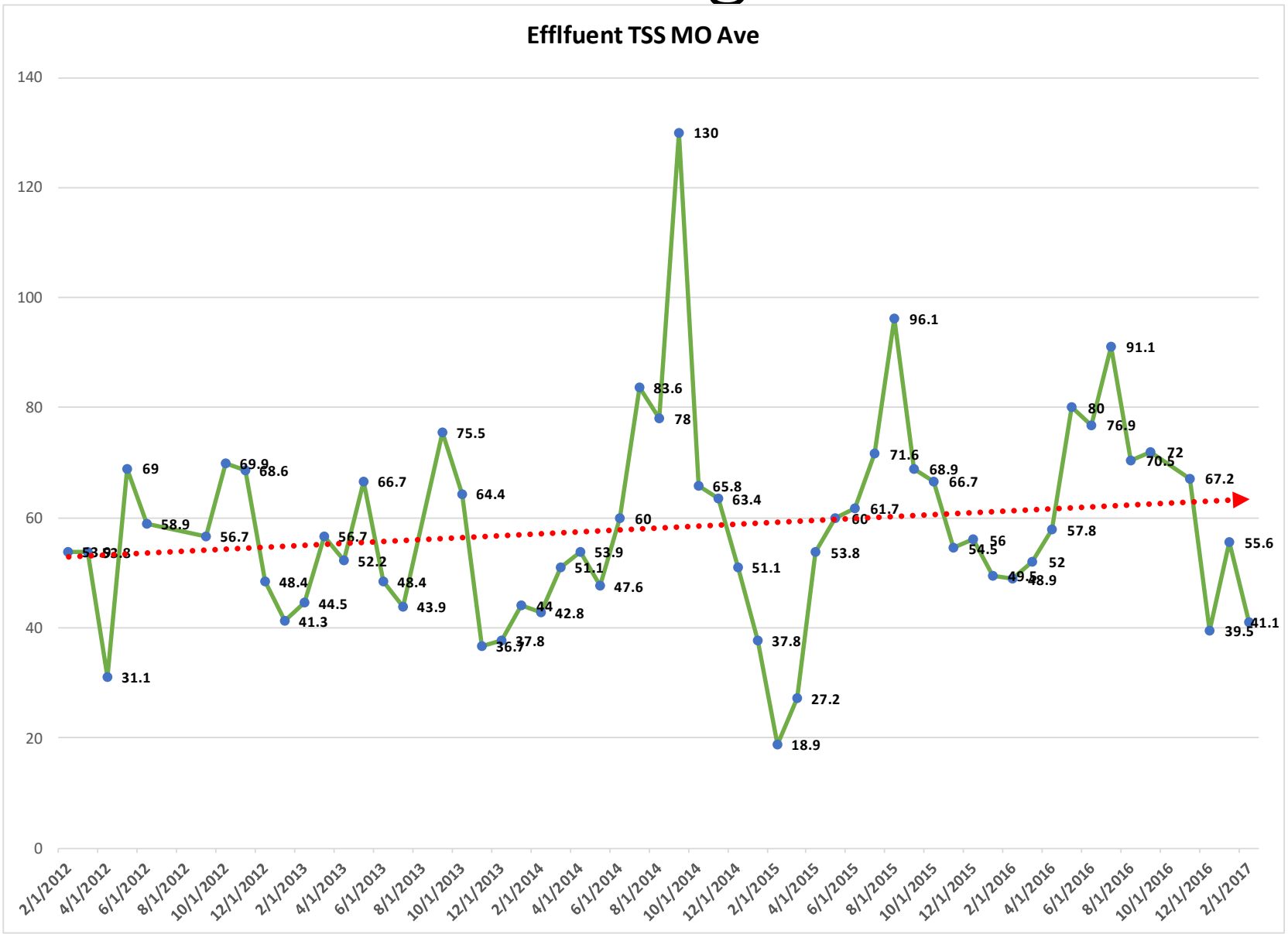
This is what benthal feedback looks like

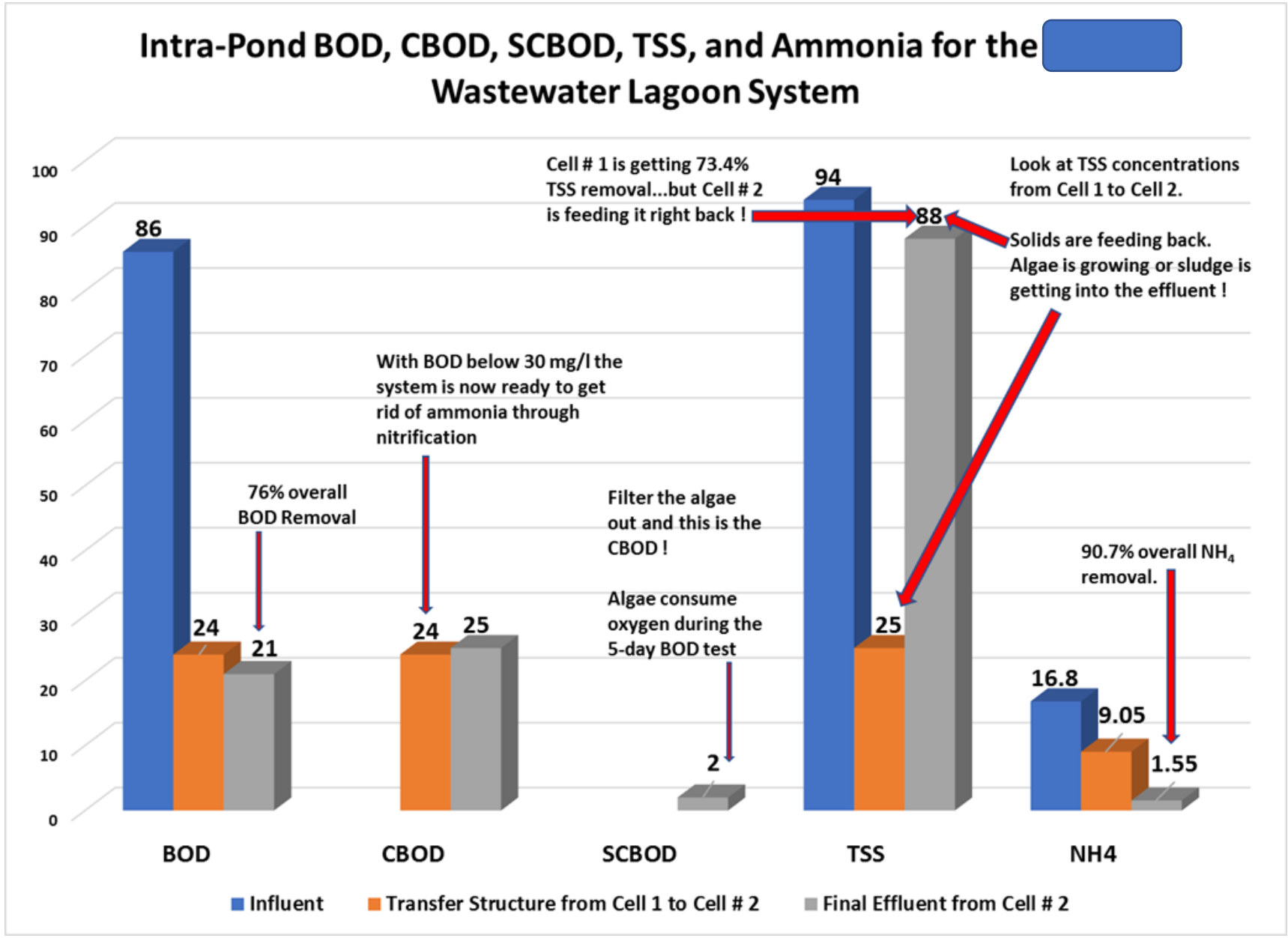

Intra-Pond BOD5 Laboratory Results for the XXXX Wastewater Pond System
80
70
60
50
40
30
20
10
0
79
35
16
15
20
14
13
7
62
53
51
30.8
1
2.1
6.9
BOD5
CBOD5
SBOD5
TSS
Ammonia
Ortho Phosphate
Sampled by XXXX
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent

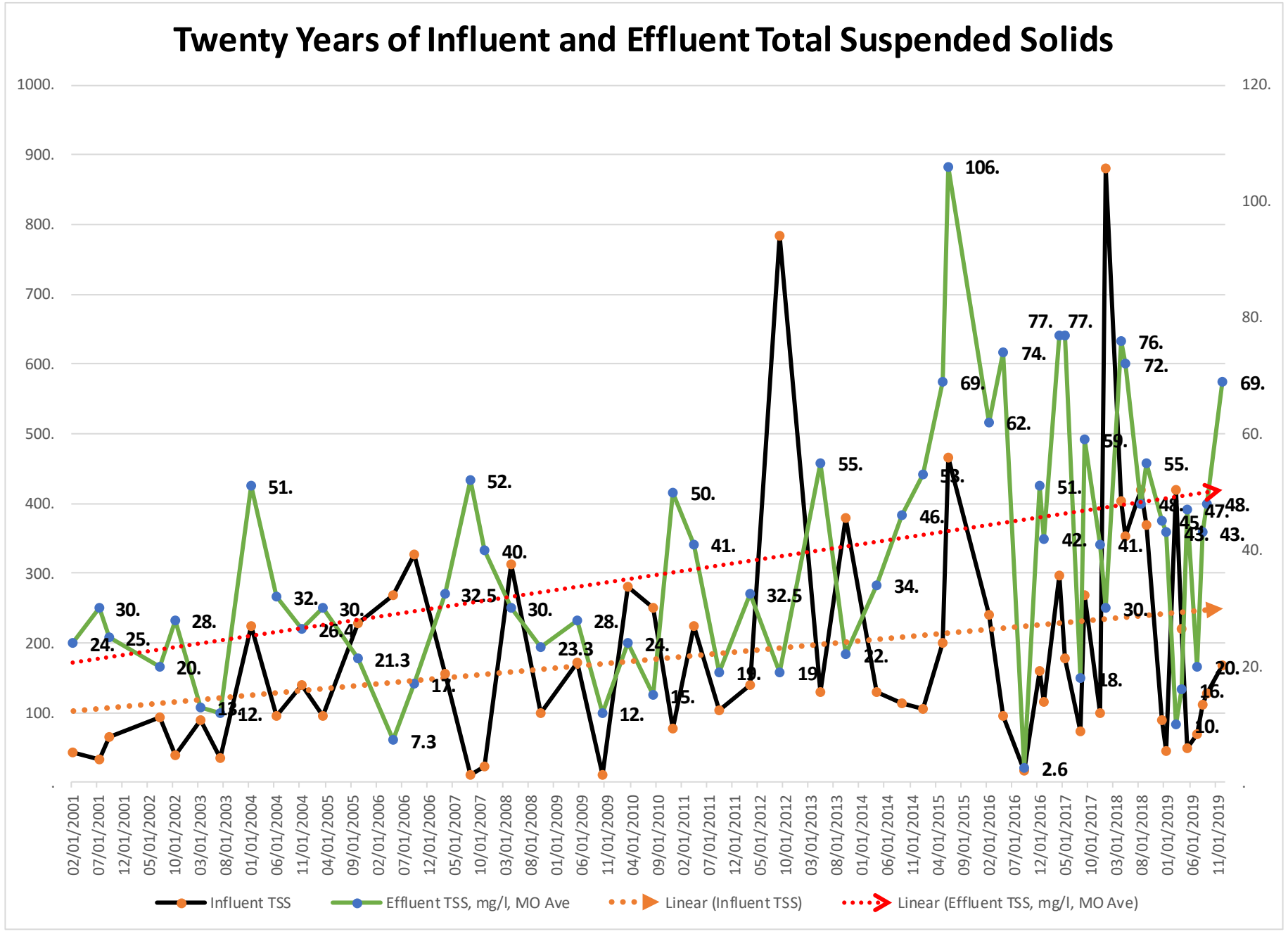
Sludge accumulation like this is common in diffused air systems

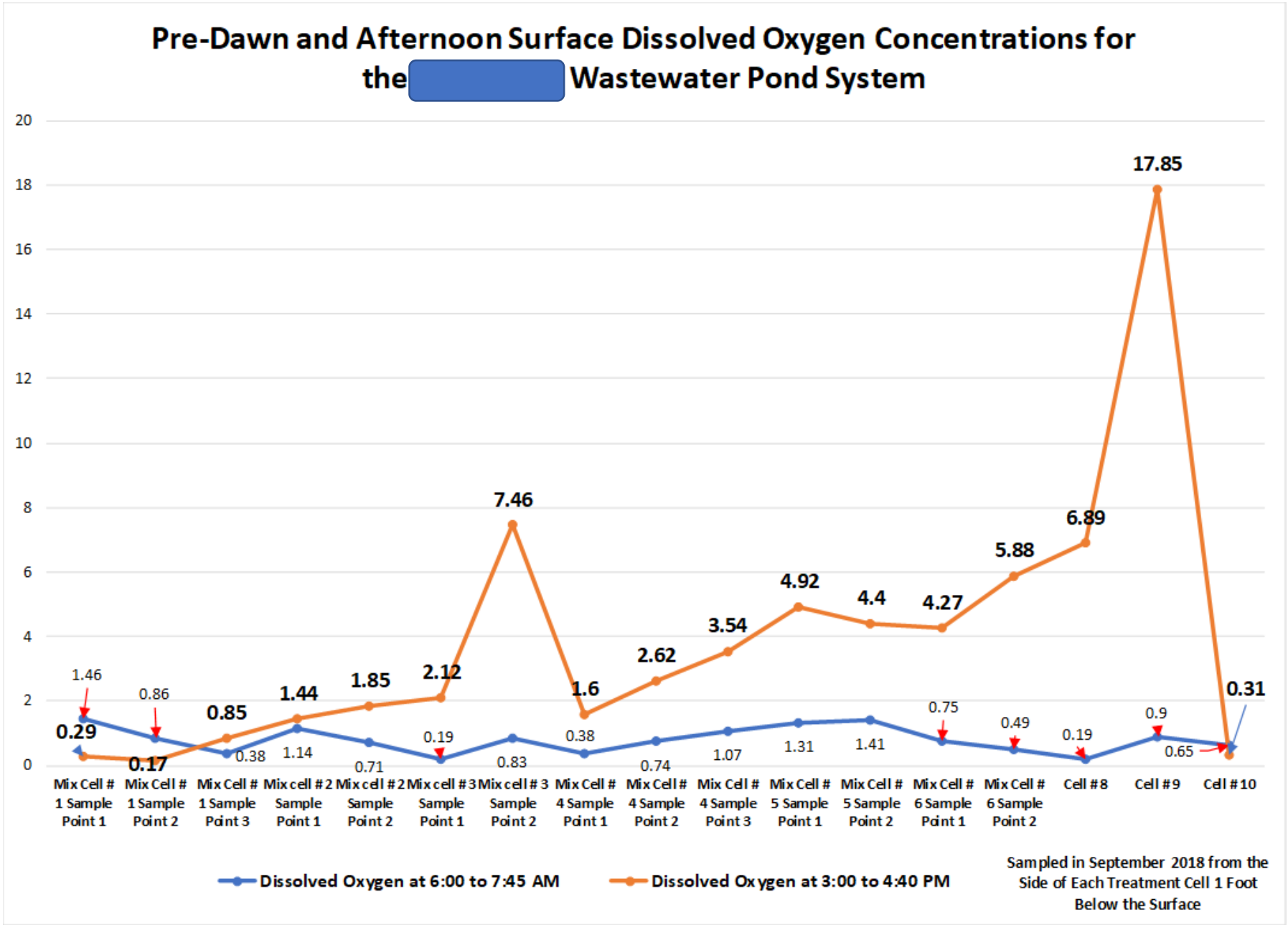
Solids Accumulate Where There is Not Enough Mixing Energy to Suspend solids

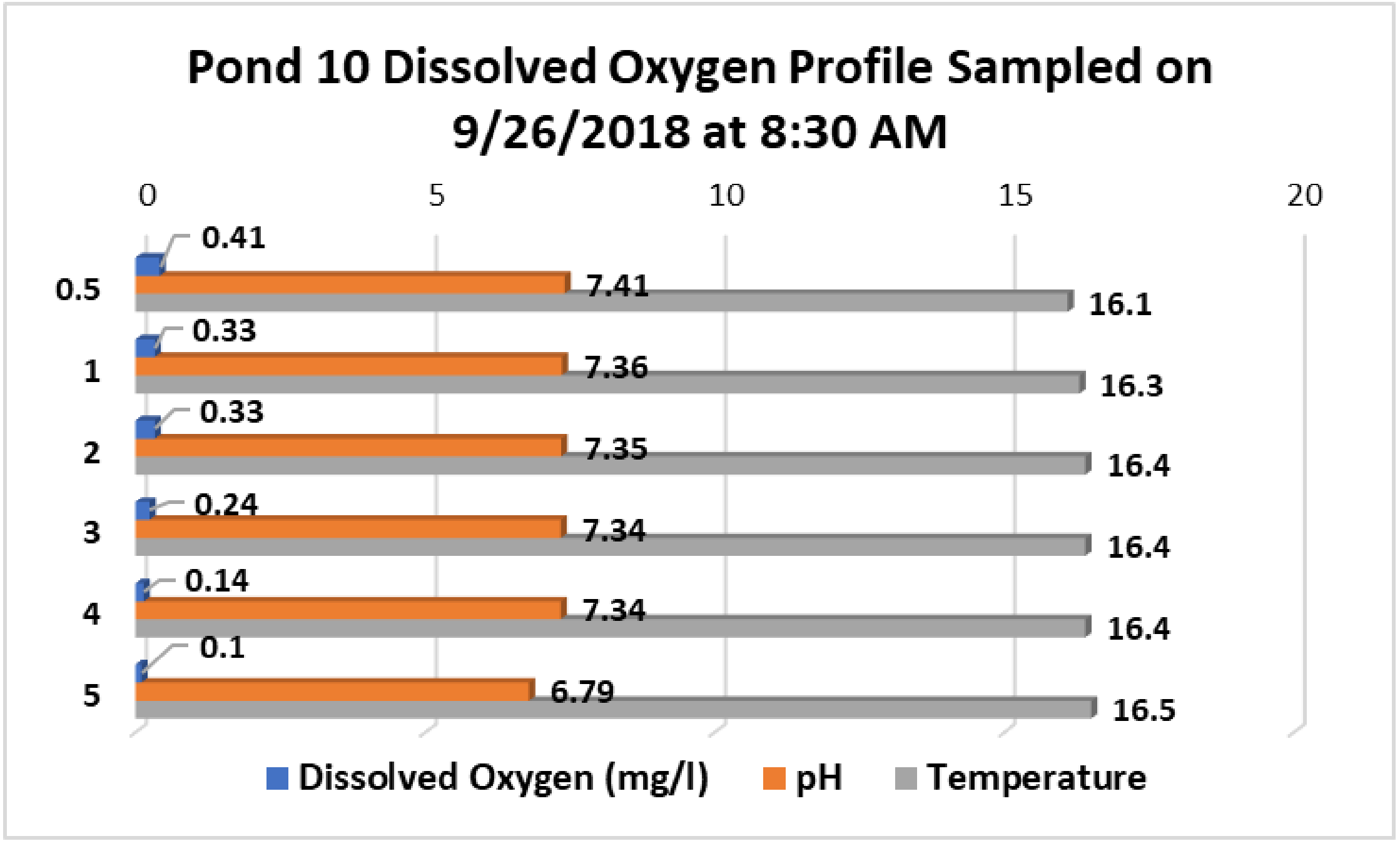
Here is what accumulated sludge looks like over time:

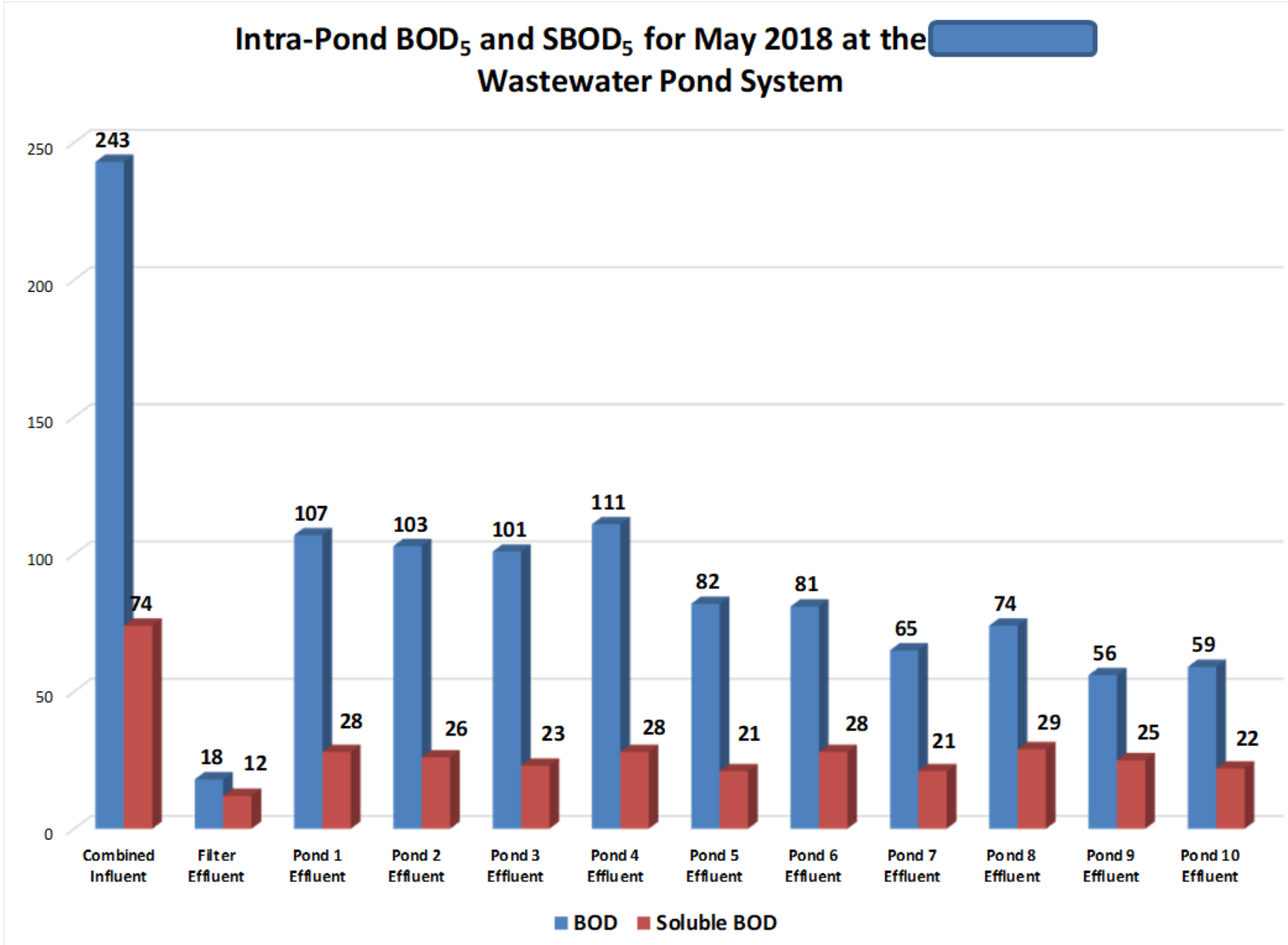


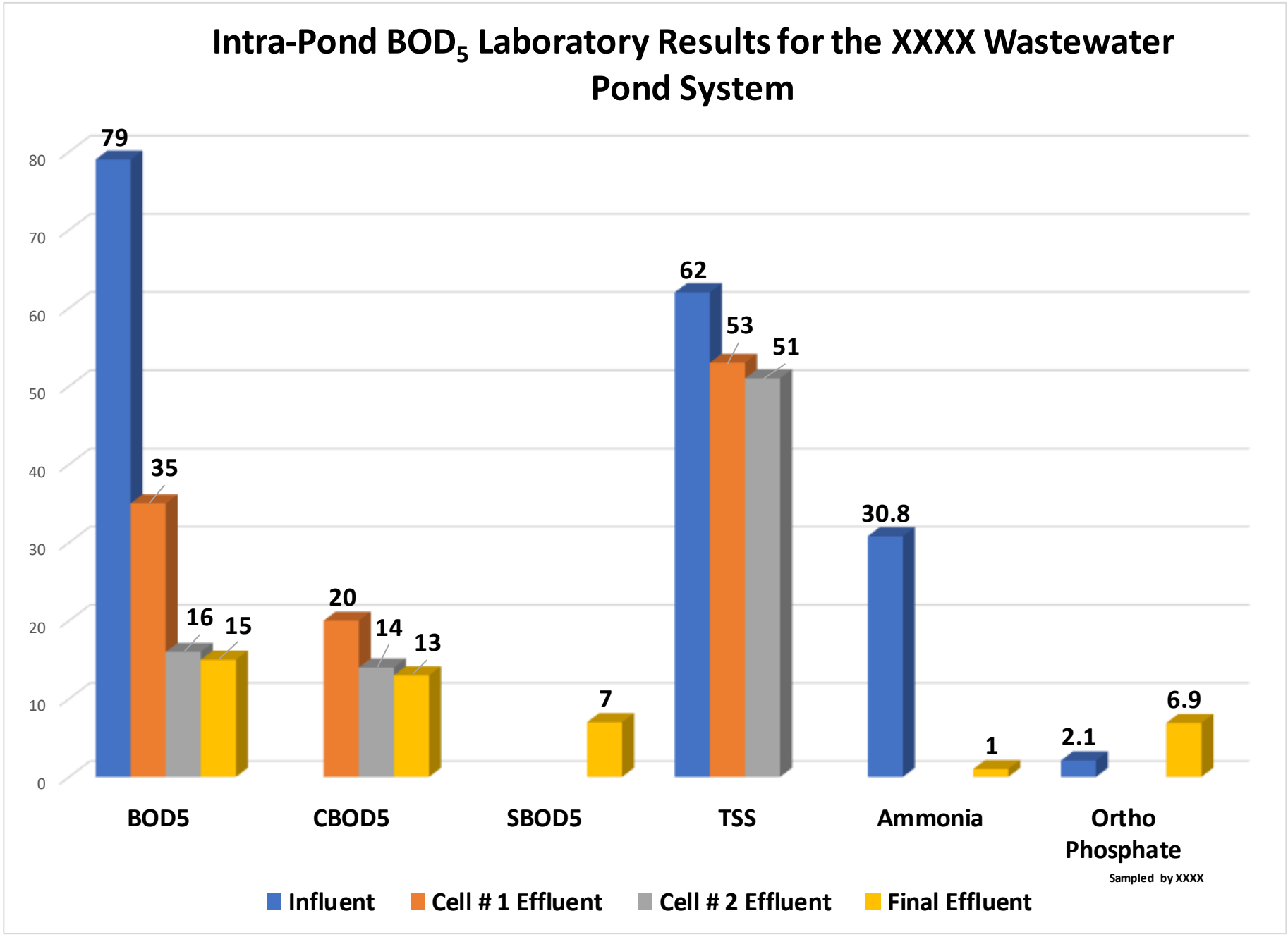

Intra-Pond BOD, CBOD, SCBOD, TSS, and Ammonia for the
Wastewater Lagoon System
100
90
80
70
60
50
40
30
20
10
0
86
24
21
24
25
2
94
88
25
16.8
9.05
1.55
Cell # 1 is getting 73.4% TSS removal...but Cell # 2 is feeding it right back !
Look at TSS concentrations from Cell 1 to Cell 2.
Solids are feeding back. Algae is growing or sludge is getting into the effluent !
With BOD below 30 mg/l the system is now ready to get rid of ammonia through nitrification
76% overall BOD Removal
Filter the algae out and this is the CBOD !
Algae consume oxygen during the 5-day BOD test
90.7% overall NH_4 removal.
BOD
CBOD
SCBOD
TSS
NH4
Influent
Transfer Structure from Cell 1 to Cell # 2
Final Effluent from Cell # 2


Twenty Years of Influent and Effluent Total Suspended Solids
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
120.
100.
80.
60.
40.
20.
02/01/2001
07/01/2001
12/01/2001
05/01/2002
10/01/2002
03/01/2003
08/01/2003
01/01/2004
06/01/2004
11/01/2004
04/01/2005
09/01/2005
02/01/2006
07/01/2006
12/01/2006
05/01/2007
10/01/2007
03/01/2008
08/01/2008
01/01/2009
06/01/2009
11/01/2009
04/01/2010
09/01/2010
02/01/2011
07/01/2011
12/01/2011
05/01/2012
10/01/2012
03/01/2013
08/01/2013
01/01/2014
06/01/2014
11/01/2014
04/01/2015
09/01/2015
02/01/2016
07/01/2016
12/01/2016
05/01/2017
10/01/2017
03/01/2018
08/01/2018
01/01/2019
06/01/2019
11/01/2019
Influent TSS
Effluent TSS, mg/l, MO Ave
Linear (Influent TSS)
Linear (Effluent TSS, mg/l, MO Ave)


Pre-Dawn and Afternoon Surface Dissolved Oxygen Concentrations for the [redacted] Wastewater Pond System
20
18
16
14
12
10
8
6
4
2
0
1.46
0.29
0.86
0.17
0.85
0.38
1.44
1.14
1.85
0.71
2.12
0.19
7.46
0.83
1.6
0.38
2.62
0.74
3.54
1.07
4.92
1.31
4.4
1.41
4.27
0.75
5.88
0.49
6.89
0.19
17.85
0.9
0.65
0.31
Mix Cell # 1 Sample Point 1
Mix Cell # 1 Sample Point 2
Mix Cell # 1 Sample Point 3
Mix cell # 2 Sample Point 1
Mix cell # 2 Sample Point 2
Mix cell # 3 Sample Point 1
Mix cell # 3 Sample Point 2
Mix Cell # 4 Sample Point 1
Mix Cell # 4 Sample Point 2
Mix Cell # 4 Sample Point 3
Mix Cell # 5 Sample Point 1
Mix Cell # 5 Sample Point 2
Mix Cell # 6 Sample Point 1
Mix Cell # 6 Sample Point 2
Cell #8
Cell #9
Cell #10
Dissolved Oxygen at 6:00 to 7:45 AM
Dissolved Oxygen at 3:00 to 4:40 PM
Sampled in September 2018 from the Side of Each Treatment Cell 1 Foot Below the Surface


Pond 10 Dissolved Oxygen Profile Sampled on 9/26/2018 at 8:30 AM
0
5
10
15
20
0.5
0.41
7.41
16.1
1
0.33
7.36
16.3
2
0.33
7.35
16.4
3
0.24
7.34
16.4
4
0.14
7.34
16.4
5
0.1
6.79
16.5
Dissolved Oxygen (mg/l)
pH
Temperature


Intra-Pond BOD_5 and $SBOD_5$ for May 2018 at the [redacted] Wastewater Pond System
250
200
150
100
50
0
243
74
18
12
107
28
103
26
101
23
111
28
82
21
81
28
65
21
74
29
56
25
59
22
Combined Influent
Filter Effluent
Pond 1 Effluent
Pond 2 Effluent
Pond 3 Effluent
Pond 4 Effluent
Pond 5 Effluent
Pond 6 Effluent
Pond 7 Effluent
Pond 8 Effluent
Pond 9 Effluent
Pond 10 Effluent
BOD
Soluble BOD



Here is an example of benthal feedback…nutrient release from the sludge blanket.

This system has a severe effluent TSS problem.

Sampled last month. Temperatures 5.5 degrees C

Diagnostic BODs

Diagnostic BOD_5 Tests

TSS Filter
1 – 1.5 um

TSS Filter
1 – 1.5 um

BOD_5

Regular BOD_5

$CBOD_5$

Carbonaceous BOD_5

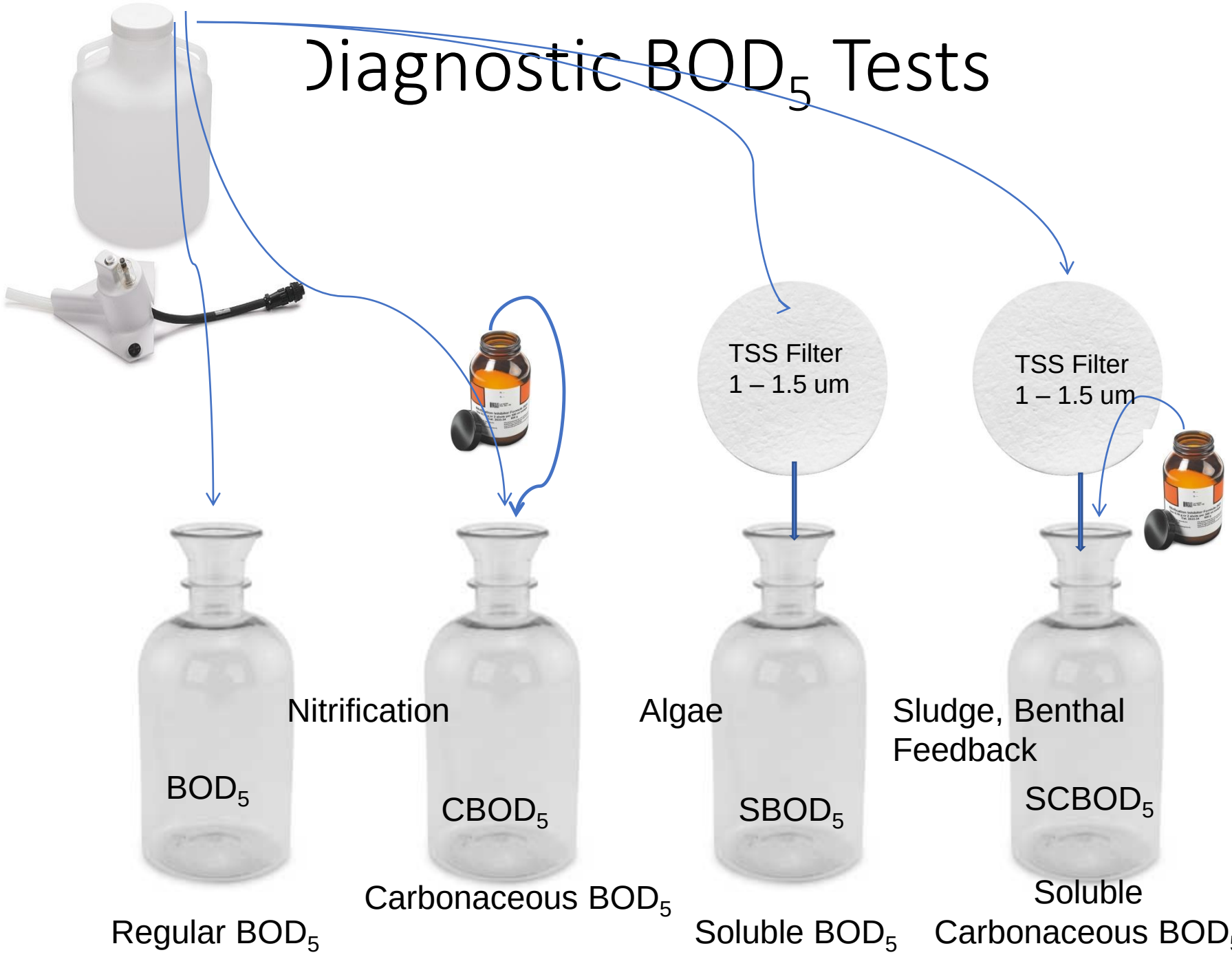
$SBOD_5$

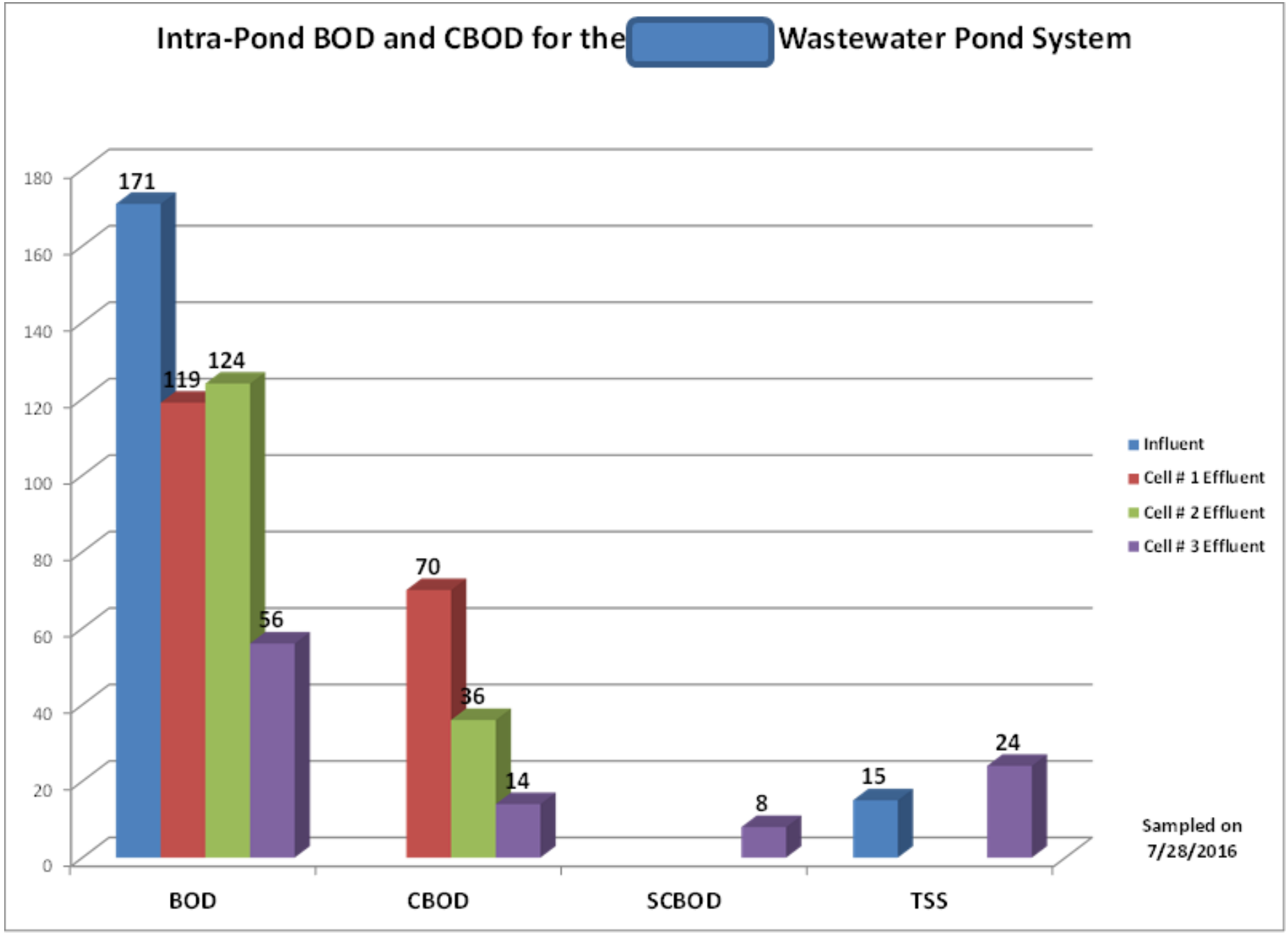
Soluble BOD_5

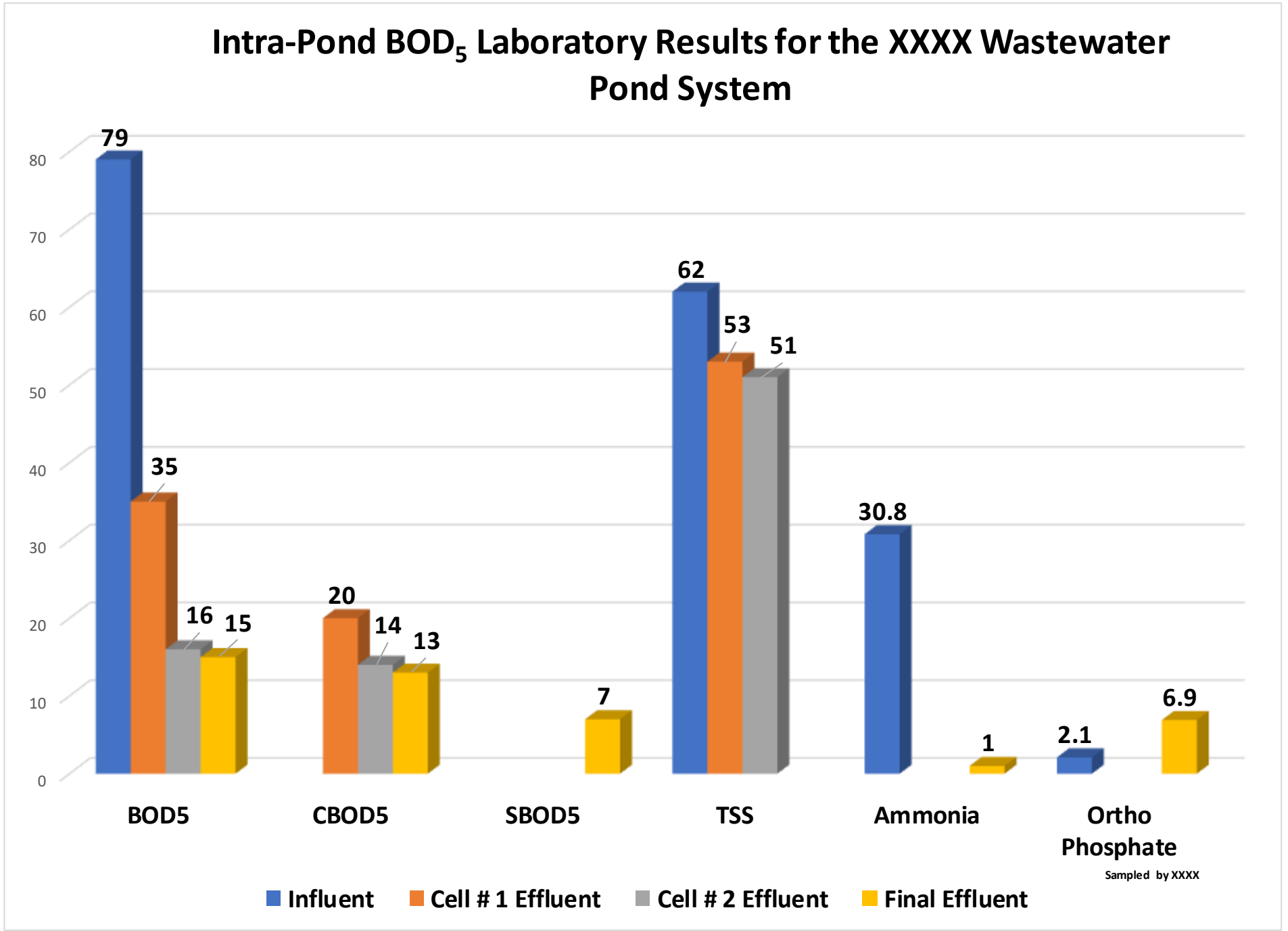
$SCBOD_5$

Soluble Carbonaceous BOD_5

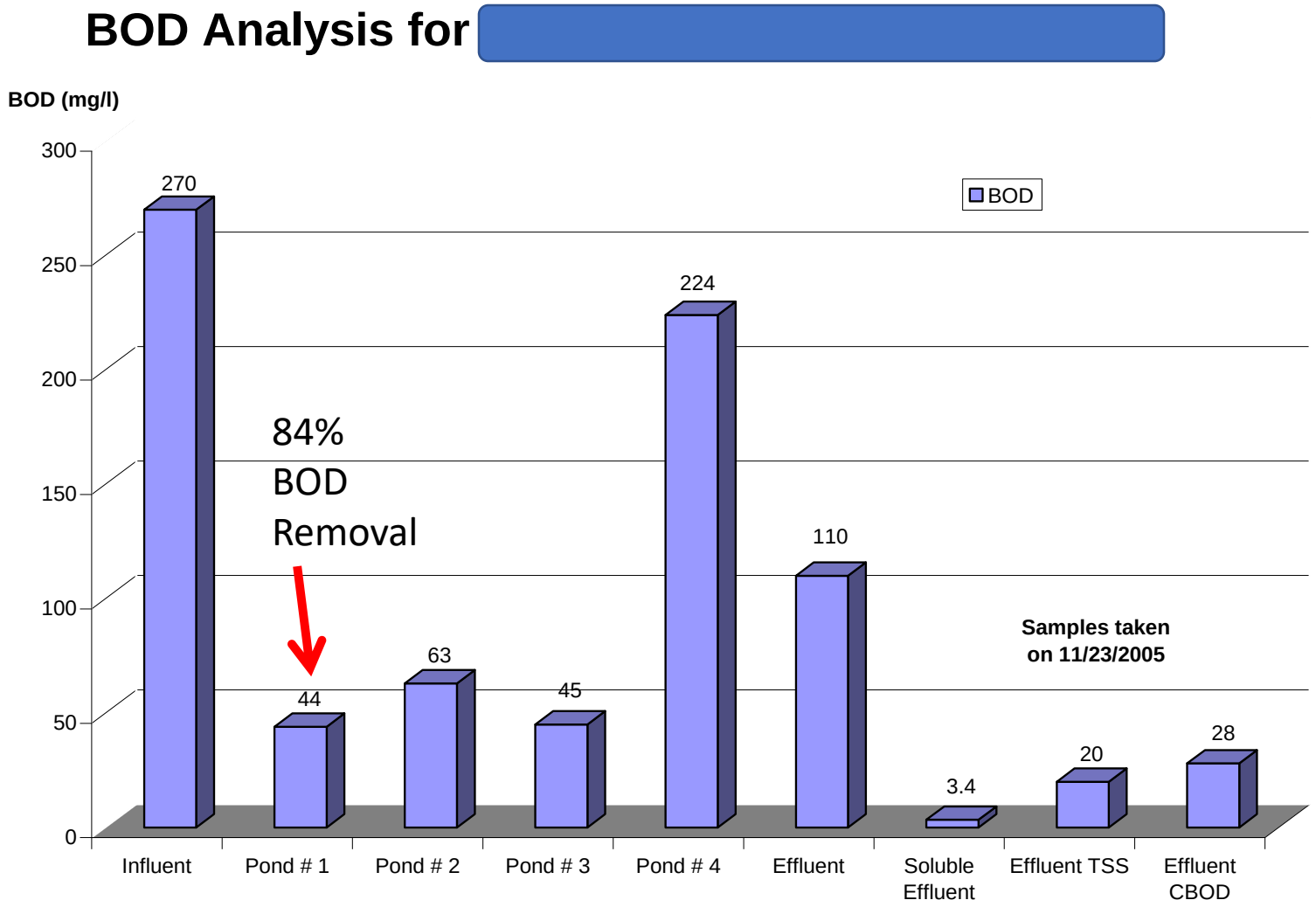
Diagnostic BOD_5 Tests




Intra-Pond BOD and CBOD for the [redacted] Wastewater Pond System
180
160
140
120
100
80
60
40
20
0
171
119
124
56
70
36
14
8
15
24
BOD
CBOD
SCBOD
TSS
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent
Sampled on
7/28/2016


Intra-Pond BOD5 Laboratory Results for the XXXX Wastewater Pond System
80
70
60
50
40
30
20
10
0
79
35
16
15
20
14
13
7
62
53
51
30.8
1
2.1
6.9
BOD5
CBOD5
SBOD5
TSS
Ammonia
Ortho Phosphate
Sampled by XXXX
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent

It is Important to know Where the Problem is Occurring



What do you suppose the difference in pH would be? BOD_5? TSS?

Picture Courtesy of **Mark Court**, Wyoming Rural Water Association

Biochemical Oxygen Demand	SM 5210B	54	10	mg/L	10	A613004	09/23/16 16:37	09/28/16	

Sample ID: A6I2745-04
Sampled By: [redacted]
Sample Description: Pond 2 out

Sample Date - Time: 09/22/16 - 13:10
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand	SM 5210B	130	30	mg/L	30	A613004	09/23/16 16:39	09/28/16	

Sample ID: A6I2745-05
Sampled By: [redacted]
Sample Description: Pond 3 Discharge

Both Pond # 3 Discharges!!!

Sample Date - Time: 09/22/16 - 13:15
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand	SM 5210B	100	15	mg/L	15	A613004	09/23/16 16:41	09/28/16	

Sample ID: A6I2745-06
Sampled By: [redacted]
Sample Description: Pond 3 Discharge

100 mg/l

Sample Date - Time: 09/22/16 - 13:15
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand - Dissolved (1)	SM 5210B	6.0	4.0	mg/L	4	A613004	09/23/16 16:43	09/28/16	

Figure 3. Final Filtered BOD, BOD without Algae Cells, is 6 mg/l. 94 mg/l of BOD is caused by Algae Respiring in the BOD test bottle

6 mg/l

94 mg/l caused by algae consuming oxygen in the BOD_5 test bottle for 5 days

assenvironmental@earthlink.net

Diagnostic TSS

Diagnostic TSS

- TSS = BTSS + ATSS + MTSS
  - BTSS is suspended bacterial solids
  - ATSS is the algal component of TSS
  - MTSS is silt, clay, cell debris, bottom solids

Solids Types Lost to the Effluent

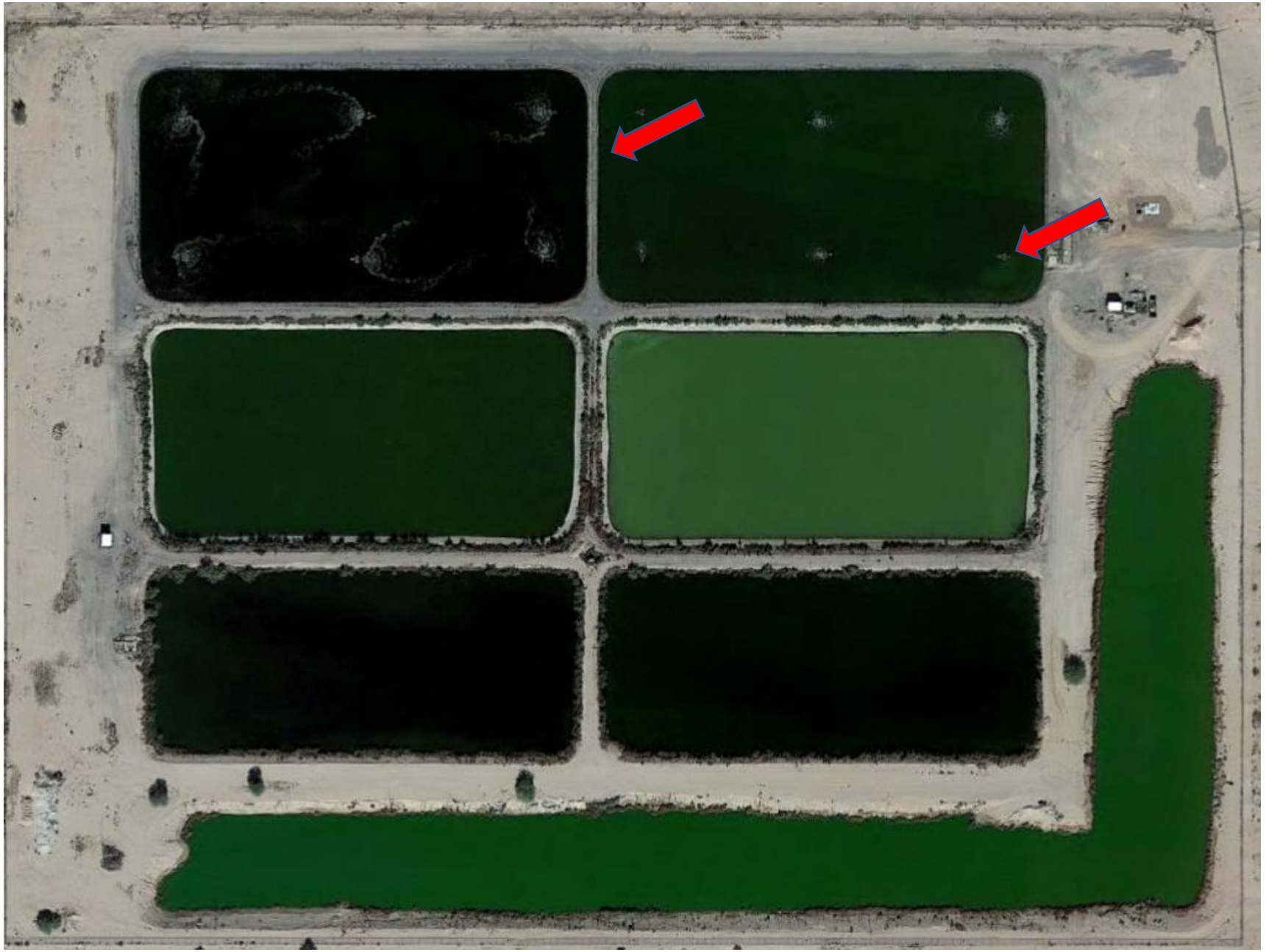
- Raw Wastewater Solids - Short Circuiting or
  Poor aeration
- Old Sludge Particles - Sludge buildup
- Treatment Solids (bacterial flocs)
  organic overload or sludge accumulation
- Filamentous Bacteria - indicates low D.O. or septicity
- Sulfur Bacteria - anoxic conditions and sulfides forming
- Algae or Protozoa

This is an effluent structure

What would Sludge Look Like on a TSS Filter Under the Microscope?

Hydraulics

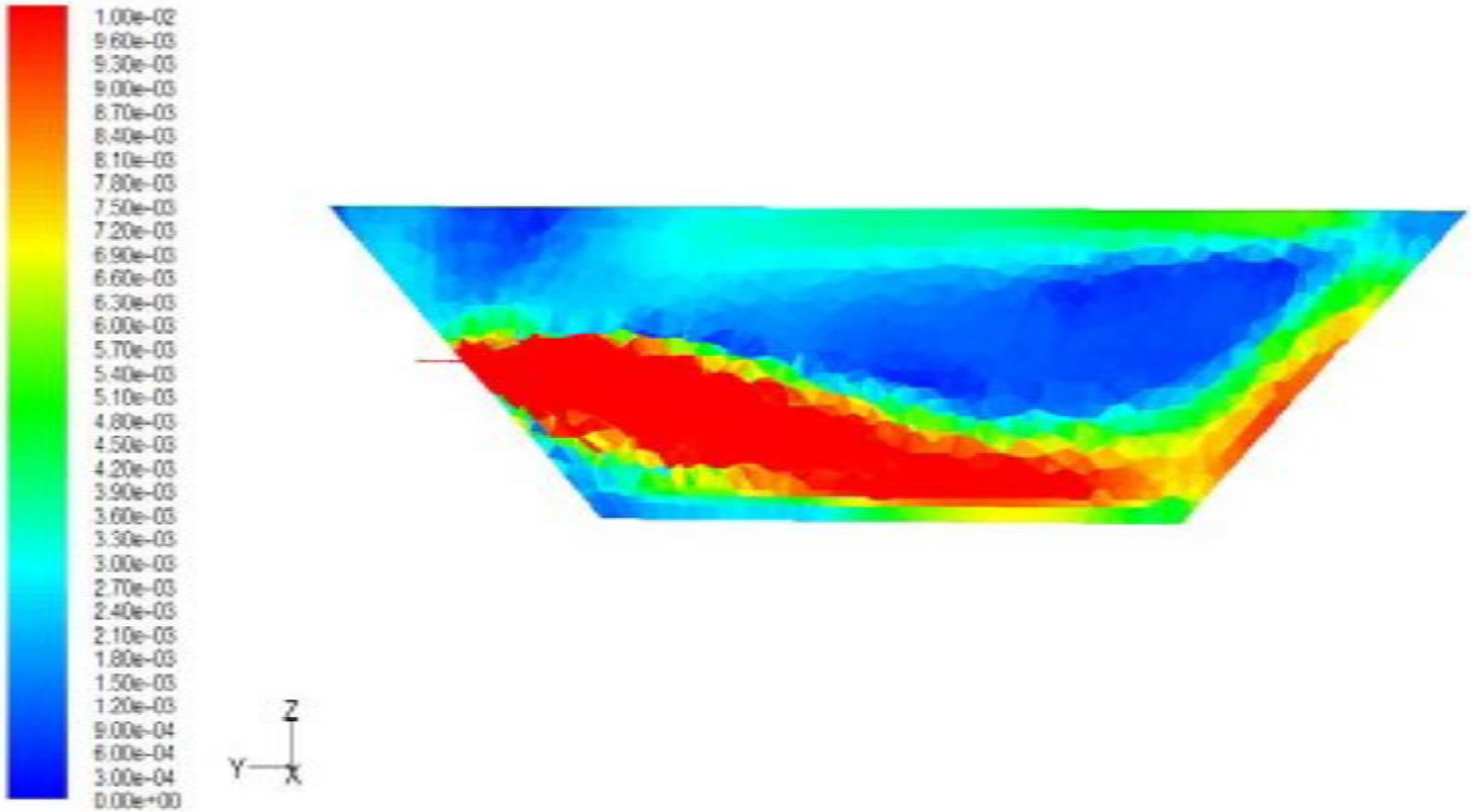

Stinger Jacket



Drogues set at influent of Cell # 1 and traveled to the effluent of Cell # 1 in 45 minutes!

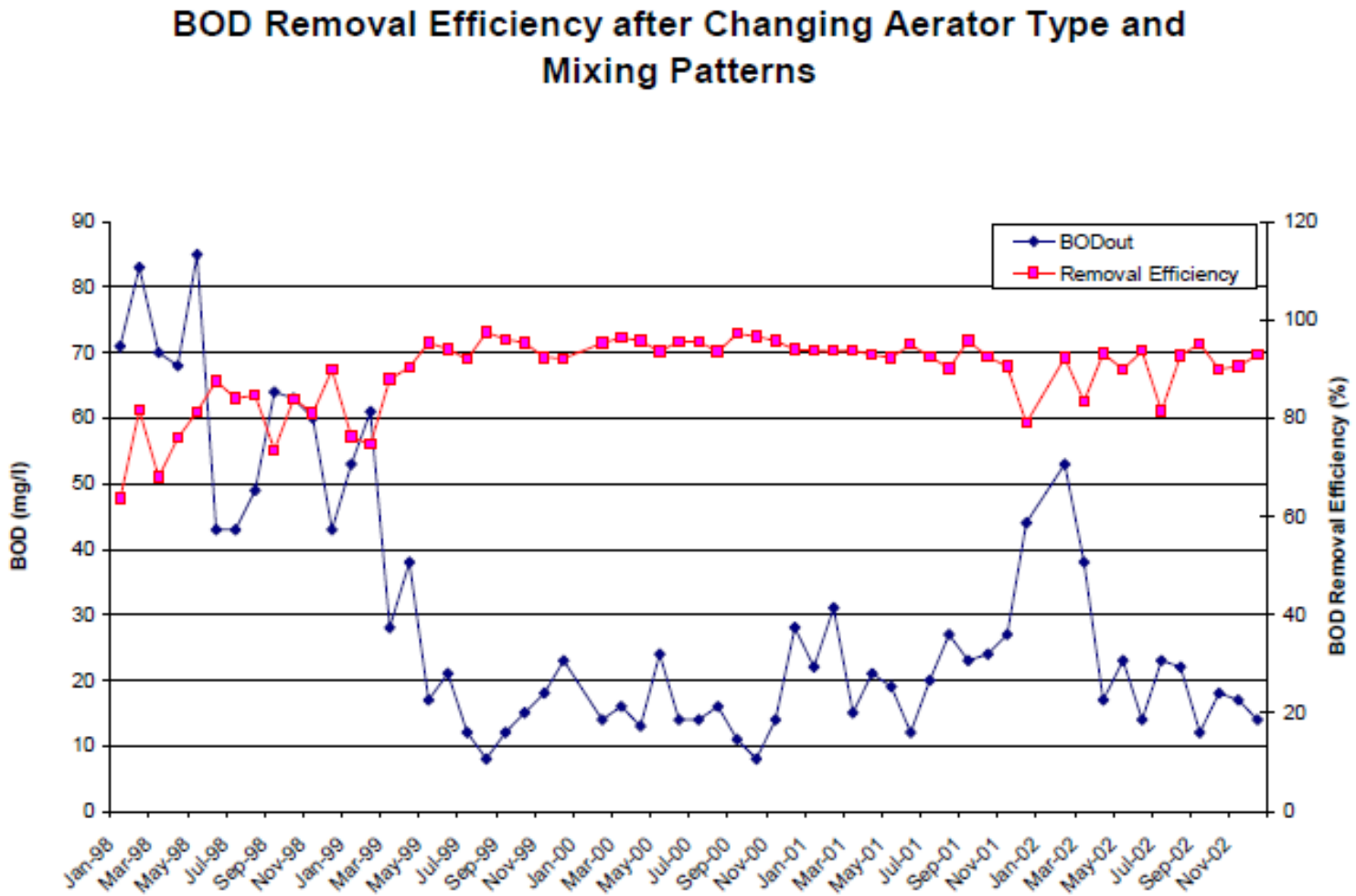
“Short-circuiting is the greatest deterrent to successful pond performance, barring any toxic effects. The importance of the hydraulic design of a pond system cannot be overemphasized”

- Middlebrooks

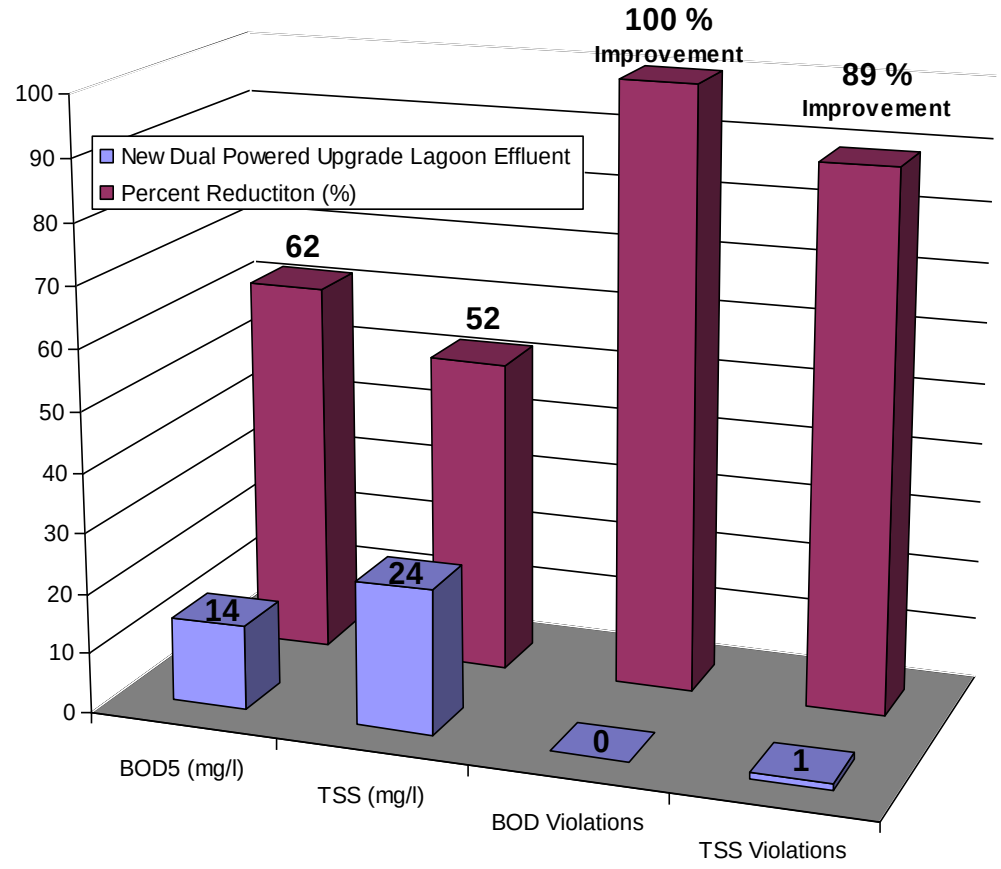

1.00e-02
9.60e-03
9.30e-03
9.00e-03
8.70e-03
8.40e-03
8.10e-03
7.80e-03
7.50e-03
7.20e-03
6.90e-03
6.60e-03
6.30e-03
6.00e-03
5.70e-03
5.40e-03
5.10e-03
4.80e-03
4.50e-03
4.20e-03
3.90e-03
3.60e-03
3.30e-03
3.00e-03
2.70e-03
2.40e-03
2.10e-03
1.80e-03
1.50e-03
1.20e-03
9.00e-04
6.00e-04
3.00e-04
0.00e+00
Z
Y
X

The Hydraulic Difference Between Types of Aeration

The Effect of Switching Aerator Types at the Wasco State Pr[redacted]



Performance of New Lagoon System Since Upgrade to Dual Power Multi-Cell System



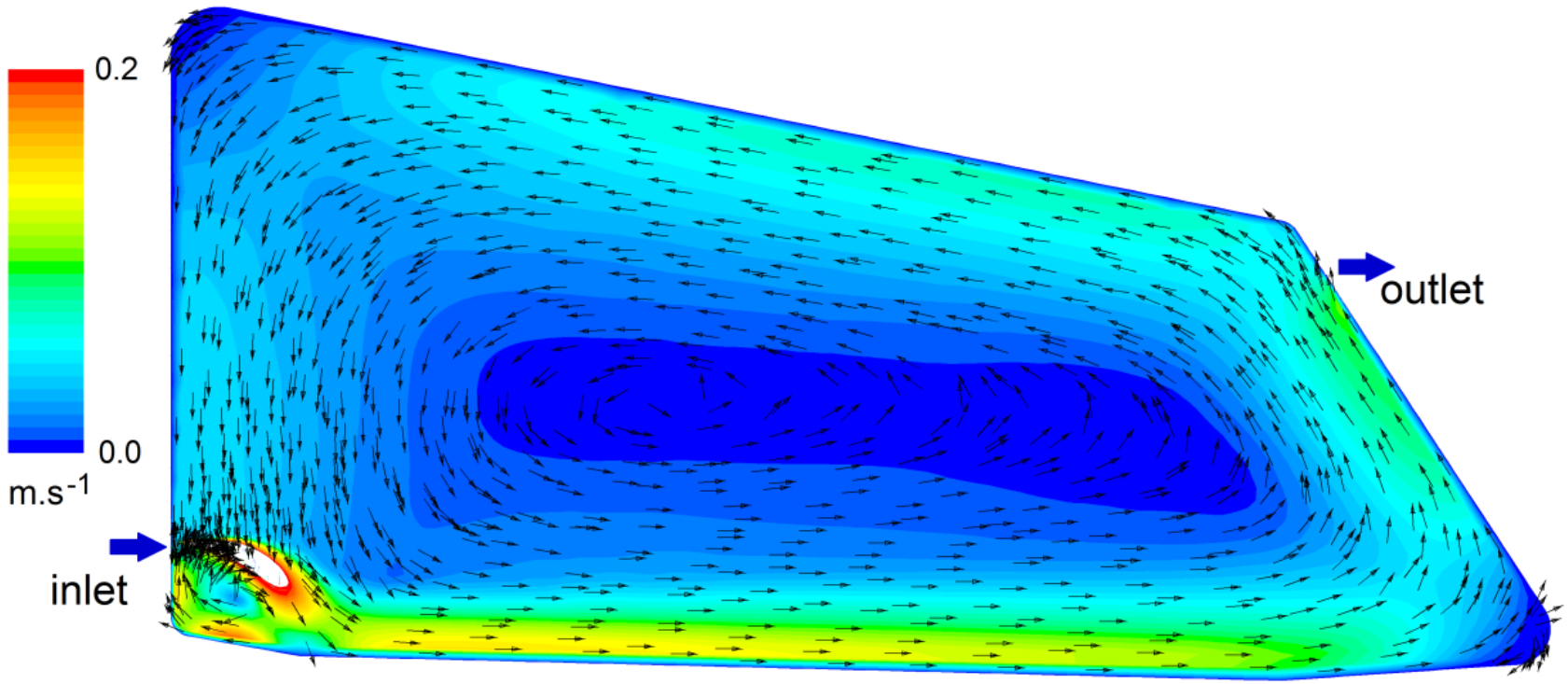
Saves $110,000/year in energy costs using 8 less aerators

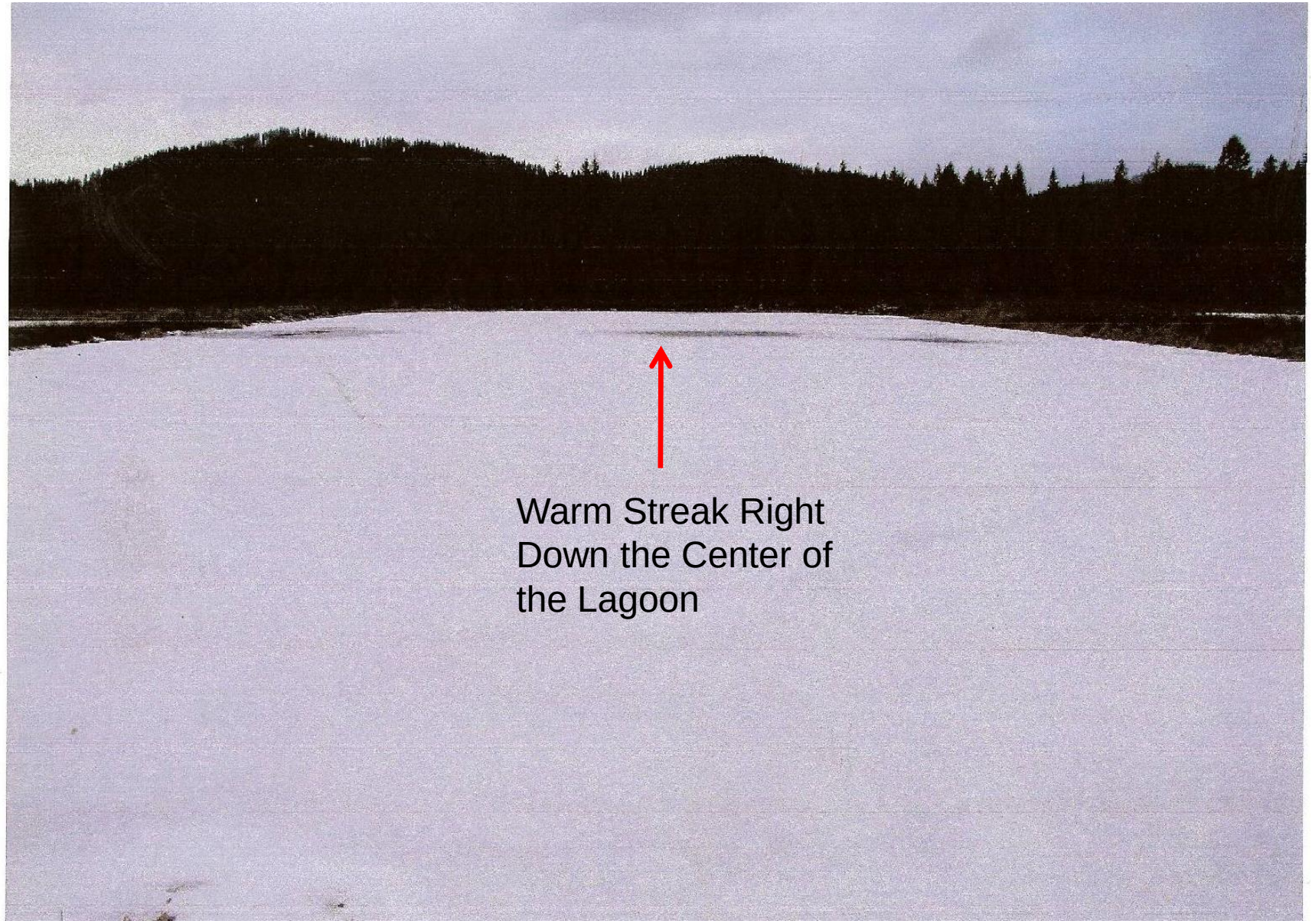
Total Construction Cost Including stabilizing lagoon embankments: **$650,000**


ENVIROMETICS


HN DEERE

Notice the Dead Zones




Warm Streak Right
Down the Center of
the Lagoon

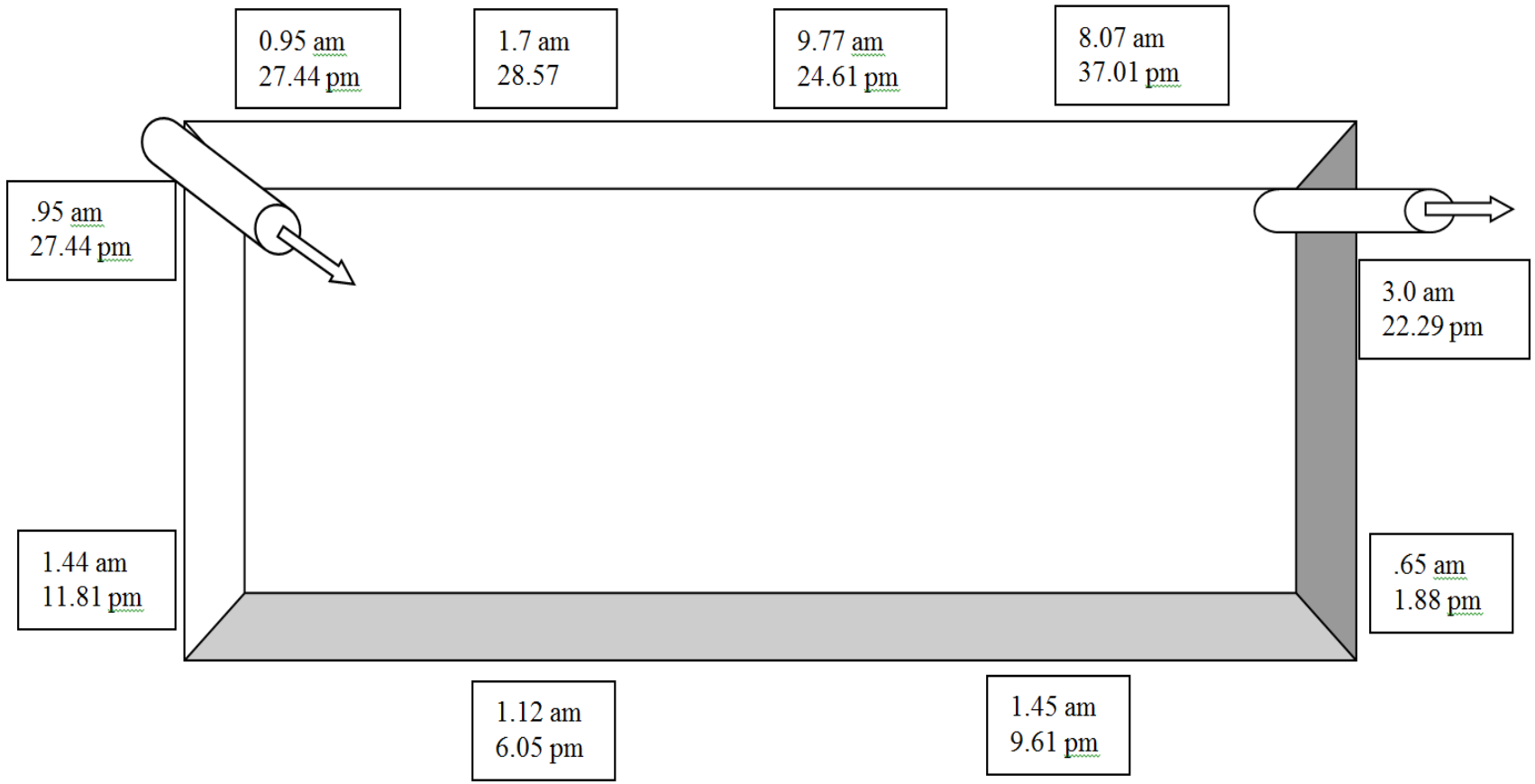

SANITARY
SEWER


0923 016846

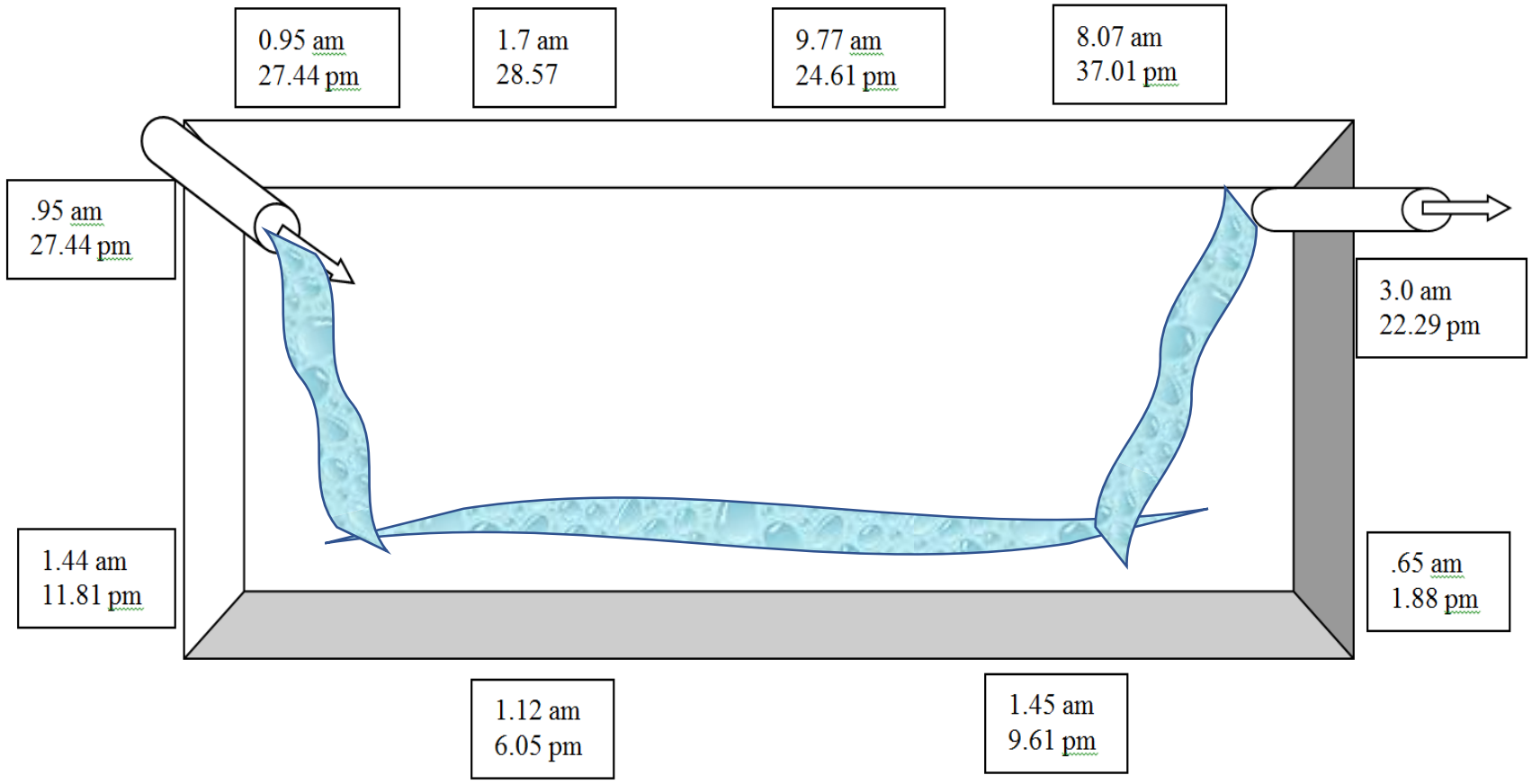
CLOSED
CLOSED
PARADE

Center of Pond Influent Structure

Spatial Changes in D.O. Measurements at



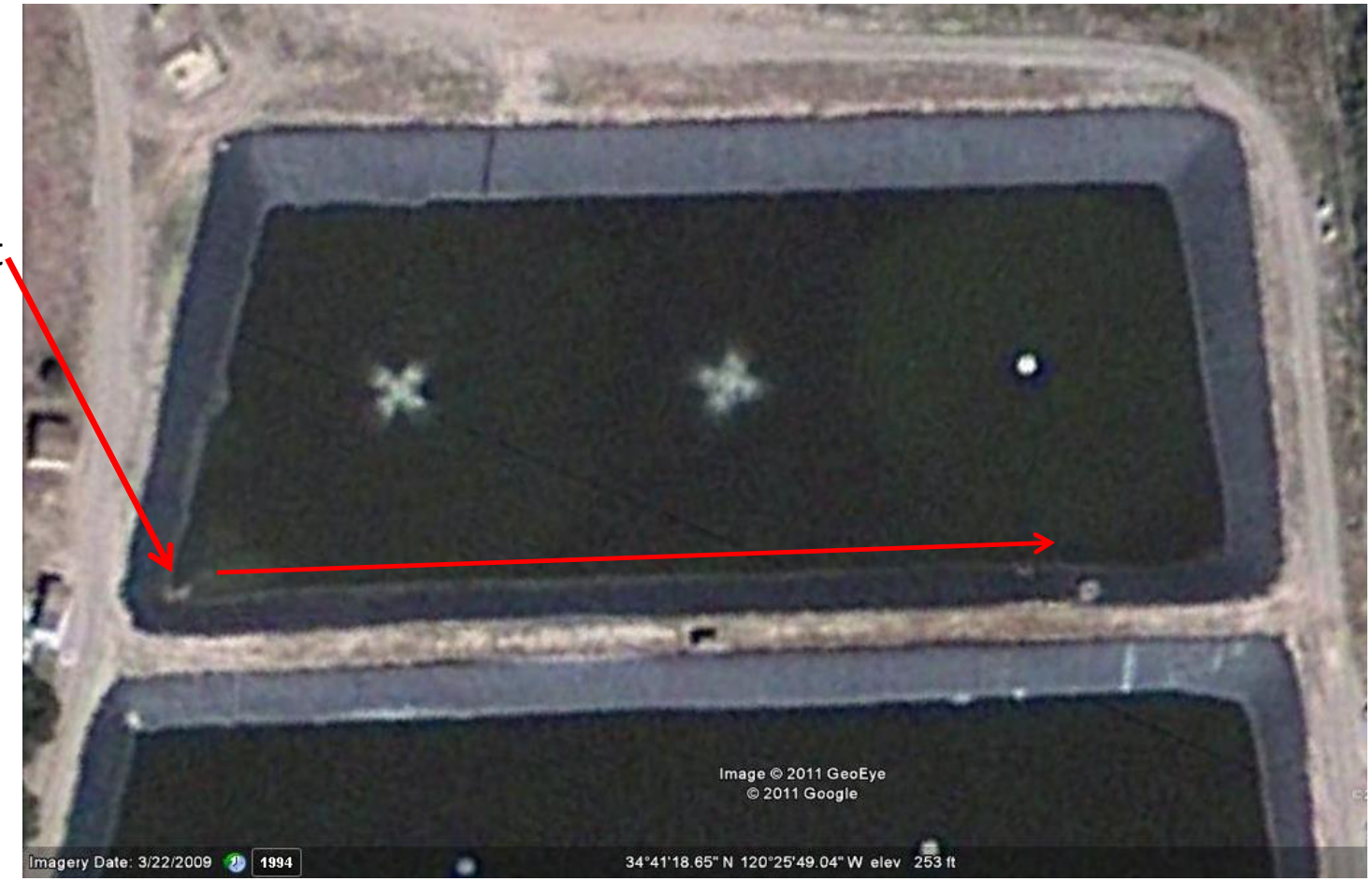
Spatial Changes in D.O. Measurements at



XXXX Pond Hydraulics

Repositioning Aerators for Enhanced Hydraulics Performance

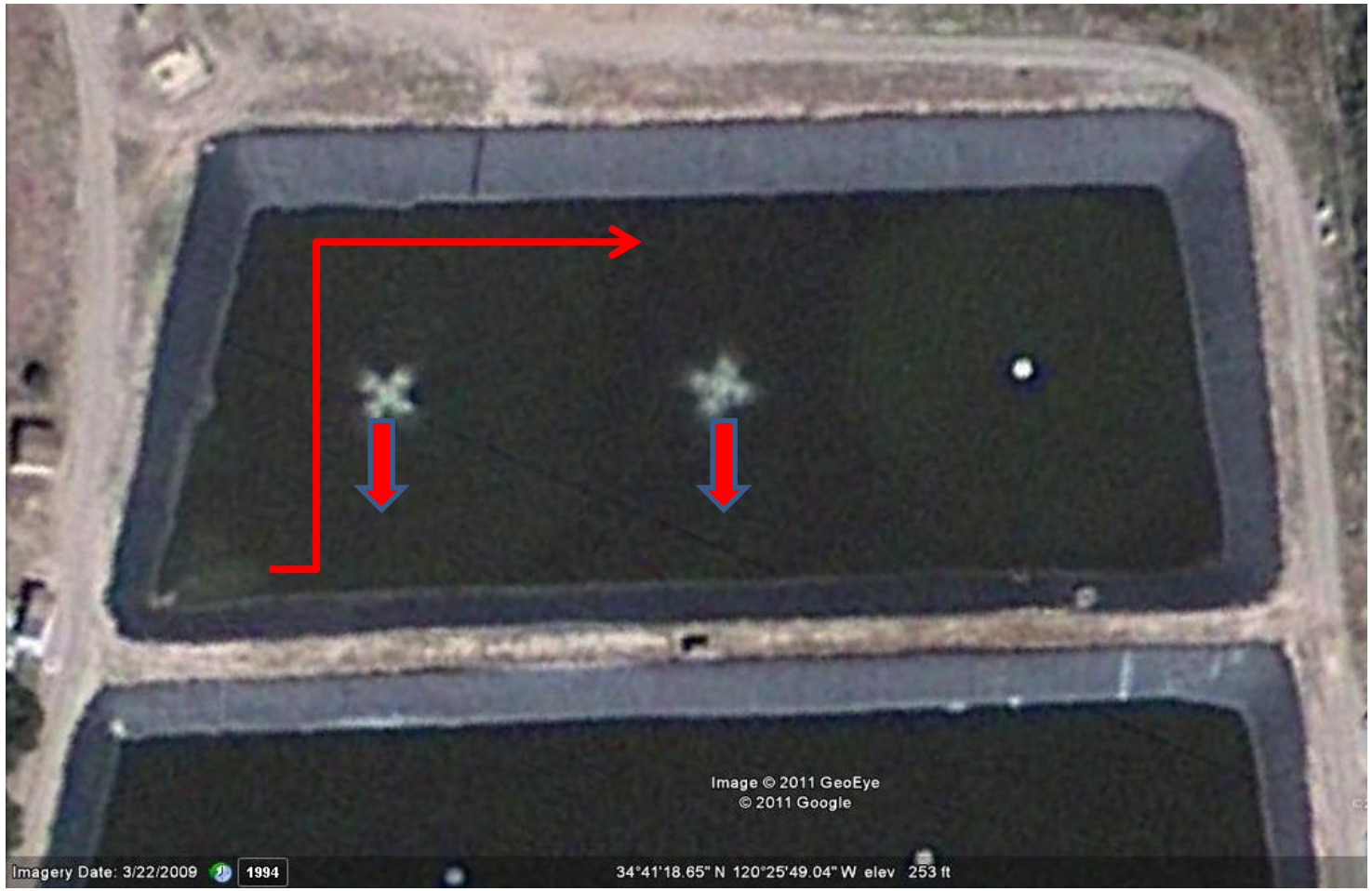
XXXX Cell # 1


Influent
Image © 2011 GeoEye
© 2011 Google
Imagery Date: 3/22/2009
1994
34°41'18.65" N 120°25'49.04" W elev 253 ft

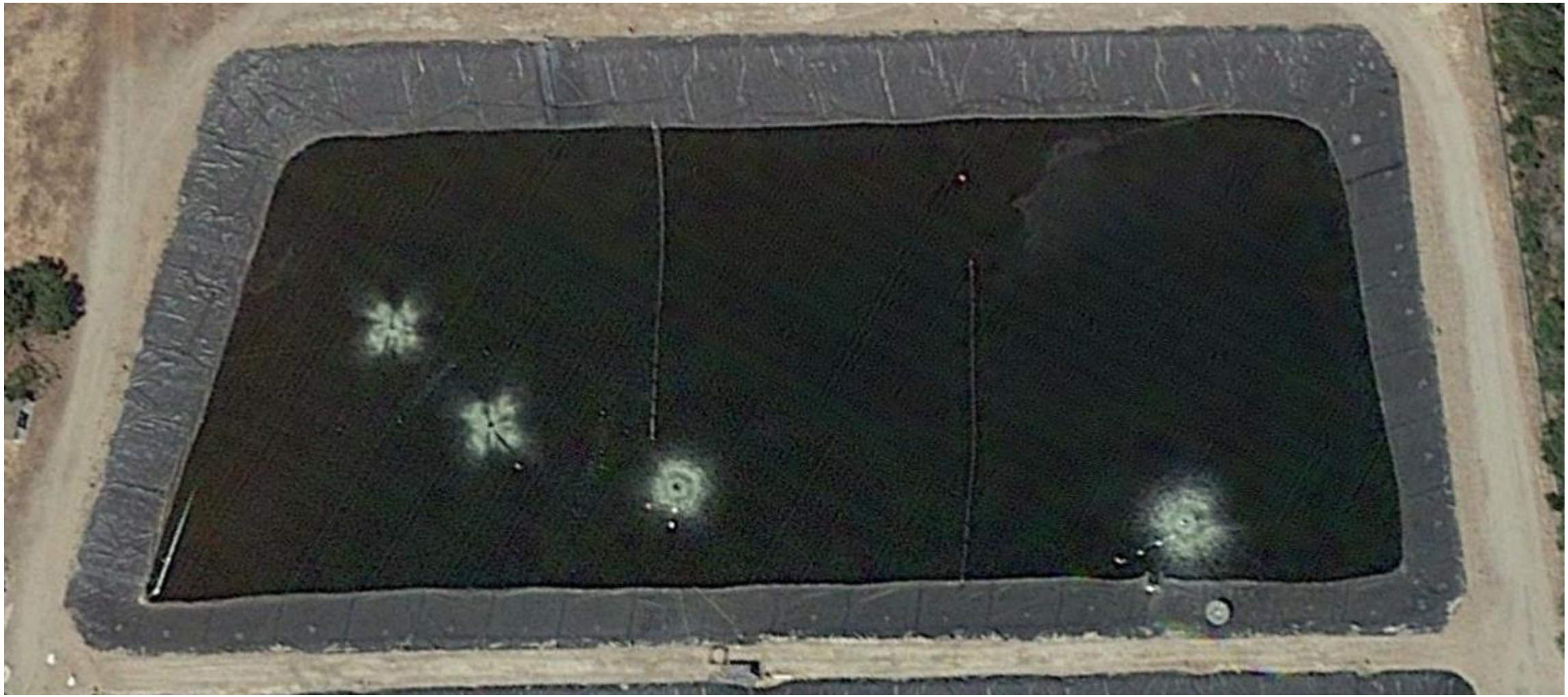
- XXX the plant operator floated lemon drogues to observe the path of the flow.
- Lemon drogues floated south along the dike and out with the effluent in just six (6) hours!
- The engineers designed the cell to operate with a twelve (12) day retention time

- Moving aerators southward caused the influent flow to move north, around the aerator.
- Now it takes nine (9) days for a lemon to reach the effluent

Aerators Moved South Now Flow Follows a more Plug-Flow Pattern

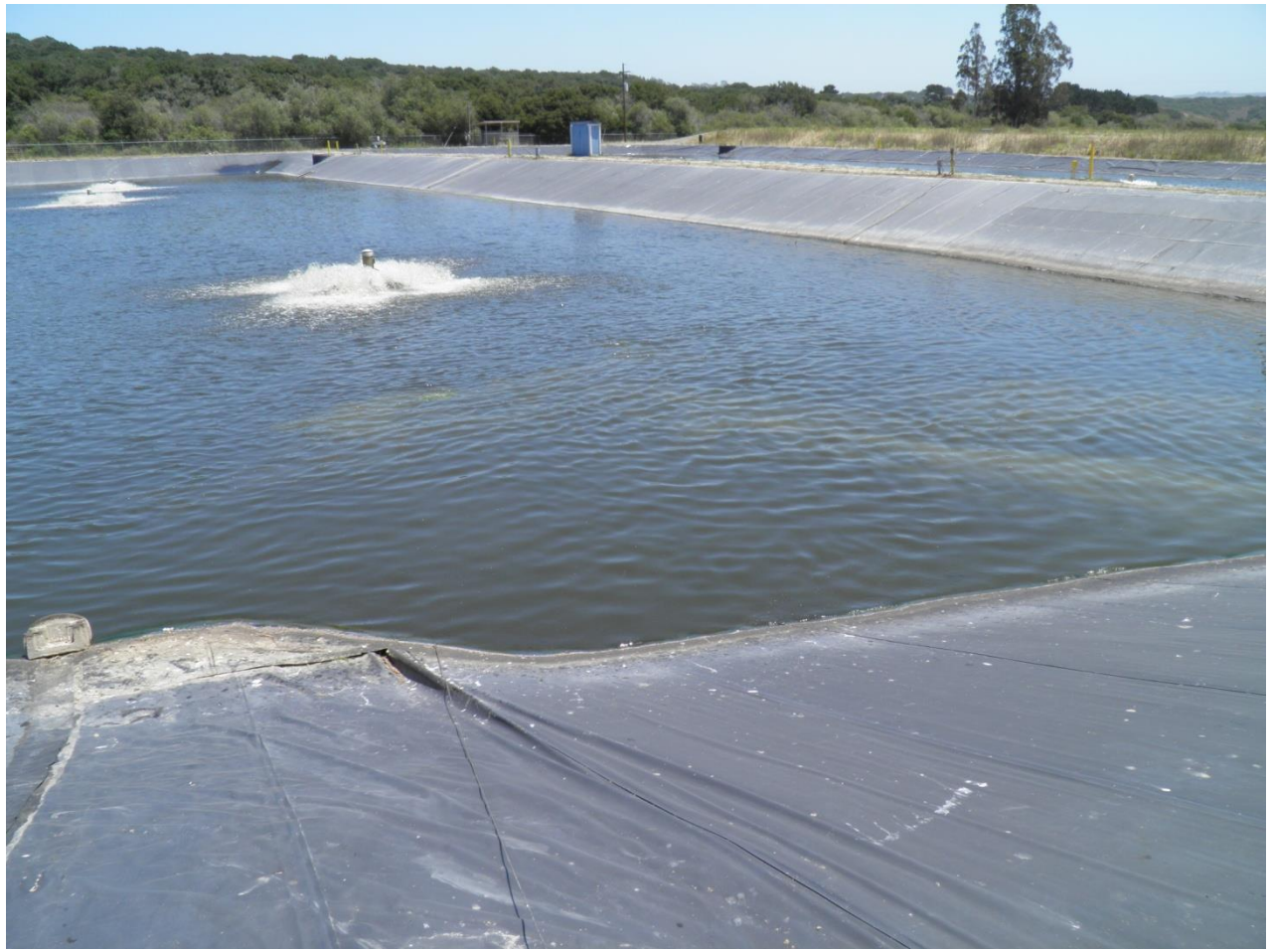


Picture Taken 3.15.2013



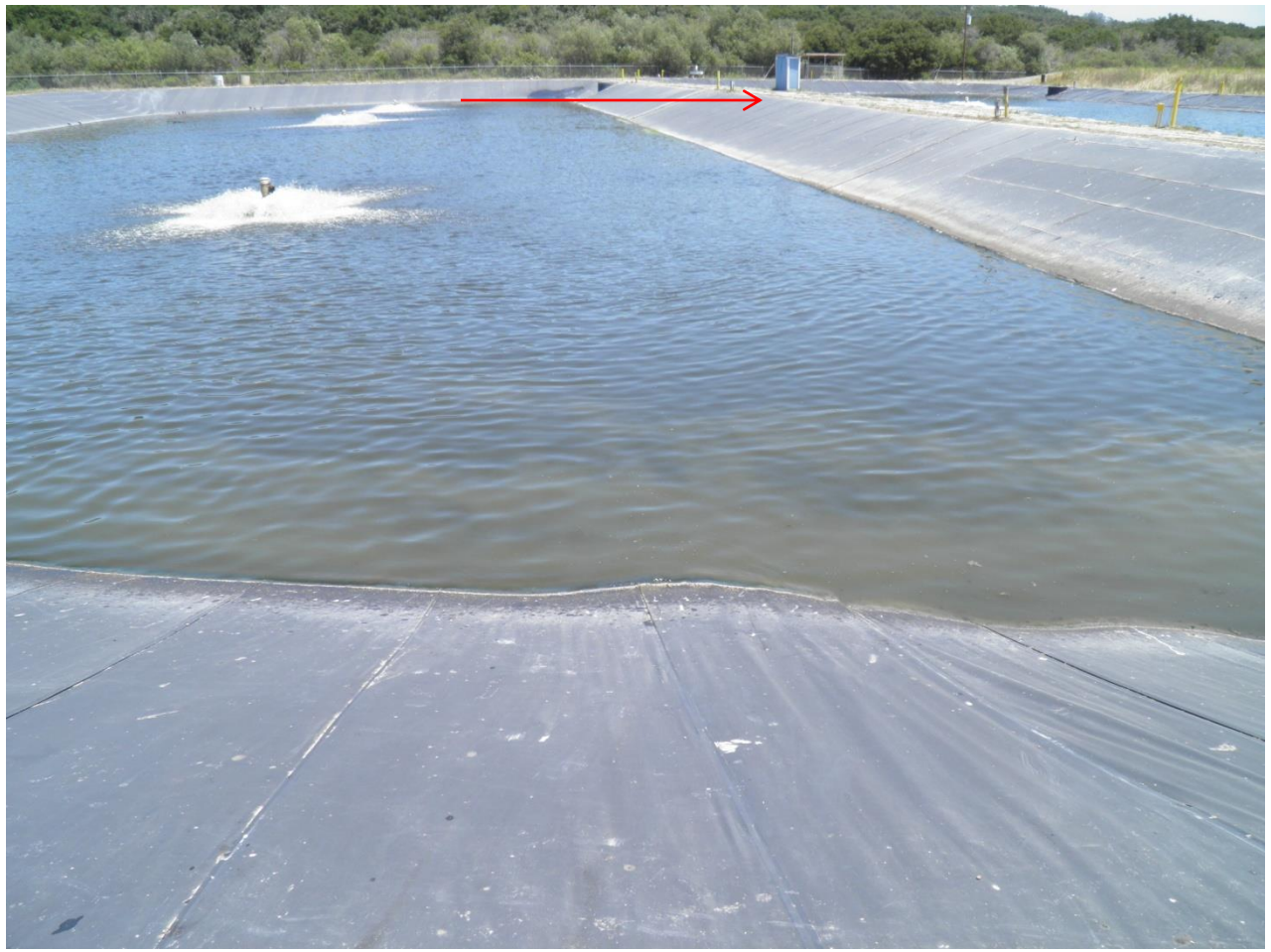
An aerator creates a momentum force pushing water in all directions. Notice how the flow moves north

Observe the waves caused by the aerator



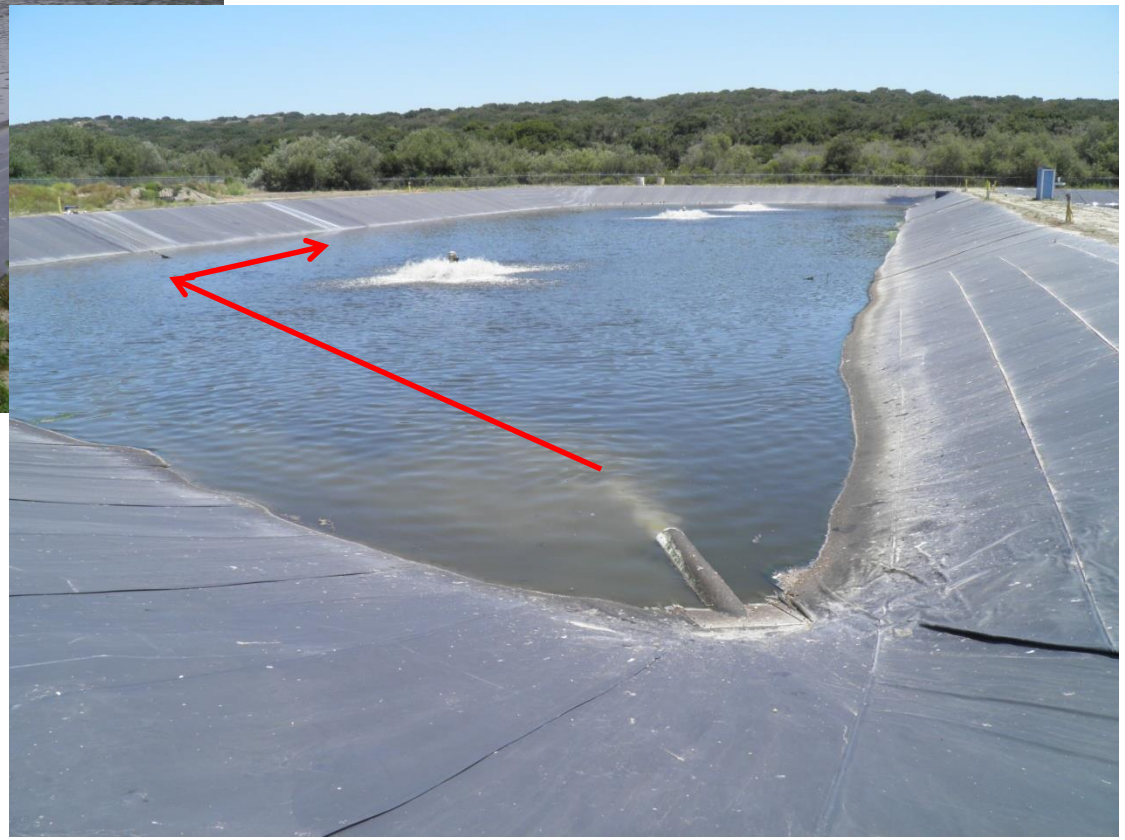
The Momentum Force Reaches Out

Notice the flow of the influent mass



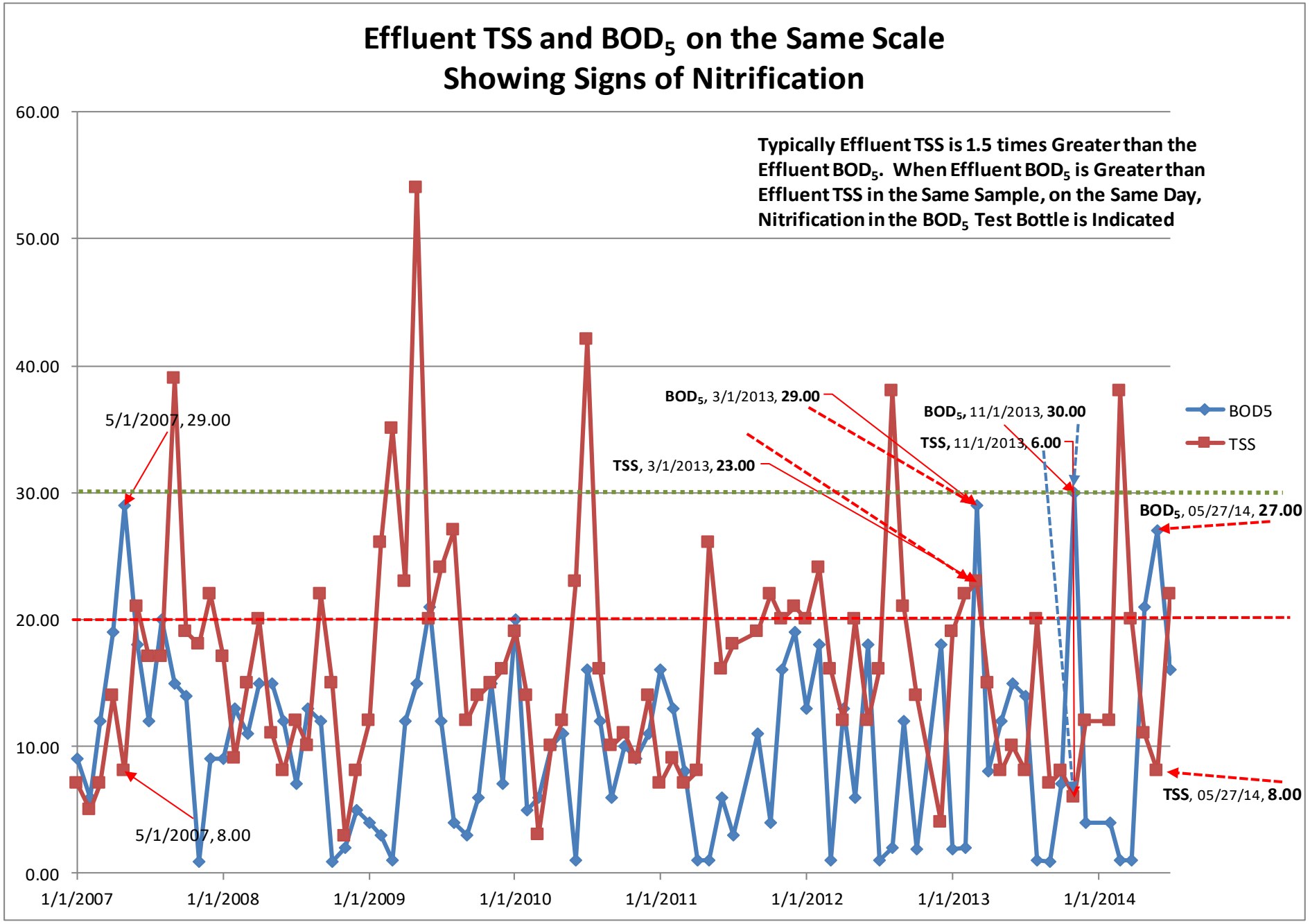
Old Configuration

New Configuration

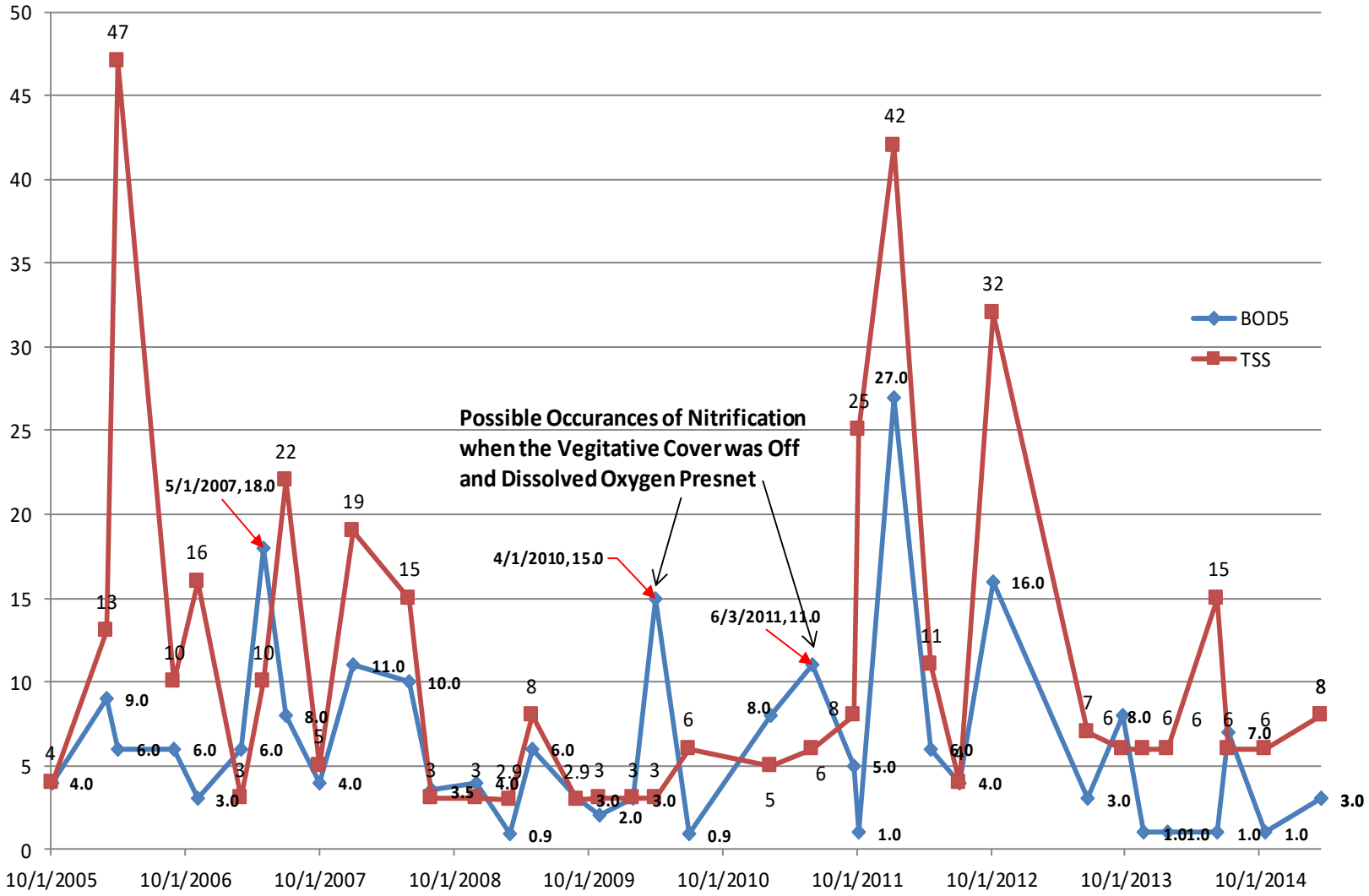


New Aerator Configuration Places Aerator Closer to Influent and in a position to Direct the Flow Path for Optimized Retention

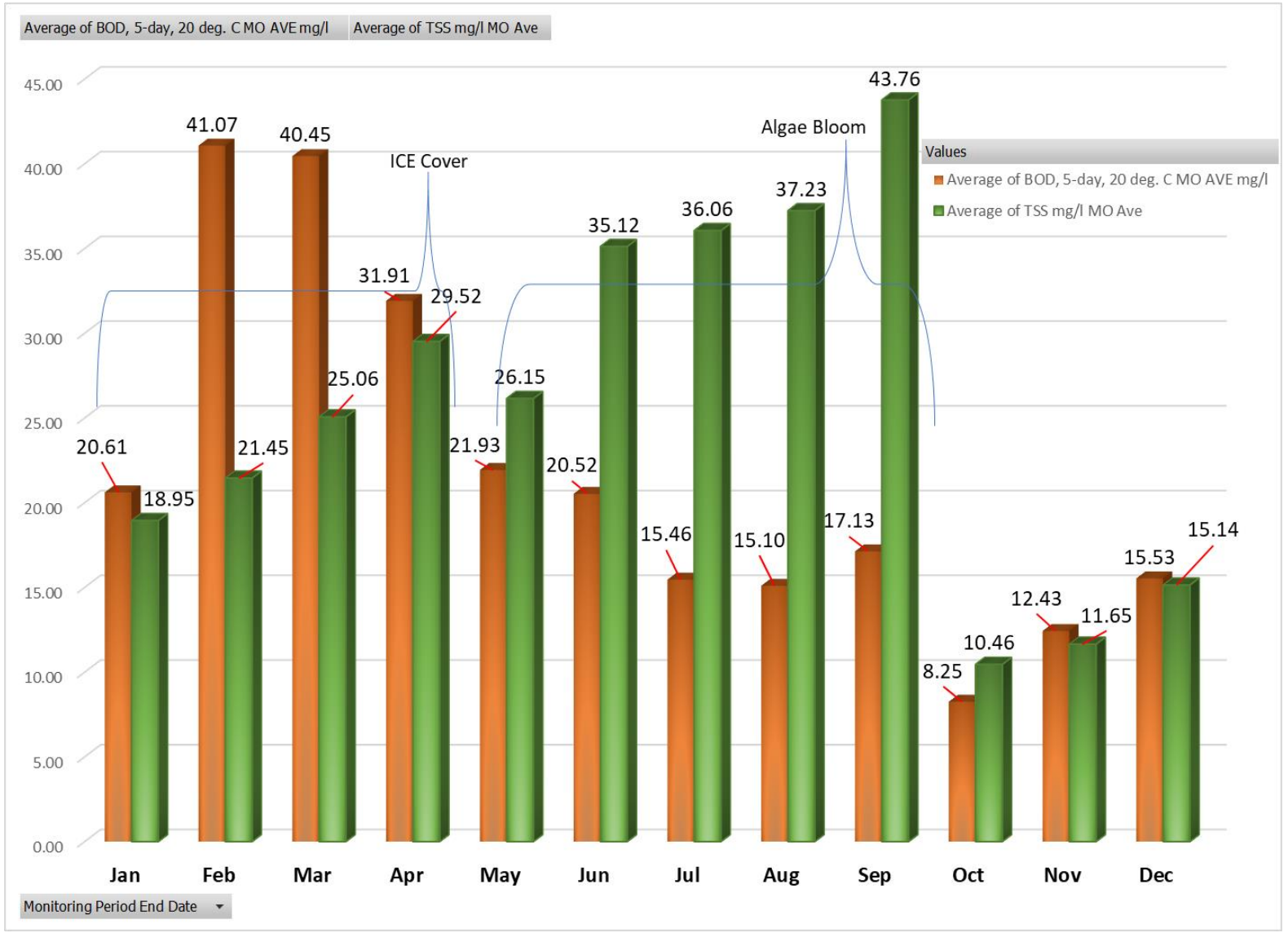
Diagnostic Tools


Effluent TSS and BOD5 on the Same Scale
Showing Signs of Nitrification
Typically Effluent TSS is 1.5 times Greater than the Effluent BOD5. When Effluent BOD5 is Greater than Effluent TSS in the Same Sample, on the Same Day, Nitrification in the BOD5 Test Bottle is Indicated
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
BOD5
TSS
5/1/2007, 29.00
5/1/2007, 8.00
BOD5, 3/1/2013, 29.00
TSS, 3/1/2013, 23.00
BOD5, 11/1/2013, 30.00
TSS, 11/1/2013, 6.00
BOD5, 05/27/14, 27.00
TSS, 05/27/14, 8.00

Effluent TSS and BOD Charted on the Same Scale



BOD can Also Be Greater Than TSS During the Winter



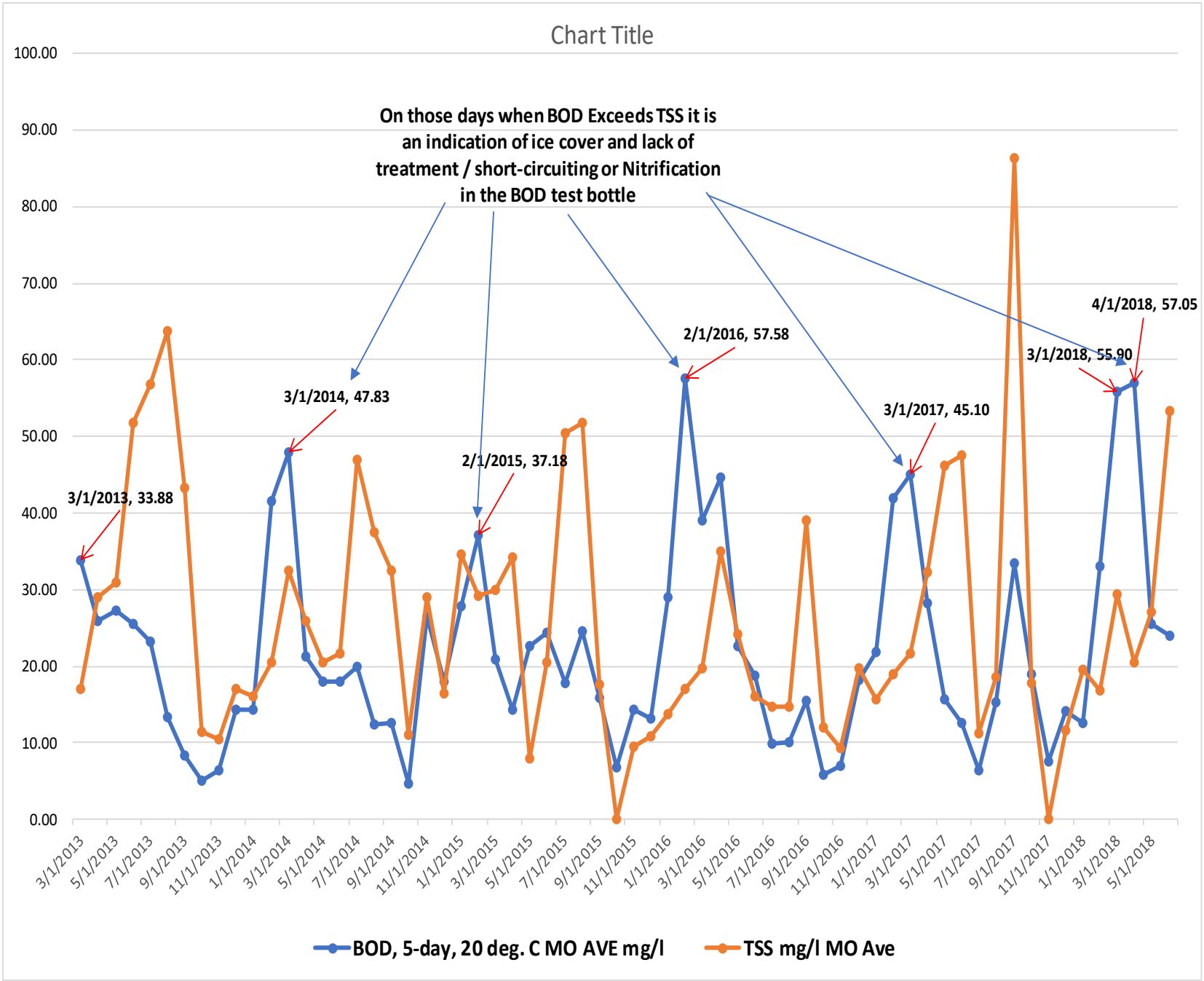
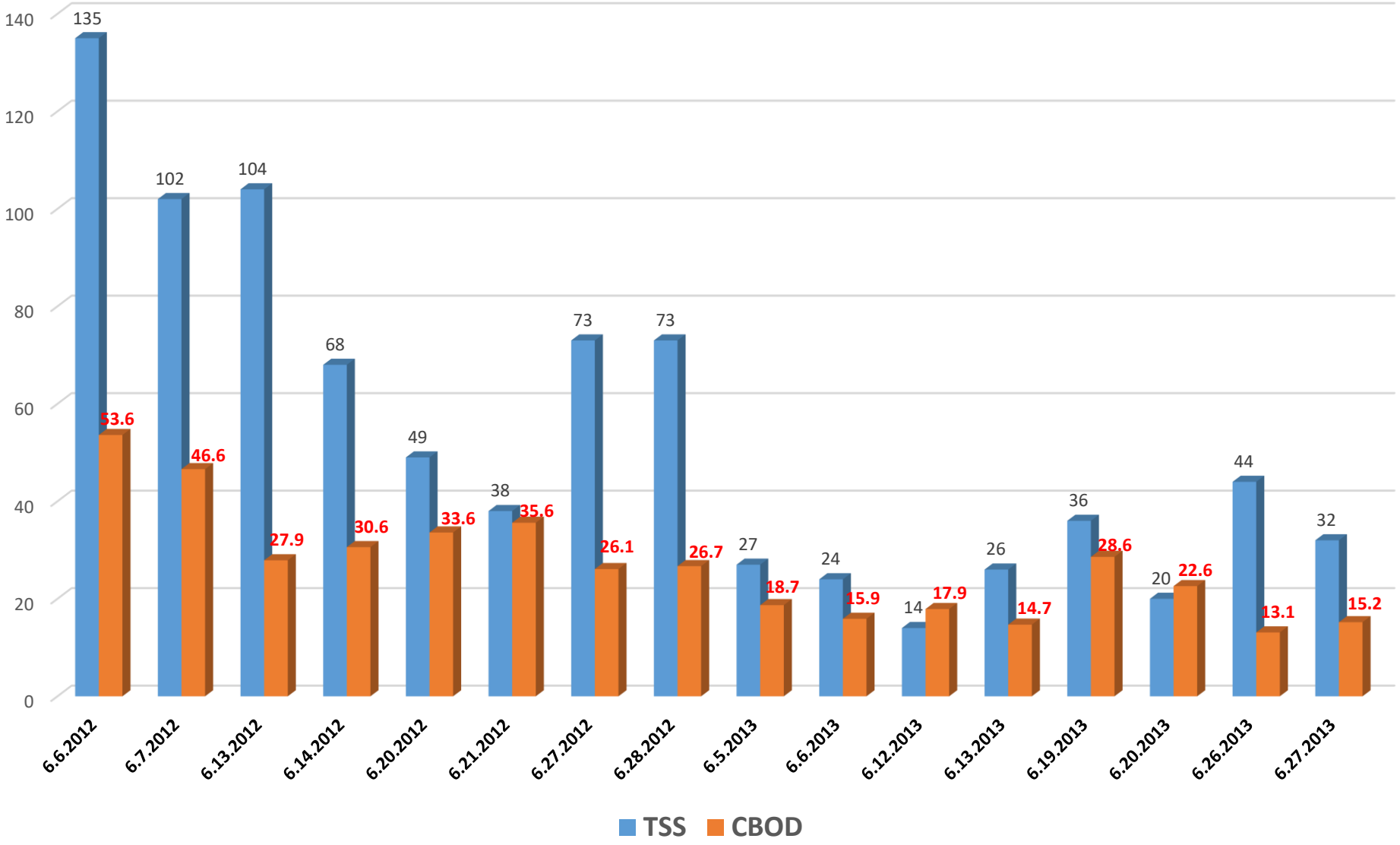


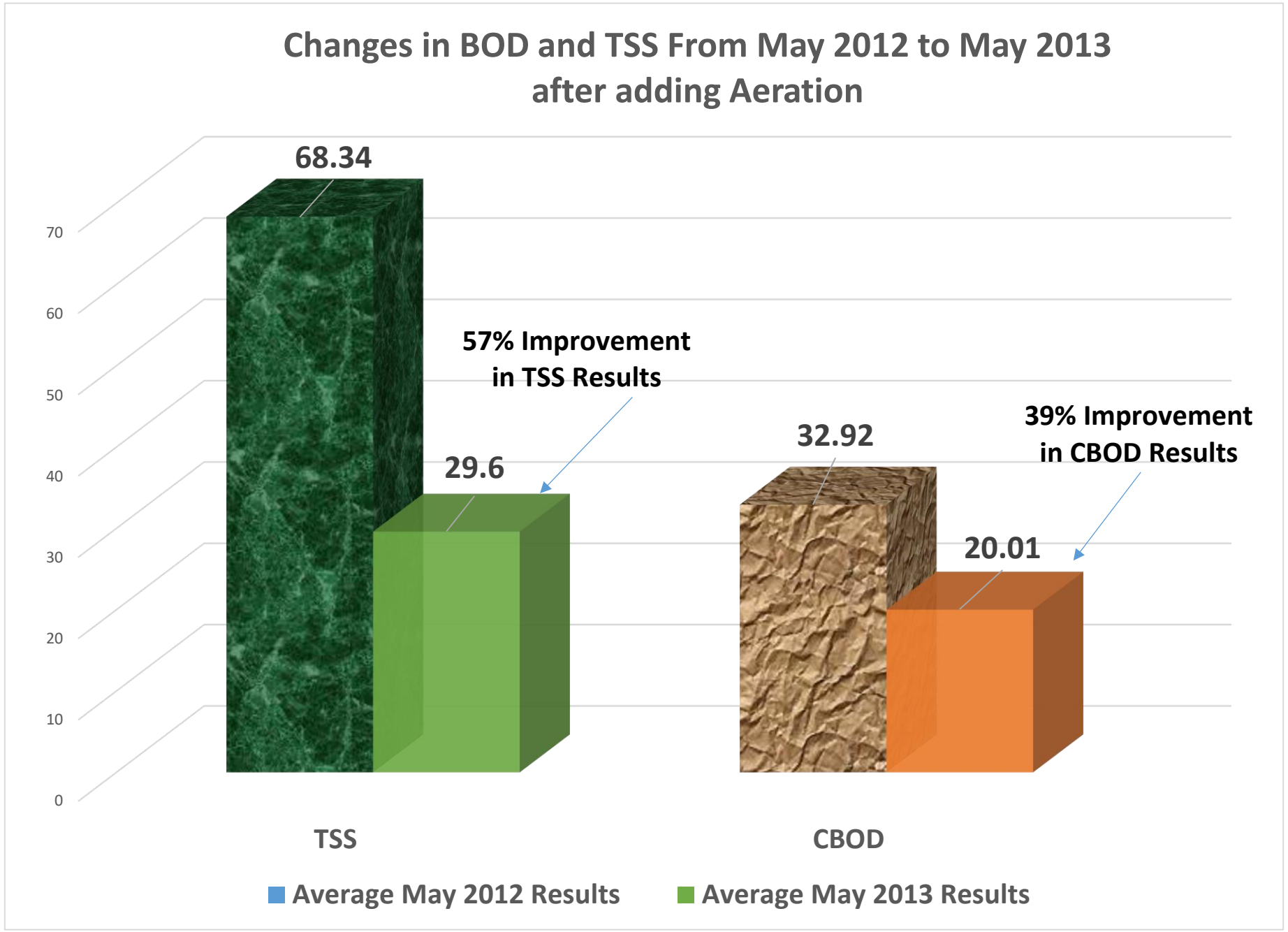
Chart Title
On those days when BOD Exceeds TSS it is an indication of ice cover and lack of treatment / short-circuiting or Nitrification in the BOD test bottle
3/1/2013, 33.88
3/1/2014, 47.83
2/1/2015, 37.18
2/1/2016, 57.58
3/1/2017, 45.10
3/1/2018, 55.90
4/1/2018, 57.05
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
3/1/2013
5/1/2013
7/1/2013
9/1/2013
11/1/2013
1/1/2014
3/1/2014
5/1/2014
7/1/2014
9/1/2014
11/1/2014
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
1/1/2017
3/1/2017
5/1/2017
7/1/2017
9/1/2017
11/1/2017
1/1/2018
3/1/2018
5/1/2018
BOD, 5-day, 20 deg. C MO AVE mg/l
TSS mg/l MO Ave

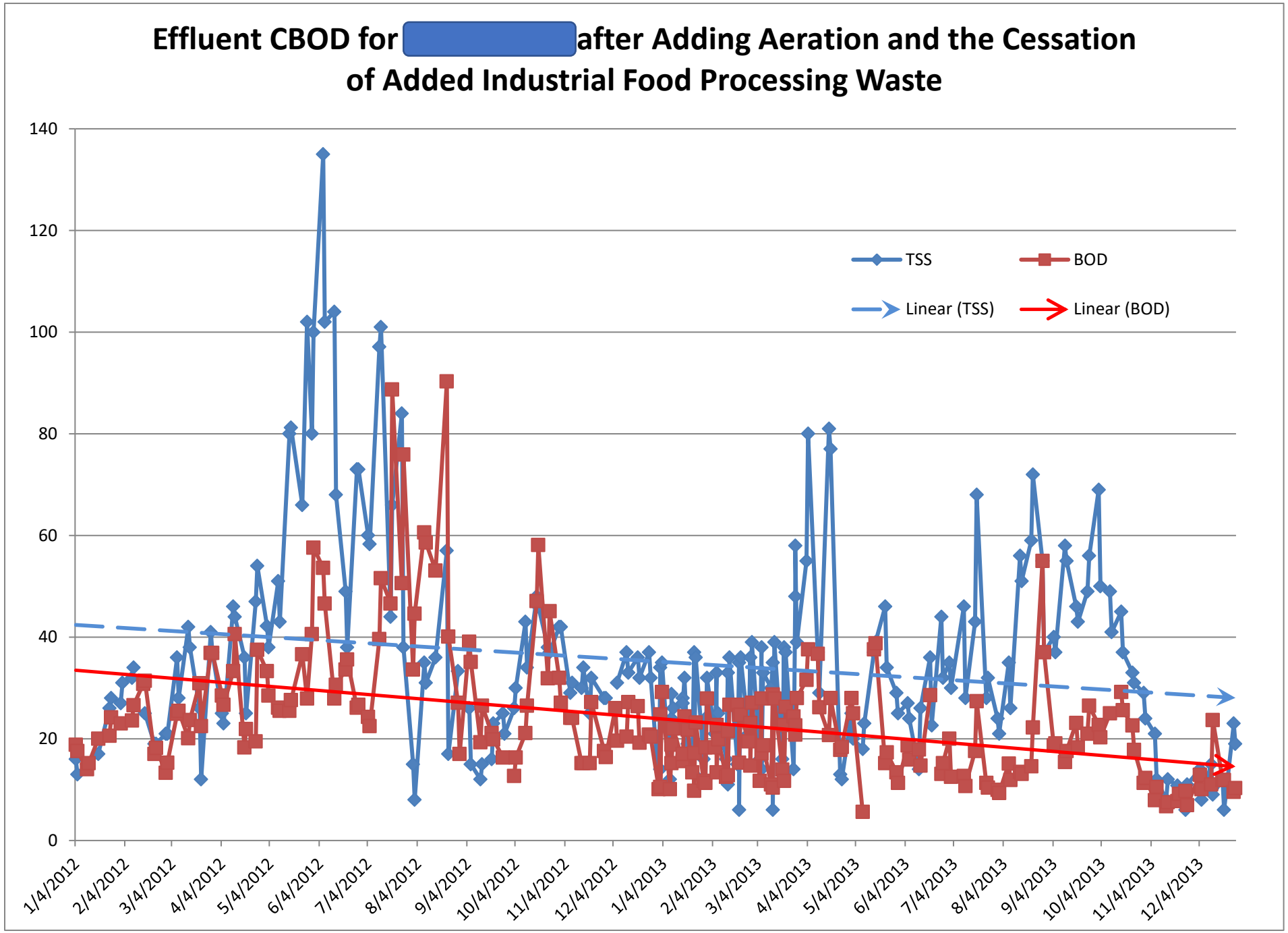
Case for Solving an Overloading Problem

Case # 4

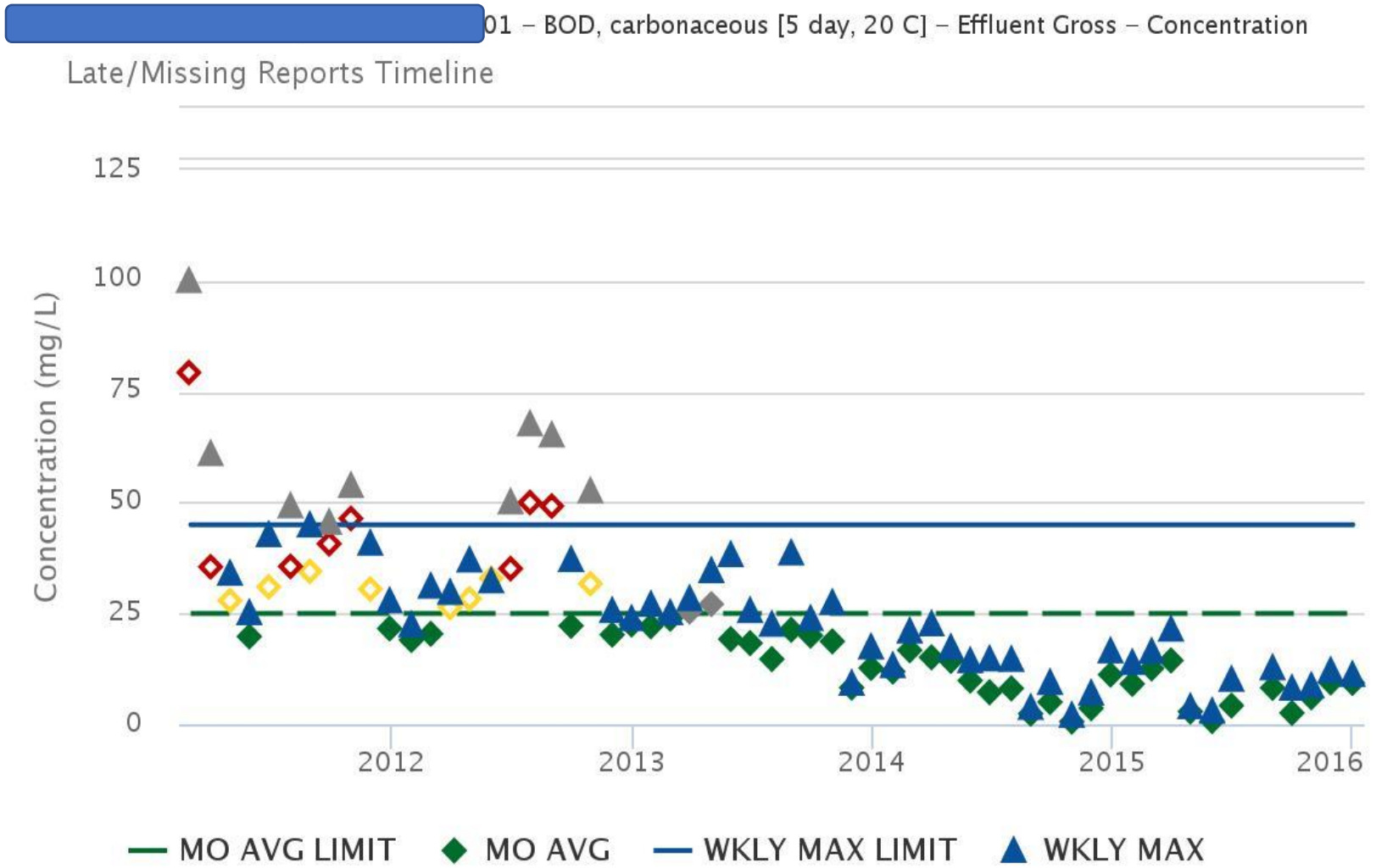
TSS & CBOD Improvement from 2012 to 2013
After Adding Aeration




Changes in BOD and TSS From May 2012 to May 2013 after adding Aeration
68.34
57% Improvement in TSS Results
29.6
32.92
39% Improvement in CBOD Results
20.01
70
60
50
40
30
20
10
0
TSS
CBOD
Average May 2012 Results
Average May 2013 Results

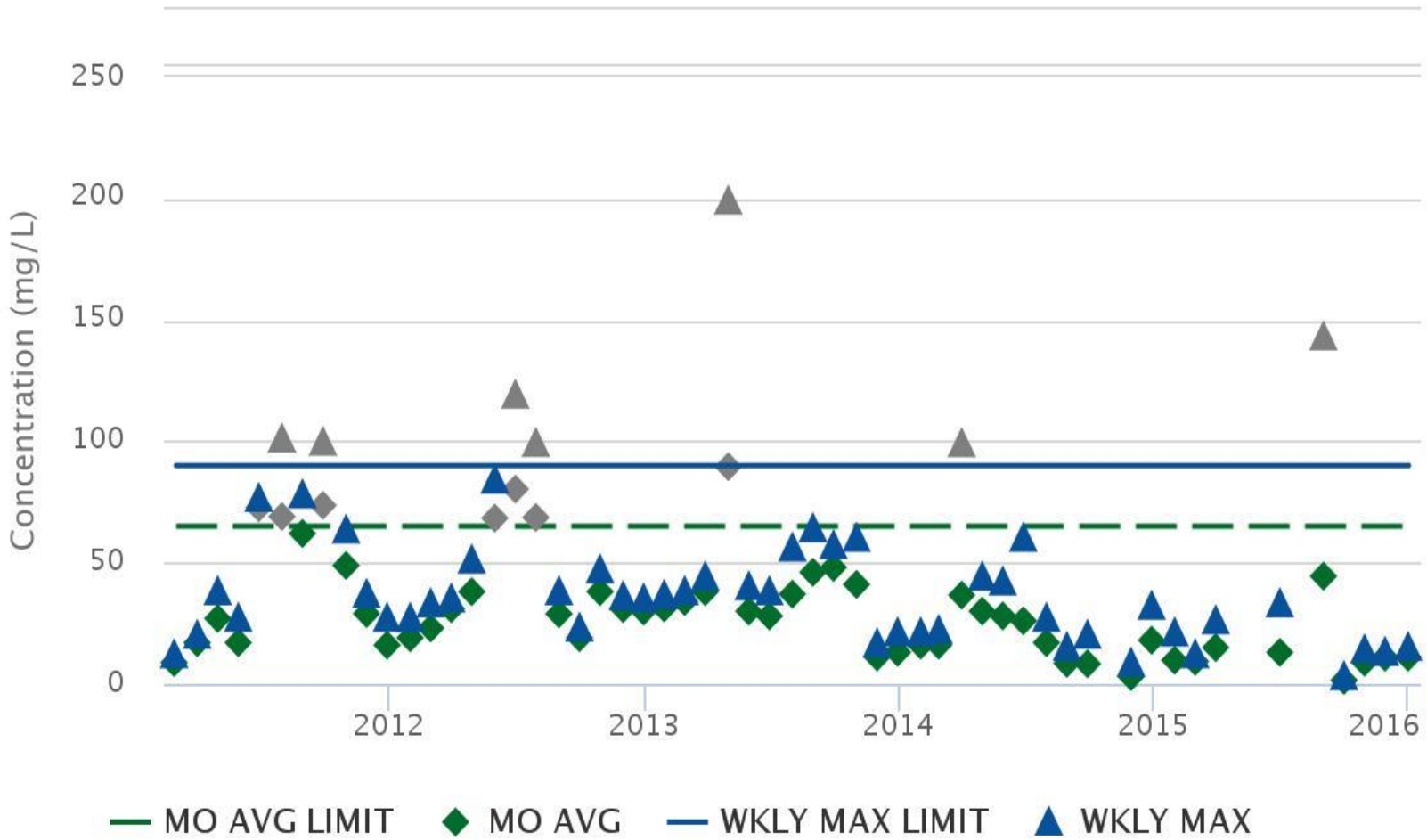

Effluent CBOD for [redacted] after Adding Aeration and the Cessation of Added Industrial Food Processing Waste
140
120
100
80
60
40
20
0
TSS
BOD
Linear (TSS)
Linear (BOD)
1/4/2012
2/4/2012
3/4/2012
4/4/2012
5/4/2012
6/4/2012
7/4/2012
8/4/2012
9/4/2012
10/4/2012
11/4/2012
12/4/2012
1/4/2013
2/4/2013
3/4/2013
4/4/2013
5/4/2013
6/4/2013
7/4/2013
8/4/2013
9/4/2013
10/4/2013
11/4/2013
12/4/2013

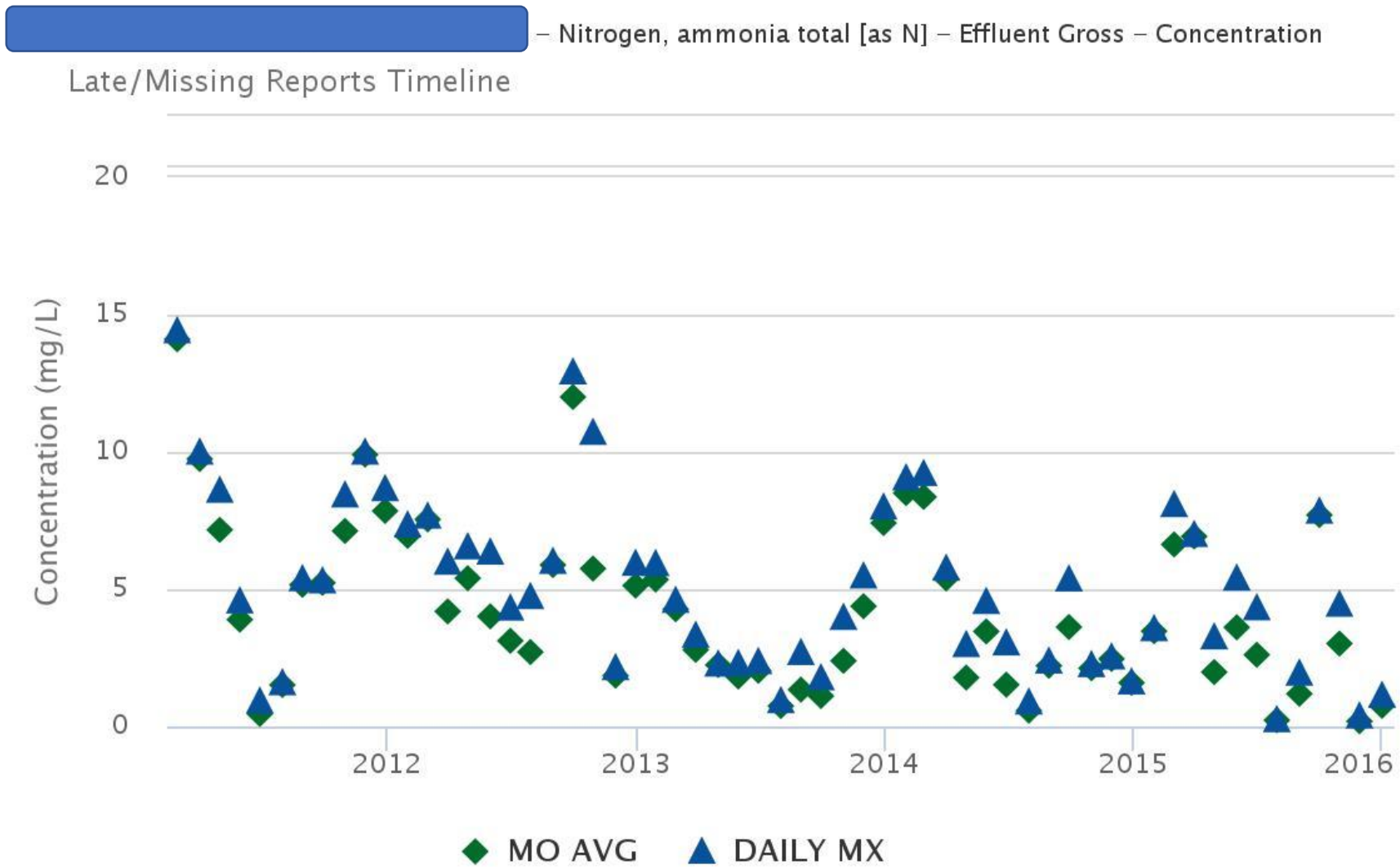
USEPA ECHO Charts



[redacted] – Solids, total suspended – Effluent Gross – Concentration

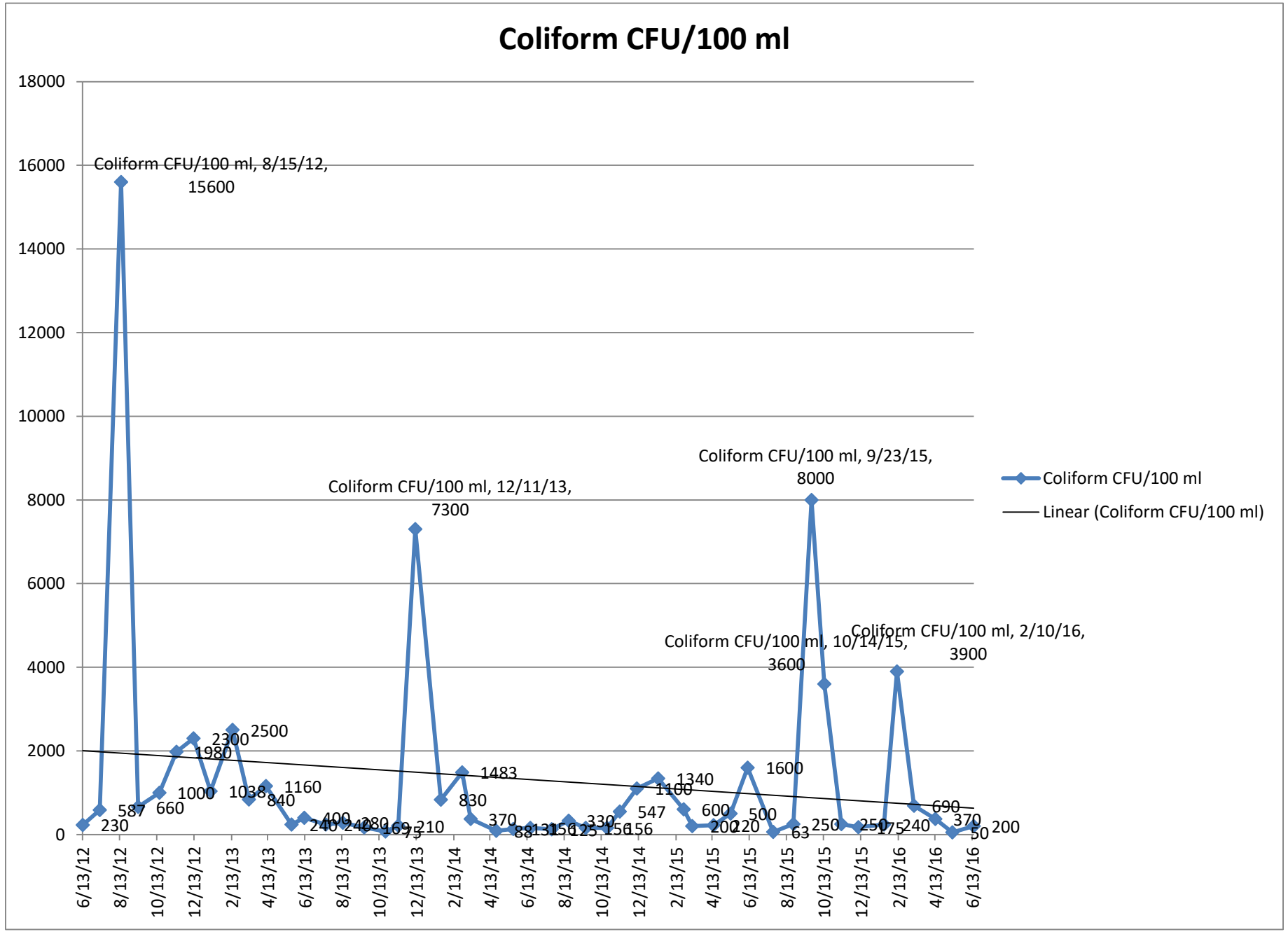
Late/Missing Reports Timeline

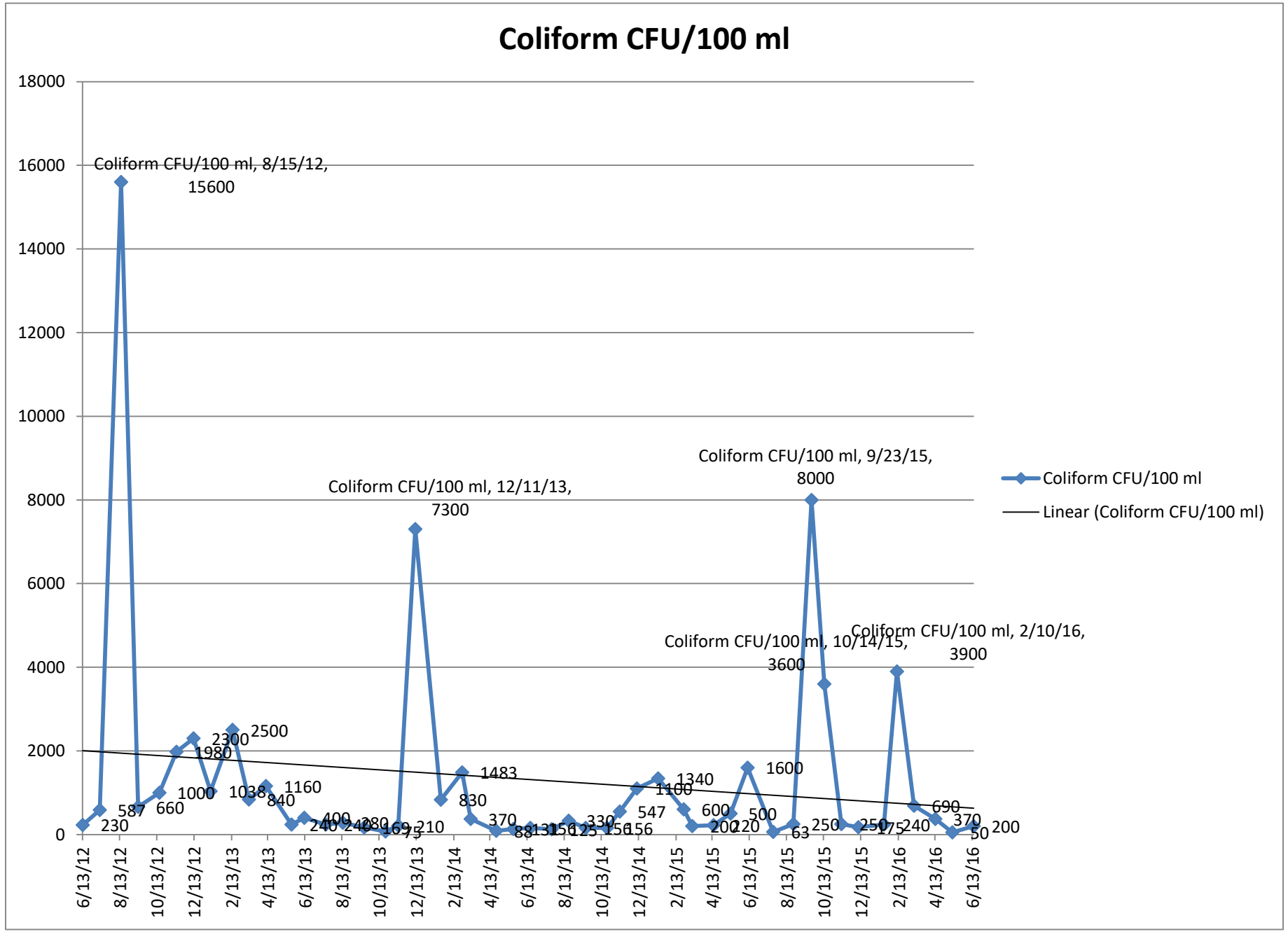


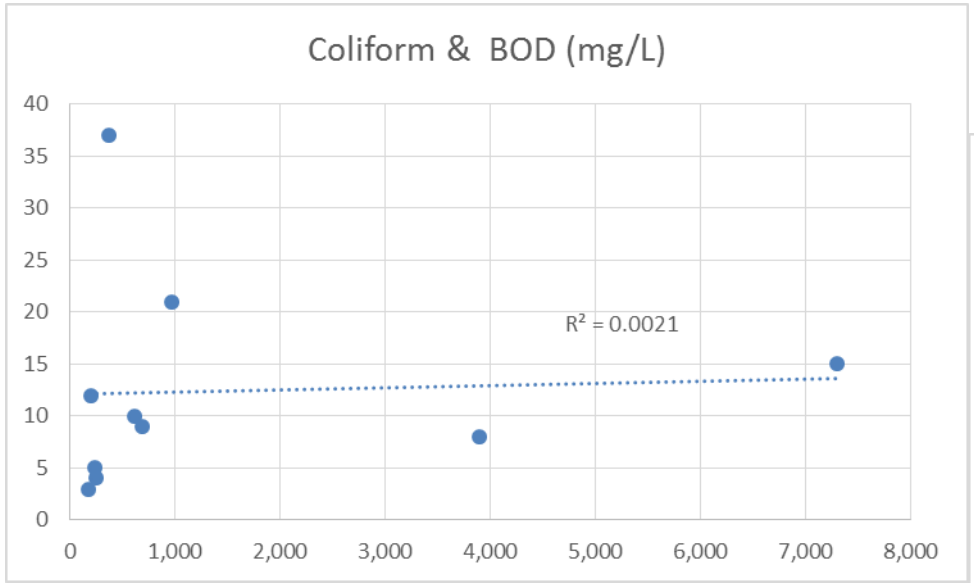

– Nitrogen, ammonia total [as N] – Effluent Gross – Concentration
Late/Missing Reports Timeline
Concentration (mg/L)
20
15
10
5
0
2012
2013
2014
2015
2016
MO AVG
DAILY MX

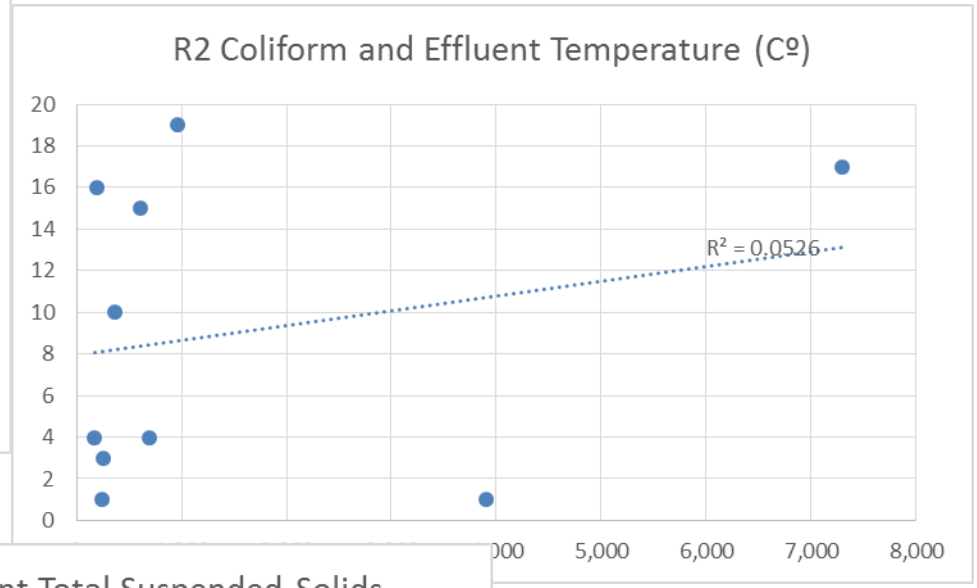
Coliform Violation

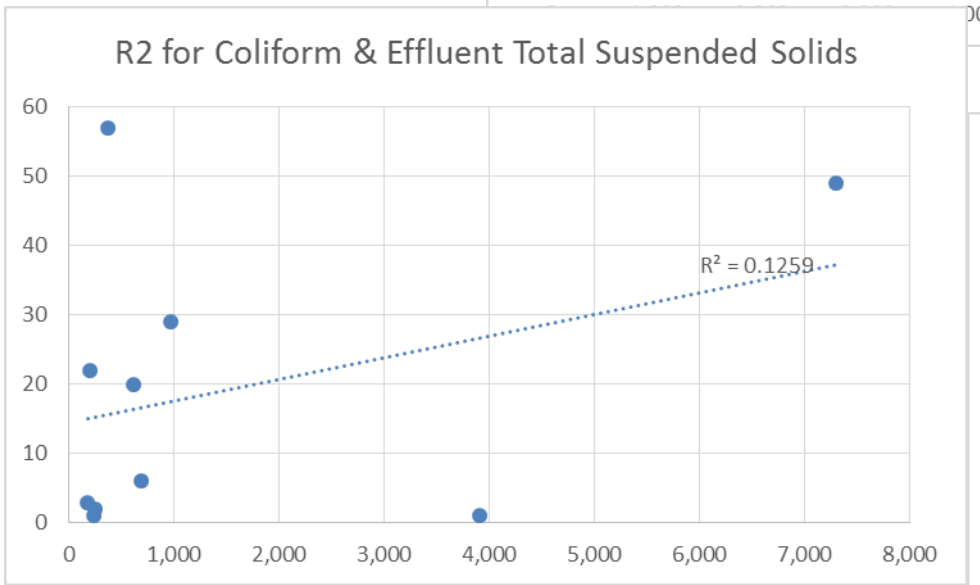
Case Study # 5

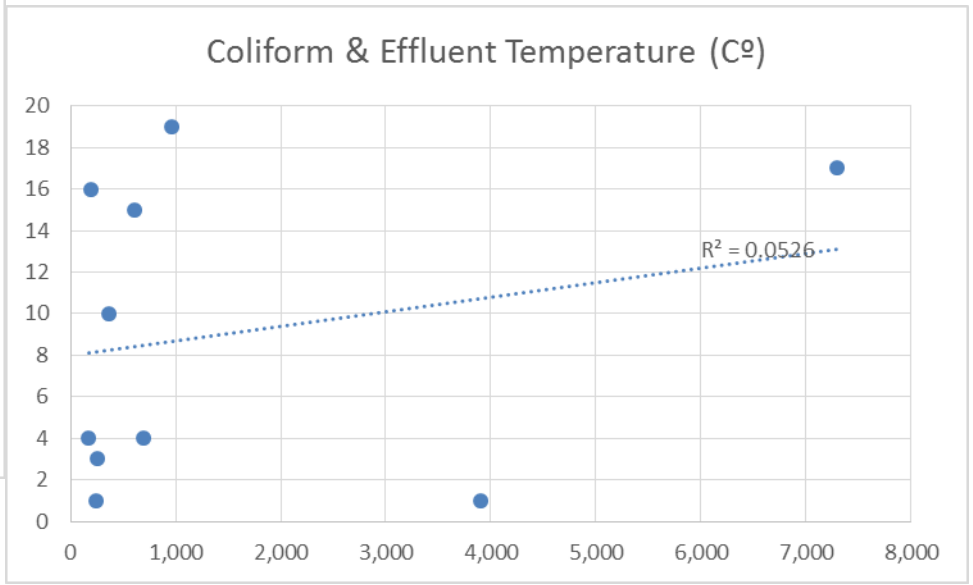

Coliform CFU/100 ml
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Coliform CFU/100 ml, 8/15/12, 15600
Coliform CFU/100 ml, 12/11/13, 7300
Coliform CFU/100 ml, 9/23/15, 8000
Coliform CFU/100 ml, 10/14/15, 3600
Coliform CFU/100 ml, 2/10/16, 3900
230
587
660
1000
1980
2300
2500
1038
1160
840
240
400
280
1673
210
7300
1483
830
370
330
547
1100
1340
600
202
1600
220
500
63
8000
250
250
175
240
690
370
50
200
6/13/12
8/13/12
10/13/12
12/13/12
2/13/13
4/13/13
6/13/13
8/13/13
10/13/13
12/13/13
2/13/14
4/13/14
6/13/14
8/13/14
10/13/14
12/13/14
2/13/15
4/13/15
6/13/15
8/13/15
10/13/15
12/13/15
2/13/16
4/13/16
6/13/16
Coliform CFU/100 ml
Linear (Coliform CFU/100 ml)

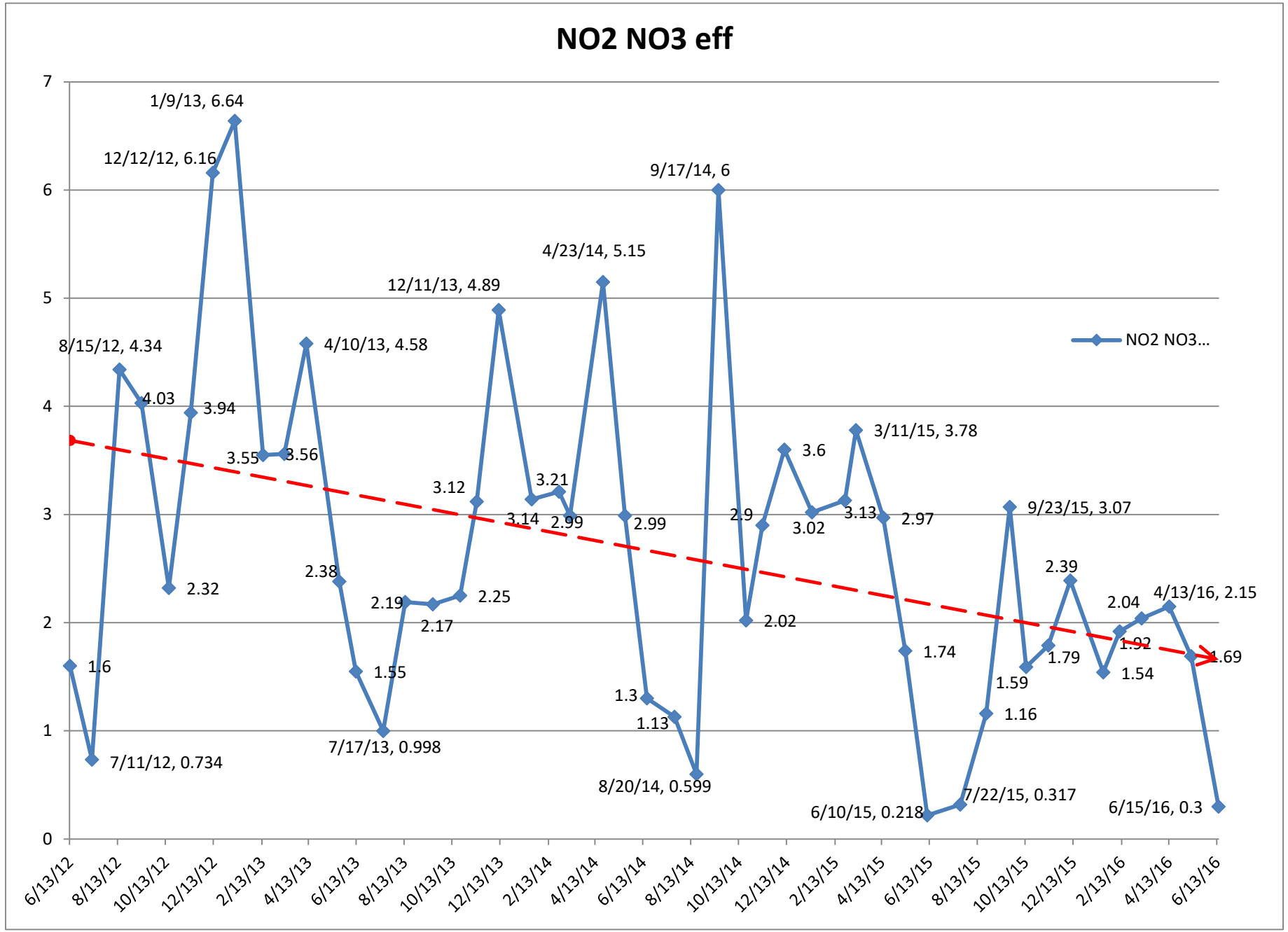

Coliform CFU/100 ml
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Coliform CFU/100 ml, 8/15/12, 15600
Coliform CFU/100 ml, 12/11/13, 7300
Coliform CFU/100 ml, 9/23/15, 8000
Coliform CFU/100 ml, 10/14/15, 3600
Coliform CFU/100 ml, 2/10/16, 3900
230
587
660
1000
1980
2300
2500
1038
1160
840
240
400
280
1673
210
7300
1483
830
370
330
547
1100
1340
600
202
1600
220
500
63
8000
250
250
175
240
690
370
50
200
6/13/12
8/13/12
10/13/12
12/13/12
2/13/13
4/13/13
6/13/13
8/13/13
10/13/13
12/13/13
2/13/14
4/13/14
6/13/14
8/13/14
10/13/14
12/13/14
2/13/15
4/13/15
6/13/15
8/13/15
10/13/15
12/13/15
2/13/16
4/13/16
6/13/16
Coliform CFU/100 ml
Linear (Coliform CFU/100 ml)

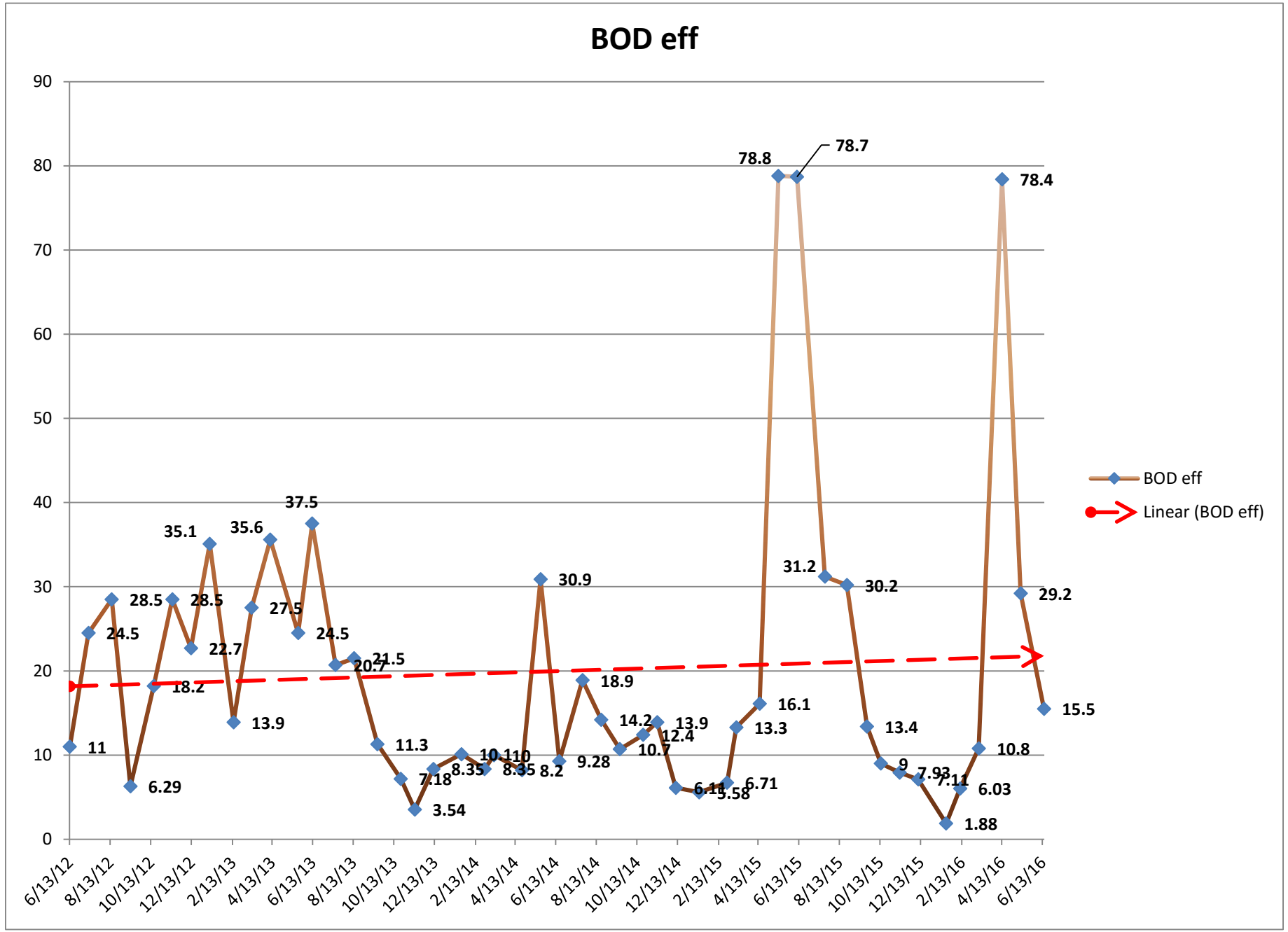

Coliform & BOD (mg/L)
R² = 0.0021
40
35
30
25
20
15
10
5
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000

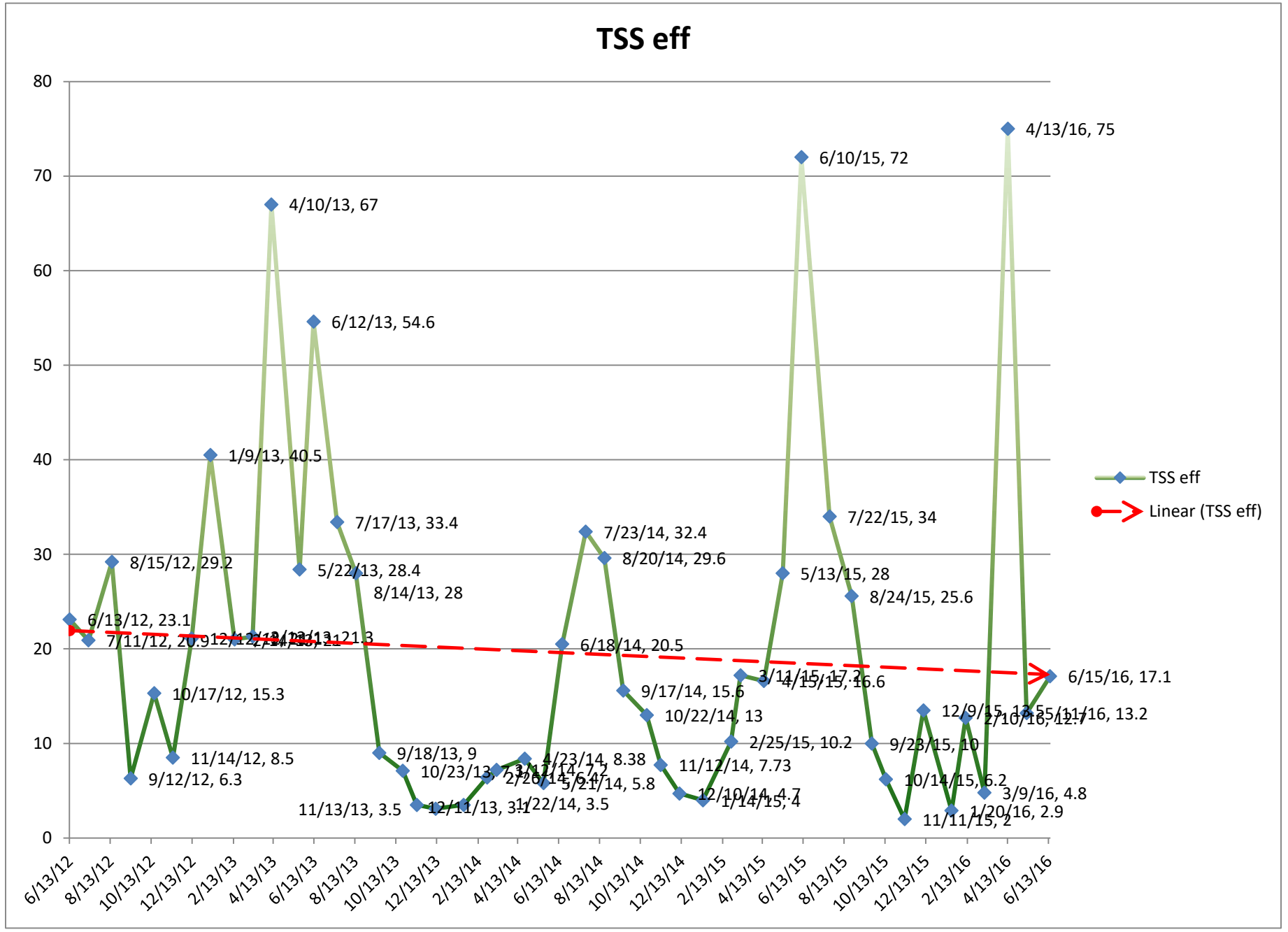

R2 Coliform and Effluent Temperature (Cº)
R² = 0.0526
20
18
16
14
12
10
8
6
4
2
0
5,000
6,000
7,000
8,000

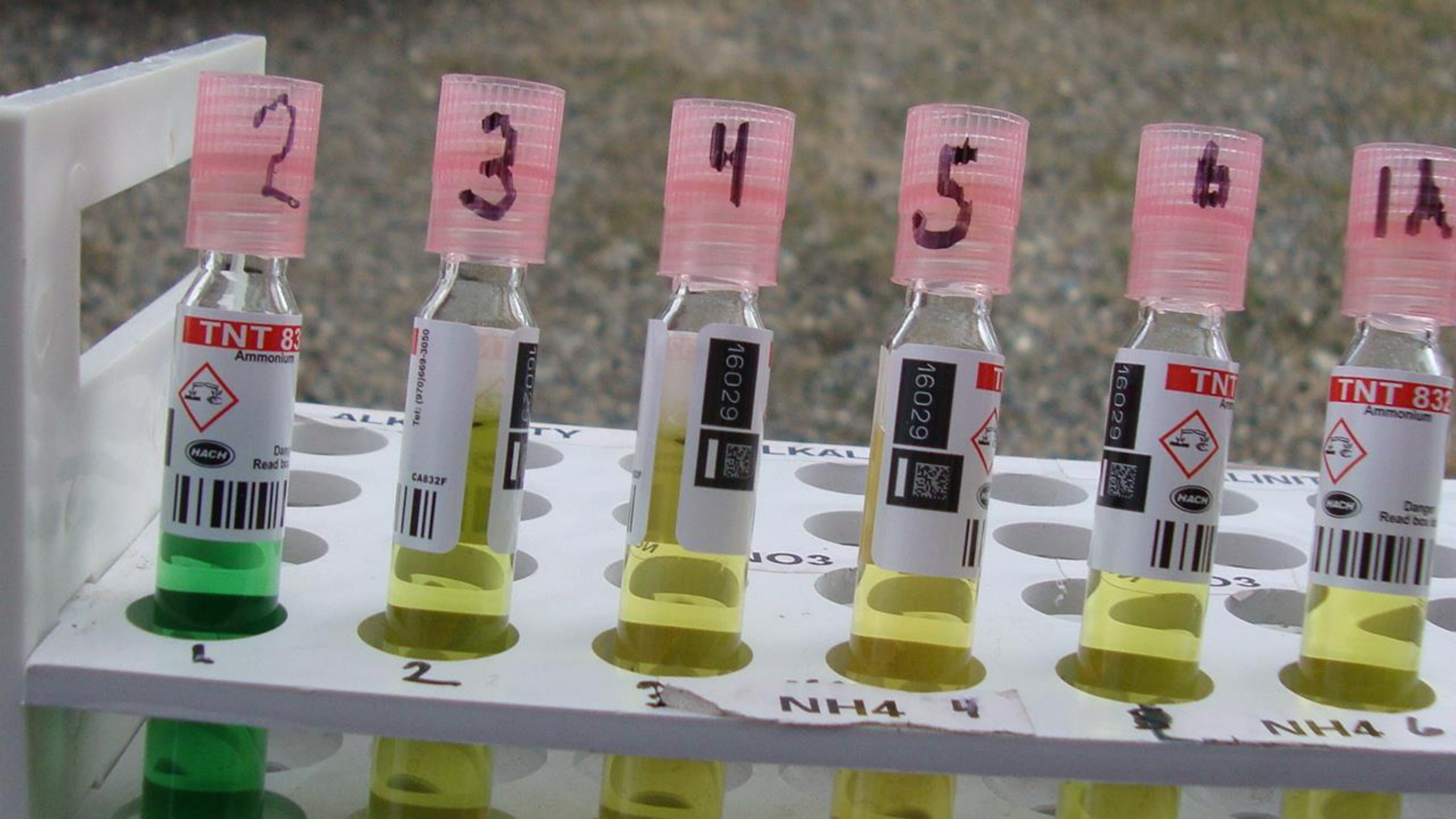

R2 for Coliform & Effluent Total Suspended Solids
R² = 0.1259
60
50
40
30
20
10
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000


Coliform & Effluent Temperature (Cº)
R² = 0.0526
20
18
16
14
12
10
8
6
4
2
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000

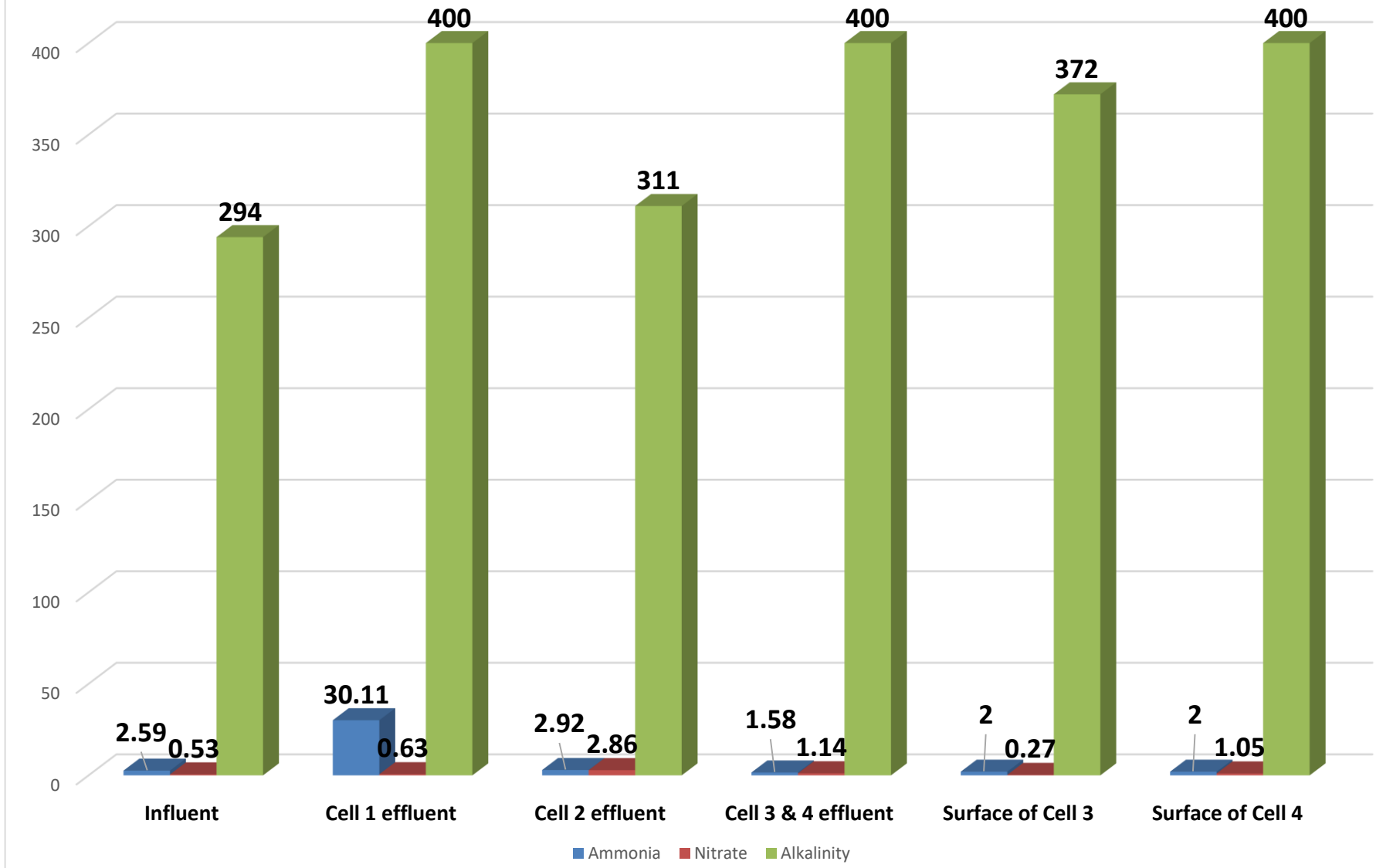

NO2 NO3 eff
NO2 NO3...
7
6
5
4
3
2
1
0
1/9/13, 6.64
12/12/12, 6.16
9/17/14, 6
4/23/14, 5.15
12/11/13, 4.89
8/15/12, 4.34
4/10/13, 4.58
4.03
3.94
3.55
3.56
3.12
3.21
3.14
2.99
2.99
3.6
3.11/15, 3.78
2.9
3.02
3.13
2.97
2.38
2.32
2.19
2.17
2.25
2.02
1.74
9/23/15, 3.07
2.39
2.04
4/13/16, 2.15
1.92
1.79
1.69
1.6
1.55
1.59
1.54
1.3
1.16
1.13
7/11/12, 0.734
7/17/13, 0.998
8/20/14, 0.599
6/10/15, 0.218
7/22/15, 0.317
6/15/16, 0.3
6/13/12
8/13/12
10/13/12
12/13/12
2/13/13
4/13/13
6/13/13
8/13/13
10/13/13
12/13/13
2/13/14
4/13/14
6/13/14
8/13/14
10/13/14
12/13/14
2/13/15
4/13/15
6/13/15
8/13/15
10/13/15
12/13/15
2/13/16
4/13/16
6/13/16


BOD eff
90
80
70
60
50
40
30
20
10
0
6/13/12
8/13/12
10/13/12
12/13/12
2/13/13
4/13/13
6/13/13
8/13/13
10/13/13
12/13/13
2/13/14
4/13/14
6/13/14
8/13/14
10/13/14
12/13/14
2/13/15
4/13/15
6/13/15
8/13/15
10/13/15
12/13/15
2/13/16
4/13/16
6/13/16
11
24.5
28.5
6.29
18.2
28.5
35.1
22.7
13.9
27.5
35.6
37.5
24.5
20.7
21.5
11.3
7.18
3.54
8.35
10.1
10.1
8.35
8.2
30.9
9.28
18.9
14.2
10.7
12.4
13.9
6.11
5.58
6.71
13.3
16.1
78.8
78.7
31.2
30.2
13.4
9
7.93
7.11
1.88
6.03
10.8
78.4
29.2
15.5
BOD eff
Linear (BOD eff)

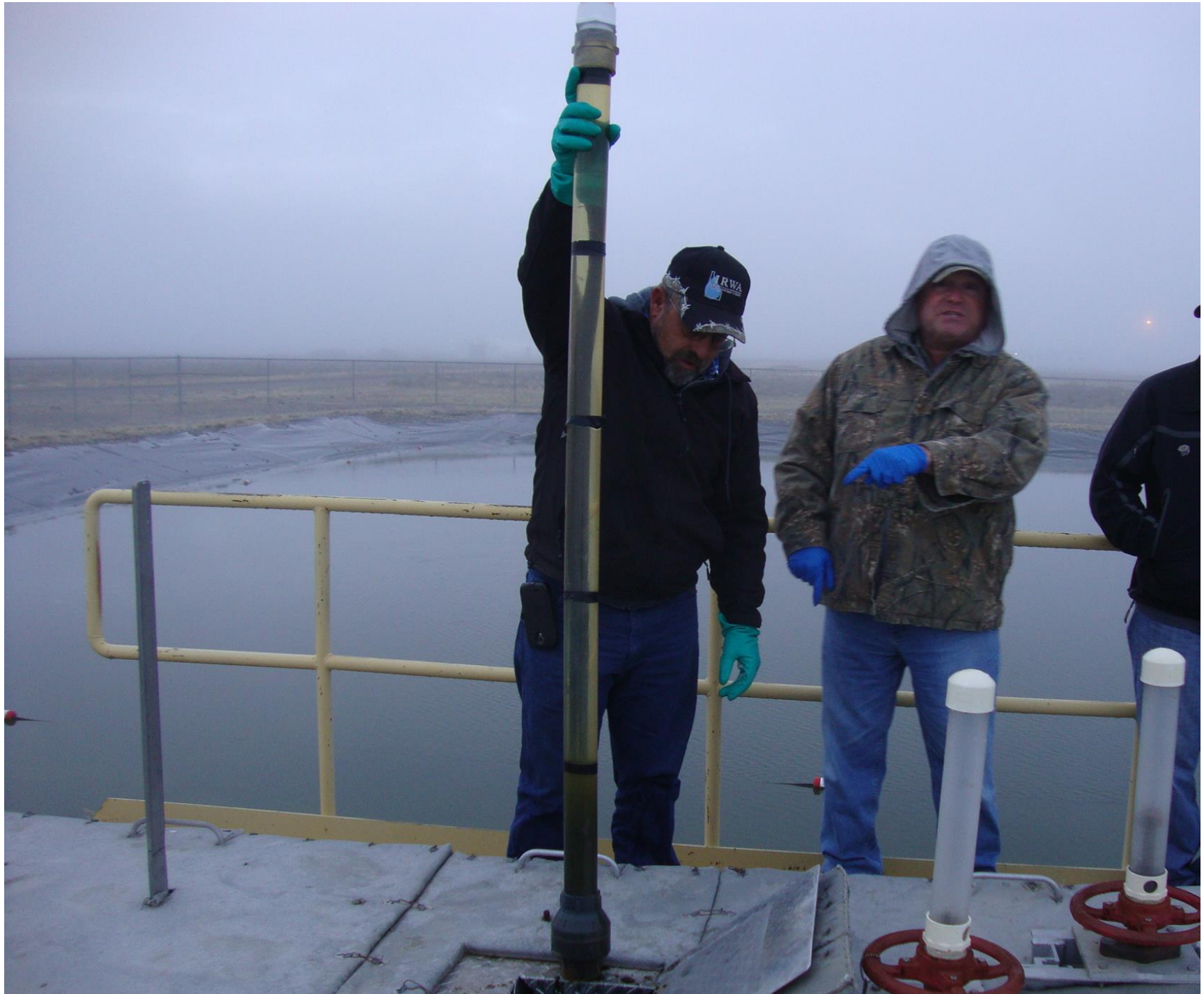

TSS eff
80
70
60
50
40
30
20
10
0
6/13/12
8/13/12
10/13/12
12/13/12
2/13/13
4/13/13
6/13/13
8/13/13
10/13/13
12/13/13
2/13/14
4/13/14
6/13/14
8/13/14
10/13/14
12/13/14
2/13/15
4/13/15
6/13/15
8/13/15
10/13/15
12/13/15
2/13/16
4/13/16
6/13/16
6/13/12, 23.1
7/11/12, 20.9
8/15/12, 29.2
9/12/12, 6.3
10/17/12, 15.3
11/14/12, 8.5
1/9/13, 40.5
4/10/13, 67
5/22/13, 28.4
6/12/13, 54.6
7/17/13, 33.4
8/14/13, 28
9/18/13, 9
10/23/13, 7.3
11/13/13, 3.5
12/11/13, 3.1
2/26/14, 6.4
4/23/14, 8.38
5/21/14, 5.8
6/18/14, 20.5
7/23/14, 32.4
8/20/14, 29.6
9/17/14, 15.6
10/22/14, 13
11/12/14, 7.73
12/10/14, 4.7
1/14/15, 4
2/25/15, 10.2
3/11/15, 17.2
4/15/15, 16.6
5/13/15, 28
6/10/15, 72
7/22/15, 34
8/24/15, 25.6
9/23/15, 10
10/14/15, 6.2
11/11/15, 2
12/9/15, 13.5
1/20/16, 2.9
2/10/16, 12.7
3/9/16, 4.8
4/13/16, 75
6/15/16, 17.1
TSS eff
Linear (TSS eff)


2
3
4
5
6
1A
TNT 83
Ammonium
HACH
16029
CA832F
NH4 4
NH4 L

Intra-Pond Ammonia, Nitrate, and Alkalinity



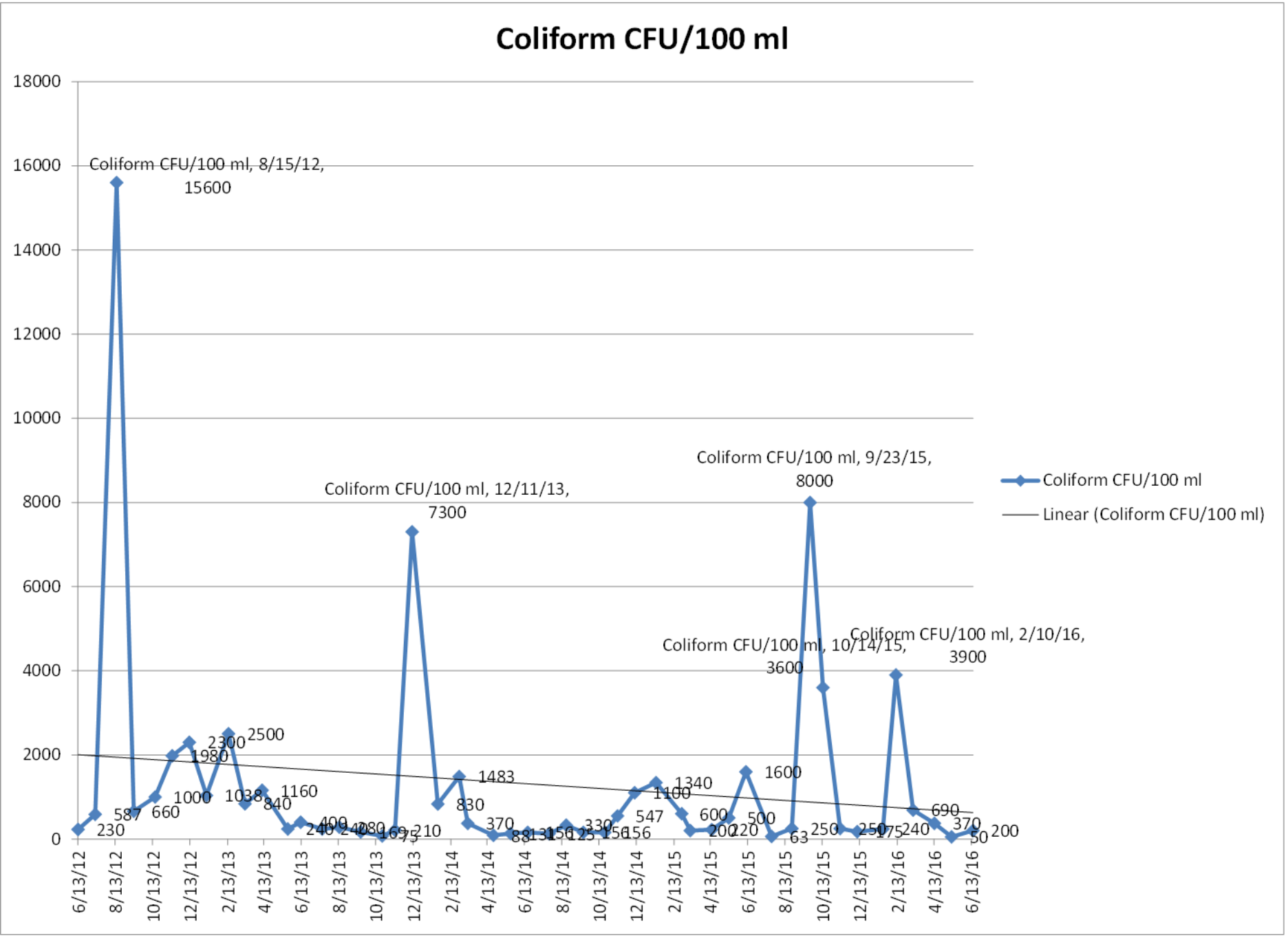
Item	Units	Cell 1	Cell 2	Cell 3	Cell 4	Total
Bottom Length	feet	**80**	**80**	**45**	**45**	
Bottom Width	feet	**80**	**80**	**41**	**41**	
Side Slopes	1 to	**3**	**3**	**3**	**3**	
Average Sludge Depth	feet	**1.08**	**0.1**	**0.4**	**0.29**	
As-Built Bottom Elevation	feet	**4901.00**	**4899.50**	**4899.00**	**4899.00**	
As-Built Top-of-Bank Elevation	feet	**4914.00**	**4912.50**	**4911.00**	**4914.00**	
Bottom Area	sq ft	6,400	6,400	1,845	1,845	
Top of Sludge Length	feet	86.48	80.6	47.4	46.74	
Top of Sludge Width	feet	86.48	80.6	43.4	42.74	
Top of Sludge Area	sq ft	7,479	6,496	2,057	1,998	
Sludge Volume	cu ft	7,495	645	780	557	
Sludge Volume	gallons	**56,059**	**4,823**	**5,838**	**4,168**	**70,888**
Sludge Mass	dry tons					
Embankment Height	feet	4914.00	4912.50	4911.00	4914.00	
Freeboard Required	feet	**3**	**4**	**4**	**4**	
Useable Remaining Lagoon Depth	feet	**8.75**	**10.07**	**9.52**	**9.63**	
Top of Water Max Length	feet	158	158	123	123	
Top of Water Max Width	feet	158	158	123	123	
Top of Water Max Area	sq ft	24,964	24,964	15,129	15,129	
Lagoon Volume	cu ft	137,218	157,918	80,796	81,730	
Current Usable Lagoon Volume using Actual Water Depths	**gallons**	**1,026,387**	**1,181,225**	**604,356**	**611,339**	
Flow 25,000 gpd						
Retention Time at 25,000 gpd	**days**	**41.1**	**47.2**	**24.2**	**24.5**	**137**


MRWA

So, Why do you think there was a coliform problem?

- Clear water
- NO sludge in Cells 3 & 4 that discharge to the final effluent structure
- High pH…over 9
- Dissolved Oxygen at 11 mg/l

How Could You Confirm it Was Accumulated Sludge in the Transfer Wells?



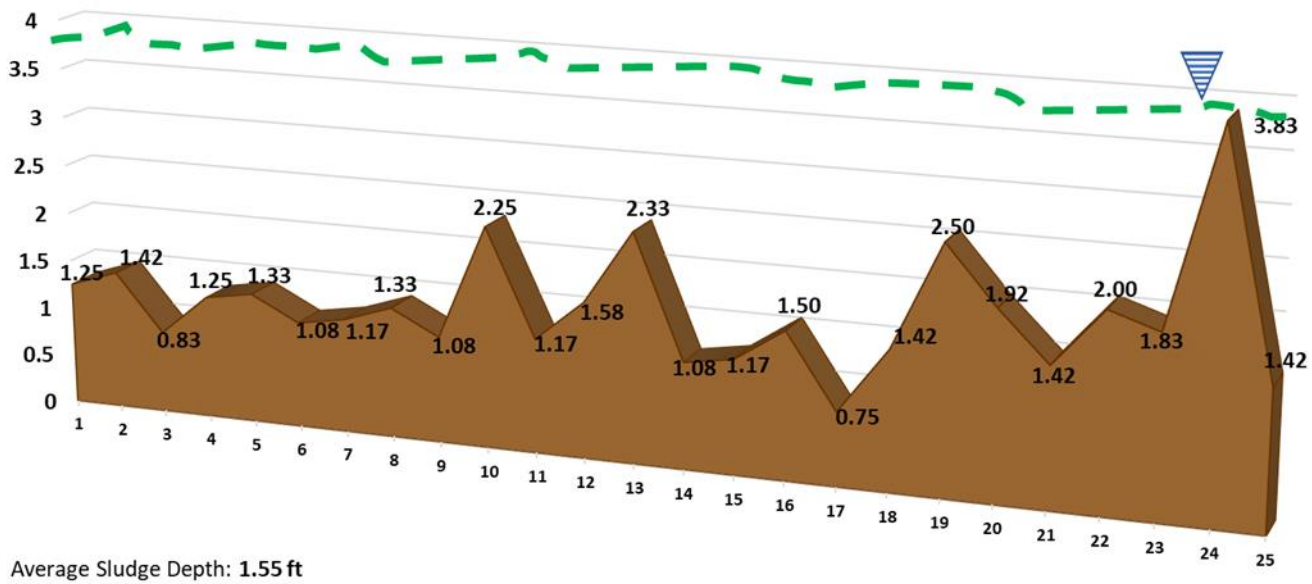
Every time you measure coliform from the transfer structure also measure from the surface of Cell # 4 Compare the two. Your chances of finding high coliforms are high from 9/2016 to 2/2017

Ammonia Removal

Case # 6

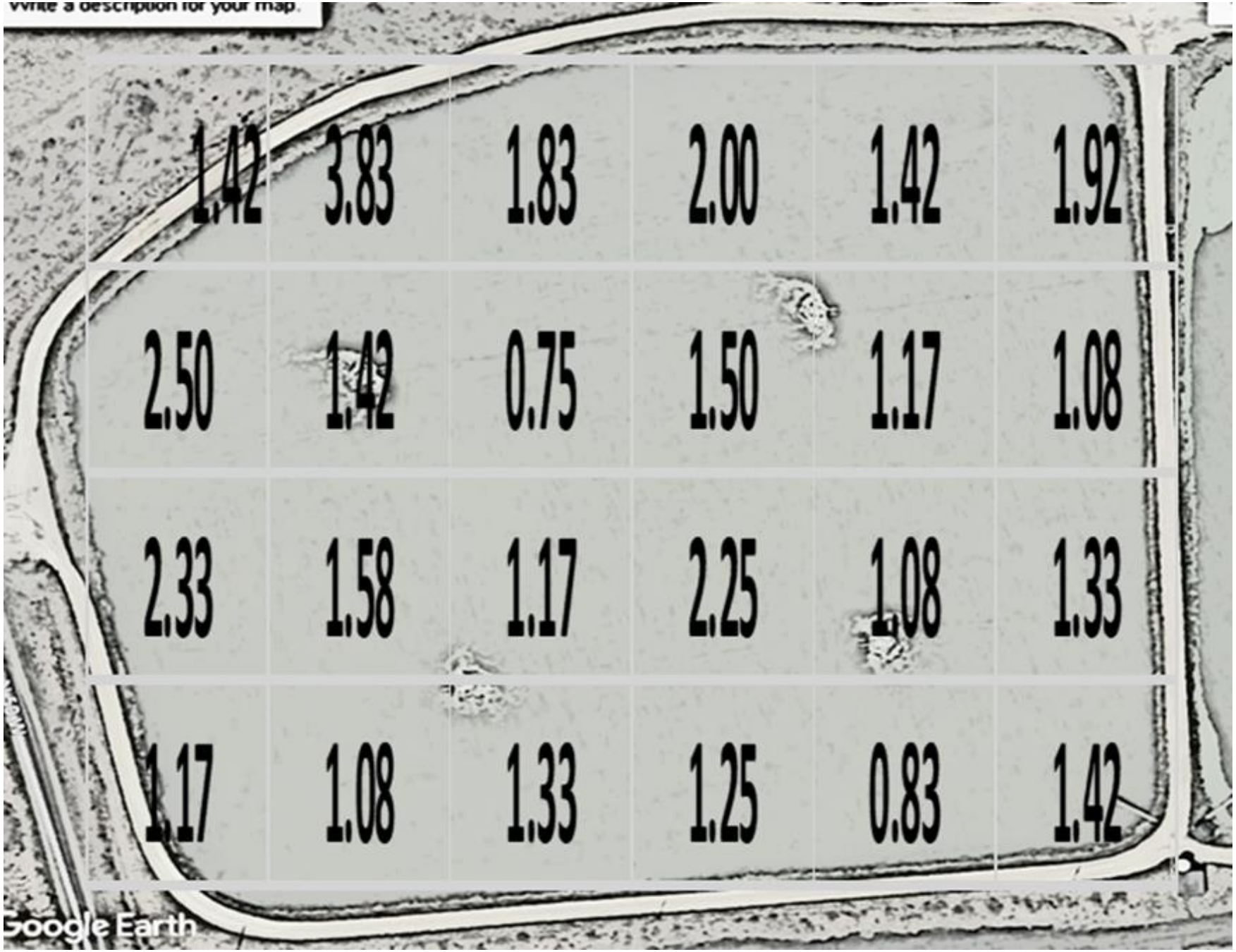

N-50-W
Google Earth

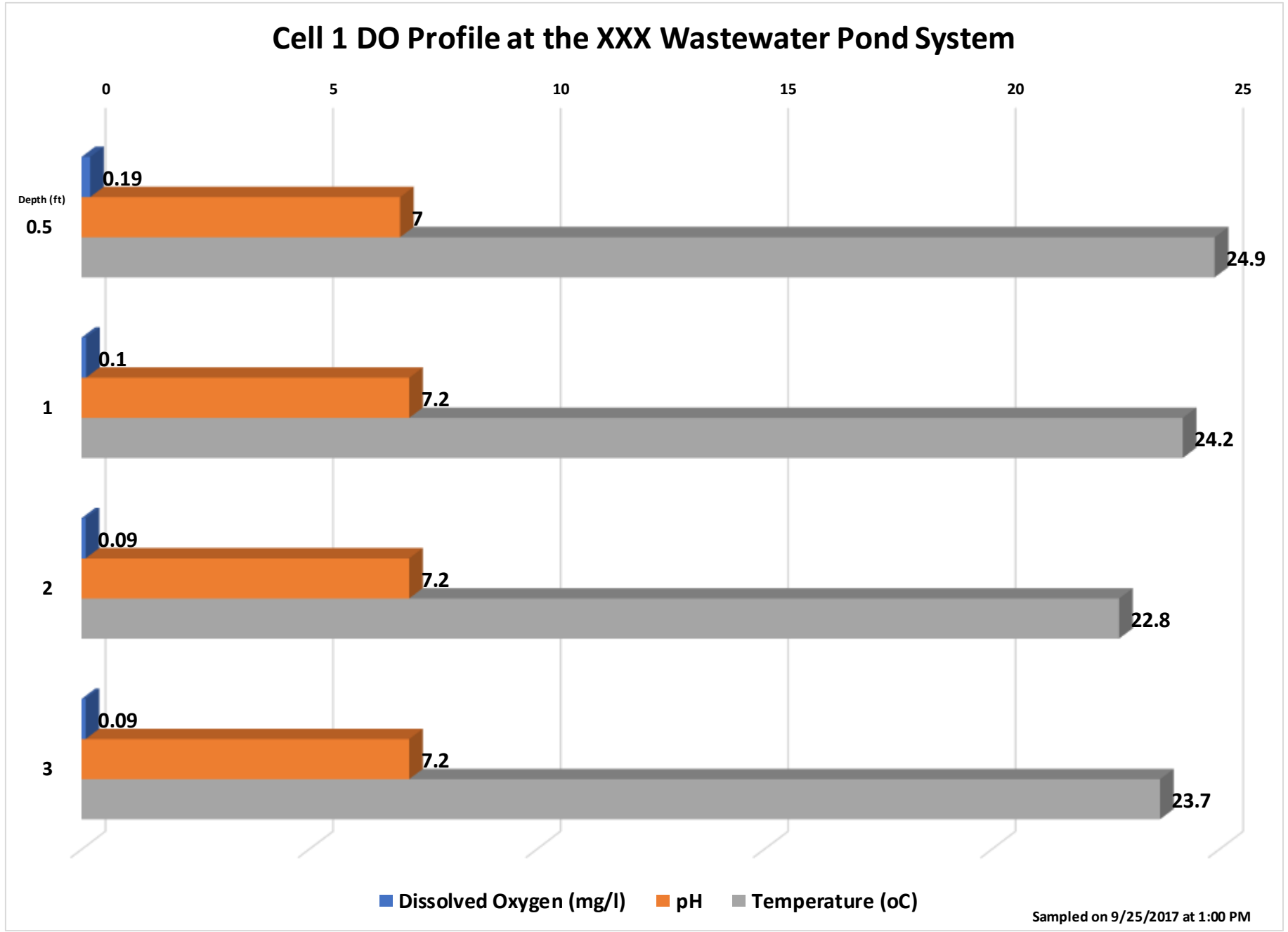
Cell # 1 Sludge Blanket Thickness Profile

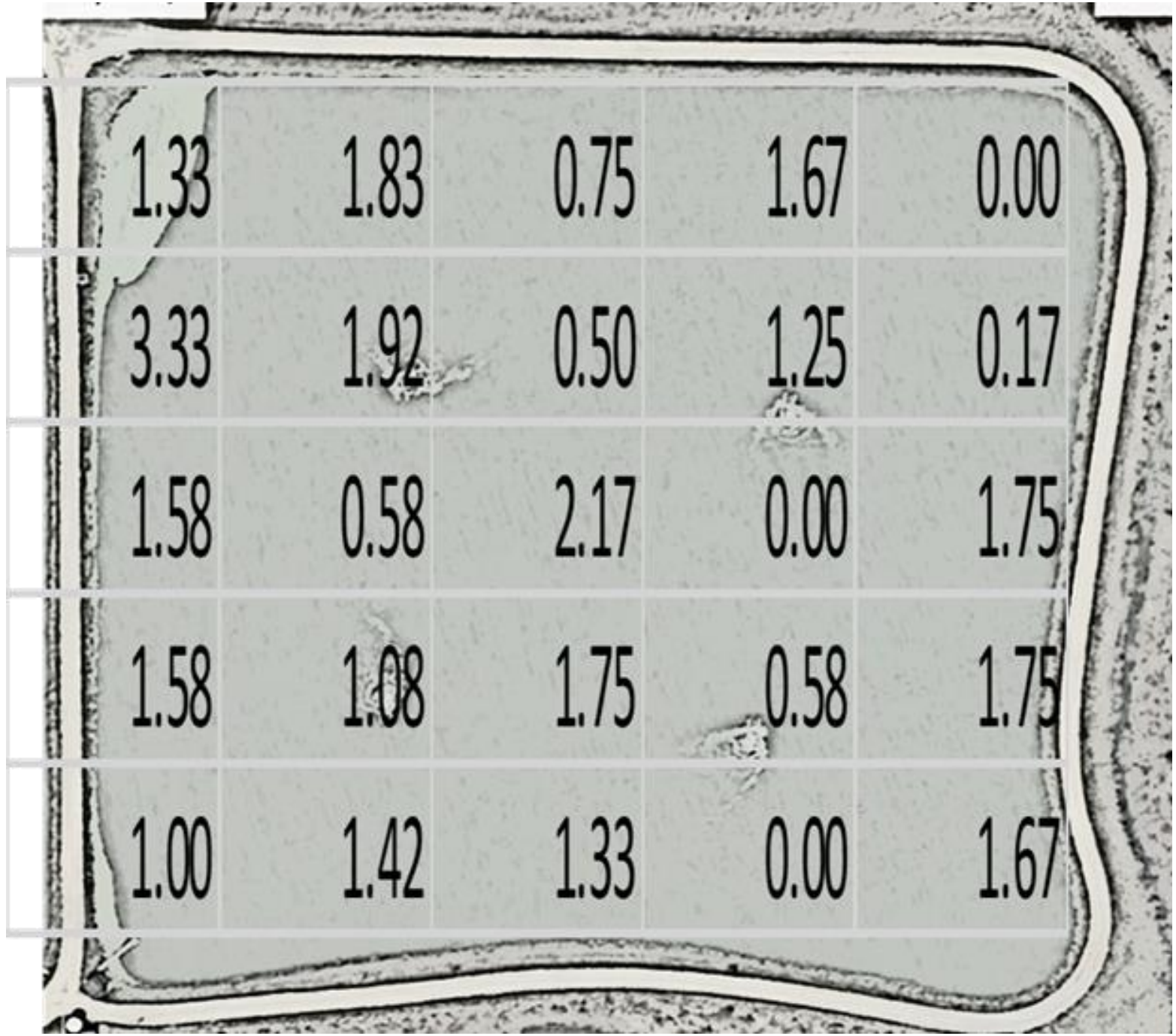


Average Sludge Depth: **1.55 ft**
Average Water Depth**: 3.82 feet**
Average Water Cap Thickness Over Sludge: **2.27 feet**

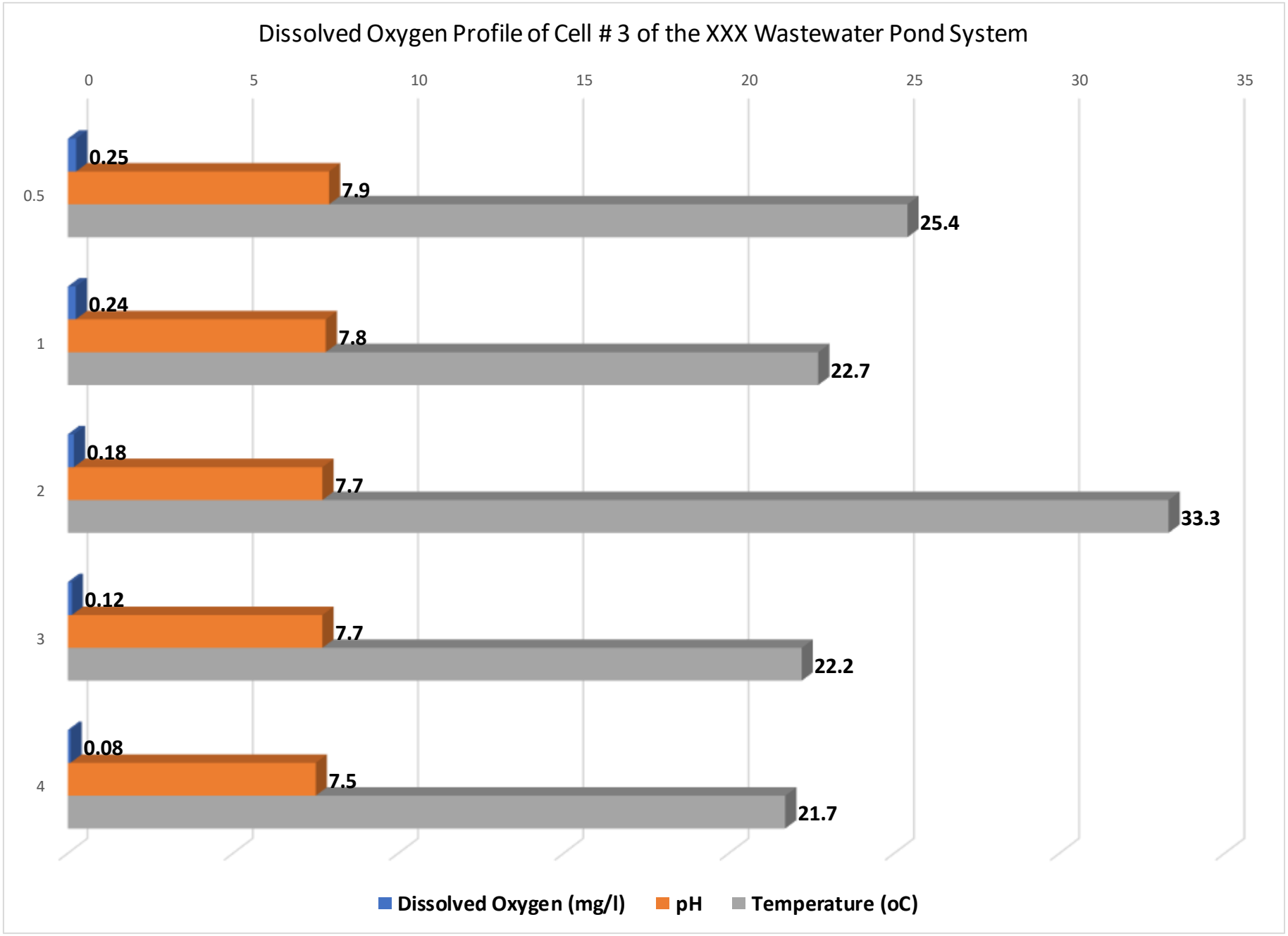
Measured on September 25, 2017

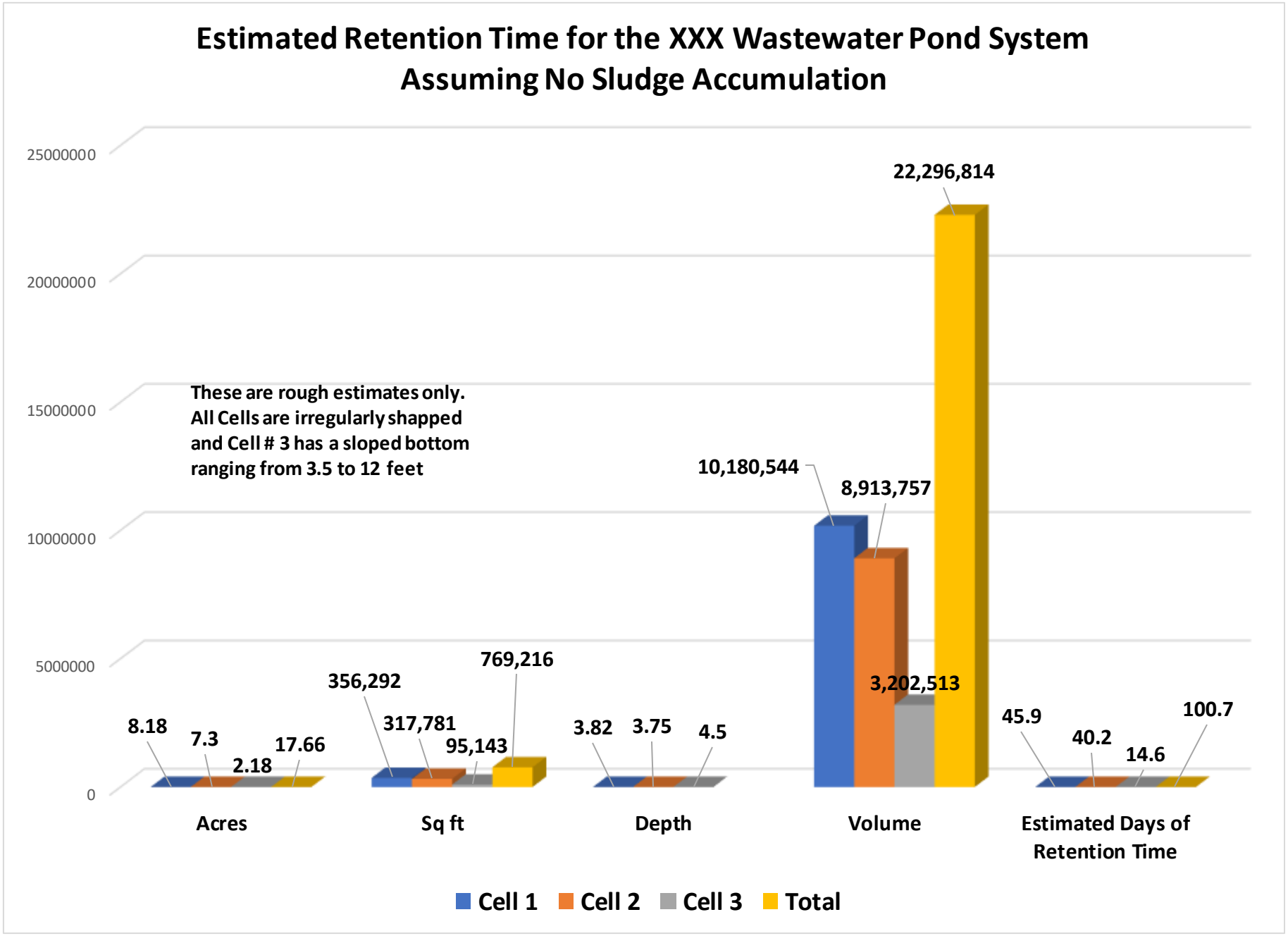

Write a description for your map.
1.42 3.83 1.83 2.00 1.42 1.92
2.50 1.42 0.75 1.50 1.17 1.08
2.33 1.58 1.17 2.25 1.08 1.33
1.17 1.08 1.33 1.25 0.83 1.42
Google Earth


Cell 1 DO Profile at the XXX Wastewater Pond System
0
5
10
15
20
25
Depth (ft)
0.5
0.19
7
24.9
1
0.1
7.2
24.2
2
0.09
7.2
22.8
3
0.09
7.2
23.7
Dissolved Oxygen (mg/l)
pH
Temperature (oC)
Sampled on 9/25/2017 at 1:00 PM

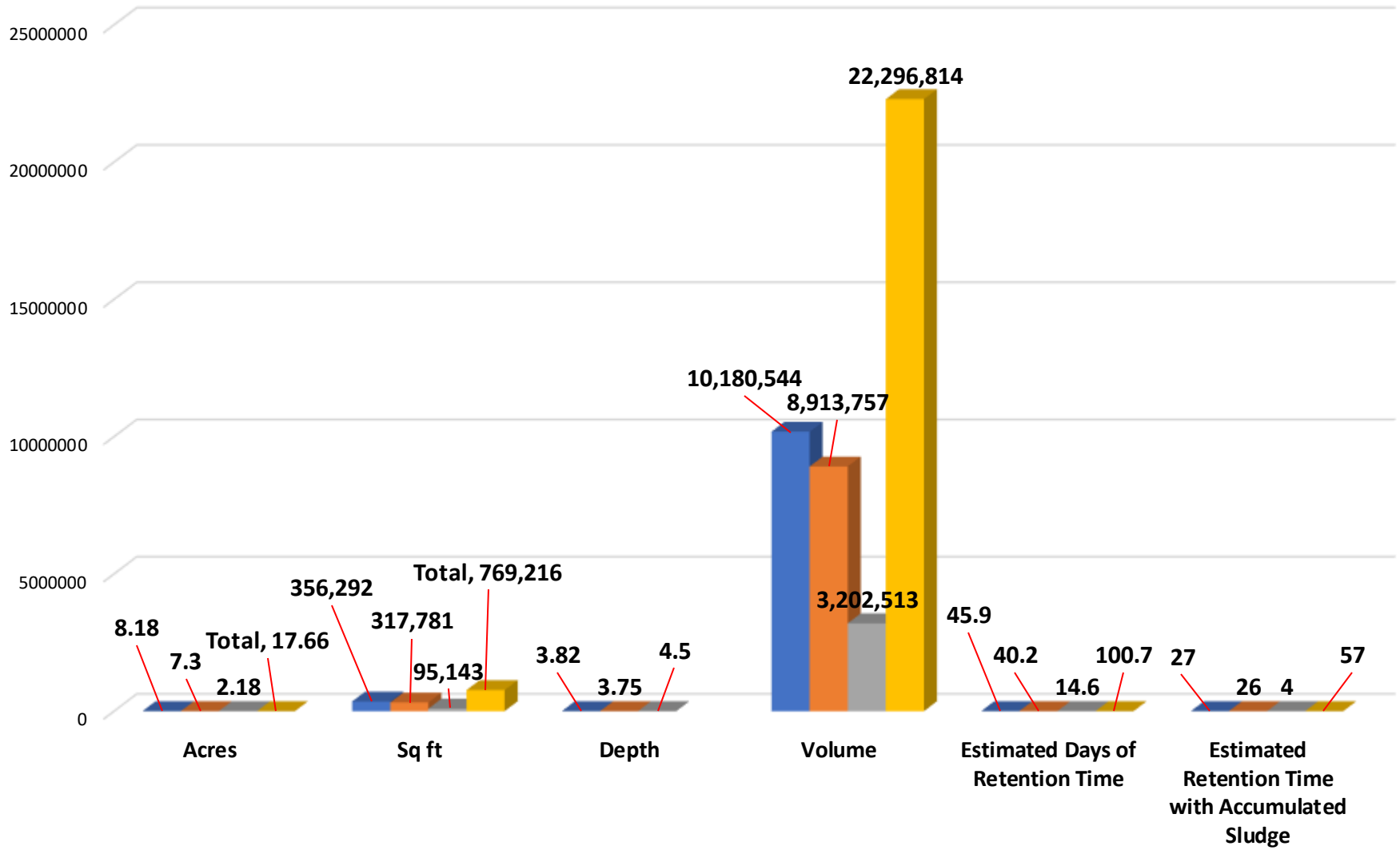


	1.33	1.83	0.75	1.67	0.00
	3.33	1.92	0.50	1.25	0.17
	1.58	0.58	2.17	0.00	1.75
	1.58	1.08	1.75	0.58	1.75
	1.00	1.42	1.33	0.00	1.67

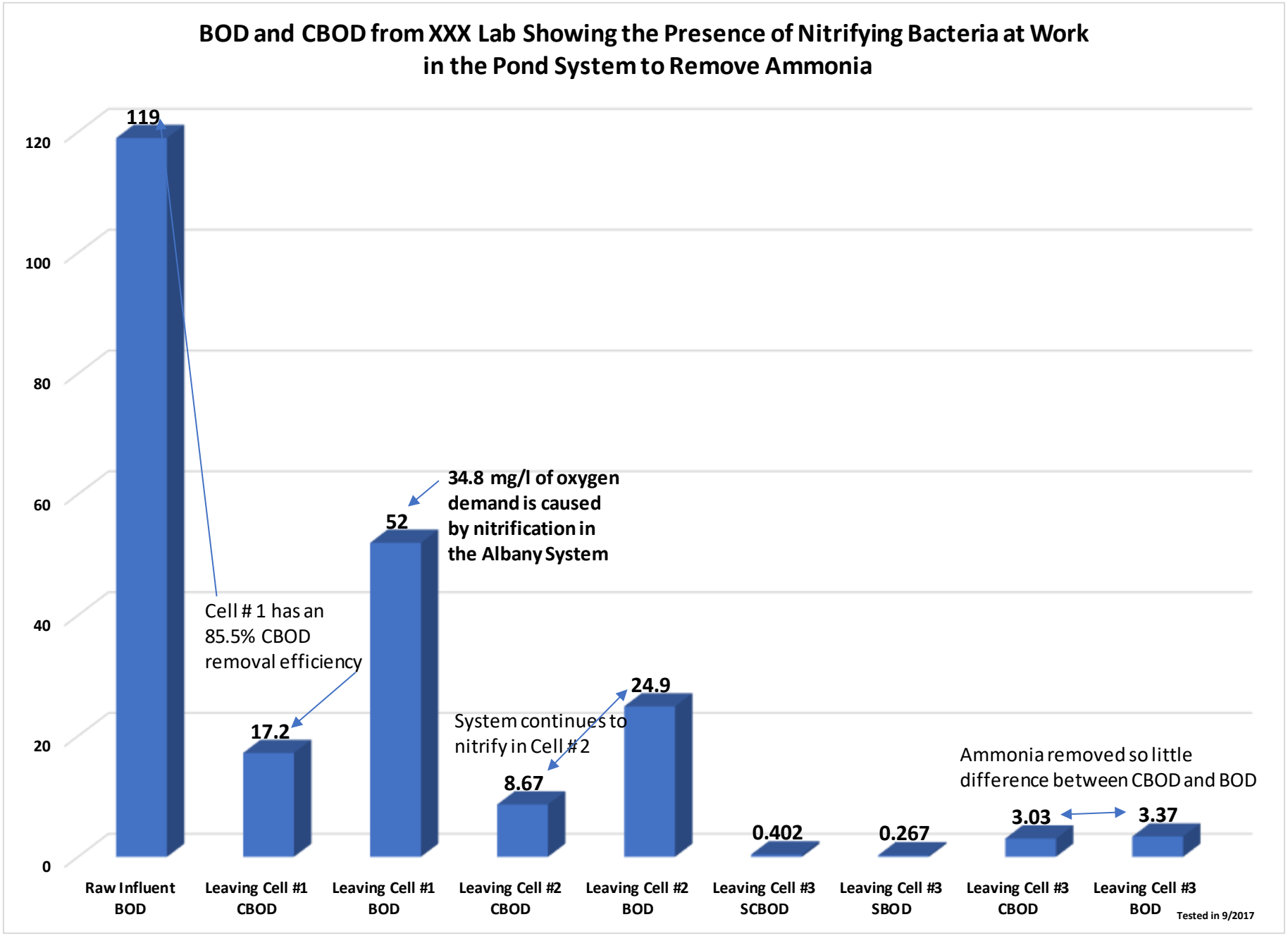

Dissolved Oxygen Profile of Cell # 3 of the XXX Wastewater Pond System
0
5
10
15
20
25
30
35
0.5
0.25
7.9
25.4
1
0.24
7.8
22.7
2
0.18
7.7
33.3
3
0.12
7.7
22.2
4
0.08
7.5
21.7
Dissolved Oxygen (mg/l)
pH
Temperature (oC)


Estimated Retention Time for the XXX Wastewater Pond System
Assuming No Sludge Accumulation
25000000
20000000
15000000
10000000
5000000
0
These are rough estimates only.
All Cells are irregularly shapped
and Cell # 3 has a sloped bottom
ranging from 3.5 to 12 feet
8.18
7.3
2.18
17.66
356,292
317,781
95,143
769,216
3.82
3.75
4.5
10,180,544
8,913,757
3,202,513
22,296,814
45.9
40.2
14.6
100.7
Acres
Sq ft
Depth
Volume
Estimated Days of Retention Time
Cell 1
Cell 2
Cell 3
Total

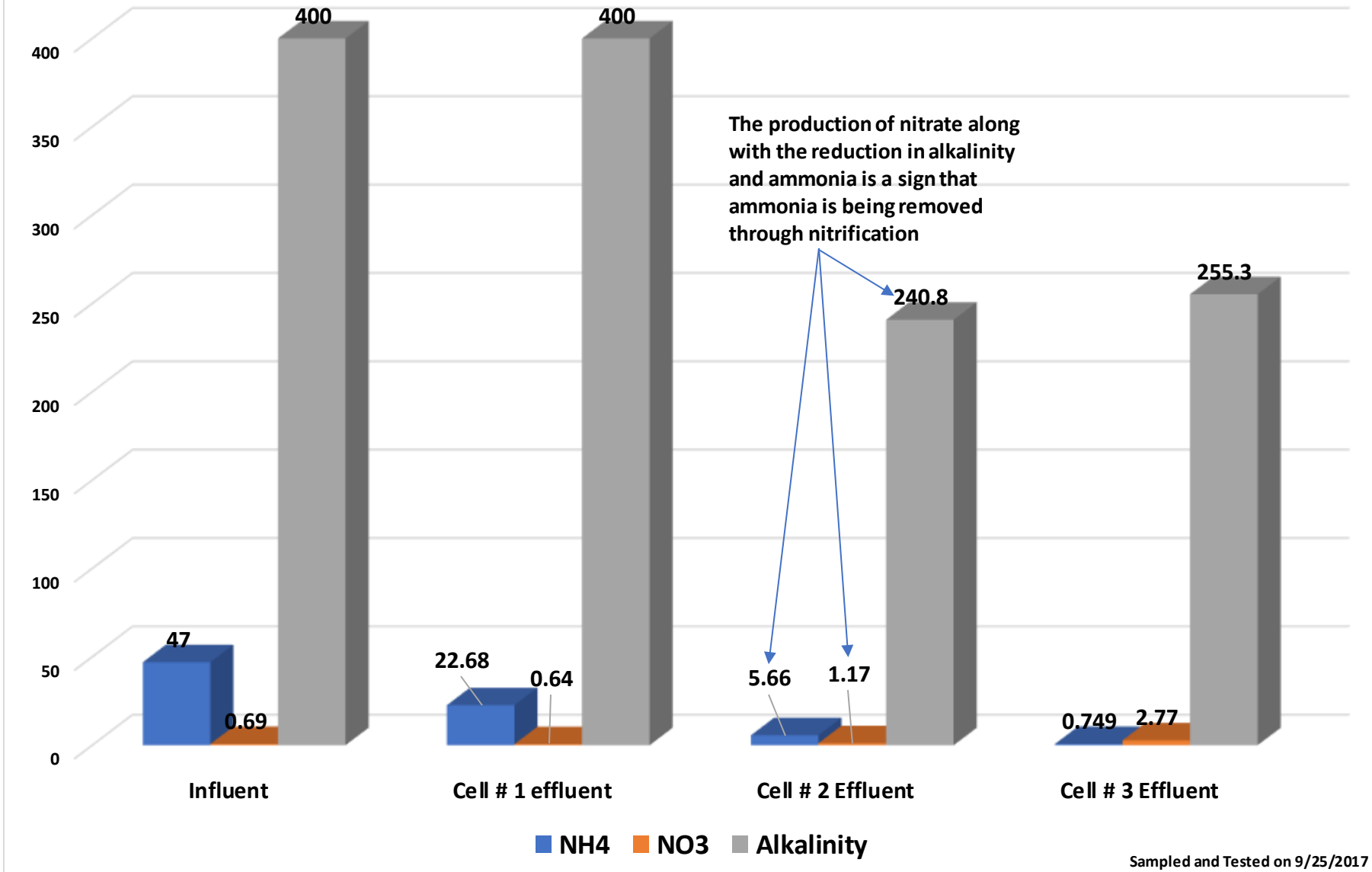
XXXX Wastewater Lagoon System Estimated Volumes and Retention Times



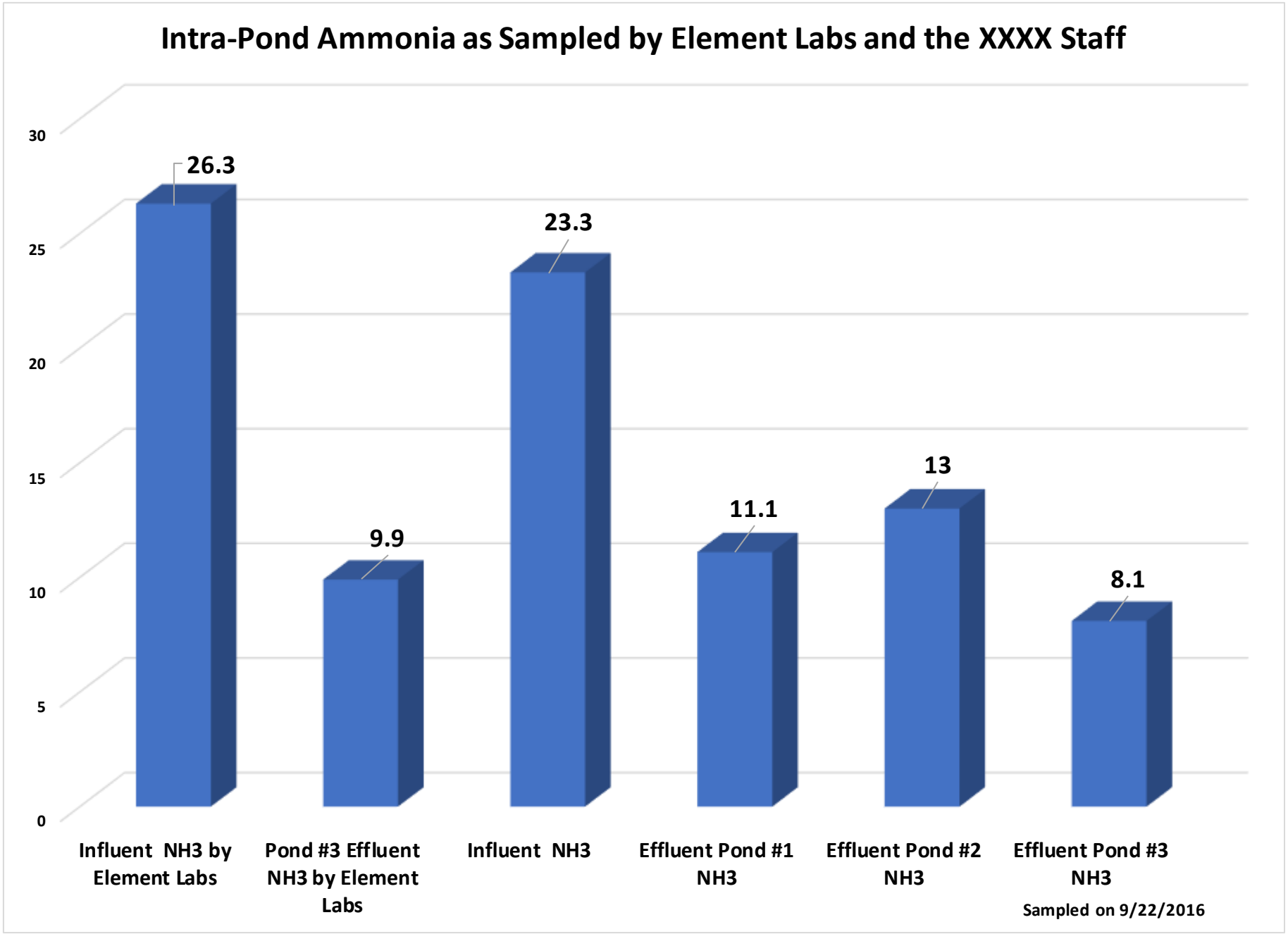
These are estimates only as the ponds are irregular in shape, have uneven pond bottoms, and Cell # 3 has a sloped bottom rtanging from 3.5 tpm 12 feet deep

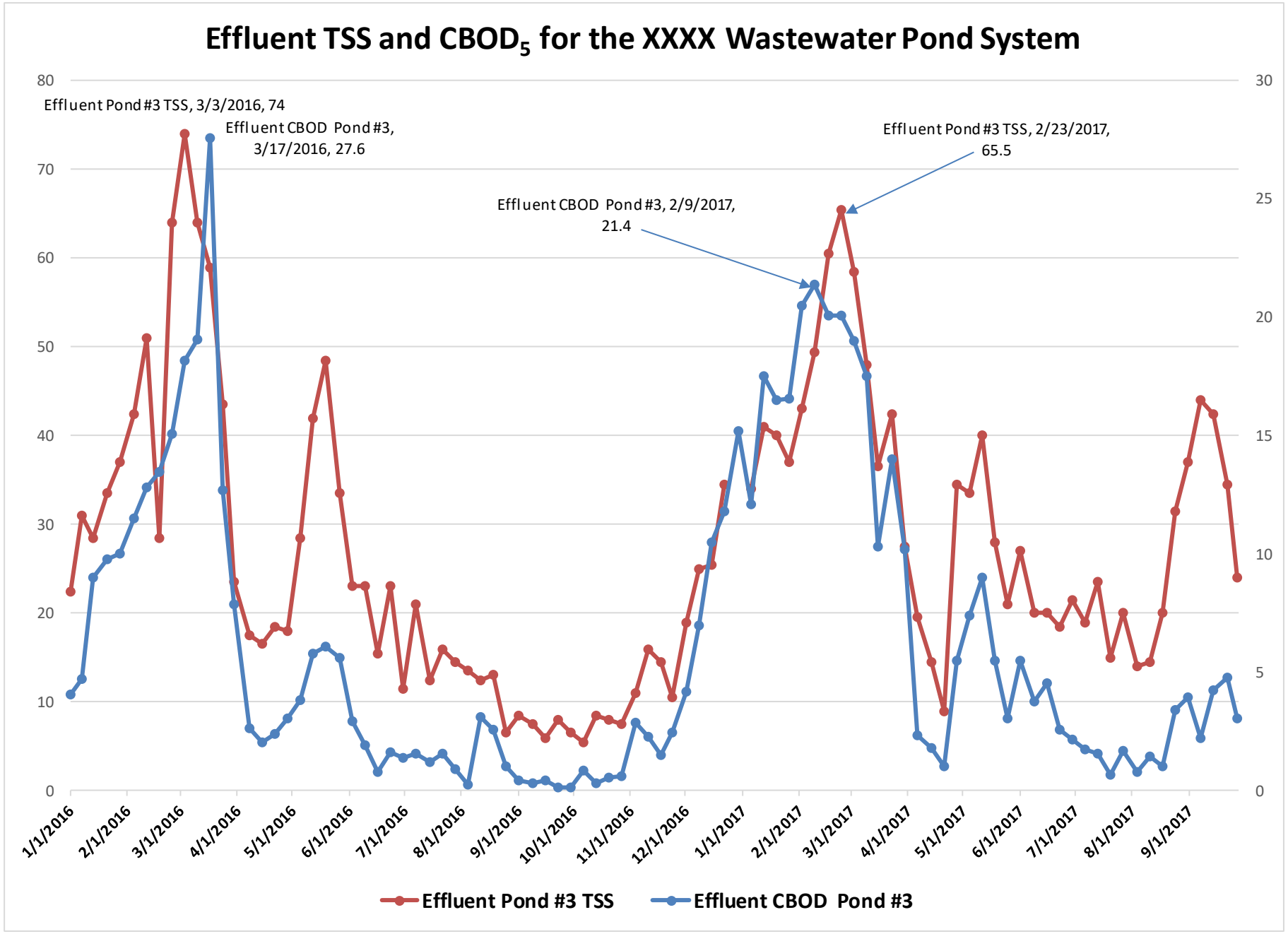

BOD and CBOD from XXX Lab Showing the Presence of Nitrifying Bacteria at Work in the Pond System to Remove Ammonia
120
100
80
60
40
20
0
119
17.2
52
8.67
24.9
0.402
0.267
3.03
3.37
Cell # 1 has an 85.5% CBOD removal efficiency
34.8 mg/l of oxygen demand is caused by nitrification in the Albany System
System continues to nitrify in Cell # 2
Ammonia removed so little difference between CBOD and BOD
Raw Influent BOD
Leaving Cell #1 CBOD
Leaving Cell #1 BOD
Leaving Cell #2 CBOD
Leaving Cell #2 BOD
Leaving Cell #3 SCBOD
Leaving Cell #3 SBOD
Leaving Cell #3 CBOD
Leaving Cell #3 BOD
Tested in 9/2017

Intra-Pond Ammonia, Nitrate and Alkalinity Grab Sample Results for the XXXX Wastewater Pond System

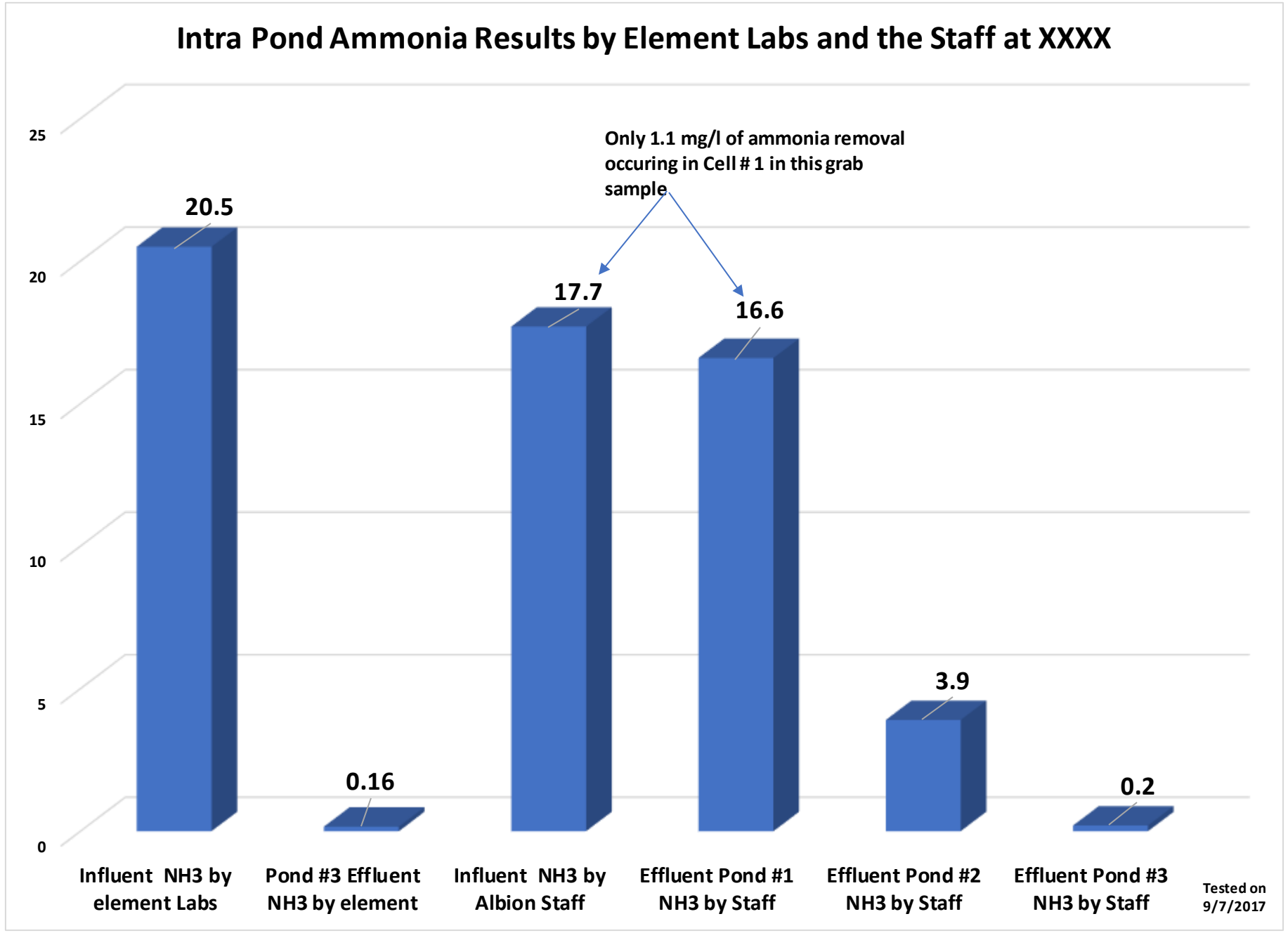


Sampled and Tested on 9/25/2017

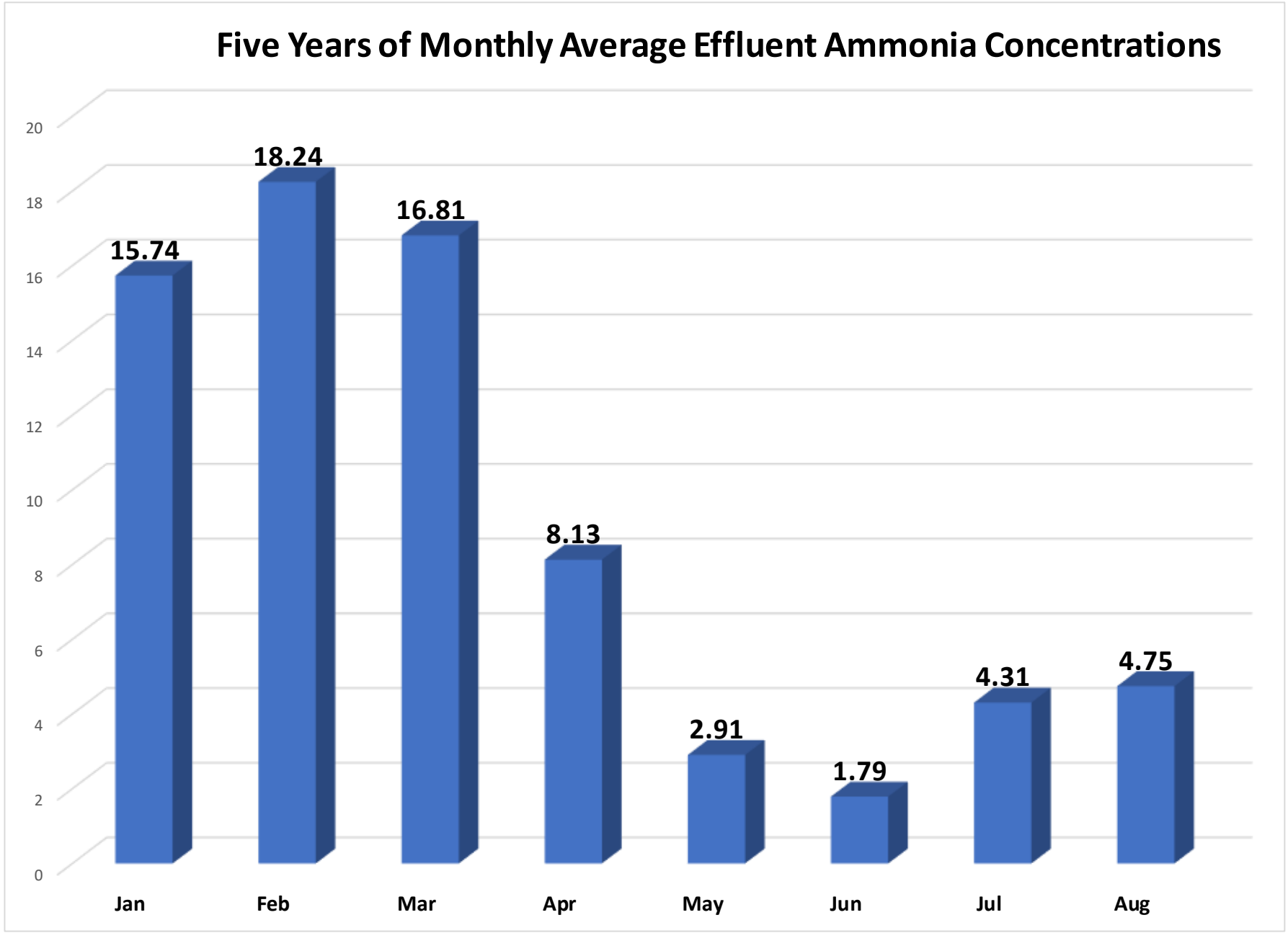

Intra-Pond Ammonia as Sampled by Element Labs and the XXXX Staff
30
25
20
15
10
5
0
26.3
9.9
23.3
11.1
13
8.1
Influent NH3 by Element Labs
Pond #3 Effluent NH3 by Element Labs
Influent NH3
Effluent Pond #1 NH3
Effluent Pond #2 NH3
Effluent Pond #3 NH3
Sampled on 9/22/2016


Effluent TSS and CBOD5 for the XXXX Wastewater Pond System
Effluent Pond #3 TSS, 3/3/2016, 74
Effluent CBOD Pond #3, 3/17/2016, 27.6
Effluent CBOD Pond #3, 2/9/2017, 21.4
Effluent Pond #3 TSS, 2/23/2017, 65.5
80
70
60
50
40
30
20
10
0
30
25
20
15
10
5
0
1/1/2016
2/1/2016
3/1/2016
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
10/1/2016
11/1/2016
12/1/2016
1/1/2017
2/1/2017
3/1/2017
4/1/2017
5/1/2017
6/1/2017
7/1/2017
8/1/2017
9/1/2017
Effluent Pond #3 TSS
Effluent CBOD Pond #3

Intra Pond Ammonia Results by Element Labs and the Staff at XXXX



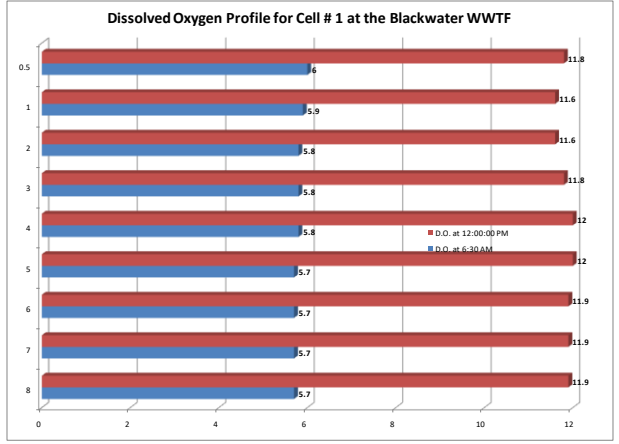

0.16

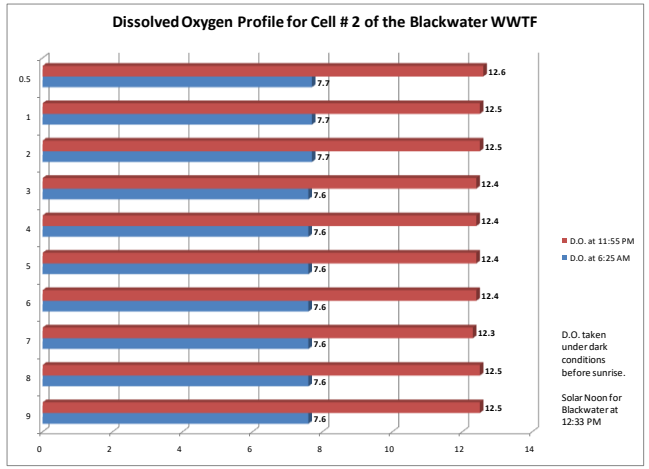

Five Years of Monthly Average Effluent Ammonia Concentrations
20
18
16
14
12
10
8
6
4
2
0
15.74
18.24
16.81
8.13
2.91
1.79
4.31
4.75
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

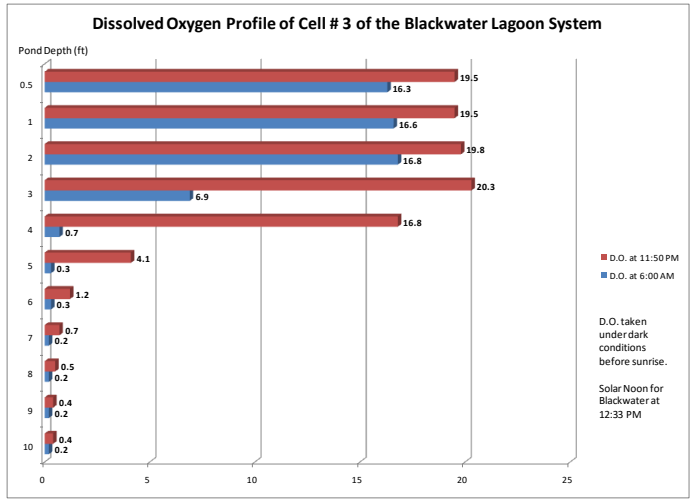
Popping sludge is a sign of denitrification as a result of low dissolved oxygen concentrations

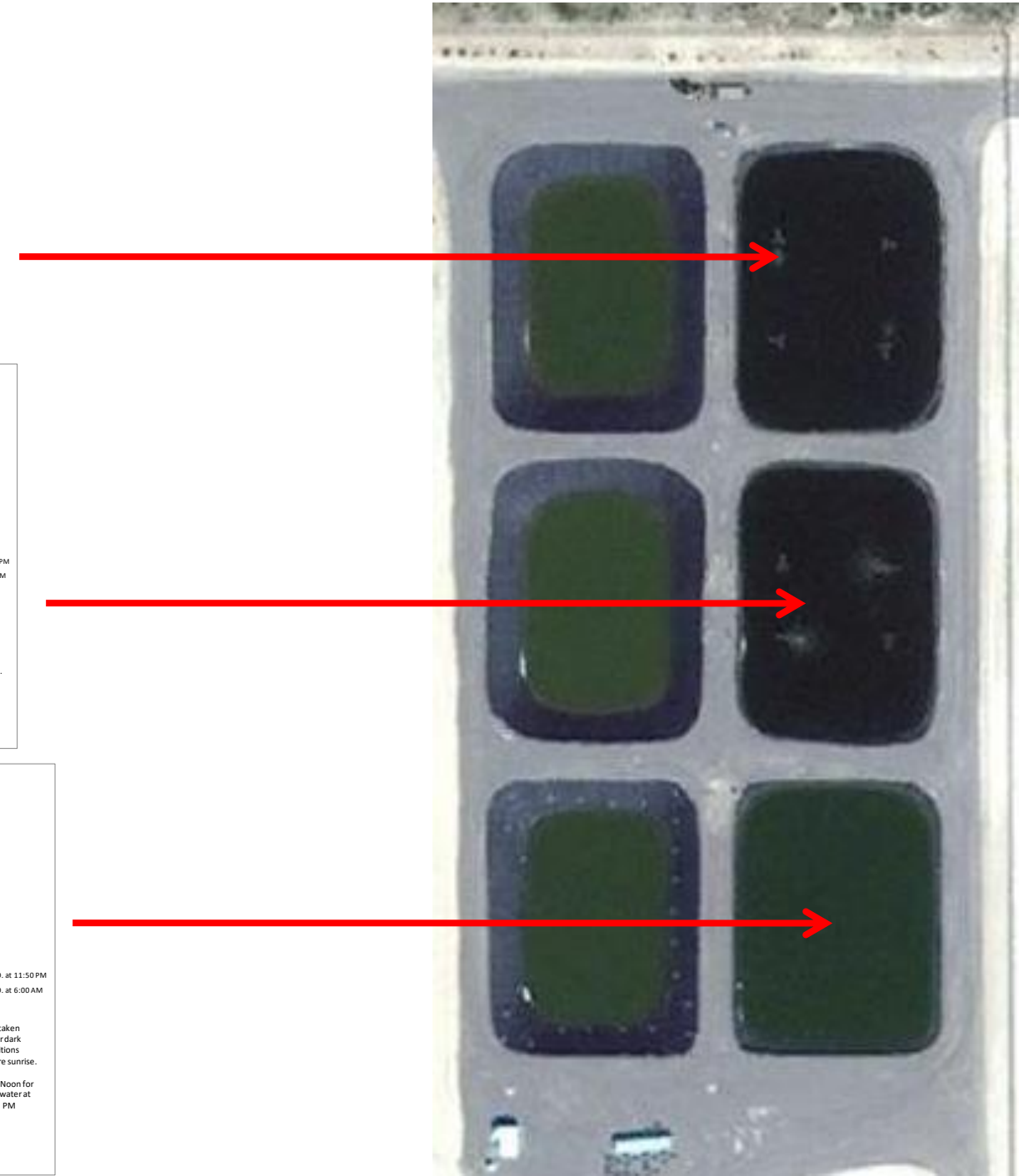
Aeration/Mixing Power

Case # 7

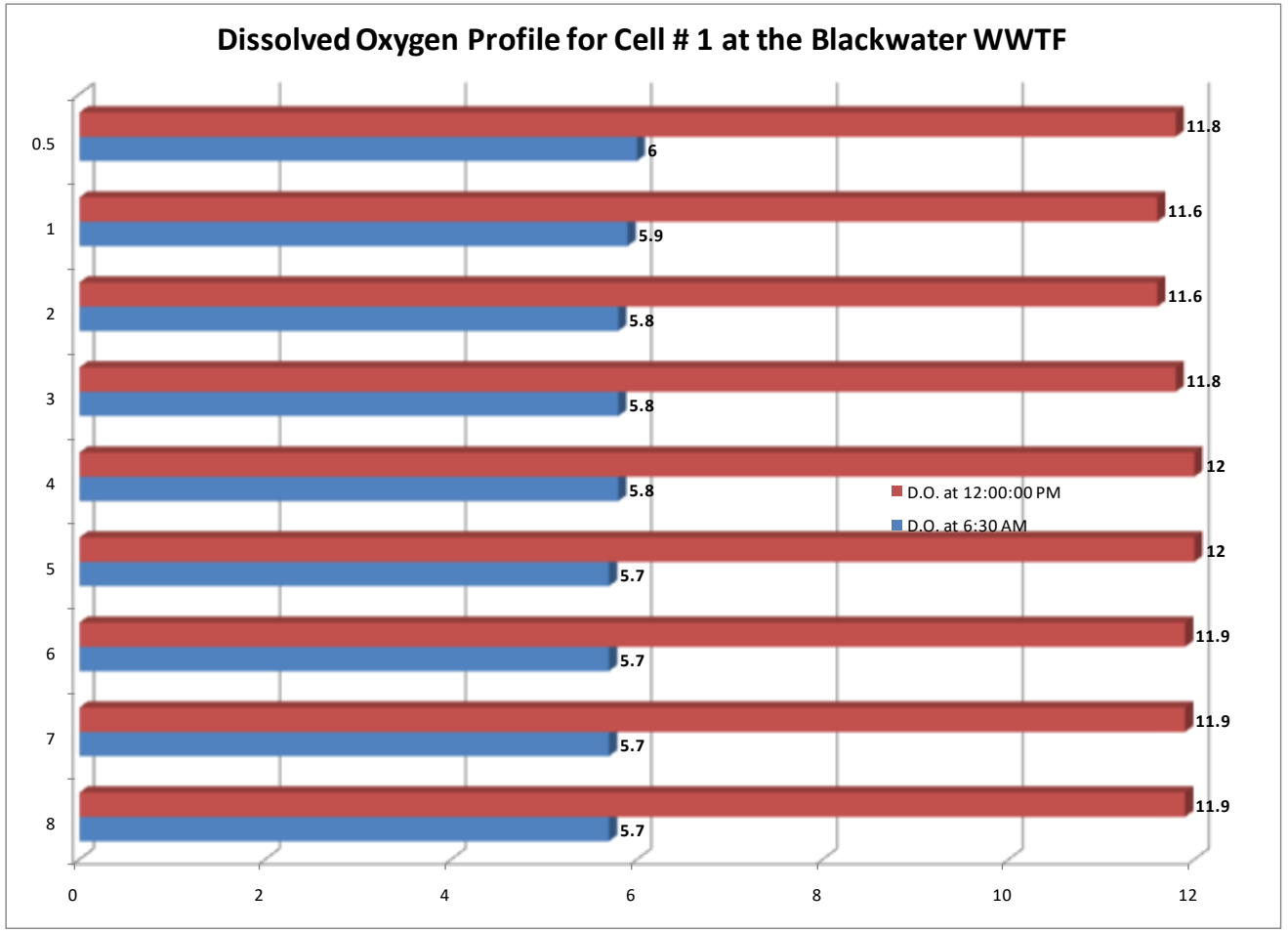

Dissolved Oxygen Profile for Cell # 1 at the Blackwater WWTF
0.5
1
2
3
4
5
6
7
8
11.8
6
11.6
5.9
11.6
5.8
11.8
5.8
12
5.8
12
5.7
11.9
5.7
11.9
5.7
11.9
5.7
D.O. at 12:00:00 PM
D.O. at 6:30 AM
0
2
4
6
8
10
12

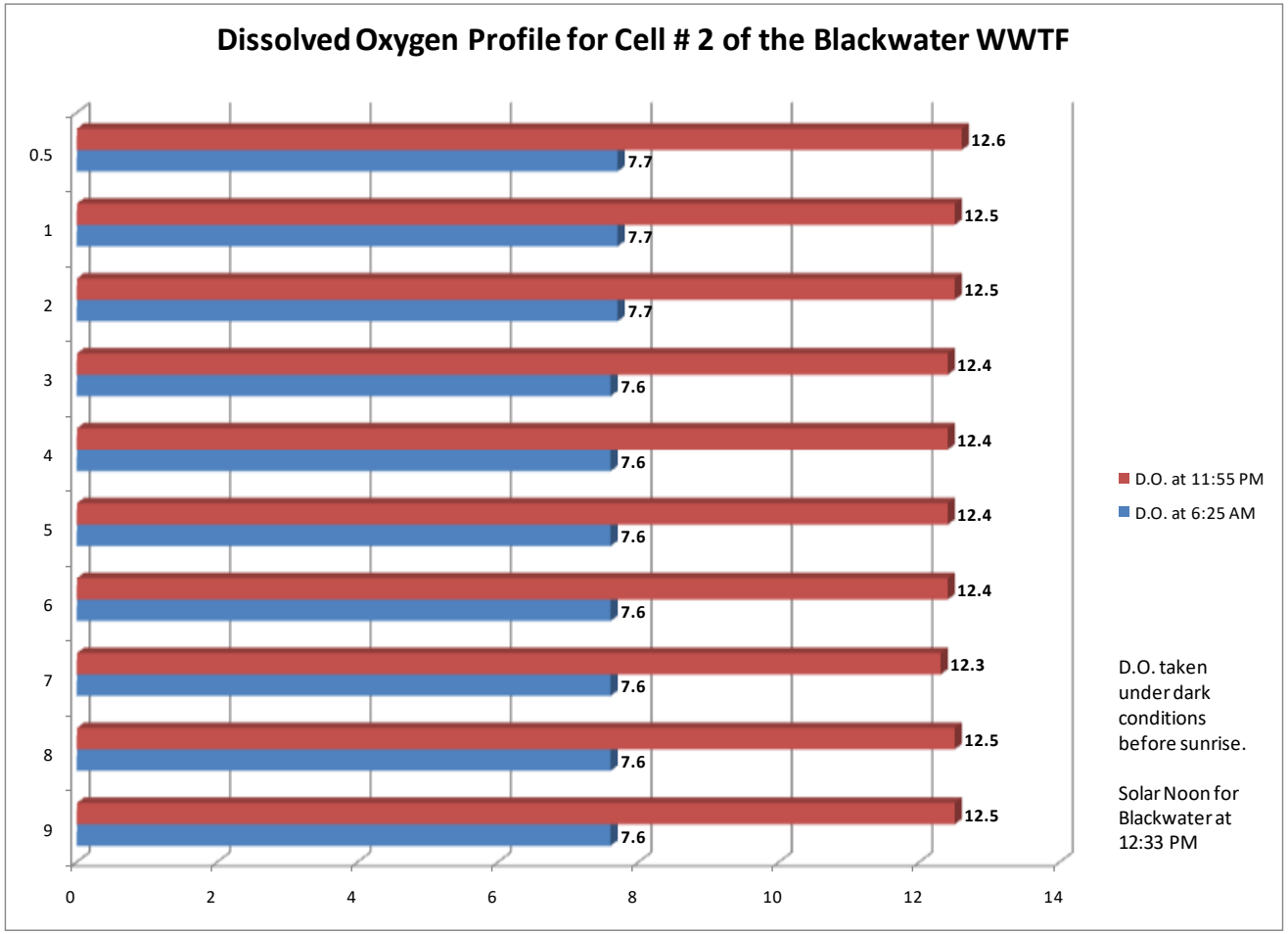

Dissolved Oxygen Profile for Cell # 2 of the Blackwater WWTF
0.5
1
2
3
4
5
6
7
8
9
12.6
7.7
12.5
7.7
12.5
7.7
12.4
7.6
12.4
7.6
12.4
7.6
12.4
7.6
12.3
7.6
12.5
7.6
12.5
7.6
D.O. at 11:55 PM
D.O. at 6:25 AM
D.O. taken under dark conditions before sunrise.
Solar Noon for Blackwater at 12:33 PM
0
2
4
6
8
10
12
14


Dissolved Oxygen Profile of Cell # 3 of the Blackwater Lagoon System
Pond Depth (ft)
0.5
1
2
3
4
5
6
7
8
9
10
19.5
16.3
19.5
16.6
19.8
16.8
20.3
6.9
16.8
0.7
4.1
0.3
1.2
0.3
0.7
0.2
0.5
0.2
0.4
0.2
0.4
0.2
D.O. at 11:50 PM
D.O. at 6:00 AM
D.O. taken under dark conditions before sunrise.
Solar Noon for Blackwater at 12:33 PM
0
5
10
15
20
25

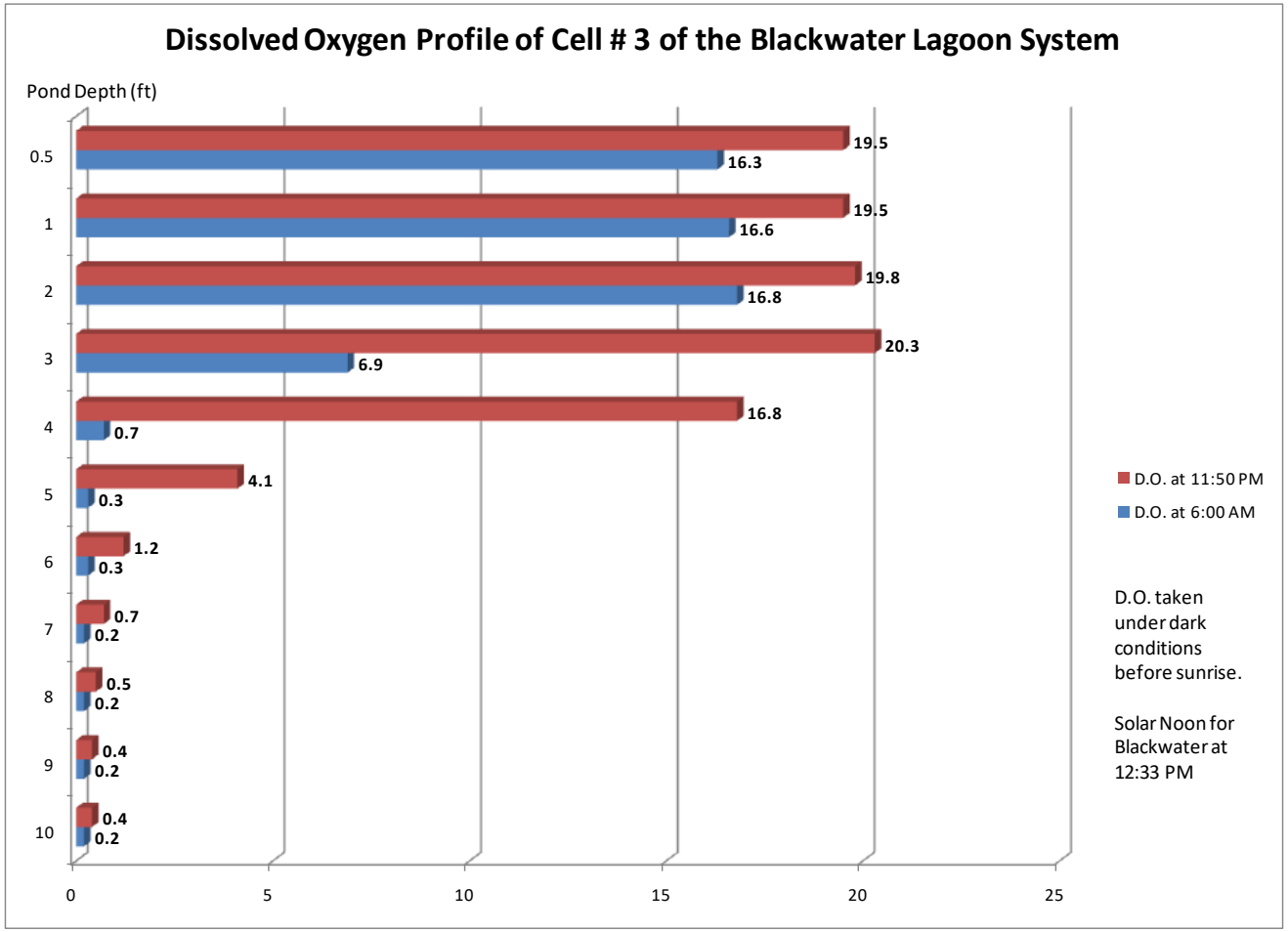


The uniformity of these numbers across the pond and at depth tells us there is good mixing in this pond




Dissolved Oxygen Profile for Cell # 2 of the Blackwater WWTF
0.5
1
2
3
4
5
6
7
8
9
12.6
7.7
12.5
7.7
12.5
7.7
12.4
7.6
12.4
7.6
12.4
7.6
12.4
7.6
12.3
7.6
12.5
7.6
12.5
7.6
0
2
4
6
8
10
12
14
D.O. at 11:55 PM
D.O. at 6:25 AM
D.O. taken under dark conditions before sunrise.
Solar Noon for Blackwater at 12:33 PM

Notice the Stratification in this Non-aerated Polishing Pond

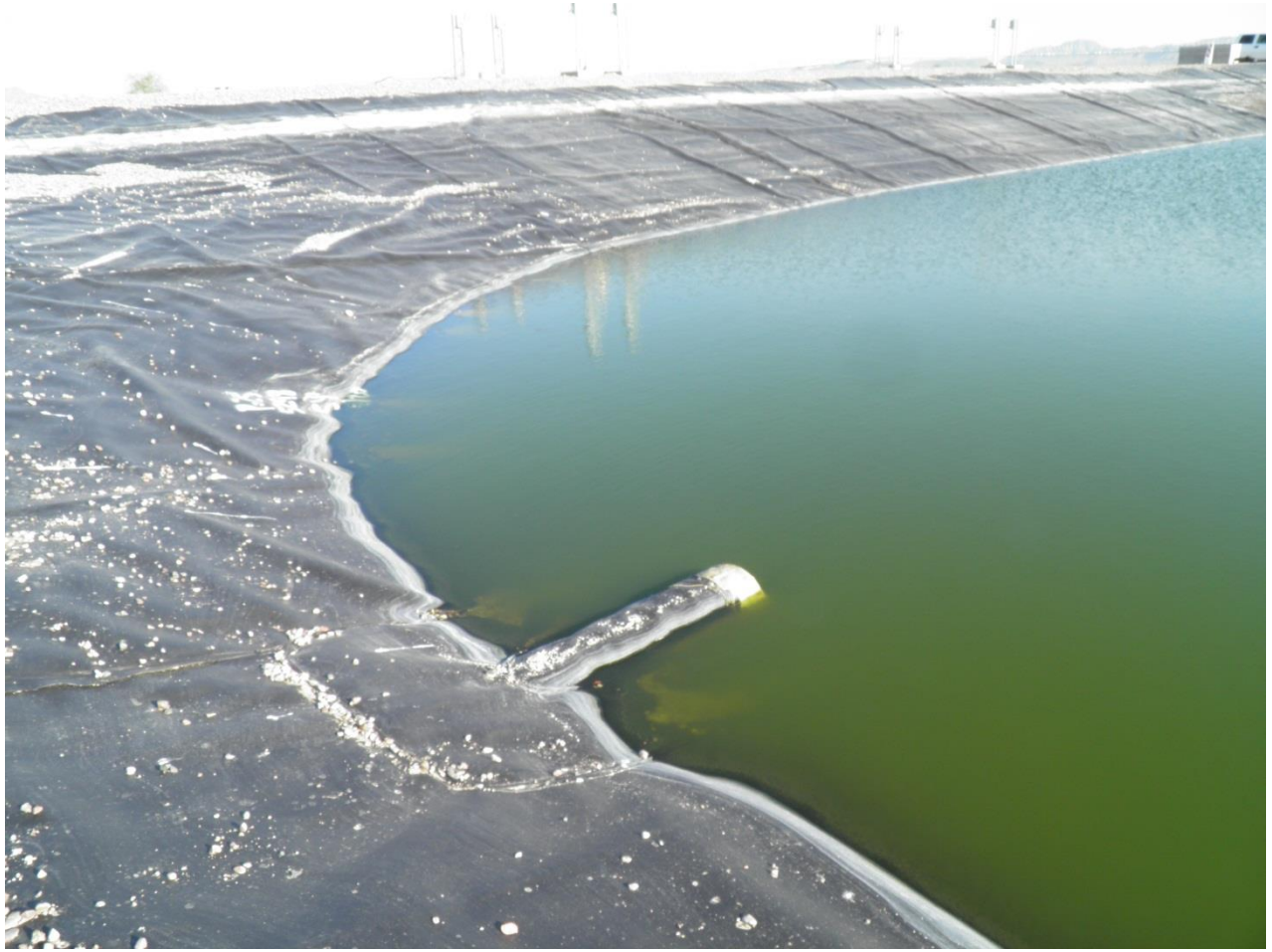


Could Aeration be Cut Back?

- How would you know if you could cut aerator run times?
- What measurements would you take?
- What precautions would you take in cutting aerator run times?

Pond # 1

Pond # 2



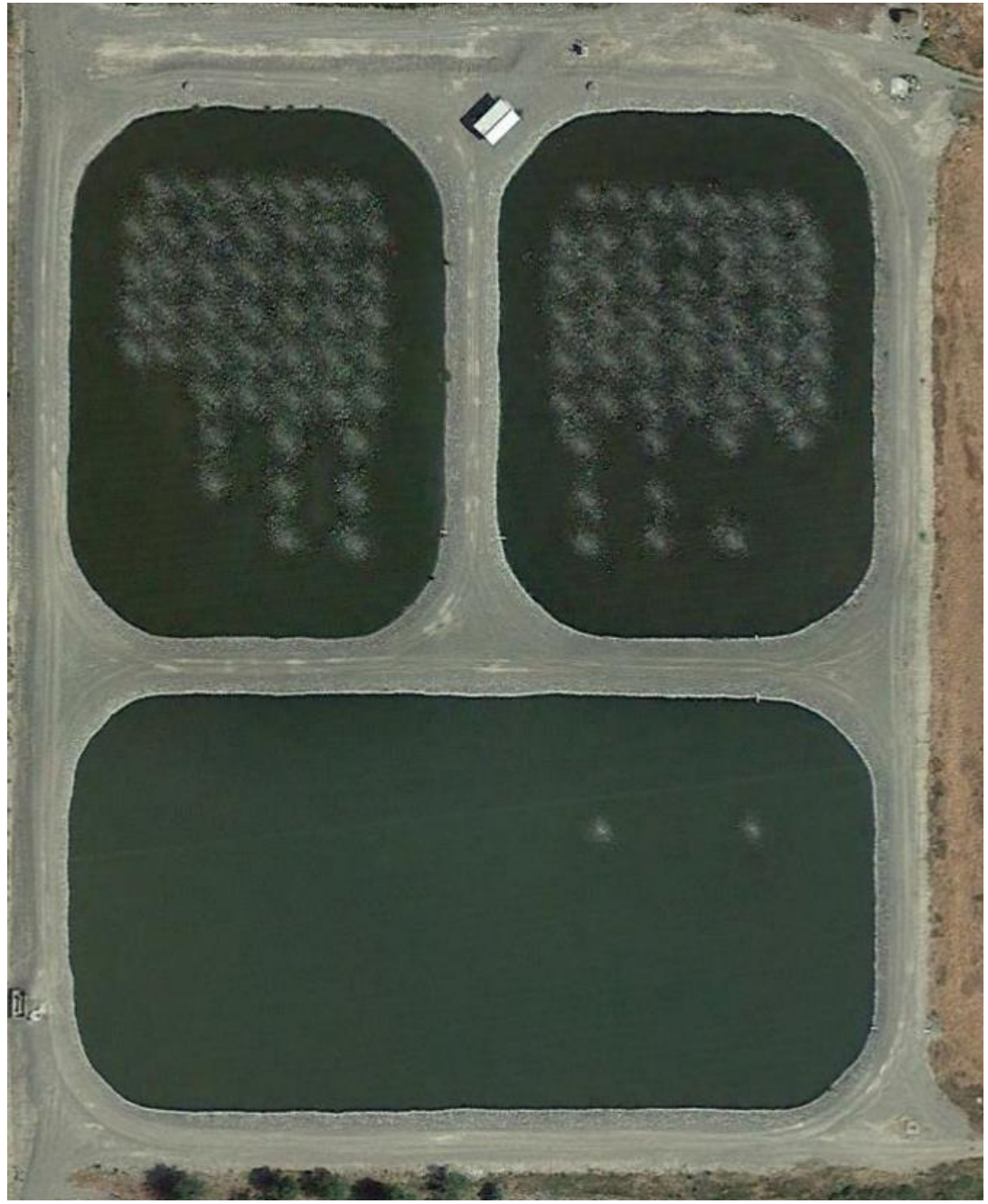
Pond # 3

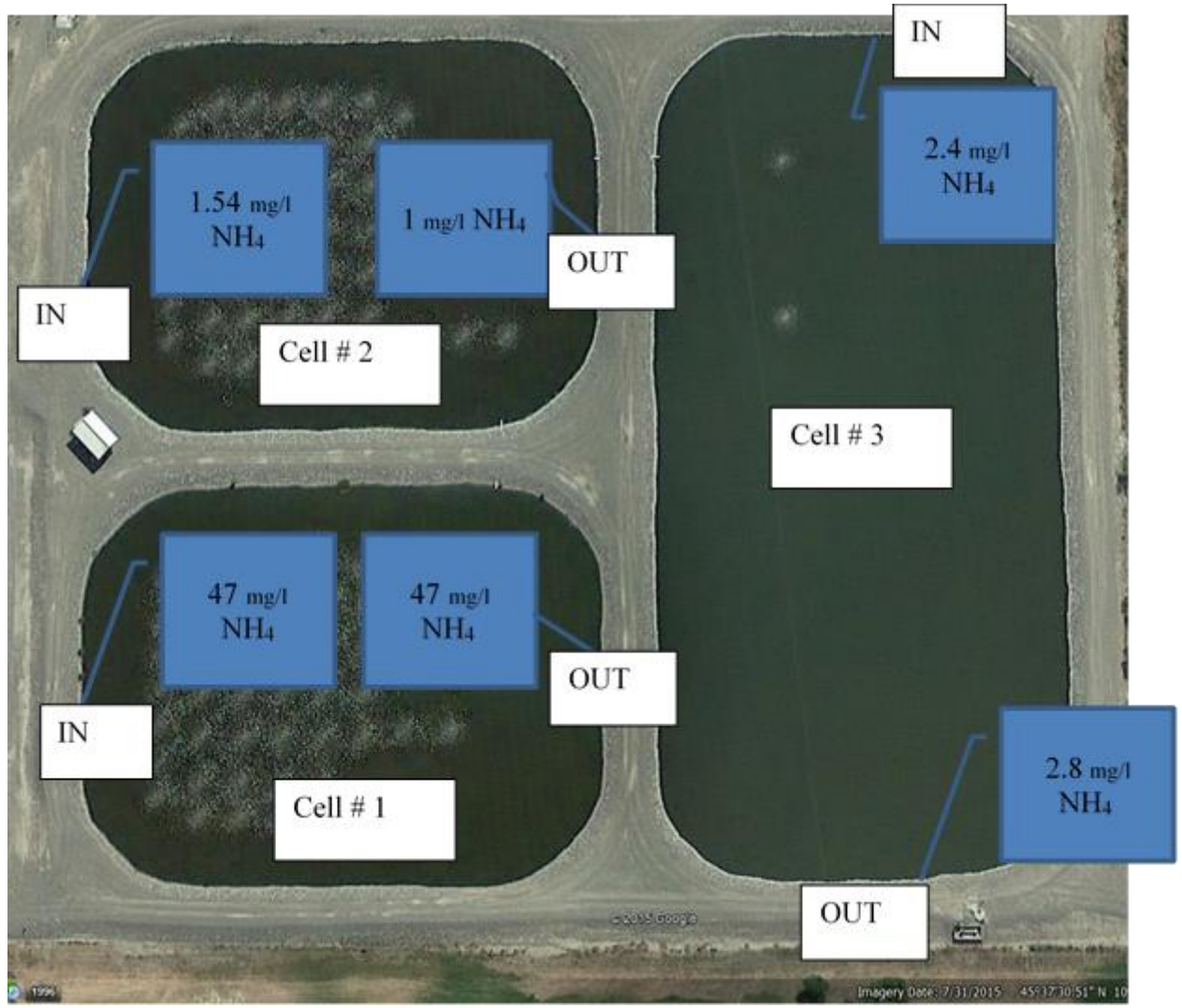
Pond # 3

Pond # 3 Influent Pipe

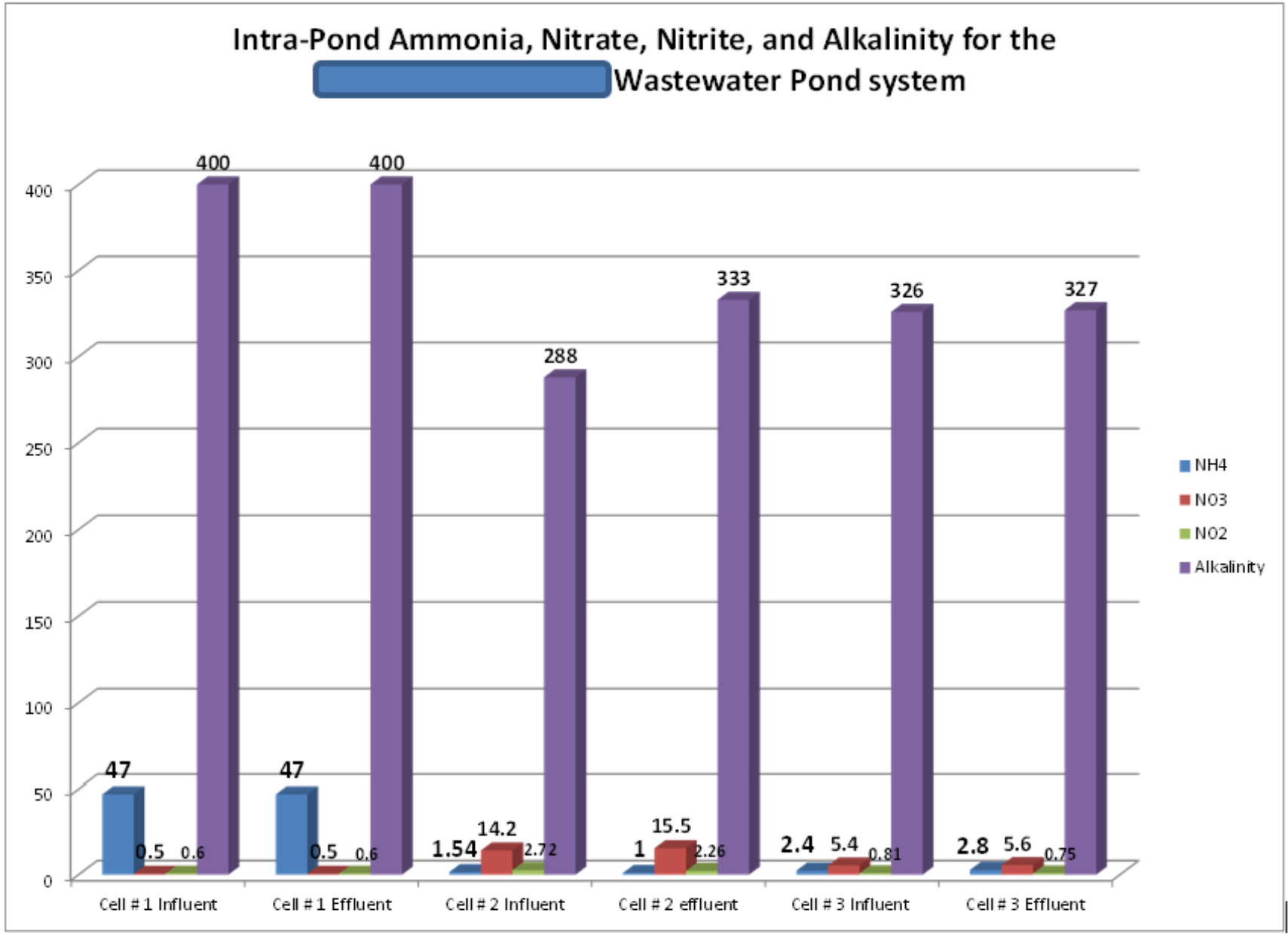
Pond # 3 Influent Pipe

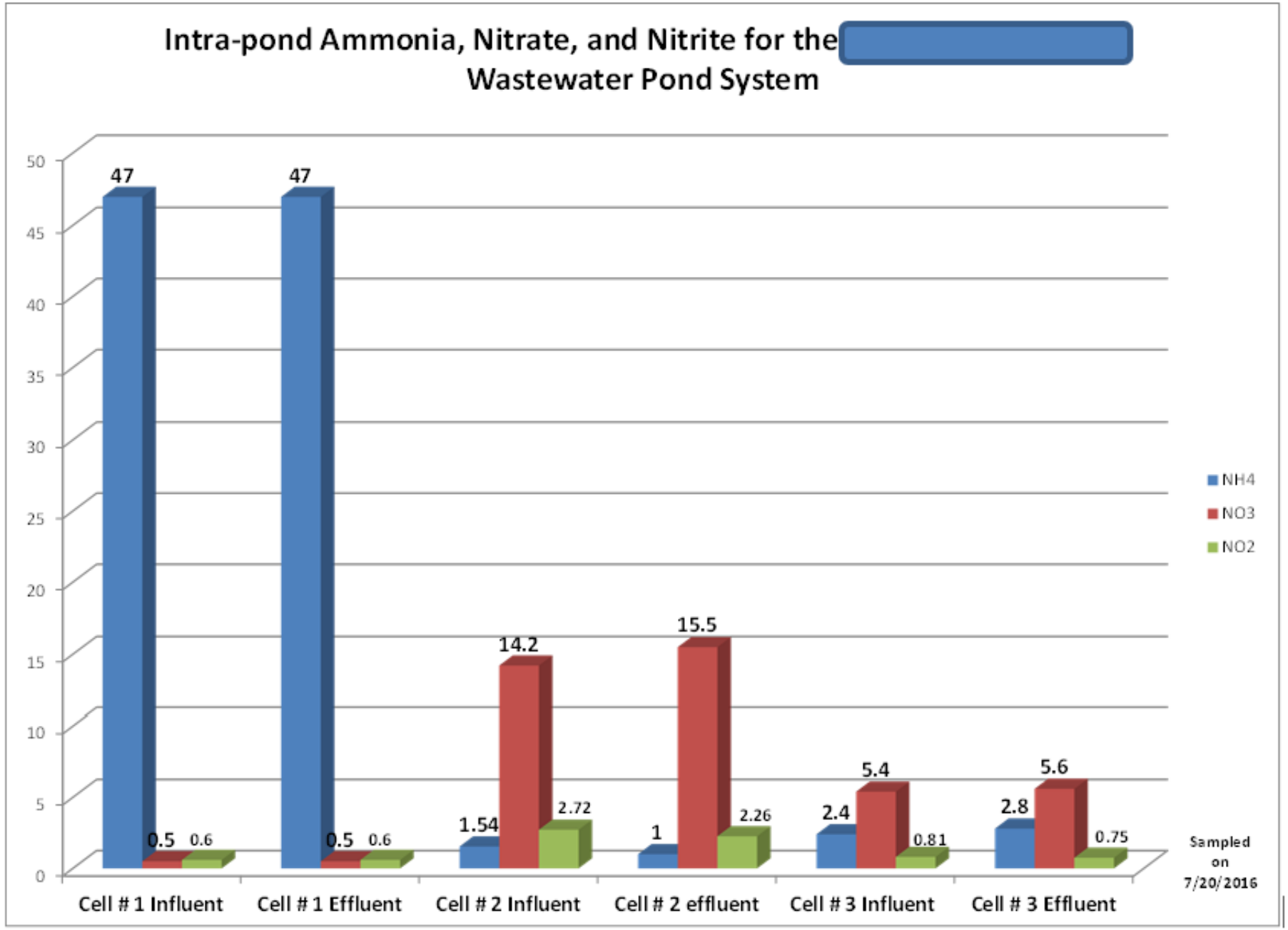
Low Air Case



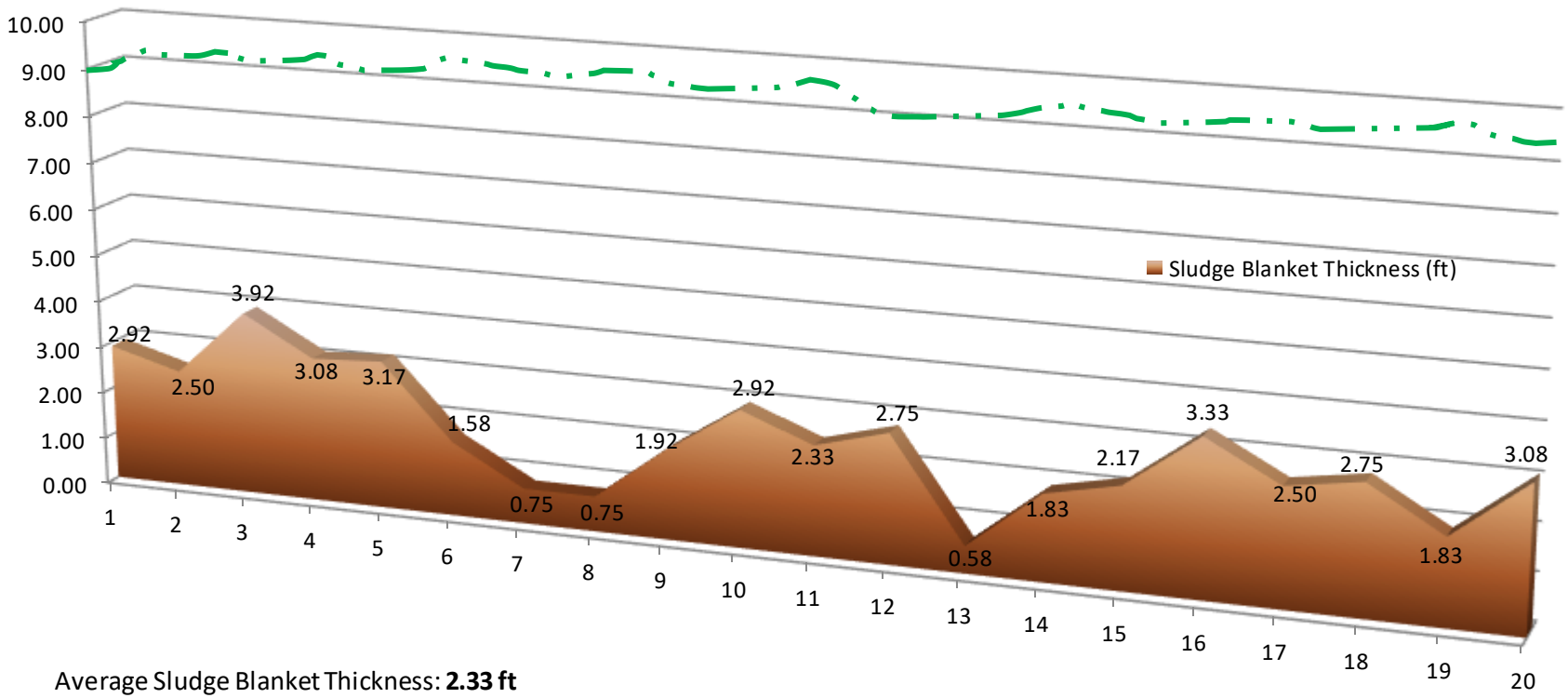

IN
2.4 mg/l NH4
1.54 mg/l NH4
1 mg/l NH4
OUT
IN
Cell # 2
Cell # 3
47 mg/l NH4
47 mg/l NH4
OUT
IN
2.8 mg/l NH4
Cell # 1
OUT
Imagery Date: 7/31/2015


Clocktower Inn
GUEST
CLOROX
DISINFECTING WIPES
Kills 99.999%
TouchNTuff
Water Quality Test Strips for
Ammonia
Columbus


Intra-Pond Ammonia, Nitrate, Nitrite, and Alkalinity for the
Wastewater Pond system
400
350
300
250
200
150
100
50
0
47
0.5
0.6
400
47
0.5
0.6
400
1.54
14.2
2.72
288
1
15.5
2.26
333
2.4
5.4
0.81
326
2.8
5.6
0.75
327
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 effluent
Cell # 3 Influent
Cell # 3 Effluent
NH4
NO3
NO2
Alkalinity

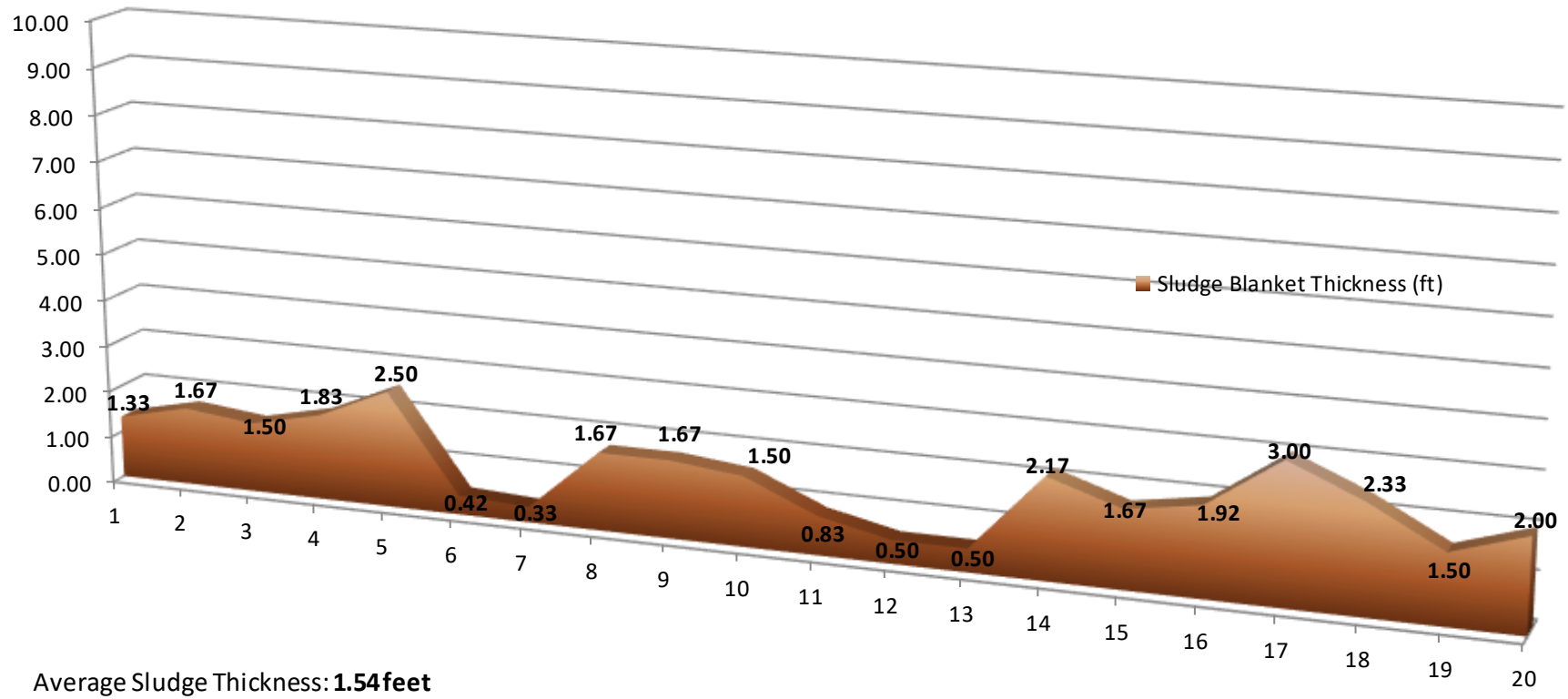

Intra-pond Ammonia, Nitrate, and Nitrite for the
Wastewater Pond System
50
45
40
35
30
25
20
15
10
5
0
47
47
0.5
0.6
0.5
0.6
1.54
14.2
2.72
1
15.5
2.26
2.4
5.4
0.81
2.8
5.6
0.75
NH4
NO3
NO2
Sampled on 7/20/2016
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 effluent
Cell # 3 Influent
Cell # 3 Effluent

Cell # 1 Sludge Blanket Thickness Profile for the xxxxx Wastewater Pond System

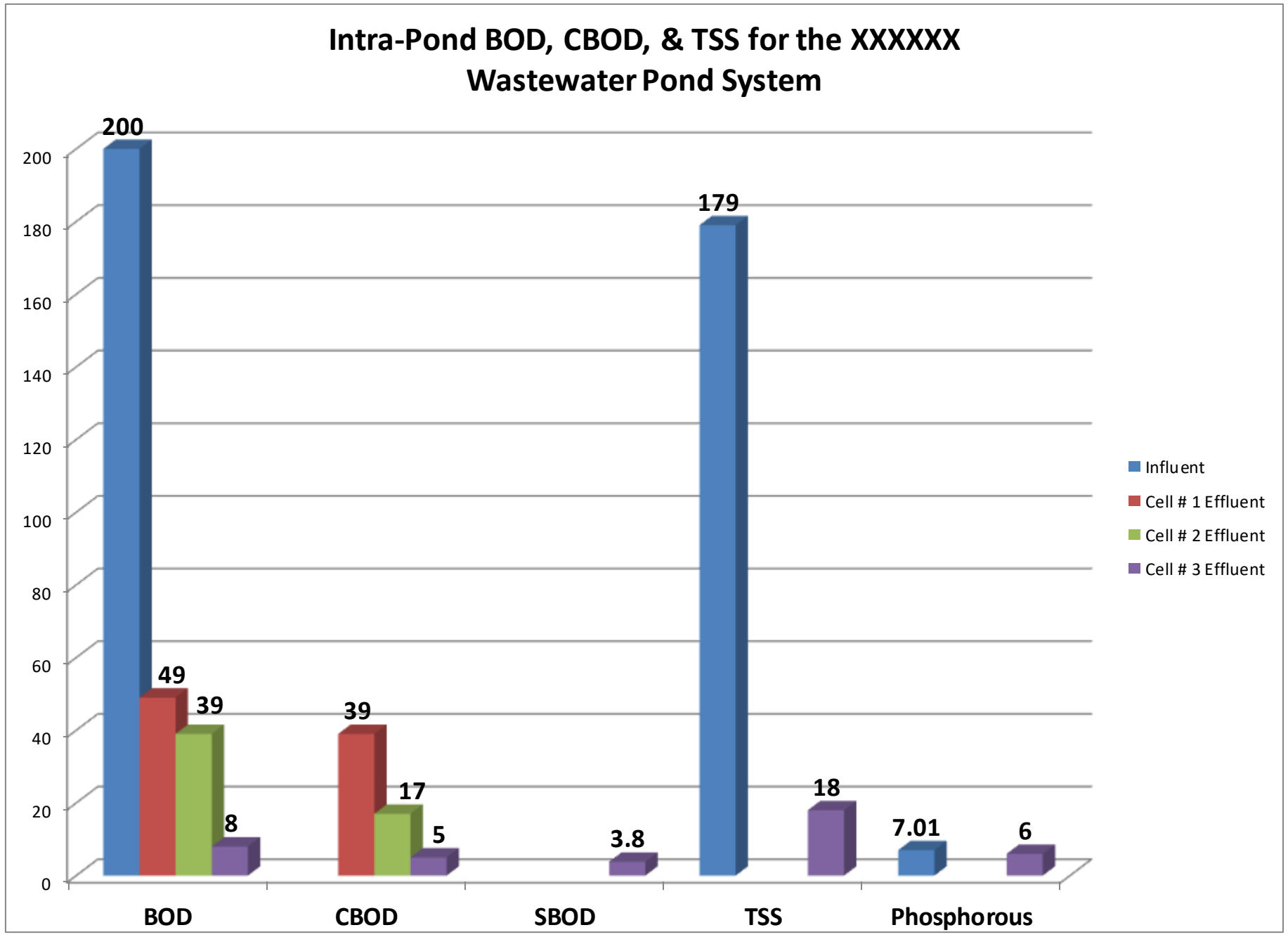


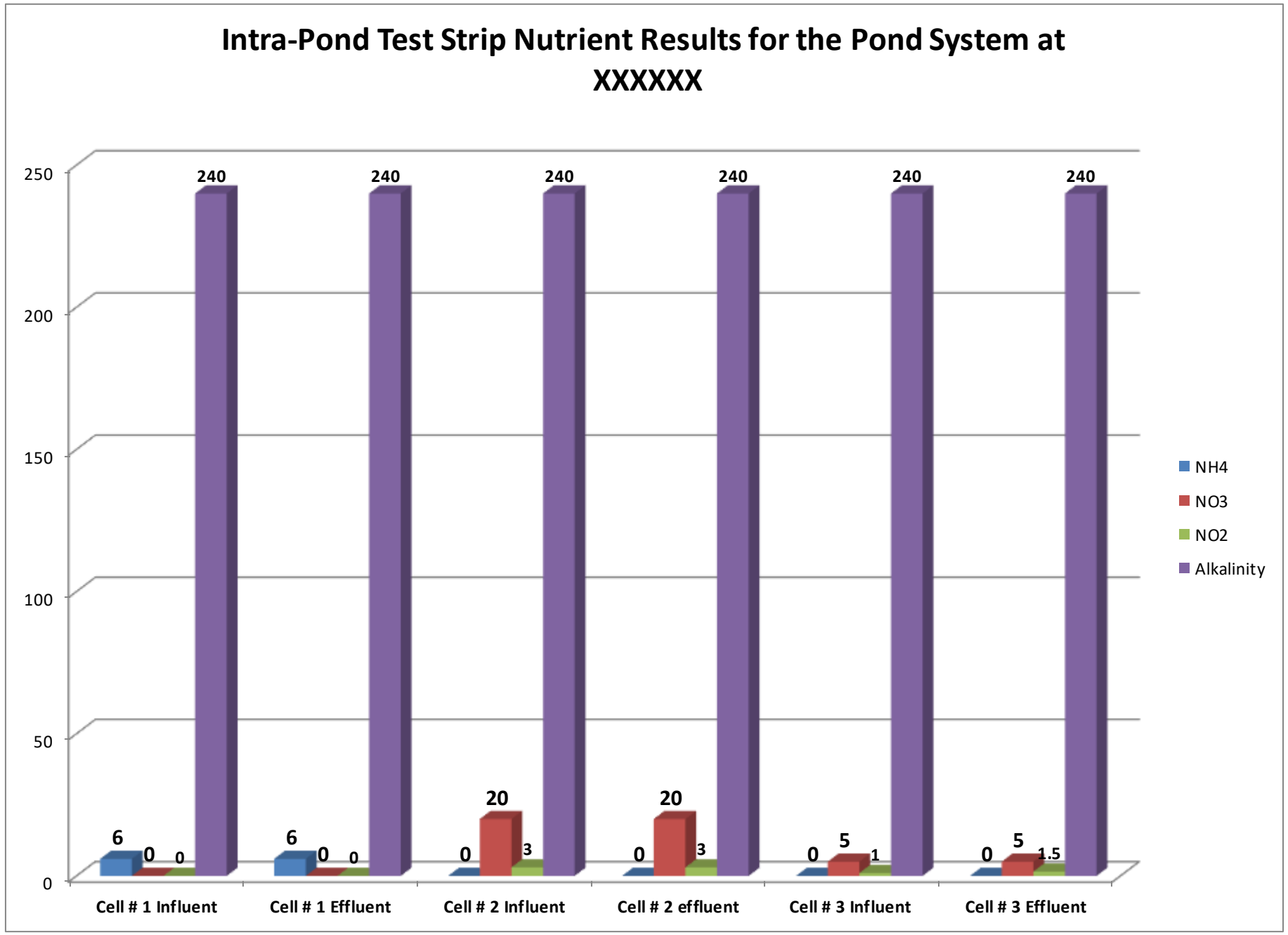
Average Sludge Blanket Thickness: **2.33 ft**
Average Water Depth **9.99 ft**
Sludge Volume: **1,020,484 gallons**

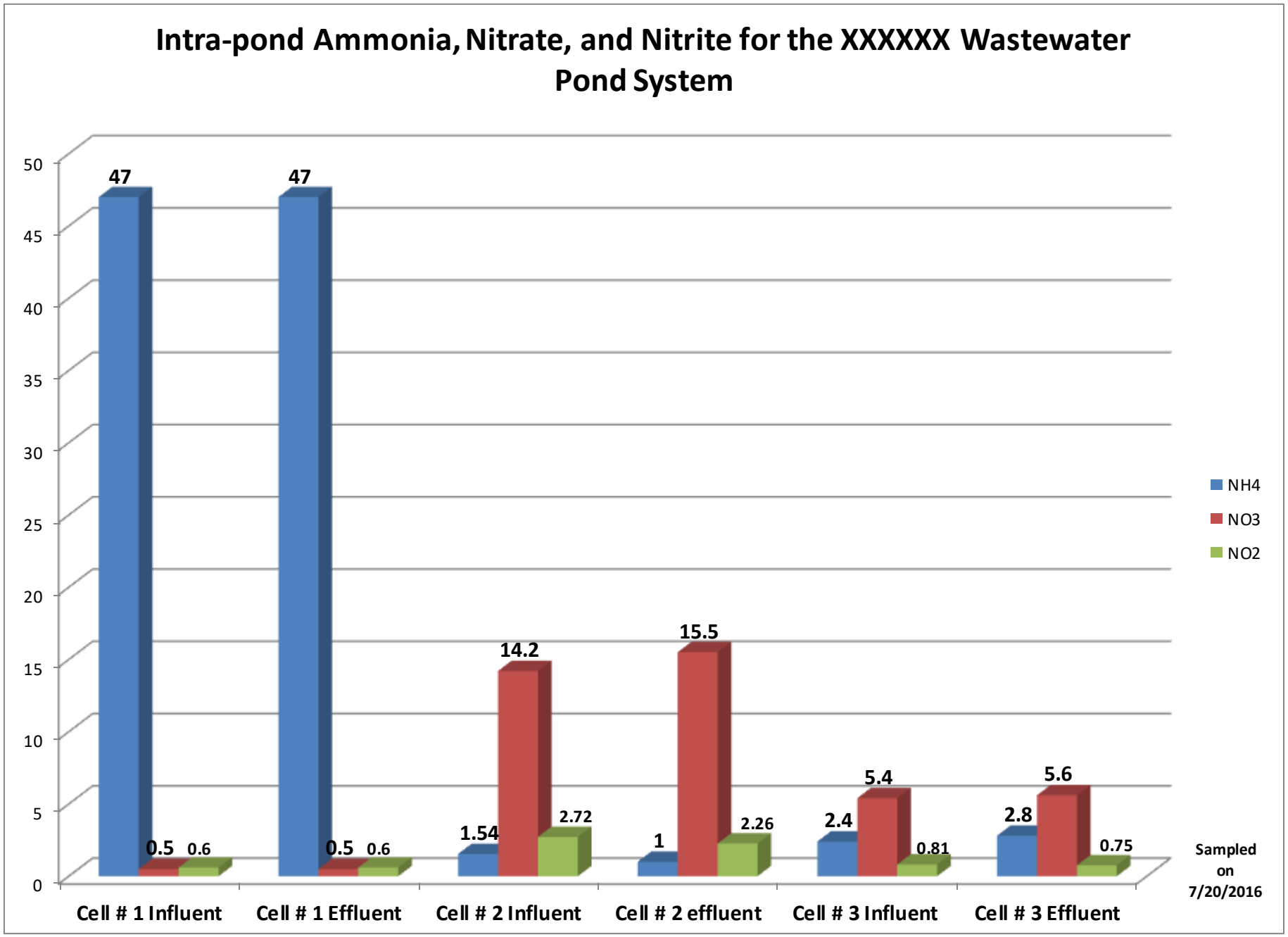
Cell # 2 Sludge Blanket Thickness Profile for the XXXXXX Wastewater Pond System

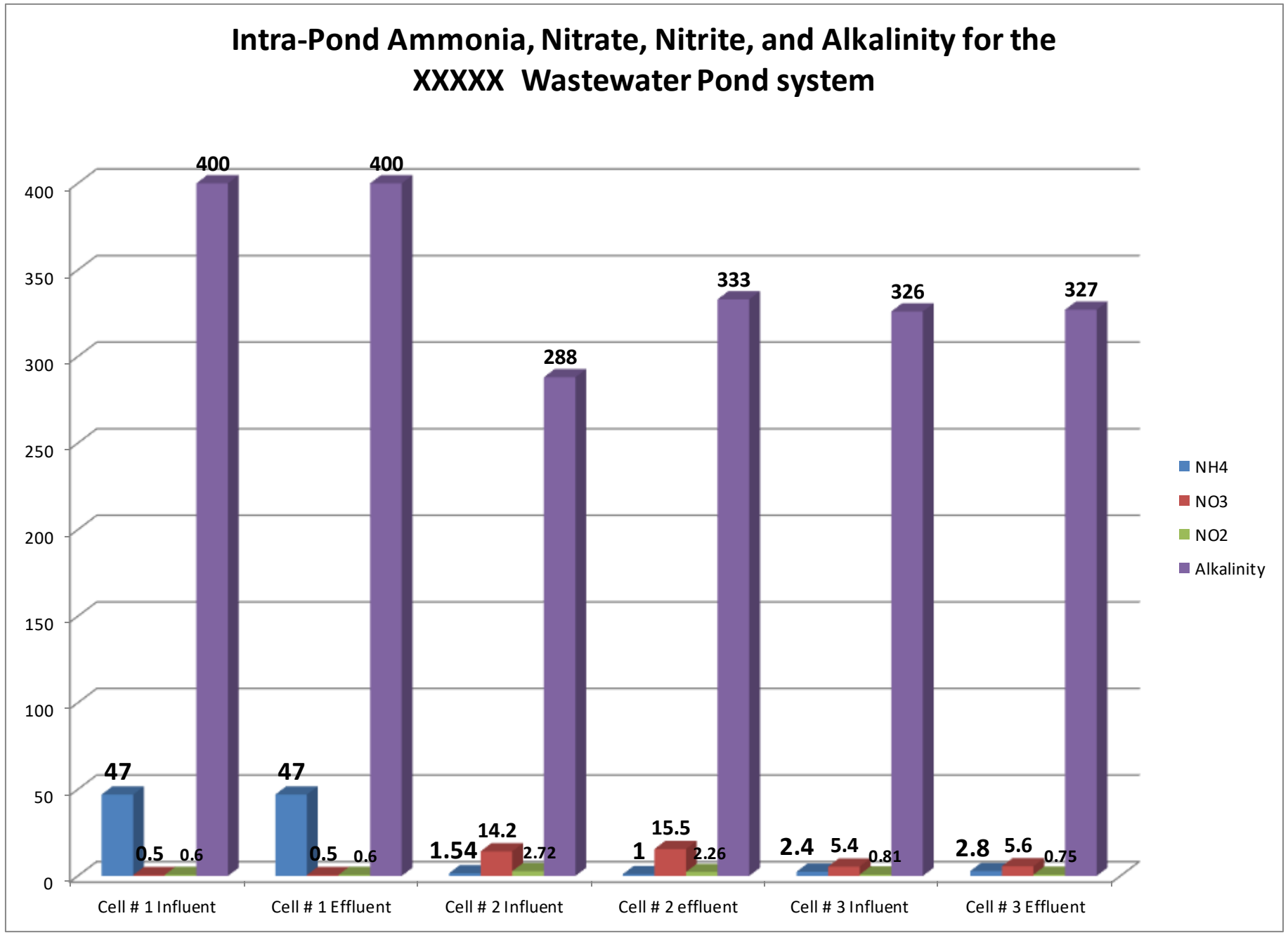


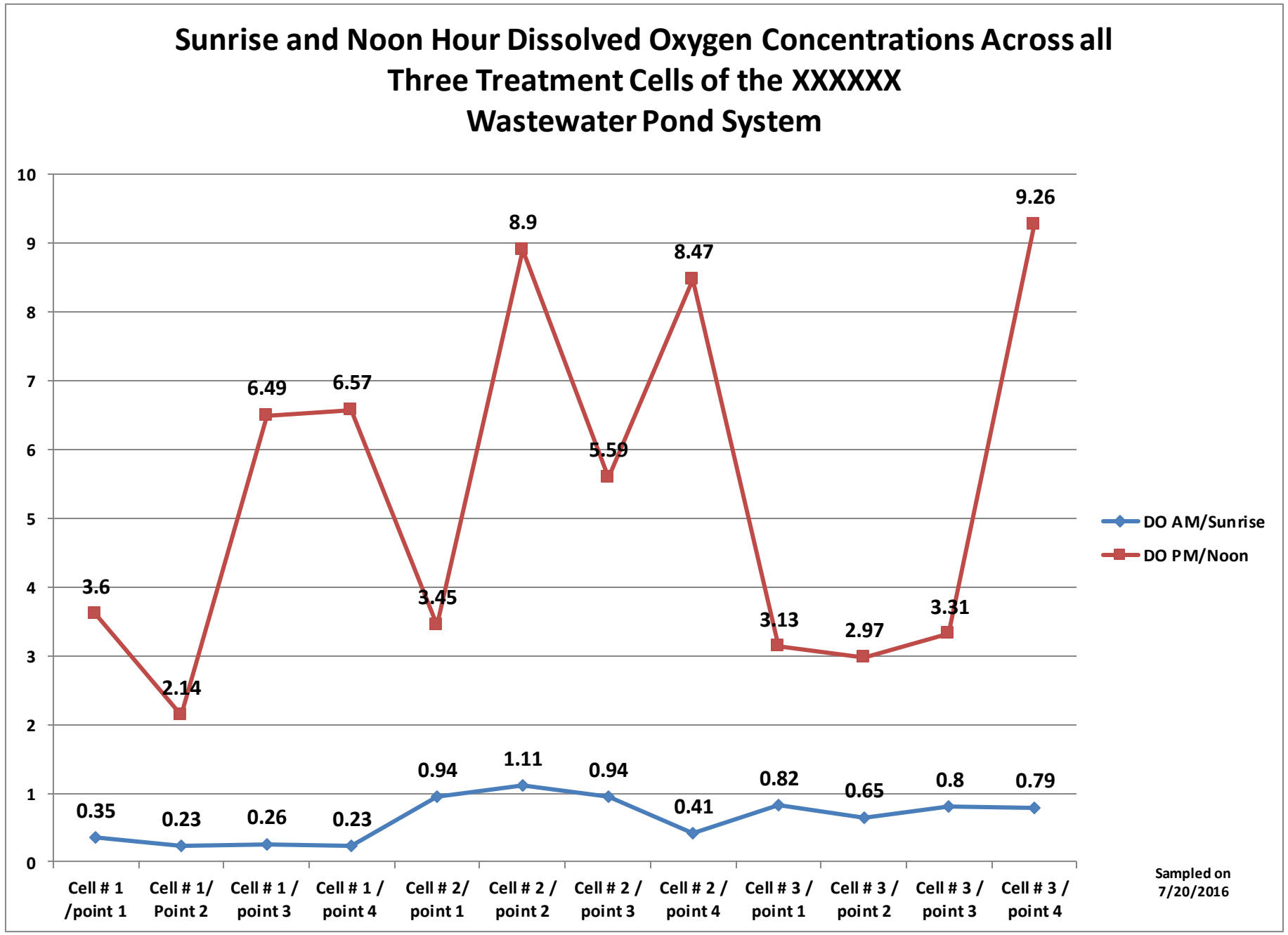
Average Sludge Thickness: **1.54 feet**
Average Water Depth: **10.02 ft**
Sludge Volume: **660,745 gallons**

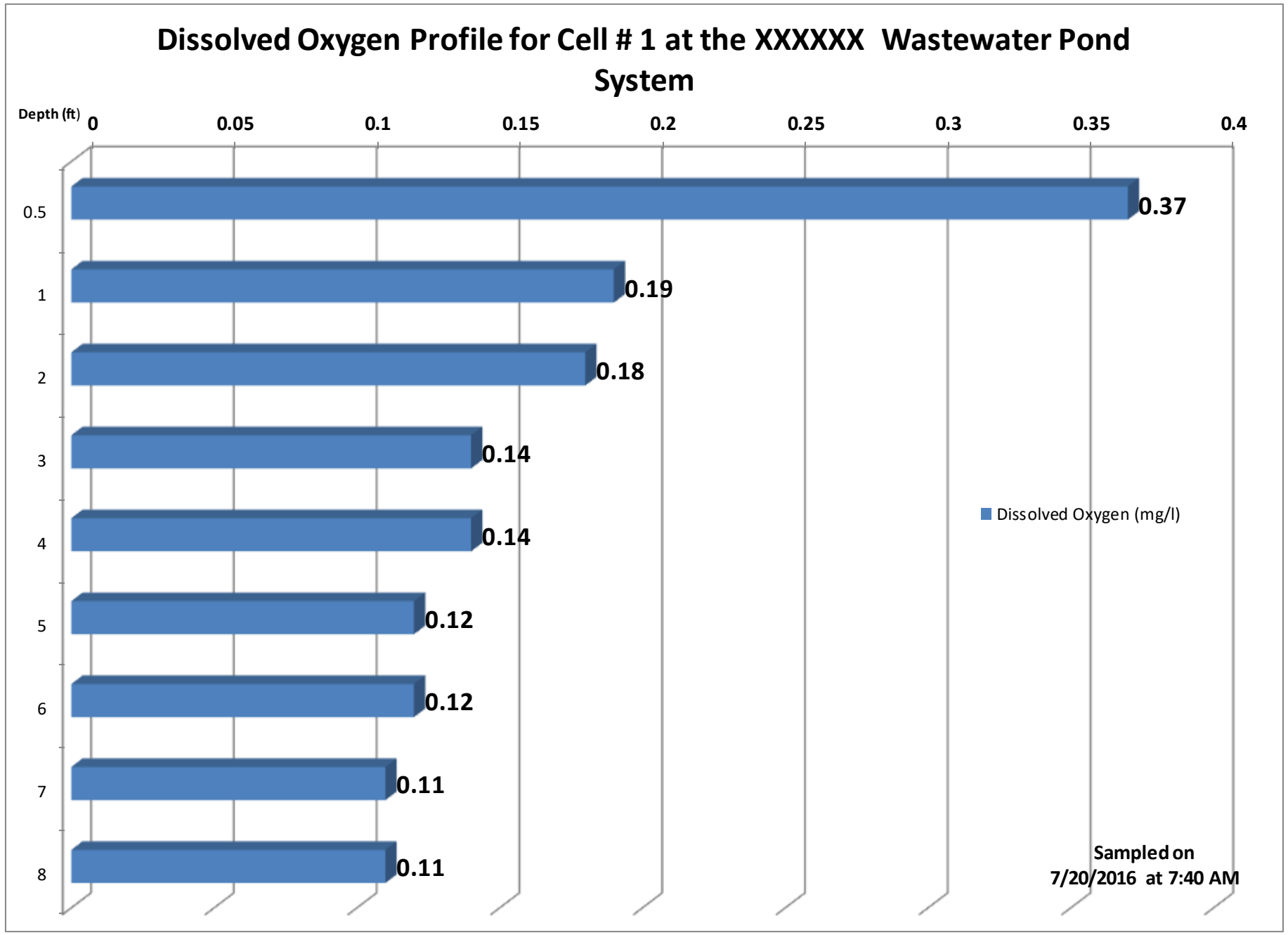

Intra-Pond BOD, CBOD, & TSS for the XXXXXX
Wastewater Pond System
200
180
160
140
120
100
80
60
40
20
0
200
49
39
8
39
17
5
3.8
179
18
7.01
6
BOD
CBOD
SBOD
TSS
Phosphorous
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent

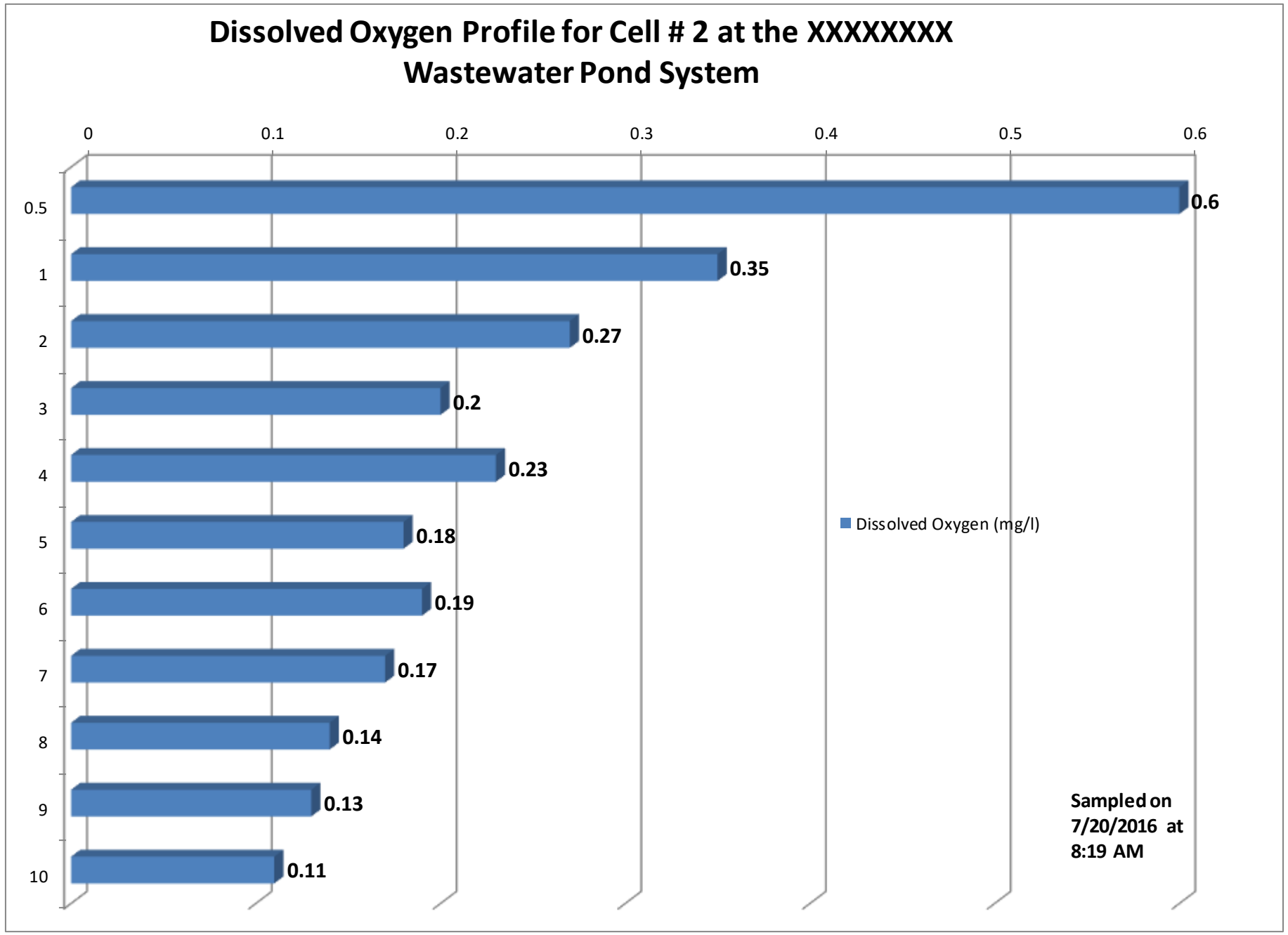

Intra-Pond Test Strip Nutrient Results for the Pond System at XXXXXX
250
200
150
100
50
0
240
240
240
240
240
240
6
0
0
6
0
0
0
20
3
0
20
3
0
5
1
0
5
1.5
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 effluent
Cell # 3 Influent
Cell # 3 Effluent
NH4
NO3
NO2
Alkalinity

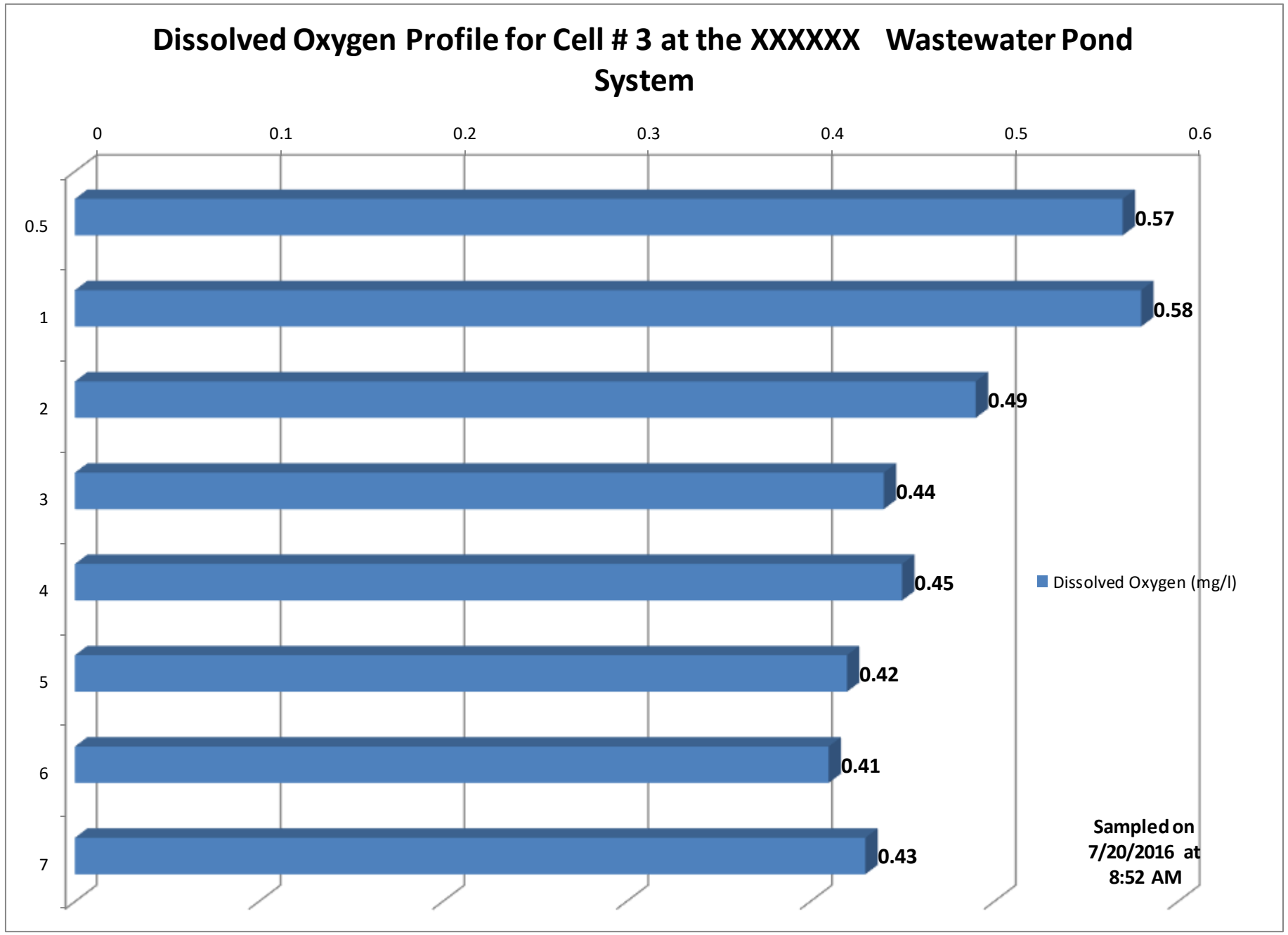

Intra-pond Ammonia, Nitrate, and Nitrite for the XXXXXX Wastewater Pond System
50
45
40
35
30
25
20
15
10
5
0
47
47
0.5
0.6
0.5
0.6
1.54
14.2
2.72
1
15.5
2.26
2.4
5.4
0.81
2.8
5.6
0.75
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 effluent
Cell # 3 Influent
Cell # 3 Effluent
NH4
NO3
NO2
Sampled on 7/20/2016

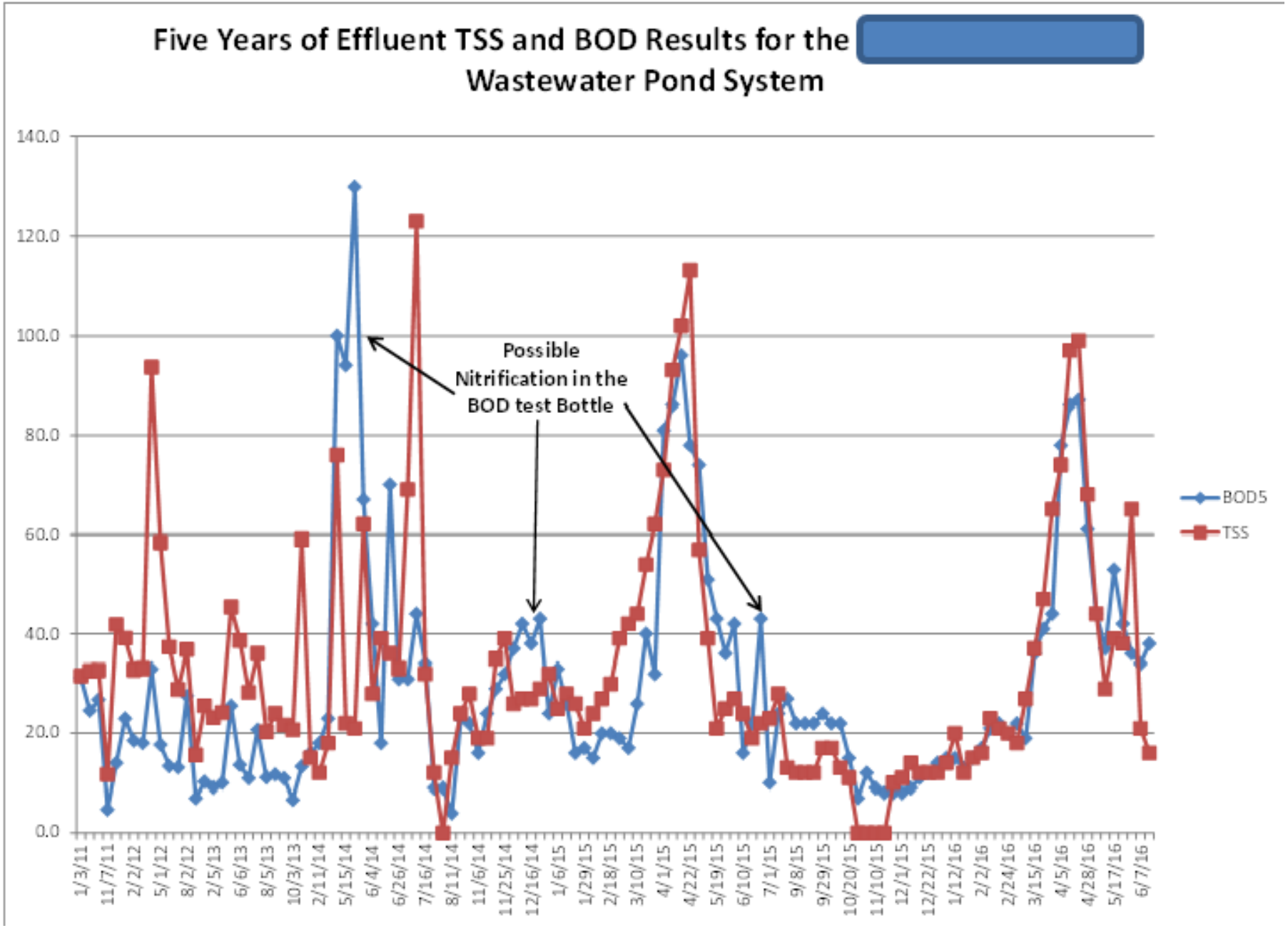

Intra-Pond Ammonia, Nitrate, Nitrite, and Alkalinity for the XXXXX Wastewater Pond system
400
350
300
250
200
150
100
50
0
47
0.5
0.6
400
47
0.5
0.6
400
1.54
14.2
2.72
288
1
15.5
2.26
333
2.4
5.4
0.81
326
2.8
5.6
0.75
327
Cell # 1 Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 effluent
Cell # 3 Influent
Cell # 3 Effluent
NH4
NO3
NO2
Alkalinity

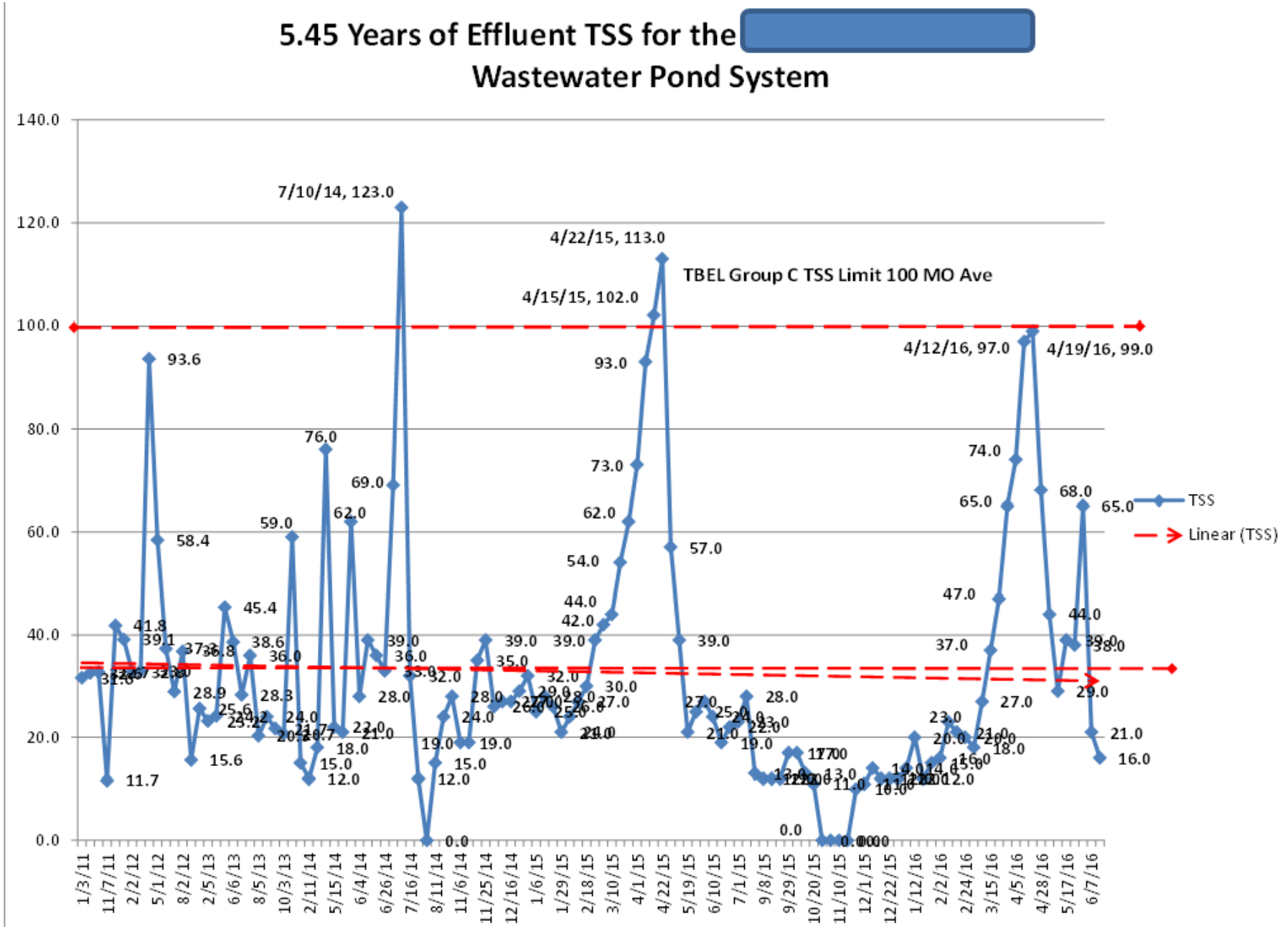

Sunrise and Noon Hour Dissolved Oxygen Concentrations Across all Three Treatment Cells of the XXXXXX Wastewater Pond System
10
9
8
7
6
5
4
3
2
1
0
3.6
2.14
6.49
6.57
3.45
8.9
5.59
8.47
3.13
2.97
3.31
9.26
0.35
0.23
0.26
0.23
0.94
1.11
0.94
0.41
0.82
0.65
0.8
0.79
Cell # 1 /point 1
Cell # 1/ Point 2
Cell # 1 / point 3
Cell # 1 / point 4
Cell # 2/ point 1
Cell # 2 / point 2
Cell # 2 / point 3
Cell # 2 / point 4
Cell # 3 / point 1
Cell # 3 / point 2
Cell # 3 / point 3
Cell # 3 / point 4
DO AM/Sunrise
DO PM/Noon
Sampled on 7/20/2016

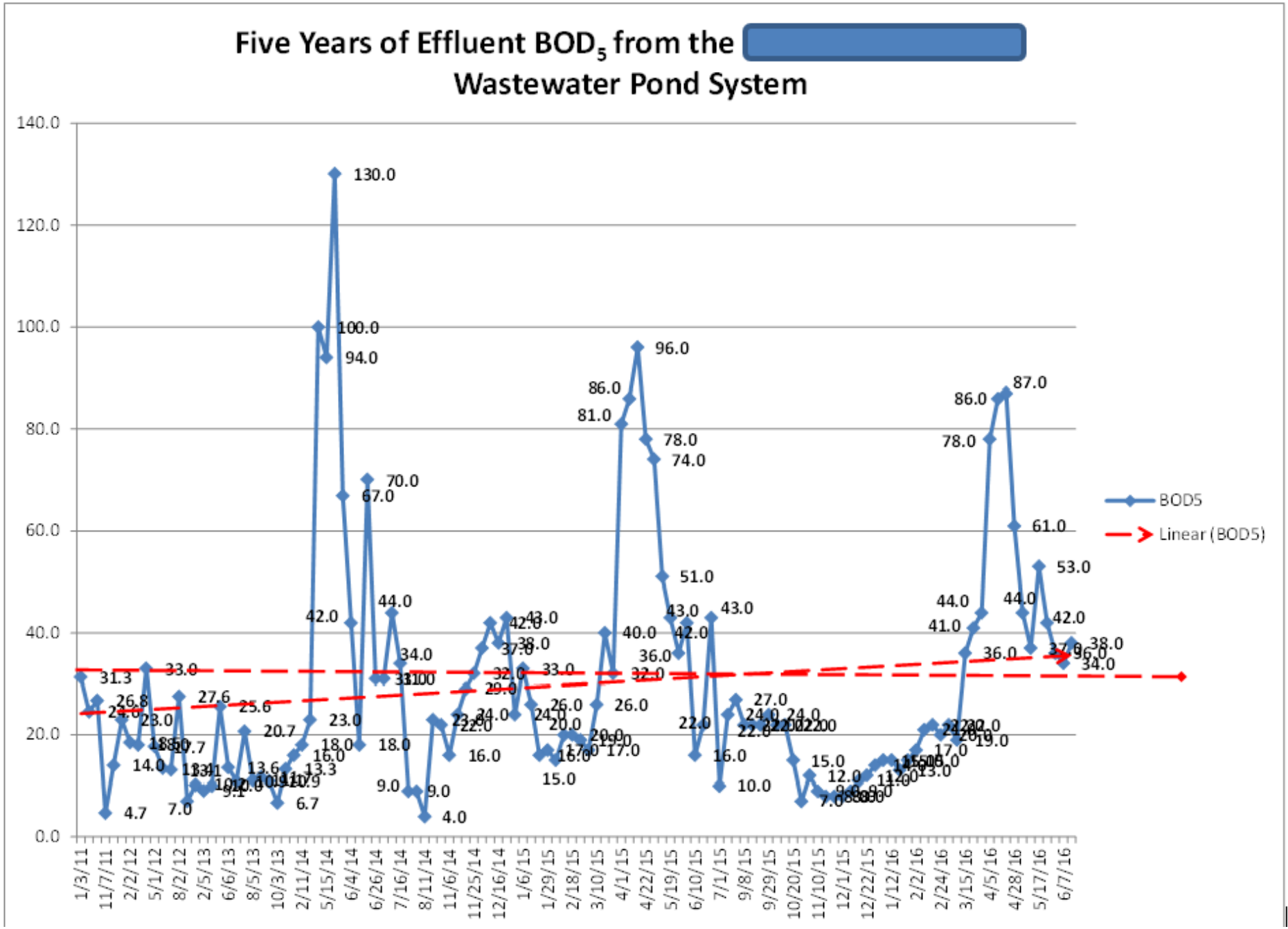

Dissolved Oxygen Profile for Cell # 1 at the XXXXXX Wastewater Pond System
Depth (ft)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.5
1
2
3
4
5
6
7
8
0.37
0.19
0.18
0.14
0.14
0.12
0.12
0.11
0.11
Dissolved Oxygen (mg/l)
Sampled on
7/20/2016 at 7:40 AM

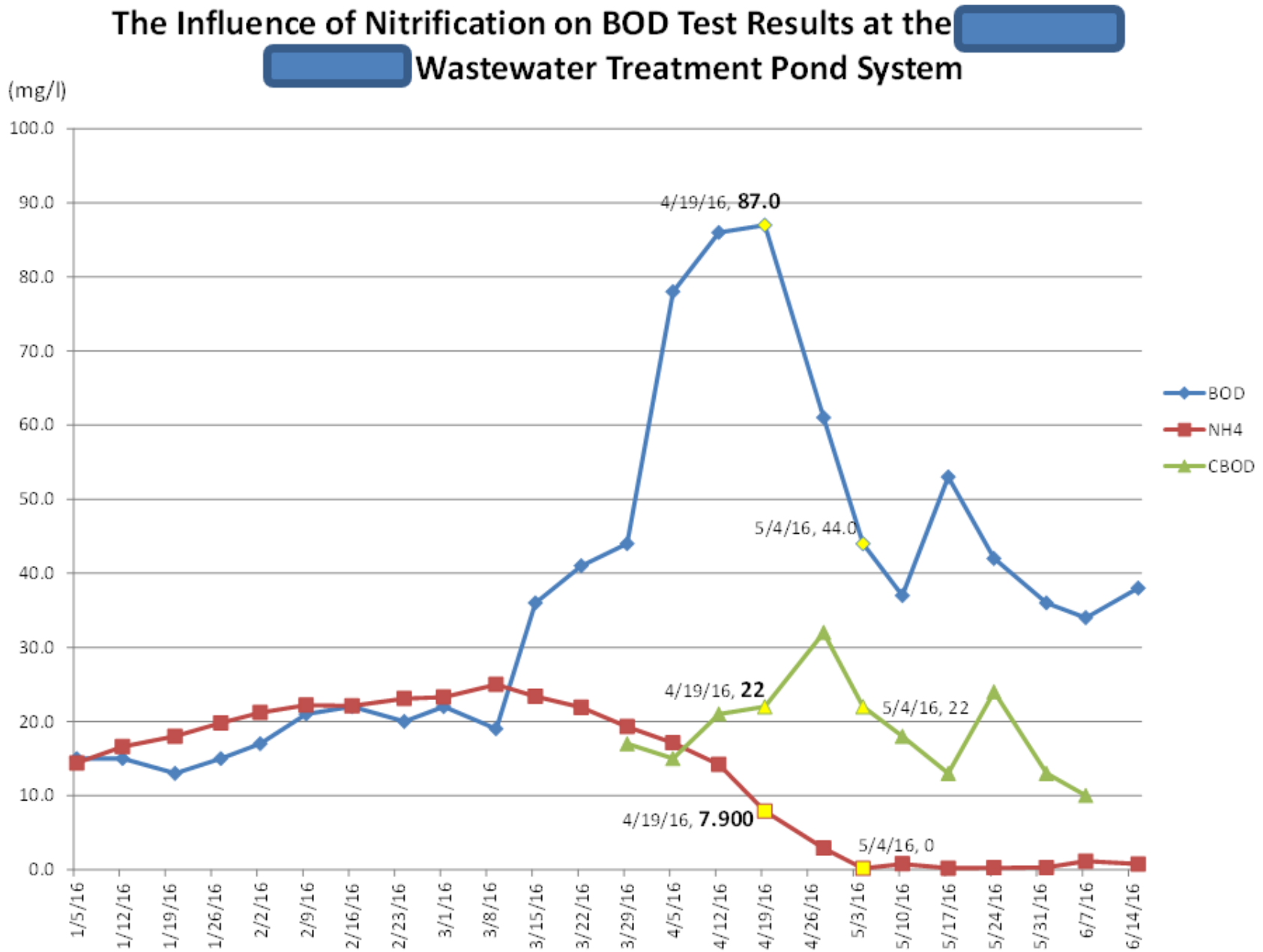

Dissolved Oxygen Profile for Cell # 2 at the XXXXXXXX Wastewater Pond System
0
0.1
0.2
0.3
0.4
0.5
0.6
0.5
1
2
3
4
5
6
7
8
9
10
0.6
0.35
0.27
0.2
0.23
0.18
0.19
0.17
0.14
0.13
0.11
Dissolved Oxygen (mg/l)
Sampled on 7/20/2016 at 8:19 AM

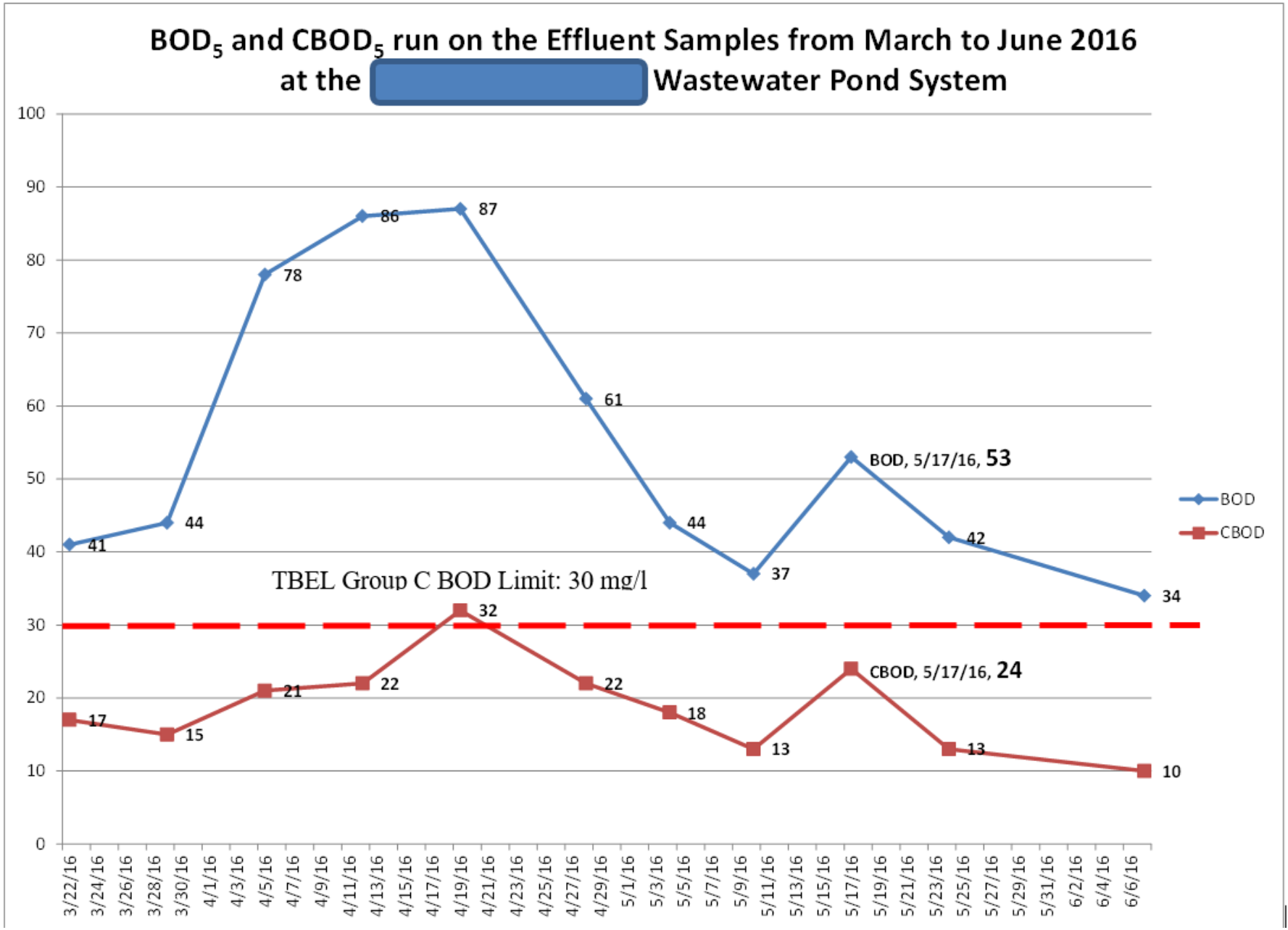

Dissolved Oxygen Profile for Cell # 3 at the XXXXXX Wastewater Pond System
0
0.1
0.2
0.3
0.4
0.5
0.6
0.5
1
2
3
4
5
6
7
0.57
0.58
0.49
0.44
0.45
0.42
0.41
0.43
Dissolved Oxygen (mg/l)
Sampled on 7/20/2016 at 8:52 AM

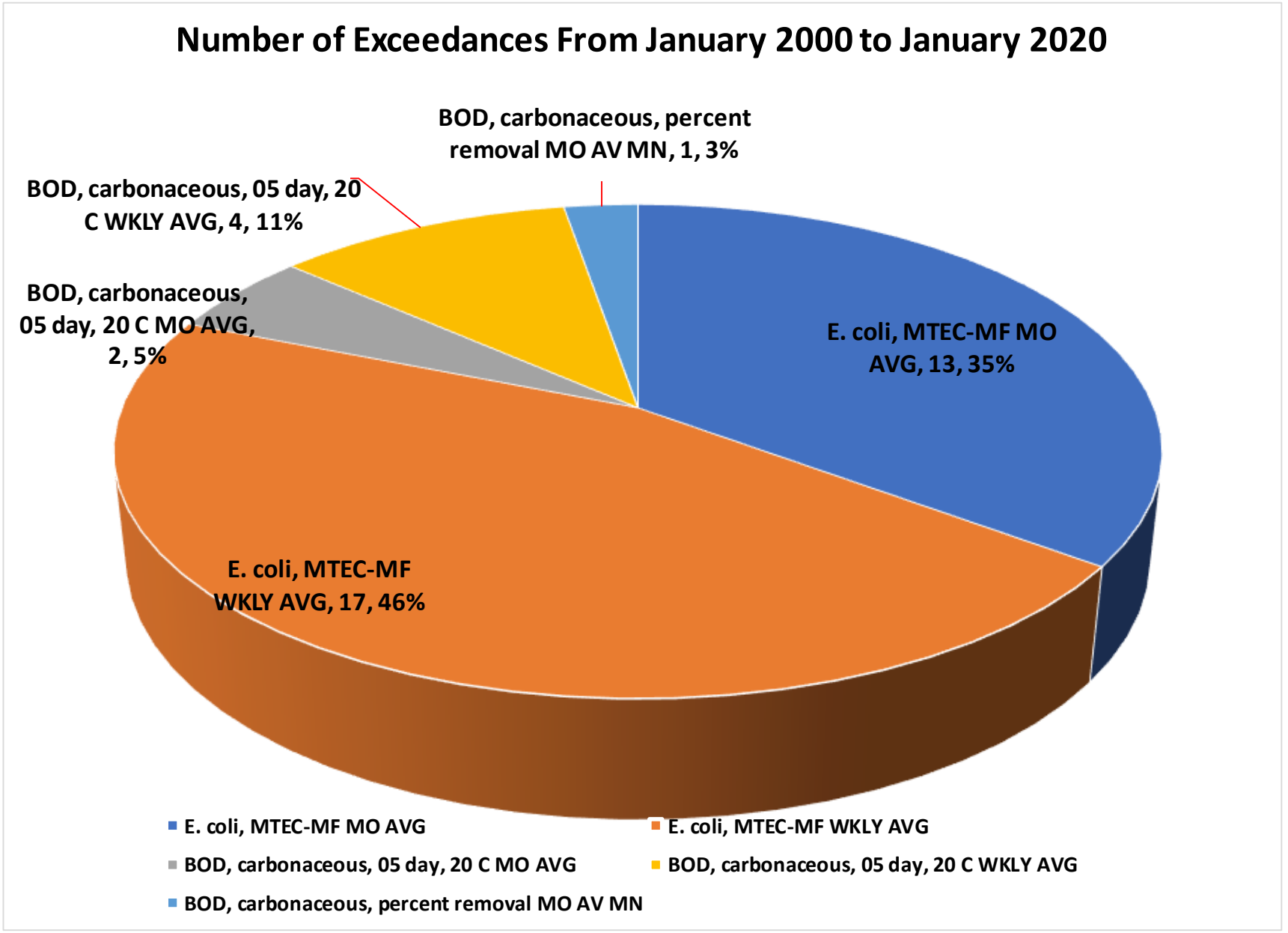

Five Years of Effluent TSS and BOD Results for the
Wastewater Pond System
Possible
Nitrification in the
BOD test Bottle
BOD5
TSS
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1/3/11
11/7/11
2/2/12
5/1/12
8/2/12
2/5/13
6/6/13
8/5/13
10/3/13
2/11/14
5/15/14
6/4/14
6/26/14
7/16/14
8/11/14
11/6/14
11/25/14
12/16/14
1/6/15
1/29/15
2/18/15
3/10/15
4/1/15
4/22/15
5/19/15
6/10/15
7/1/15
9/8/15
9/29/15
10/20/15
11/10/15
12/1/15
12/22/15
1/12/16
2/2/16
2/24/16
3/15/16
4/5/16
4/28/16
5/17/16
6/7/16


5.45 Years of Effluent TSS for the [redacted] Wastewater Pond System
TBEL Group C TSS Limit 100 MO Ave
TSS
Linear (TSS)
7/10/14, 123.0
4/22/15, 113.0
4/15/15, 102.0
4/12/16, 97.0
4/19/16, 99.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1/3/11
11/7/11
2/2/12
5/1/12
8/2/12
2/5/13
6/6/13
8/5/13
10/3/13
2/11/14
5/15/14
6/4/14
6/26/14
7/16/14
8/11/14
11/6/14
11/25/14
12/16/14
1/6/15
1/29/15
2/18/15
3/10/15
4/1/15
4/22/15
5/19/15
6/10/15
7/1/15
9/8/15
9/29/15
10/20/15
11/10/15
12/1/15
12/22/15
1/12/16
2/2/16
2/24/16
3/15/16
4/5/16
4/28/16
5/17/16
6/7/16


Five Years of Effluent BOD5 from the [redacted] Wastewater Pond System
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
BOD5
Linear (BOD5)
1/3/11
11/7/11
2/2/12
5/1/12
8/2/12
2/5/13
6/6/13
8/5/13
10/3/13
2/11/14
5/15/14
6/4/14
6/26/14
7/16/14
8/11/14
11/6/14
11/25/14
12/16/14
1/6/15
1/29/15
2/18/15
3/10/15
4/1/15
4/22/15
5/19/15
6/10/15
7/1/15
9/8/15
9/29/15
10/20/15
11/10/15
12/1/15
12/22/15
1/12/16
2/2/16
2/24/16
3/15/16
4/5/16
4/28/16
5/17/16
6/7/16

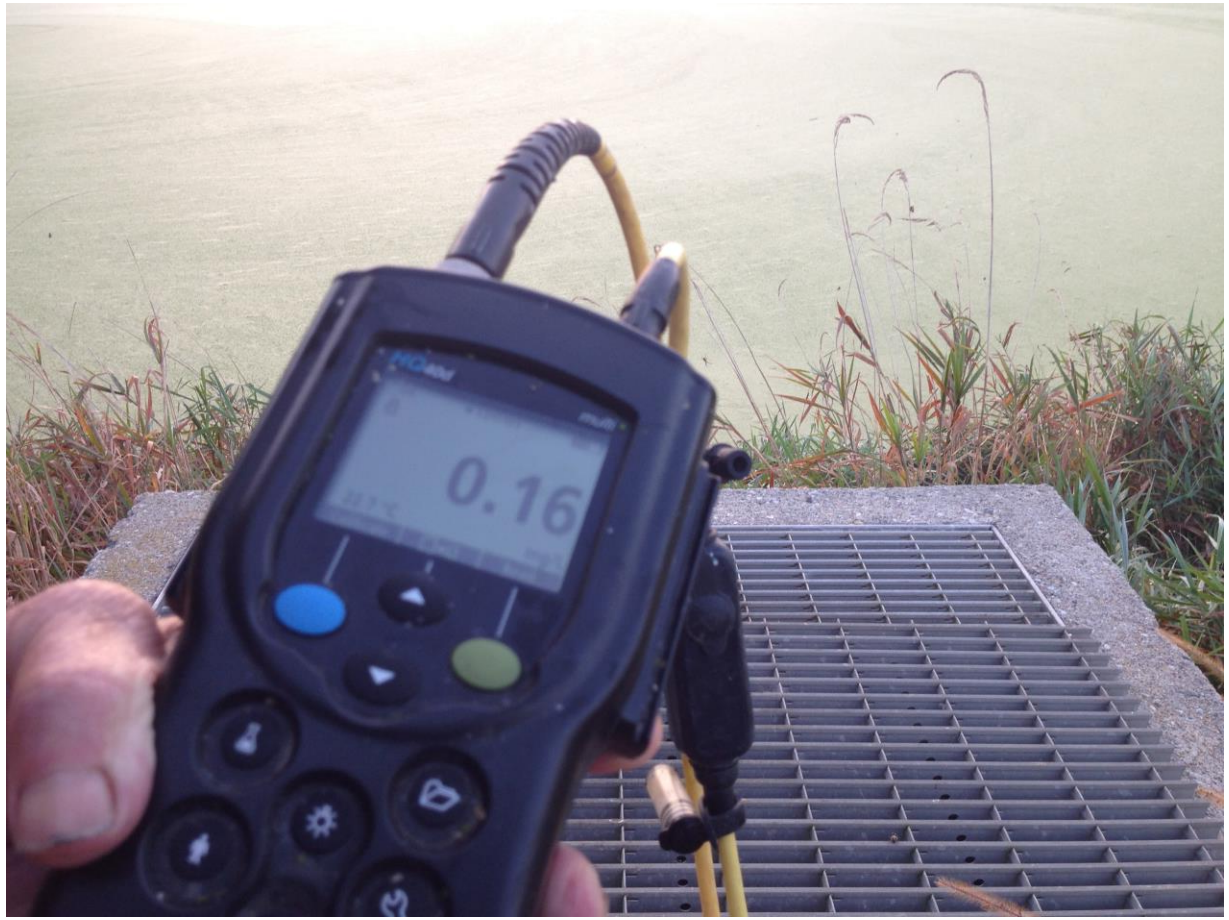

The Influence of Nitrification on BOD Test Results at the [redacted] Wastewater Treatment Pond System
(mg/l)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4/19/16, 87.0
5/4/16, 44.0
4/19/16, 22
5/4/16, 22
4/19/16, 7.900
5/4/16, 0
BOD
NH4
CBOD
1/5/16
1/12/16
1/19/16
1/26/16
2/2/16
2/9/16
2/16/16
2/23/16
3/1/16
3/8/16
3/15/16
3/22/16
3/29/16
4/5/16
4/12/16
4/19/16
4/26/16
5/3/16
5/10/16
5/17/16
5/24/16
5/31/16
6/7/16
6/14/16

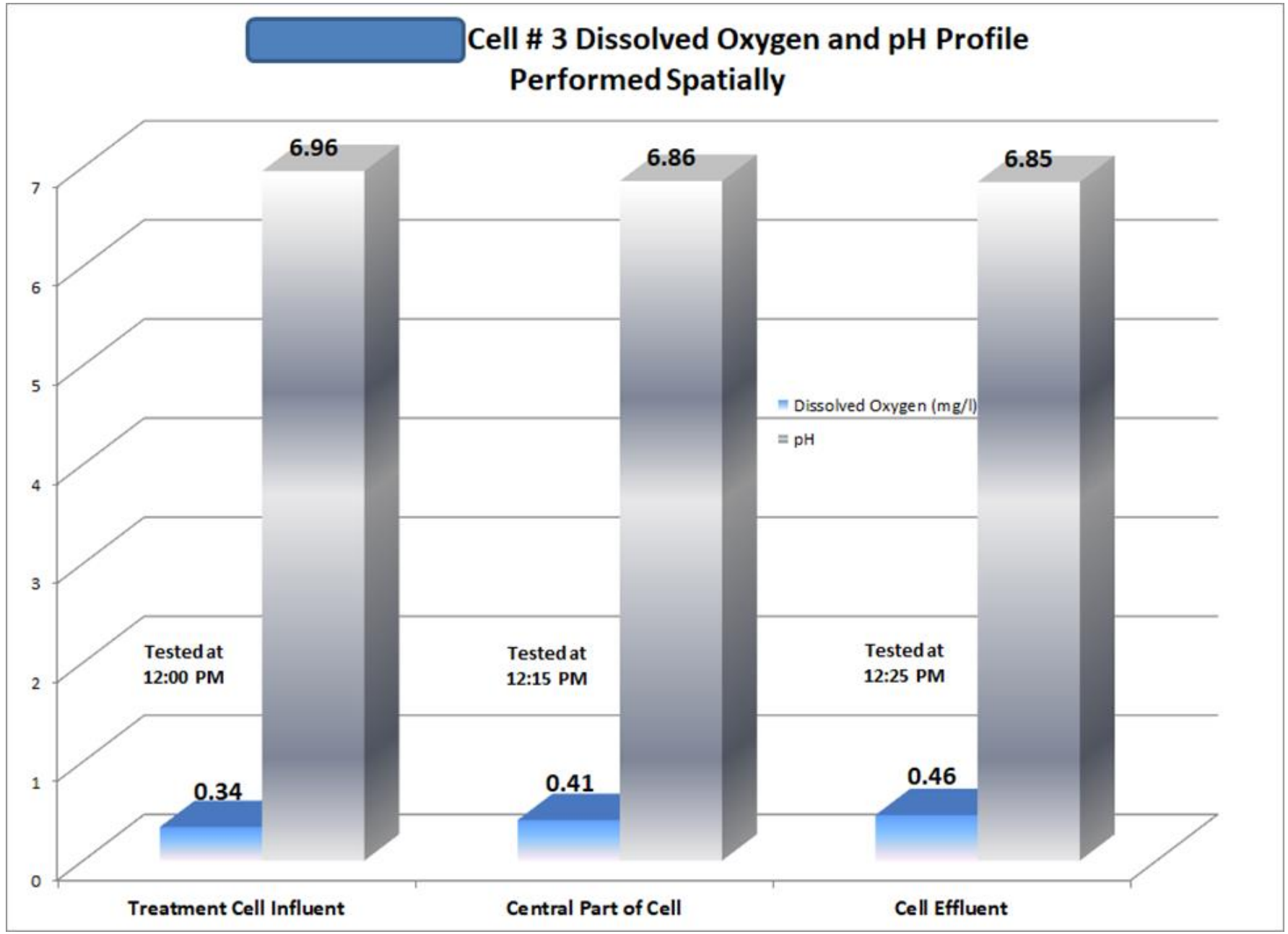

BOD5 and CBOD5 run on the Effluent Samples from March to June 2016
at the [redacted] Wastewater Pond System
100
90
80
70
60
50
40
30
20
10
0
41
44
78
86
87
61
44
37
53
42
34
17
15
21
22
32
22
18
13
24
13
10
TBEL Group C BOD Limit: 30 mg/l
BOD, 5/17/16, 53
CBOD, 5/17/16, 24
BOD
CBOD
3/22/16
3/24/16
3/26/16
3/28/16
3/30/16
4/1/16
4/3/16
4/5/16
4/7/16
4/9/16
4/11/16
4/13/16
4/15/16
4/17/16
4/19/16
4/21/16
4/23/16
4/25/16
4/27/16
4/29/16
5/1/16
5/3/16
5/5/16
5/7/16
5/9/16
5/11/16
5/13/16
5/15/16
5/17/16
5/19/16
5/21/16
5/23/16
5/25/16
5/27/16
5/29/16
5/31/16
6/2/16
6/4/16
6/6/16


Number of Exceedances From January 2000 to January 2020
BOD, carbonaceous, percent removal MO AV MN, 1, 3%
BOD, carbonaceous, 05 day, 20 C WKLY AVG, 4, 11%
BOD, carbonaceous, 05 day, 20 C MO AVG, 2, 5%
E. coli, MTEC-MF MO AVG, 13, 35%
E. coli, MTEC-MF WKLY AVG, 17, 46%
E. coli, MTEC-MF MO AVG
E. coli, MTEC-MF WKLY AVG
BOD, carbonaceous, 05 day, 20 C MO AVG
BOD, carbonaceous, 05 day, 20 C WKLY AVG
BOD, carbonaceous, percent removal MO AV MN

A Word About Duckweed

Duckweed


0.16


Cell # 3 Dissolved Oxygen and pH Profile
Performed Spatially
7
6
5
4
3
2
1
0
6.96
6.86
6.85
0.34
0.41
0.46
Tested at
12:00 PM
Tested at
12:15 PM
Tested at
12:25 PM
Dissolved Oxygen (mg/l)
pH
Treatment Cell Influent
Central Part of Cell
Cell Effluent

Ninteen Years and Eight Months of TSS Data Arranged by Month





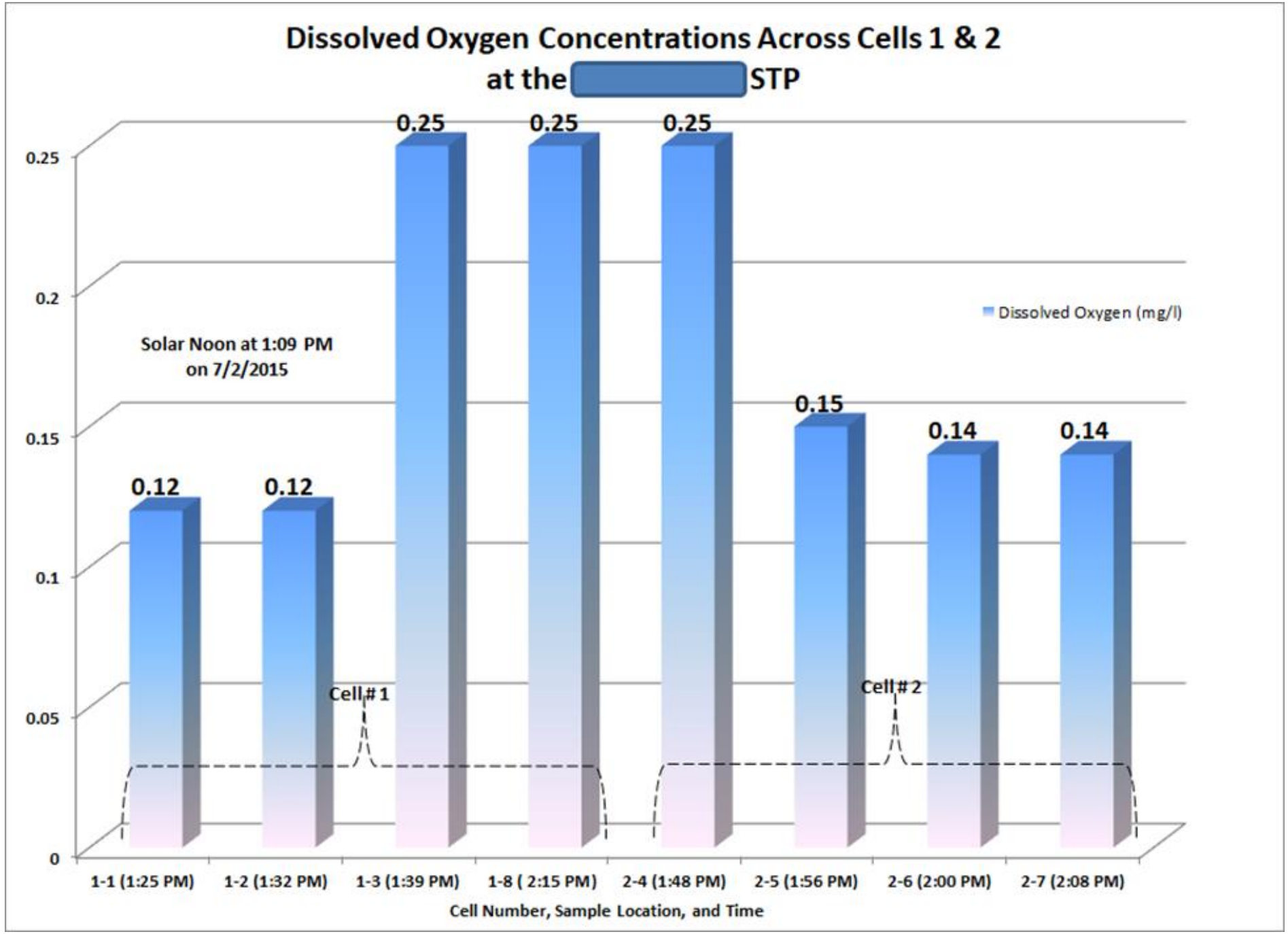


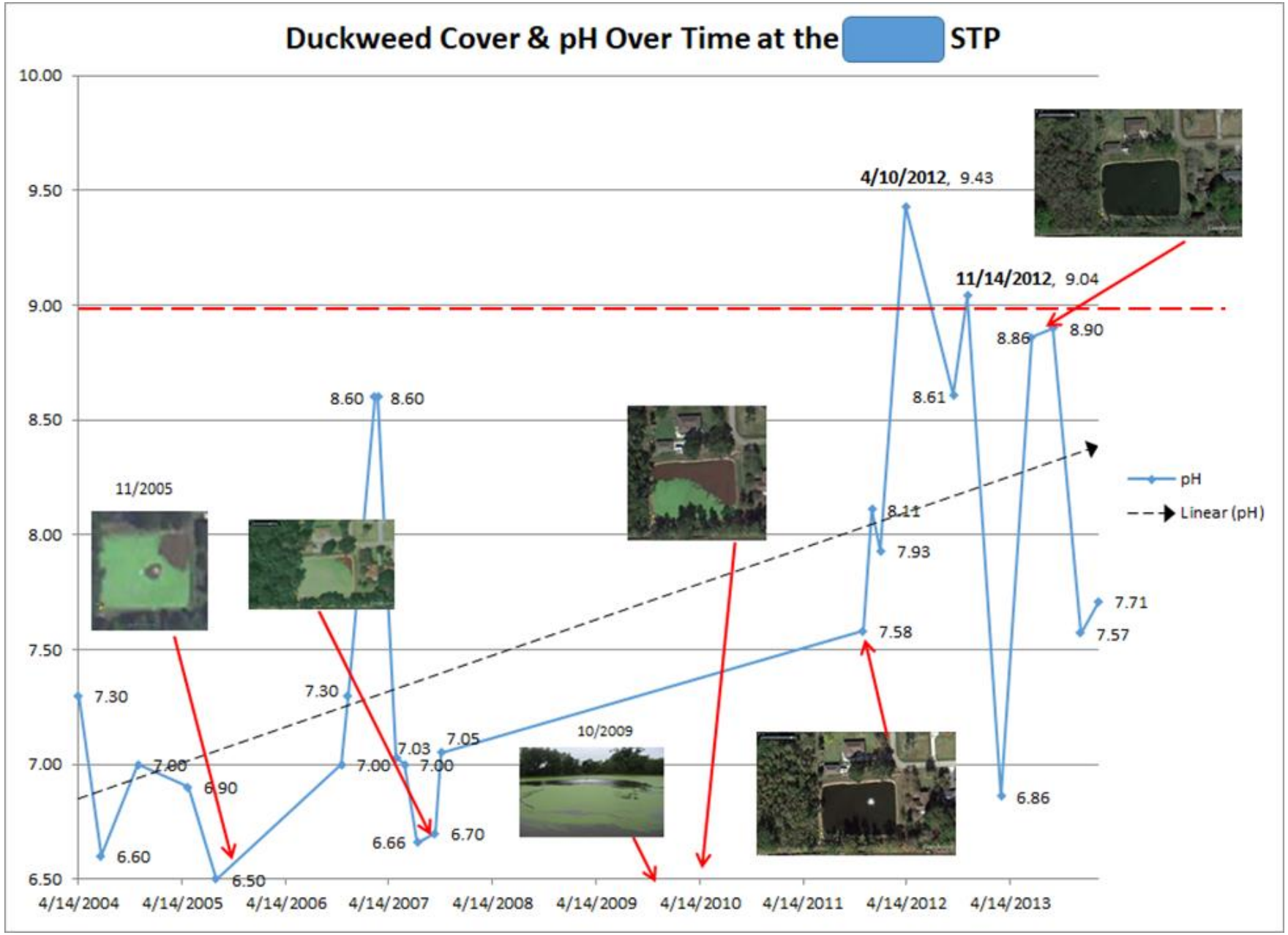
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
25.52	24.02	41.25	41.21	47.38	28.58	24.78	28.93	26.21	32.52	29.06	24.37

50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00

Total

Date

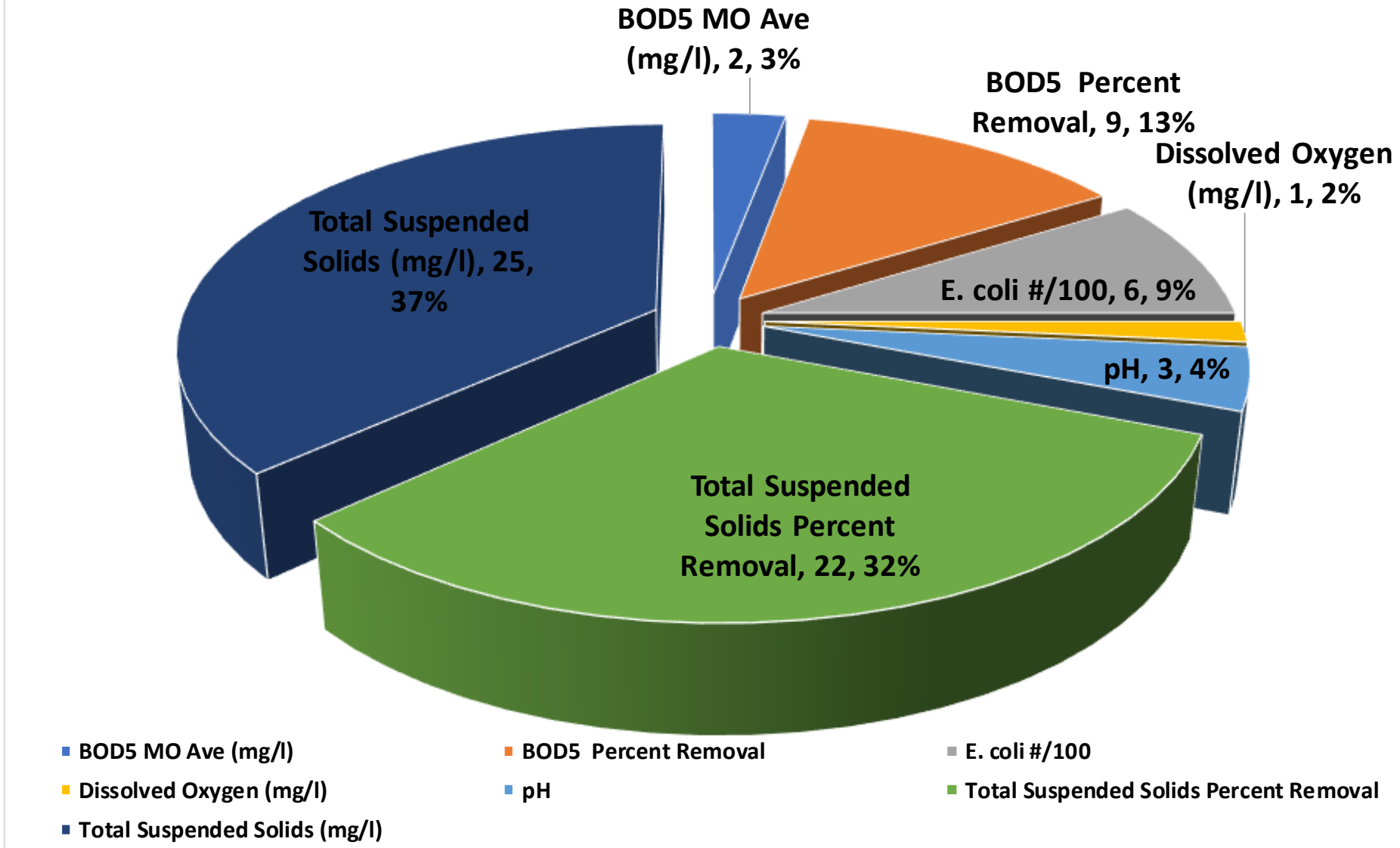

Dissolved Oxygen Concentrations Across Cells 1 & 2
at the STP
0.25
0.2
0.15
0.1
0.05
0
Solar Noon at 1:09 PM
on 7/2/2015
Dissolved Oxygen (mg/l)
0.12
0.12
0.25
0.25
0.25
0.15
0.14
0.14
Cell # 1
Cell # 2
1-1 (1:25 PM)
1-2 (1:32 PM)
1-3 (1:39 PM)
1-8 (2:15 PM)
2-4 (1:48 PM)
2-5 (1:56 PM)
2-6 (2:00 PM)
2-7 (2:08 PM)
Cell Number, Sample Location, and Time


Duckweed Cover & pH Over Time at the [redacted] STP
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
4/14/2004
4/14/2005
4/14/2006
4/14/2007
4/14/2008
4/14/2009
4/14/2010
4/14/2011
4/14/2012
4/14/2013
11/2005
10/2009
4/10/2012, 9.43
11/14/2012, 9.04
8.60
8.60
8.61
8.86
8.90
8.11
7.93
7.71
7.57
7.58
7.30
7.30
7.00
7.00
7.03
7.05
7.00
6.90
6.60
6.50
6.66
6.70
6.86
pH
Linear (pH)

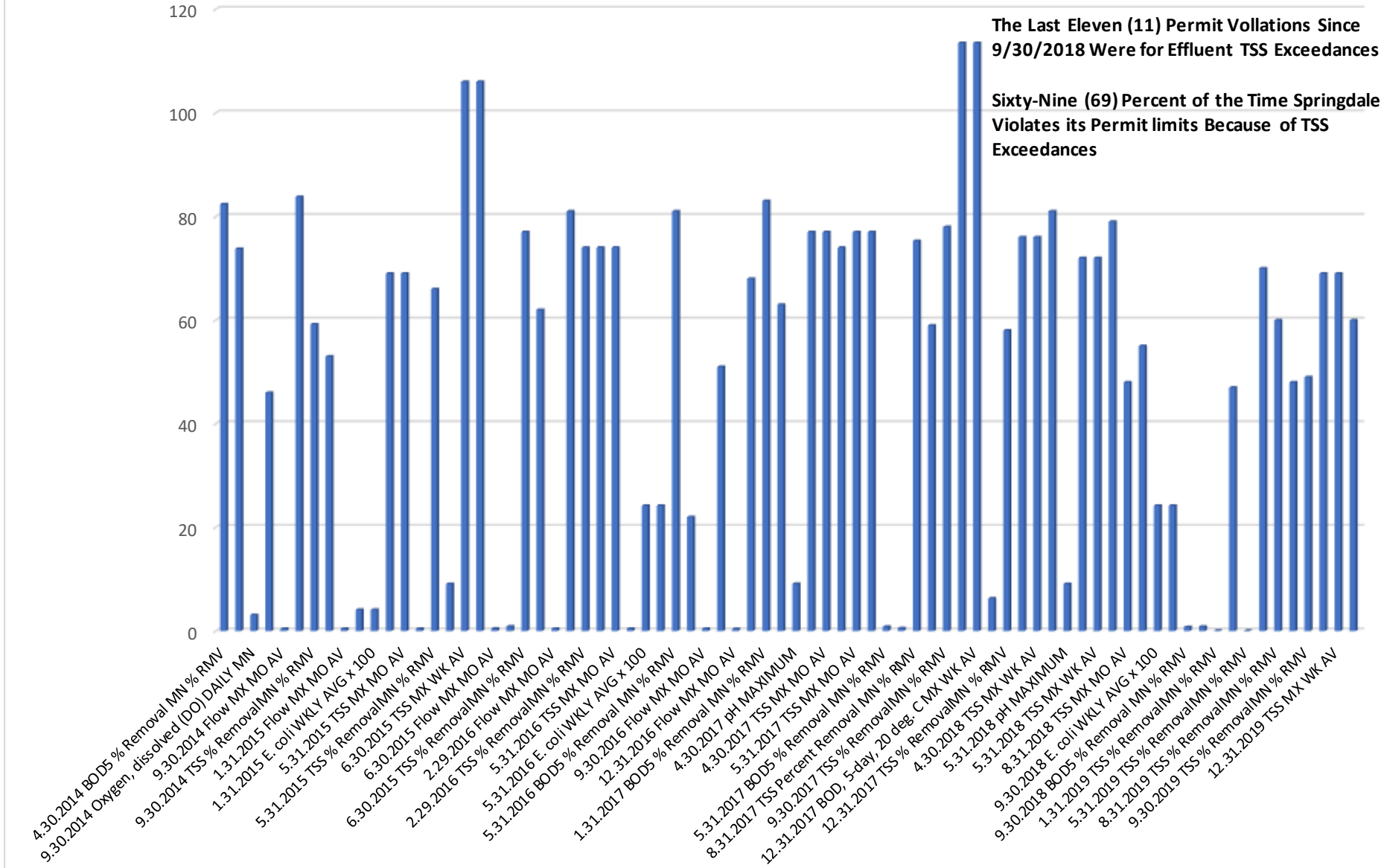
TSS violations due to dilute influent and too much sludge

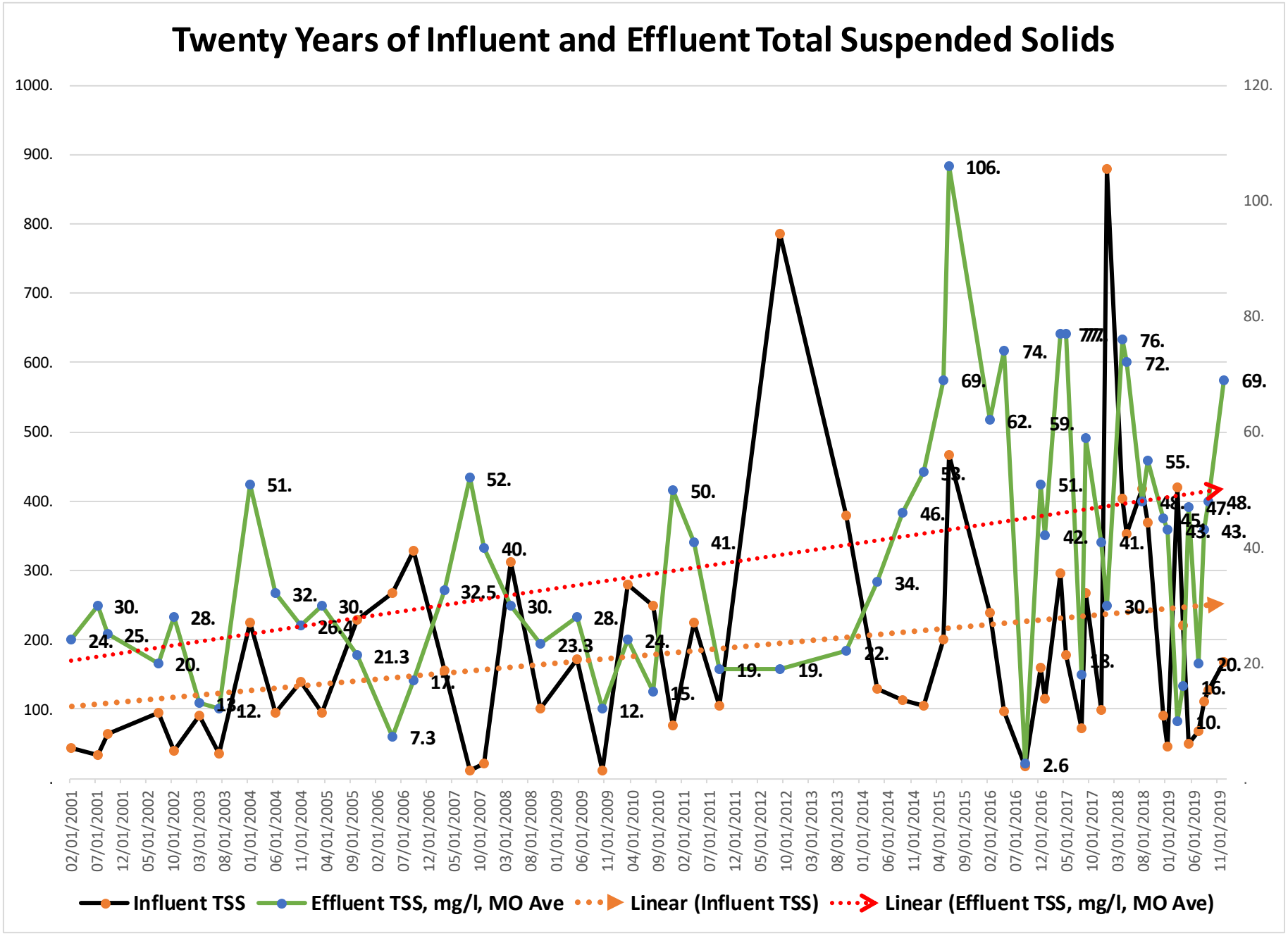
Case # 8

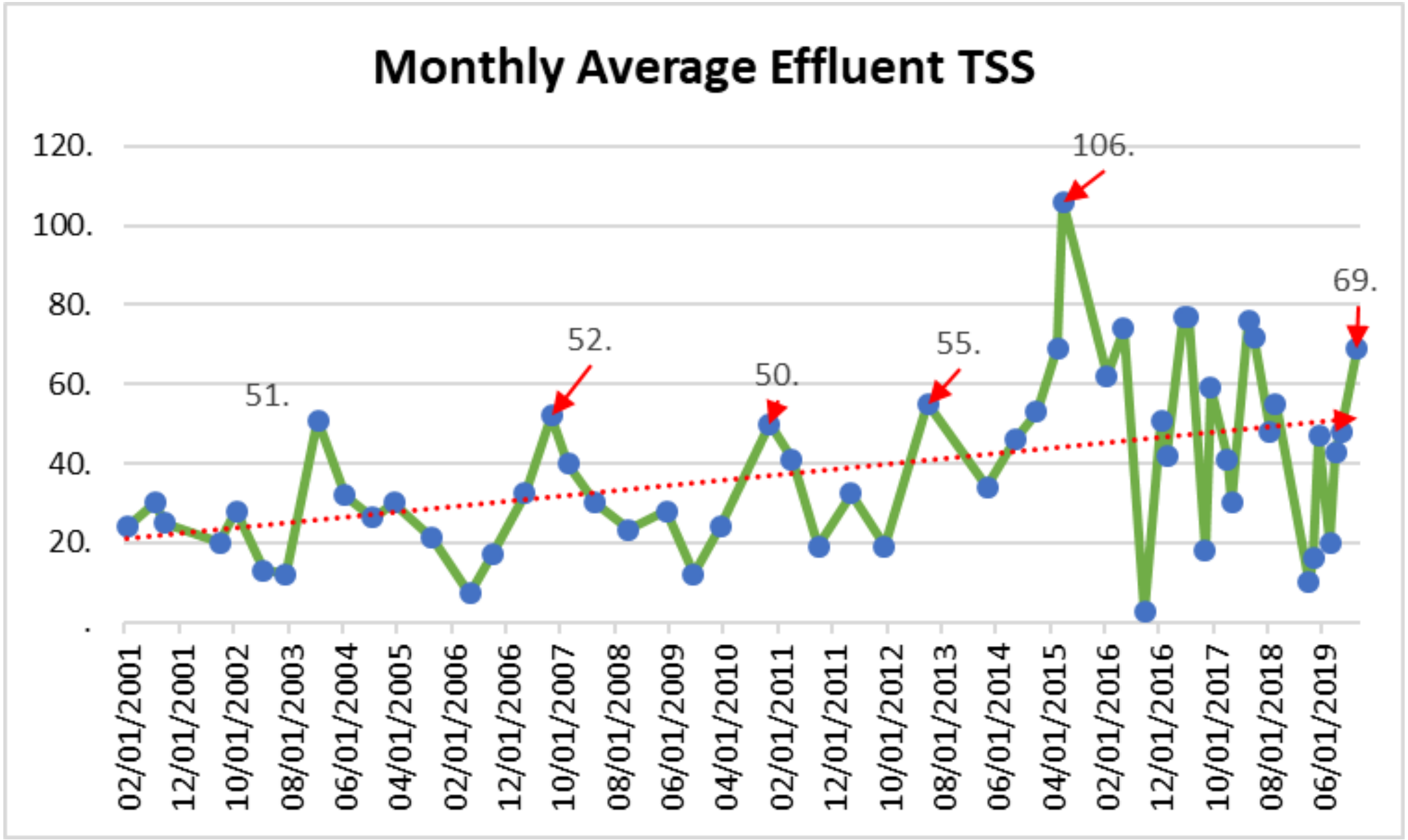
Number of Violations by Type Over the Past Five Years and Eight Months for the XXXX Wastewater Pond System

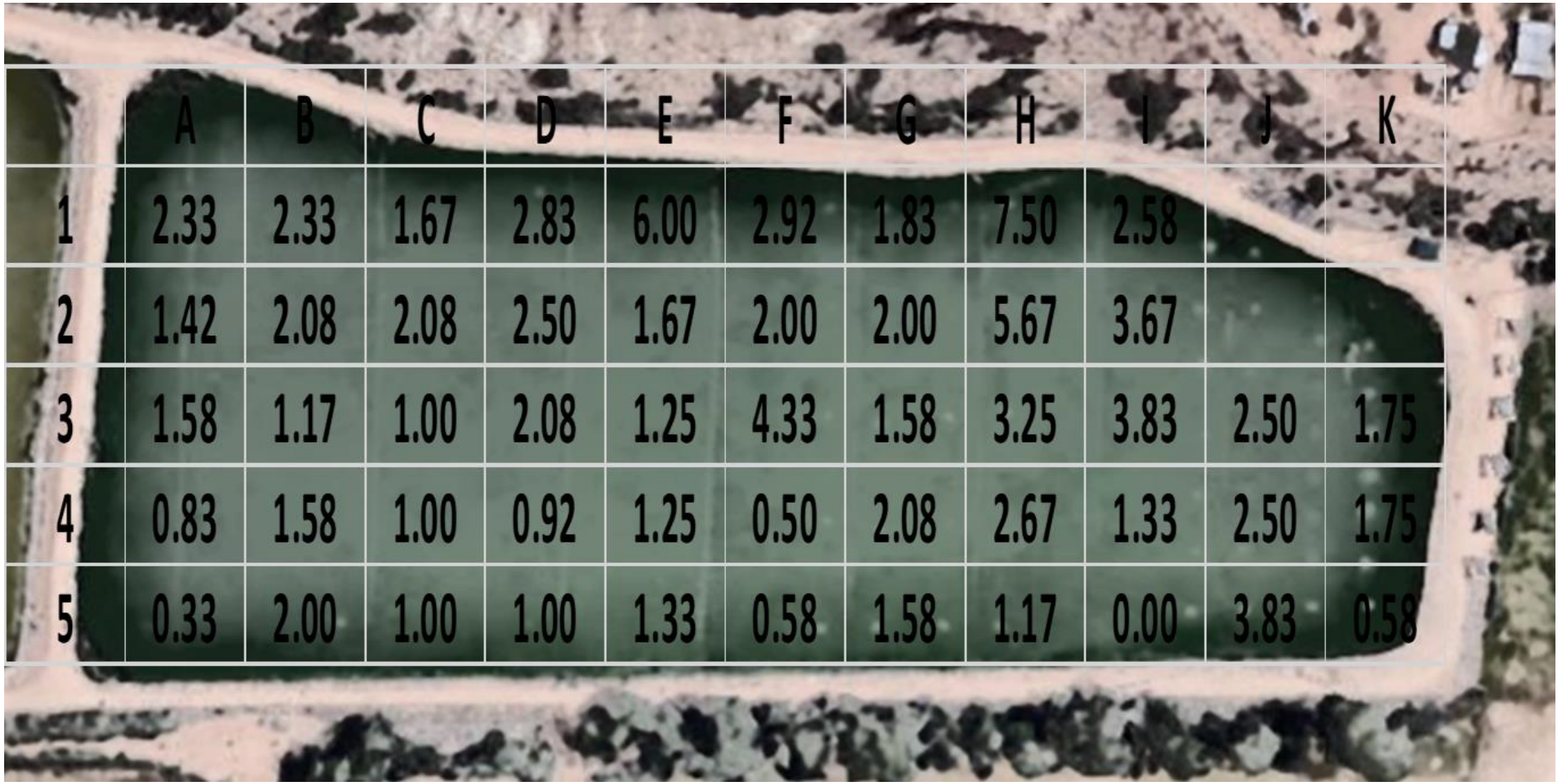


Five Years and Eight Months of Permit Violations for the XXXXX Wastwater Pond system



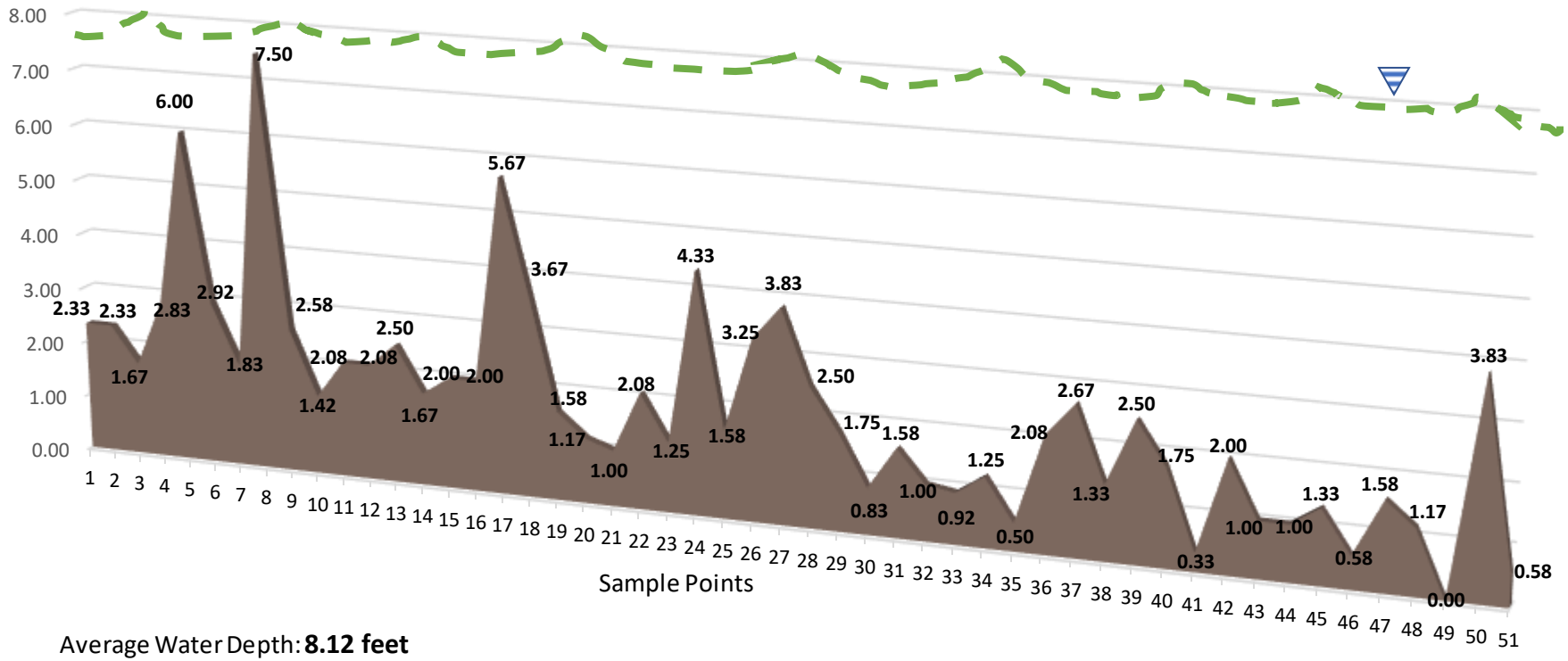

Twenty Years of Influent and Effluent Total Suspended Solids
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
.
120.
100.
80.
60.
40.
20.
.
02/01/2001
07/01/2001
12/01/2001
05/01/2002
10/01/2002
03/01/2003
08/01/2003
01/01/2004
06/01/2004
11/01/2004
04/01/2005
09/01/2005
02/01/2006
07/01/2006
12/01/2006
05/01/2007
10/01/2007
03/01/2008
08/01/2008
01/01/2009
06/01/2009
11/01/2009
04/01/2010
09/01/2010
02/01/2011
07/01/2011
12/01/2011
05/01/2012
10/01/2012
03/01/2013
08/01/2013
01/01/2014
06/01/2014
11/01/2014
04/01/2015
09/01/2015
02/01/2016
07/01/2016
12/01/2016
05/01/2017
10/01/2017
03/01/2018
08/01/2018
01/01/2019
06/01/2019
11/01/2019
Influent TSS
Effluent TSS, mg/l, MO Ave
Linear (Influent TSS)
Linear (Effluent TSS, mg/l, MO Ave)


Monthly Average Effluent TSS
120.
100.
80.
60.
40.
20.
.
51.
52.
50.
55.
106.
69.
02/01/2001
12/01/2001
10/01/2002
08/01/2003
06/01/2004
04/01/2005
02/01/2006
12/01/2006
10/01/2007
08/01/2008
06/01/2009
04/01/2010
02/01/2011
12/01/2011
10/01/2012
08/01/2013
06/01/2014
04/01/2015
02/01/2016
12/01/2016
10/01/2017
08/01/2018
06/01/2019



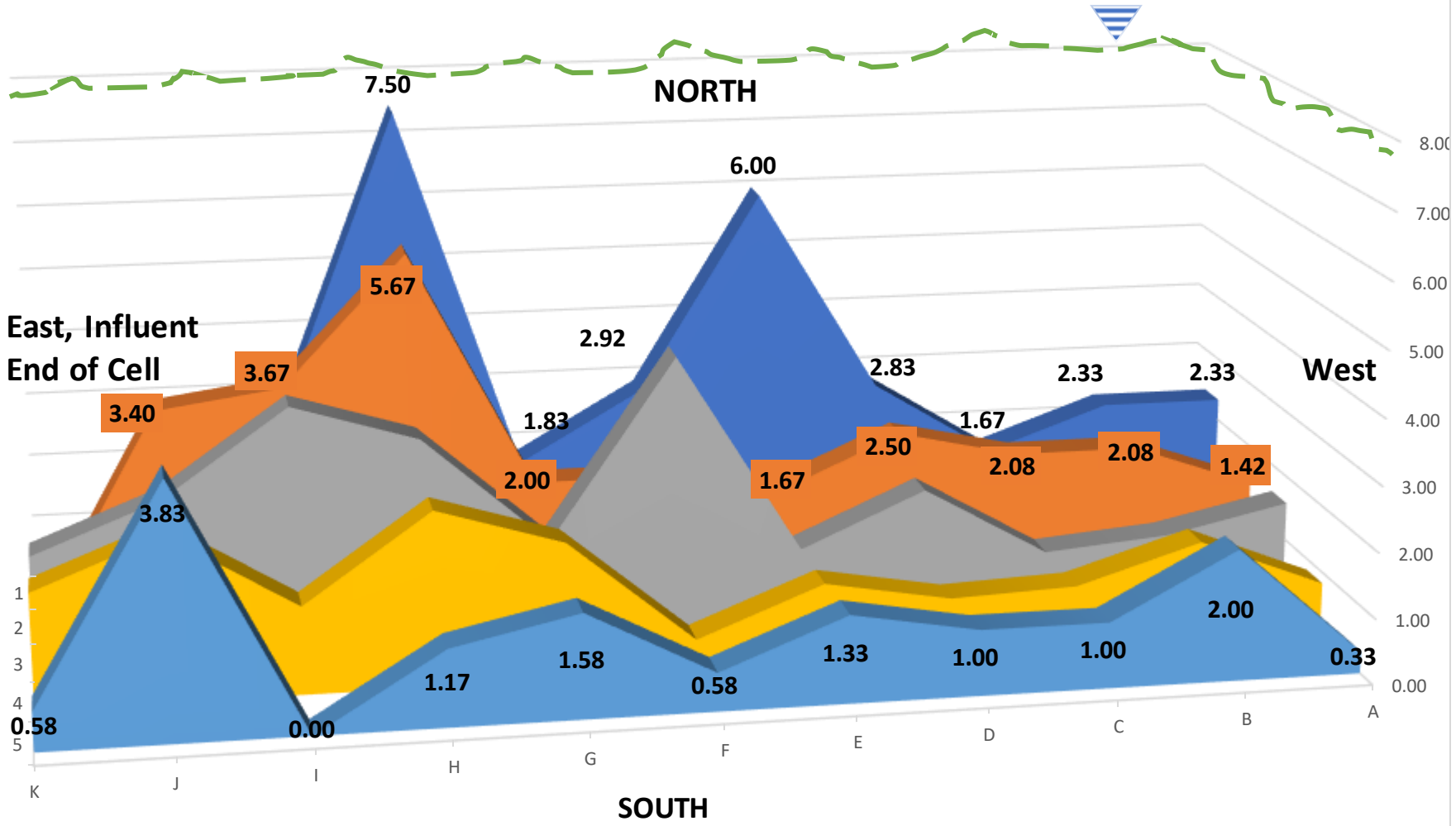
	A	B	C	D	E	F	G	H	I	J	K
1	2.33	2.33	1.67	2.83	6.00	2.92	1.83	7.50	2.58		
2	1.42	2.08	2.08	2.50	1.67	2.00	2.00	5.67	3.67		
3	1.58	1.17	1.00	2.08	1.25	4.33	1.58	3.25	3.83	2.50	1.75
4	0.83	1.58	1.00	0.92	1.25	0.50	2.08	2.67	1.33	2.50	1.75
5	0.33	2.00	1.00	1.00	1.33	0.58	1.58	1.17	0.00	3.83	0.58

Sludge Blanket Thickness Relative to the Water Depth of Cell # 1 at the XXXXX Wastewater Pond System

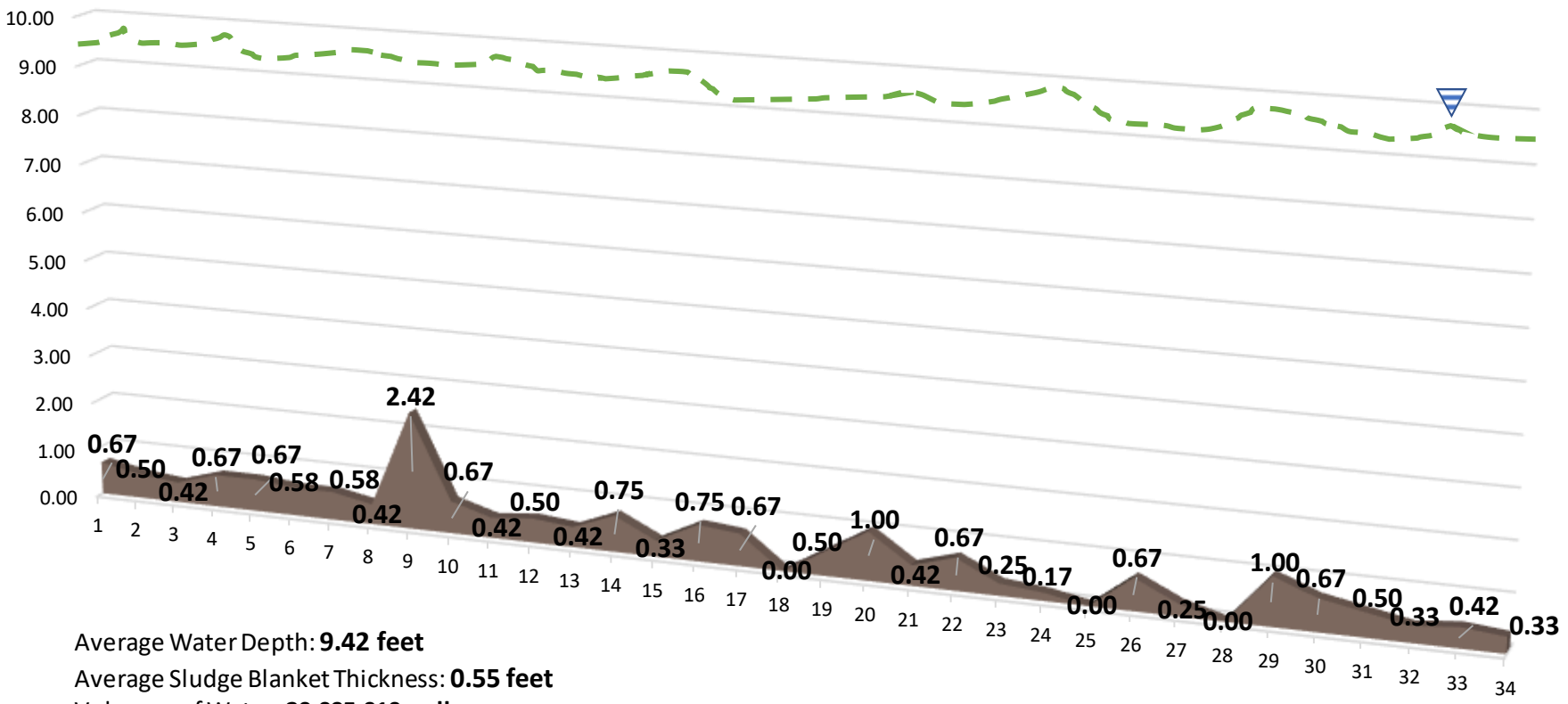


Average Water Depth: **8.12 feet**
Average Sludge Blanket Thickness: **2.10 feet**
Volume of Water: **20,313,776 gallons**
Volume of Sludge: **7,124,938 gallons**
Water Cap Remaining to Treat the Daily Load: **6.02 feet**

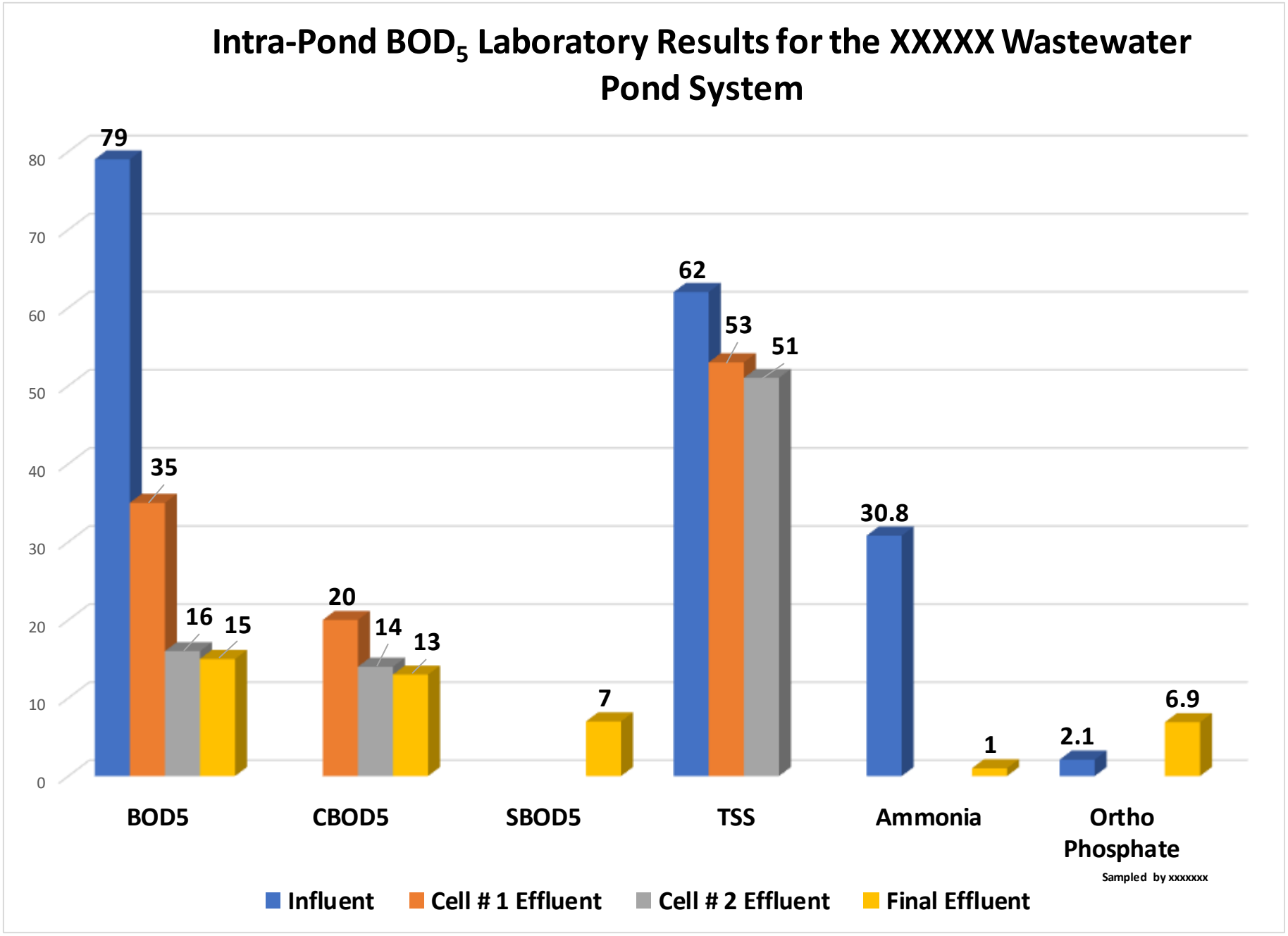
Sludge Accumulation in Cell # 1 Relative to Water Depth



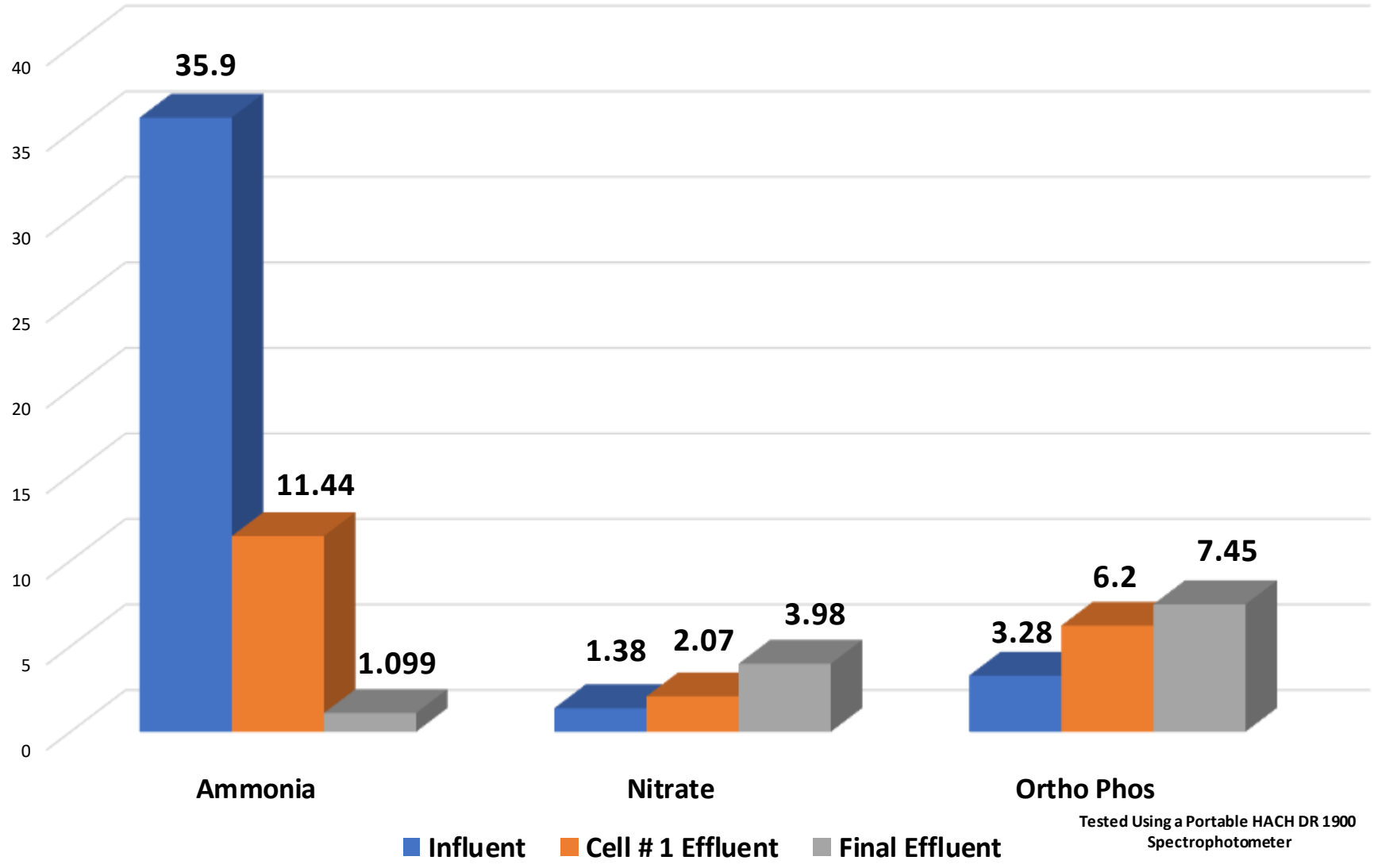
Cell # 2 Sludge Blanket Thickness Relative to Average Water Depth at the XXXXXX Wastewater Pond System

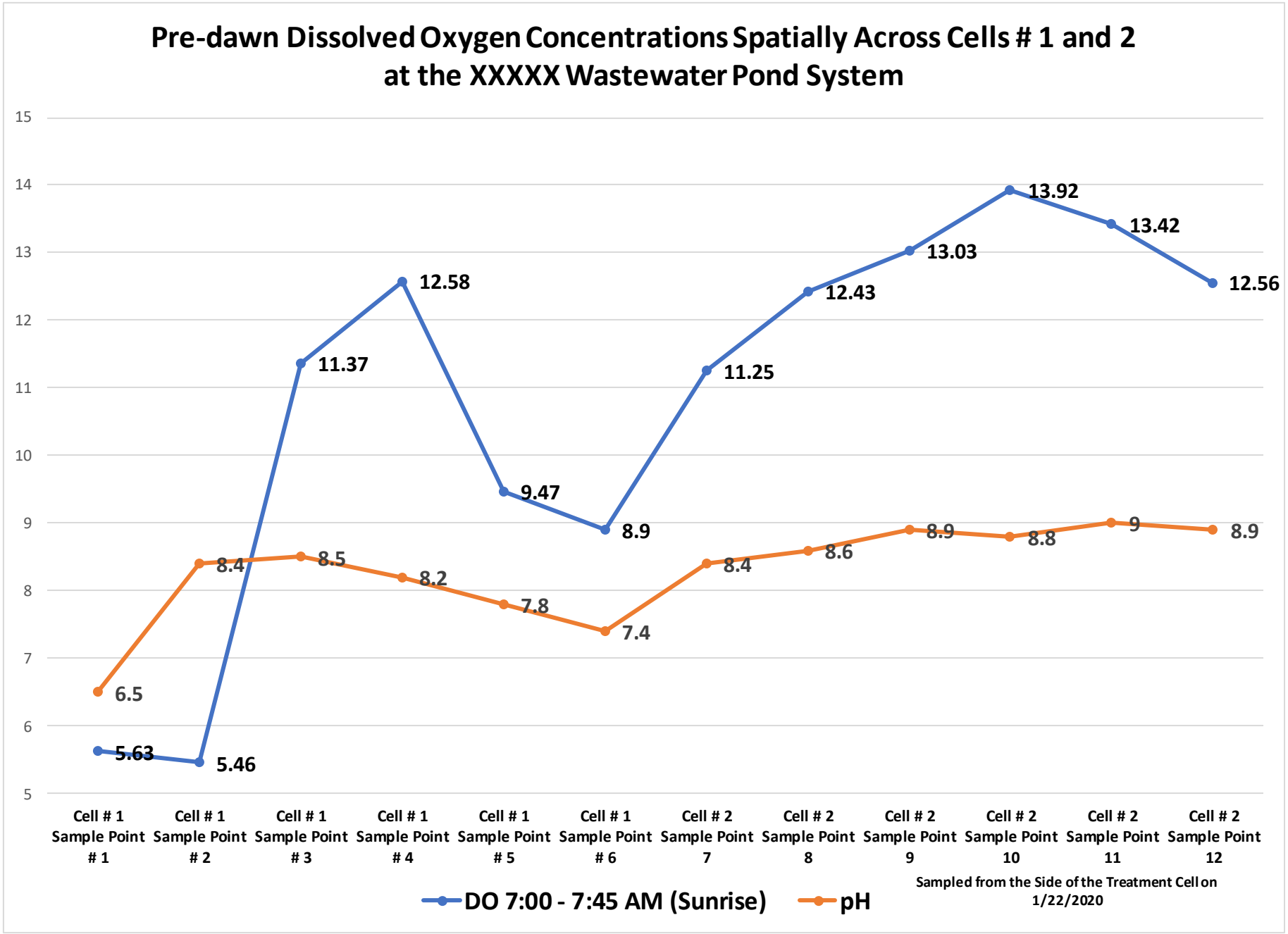


Average Water Depth: **9.42 feet**
Average Sludge Blanket Thickness: **0.55 feet**
Volunme of Water: **30,095,010 gallons**
Volume of Sludge: **1,806,838 gallons**
Water Cap remaining Over Sludge: **8.87 feet**

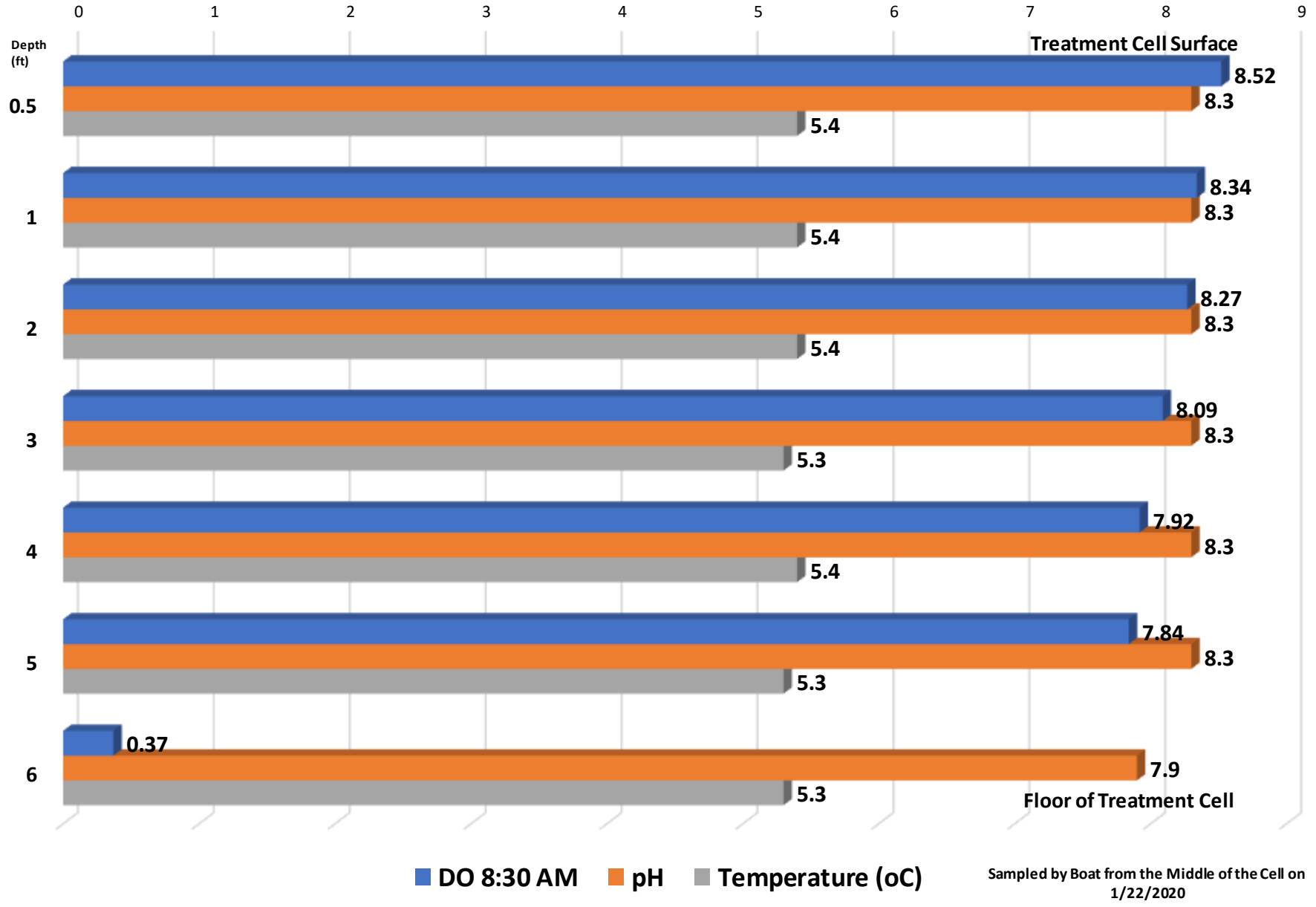

Intra-Pond BOD_5 Laboratory Results for the XXXXX Wastewater Pond System
80
70
60
50
40
30
20
10
0
79
35
16
15
20
14
13
7
62
53
51
30.8
1
2.1
6.9
BOD5
CBOD5
SBOD5
TSS
Ammonia
Ortho Phosphate
Sampled by xxxxxxx
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent

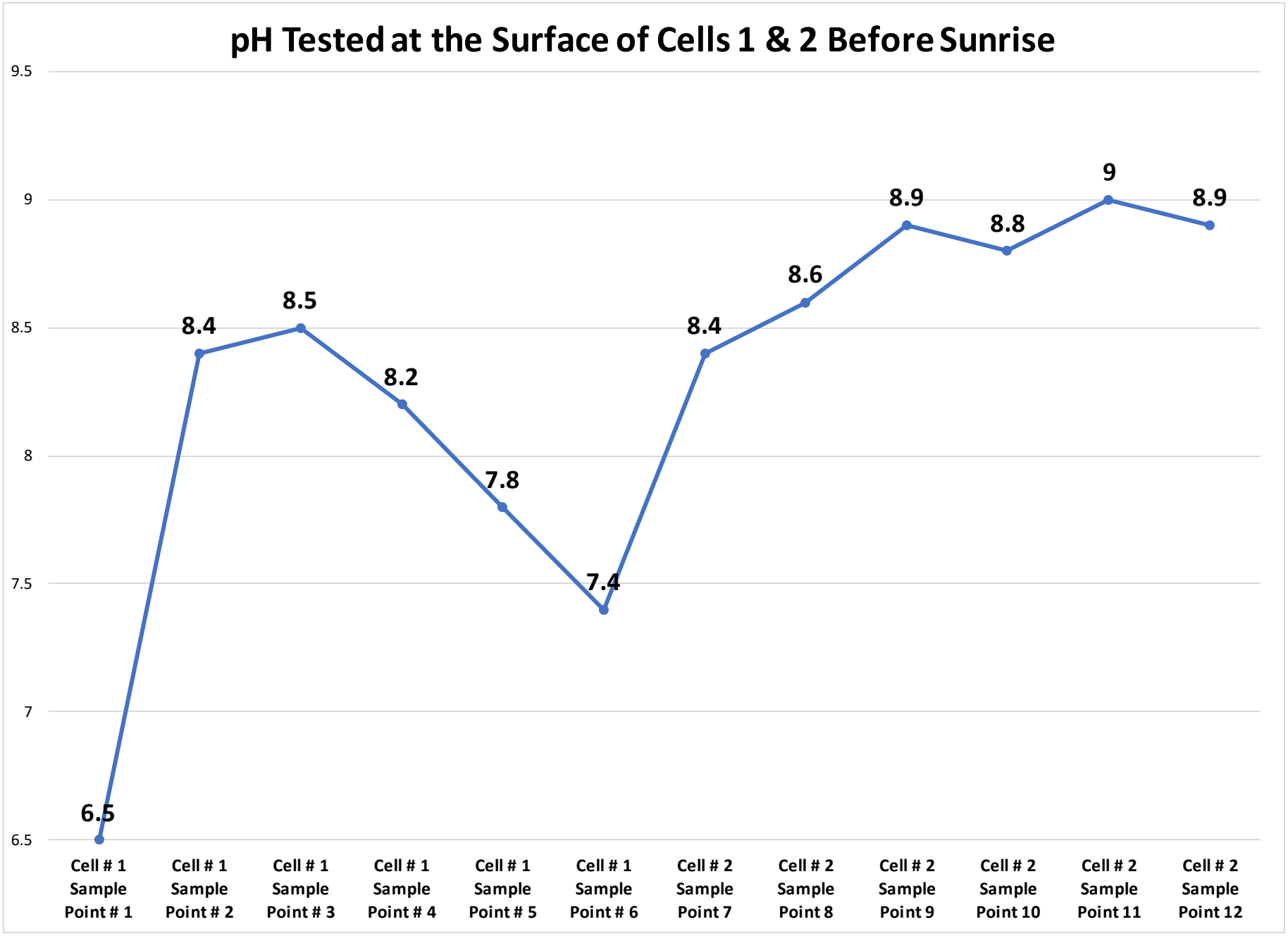
Field Nutrient Sampling Results on January 24, 2020

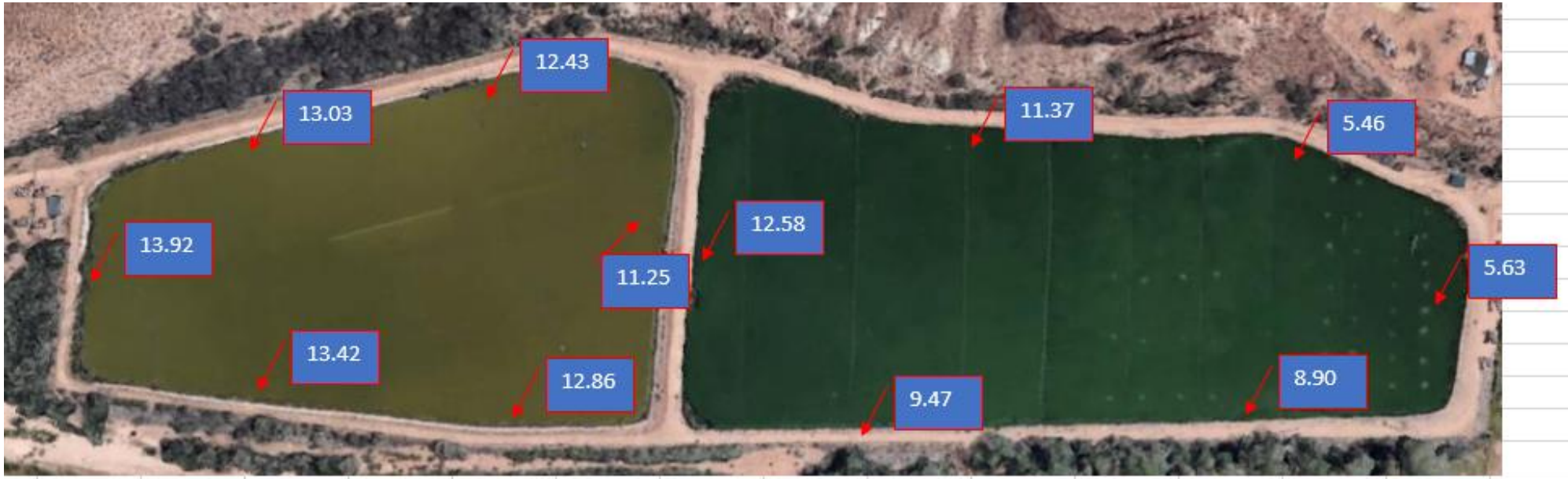


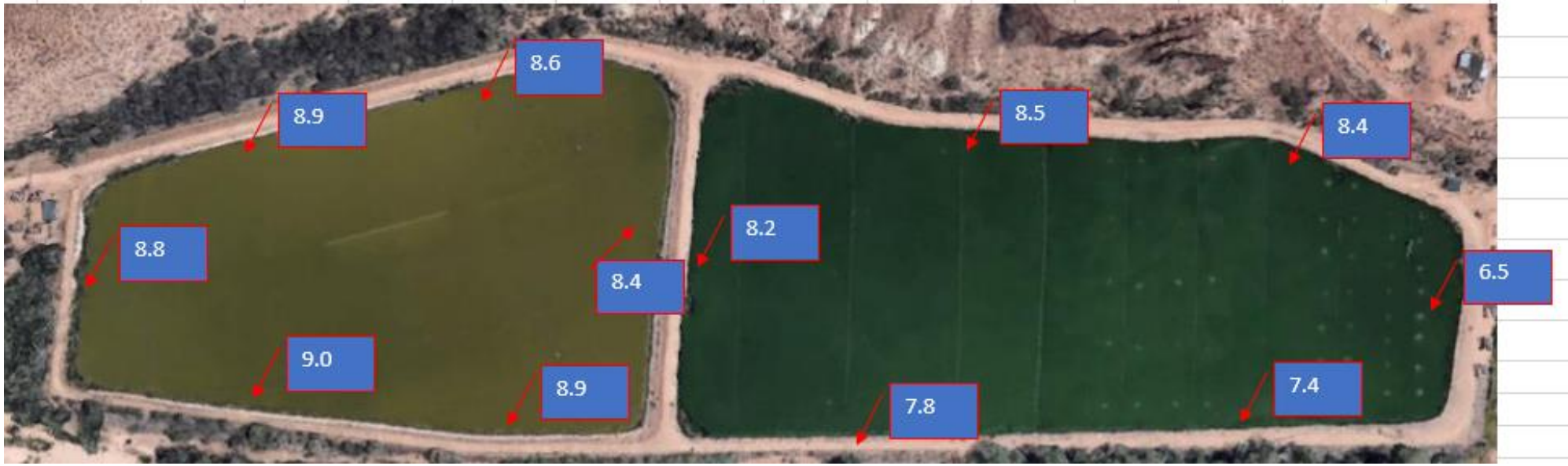

Pre-dawn Dissolved Oxygen Concentrations Spatially Across Cells # 1 and 2 at the XXXXX Wastewater Pond System
15
14
13
12
11
10
9
8
7
6
5
5.63
5.46
11.37
12.58
9.47
8.9
11.25
12.43
13.03
13.92
13.42
12.56
6.5
8.4
8.5
8.2
7.8
7.4
8.4
8.6
8.9
8.8
9
8.9
Cell # 1 Sample Point # 1
Cell # 1 Sample Point # 2
Cell # 1 Sample Point # 3
Cell # 1 Sample Point # 4
Cell # 1 Sample Point # 5
Cell # 1 Sample Point # 6
Cell # 2 Sample Point 7
Cell # 2 Sample Point 8
Cell # 2 Sample Point 9
Cell # 2 Sample Point 10
Cell # 2 Sample Point 11
Cell # 2 Sample Point 12
DO 7:00 - 7:45 AM (Sunrise)
pH
Sampled from the Side of the Treatment Cell on 1/22/2020

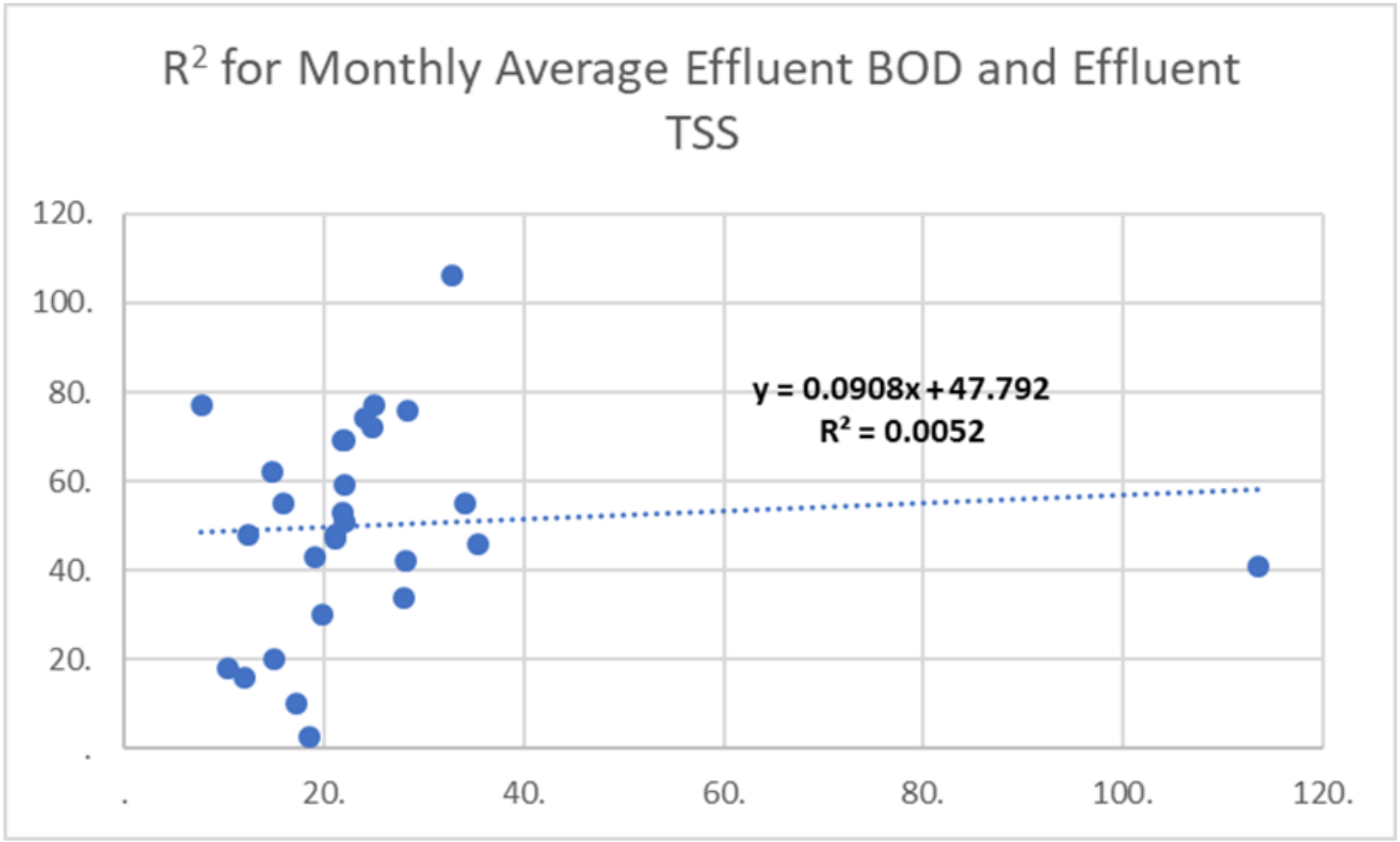
Dissolved Oxygen Profile from the Surface to the Bottom of Cell # 1

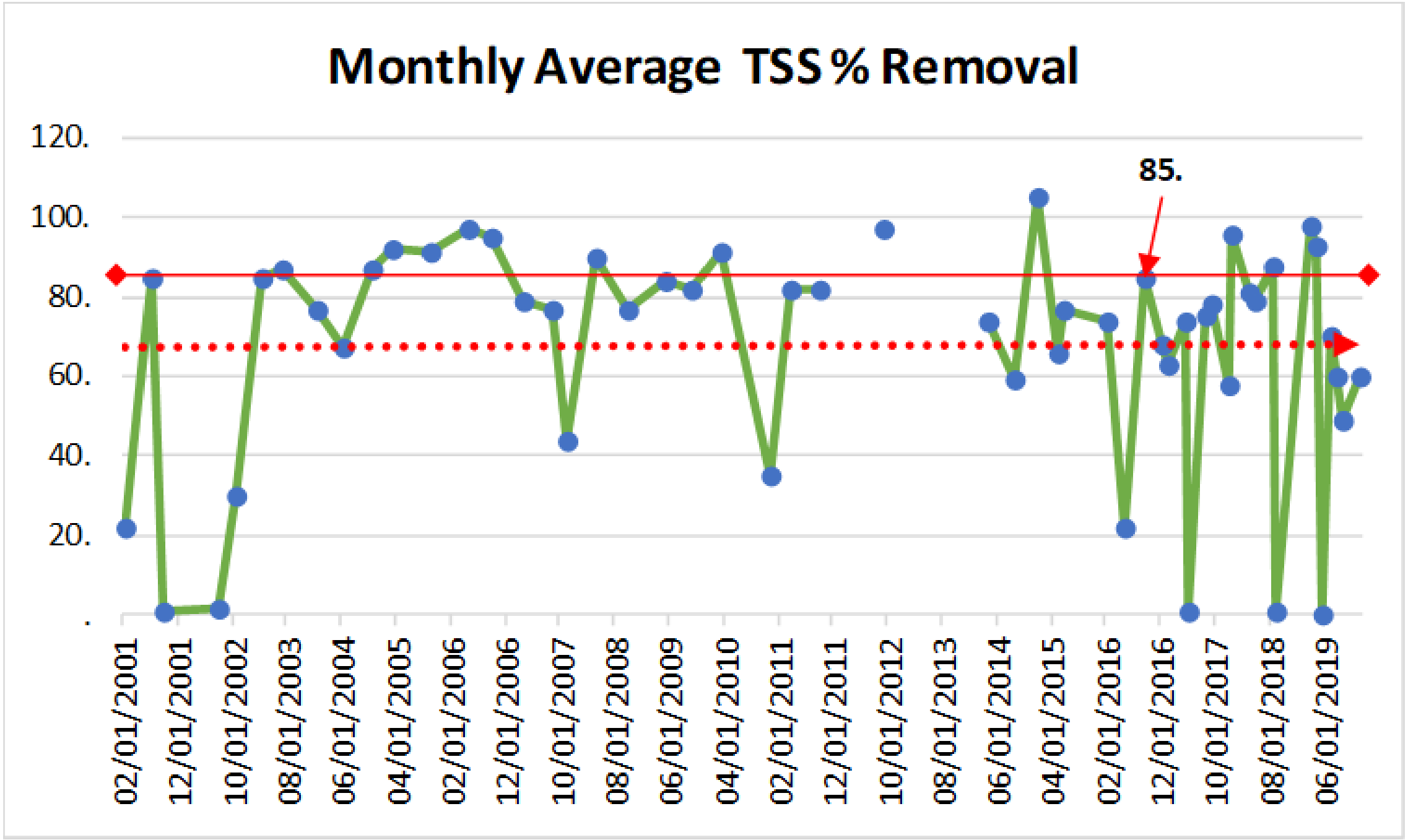


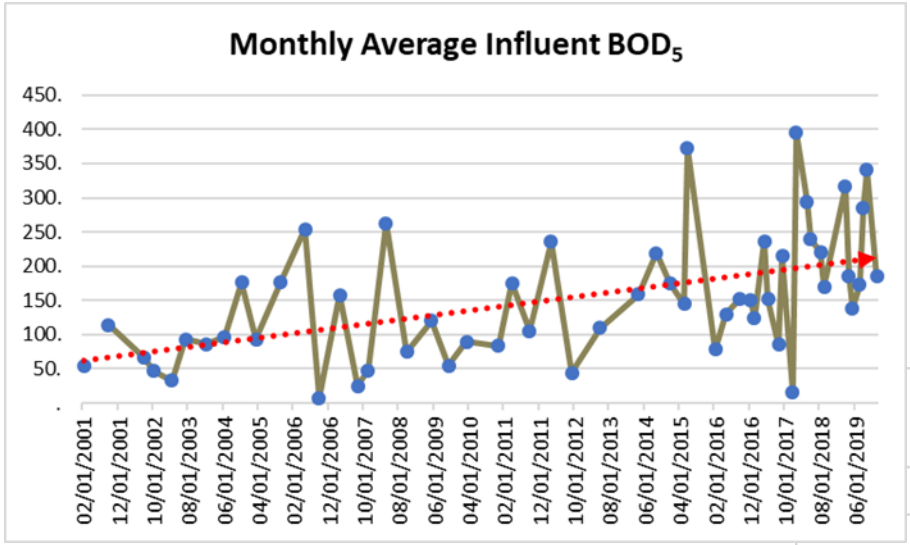

pH Tested at the Surface of Cells 1 & 2 Before Sunrise
9.5
9
8.5
8
7.5
7
6.5
6.5
8.4
8.5
8.2
7.8
7.4
8.4
8.6
8.9
8.8
9
8.9
Cell # 1 Sample Point # 1
Cell # 1 Sample Point # 2
Cell # 1 Sample Point # 3
Cell # 1 Sample Point # 4
Cell # 1 Sample Point # 5
Cell # 1 Sample Point # 6
Cell # 2 Sample Point 7
Cell # 2 Sample Point 8
Cell # 2 Sample Point 9
Cell # 2 Sample Point 10
Cell # 2 Sample Point 11
Cell # 2 Sample Point 12

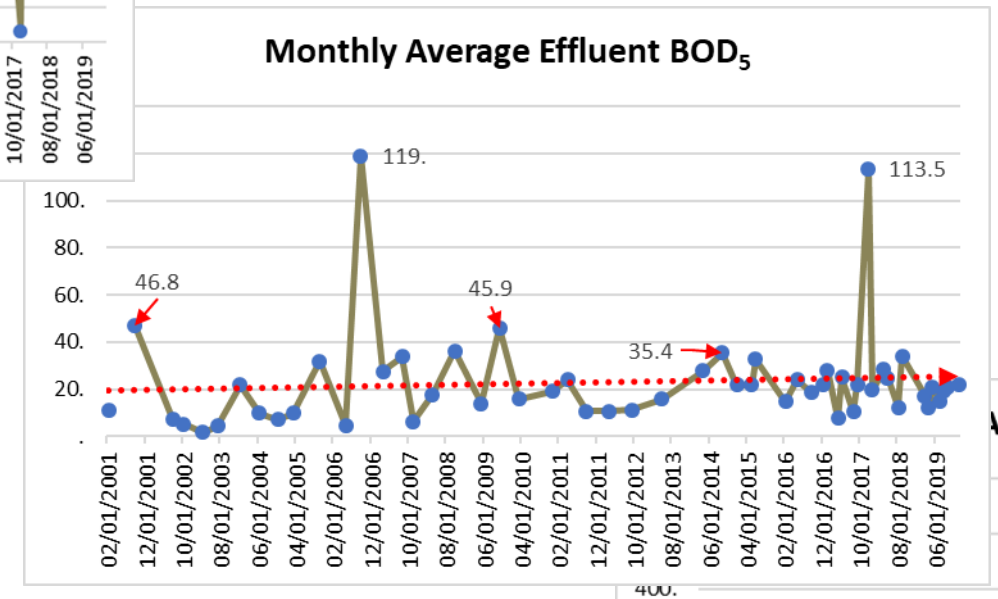

12.43
13.03
11.37
5.46
13.92
12.58
11.25
5.63
13.42
12.86
9.47
8.90

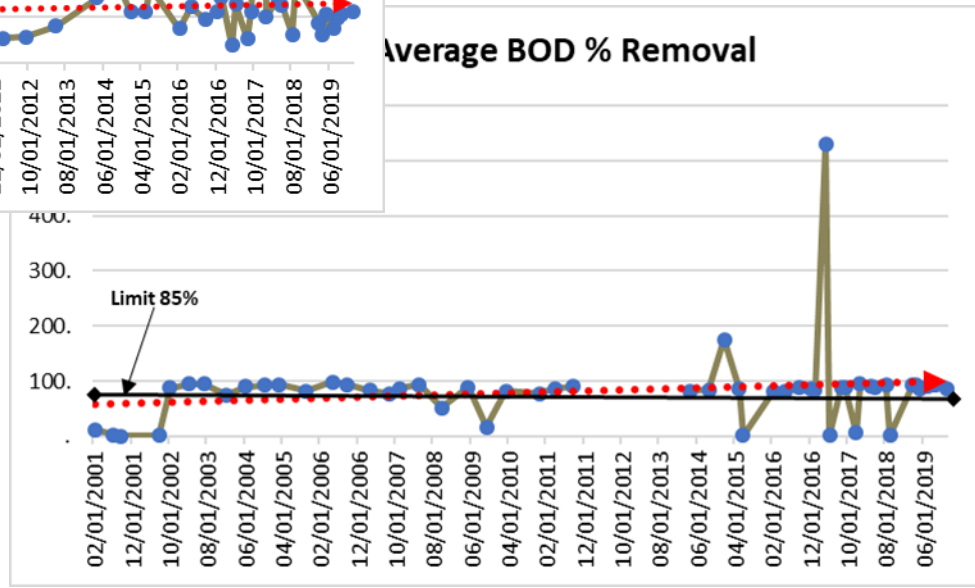

8.6
8.9
8.5
8.4
8.8
8.2
8.4
6.5
9.0
8.9
7.8
7.4


R2 for Monthly Average Effluent BOD and Effluent TSS
120.
100.
80.
60.
40.
20.
.
y = 0.0908x + 47.792
R² = 0.0052
.
20.
40.
60.
80.
100.
120.


Monthly Average TSS % Removal
120.
100.
80.
60.
40.
20.
.
85.
02/01/2001
12/01/2001
10/01/2002
08/01/2003
06/01/2004
04/01/2005
02/01/2006
12/01/2006
10/01/2007
08/01/2008
06/01/2009
04/01/2010
02/01/2011
12/01/2011
10/01/2012
08/01/2013
06/01/2014
04/01/2015
02/01/2016
12/01/2016
10/01/2017
08/01/2018
06/01/2019


Monthly Average Influent BOD5
450.
400.
350.
300.
250.
200.
150.
100.
50.
.
02/01/2001
12/01/2001
10/01/2002
08/01/2003
06/01/2004
04/01/2005
02/01/2006
12/01/2006
10/01/2007
08/01/2008
06/01/2009
04/01/2010
02/01/2011
12/01/2011
10/01/2012
08/01/2013
06/01/2014
04/01/2015
02/01/2016
12/01/2016
10/01/2017
08/01/2018
06/01/2019


Monthly Average Effluent BOD5
119.
113.5
100.
80.
60.
40.
20.
.
46.8
45.9
35.4
02/01/2001
12/01/2001
10/01/2002
08/01/2003
06/01/2004
04/01/2005
02/01/2006
12/01/2006
10/01/2007
08/01/2008
06/01/2009
04/01/2010
02/01/2011
12/01/2011
10/01/2012
08/01/2013
06/01/2014
04/01/2015
02/01/2016
12/01/2016
10/01/2017
08/01/2018
06/01/2019


Average BOD % Removal
400.
300.
200.
100.
.
Limit 85%
02/01/2001
12/01/2001
10/01/2002
08/01/2003
06/01/2004
04/01/2005
02/01/2006
12/01/2006
10/01/2007
08/01/2008
06/01/2009
04/01/2010
02/01/2011
12/01/2011
10/01/2012
08/01/2013
06/01/2014
04/01/2015
02/01/2016
12/01/2016
10/01/2017
08/01/2018
06/01/2019

Headworks

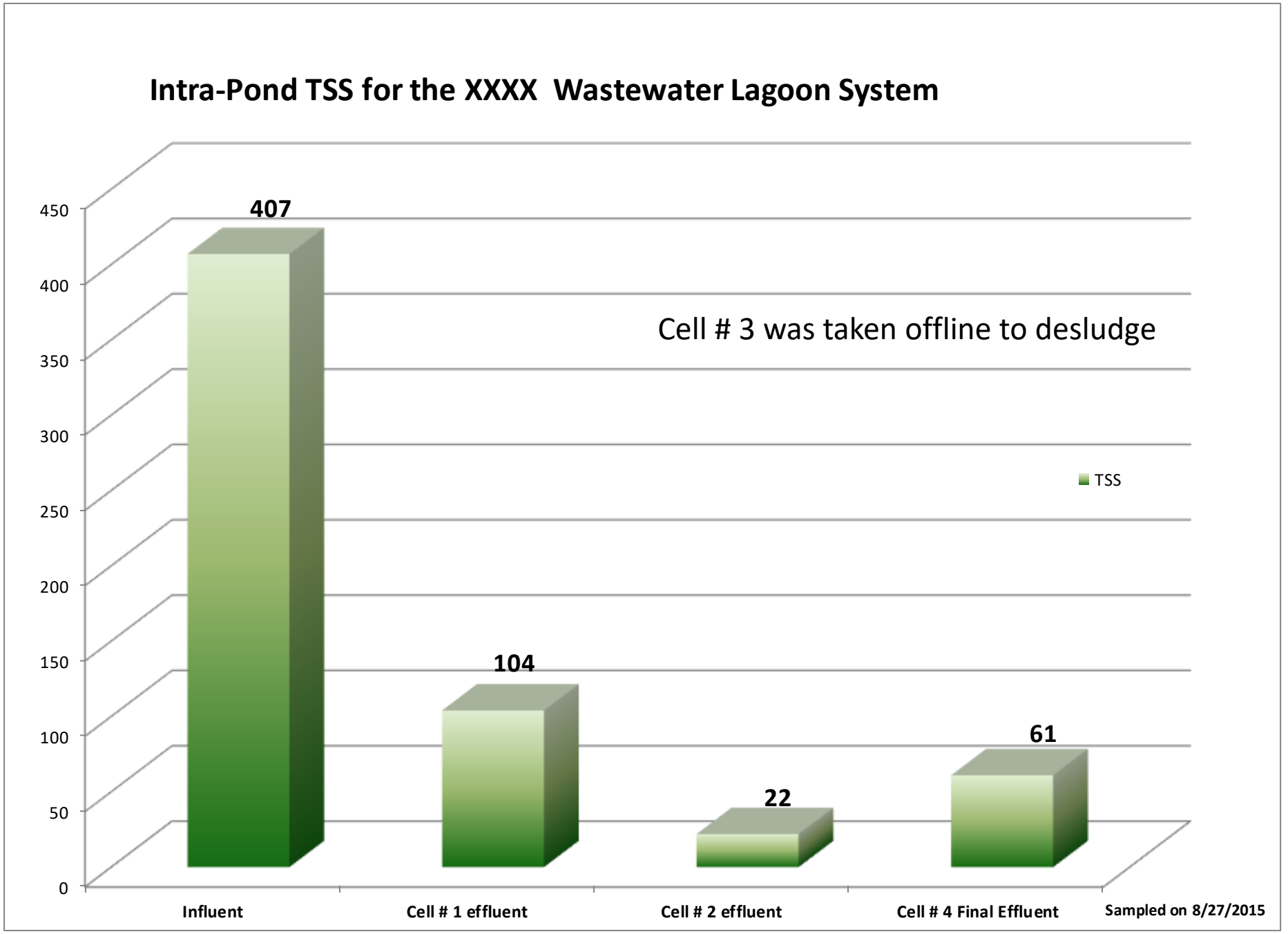
- Will reduce influent BOD
- Extend the time between desludging
- Control vectors

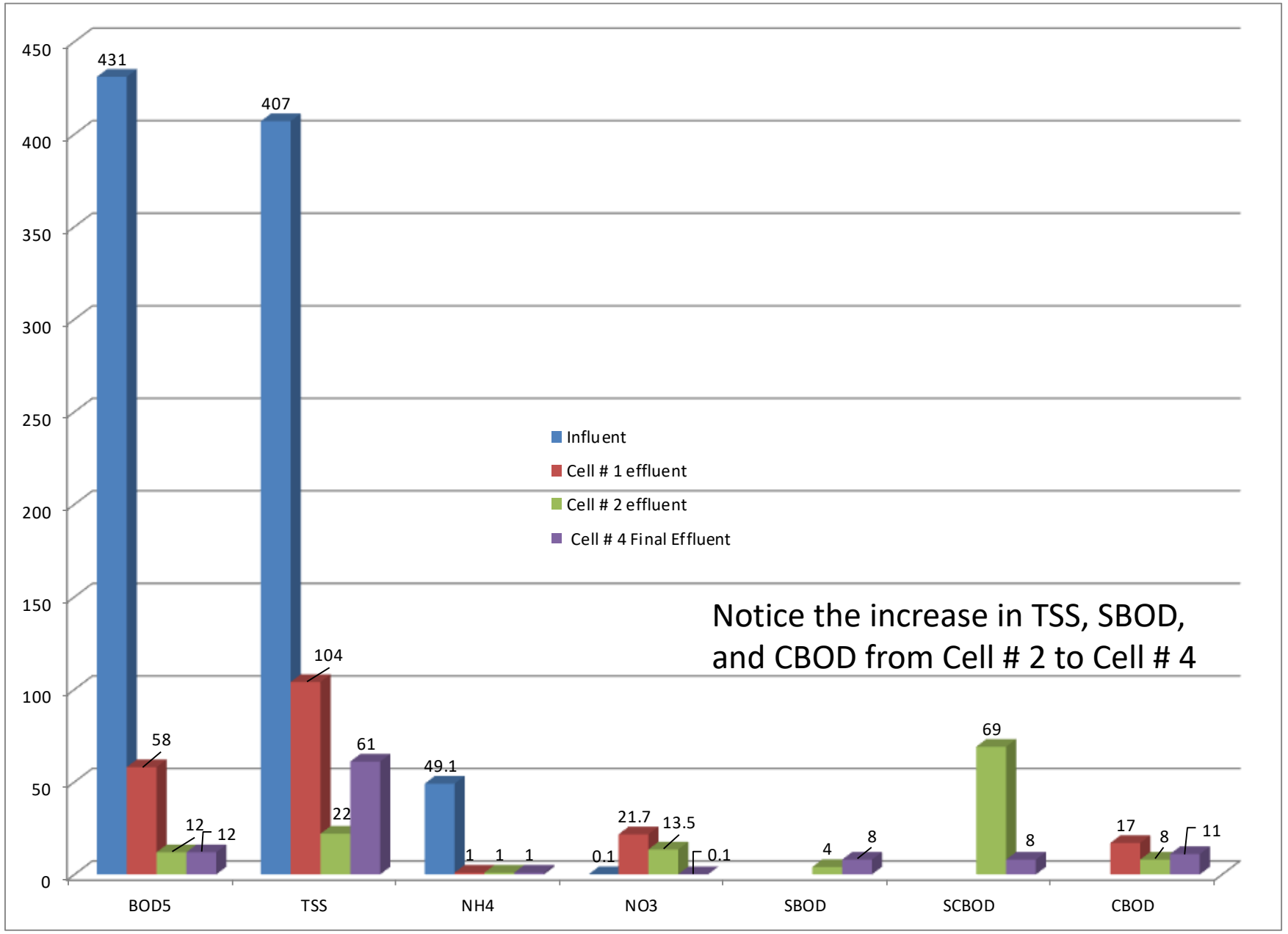

DANGER

Case # 9

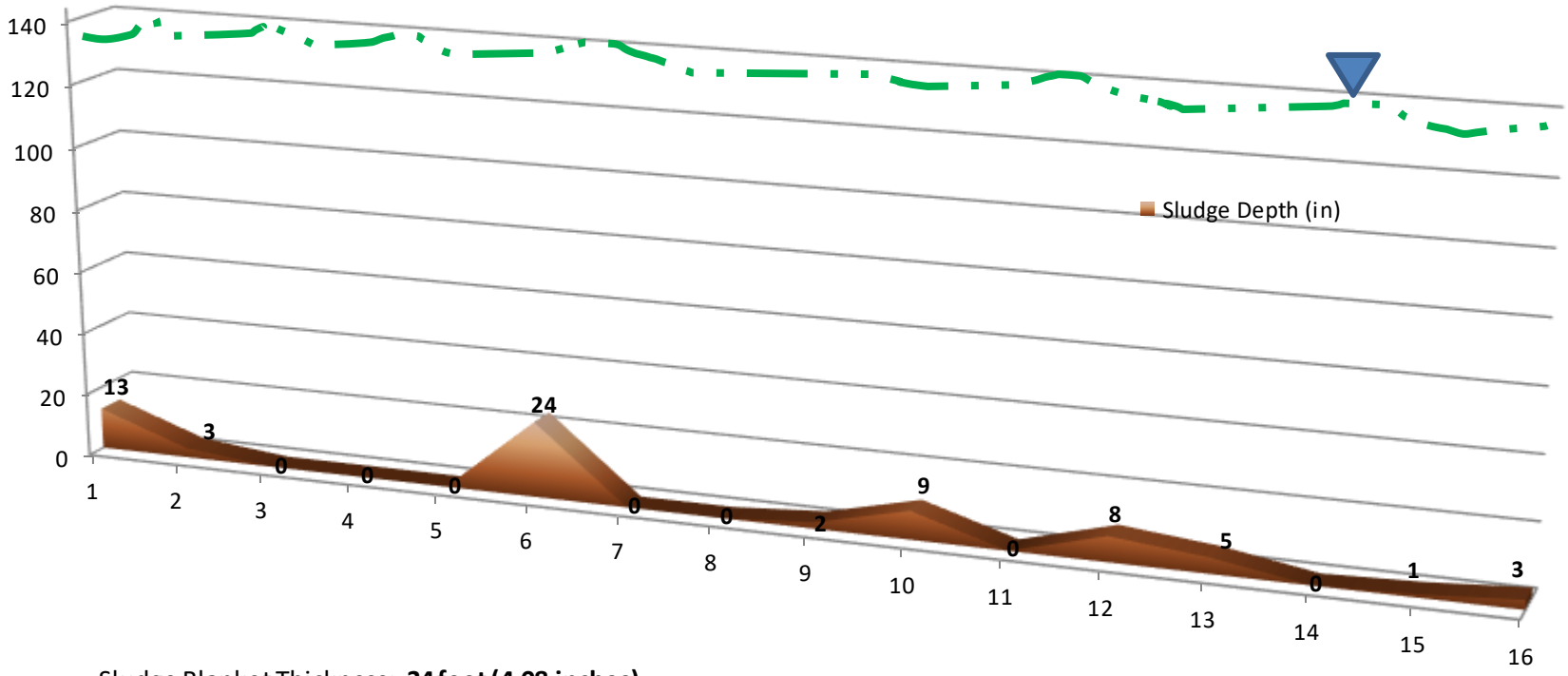
Intra Pond Testing

The evidence of benthal feedback


Intra-Pond TSS for the XXXX Wastewater Lagoon System
450
400
350
300
250
200
150
100
50
0
407
104
22
61
Cell # 3 was taken offline to desludge
TSS
Influent
Cell # 1 effluent
Cell # 2 effluent
Cell # 4 Final Effluent
Sampled on 8/27/2015


450
400
350
300
250
200
150
100
50
0
431
58
12
12
407
104
22
61
49.1
1
1
1
0.1
21.7
13.5
0.1
4
8
69
8
17
8
11
BOD5
TSS
NH4
NO3
SBOD
SCBOD
CBOD
Influent
Cell # 1 effluent
Cell # 2 effluent
Cell # 4 Final Effluent
Notice the increase in TSS, SBOD, and CBOD from Cell # 2 to Cell # 4

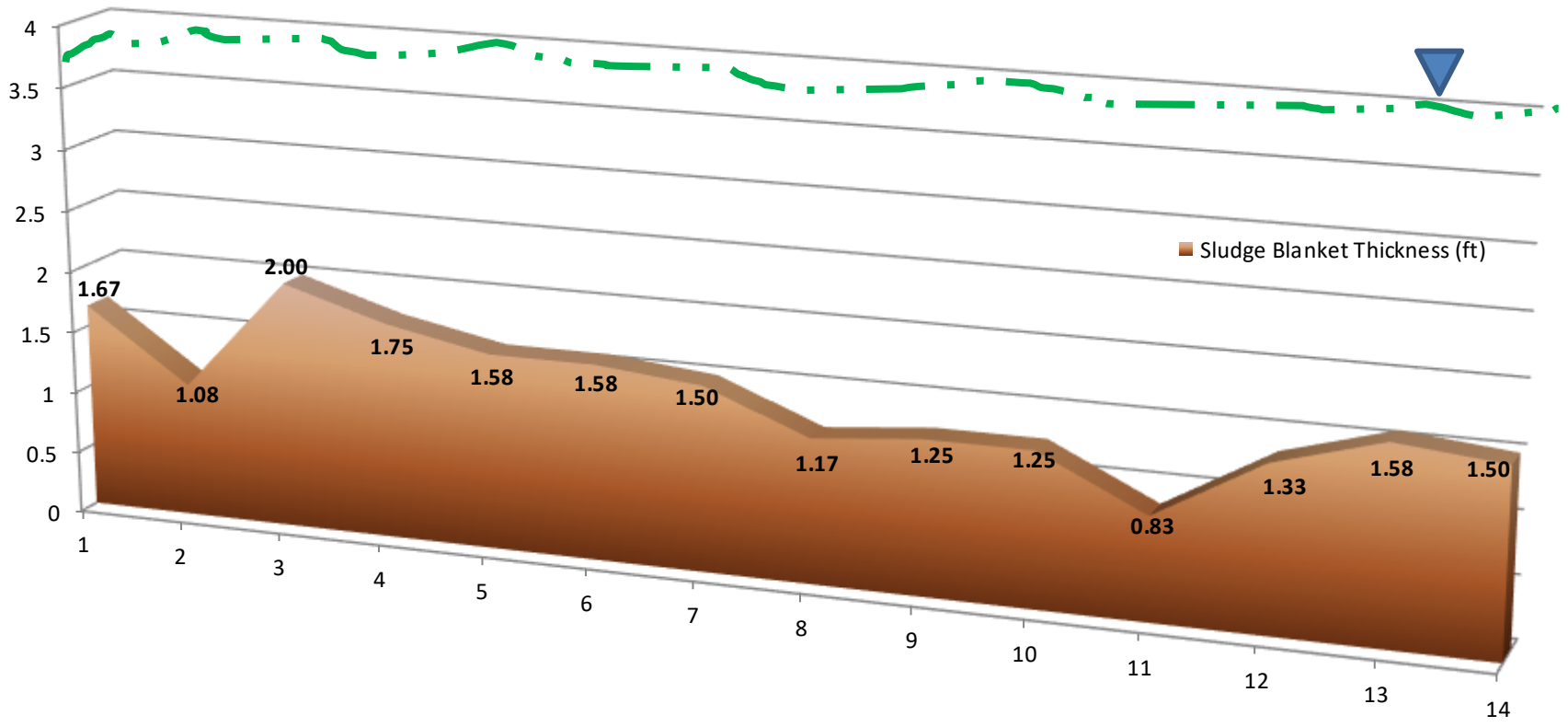
Sludge Blanket Thickness Profile for the City of XXXX's Wastewater Lagoon Cell # 1



Sludge Blanket Thickness: **.34 feet (4.08 inches)**
Sludge Volume: **34,056 gallons**
Water Depth at the Deepest Point: **12 feet**
Estimated Water Volume: **2,109,091 gallons**

Sampled on August 25, 2015

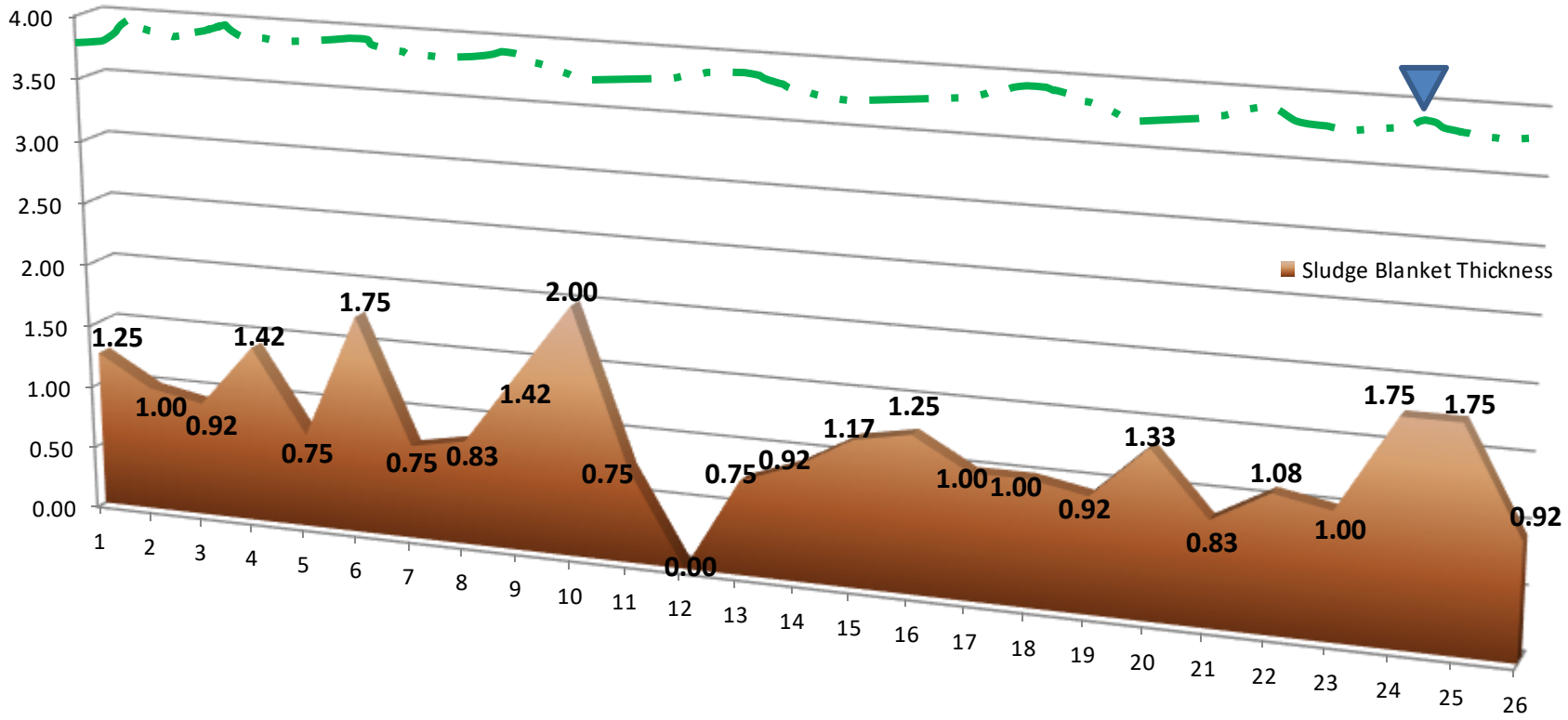
XXXXX Wastewater Treatment lagoon Cell # 3
Sludge Blanket Thickness Profile



Average Sludge Blanket Thickness: **1.43 feet**
Sludge Volume: **1,943,138 gallons**

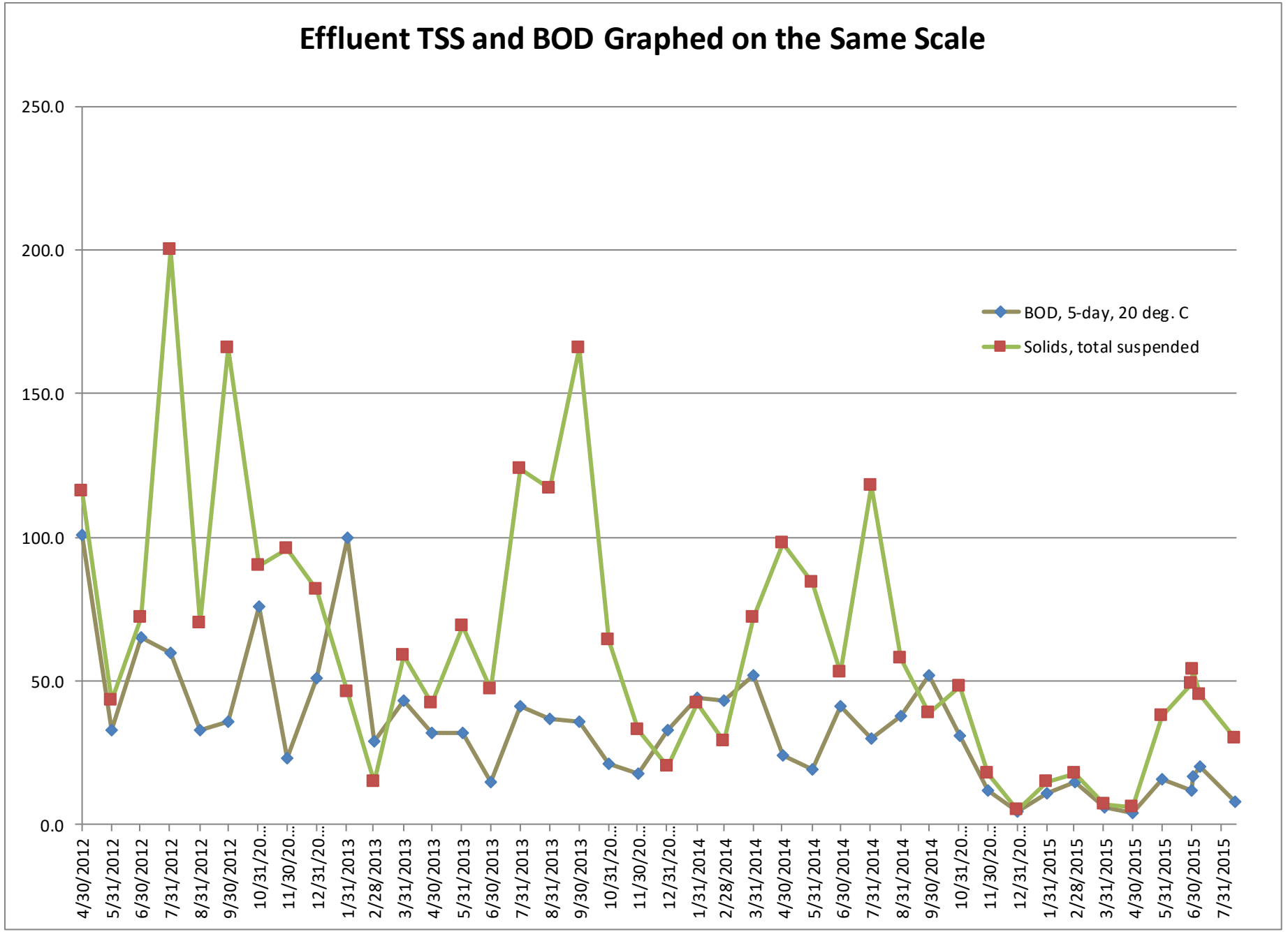
Sampled on August 25, 2015

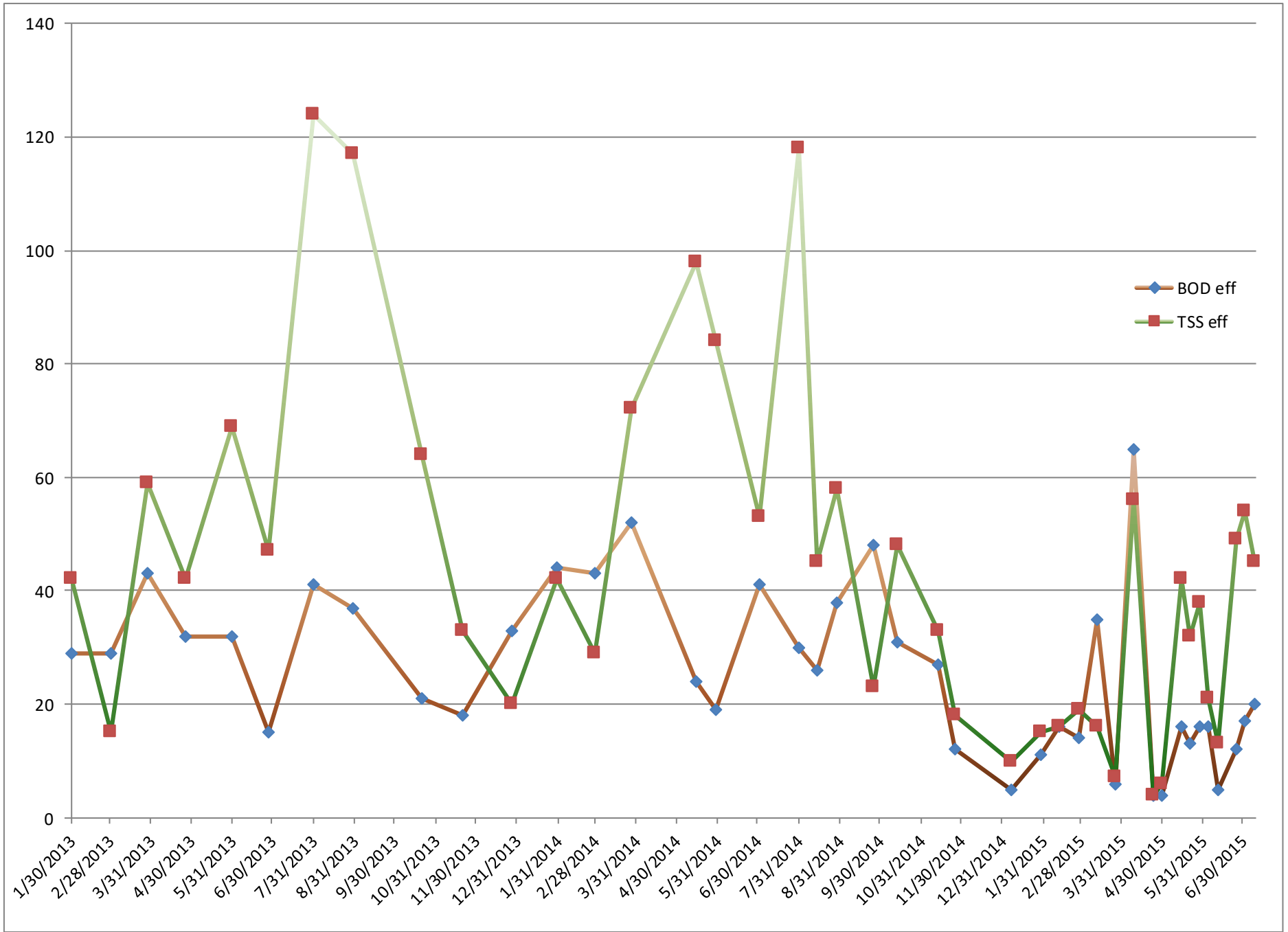
XXXX's Cell # 4 Sludge Blanket Thickness Profile

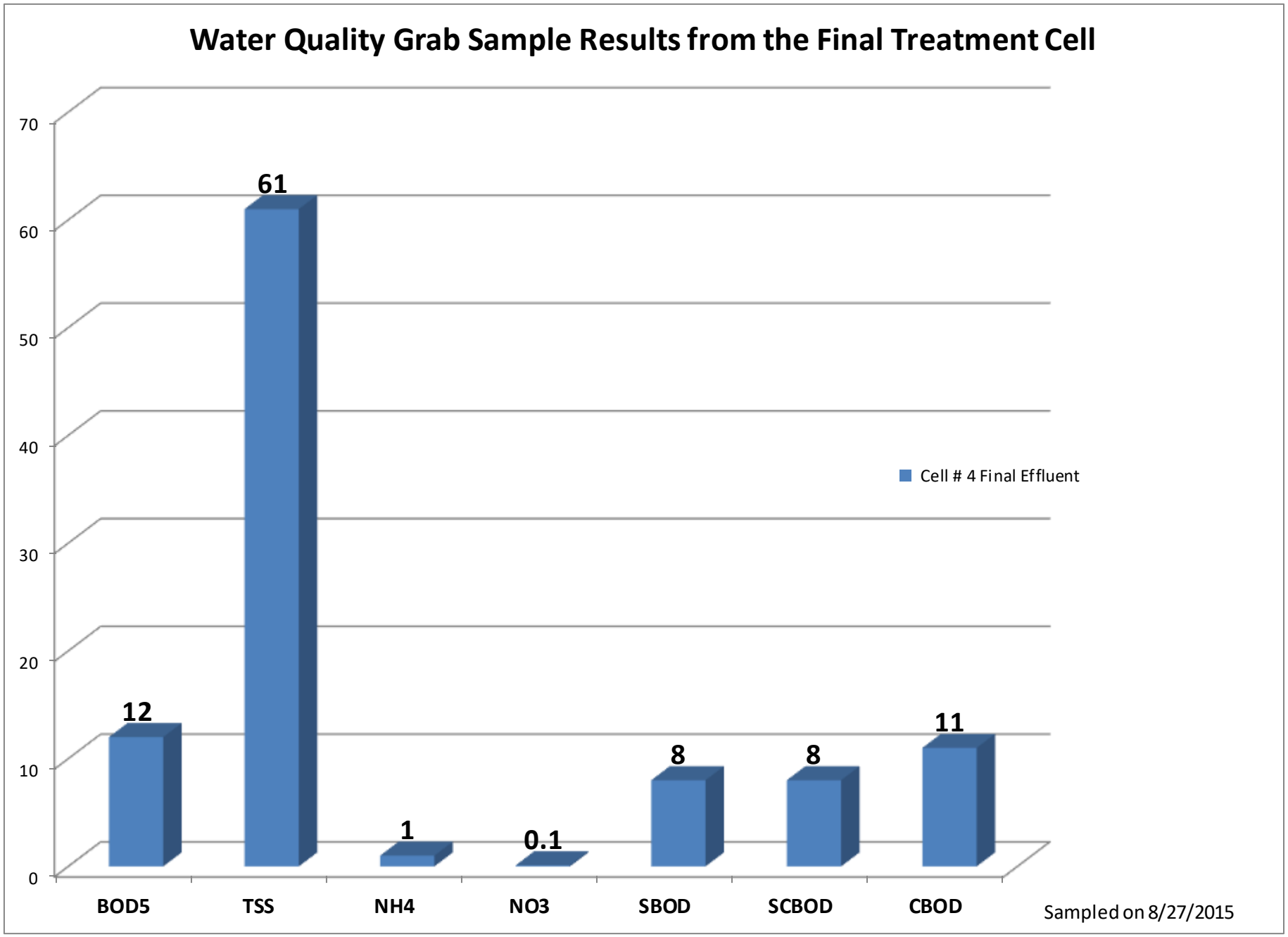


Average Sluege Blanket Thickness: **1.10 feet**
Sludge Blanket Volume: **1,347,420 gallons**
Average Water Depth: **3.81 feet**

Sampled on August 25, 2015


Effluent TSS and BOD Graphed on the Same Scale
250.0
200.0
150.0
100.0
50.0
0.0
BOD, 5-day, 20 deg. C
Solids, total suspended
4/30/2012
5/31/2012
6/30/2012
7/31/2012
8/31/2012
9/30/2012
10/31/20...
11/30/20...
12/31/20...
1/31/2013
2/28/2013
3/31/2013
4/30/2013
5/31/2013
6/30/2013
7/31/2013
8/31/2013
9/30/2013
10/31/20...
11/30/20...
12/31/20...
1/31/2014
2/28/2014
3/31/2014
4/30/2014
5/31/2014
6/30/2014
7/31/2014
8/31/2014
9/30/2014
10/31/20...
11/30/20...
12/31/20...
1/31/2015
2/28/2015
3/31/2015
4/30/2015
5/31/2015
6/30/2015
7/31/2015


140
120
100
80
60
40
20
0
BOD eff
TSS eff
1/30/2013
2/28/2013
3/31/2013
4/30/2013
5/31/2013
6/30/2013
7/31/2013
8/31/2013
9/30/2013
10/31/2013
11/30/2013
12/31/2013
1/31/2014
2/28/2014
3/31/2014
4/30/2014
5/31/2014
6/30/2014
7/31/2014
8/31/2014
9/30/2014
10/31/2014
11/30/2014
12/31/2014
1/31/2015
2/28/2015
3/31/2015
4/30/2015
5/31/2015
6/30/2015

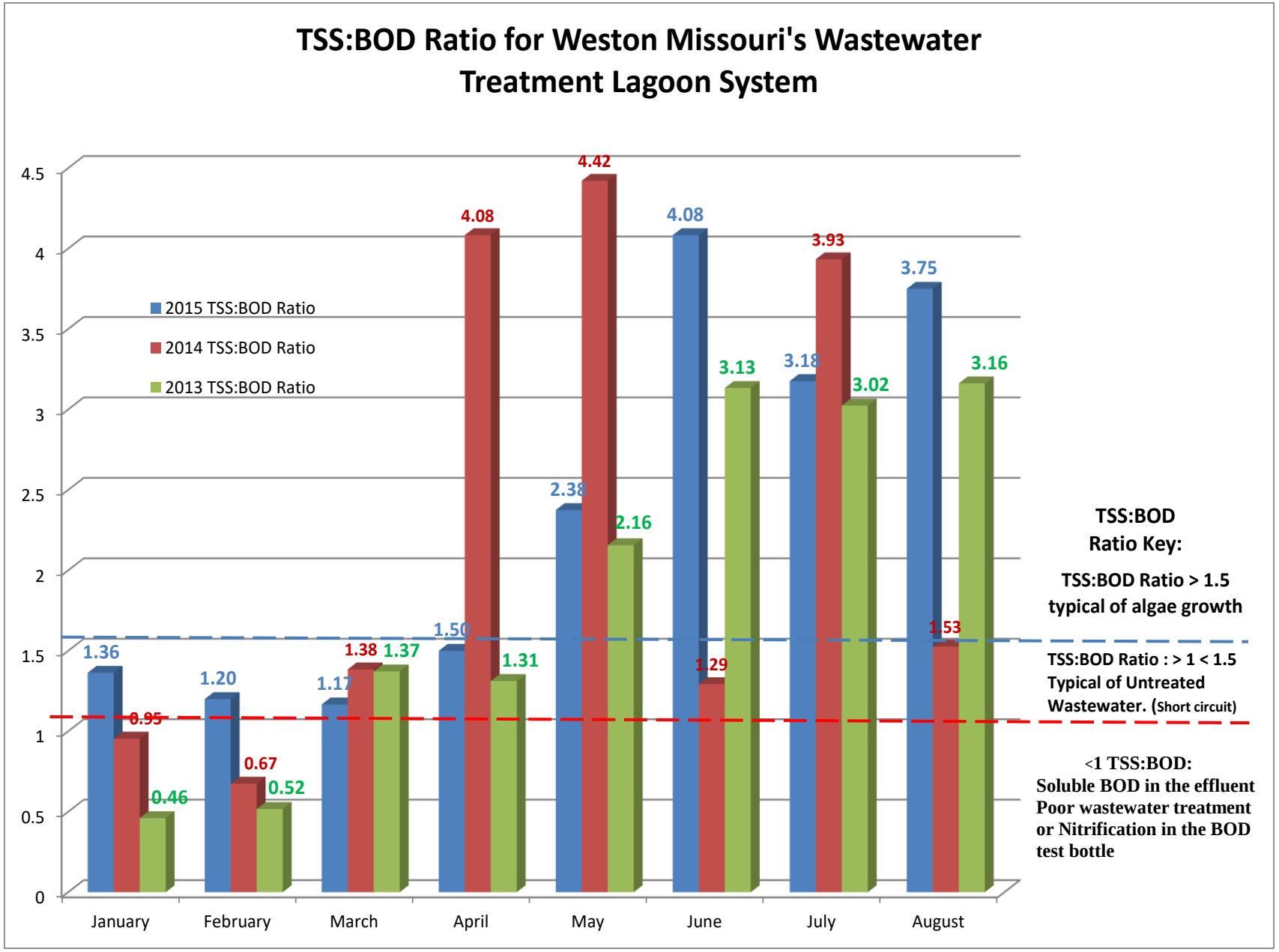

Water Quality Grab Sample Results from the Final Treatment Cell
70
60
50
40
30
20
10
0
61
12
1
0.1
8
8
11
BOD5
TSS
NH4
NO3
SBOD
SCBOD
CBOD
Cell # 4 Final Effluent
Sampled on 8/27/2015

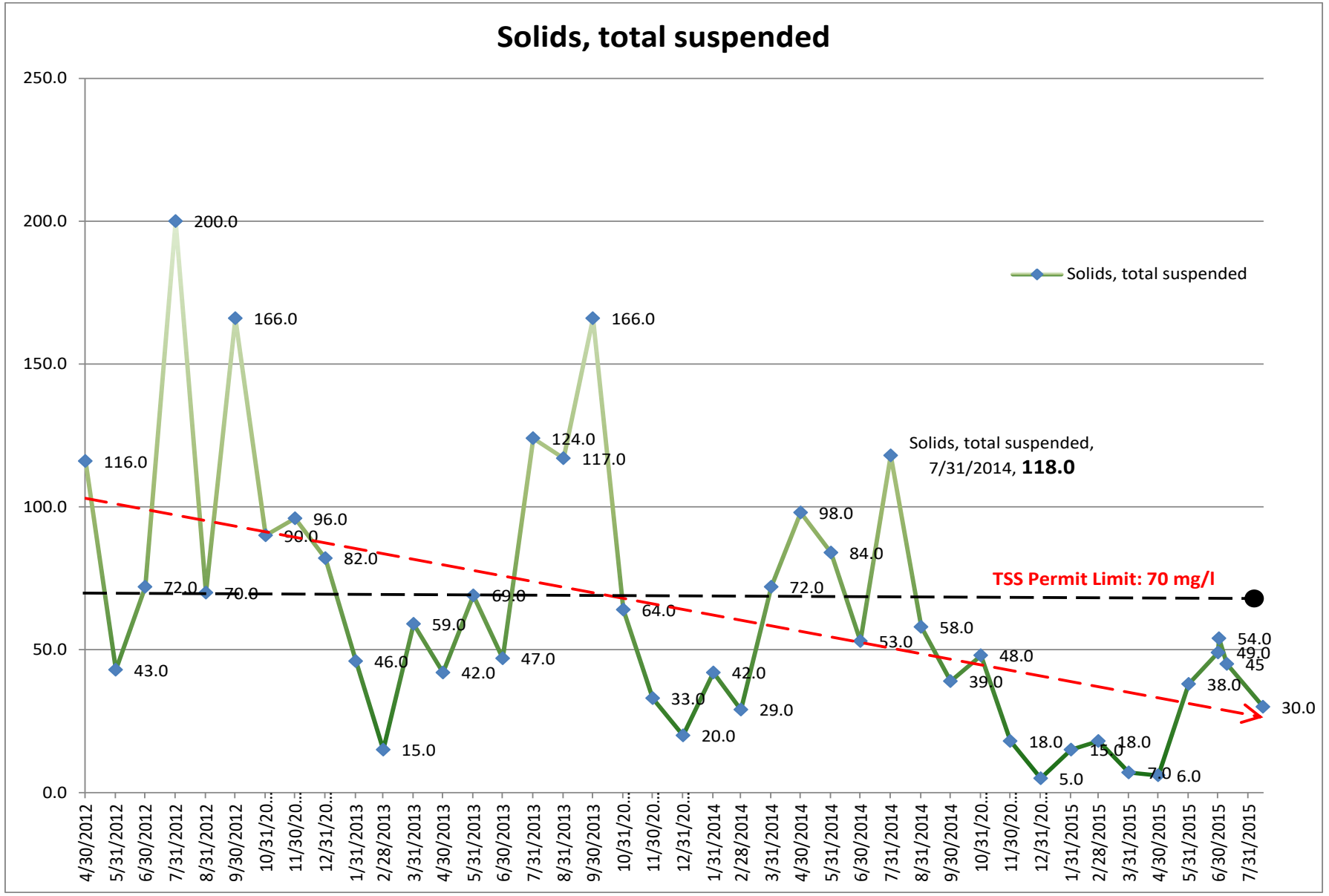
Permit Limits

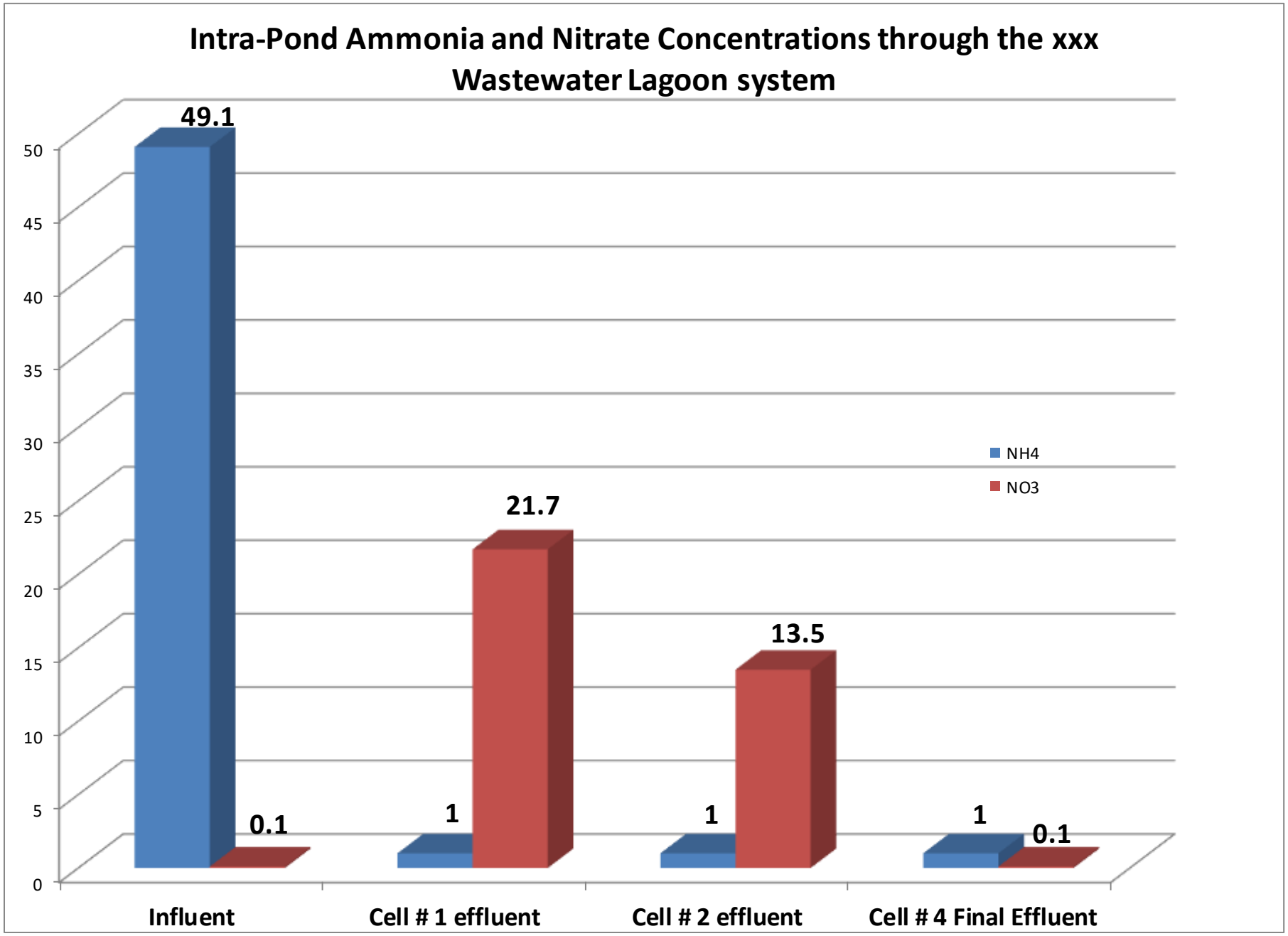
- TSS 7 day Average Limit: 70 mg/l
- TSS 30 day Average Limit: 110

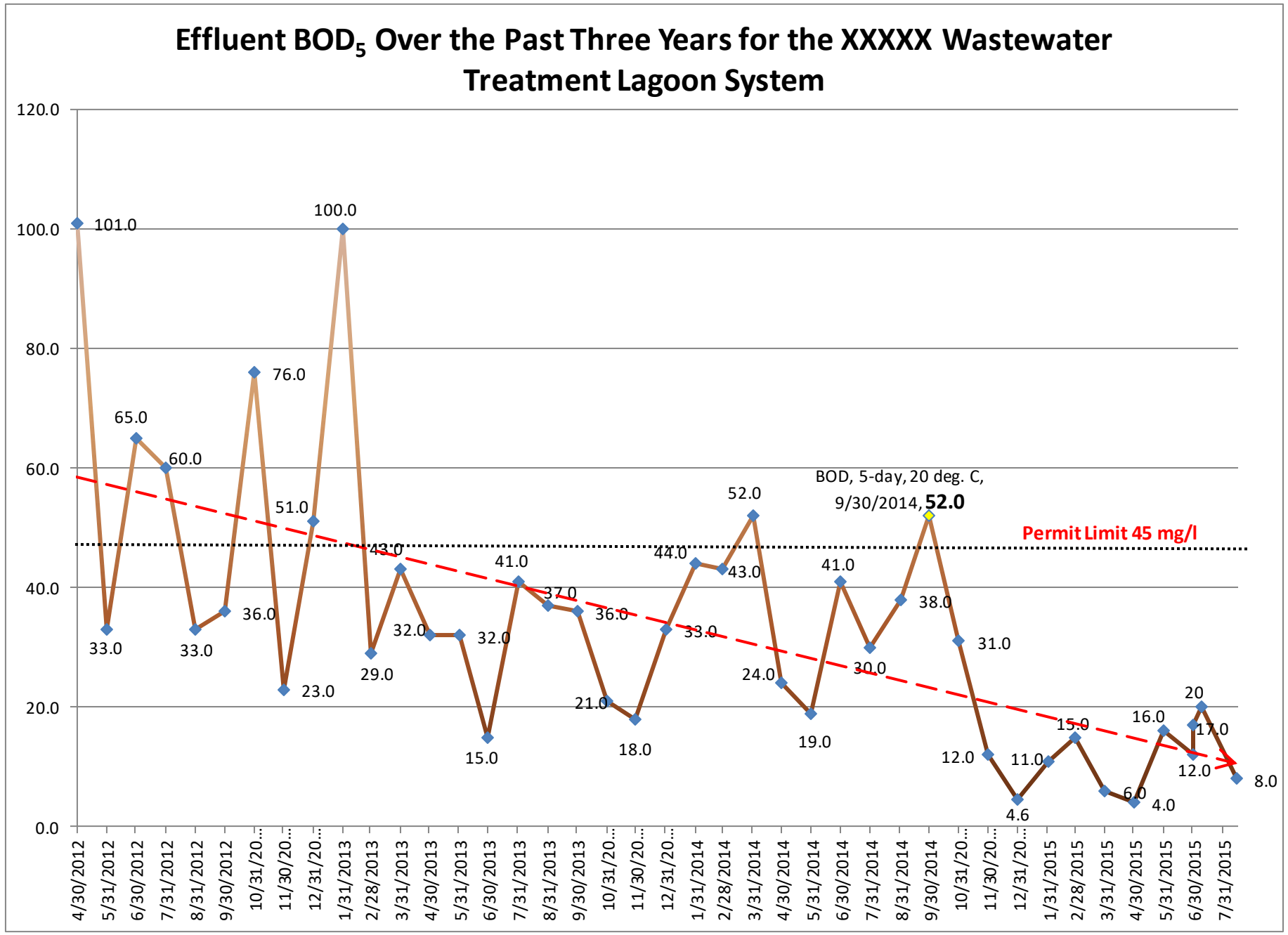
- BOD 7 day average limit: 45 mg/l
- BOD 30 day average Limit: 65

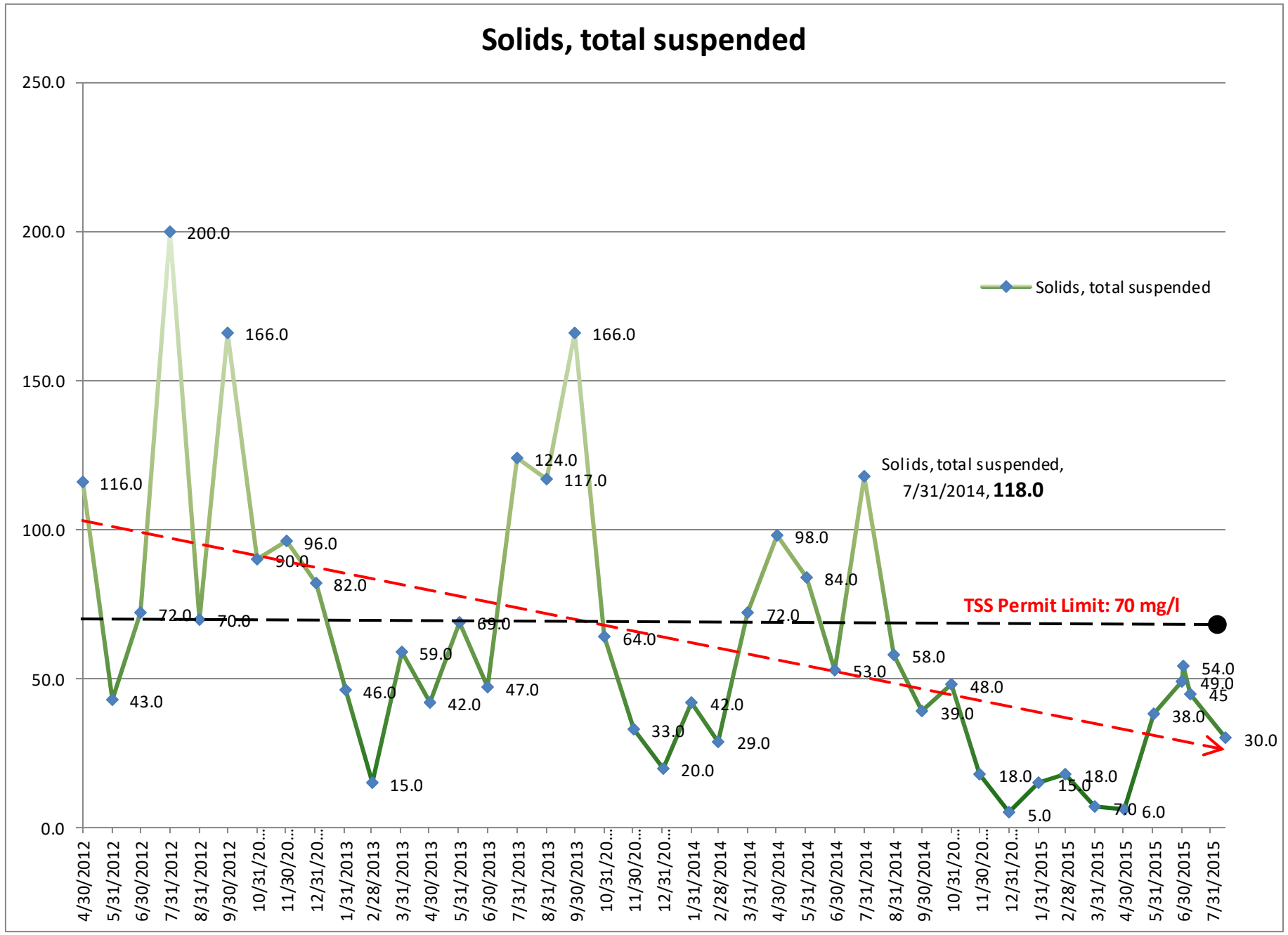
TSS:BOD Ratio for Weston Missouri's Wastewater Treatment Lagoon System

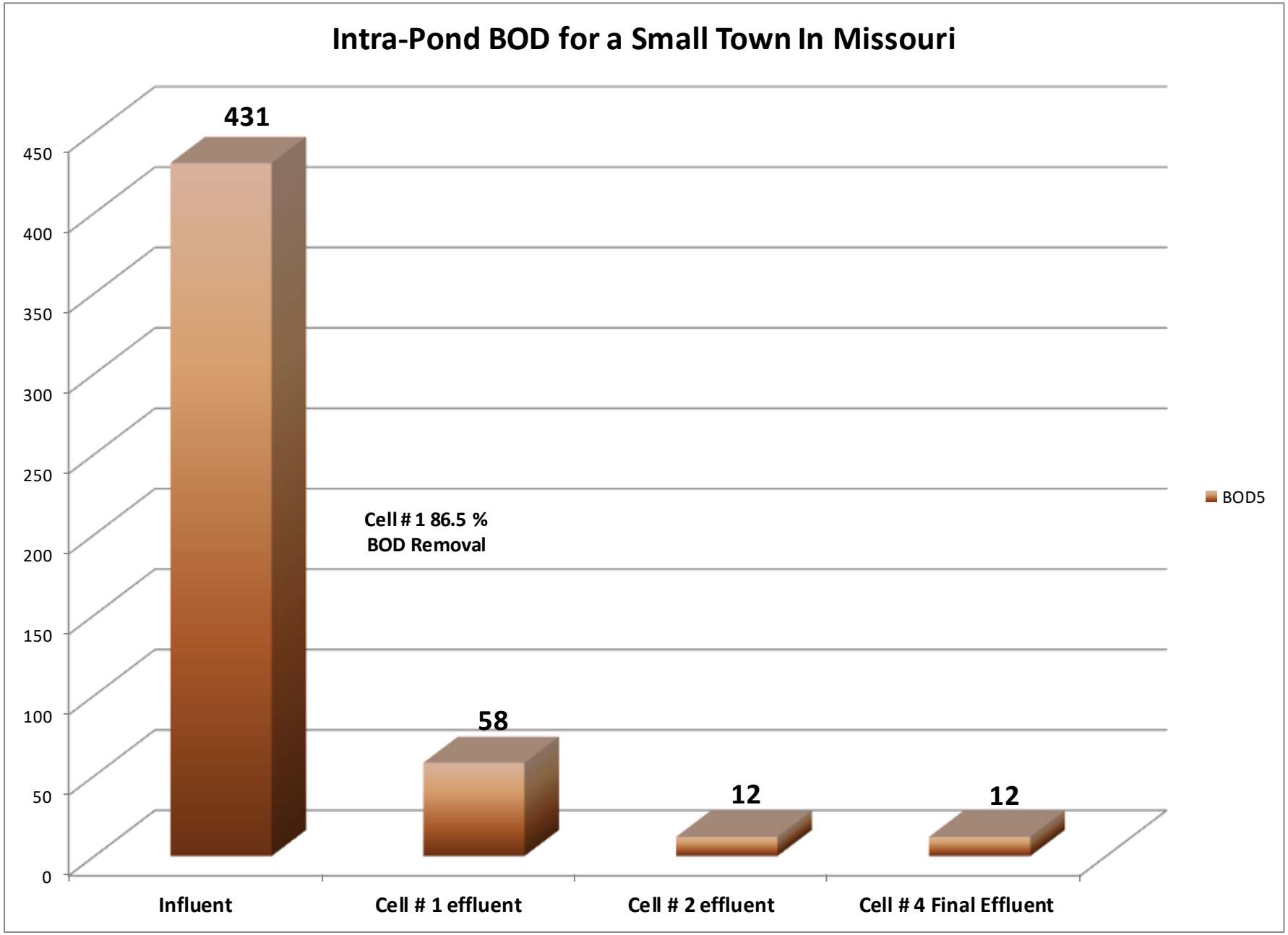



Solids, total suspended
250.0
200.0
150.0
100.0
50.0
0.0
Solids, total suspended
TSS Permit Limit: 70 mg/l
Solids, total suspended, 7/31/2014, 118.0
116.0
43.0
72.0
200.0
70.0
166.0
90.0
96.0
82.0
46.0
15.0
59.0
42.0
69.0
47.0
124.0
117.0
166.0
64.0
33.0
20.0
42.0
29.0
72.0
98.0
84.0
53.0
58.0
39.0
48.0
18.0
5.0
15.0
18.0
7.0
6.0
38.0
54.0
49.0
45
30.0
4/30/2012
5/31/2012
6/30/2012
7/31/2012
8/31/2012
9/30/2012
10/31/20...
11/30/20...
12/31/20...
1/31/2013
2/28/2013
3/31/2013
4/30/2013
5/31/2013
6/30/2013
7/31/2013
8/31/2013
9/30/2013
10/31/20...
11/30/20...
12/31/20...
1/31/2014
2/28/2014
3/31/2014
4/30/2014
5/31/2014
6/30/2014
7/31/2014
8/31/2014
9/30/2014
10/31/20...
11/30/20...
12/31/20...
1/31/2015
2/28/2015
3/31/2015
4/30/2015
5/31/2015
6/30/2015
7/31/2015


Intra-Pond Ammonia and Nitrate Concentrations through the xxx Wastewater Lagoon system
50
45
40
35
30
25
20
15
10
5
0
49.1
0.1
1
21.7
1
13.5
1
0.1
NH4
NO3
Influent
Cell # 1 effluent
Cell # 2 effluent
Cell # 4 Final Effluent

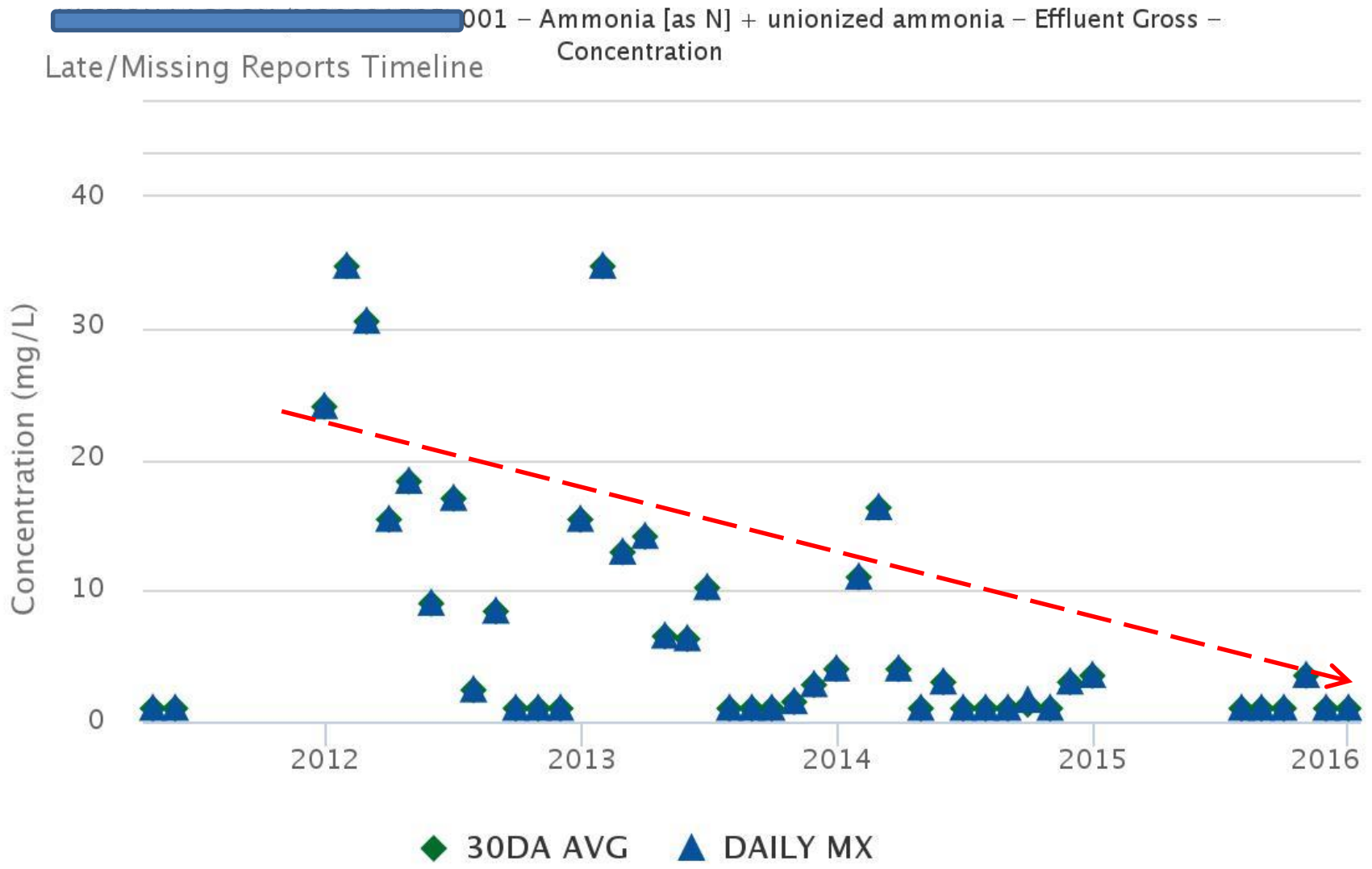

Effluent BOD5 Over the Past Three Years for the XXXXX Wastewater Treatment Lagoon System
120.0
100.0
80.0
60.0
40.0
20.0
0.0
BOD, 5-day, 20 deg. C, 9/30/2014, 52.0
Permit Limit 45 mg/l
101.0
33.0
65.0
60.0
33.0
36.0
76.0
51.0
23.0
100.0
29.0
43.0
32.0
32.0
15.0
41.0
37.0
36.0
21.0
18.0
44.0
43.0
52.0
33.0
24.0
19.0
41.0
30.0
38.0
52.0
31.0
12.0
11.0
4.6
15.0
6.0
4.0
16.0
12.0
20
17.0
8.0
4/30/2012
5/31/2012
6/30/2012
7/31/2012
8/31/2012
9/30/2012
10/31/20...
11/30/20...
12/31/20...
1/31/2013
2/28/2013
3/31/2013
4/30/2013
5/31/2013
6/30/2013
7/31/2013
8/31/2013
9/30/2013
10/31/20...
11/30/20...
12/31/20...
1/31/2014
2/28/2014
3/31/2014
4/30/2014
5/31/2014
6/30/2014
7/31/2014
8/31/2014
9/30/2014
10/31/20...
11/30/20...
12/31/20...
1/31/2015
2/28/2015
3/31/2015
4/30/2015
5/31/2015
6/30/2015
7/31/2015


Solids, total suspended
250.0
200.0
150.0
100.0
50.0
0.0
Solids, total suspended
TSS Permit Limit: 70 mg/l
Solids, total suspended, 7/31/2014, 118.0
116.0
43.0
72.0
200.0
70.0
166.0
90.0
96.0
82.0
46.0
15.0
59.0
42.0
69.0
47.0
124.0
117.0
166.0
64.0
33.0
20.0
42.0
29.0
72.0
98.0
84.0
53.0
118.0
58.0
39.0
48.0
18.0
5.0
15.0
18.0
7.0
6.0
38.0
54.0
49.0
45
30.0
4/30/2012
5/31/2012
6/30/2012
7/31/2012
8/31/2012
9/30/2012
10/31/20...
11/30/20...
12/31/20...
1/31/2013
2/28/2013
3/31/2013
4/30/2013
5/31/2013
6/30/2013
7/31/2013
8/31/2013
9/30/2013
10/31/20...
11/30/20...
12/31/20...
1/31/2014
2/28/2014
3/31/2014
4/30/2014
5/31/2014
6/30/2014
7/31/2014
8/31/2014
9/30/2014
10/31/20...
11/30/20...
12/31/20...
1/31/2015
2/28/2015
3/31/2015
4/30/2015
5/31/2015
6/30/2015
7/31/2015

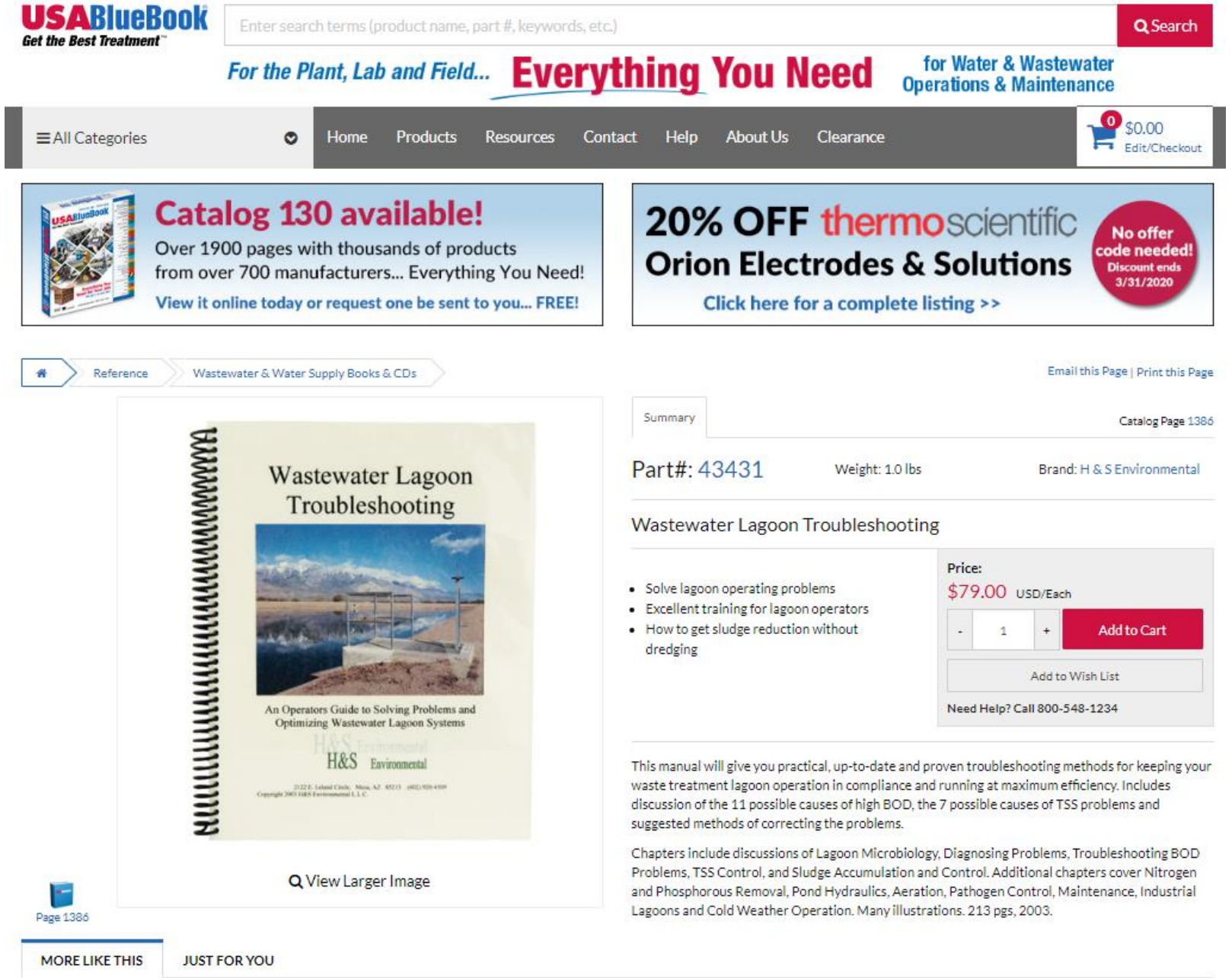

Intra-Pond BOD for a Small Town In Missouri
431
58
12
12
Cell # 1 86.5 %
BOD Removal
450
400
350
300
250
200
150
100
50
0
Influent
Cell # 1 effluent
Cell # 2 effluent
Cell # 4 Final Effluent
BOD5

In Cell # 1, Very Little Sludge Accumulation, almost Complete Mix

NH3 Chart from USEPA ECHO



- Changes to the xxxx plant have continued. The effluent numbers are still coming down.



A Good Wastewater Lagoon Book

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www.lagoonops.com
1 (480) 274-8410

Lagoon Troubleshooting book available at usabluebook.com Part # 43431, Page 1386 in Catalog

Online at: https://www.usabluebook.com/p-286936-wastewater-lagoon-troubleshooting.aspx

References:

- Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers https://www.epa.gov/nutrient-policy-data/principles-design-and-operations-wastewater-treatment-pond-systems-plant (see Appendix E for Troubleshooting)
- https://www.rcap.org/resource/wastewater-lagoon-basics/ (56 minutes webinar)
- https://www.rcap.org/resource/wastewater-lagoon-troubleshooting/ (61 minutes webinar)
- EPA - Wastewater Technology Fact Sheet Facultative Lagoons (4 pages)
- EPA - Wastewater Technology Fact Sheet Aerated, Partial Mix Lagoons (https://www3.epa.gov/npdes/pubs/apartlag.pdf) (5 pages)