Troubleshooting Sludge Problems in Wastewater Lagoons Systems!

What we will do today:

Make introductions

Then Steve will:

- Review today’s learning objective
- Clear up some sludge judging issues
- Define what sludge is
- Free sludge removal
- The problems sludge creates
- How to sludge judge and core sample a lagoon
- Go through case studies on sludge control

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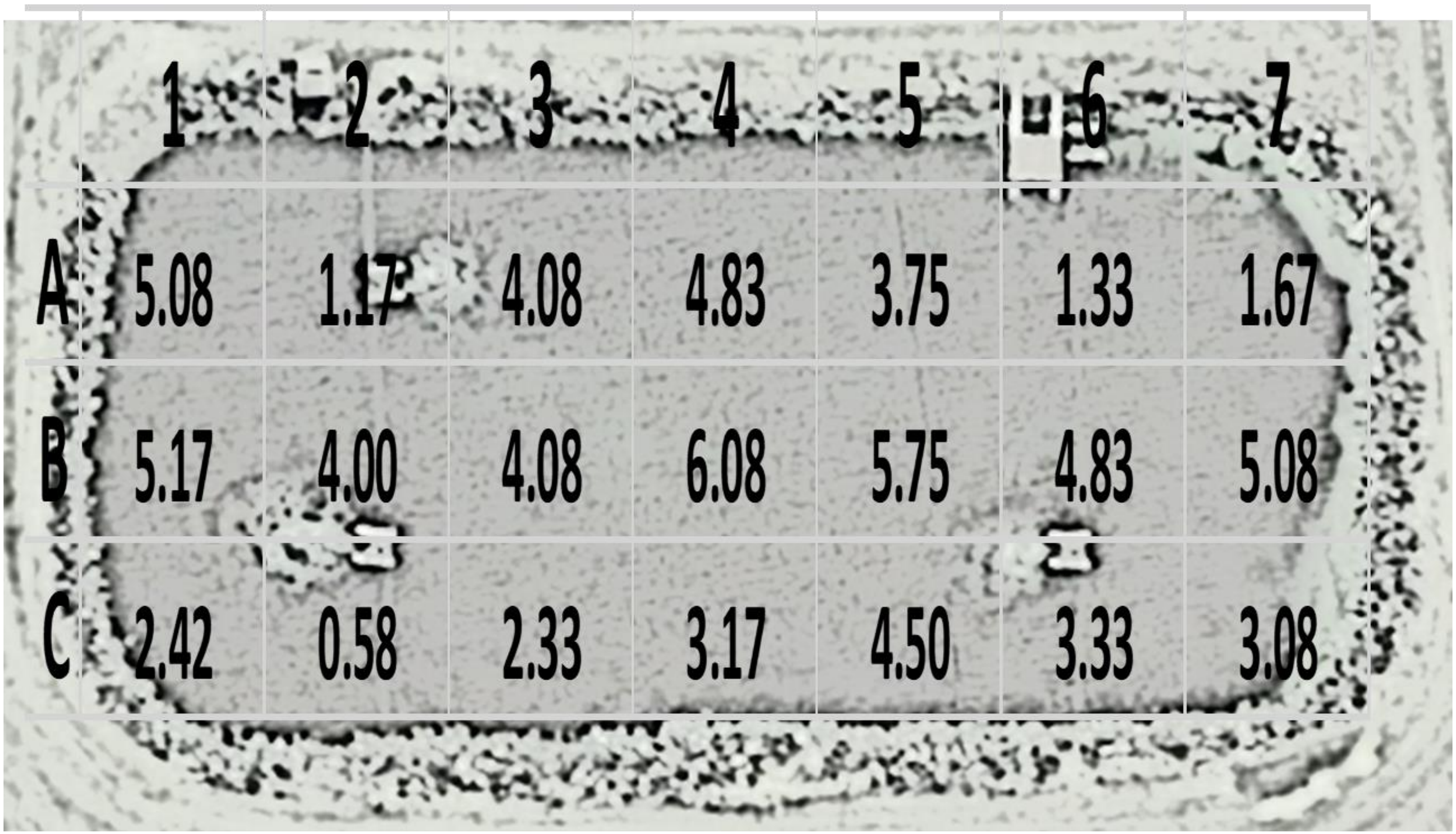
Troubleshooting Sludge Problems in Wastewater Lagoon Systems


A26829K

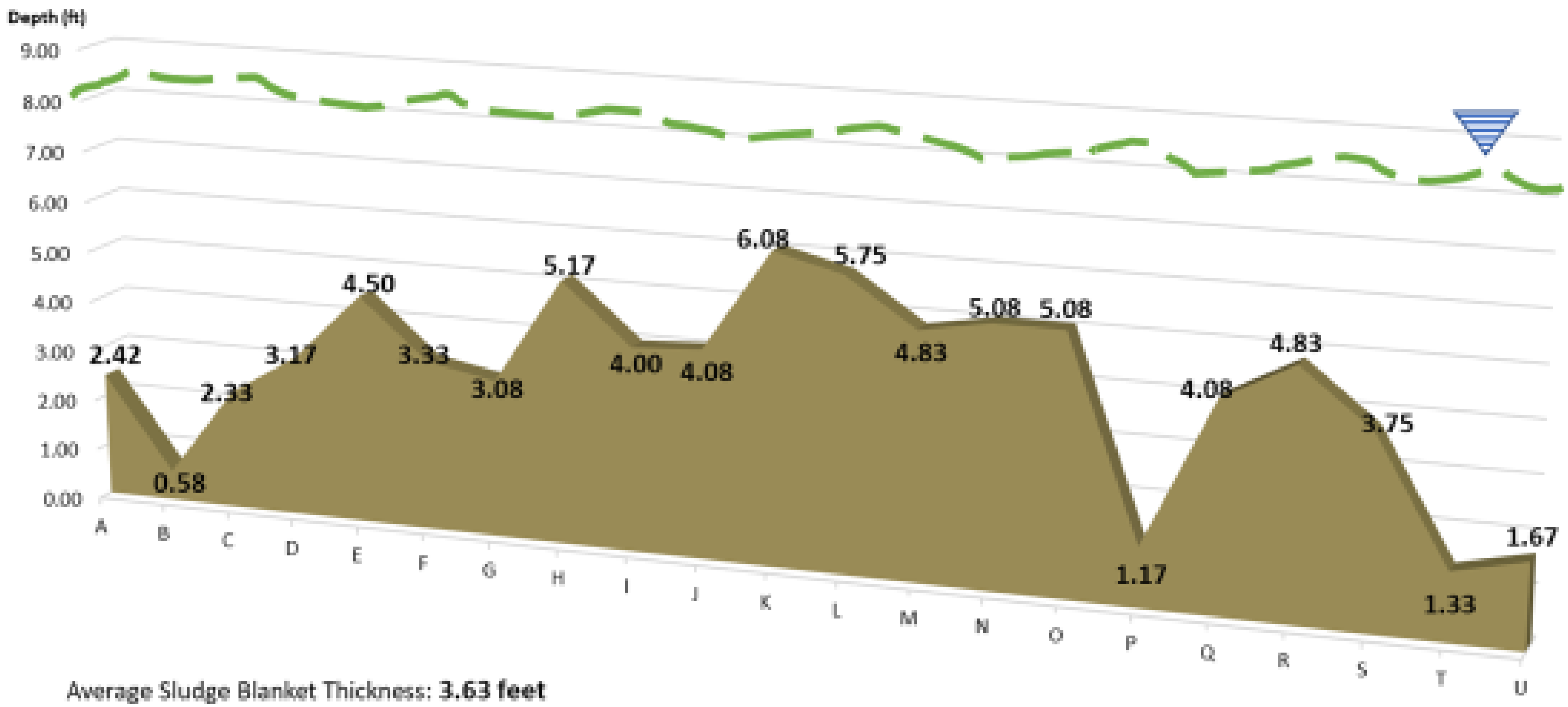
Objective

To broaden your understanding of sludge and its effect on a wastewater lagoon system

Cell # A of the City of Marsing Idaho's Wastewater Lagoon System

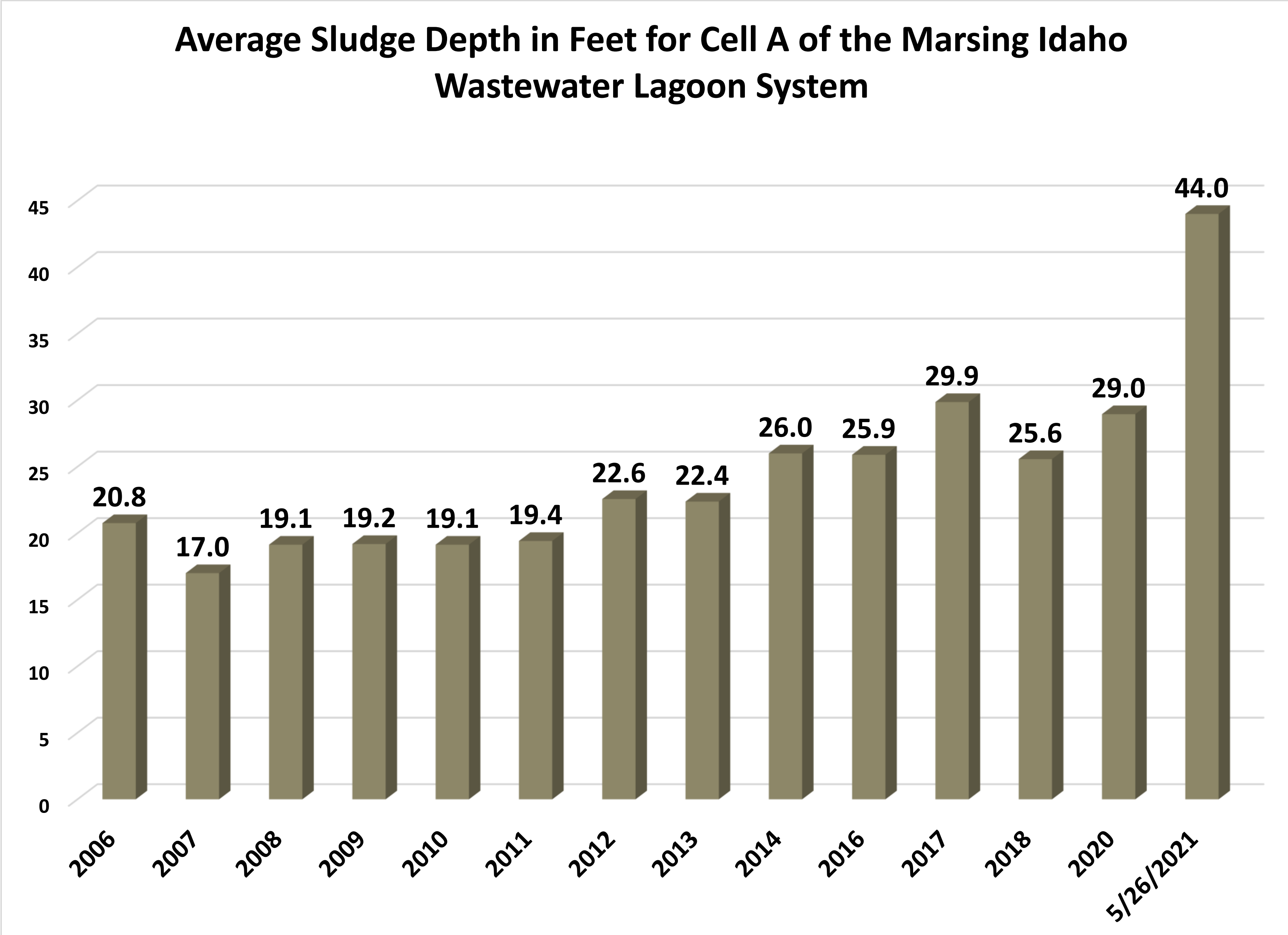


Cell A Sludge Blanket Thickness Relative to Water Depth in Feet



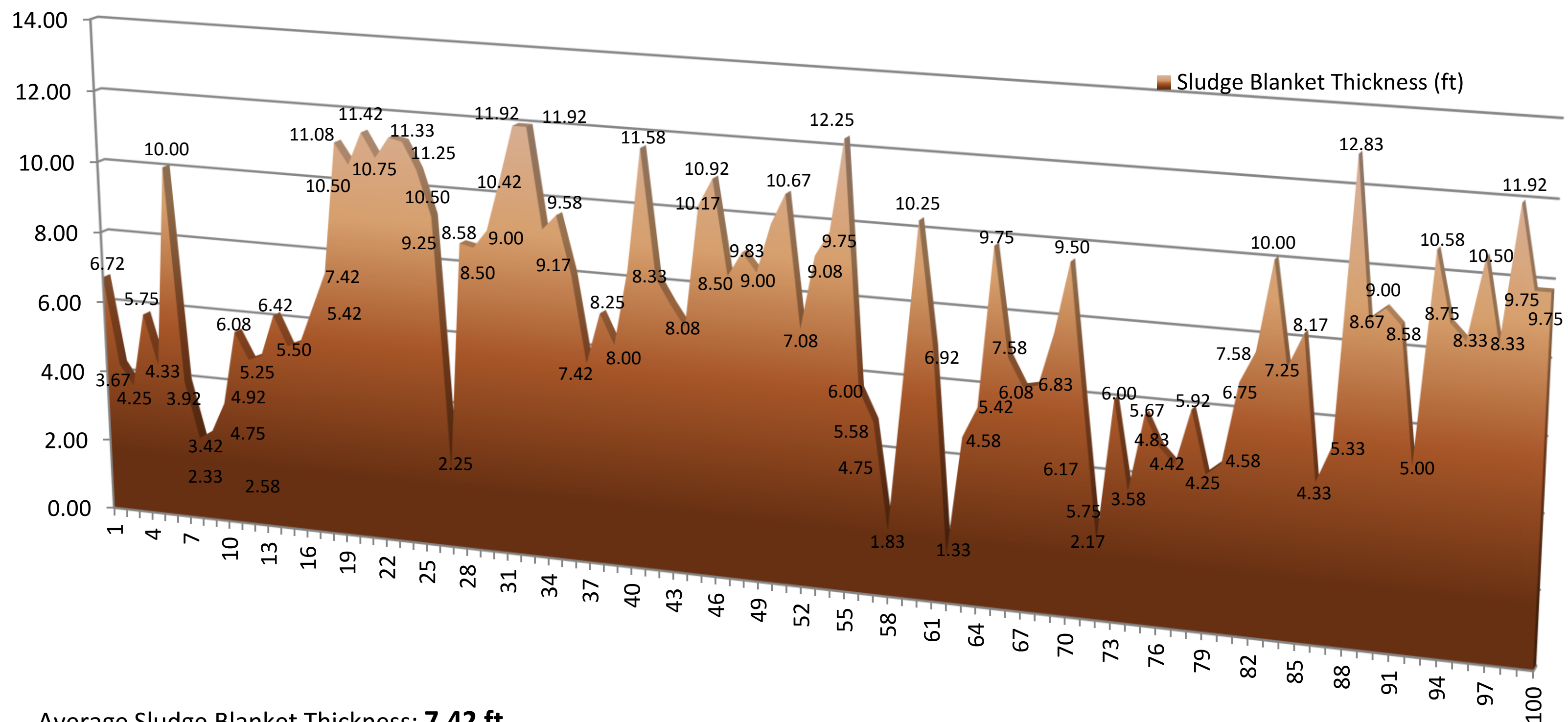
Average Sludge Blanket Thickness: **3.63 feet**
Average Water Depth: **7.86 feet**
Average Water Cap Remaining Over the Sludge Blanket: **4.23 feet**
Percent of Treatment Cell Occupied by Sludge: **46.2 %**

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016	2017	2018	2020		Sludge Blanket Thickness on 5/26/2021
A	4’	2’3”	3’	2’6”	3’	2’8”	3’	3’	1’6”	0’8”	1’3”	1'3"	1'	A	2'5"
B	1’	1’	1’6”	2’	1’	1’	0’2”	1’	1’3”	1’	1’8”	1'	2'6"	B	0'7"
C	1’	0’6”	1’6”	1’6”	1’10”	2’	2’	2’	1’11”	1’	2’	2'	8"	C	2'4"
D	2’	2’	1’6”	2’6”	1’10”	2’6”	2’3”	2’2”	2’3”	2’	2’4”	2'3"	2'6"	D	3'2"
E	2’8”	1’	2’	1’6”	1’6”	1’2”	2’2”	2’3”	0’10”	2’6”	2’6”	2'2"	2'2"	E	4'6"
F	1’	1’	1’	0’10”	0’10”	0’10”	1’2”	1’4”	0’11”	2’	1’6”	1'	1'8"	F	3'4"
G	2’	1’	0’6”	0’1”	0’	0’6”	1’	0’10”	3’2”	3’	3’	2'2"	1'8"	G	3'1"
H	2’	2’6”	2’6”	2’6”	3’	2’6”	2’10”	2’10”	2’3”	2’4”	3’	2'4"	2'10"	H	5'2"
I	1’	2’	2’	2’	2’4”	2’	3’6”	1’11”	2’6”	2’6”	2’6”	3'	3'	I	4'
J	1’	1’6”	0’6”	1’2”	1’	0’6”	1’2”	1’6”	2’10”	3’	3’2”	3'	3'2"	J	4'1"
K	1’	1’	1’	1’	1’4”	1’6”	2’1”	1’6”	2’8”	3’	3’	3'	3'8"	K	6'1"
L	1’6”	1’	1’	1’	1’1”	0’10”	1’2”	1’10”	2’3”	2’	3’	3'	3'3"	L	5'9"
M	2’	1’6”	2’	2’	1’10”	1’10”	2’3”	2’2”	2’10”	3’	2’10”	2'	2'10"	M	4'10"
N	1’6”	2’6”	2’	2’	2’6”	3’	2’6”	2’10”	2’4”	3’2”	2’10”	3'	3'	N	5'1"
O	2’	1’	2’6”	0’6”	0’5”	0’1”	0’4”	0’6”	2’2”	2’	3’	3'	2'10"	O	5'1"
P	1’6”	0’6”	0’6”	1’	1’4”	1’4”	1’6”	1’6”	1’9”	1’8”	2’6”	1'8"	2'6"	P	1'2"
Q	2’	1’6”	2’	2’	2’	2’	2’	2’2”	2’4”	2’6”	2’10”	3'	2'10"	Q	4'1"
R	1’6”	2’	3’	2’	2’4”	2’2”	3’	2’8”	1’11”	2’6”	2’10”	1'6"	2'3"	R	4'10"
S	1’6”	1’	1’	2’	1’4”	2’4”	1’2”	2’4”	2’	2’4”	2’1”	2'	1'8"	S	3'9"
T	1’6”	0’6”	0’6”	1’	0’6”	0’7”	0’6”	1’6”	1’8”	2’	2’3”	2'	2'	T	1'4"
U	2’8”	2’6”	2’	2’6”	2’6”	2’8”	3’	1’4”	1’2”	1’6”	1’2”	1'4"	2'2"	U	1'8"
Tota	**36’4”**	**29’9”**	**33’6”**	**33’7”**	**33’6”**	**34’**	**39’6”**	**39’2”**	**45’6”**	**45’4”**	**52’3”**	**44'9"**	**50'8"**	**To**	**76'4"**
Ave	**20.76"**	**17"**	**19.14"**	**19.19"**	**19.14"**	**19.42"**	**22.57"**	**22.38"**	**26"**	**25.90"**	**29.86"**	**25.57"**	**28.95"**	**Av**	**44"**


Average Sludge Depth in Feet for Cell A of the Marsing Idaho Wastewater Lagoon System
45
40
35
30
25
20
15
10
5
0
20.8
17.0
19.1
19.2
19.1
19.4
22.6
22.4
26.0
25.9
29.9
25.6
29.0
44.0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2016
2017
2018
2020
5/26/2021

2-Cell, Aerated Lagoon System Built in 1970, 20 Acre Cells, 14 feet Deep 85 MG Capacity Each

Results of a 100 Point Sludge Blanket Thickness Profile of Cell # 1 of the XXXX Pond System



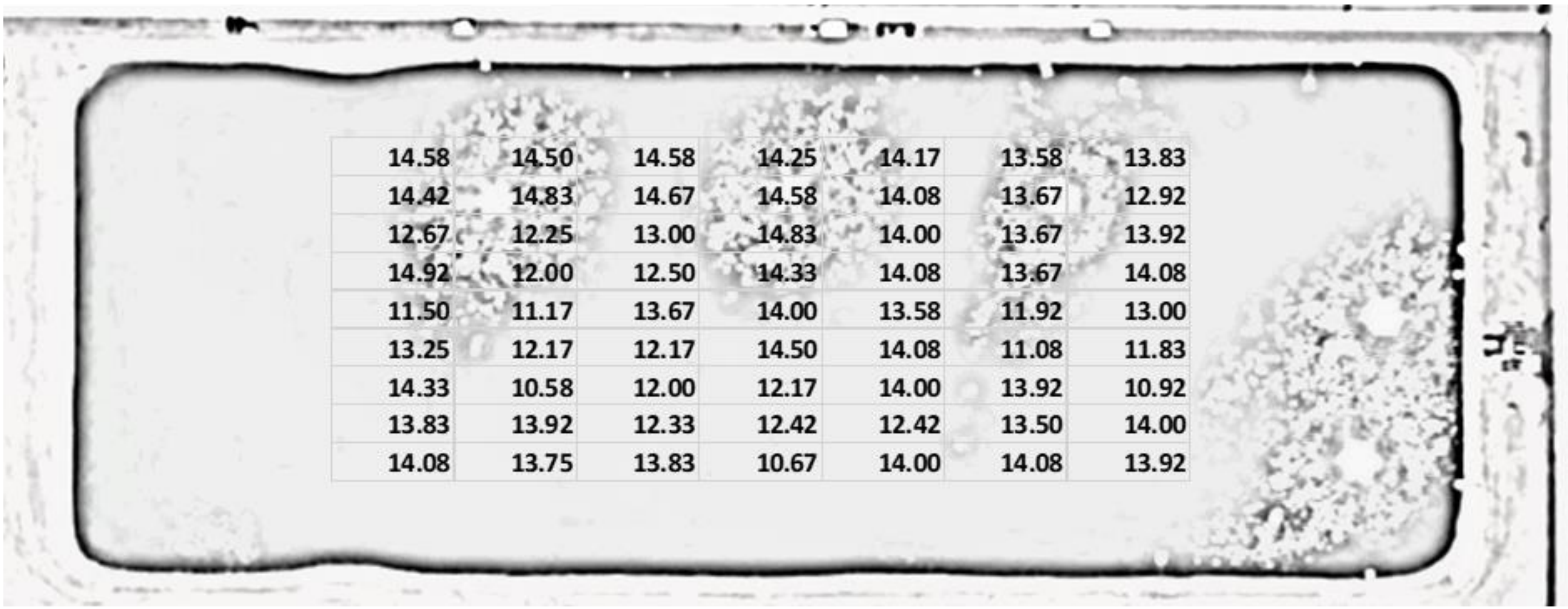
Average Sludge Blanket Thickness: **7.42 ft**

Average Water Depth: **13.4 ft**

Estimated Sludge Volume: **44,720,414 gallons**

Sampled on 6/25/2014

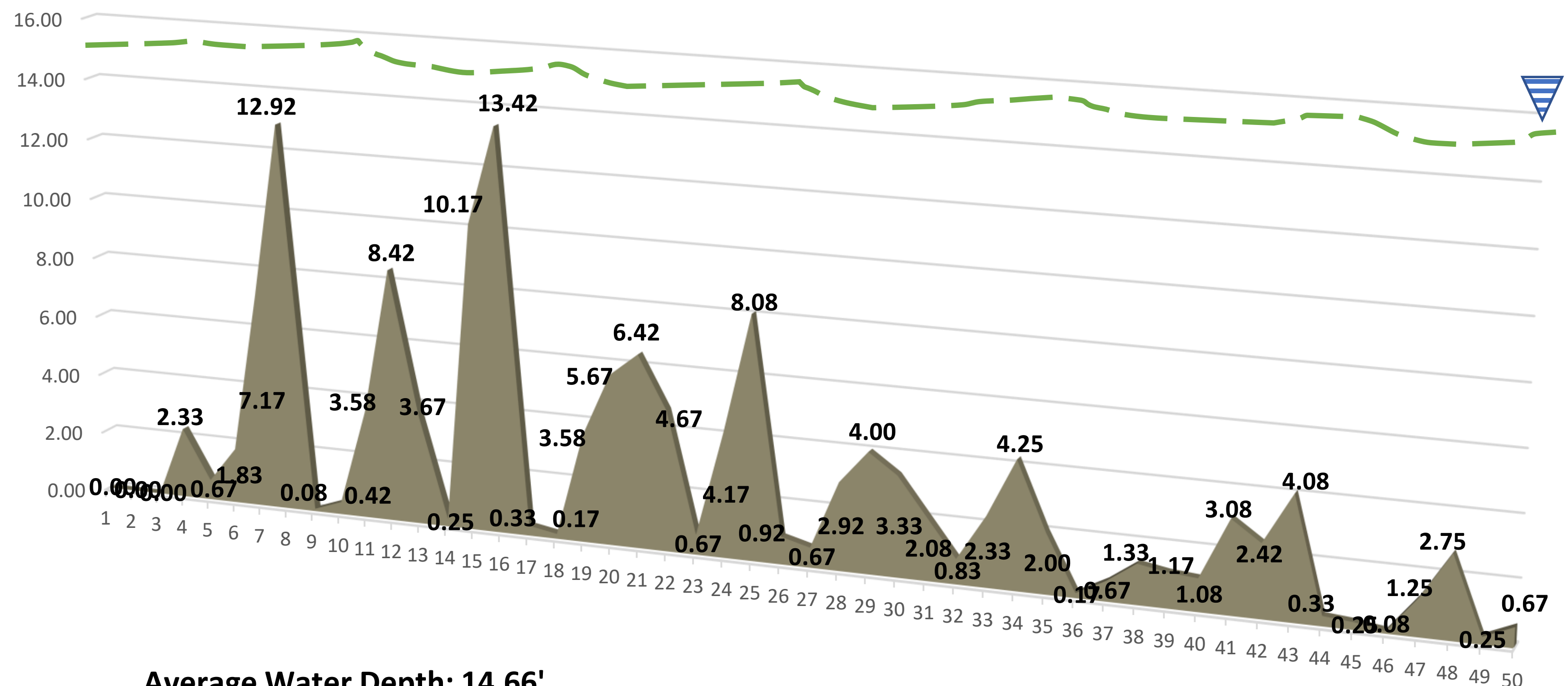
Change	3.42	4.25	2.67	4.17	3	3.17	3.2		
3.20 feet x 43,560 x 20 acres x 7.48 x 8.34 x .0675 % Solids /2000 = 5,870 dry tons x $250 = $1,467,403									



14.58	14.50	14.58	14.25	14.17	13.58	13.83
14.42	14.83	14.67	14.58	14.08	13.67	12.92
12.67	12.25	13.00	14.83	14.00	13.67	13.92
14.92	12.00	12.50	14.33	14.08	13.67	14.08
11.50	11.17	13.67	14.00	13.58	11.92	13.00
13.25	12.17	12.17	14.50	14.08	11.08	11.83
14.33	10.58	12.00	12.17	14.00	13.92	10.92
13.83	13.92	12.33	12.42	12.42	13.50	14.00
14.08	13.75	13.83	10.67	14.00	14.08	13.92

	12.00	12.50	14.33	14.08	13.67		
	11.17	13.67	14.00	13.58	11.92		
	12.17	12.17	14.50	14.08	11.08		
Ave	11.78	12.78	14.28	13.92	12.22		
Min	11.17	12.17	14.00	13.58	11.08		
Max	12.17	13.67	14.50	14.08	13.67		
						Average	
delta:	1.00	1.50	0.50	0.50	2.58	1.22	
1.22 feet x 20 x 43560 x 7,48 x 8.34 x .0675 / 2000 = 2,238 dry tons x $350 = $783,226							

Sludge Blanket Thickness Relative to the Surface of the Water



Average Water Depth: 14.66'
Min Water Depth: 10.55'
Max Water Depth: 16.58'

	1	2	3	4	5	6	7	8	9	10	11
A			16.58	16.33	16.33	15.00					
B		13.00	16.67	16.00	16.42	16.50	16.50	15.25	15.83	13.58	7.17
C		14.58	16.67	16.33	16.25	16.25	16.75	16.75	16.80	16.50	14.83
D		16.58	16.17	16.75	16.33	16.25	16.67	16.92	16.75	16.58	14.92
E	14.75	16.58	16.58	15.67	16.00	16.33	16.58	16.83	17.00	16.00	15.17
F	16.33	14.83	11.50				12.50	12.67	10.00	11.58	13.33

16.17 - 16.92 = .75 feet

9 inch variance

352,900 sq feet x .75 x 7.48 x 8.34 x .065 / 2000 = 537 dry tons x $350/dry ton $187,816

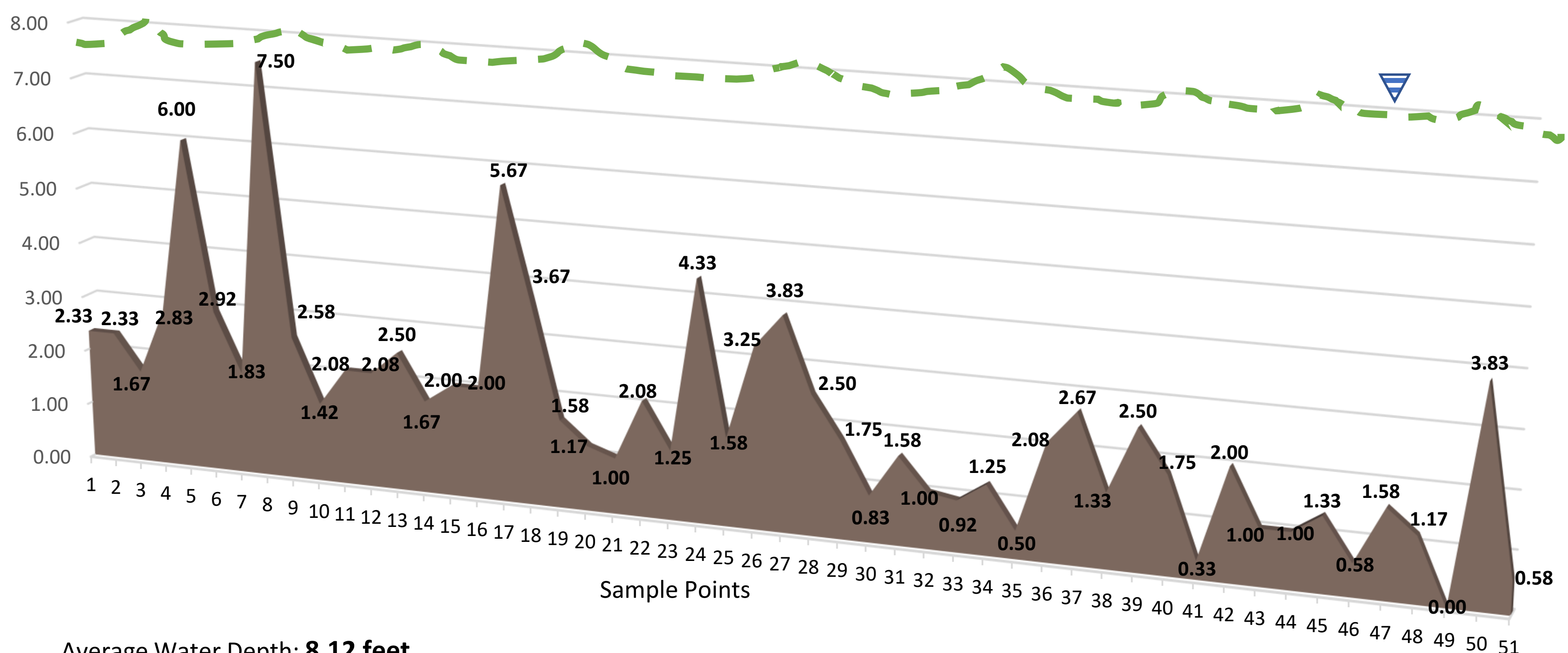
16.67	**16.00**	**16.42**	**16.50**	**16.50**	**15.25**	**15.83**	**13.58**
16.67	**16.33**	**16.25**	**16.25**	**16.75**	**16.75**	**16.80**	**16.50**
16.17	**16.75**	**16.33**	**16.25**	**16.67**	**16.92**	**16.75**	**16.58**
16.58	**15.67**	**16.00**	**16.33**	**16.58**	**16.83**	**17.00**	**16.00**

Through out the high and low 13.58 and 17.00 average variance is = 1 foot

352,900 sq feet x 1.00 x 7.48 x 8.34 x .065 / 2000 = 715 dry tons x $350/dry ton $250,420

	A	B	C	D	E	F	G	H	I	J	K
1	8.42	7.42	8.33	7.92	7.92	8.25	8.75	7.42	8.00		
2	9.00	8.58	8.50	8.25	8.00	8.25	8.00	8.08	9.00	8.25	
3	8.17	8.33	7.67	8.00	7.33	8.25	8.58	7.50	7.33	8.25	8.50
4	8.58	8.00	8.25	8.08	8.08	8.17	8.33	8.75	7.42	8.50	8.50
5	8.00	8.00	8.00	8.00	8.08	7.25	7.92	8.10	8.00	8.25	8.50

Sludge Blanket Thickness Relative to the Water Depth of Cell # 1 at the XXXXXXXX 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**

	A	B	C	D	E	F	G	H	I	J	K
1	**8.42**	**7.42**	**8.33**	**7.92**	**7.92**	**8.25**	**8.75**	**7.42**	**8.00**		
2	**9.00**	**8.58**	**8.50**	**8.25**	**8.00**	**8.25**	**8.00**	**8.08**	**9.00**	**8.25**	
3	**8.17**	**8.33**	**7.67**	**8.00**	**7.33**	**8.25**	**8.58**	**7.50**	**7.33**	**8.25**	**8.50**
4	**8.58**	**8.00**	**8.25**	**8.08**	**8.08**	**8.17**	**8.33**	**8.75**	**7.42**	**8.50**	**8.50**
5	**8.00**	**8.00**	**8.00**	**8.00**	**8.08**	**7.25**	**7.92**	**8.10**	**8.00**	**8.25**	**8.50**

	8.58	**8.50**	**8.25**	**8.00**	**8.25**	**8.00**	**8.08**	**9.00**			
	8.33	**7.67**	**8.00**	**7.33**	**8.25**	**8.58**	**7.50**	**7.33**			
	8.00	**8.25**	**8.08**	**8.08**	**8.17**	**8.33**	**8.75**	**7.42**	Average	Minimum	Maximum
Average	8.31	8.14	8.11	7.81	8.22	8.31	8.11	7.92	8.11	7.81	8.31
Difference	8.32 - 7.81 = 0.5 feet (6 inches)										
552,980 sq ft x 0.5 x 7.47 x 8.34 x .0675 /2000 lbs/ton = 561 dry tons at $350/dry ton = $196,199											

What is Sludge?

Sludge is composed of :

- Primary organic matter…poop
- Dead Algae
- Living and Dead Bacteria
- Dead Protozoa
- Dead Duckweed
- Dead cattails and rush
- Grit
- Clay
- Sand
- Dirt, trash, plastics, fabrics

Much of the sludge you see in a wastewater lagoon is potentially gas

Sludge is:

$C_5H_7O_2N$ & P

Other empirical formulas for biomass are:

- Activated sludge: $C_{60}H_{87}0_{23}N_{12}P$
- Anaerobic sludge: $C_{54}H_{99}O_{32}N_{11}P$
- Algae: $C_{106}H_{181}O_{45}N_{16}P$

(WEF, 1994)

The building blocks of sludge

Table 3.1 Elemental composition of microbial cells.

Elemental	Variations in composition of microbial cells, dry weight %
Carbon	45 – 55
Oxygen	16 – 22
Nitrogen	12 – 16
Hydrogen	7 – 10
Phosphorus	2 – 5
Sulfur	0.8 – 1.5
Potassium	0.8 – 1.5
Sodium	0.5 – 2.0
Calcium	0.4 – 0.7
Magnesium	0.4 – 0.7
Chlorine	0.4 – 0.7
Iron	0.1 – 0.4
All others*	0.2 – 0.5

* Includes trace elements.

These elements can form gasses

85% of dead bacteria and algae mass can be converted to gas

Sludge is mostly composed of Carbon, Oxygen, Nitrogen, and Hydrogen, and under the right conditions, these elements can be converted into gas.

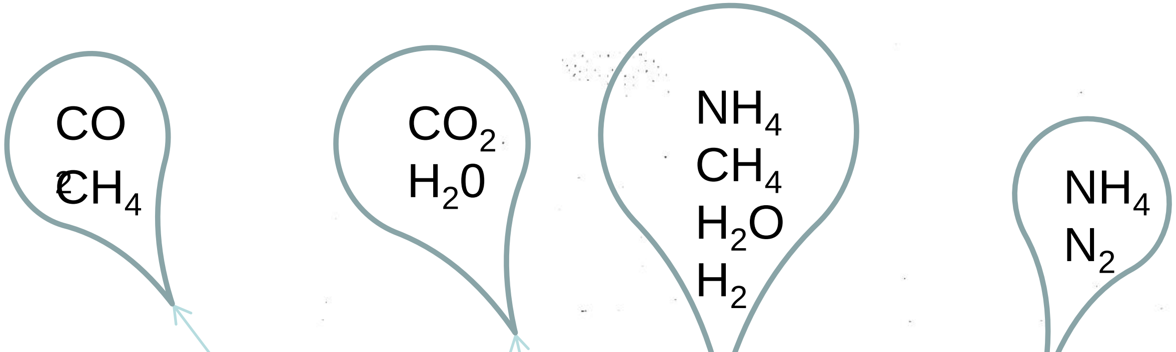


Table 3.4 Empirical formulas for biomass

Empirical formula	Carbon	Oxygen	Hydrogen	Nitrogen	Phosphorus	References
	Organic fraction, %					
Activated sludge						
$C_{60}H_{87}O_{23}N_{12}P$	52.4	26.8	6.3	12.2	2.3	McCarty (1970)
$C_{118}H_{170}O_{51}N_{17}P$	53	30.5	6.4	8.9	1.2	Sawyer (1956)
Anaerobic sludge						
$C_{54}H_{99}O_{32}N_{11}P$	44.9	35.4	6.9	10.7	2.1	Speece and McCarty (1964)
Algae						
$C_{106}H_{181}O_{45}N_{16}P$	52.4	29.7	7.4	9.2	1.3	Stumm and Tenney (1964)

Sludge is potentially all gas and water

$$C_{60}H_{87}O_{23}N_{12}P$$

C →
- CO_2
- CH_4

H →
- NH_4
- CH_4
- H_20
- H_2

O →
- CO_2
- H_20

N →
- NH_4
- N_2

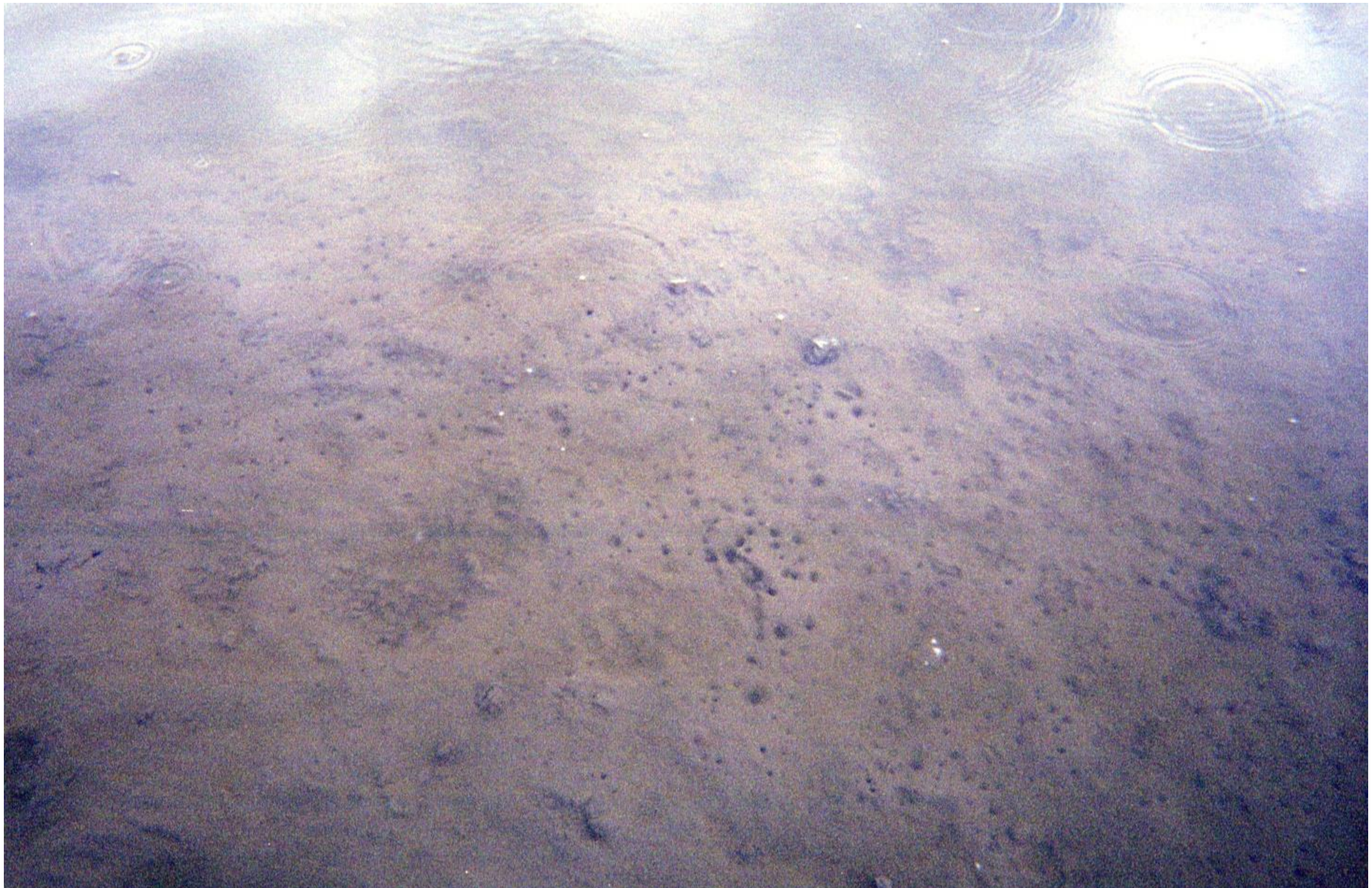
St. Henry

Mixing the Sludge blanket with a Trash Pump

Mixing the sludge blanket can stir it up a bit so be prepared

Think of a log in a fireplace


ANNIVERSARY



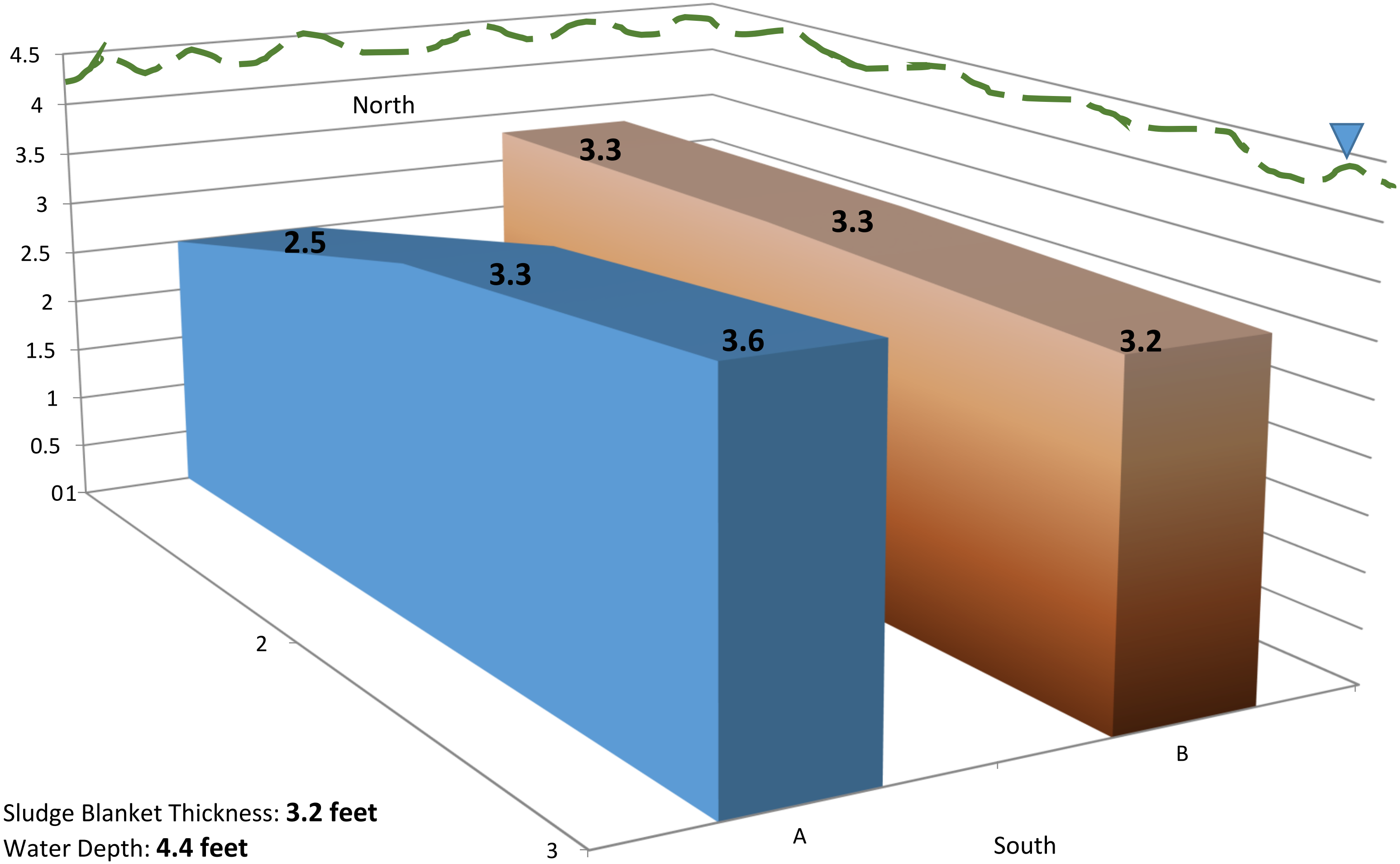
What Effect does Sludge have on a System?

“other than displacing capacity”

Sludge Causes Problems in 4 Ways:

- Sludge displaces valuable treatment capacity
- It creates channeling of sewage flows creating short circuiting
- It feeds nutrients back into the water column feeding new algae cell growth
- Creates/Causes odors

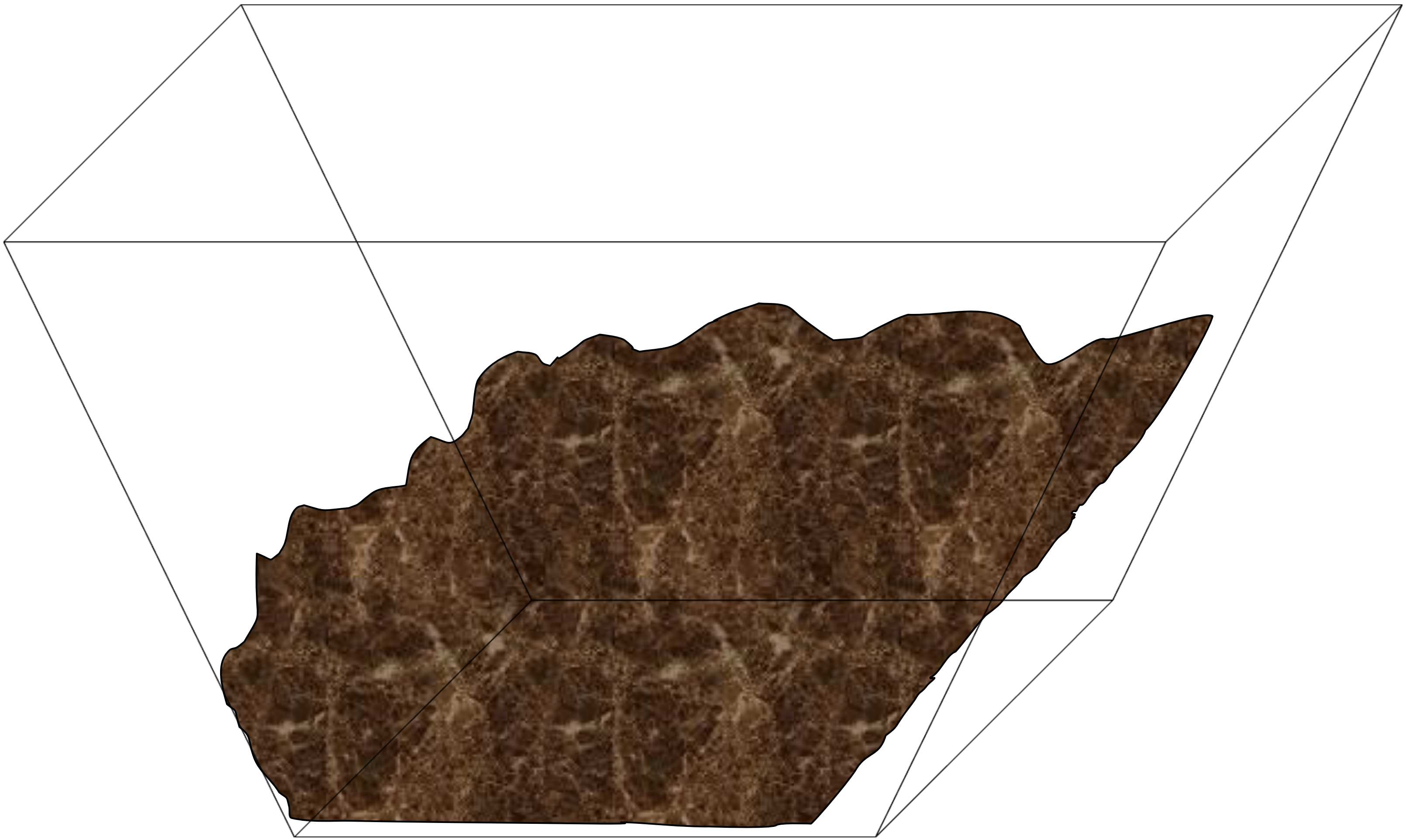
Sludge Blanket Profile for Cell # 3 of the [redacted] STP



Average Sludge Blanket Thickness: **3.2 feet**
Average Water Depth: **4.4 feet**
Average Clearwater Cap Over Top of Sludge: **1.2 feet**
Volume of Sludge: **181,598 gallons**
Estimated Mass of Sludge Based on 20.3% Total Solids: **154 dry tons**
Sampled on: **4/1/2014**

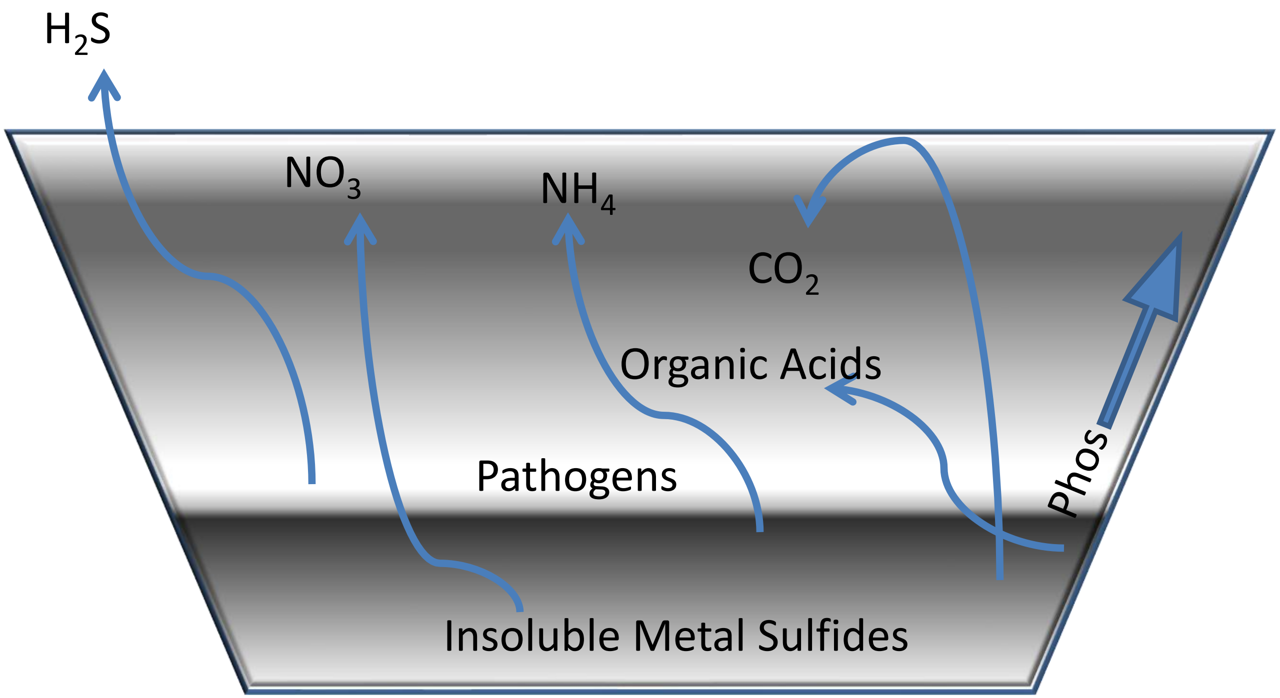
73% of this Treatment Cell's Capacity is Occupied by Sludge

These Cattails Could not Grow Except on Accumulated Sludge



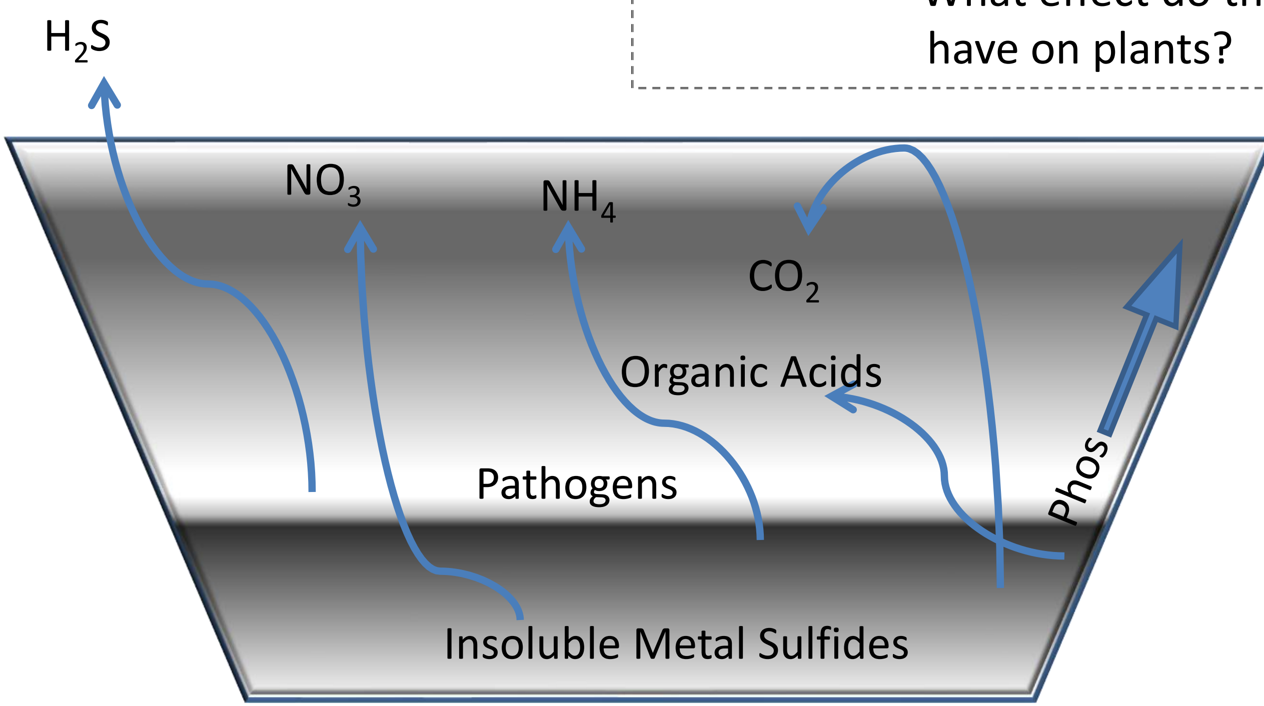
What is in Sludge?

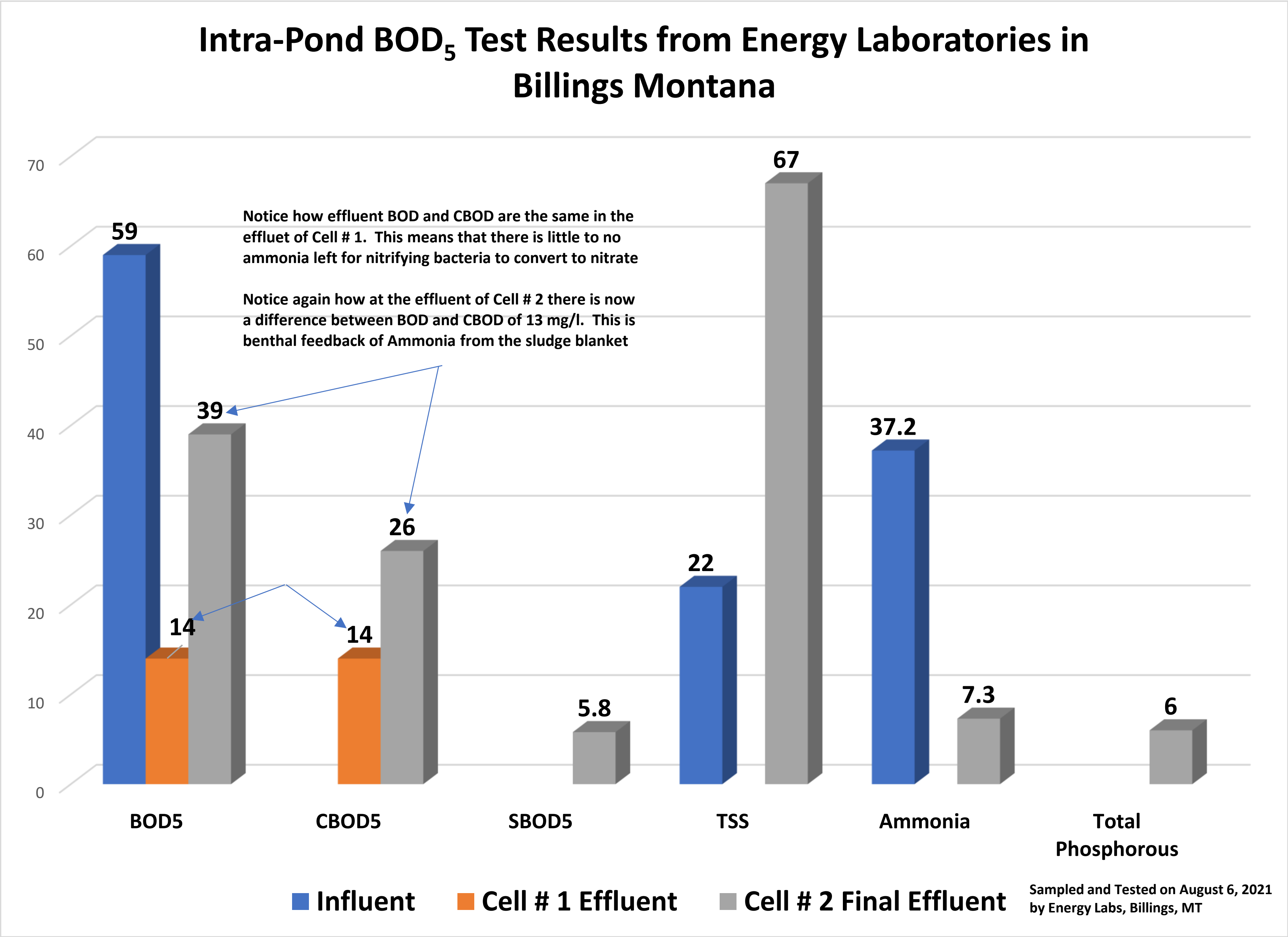
The Other Effects of Sludge



The Other Effects of Sludge

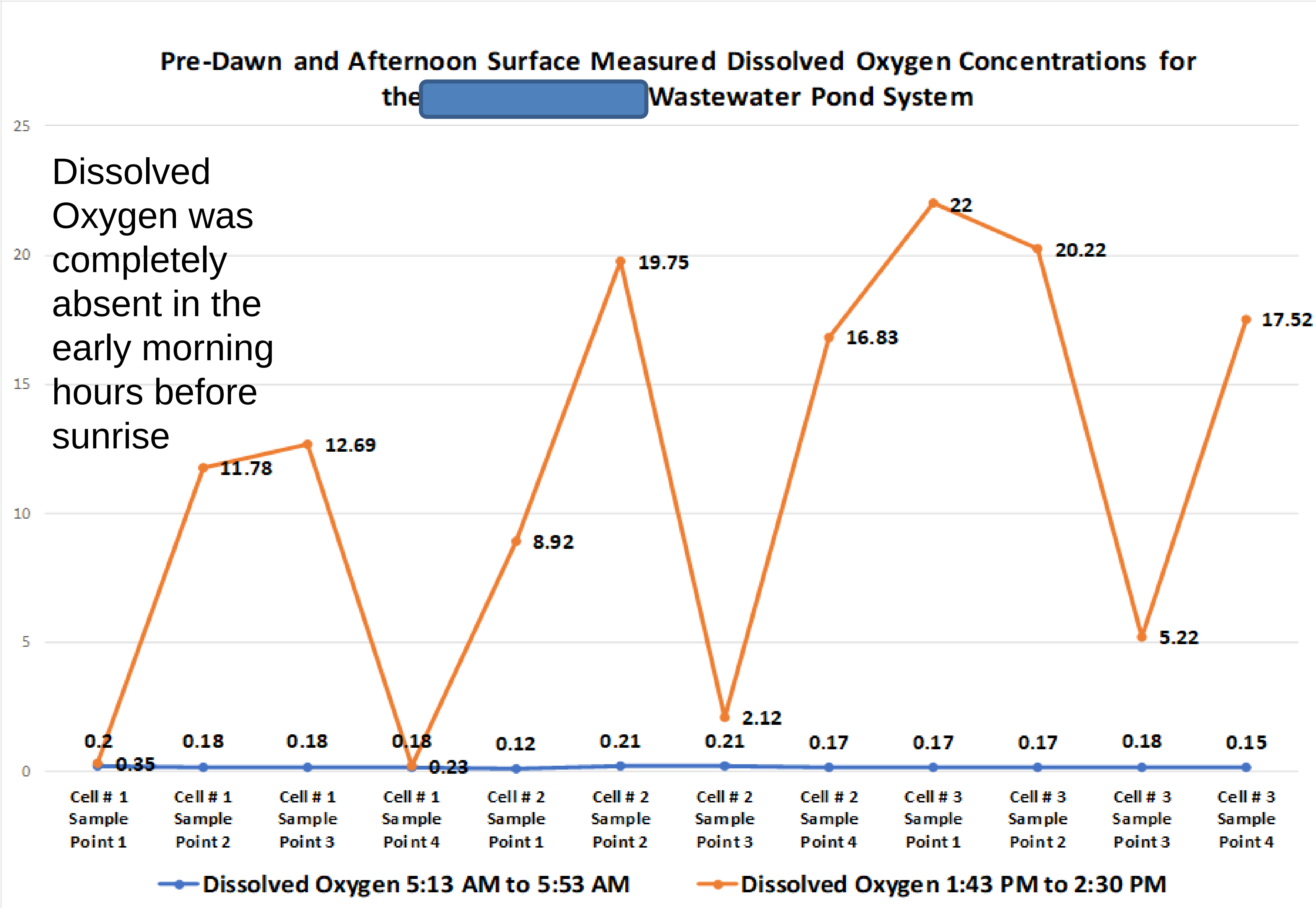
OK Farmers…What are these things?
What is algae?
What effect do these things have on plants?

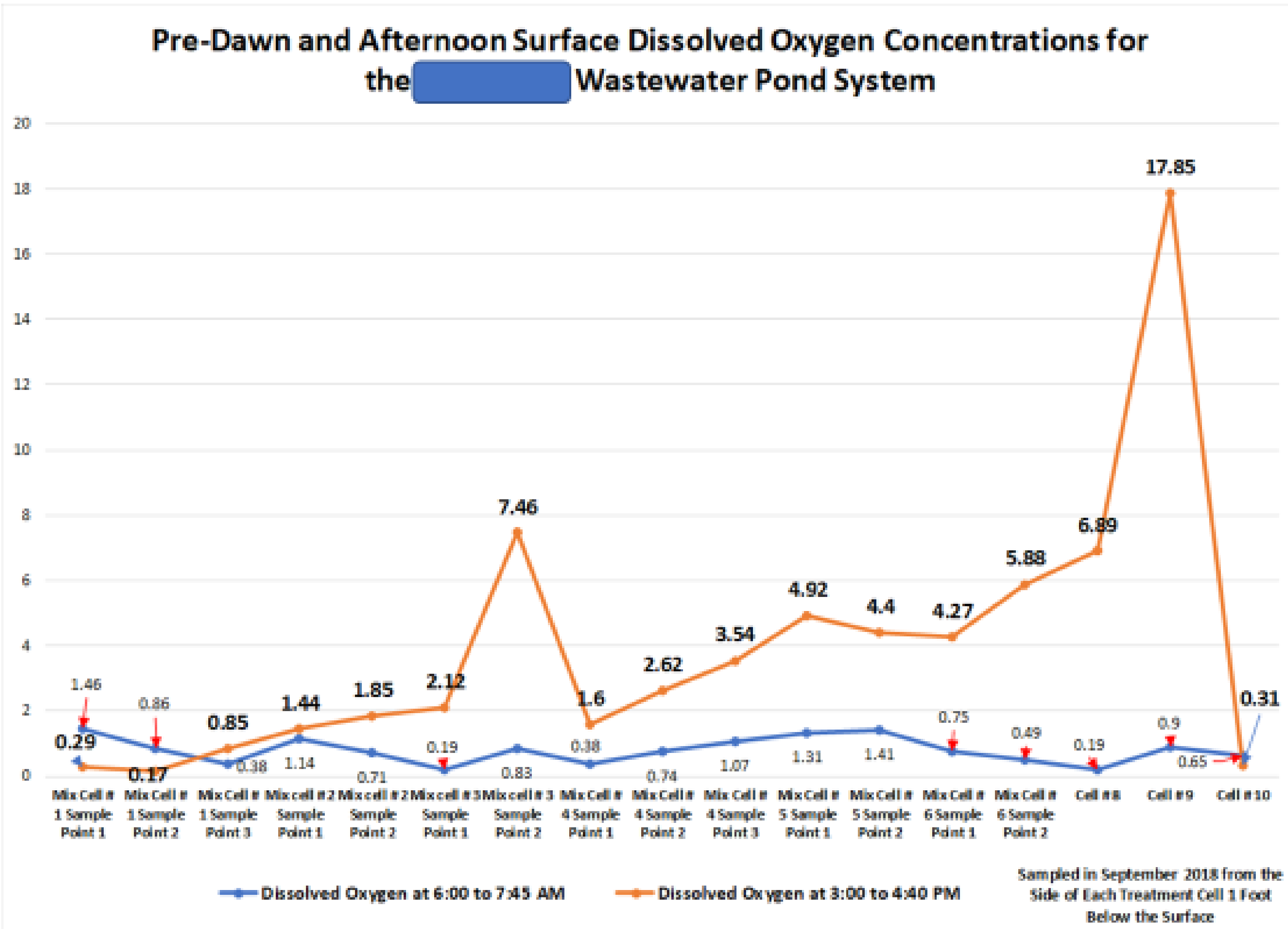



Intra-Pond BOD5 Test Results from Energy Laboratories in Billings Montana
70
60
50
40
30
20
10
0
59
14
39
14
26
5.8
22
67
37.2
7.3
6
Notice how effluent BOD and CBOD are the same in the effluet of Cell # 1. This means that there is little to no ammonia left for nitrifying bacteria to convert to nitrate
Notice again how at the effluent of Cell # 2 there is now a difference between BOD and CBOD of 13 mg/l. This is benthal feedback of Ammonia from the sludge blanket
BOD5
CBOD5
SBOD5
TSS
Ammonia
Total Phosphorous
Influent
Cell # 1 Effluent
Cell # 2 Final Effluent
Sampled and Tested on August 6, 2021 by Energy Labs, Billings, MT

Nutrients Feed Back to the Water Column Feeding Algae & Bacteria

Excess Algae Cause TSS problems and **Oxygen Depletion Problems**


Pre-Dawn and Afternoon Surface Measured Dissolved Oxygen Concentrations for the [redacted] Wastewater Pond System
Dissolved Oxygen was completely absent in the early morning hours before sunrise
25
20
15
10
5
0
0.2
11.78
12.69
0.23
8.92
19.75
2.12
16.83
22
20.22
5.22
17.52
0.35
0.18
0.18
0.18
0.12
0.21
0.21
0.17
0.17
0.17
0.18
0.15
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
Dissolved Oxygen 5:13 AM to 5:53 AM
Dissolved Oxygen 1:43 PM to 2:30 PM



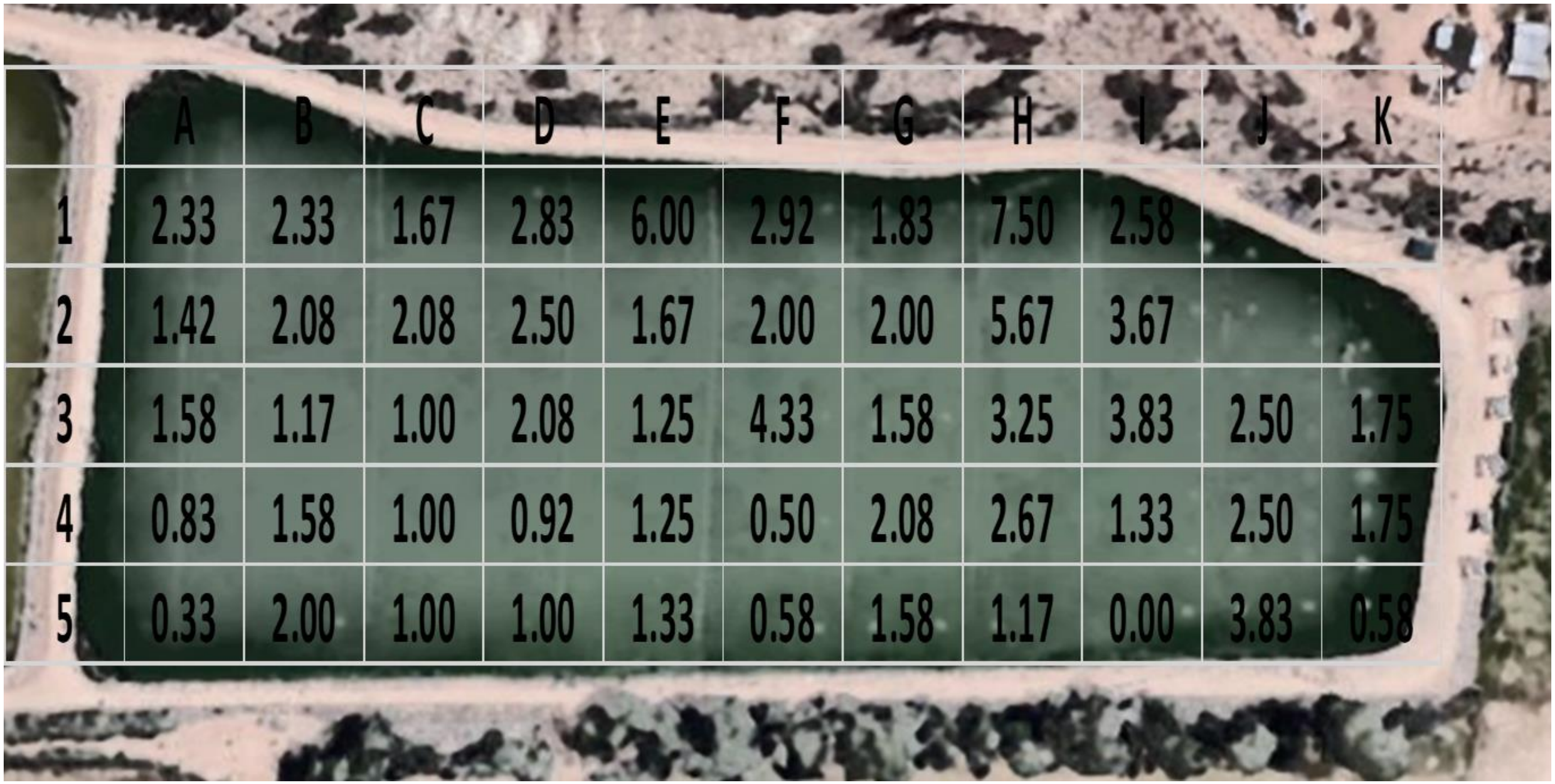
Pre-Dawn and Afternoon Surface Dissolved Oxygen Concentrations for the [redacted] Wastewater Pond System
20
18
16
14
12
10
8
6
4
2
0
17.85
7.46
6.89
5.88
4.92
4.4
4.27
3.54
2.62
2.12
1.85
1.6
1.44
0.85
0.29
0.17
0.31
1.46
0.86
0.38
1.14
0.71
0.19
0.83
0.38
0.74
1.07
1.31
1.41
0.75
0.49
0.19
0.9
0.65
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

Sludge Causes TSS Problems in Two Ways

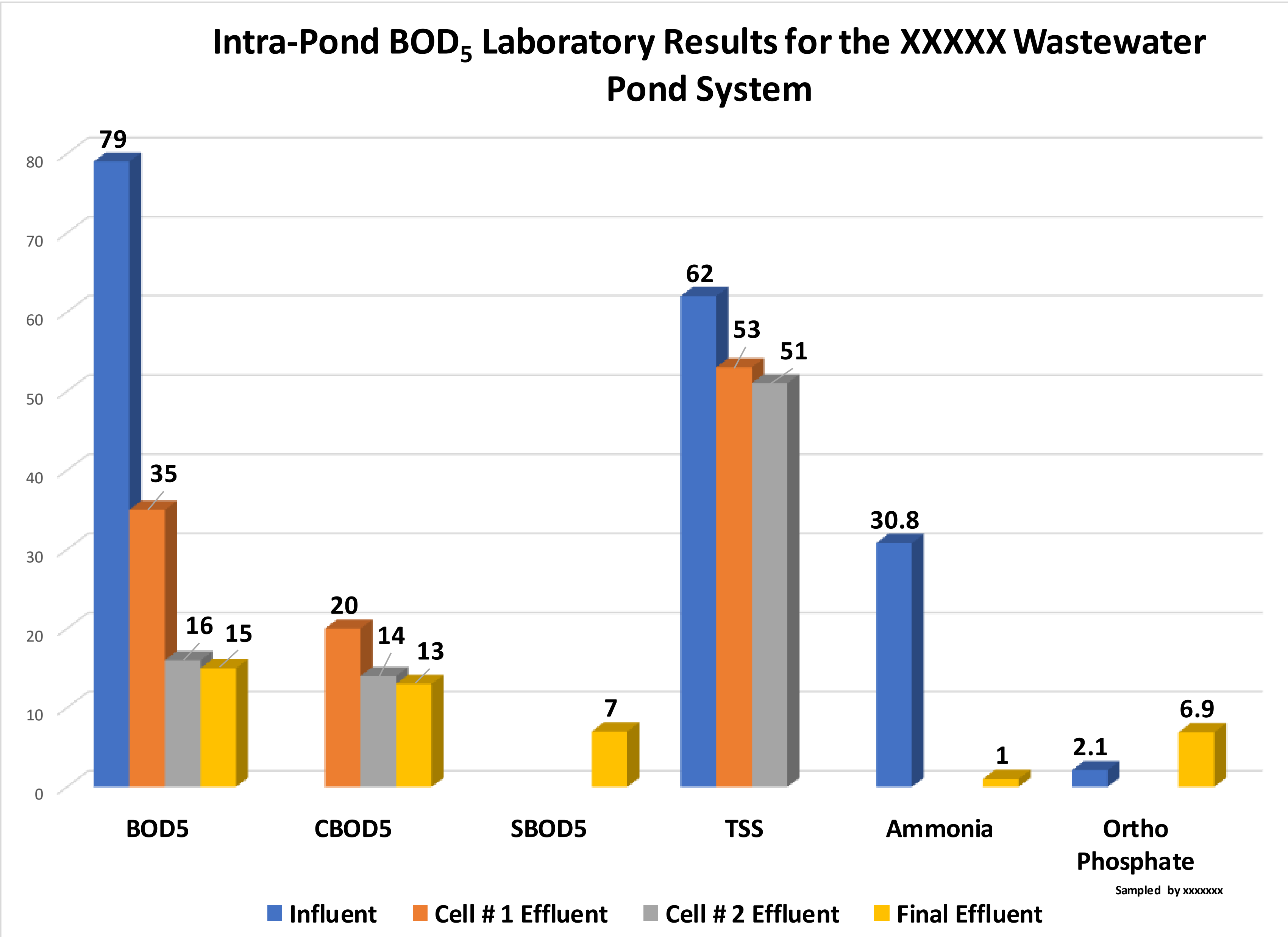
TSS as particulate matter

Soluble BOD and Nutrients feeding algae growth

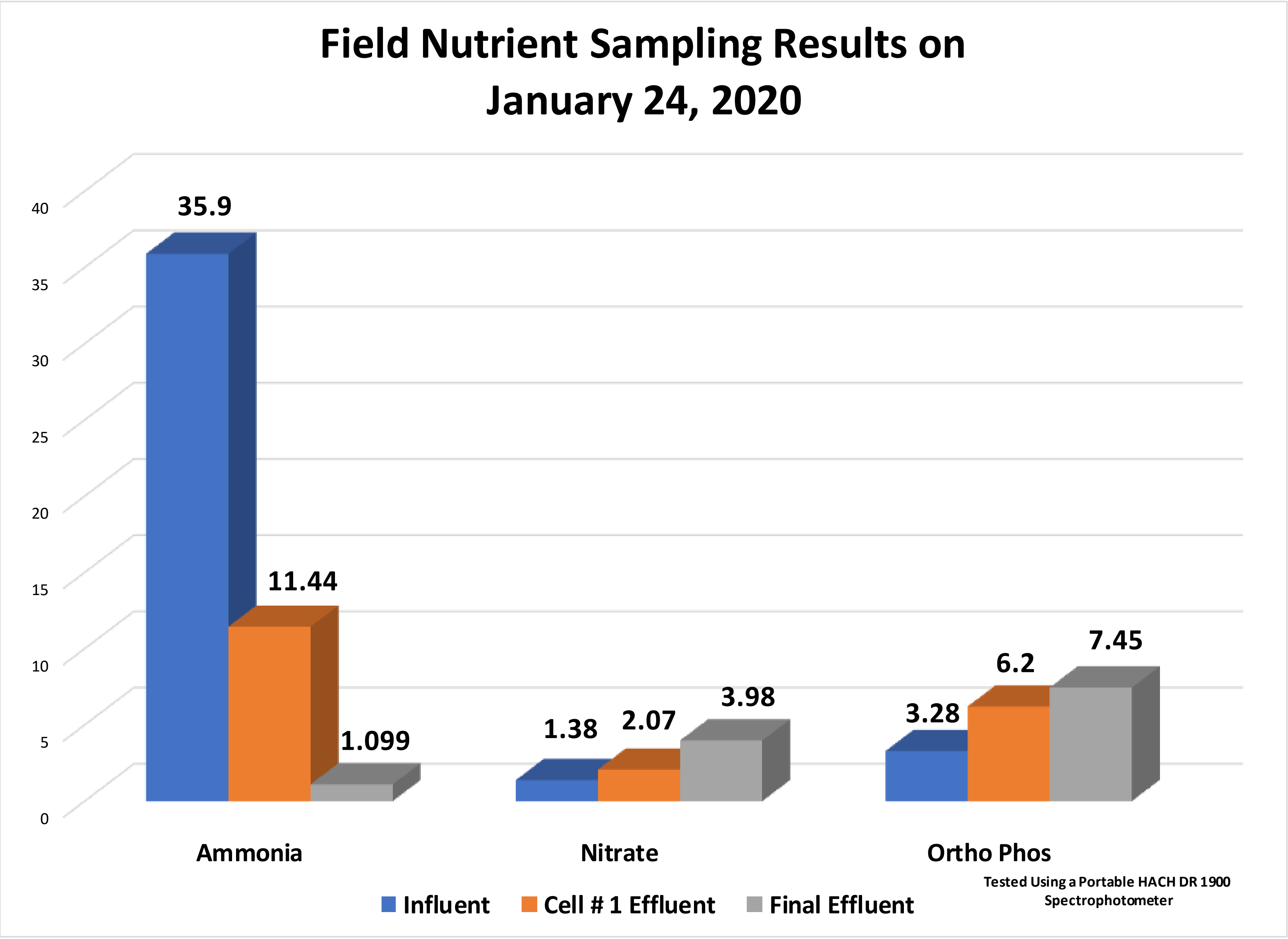
Polling Question # 1



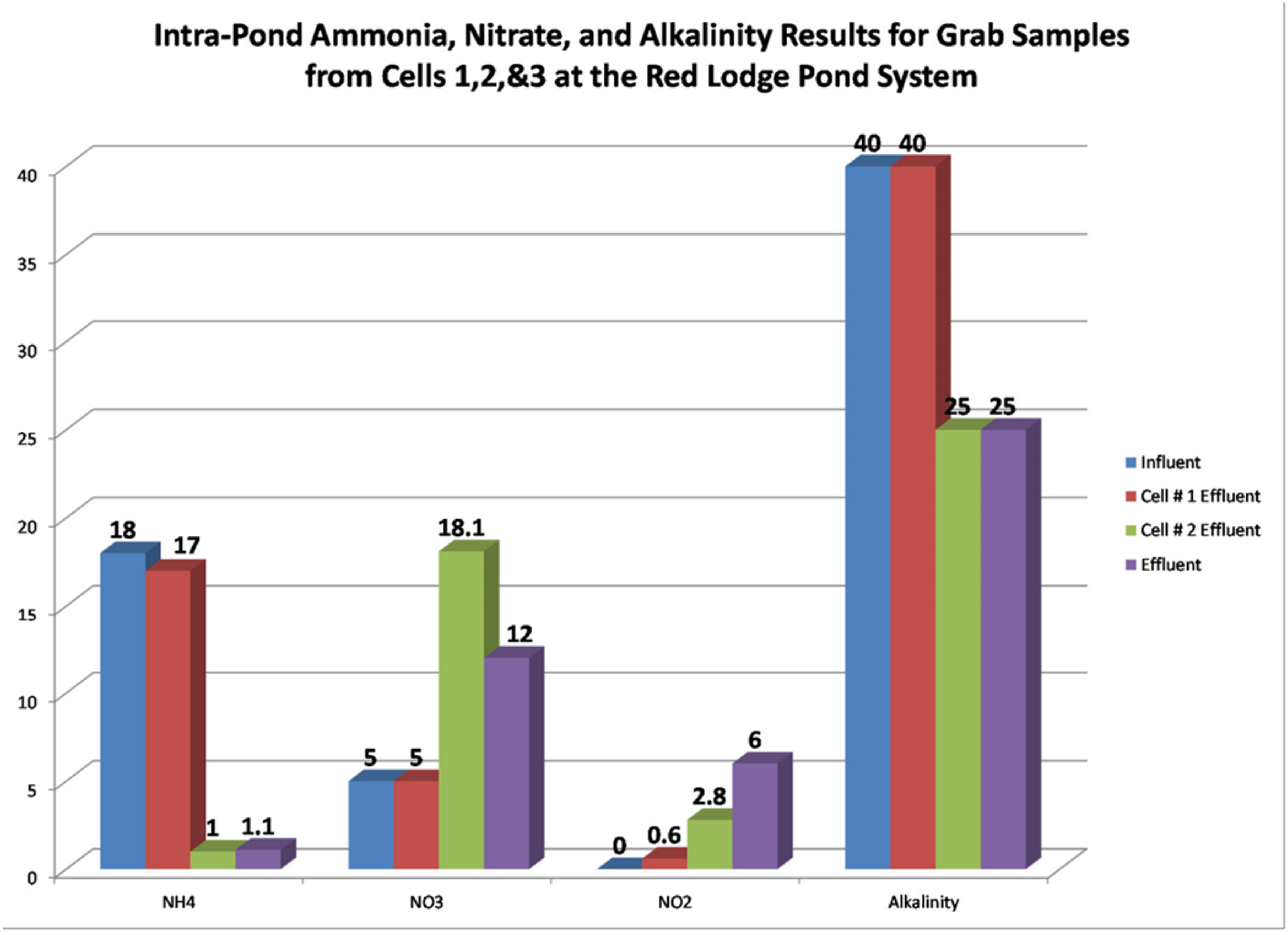
	A	B	C	D	E	F	G	H	I	J	K
1	2.33	2.33	1.67	2.83	6.00	2.92	1.83	7.50	2.58		
2	1.42	2.08	2.08	2.50	1.67	2.00	2.00	5.67	3.67		
3	1.58	1.17	1.00	2.08	1.25	4.33	1.58	3.25	3.83	2.50	1.75
4	0.83	1.58	1.00	0.92	1.25	0.50	2.08	2.67	1.33	2.50	1.75
5	0.33	2.00	1.00	1.00	1.33	0.58	1.58	1.17	0.00	3.83	0.58



Intra-Pond BOD5 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

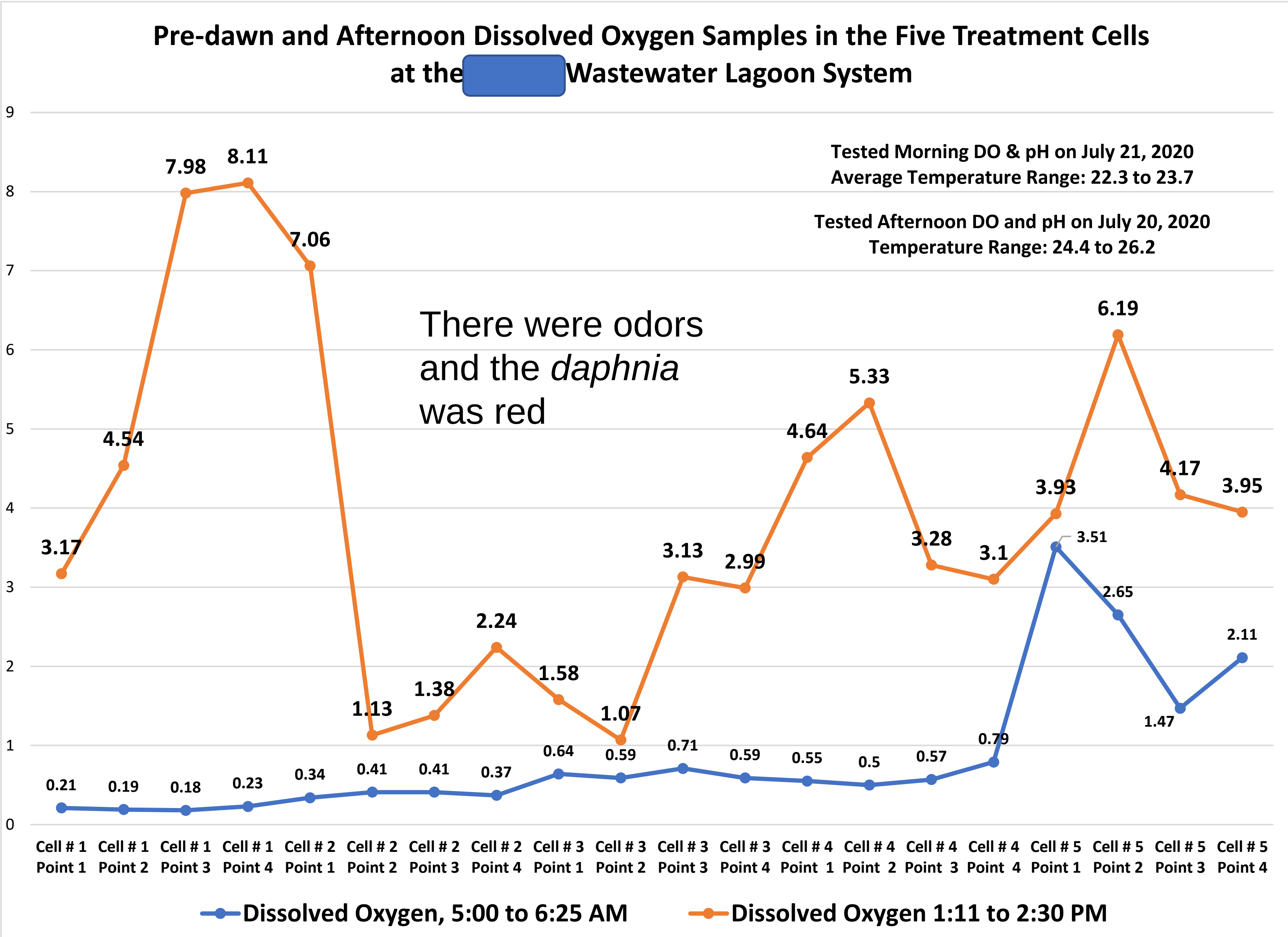


Field Nutrient Sampling Results on January 24, 2020
40
35
30
25
20
15
10
5
0
35.9
11.44
1.099
1.38
2.07
3.98
3.28
6.2
7.45
Ammonia
Nitrate
Ortho Phos
Influent
Cell # 1 Effluent
Final Effluent
Tested Using a Portable HACH DR 1900 Spectrophotometer

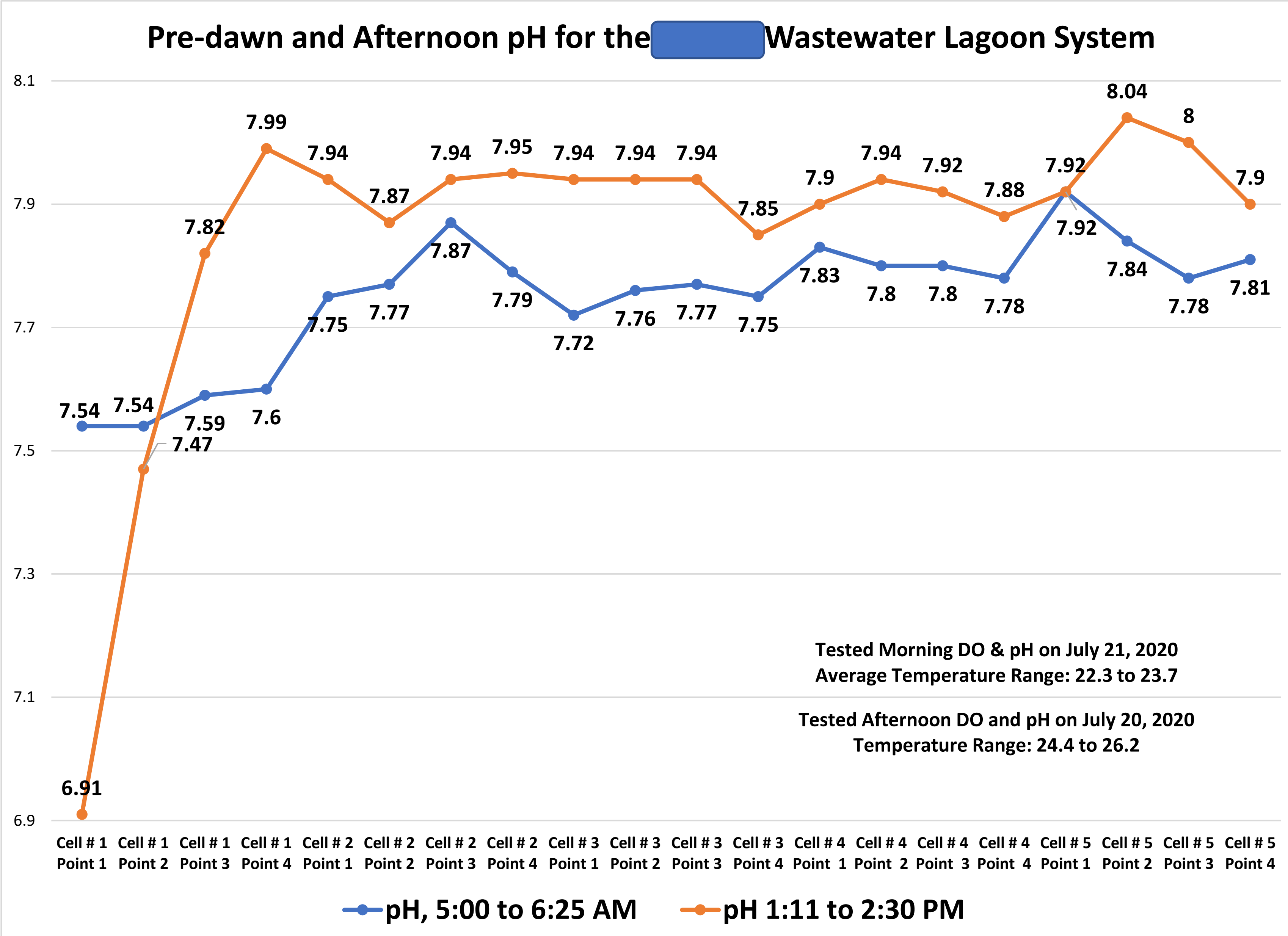


Intra-Pond Ammonia, Nitrate, and Alkalinity Results for Grab Samples from Cells 1,2,&3 at the Red Lodge Pond System
40
35
30
25
20
15
10
5
0
18
17
1
1.1
5
5
18.1
12
0
0.6
2.8
6
40
40
25
25
NH4
NO3
NO2
Alkalinity
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Effluent

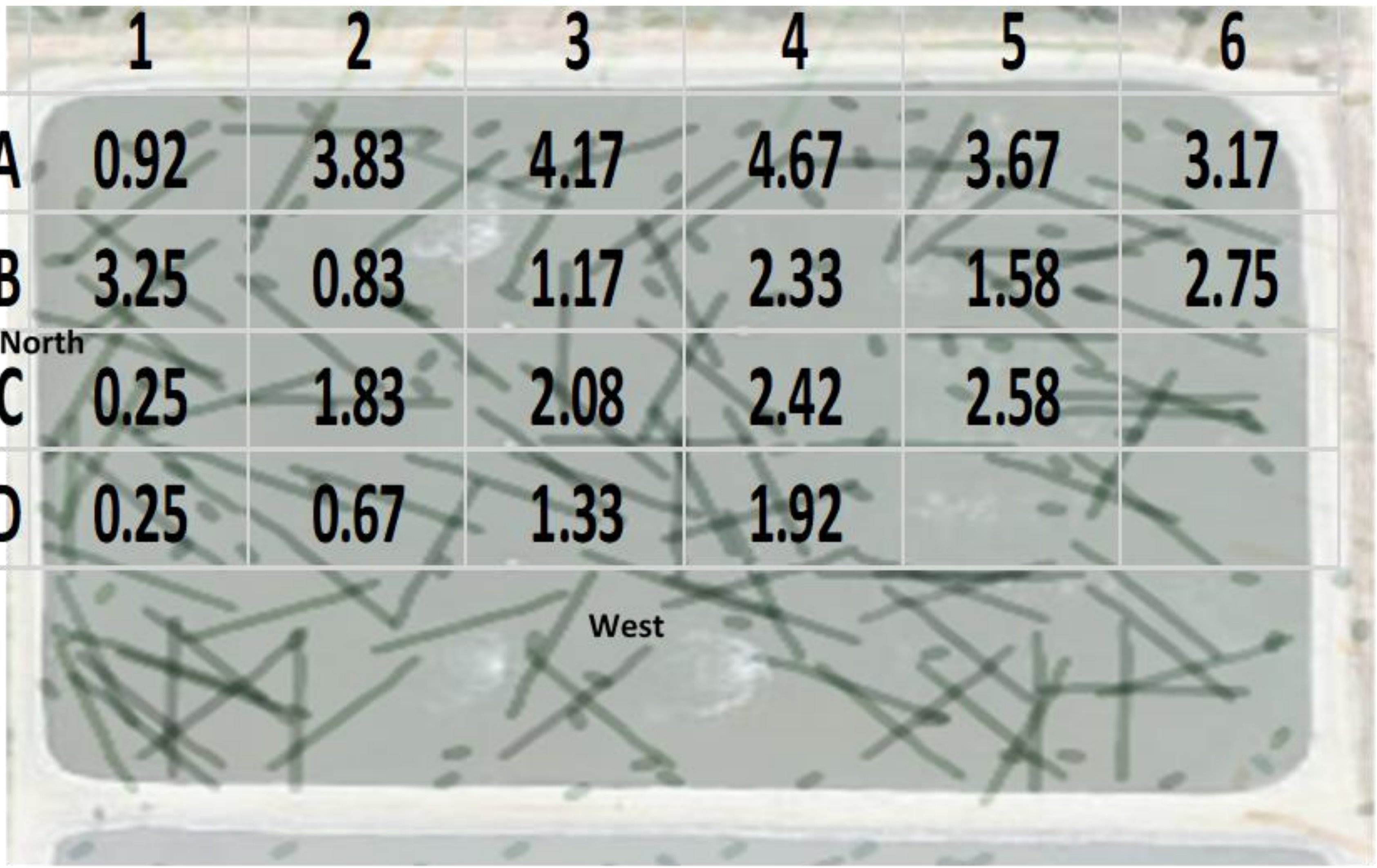
A Five Cell Lagoon system with Benthal Feedback



Pre-dawn and Afternoon Dissolved Oxygen Samples in the Five Treatment Cells
at the [redacted] Wastewater Lagoon System
Tested Morning DO & pH on July 21, 2020
Average Temperature Range: 22.3 to 23.7
Tested Afternoon DO and pH on July 20, 2020
Temperature Range: 24.4 to 26.2
There were odors and the daphnia was red
9
8
7
6
5
4
3
2
1
0
3.17
4.54
7.98
8.11
7.06
1.13
1.38
2.24
1.58
1.07
3.13
2.99
4.64
5.33
3.28
3.1
3.93
6.19
4.17
3.95
0.21
0.19
0.18
0.23
0.34
0.41
0.41
0.37
0.64
0.59
0.71
0.59
0.55
0.5
0.57
0.79
3.51
2.65
1.47
2.11
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
Cell # 4 Point 1
Cell # 4 Point 2
Cell # 4 Point 3
Cell # 4 Point 4
Cell # 5 Point 1
Cell # 5 Point 2
Cell # 5 Point 3
Cell # 5 Point 4
Dissolved Oxygen, 5:00 to 6:25 AM
Dissolved Oxygen 1:11 to 2:30 PM

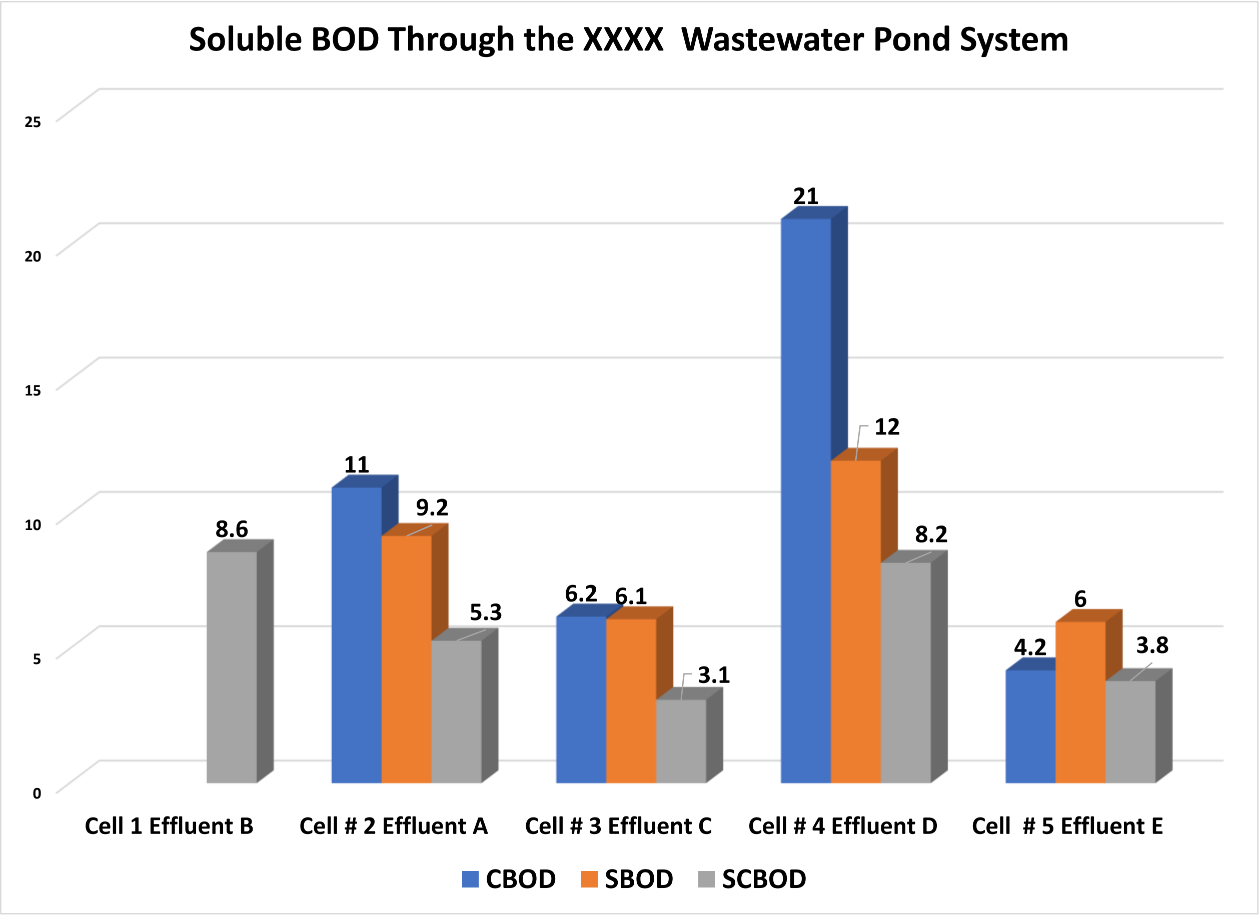

Pre-dawn and Afternoon pH for the [redacted] Wastewater Lagoon System
8.1
7.9
7.7
7.5
7.3
7.1
6.9
7.54
7.54
7.59
7.6
7.75
7.77
7.87
7.79
7.72
7.76
7.77
7.75
7.83
7.8
7.8
7.78
7.92
7.84
7.78
7.81
6.91
7.47
7.82
7.99
7.94
7.87
7.94
7.95
7.94
7.94
7.94
7.85
7.9
7.94
7.92
7.88
7.92
8.04
8
7.9
Tested Morning DO & pH on July 21, 2020
Average Temperature Range: 22.3 to 23.7
Tested Afternoon DO and pH on July 20, 2020
Temperature Range: 24.4 to 26.2
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
Cell # 4 Point 1
Cell # 4 Point 2
Cell # 4 Point 3
Cell # 4 Point 4
Cell # 5 Point 1
Cell # 5 Point 2
Cell # 5 Point 3
Cell # 5 Point 4
pH, 5:00 to 6:25 AM
pH 1:11 to 2:30 PM

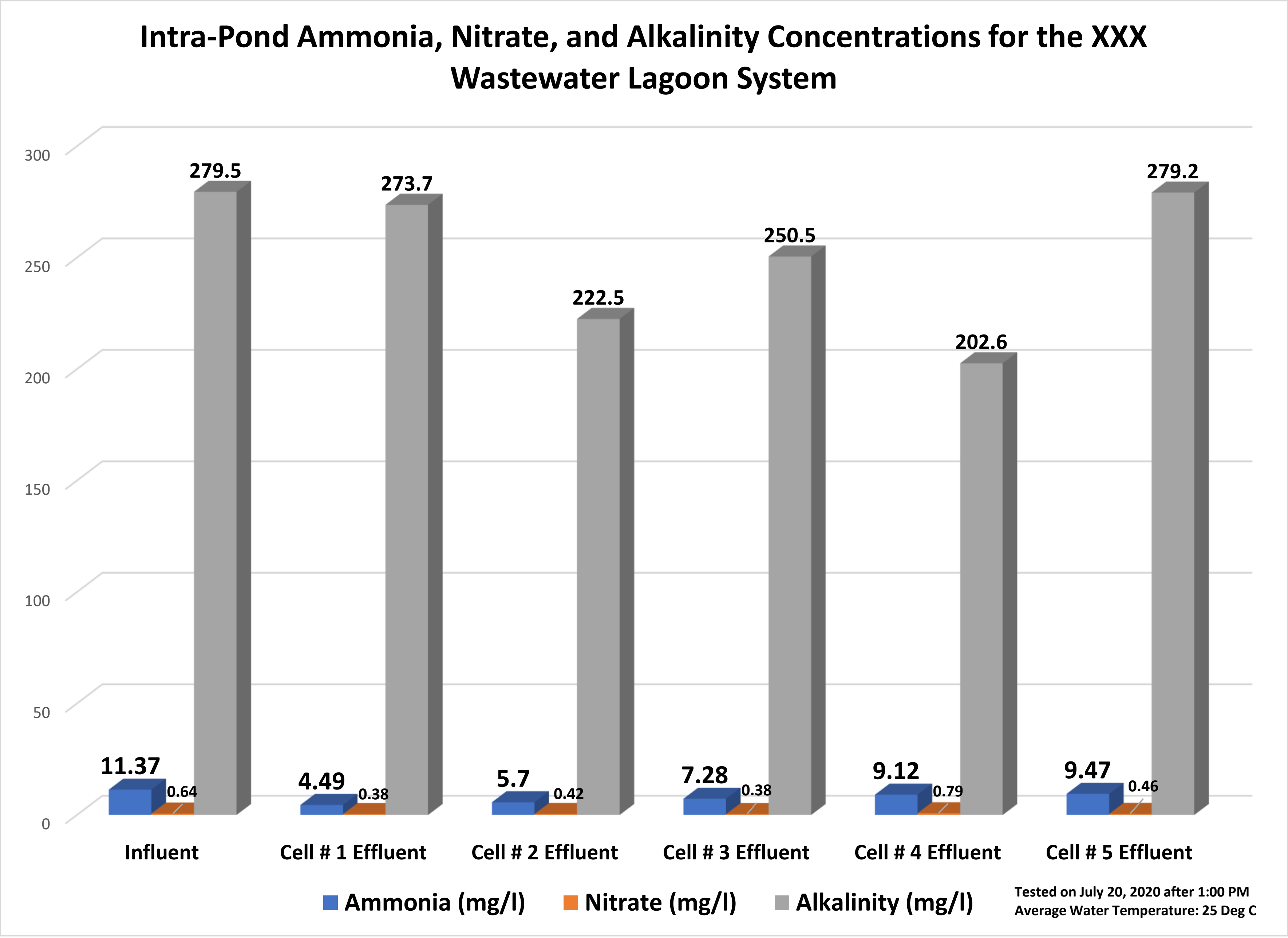
They laid the diffused air system right over the sludge blanket, added bacteria, and after two years the sludge was still there

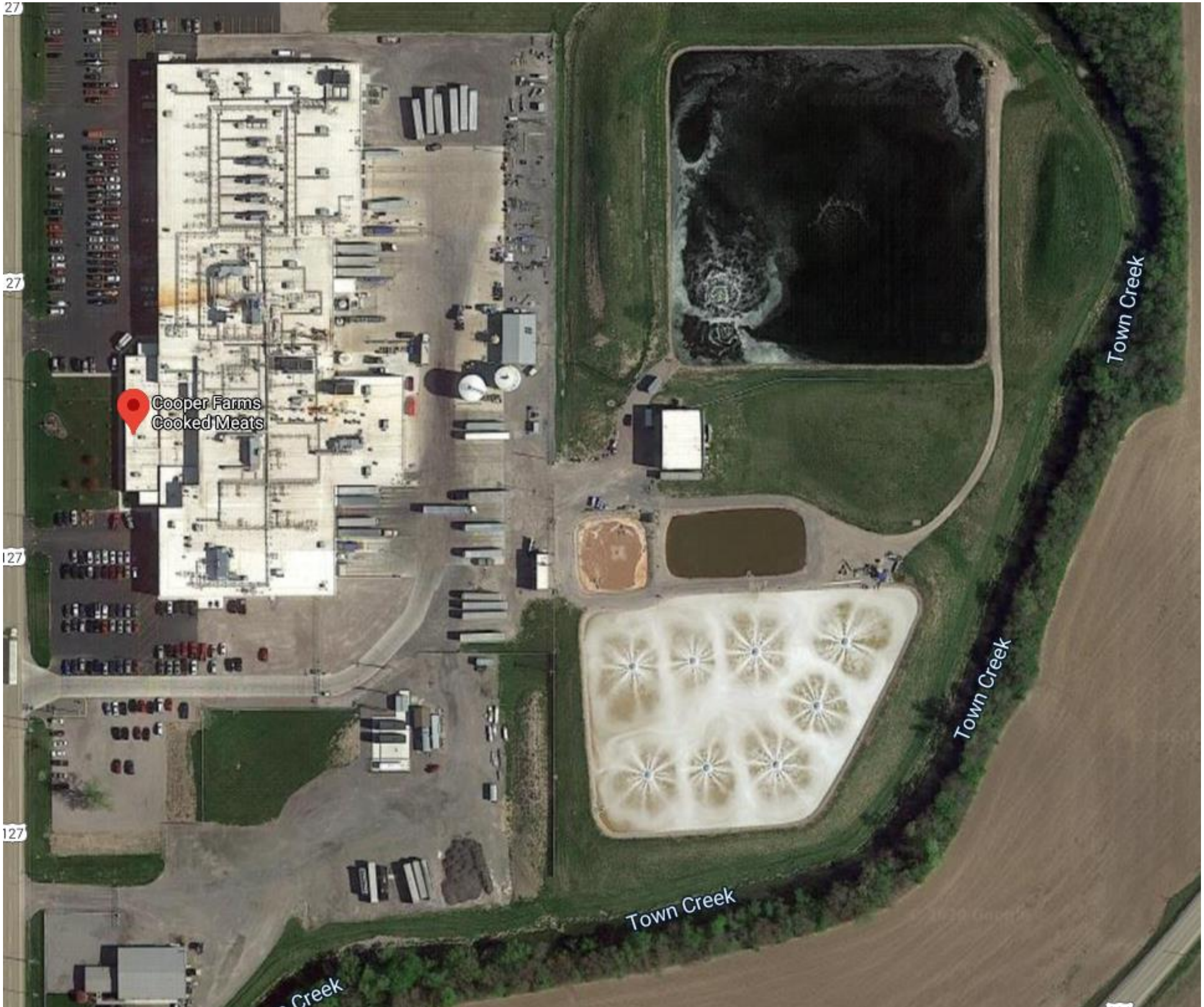


	1	2	3	4	5	6
A	0.92	3.83	4.17	4.67	3.67	3.17
B	3.25	0.83	1.17	2.33	1.58	2.75
C	0.25	1.83	2.08	2.42	2.58	
D	0.25	0.67	1.33	1.92		

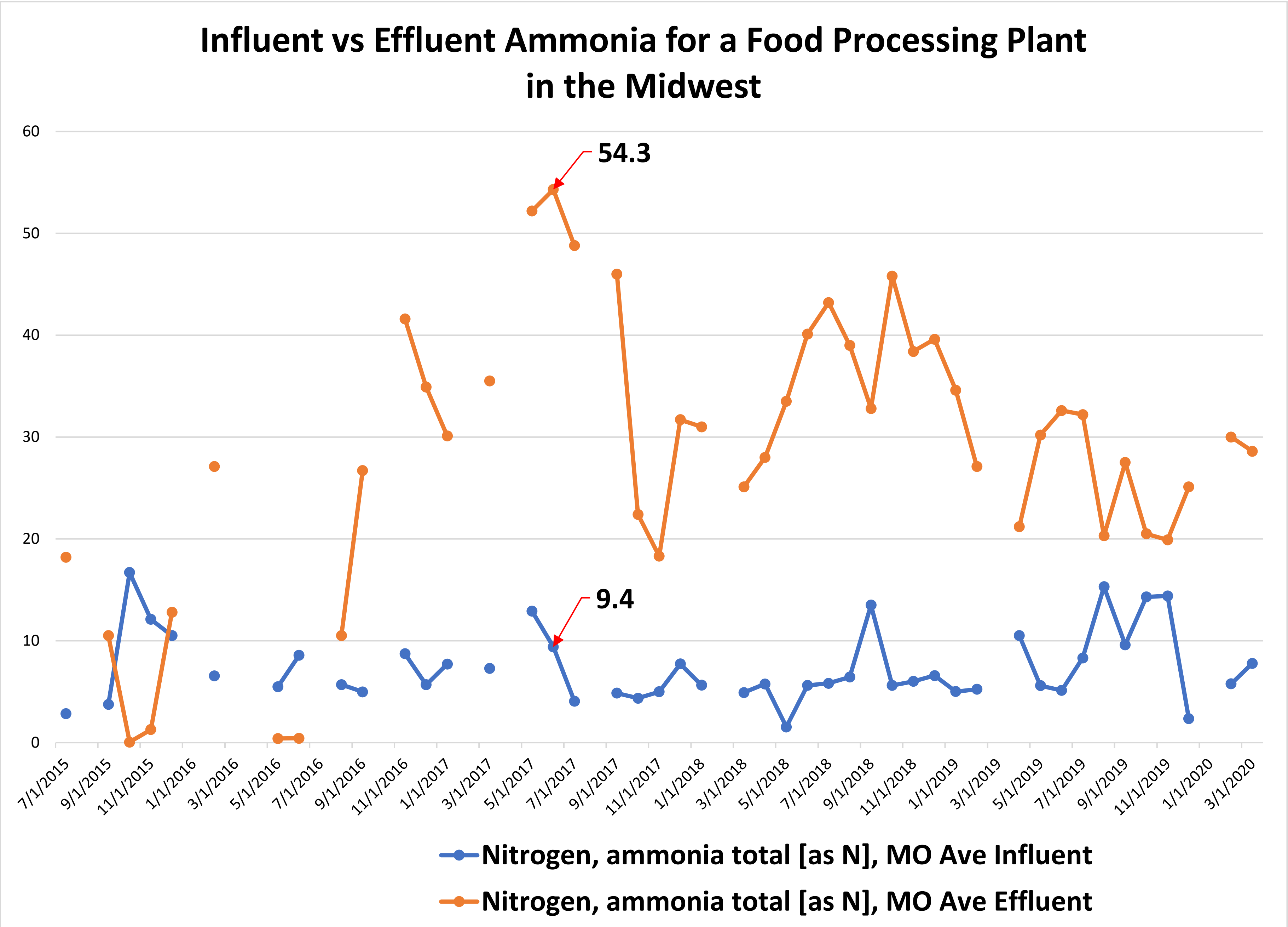
Notice the Increase in Cell # 4 SBOD and the Ammonia in the Next slide




Intra-Pond Ammonia, Nitrate, and Alkalinity Concentrations for the XXX Wastewater Lagoon System
300
250
200
150
100
50
0
279.5
273.7
222.5
250.5
202.6
279.2
11.37
0.64
4.49
0.38
5.7
0.42
7.28
0.38
9.12
0.79
9.47
0.46
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent
Cell # 4 Effluent
Cell # 5 Effluent
Ammonia (mg/l)
Nitrate (mg/l)
Alkalinity (mg/l)
Tested on July 20, 2020 after 1:00 PM
Average Water Temperature: 25 Deg C



Cooper Farms
Cooked Meats
Town Creek
Town Creek
Town Creek
127
127
127
127
224

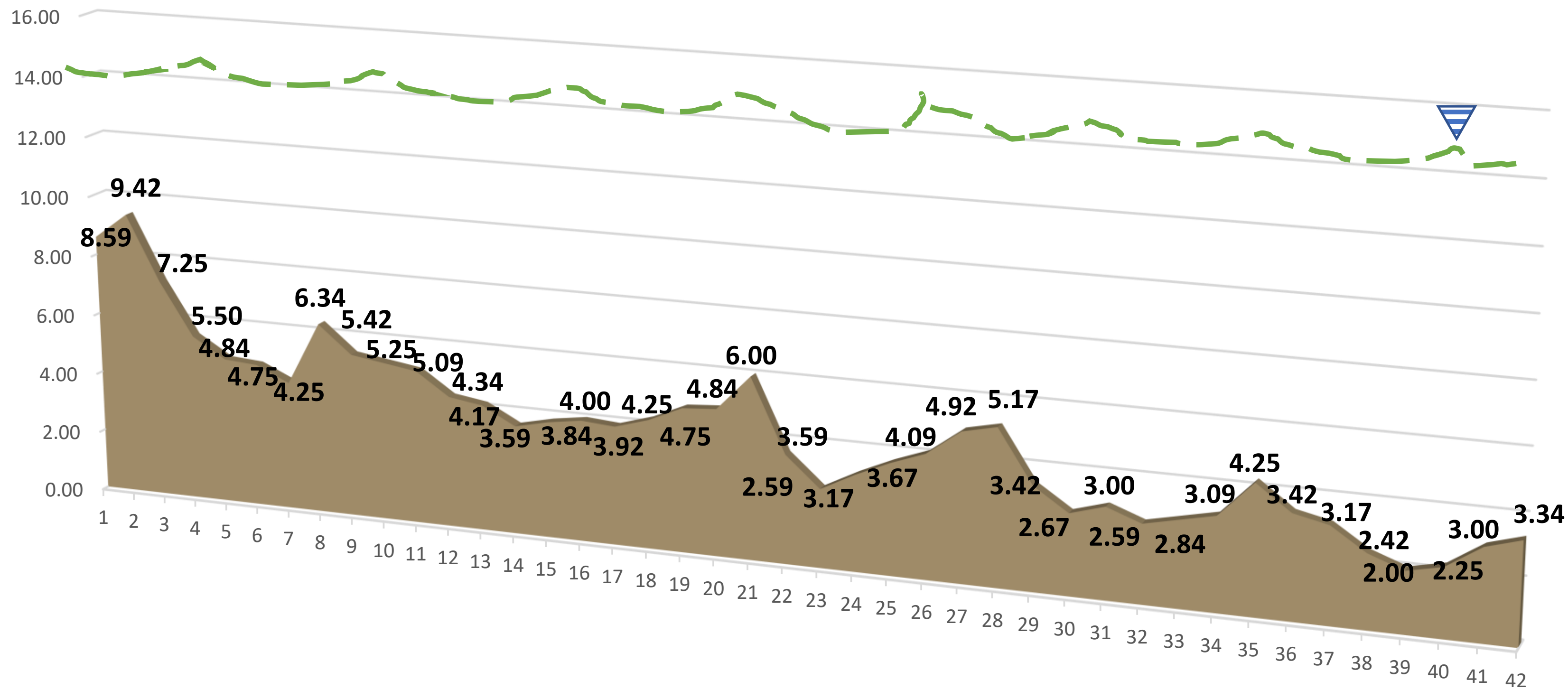

Influent vs Effluent Ammonia for a Food Processing Plant in the Midwest
60
50
40
30
20
10
0
54.3
9.4
7/1/2015
9/1/2015
11/1/2015
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
1/1/2017
3/1/2017
5/1/2017
7/1/2017
9/1/2017
11/1/2017
1/1/2018
3/1/2018
5/1/2018
7/1/2018
9/1/2018
11/1/2018
1/1/2019
3/1/2019
5/1/2019
7/1/2019
9/1/2019
11/1/2019
1/1/2020
3/1/2020
Nitrogen, ammonia total [as N], MO Ave Influent
Nitrogen, ammonia total [as N], MO Ave Effluent

Benthal Feedback and the Principle of Residuals

Average Sludge Blanket Thickness: **4.26 feet**

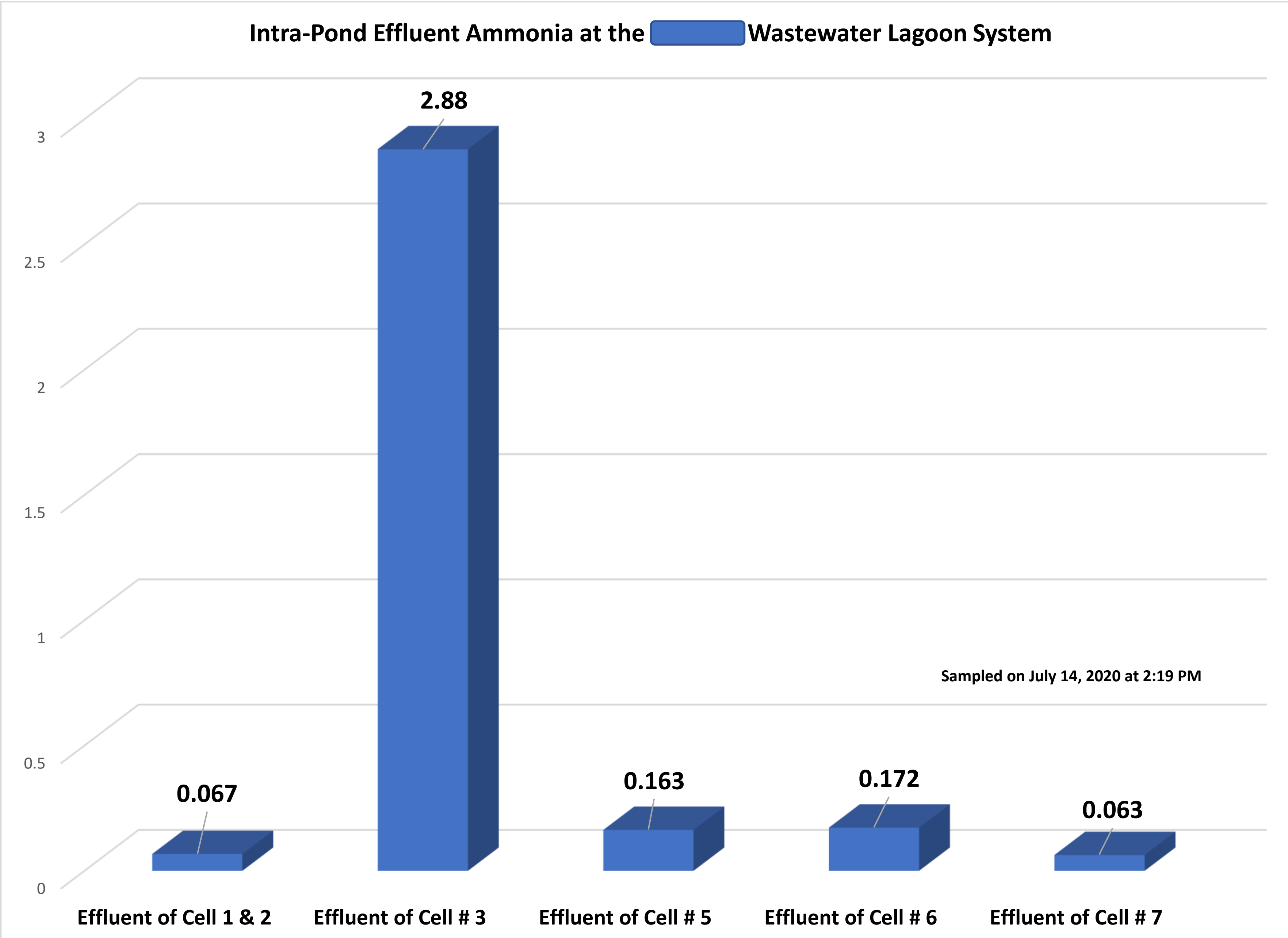
	1	2	3	4	54	6	7
A	3.42	3.17	2.42	2.00	2.25	3.00	3.34
B	3.42	2.67	3.00	2.59	2.84	3.09	4.25
C	3.59	2.59	3.17	3.67	4.09	4.92	5.17
D	3.84	4.00	3.92	4.25	4.75	4.84	6.00
E	6.34	5.42	5.25	5.09	4.34	4.17	3.59
F	8.59	9.42	7.25	5.50	4.84	4.75	4.25

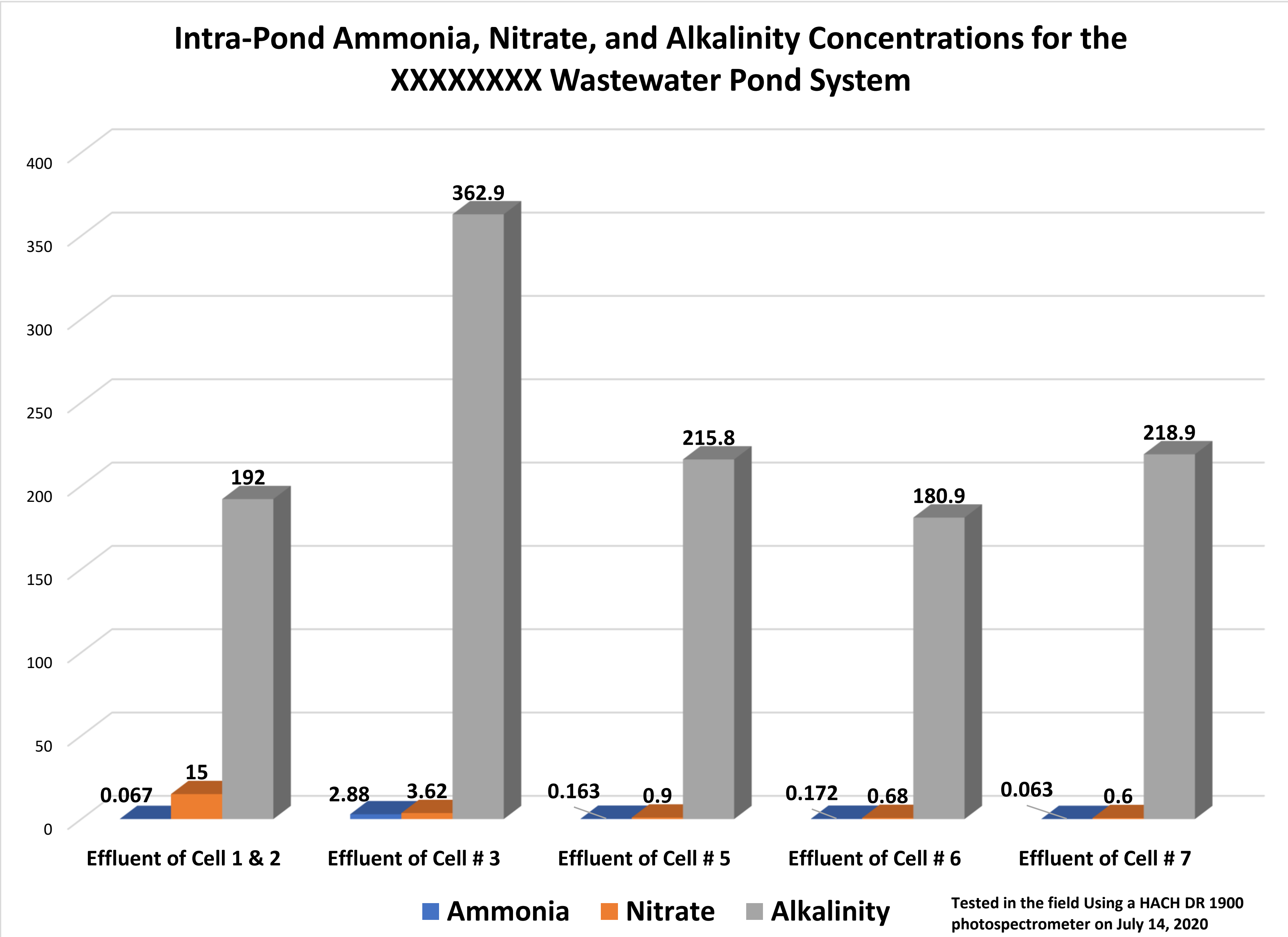
Sludge Blanket Thickness (ft) for XXXXXXXX's Cell # 3

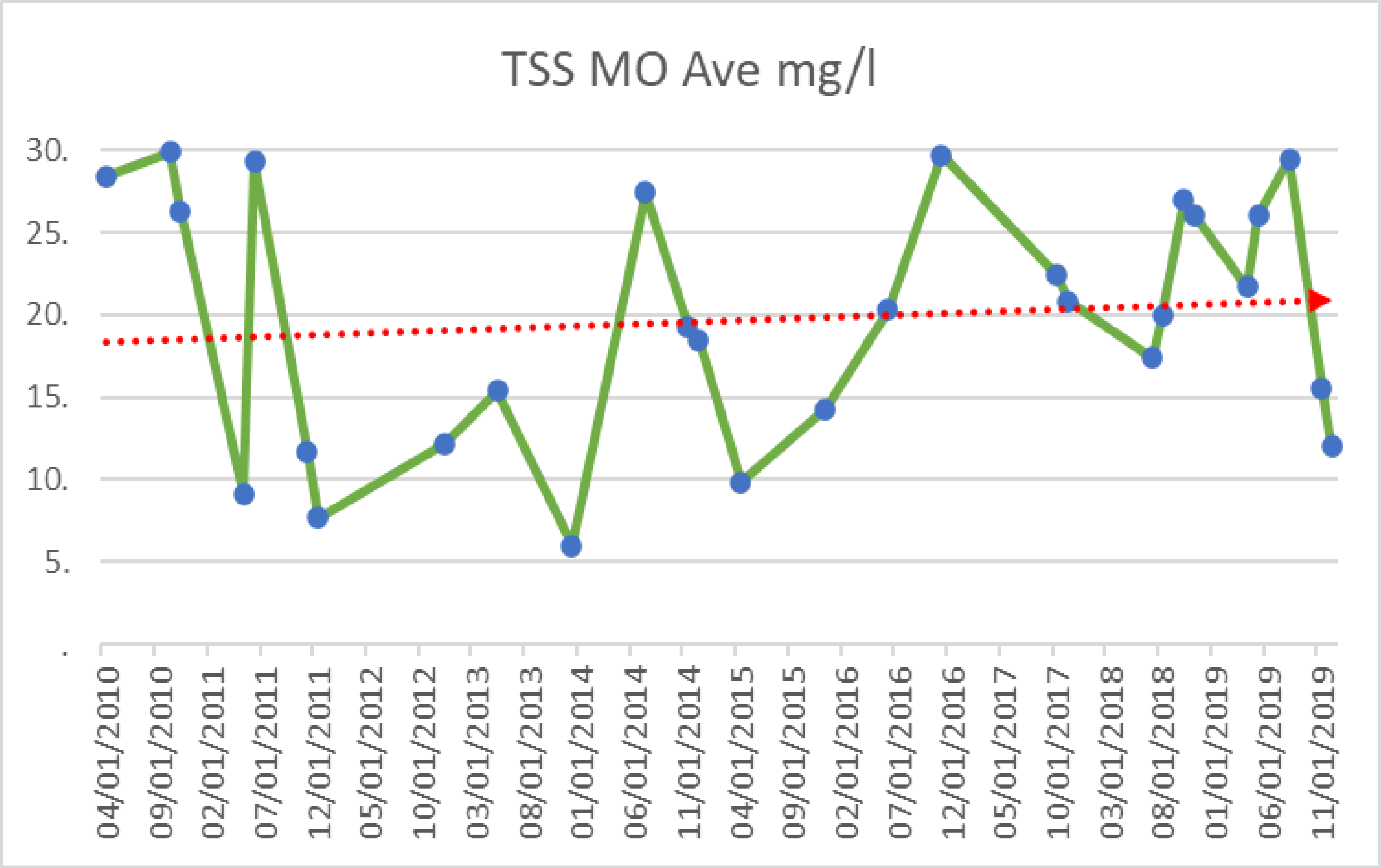


Average Water Depth: **14.8 feet**
Average Sludge Depth: **4.26 feet**

Sampled on July 14, 2020. Pond bottom varied in depth from 13.8 to 15.8 feet. Used 14.8 feet average for thickness calculations

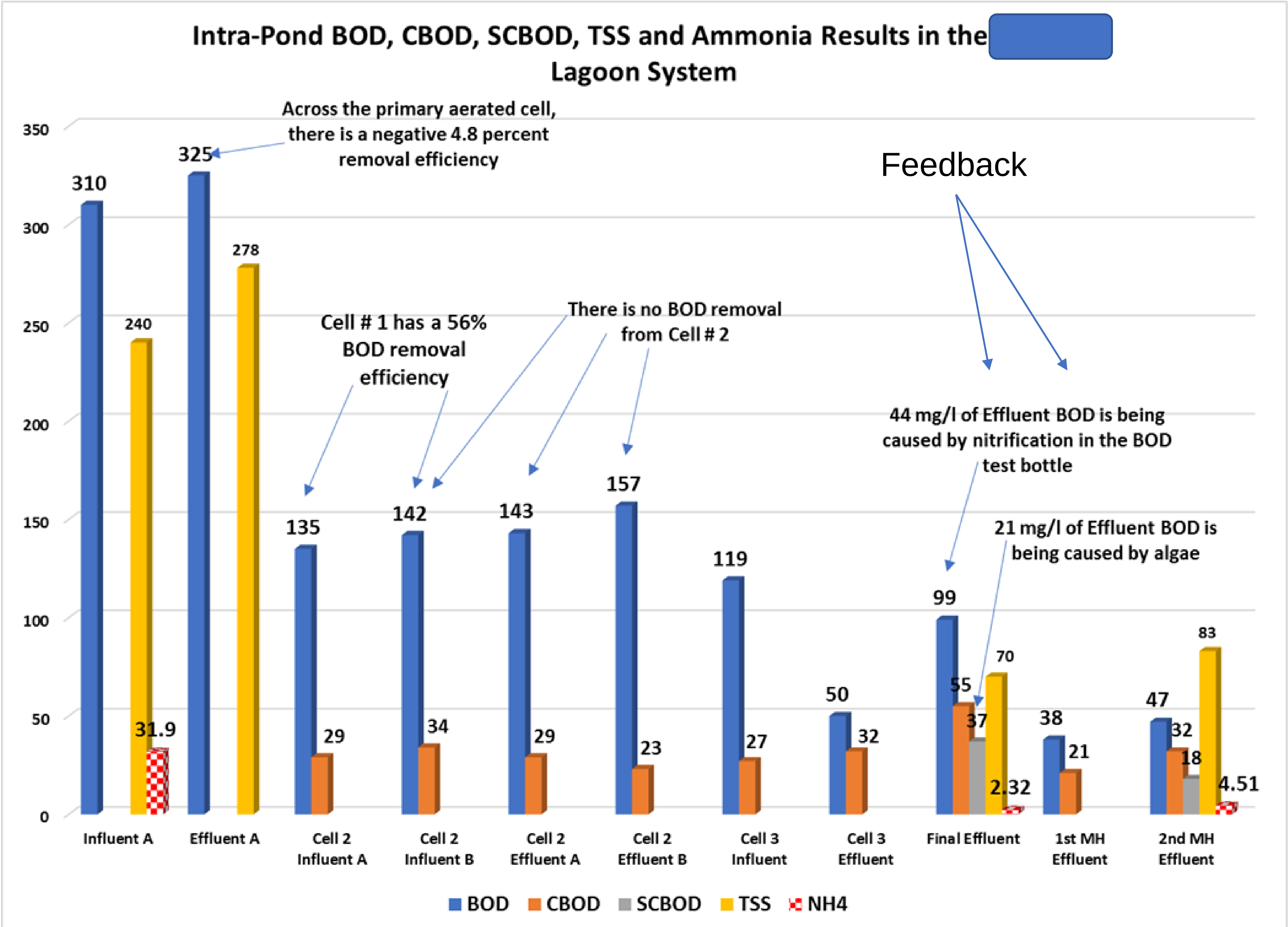

Intra-Pond Effluent Ammonia at the [redacted] Wastewater Lagoon System
3
2.5
2
1.5
1
0.5
0
2.88
0.067
0.163
0.172
0.063
Sampled on July 14, 2020 at 2:19 PM
Effluent of Cell 1 & 2
Effluent of Cell # 3
Effluent of Cell # 5
Effluent of Cell # 6
Effluent of Cell # 7


Intra-Pond Ammonia, Nitrate, and Alkalinity Concentrations for the XXXXXXXX Wastewater Pond System
400
350
300
250
200
150
100
50
0
0.067
15
192
2.88
3.62
362.9
0.163
0.9
215.8
0.172
0.68
180.9
0.063
0.6
218.9
Effluent of Cell 1 & 2
Effluent of Cell # 3
Effluent of Cell # 5
Effluent of Cell # 6
Effluent of Cell # 7
Ammonia
Nitrate
Alkalinity
Tested in the field Using a HACH DR 1900 photospectrometer on July 14, 2020

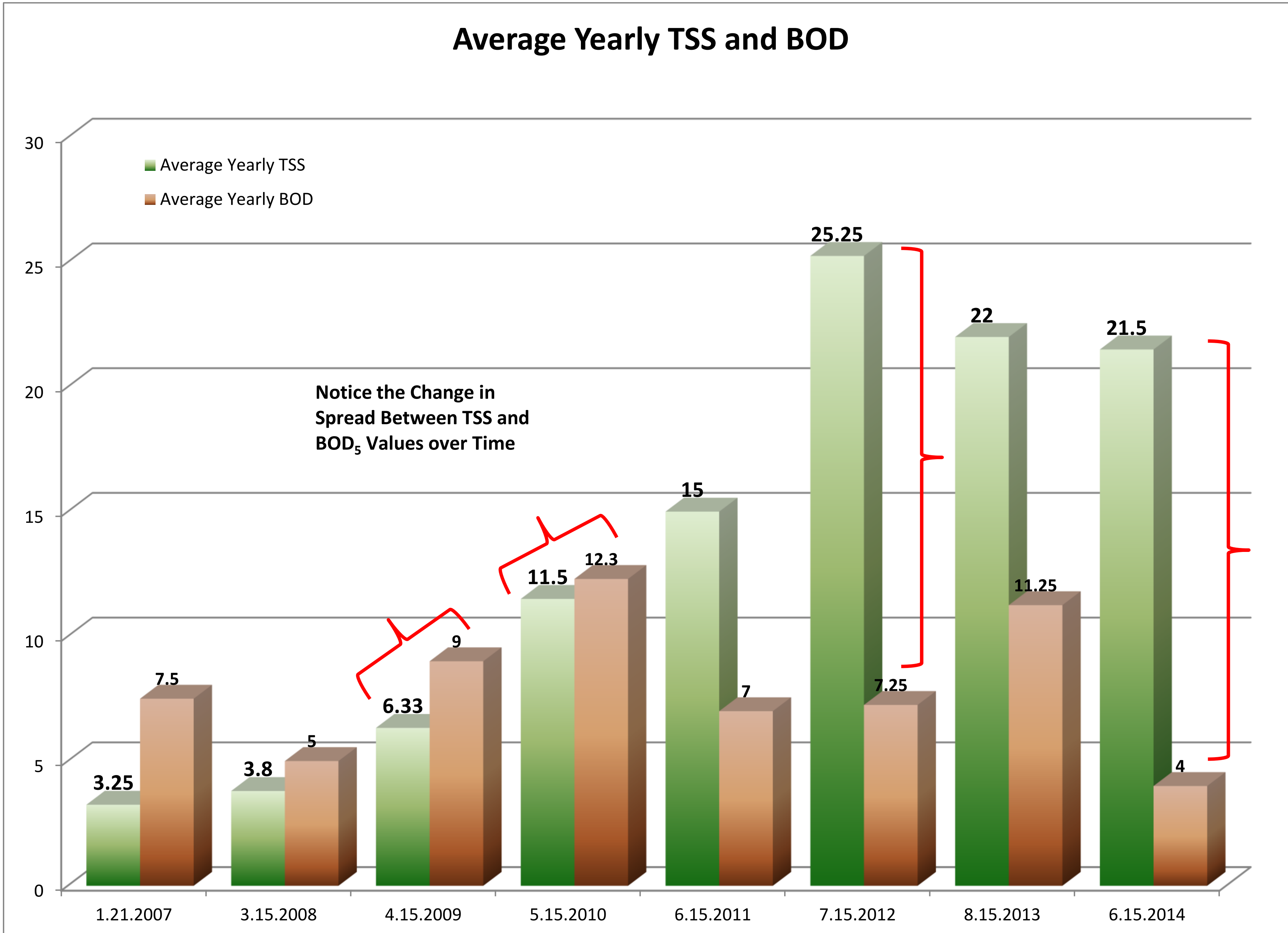

TSS MO Ave mg/l
30.
25.
20.
15.
10.
5.
.
04/01/2010
09/01/2010
02/01/2011
07/01/2011
12/01/2011
05/01/2012
10/01/2012
03/01/2013
08/01/2013
01/01/2014
06/01/2014
11/01/2014
04/01/2015
09/01/2015
02/01/2016
07/01/2016
12/01/2016
05/01/2017
10/01/2017
03/01/2018
08/01/2018
01/01/2019
06/01/2019
11/01/2019

The Principle of Residuals

- You can only measure what is left over after the microbes are finished consuming what they need
- The 2.88 mg/l of ammonia from the slide before last is what is left over after the bacteria and algae use the nutrient as a growth factor.
- There may be more than 2.88 mg/l of ammonia released from the sludge blanket. Algae and bacteria consume some portion of the nutrient feedback. All you can measure what is left!

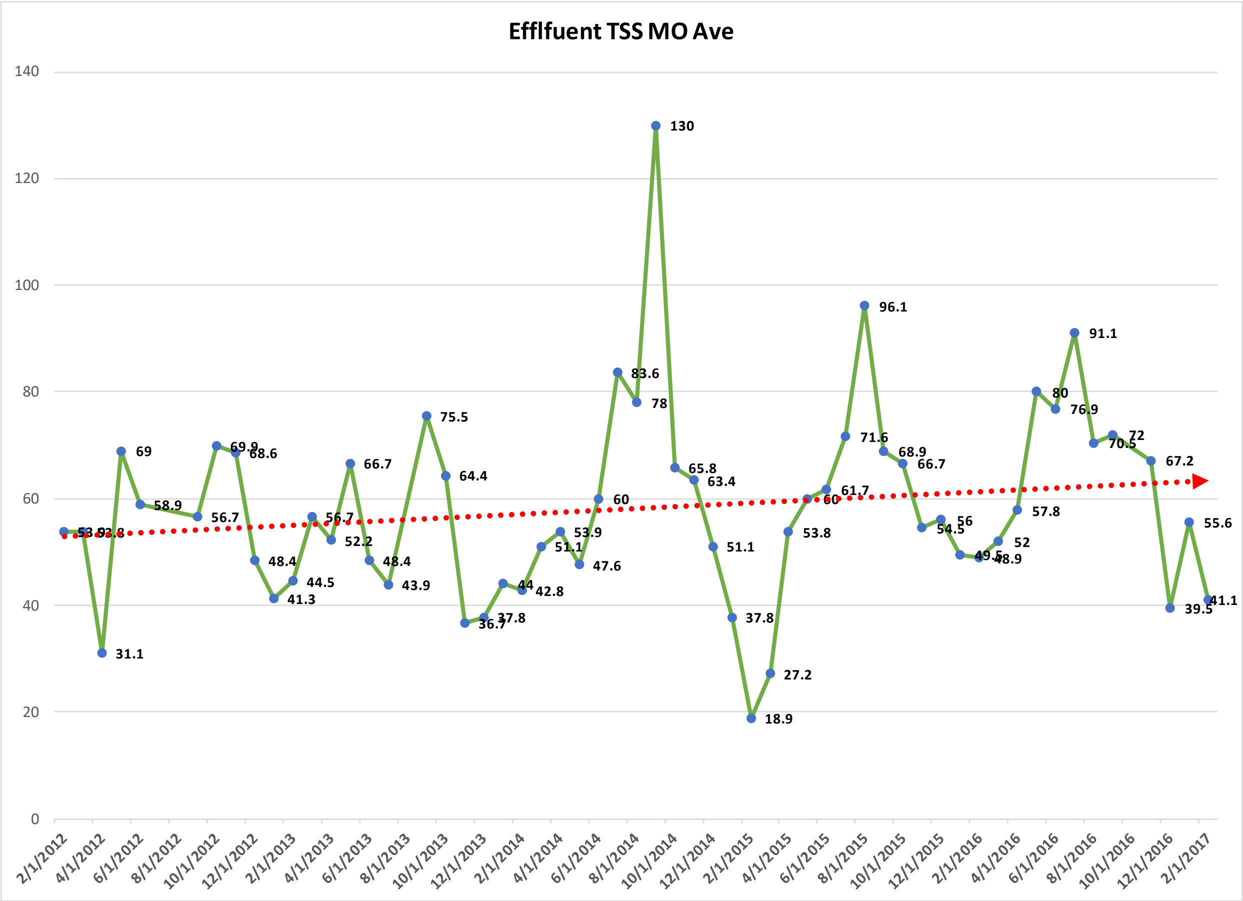


Intra-Pond BOD, CBOD, SCBOD, TSS and Ammonia Results in the [redacted] Lagoon System
Across the primary aerated cell, there is a negative 4.8 percent removal efficiency
Feedback
Cell # 1 has a 56% BOD removal efficiency
There is no BOD removal from Cell # 2
44 mg/l of Effluent BOD is being caused by nitrification in the BOD test bottle
21 mg/l of Effluent BOD is being caused by algae
350
300
250
200
150
100
50
0
310
240
31.9
325
278
135
29
142
34
143
29
157
23
119
27
50
32
99
55
37
70
2.32
38
21
47
32
18
83
4.51
Influent A
Effluent A
Cell 2 Influent A
Cell 2 Influent B
Cell 2 Effluent A
Cell 2 Effluent B
Cell 3 Influent
Cell 3 Effluent
Final Effluent
1st MH Effluent
2nd MH Effluent
BOD
CBOD
SCBOD
TSS
NH4

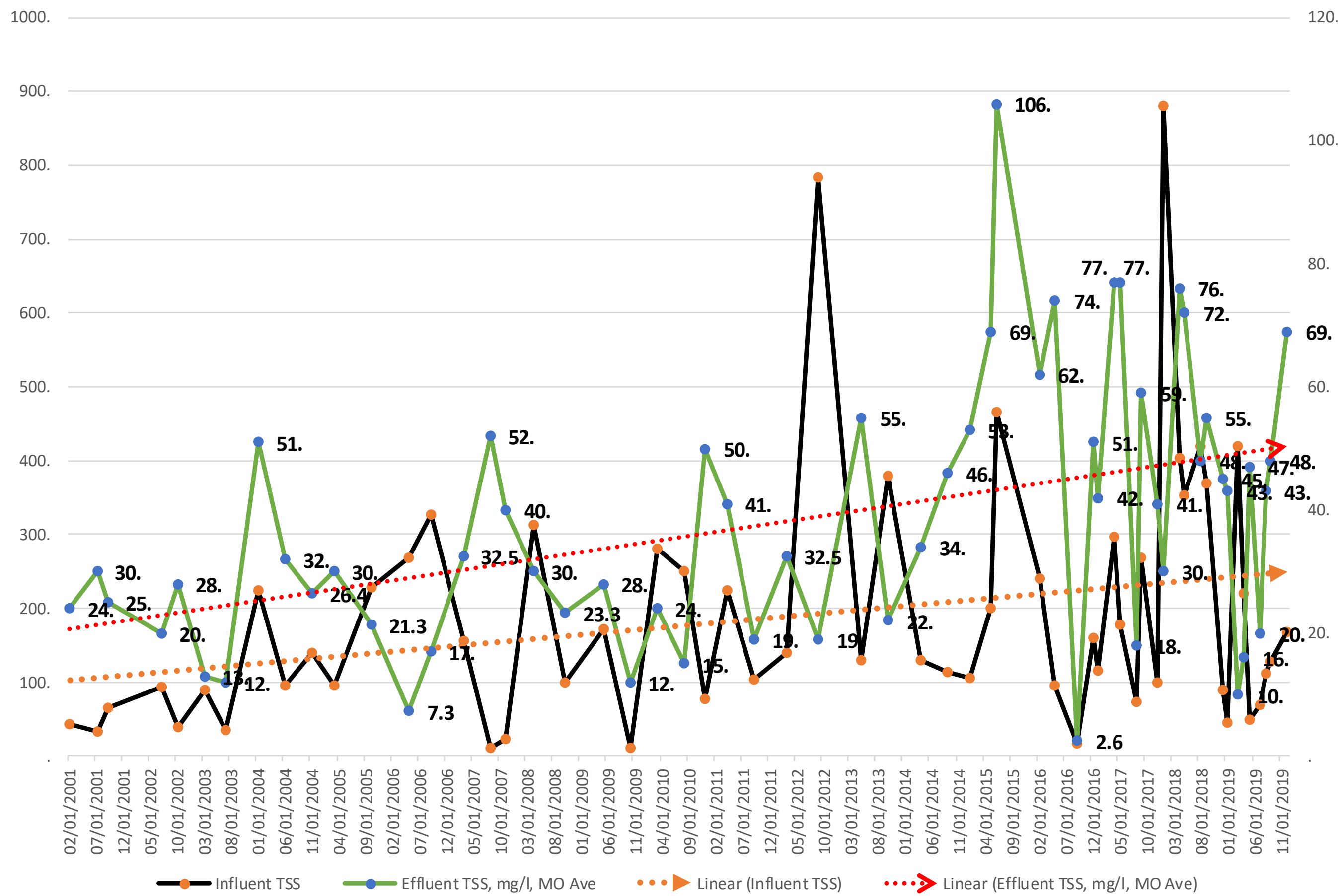


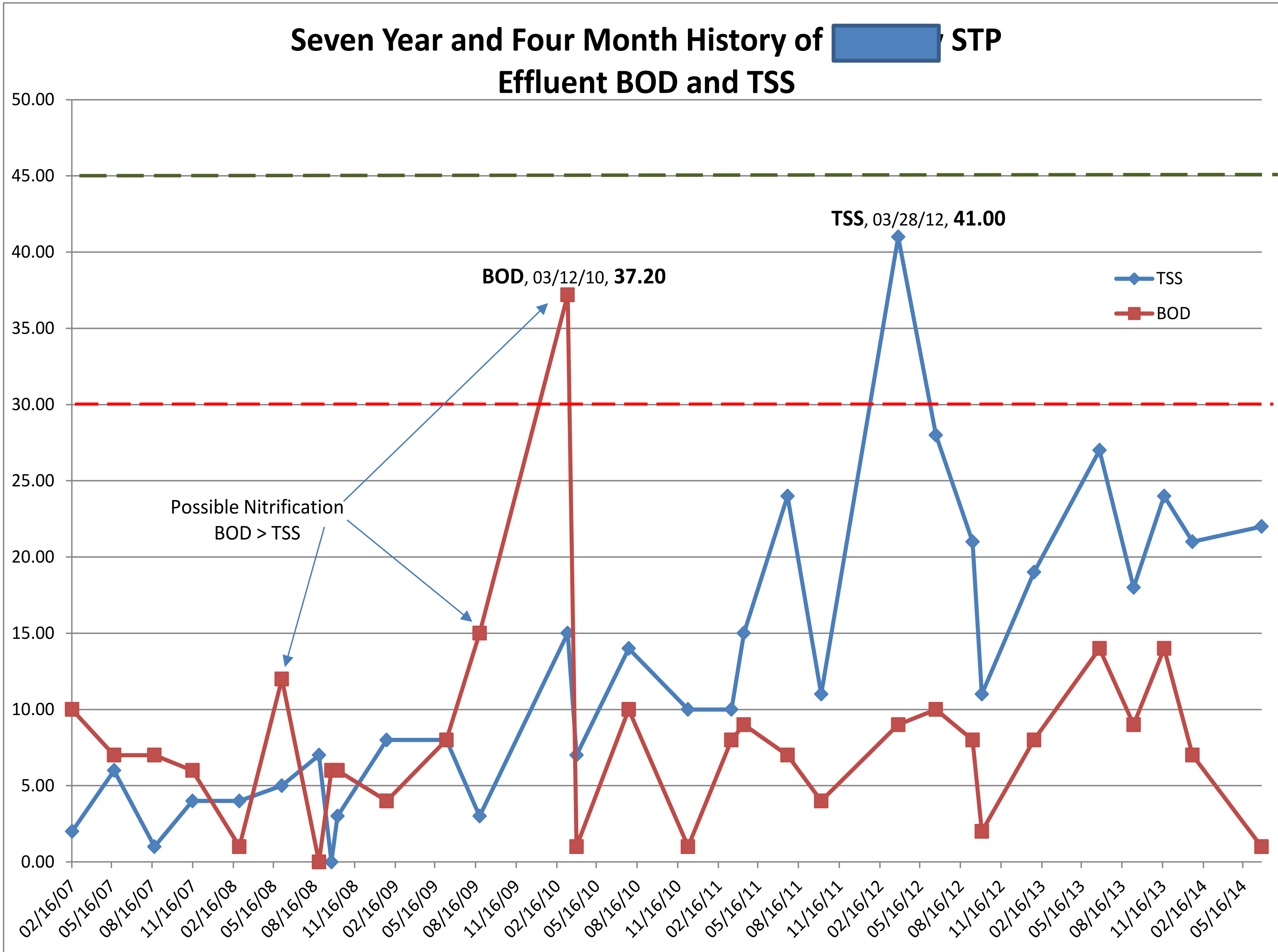
Average Yearly TSS and BOD
Average Yearly TSS
Average Yearly BOD
Notice the Change in Spread Between TSS and BOD_5 Values over Time
0
5
10
15
20
25
30
3.25
7.5
3.8
5
6.33
9
11.5
12.3
15
7
25.25
7.25
22
11.25
21.5
4
1.21.2007
3.15.2008
4.15.2009
5.15.2010
6.15.2011
7.15.2012
8.15.2013
6.15.2014

Here is what accumulated sludge looks like over time:



Twenty Years of Influent and Effluent Total Suspended Solids

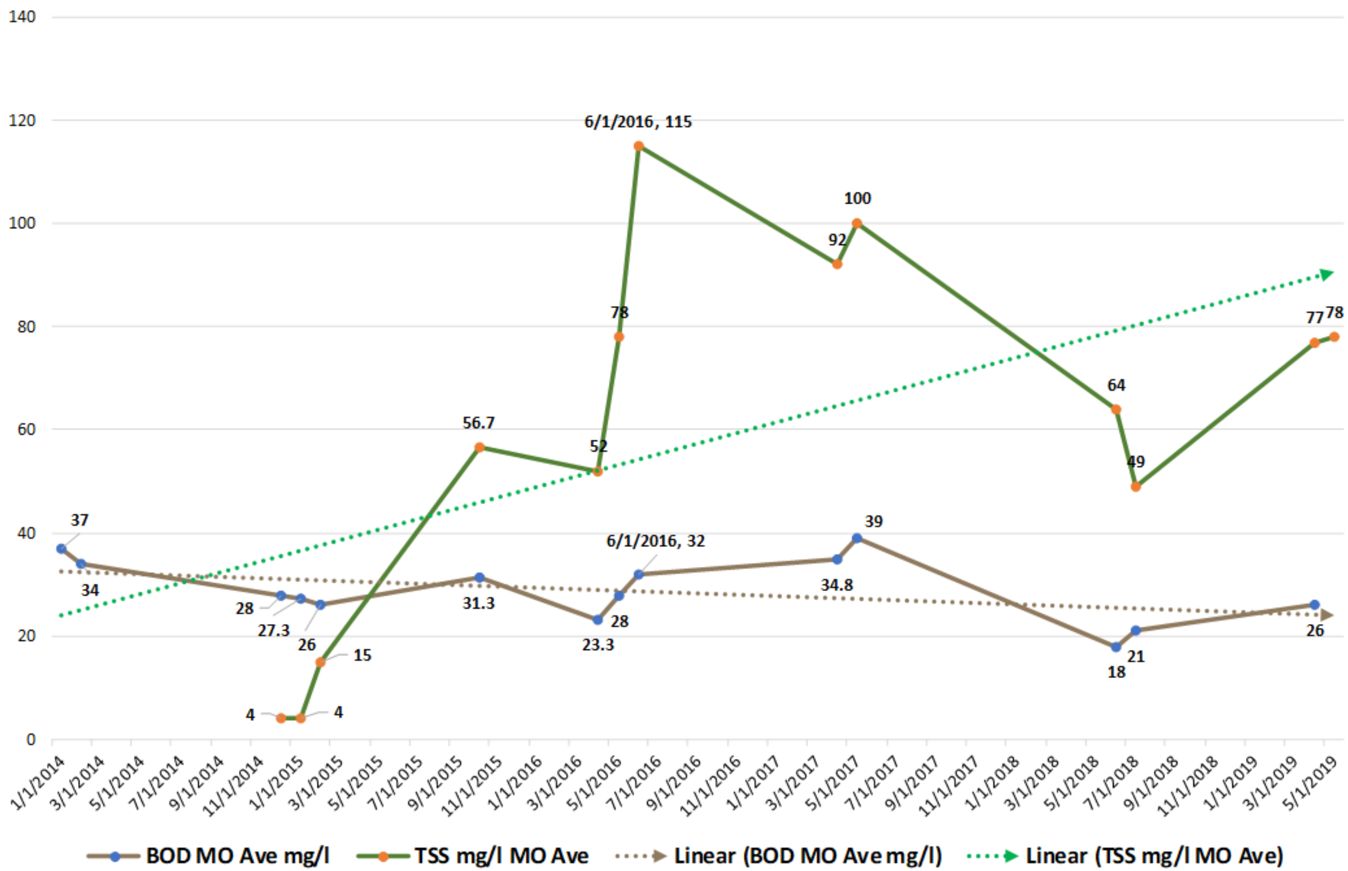



Seven Year and Four Month History of [redacted] STP
Effluent BOD and TSS
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
TSS, 03/28/12, 41.00
BOD, 03/12/10, 37.20
TSS
BOD
Possible Nitrification
BOD > TSS
02/16/07
05/16/07
08/16/07
11/16/07
02/16/08
05/16/08
08/16/08
11/16/08
02/16/09
05/16/09
08/16/09
11/16/09
02/16/10
05/16/10
08/16/10
11/16/10
02/16/11
05/16/11
08/16/11
11/16/11
02/16/12
05/16/12
08/16/12
11/16/12
02/16/13
05/16/13
08/16/13
11/16/13
02/16/14
05/16/14


15 8:58


15 8:58

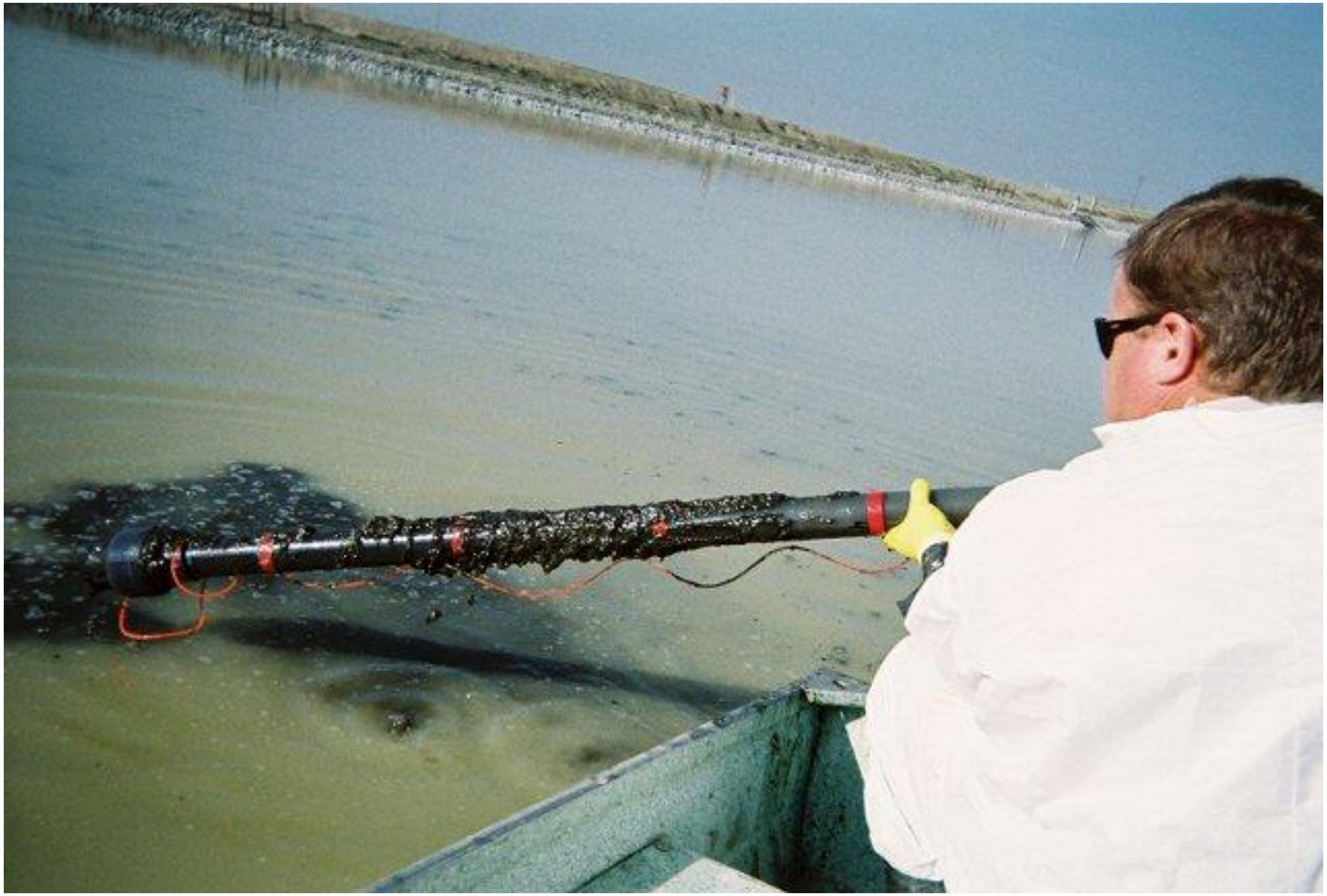
Five Years of Effluent TSS and BOD_5 for the [redacted] Wastewater Pond System



D.O Crashes in the early morning hours may be a result of too much algae or too much sludge

Rising Sludge Caused by Nitrification

Too little water over a sludge blanket can cause odors



Odors

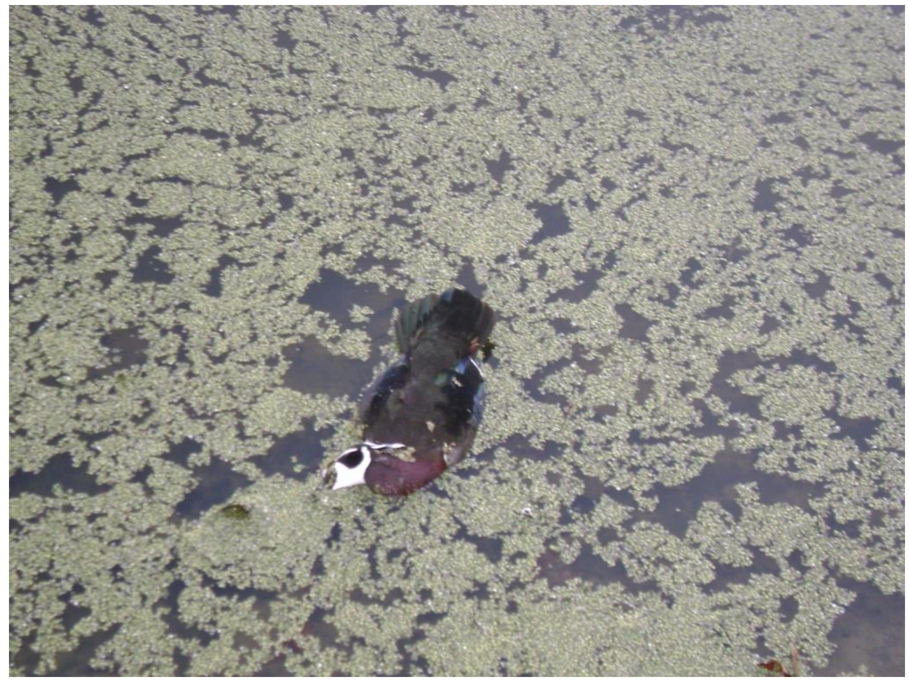
Things that Add to Sludge Accumulation

Erosion

Septage

Causes of Sludge Accumulation

Leaves



Duck Weed

Solids Leaving the lagoon
Can Cause Clogging of Perc Basins

If not removed, cattails and rushes can cause solids accumulation as they die and decay. These cattails are growing on top of accumulated sludge.

Sludge can choke off transfer structure flows


CAT

In this system sludge has been Leaving the lagoon through the effluent pipe for years

How to Sludge Judge a Lagoon

There are different purposes for sludge judging a lagoon system

- Determine a sludge accumulation rate
- To estimate sludge volume and mass for a dredging contractor
- To determine if accumulated sludge has reached the effluent pipe to the point where sludge is flowing out with the effluent
- For permit or compliance requirements

Grid your lagoon out


WARNING
AVISO

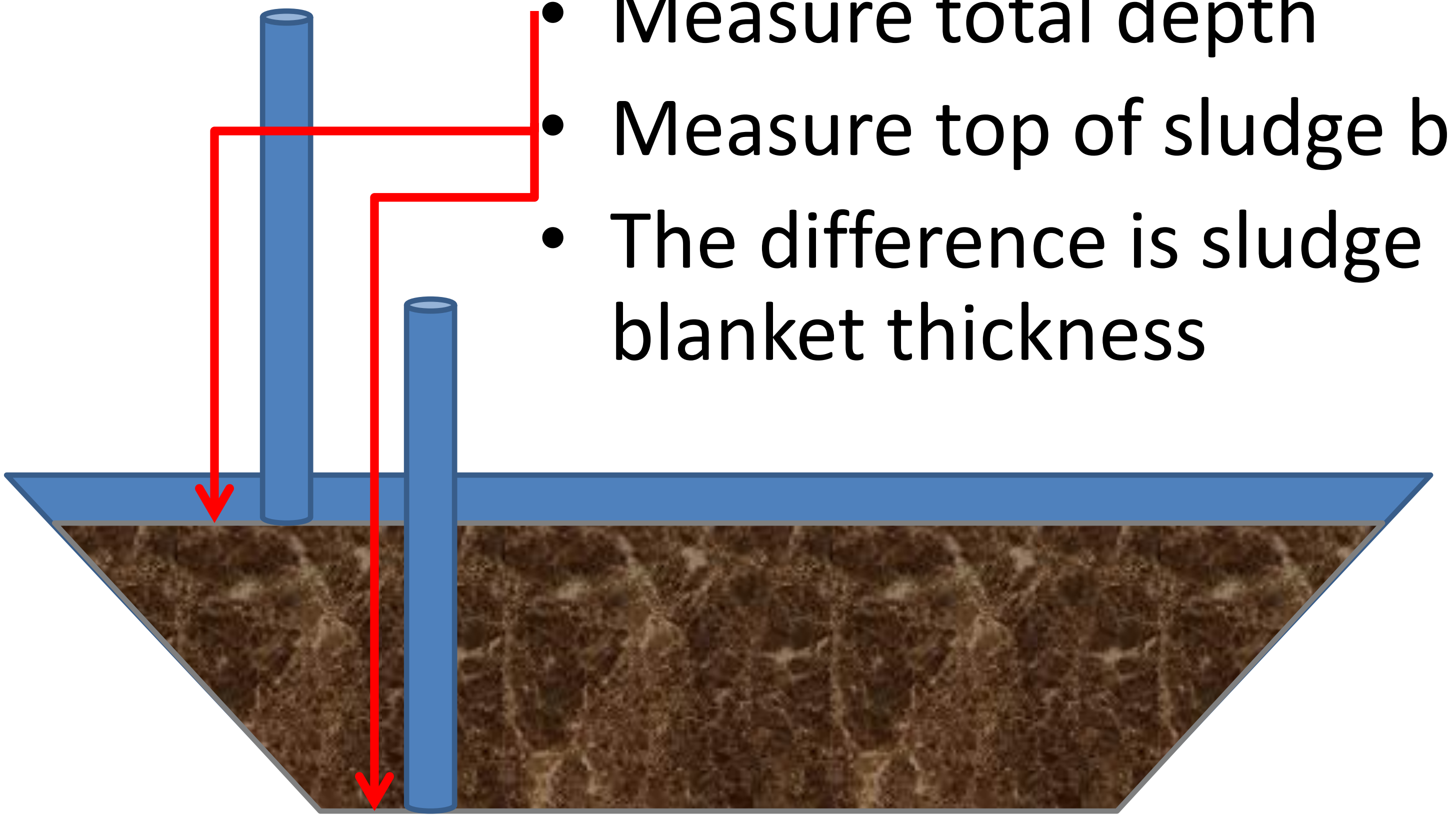
Why do you want to grid your lagoon out?


ID 6392


HQ40d
multi


'03 4 16

Measuring Sludge Blanket Thickness



- Measure total depth
- Measure top of sludge blanket
- The difference is sludge blanket thickness

How You Measure a Sludge Blanket Can Make a Difference

There is a 33.5 % Difference in Sludge Blanket Thickness by Measuring the Top of the Blanket

City of Marsing
Lagoon A Sludge Levels 2006-2021

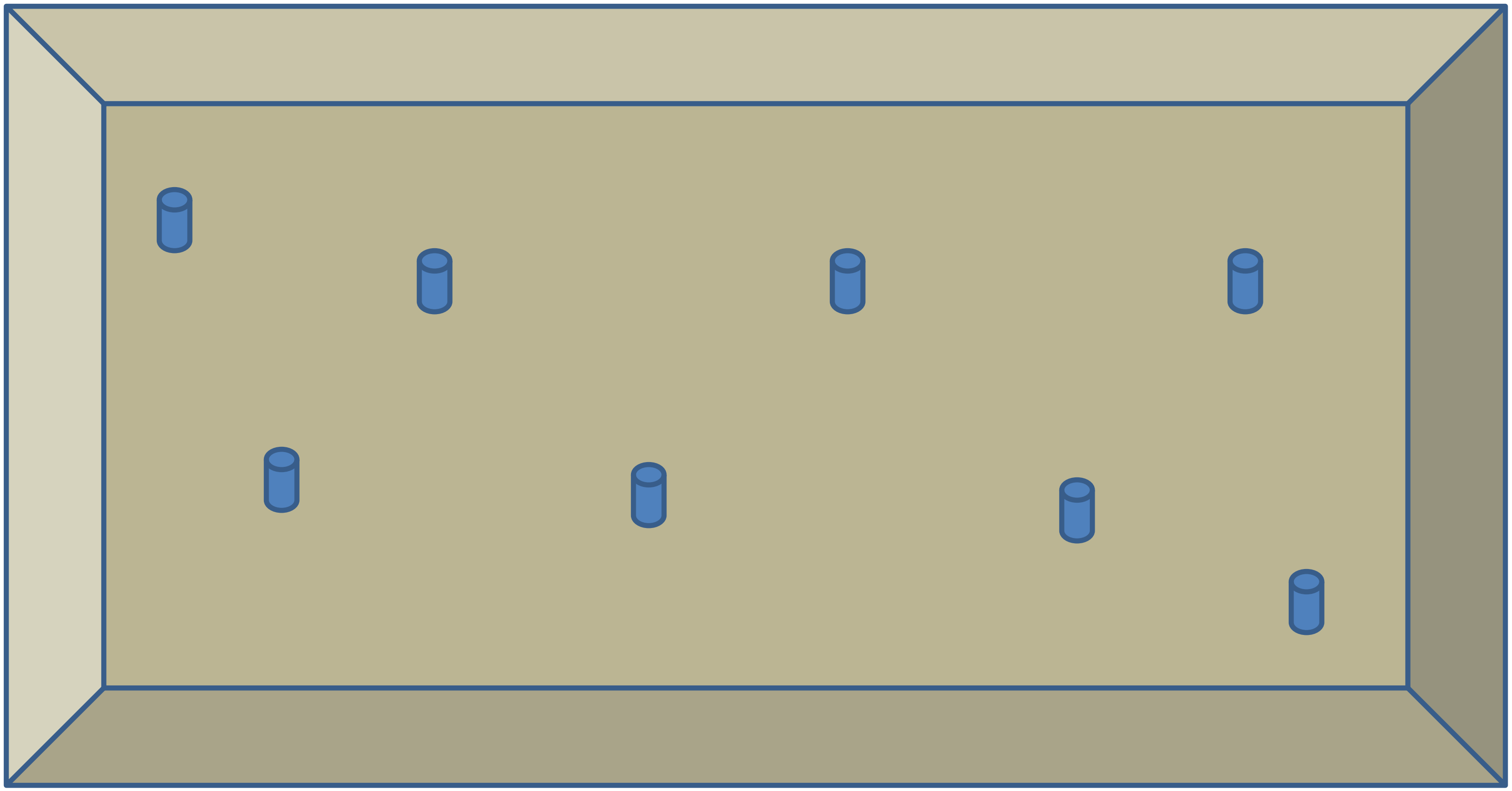
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016	2017	2018	2020		5/26/2021
A	4’	2’3”	3’	2’6”	3’	2’8”	3’	3’	1’6”	0’8”	1’3”	1'3"	1'	A	2'5"
B	1’	1’	1’6”	2’	1’	1’	0’2”	1’	1’3”	1’	1’8”	1'	2'6"	B	0'7"
C	1’	0’6”	1’6”	1’6”	1’10”	2’	2’	2’	1’11”	1’	2’	2'	8"	C	2'4"
D	2’	2’	1’6”	2’6”	1’10”	2’6”	2’3”	2’2”	2’3”	2’	2’4”	2'3"	2'6"	D	3'2"
E	2’8”	1’	2’	1’6”	1’6”	1’2”	2’2”	2’3”	0’10”	2’6”	2’6”	2'2"	2'2"	E	4'6"
F	1’	1’	1’	0’10”	0’10”	0’10”	1’2”	1’4”	0’11”	2’	1’6”	1'	1'8"	F	3'4"
G	2’	1’	0’6”	0’1”	0’	0’6”	1’	0’10”	3’2”	3’	3’	2'2"	1'8"	G	3'1"
H	2’	2’6”	2’6”	2’6”	3’	2’6”	2’10”	2’10”	2’3”	2’4”	3’	2'4"	2'10"	H	5'2"
I	1’	2’	2’	2’	2’4”	2’	3’6”	1’11”	2’6”	2’6”	2’6”	3'	3'	I	4'
J	1’	1’6”	0’6”	1’2”	1’	0’6”	1’2”	1’6”	2’10”	3’	3’2”	3'	3'2"	J	4'1"
K	1’	1’	1’	1’	1’4”	1’6”	2’1”	1’6”	2’8”	3’	3’	3'	3'8"	K	6'1"
L	1’6”	1’	1’	1’	1’1”	0’10”	1’2”	1’10”	2’3”	2’	3’	3'	3'3"	L	5'9"
M	2’	1’6”	2’	2’	1’10”	1’10”	2’3”	2’2”	2’10”	3’	2’10”	2'	2'10"	M	4'10"
N	1’6”	2’6”	2’	2’	2’6”	3’	2’6”	2’10”	2’4”	3’2”	2’10”	3'	3'	N	5'1"
O	2’	1’	2’6”	0’6”	0’5”	0’1”	0’4”	0’6”	2’2”	2’	3’	3'	2'10"	O	5'1"
P	1’6”	0’6”	0’6”	1’	1’4”	1’4”	1’6”	1’6”	1’9”	1’8”	2’6”	1'8"	2'6"	P	1'2"
Q	2’	1’6”	2’	2’	2’	2’	2’	2’2”	2’4”	2’6”	2’10”	3'	2'10"	Q	4'1"
R	1’6”	2’	3’	2’	2’4”	2’2”	3’	2’8”	1’11”	2’6”	2’10”	1'6"	2'3"	R	4'10"
S	1’6”	1’	1’	2’	1’4”	2’4”	1’2”	2’4”	2’	2’4”	2’1”	2'	1'8"	S	3'9"
T	1’6”	0’6”	0’6”	1’	0’6”	0’7”	0’6”	1’6”	1’8”	2’	2’3”	2'	2'	T	1'4"
U	2’8”	2’6”	2’	2’6”	2’6”	2’8”	3’	1’4”	1’2”	1’6”	1’2”	1'4"	2'2"	U	1'8"
Tota	**36’4”**	**29’9”**	**33’6”**	**33’7”**	**33’6”**	**34’**	**39’6”**	**39’2”**	**45’6”**	**45’4”**	**52’3”**	**44'9"**	**50'8"**	**Tota**	**76'4"**
Aver	**20.76"**	**17"**	**19.14"**	**19.19"**	**19.14"**	**19.42"**	**22.57"**	**22.38"**	**26"**	**25.90"**	**29.86"**	**25.57"**	**28.95"**	**Aver**	**44"**

Sludge Judging will tell you how thick the sludge blanket is, is there anything else?

Why would we want to take a sludge sample and send it to the lab?

Sludge Judging will give you sludge volume, core sampling will give you the mass of the sludge

Typically you want to pull enough core samples to make a couple of composite samples to get a better idea of the average Total Solids concentration of the sludge



Pulling the Sample

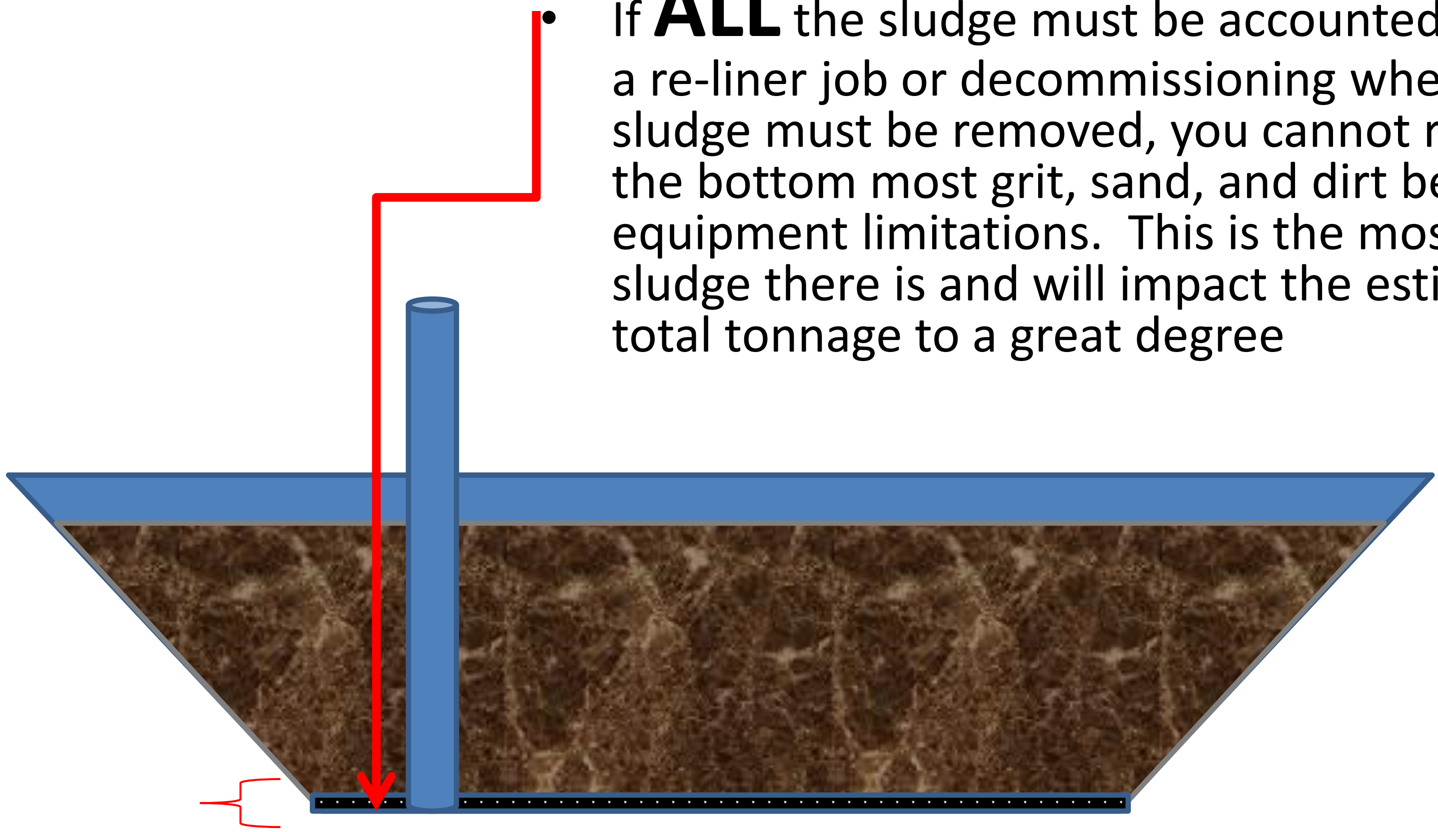
Contain and Mix the Sample. Usually three (3) or four (4) samples in one bucket for a composite.

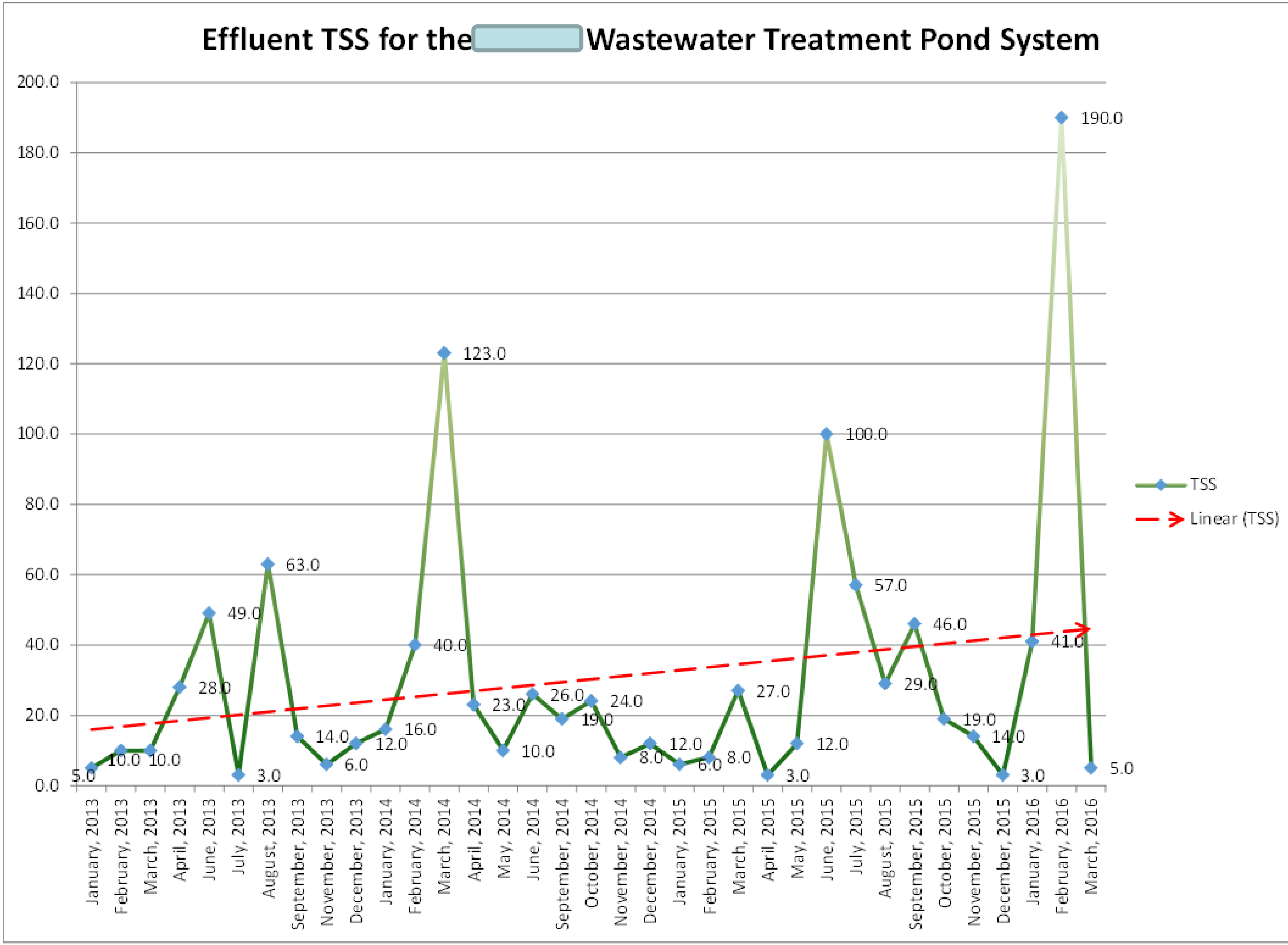
Mix Well and Put into Sample Bottles

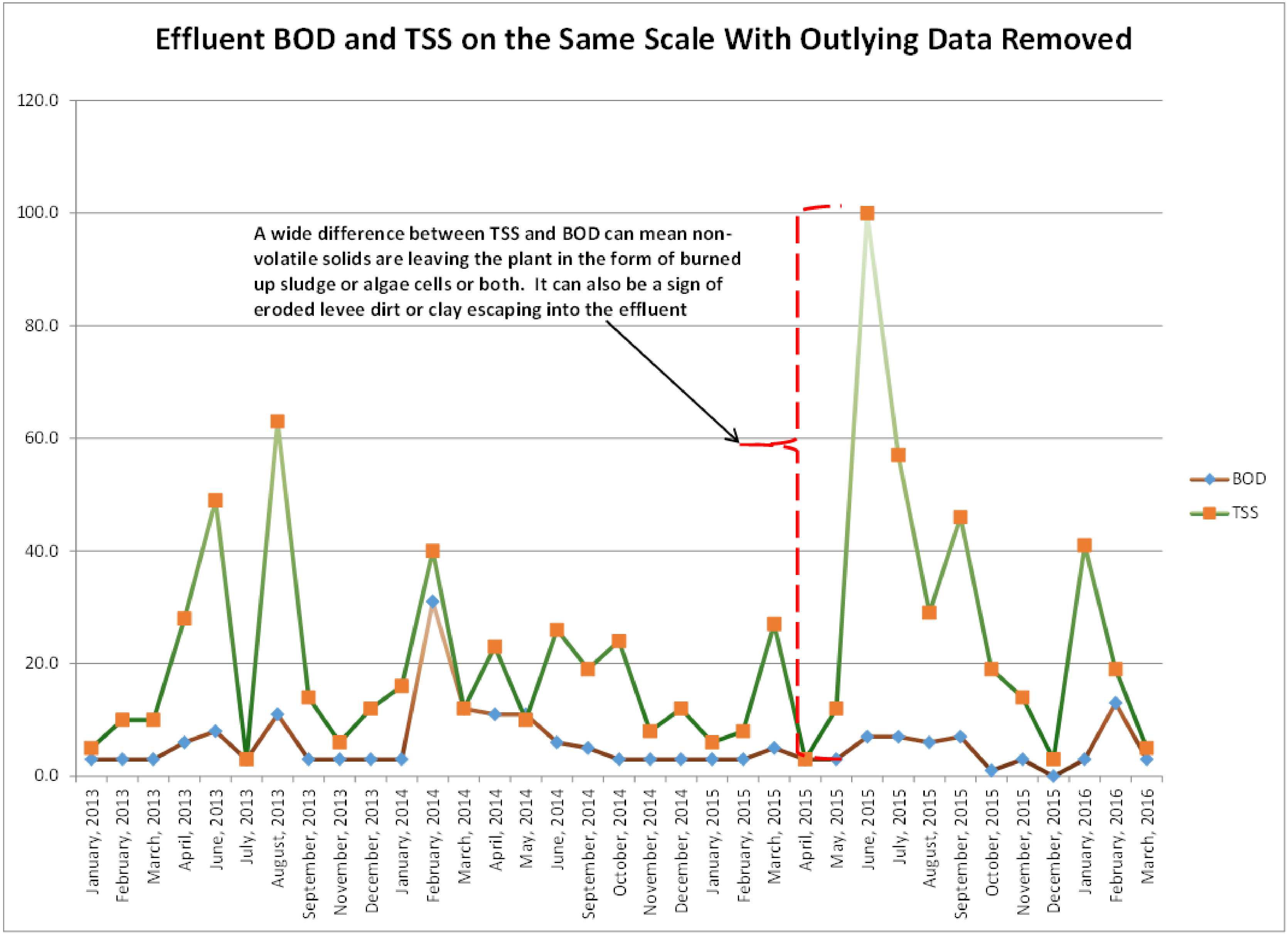

.5
HORIZONTAL USE
THIS SIDE UP
FLOW

Pulling Core Samples

- If **ALL** the sludge must be accounted for, as in a re-liner job or decommissioning where all the sludge must be removed, you cannot retrieve the bottom most grit, sand, and dirt because of equipment limitations. This is the most dense sludge there is and will impact the estimate of total tonnage to a great degree

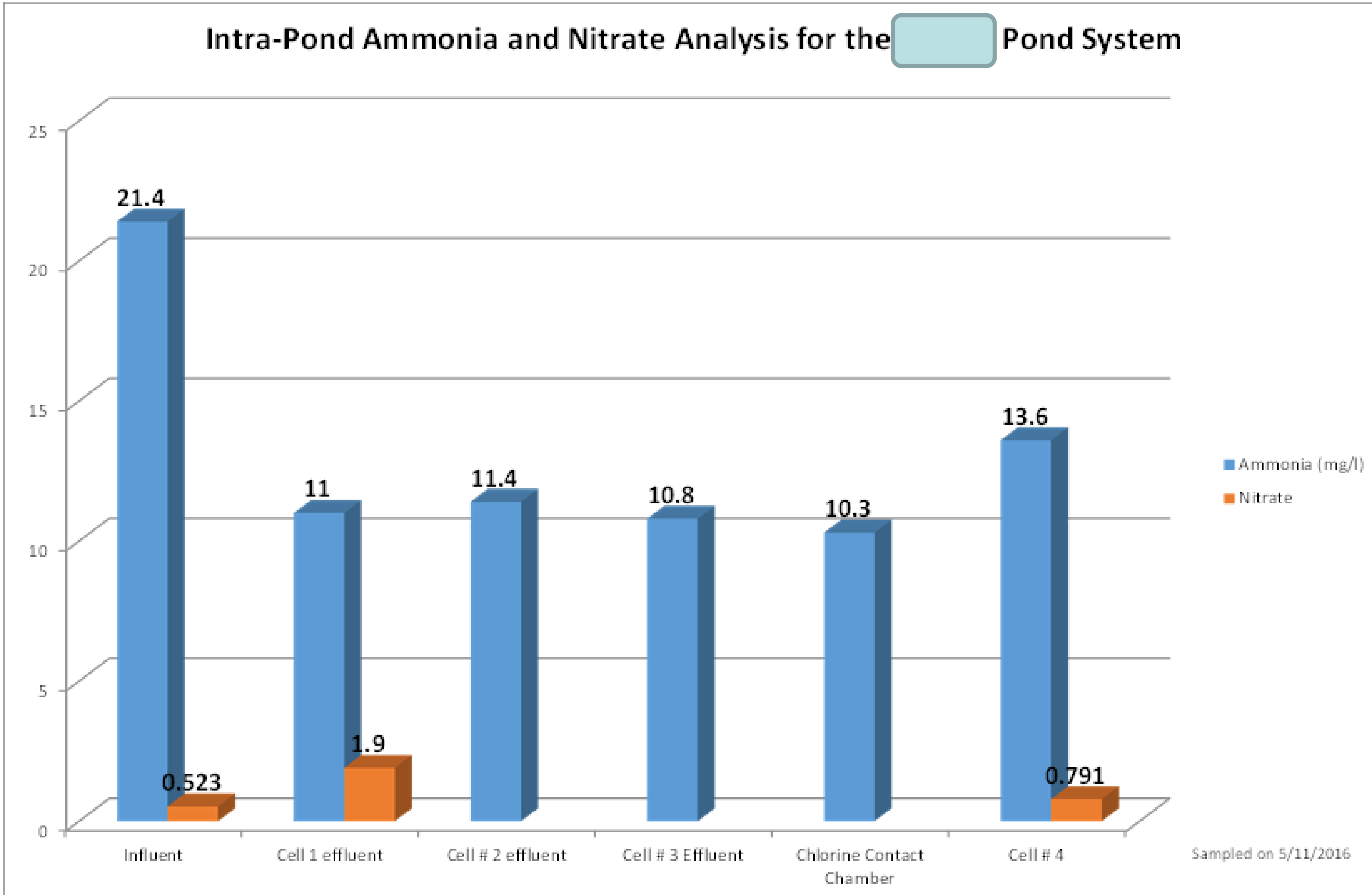



Effluent TSS for the Wastewater Treatment Pond System
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
5.0
10.0
10.0
28.0
49.0
3.0
63.0
14.0
6.0
12.0
16.0
40.0
123.0
23.0
10.0
26.0
19.0
24.0
8.0
12.0
6.0
8.0
27.0
3.0
12.0
100.0
57.0
29.0
46.0
19.0
14.0
3.0
41.0
190.0
5.0
January, 2013
February, 2013
March, 2013
April, 2013
June, 2013
July, 2013
August, 2013
September, 2013
November, 2013
December, 2013
January, 2014
February, 2014
March, 2014
April, 2014
May, 2014
June, 2014
September, 2014
October, 2014
November, 2014
December, 2014
January, 2015
February, 2015
March, 2015
April, 2015
May, 2015
June, 2015
July, 2015
August, 2015
September, 2015
October, 2015
November, 2015
December, 2015
January, 2016
February, 2016
March, 2016
TSS
Linear (TSS)

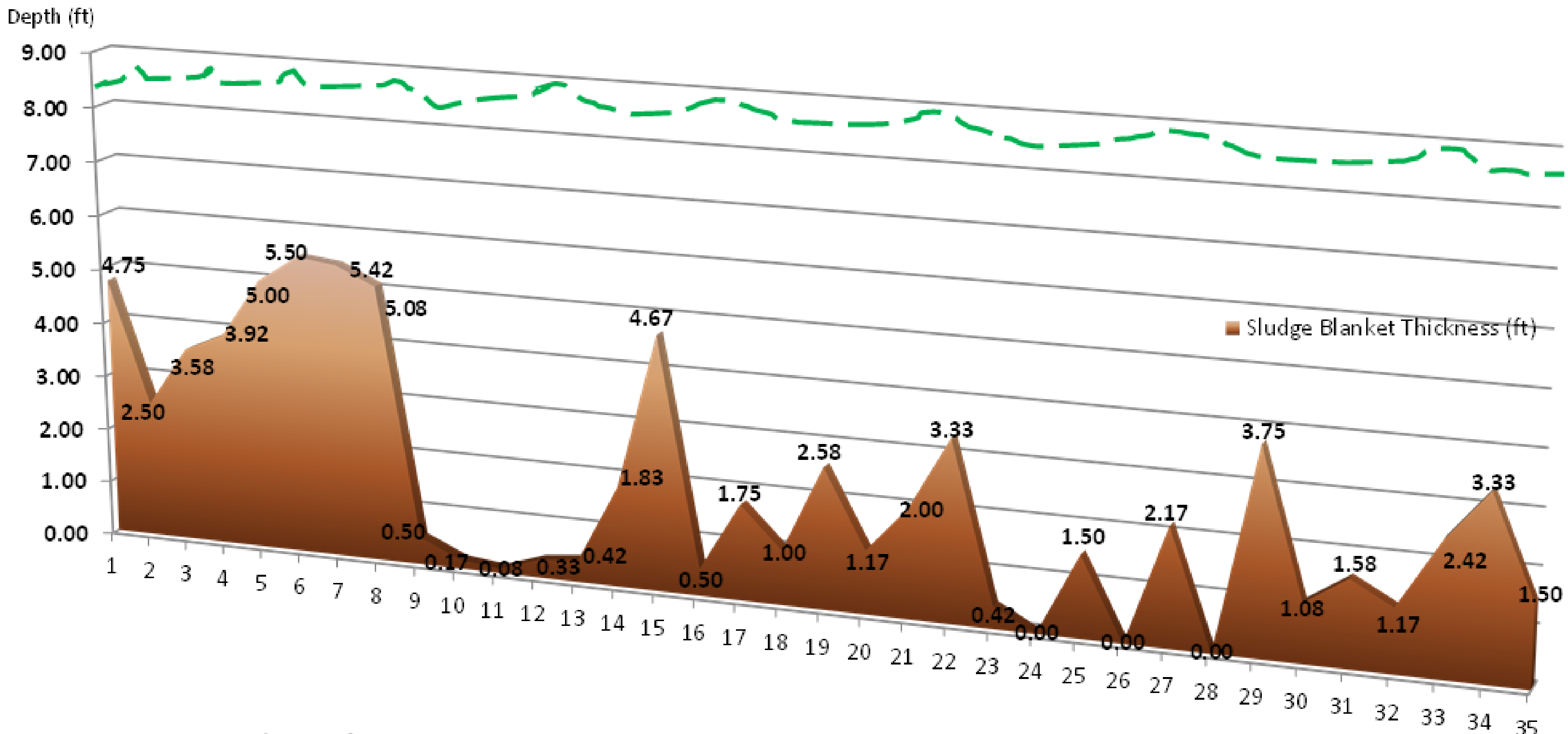


Effluent BOD and TSS on the Same Scale With Outlying Data Removed
120.0
100.0
80.0
60.0
40.0
20.0
0.0
A wide difference between TSS and BOD can mean non-volatile solids are leaving the plant in the form of burned up sludge or algae cells or both. It can also be a sign of eroded levee dirt or clay escaping into the effluent
BOD
TSS
January, 2013
February, 2013
March, 2013
April, 2013
June, 2013
July, 2013
August, 2013
September, 2013
November, 2013
December, 2013
January, 2014
February, 2014
March, 2014
April, 2014
May, 2014
June, 2014
September, 2014
October, 2014
November, 2014
December, 2014
January, 2015
February, 2015
March, 2015
April, 2015
May, 2015
June, 2015
July, 2015
August, 2015
September, 2015
October, 2015
November, 2015
December, 2015
January, 2016
February, 2016
March, 2016


Honey Dippers

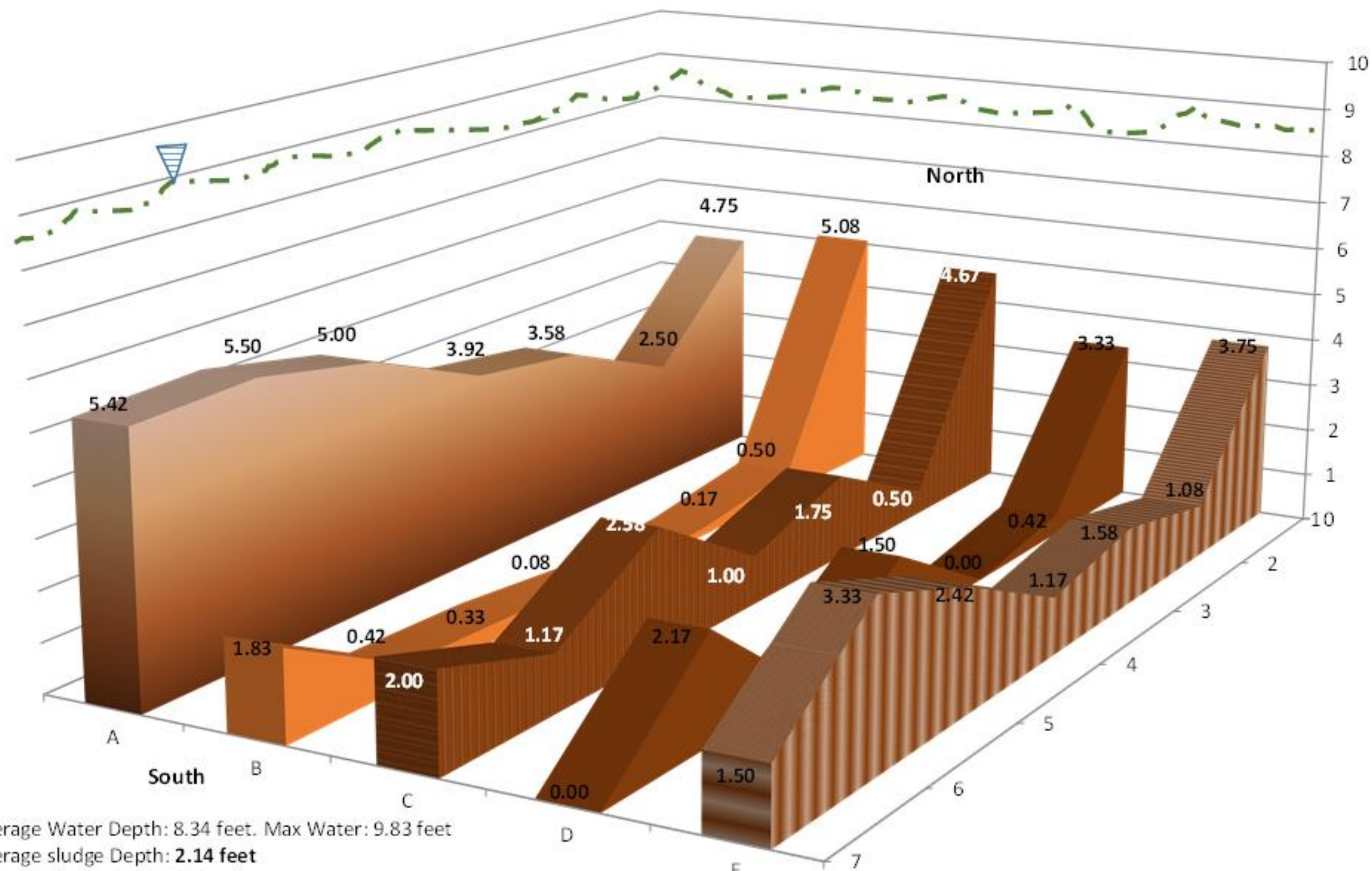

Intra-Pond Ammonia and Nitrate Analysis for the Pond System
25
20
15
10
5
0
21.4
0.523
11
1.9
11.4
10.8
10.3
13.6
0.791
Influent
Cell 1 effluent
Cell # 2 effluent
Cell # 3 Effluent
Chlorine Contact Chamber
Cell # 4
Ammonia (mg/l)
Nitrate
Sampled on 5/11/2016

Sludge Blanket Thickness Profile for Cell # 1 of the Wastewater Treatment Plant



Average Water Depth: 8.38 feet
Average Sludge Depth: **2.14 feet**
Water Volume: 6,263,739 gallons
Sludge Volume: **1,355,612 gallons**
Estimated Sludge Mass based on 6.5% Solids: **382 dry tons**

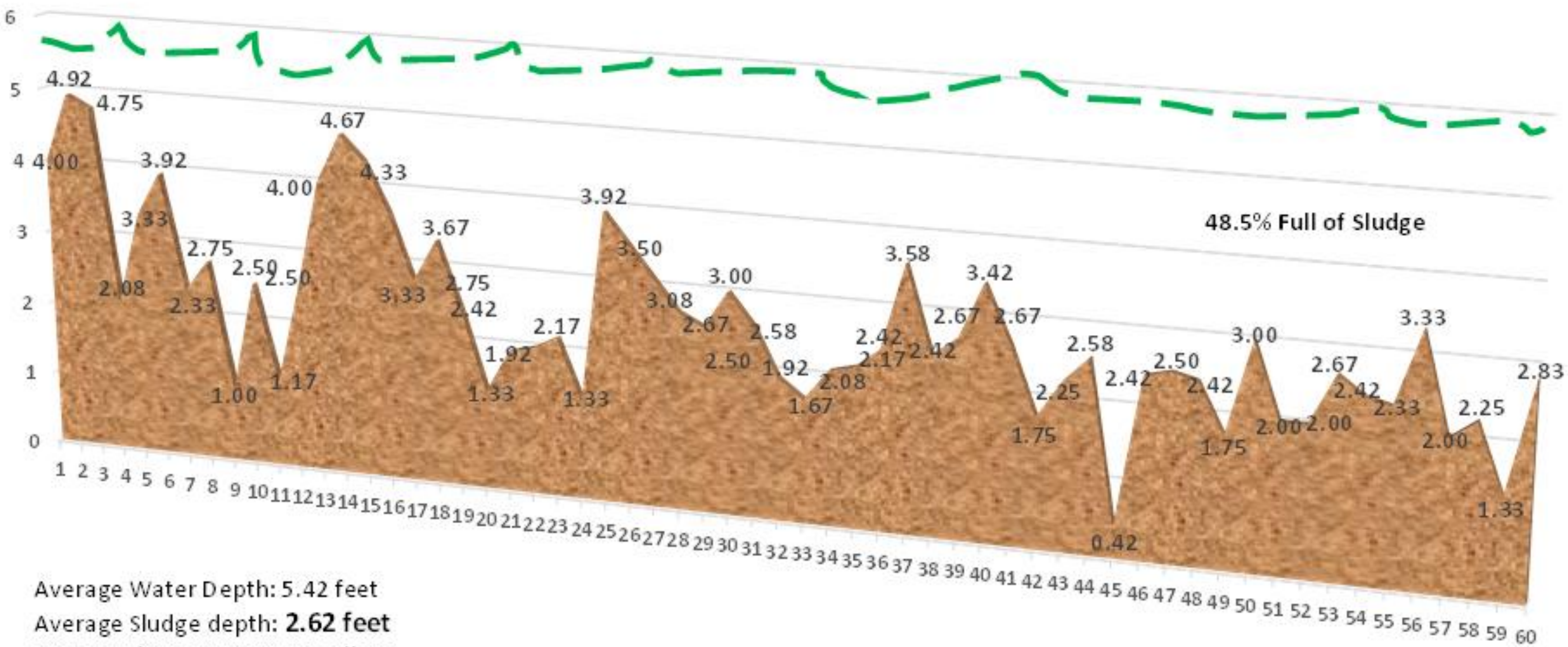
Sludge Blanket Profile of Cell # 1 of the Wastewater Pond System



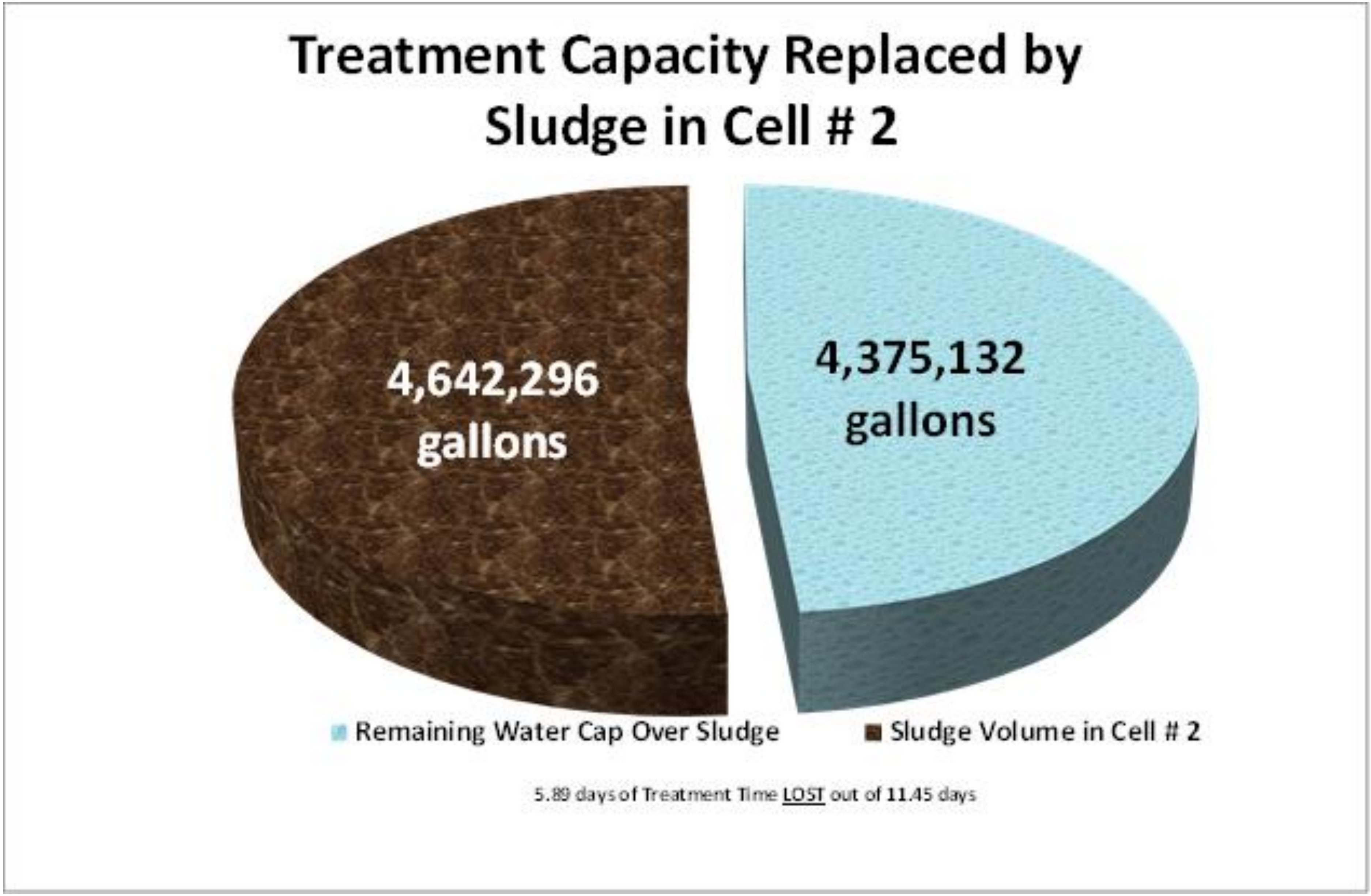
Average Water Depth: 8.34 feet. Max Water: 9.83 feet
Average sludge Depth: **2.14 feet**
Sludge Volume: **1,355,612 gallons**

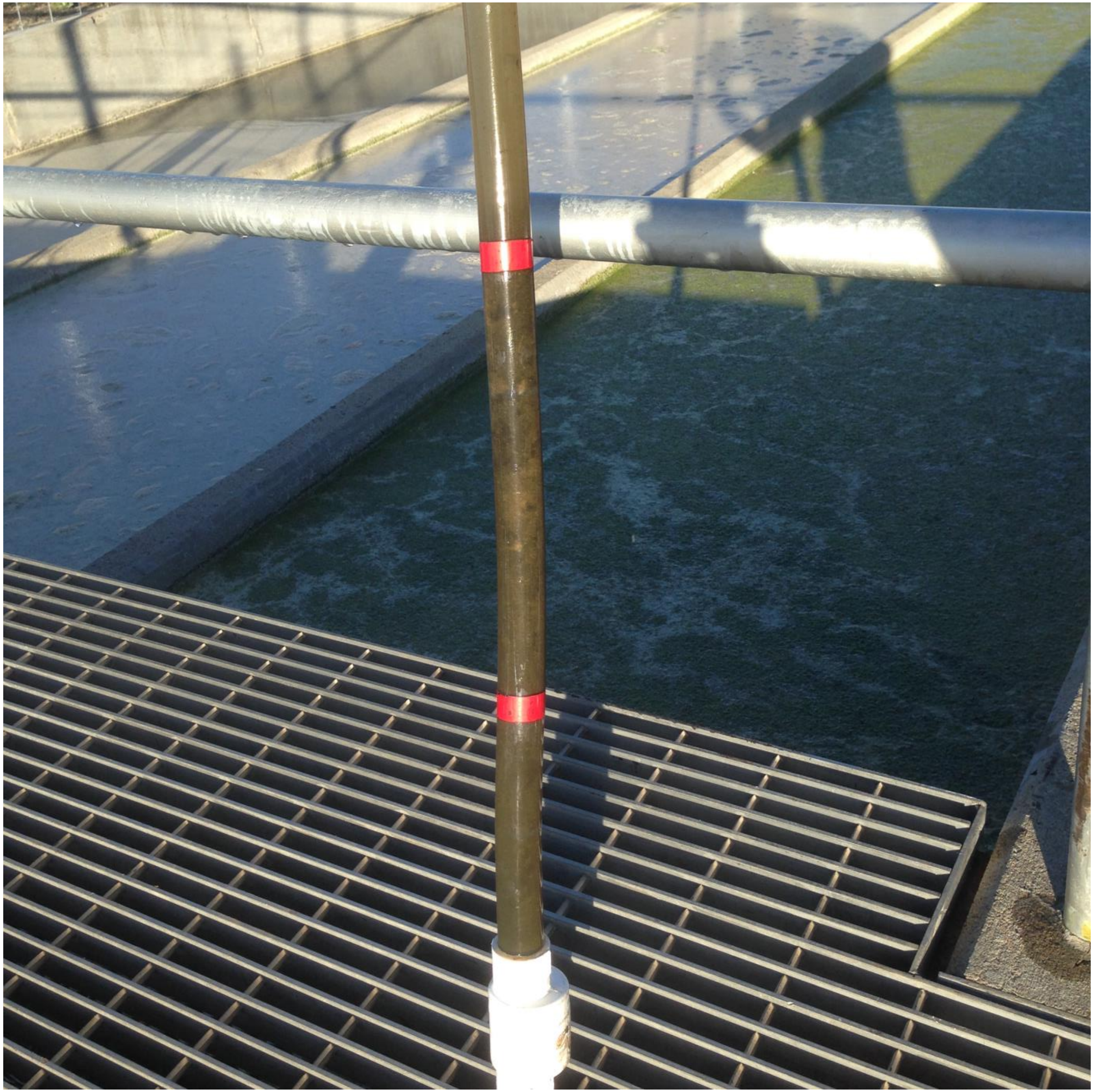
This in my experience is very typical in diffused air systems

Cell # 2 Sludge Blanket Thickness Profile at the Wastewater Lagoon System



Average Water Depth: 5.42 feet
Average Sludge depth: **2.62 feet**
Water Volume: 9,017,428 gallons
Sludge Volume: **4,642,296 gallons**
Sludge Mass Based on an average TS of 6.82: **1,320 dry tons**


Treatment Capacity Replaced by Sludge in Cell # 2
4,642,296 gallons
4,375,132 gallons
Remaining Water Cap Over Sludge
Sludge Volume in Cell # 2
5.89 days of Treatment Time LOST out of 11.45 days




MERRELL BROS.


SP272DLM
FONTAINE

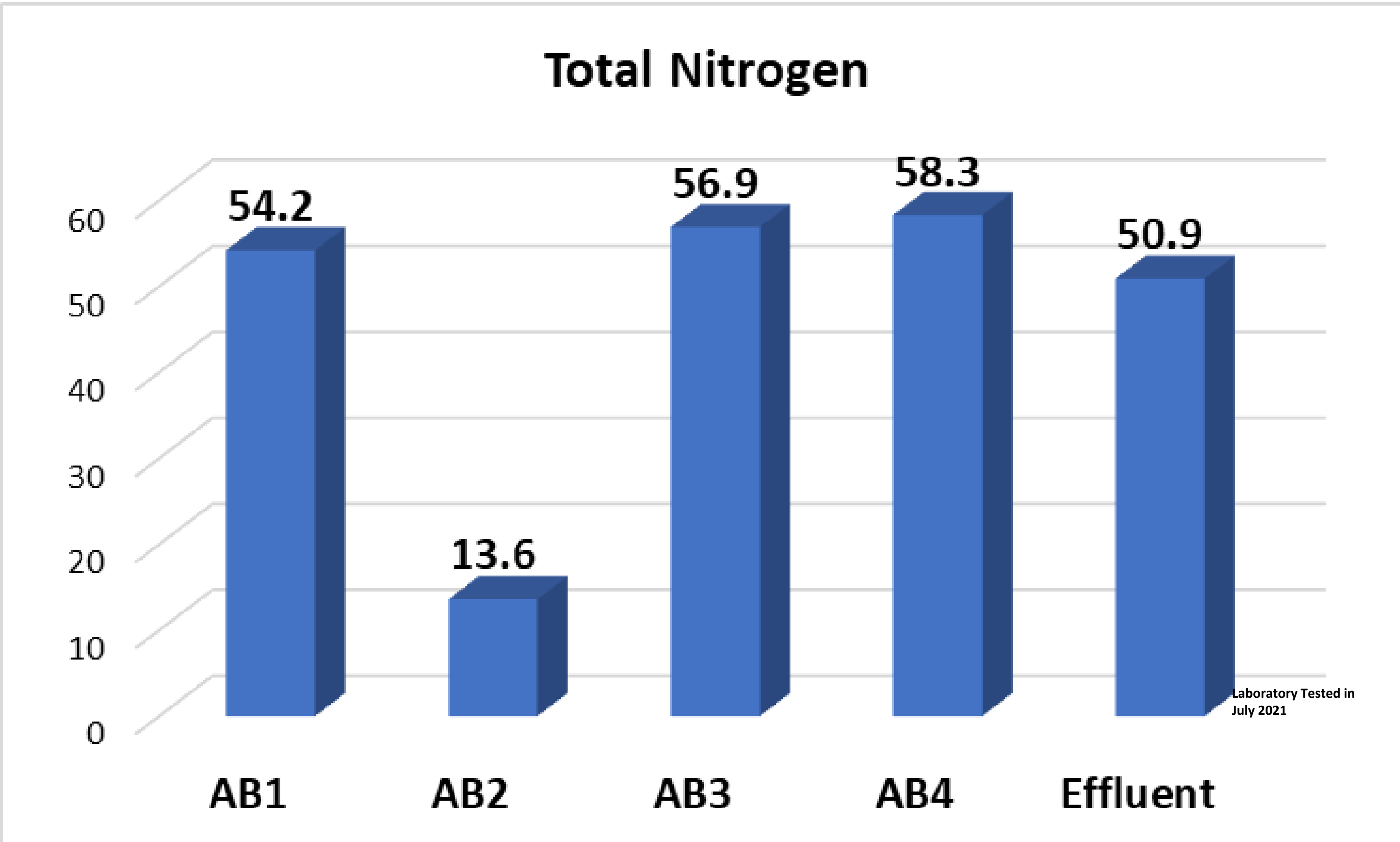

MACK
FONTAINE

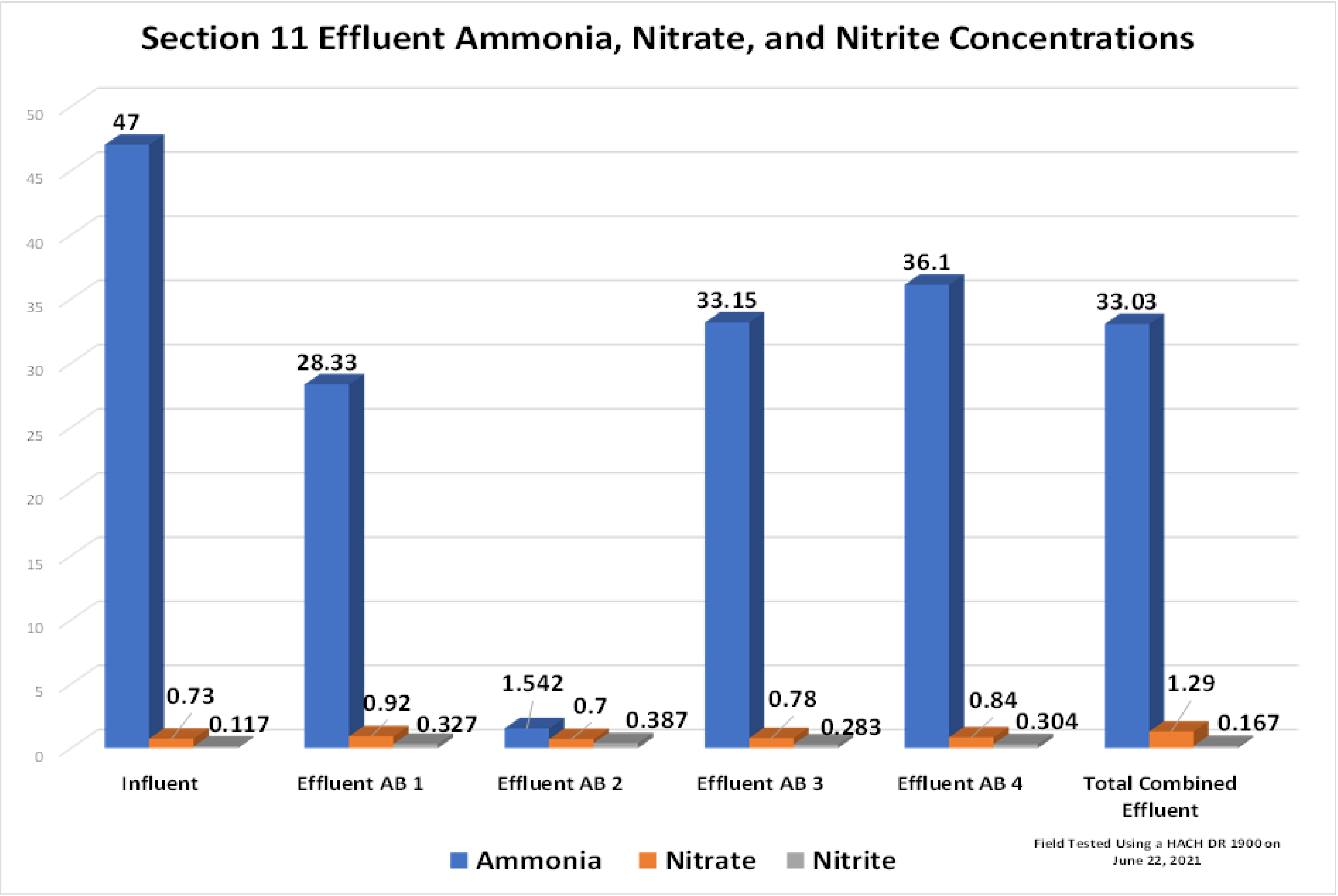

S. INC.

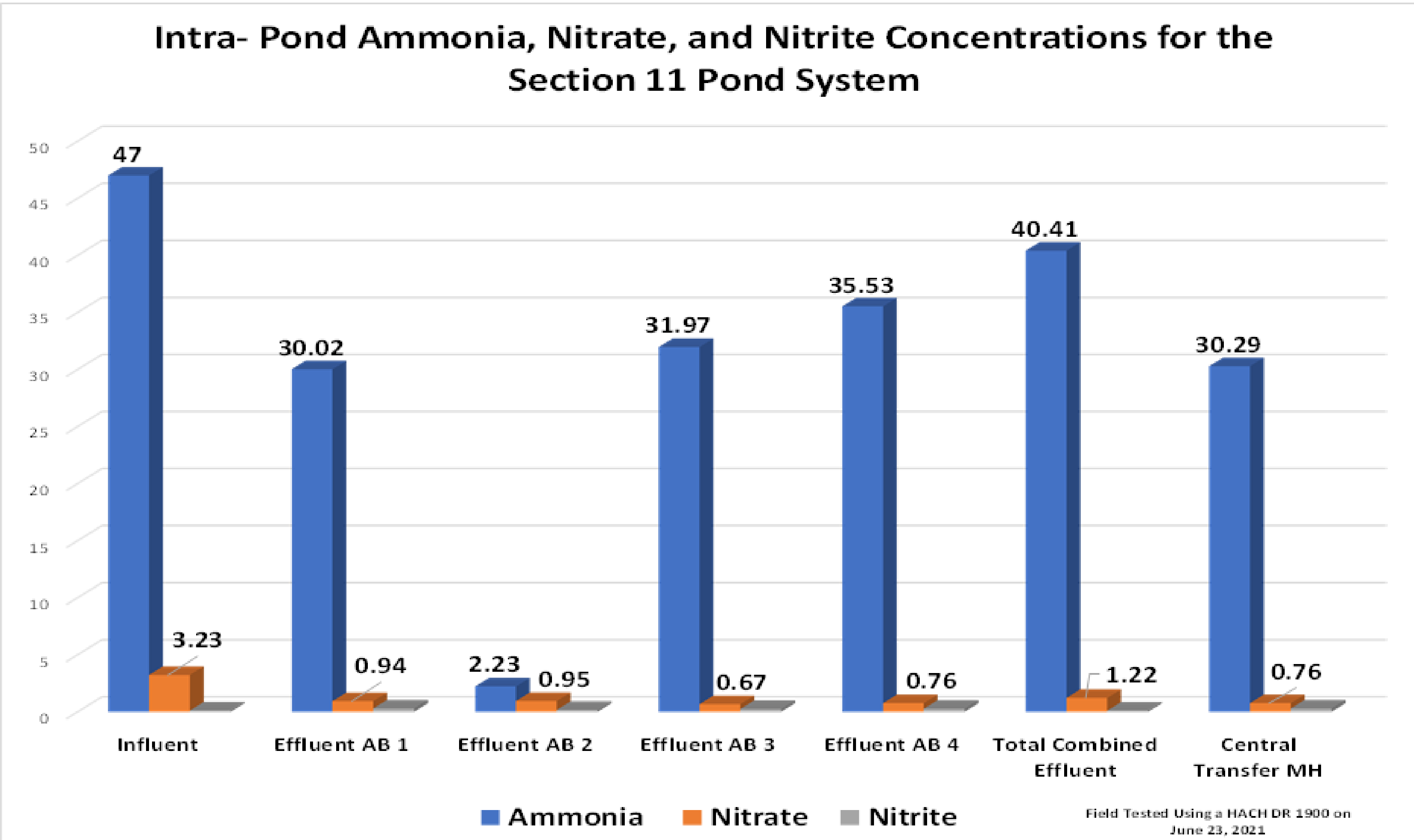
The Effect of Solids Accumulation on Effluent Water Quality

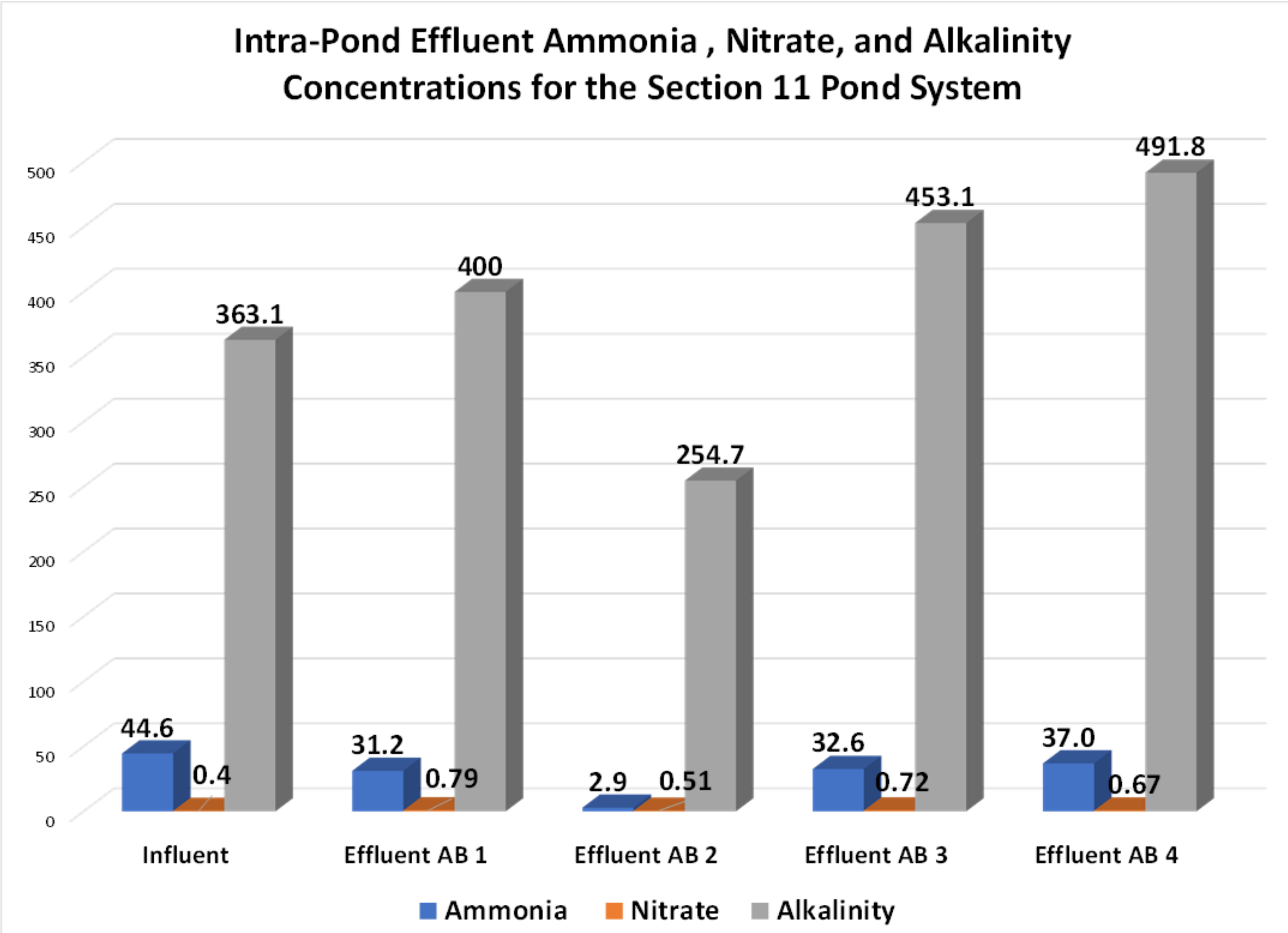
The Problem with Sludge

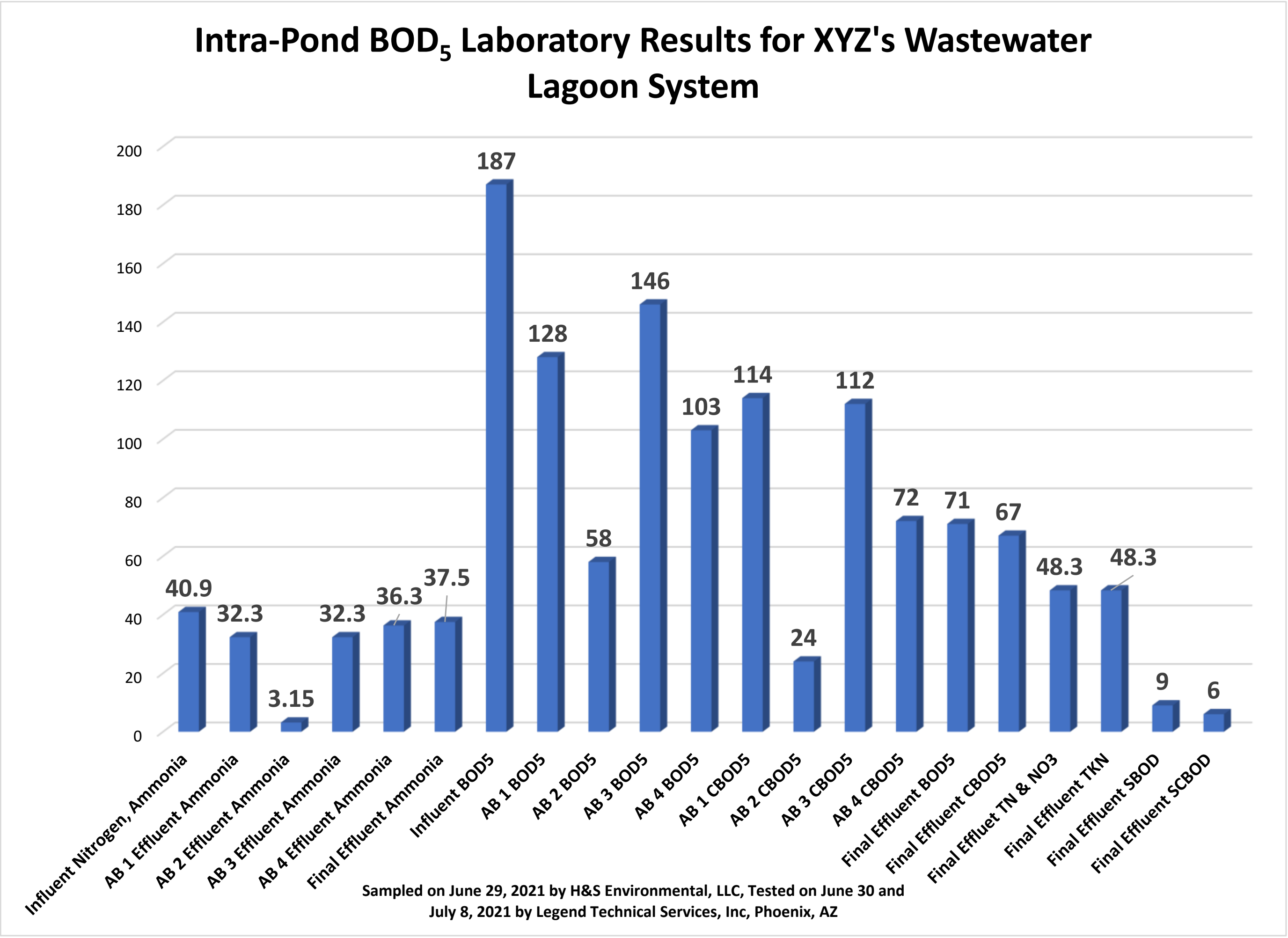
Cell AB2 was Desludged in the Summer of 2019



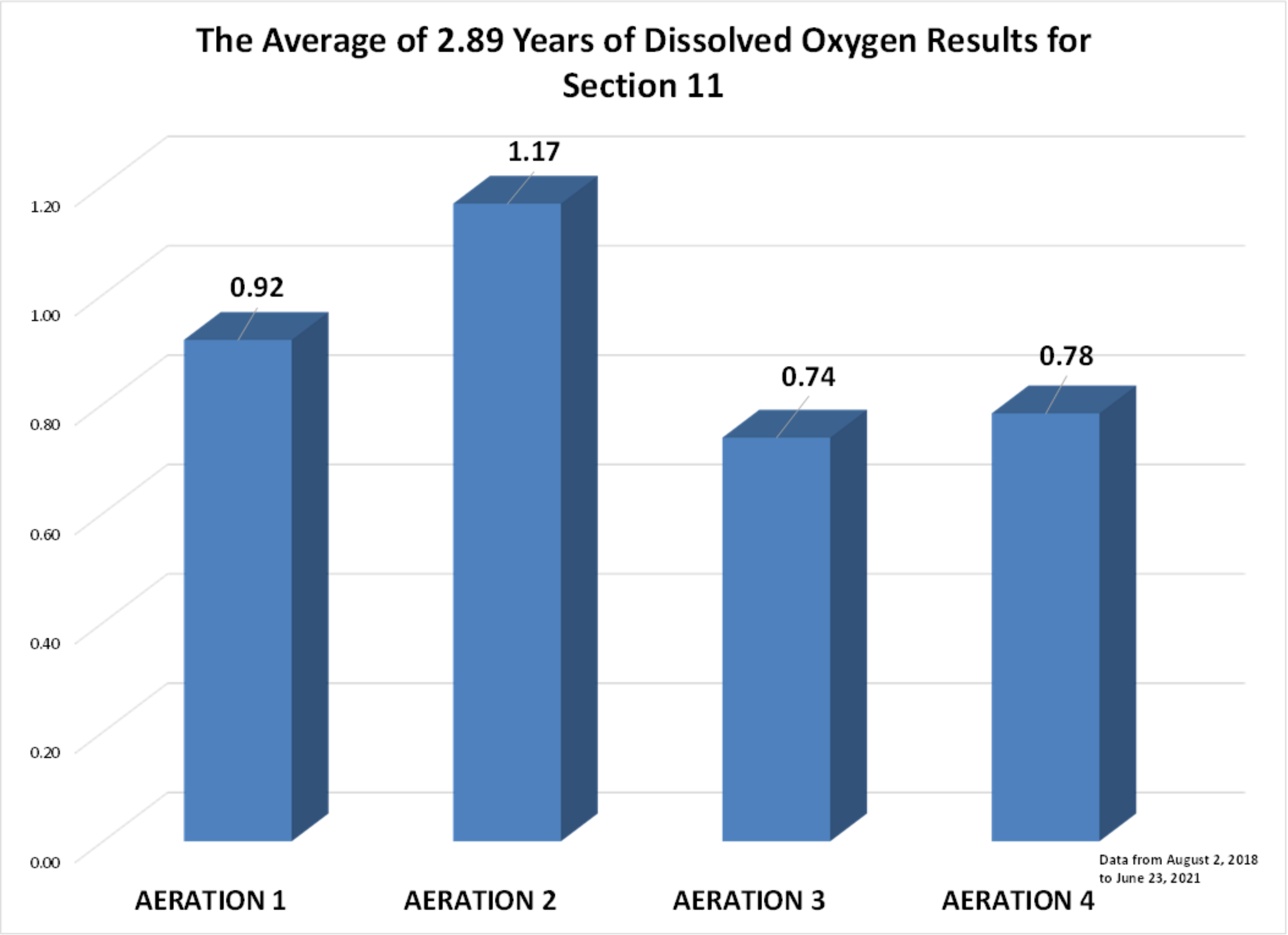

Section 11 Effluent Ammonia, Nitrate, and Nitrite Concentrations
50
45
40
35
30
25
20
15
10
5
0
47
0.73
0.117
28.33
0.92
0.327
1.542
0.7
0.387
33.15
0.78
0.283
36.1
0.84
0.304
33.03
1.29
0.167
Influent
Effluent AB 1
Effluent AB 2
Effluent AB 3
Effluent AB 4
Total Combined Effluent
Ammonia
Nitrate
Nitrite
Field Tested Using a HACH DR 1900 on June 22, 2021


Intra- Pond Ammonia, Nitrate, and Nitrite Concentrations for the Section 11 Pond System
0
5
10
15
20
25
30
35
40
45
50
47
3.23
30.02
0.94
2.23
0.95
31.97
0.67
35.53
0.76
40.41
1.22
30.29
0.76
Influent
Effluent AB 1
Effluent AB 2
Effluent AB 3
Effluent AB 4
Total Combined Effluent
Central Transfer MH
Ammonia
Nitrate
Nitrite
Field Tested Using a HACH DR 1900 on June 23, 2021

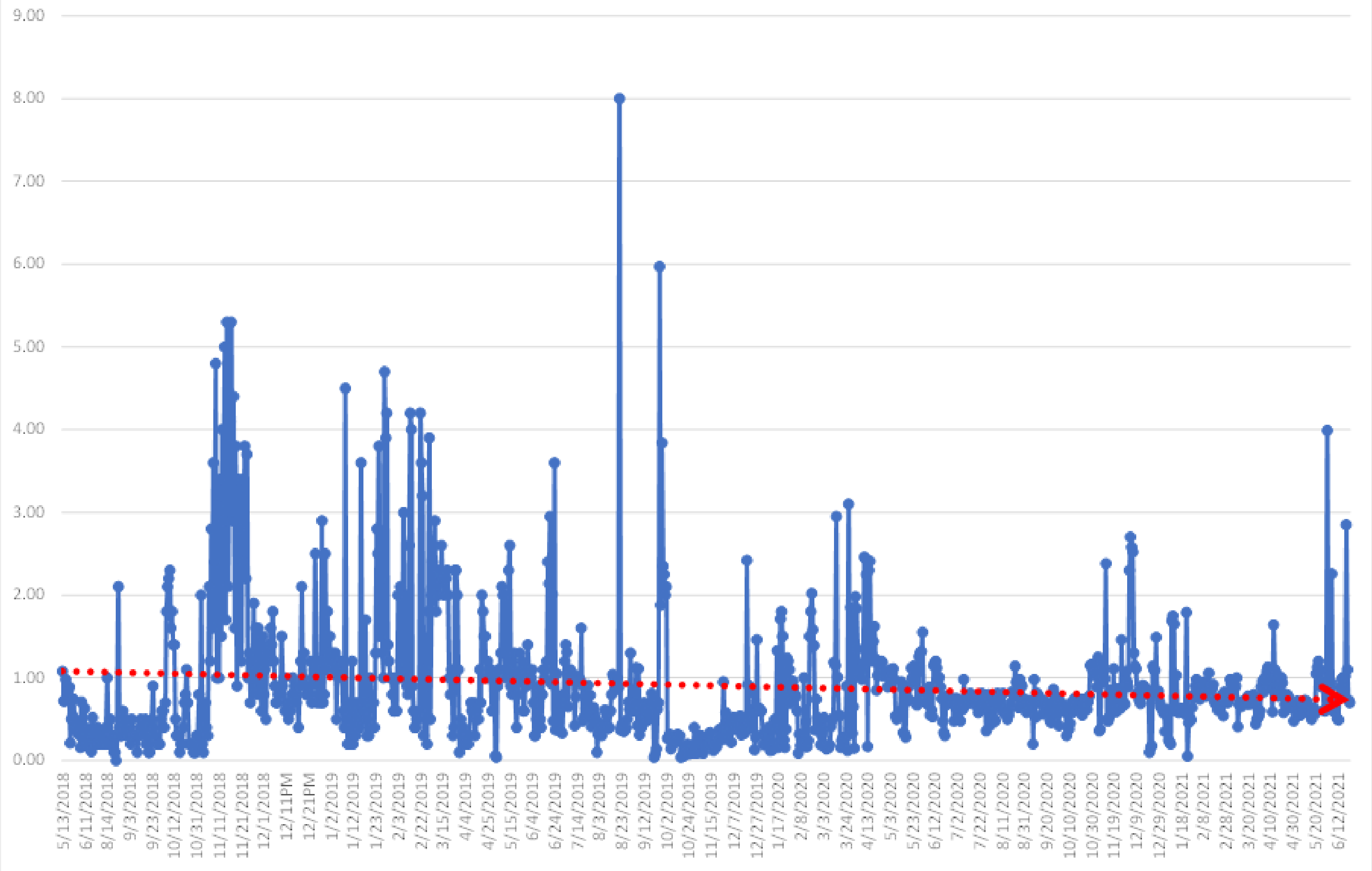

Intra-Pond Effluent Ammonia , Nitrate, and Alkalinity Concentrations for the Section 11 Pond System
500
450
400
350
300
250
200
150
100
50
0
44.6
0.4
363.1
31.2
0.79
400
2.9
0.51
254.7
32.6
0.72
453.1
37.0
0.67
491.8
Influent
Effluent AB 1
Effluent AB 2
Effluent AB 3
Effluent AB 4
Ammonia
Nitrate
Alkalinity

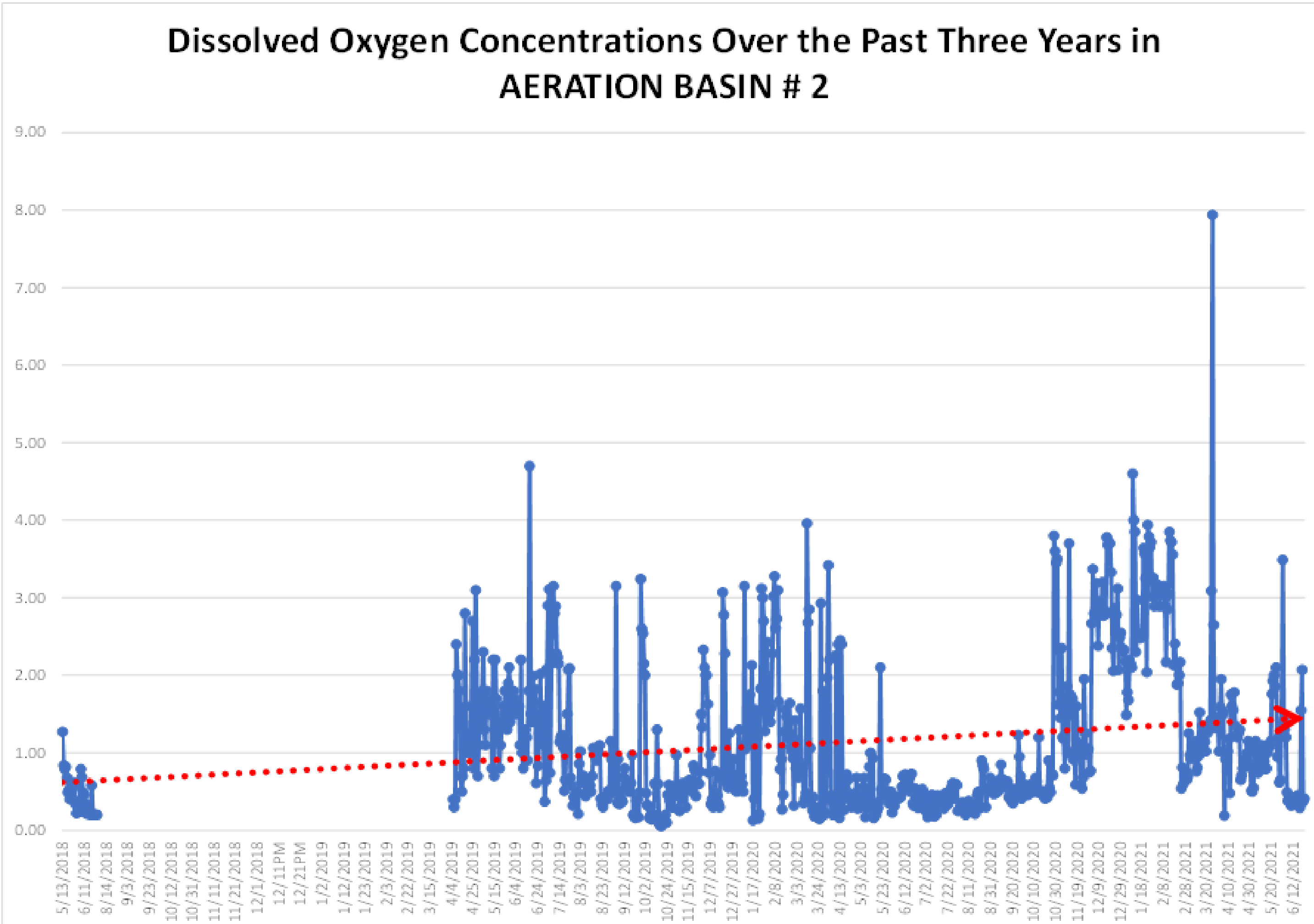


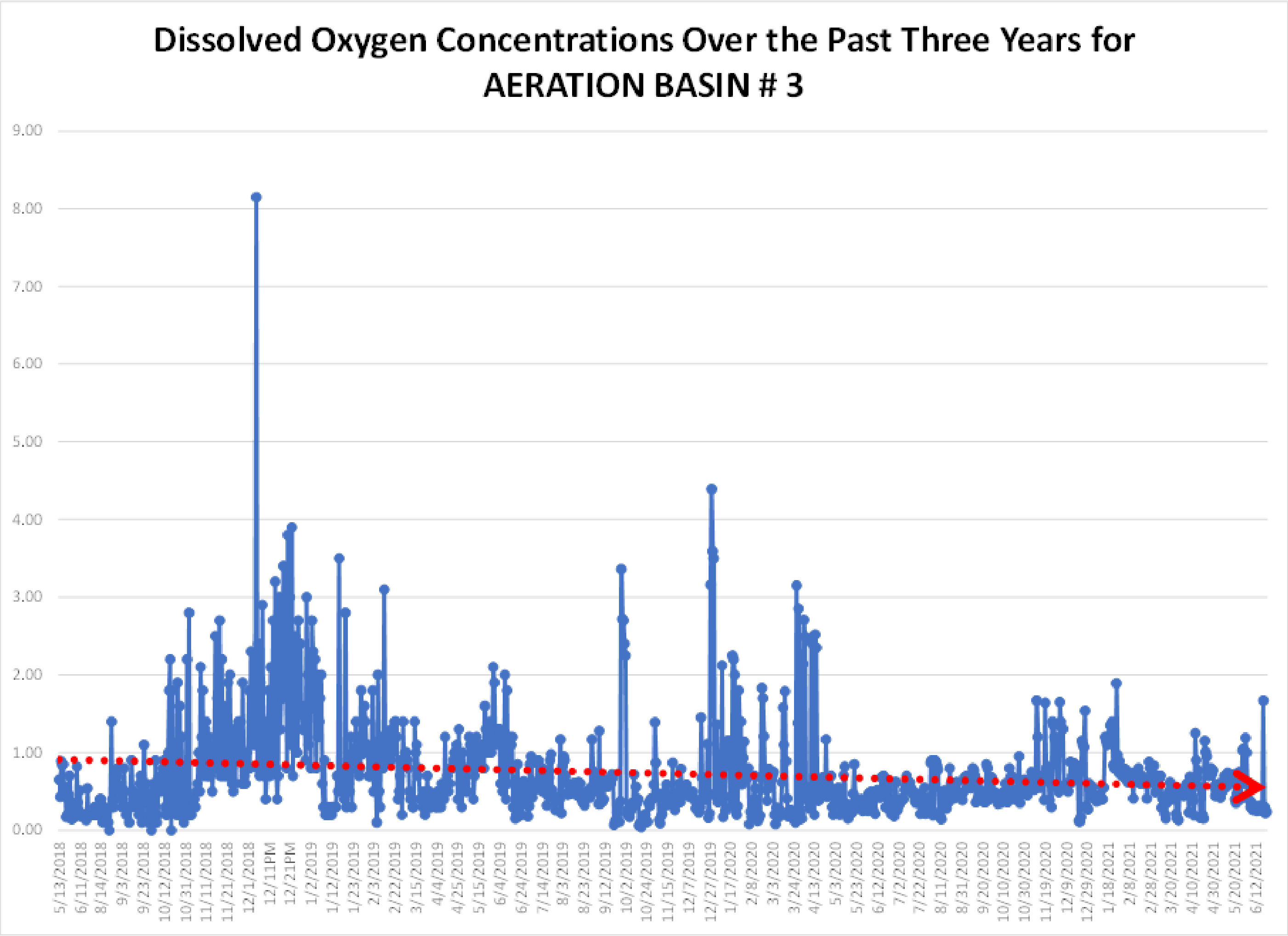
Intra-Pond BOD5 Laboratory Results for XYZ's Wastewater Lagoon System
200
180
160
140
120
100
80
60
40
20
0
40.9
32.3
3.15
32.3
36.3
37.5
187
128
58
146
103
114
24
112
72
71
67
48.3
48.3
9
6
Influent Nitrogen, Ammonia
AB 1 Effluent Ammonia
AB 2 Effluent Ammonia
AB 3 Effluent Ammonia
AB 4 Effluent Ammonia
Final Effluent Ammonia
Influent BOD5
AB 1 BOD5
AB 2 BOD5
AB 3 BOD5
AB 4 BOD5
AB 1 CBOD5
AB 2 CBOD5
AB 3 CBOD5
AB 4 CBOD5
Final Effluent BOD5
Final Effluent CBOD5
Final Effluet TN & NO3
Final Effluent TKN
Final Effluent SBOD
Final Effluent SCBOD
Sampled on June 29, 2021 by H&S Environmental, LLC, Tested on June 30 and
July 8, 2021 by Legend Technical Services, Inc, Phoenix, AZ

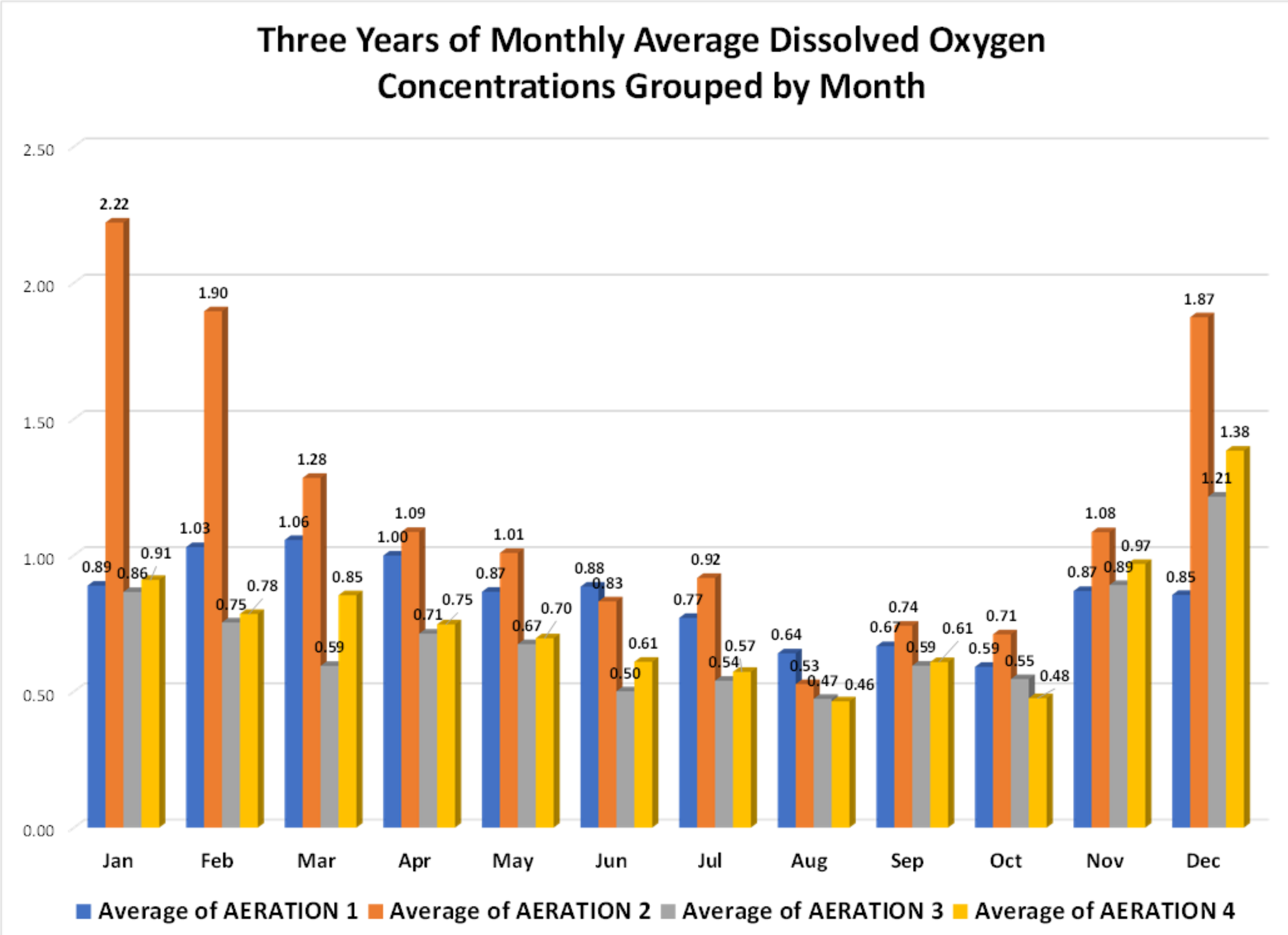

The Average of 2.89 Years of Dissolved Oxygen Results for Section 11
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.92
1.17
0.74
0.78
AERATION 1
AERATION 2
AERATION 3
AERATION 4
Data from August 2, 2018 to June 23, 2021

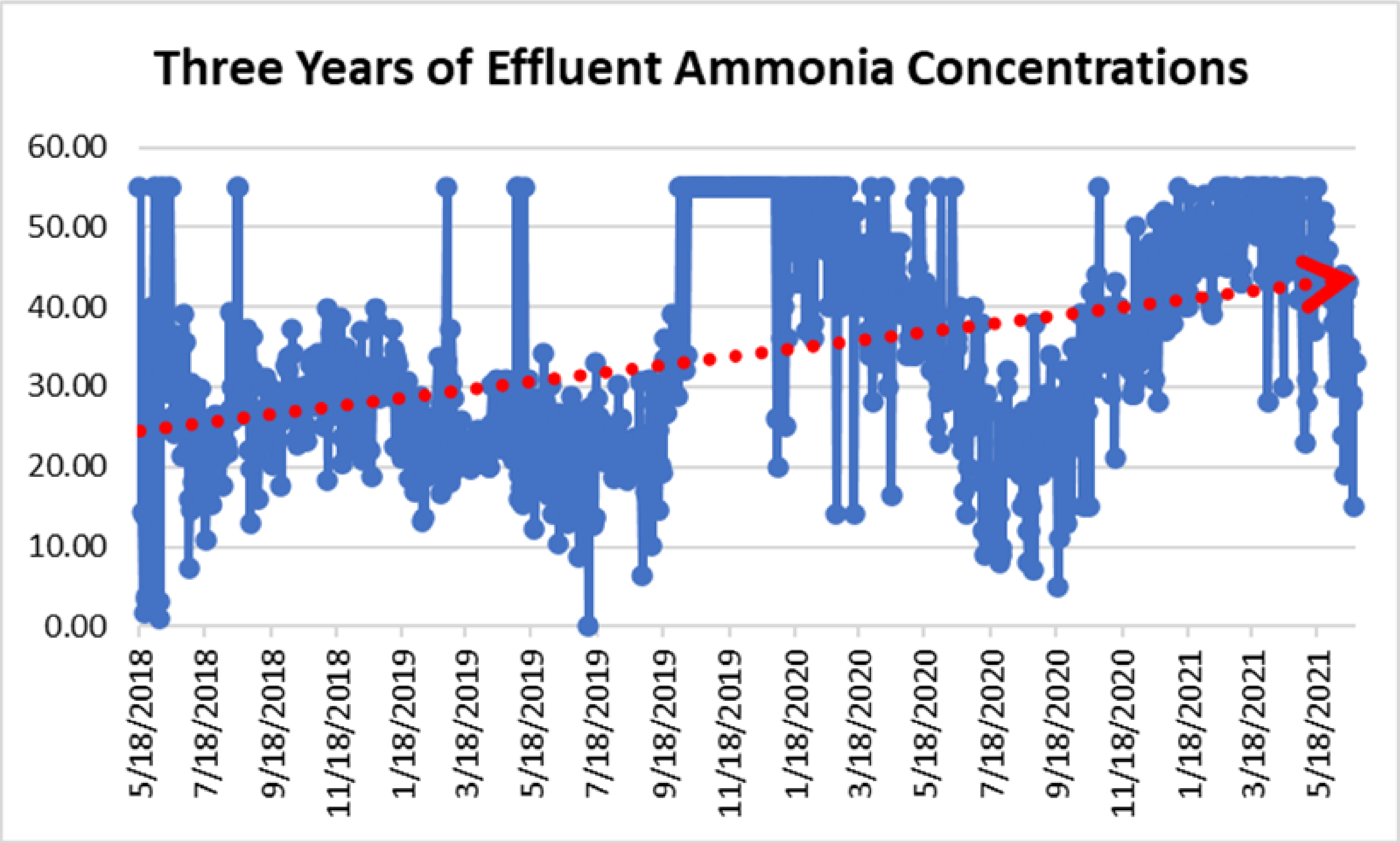
Dissolved Oxygen Concentrations Over the Past Three Years in AERATION BASIN # 1



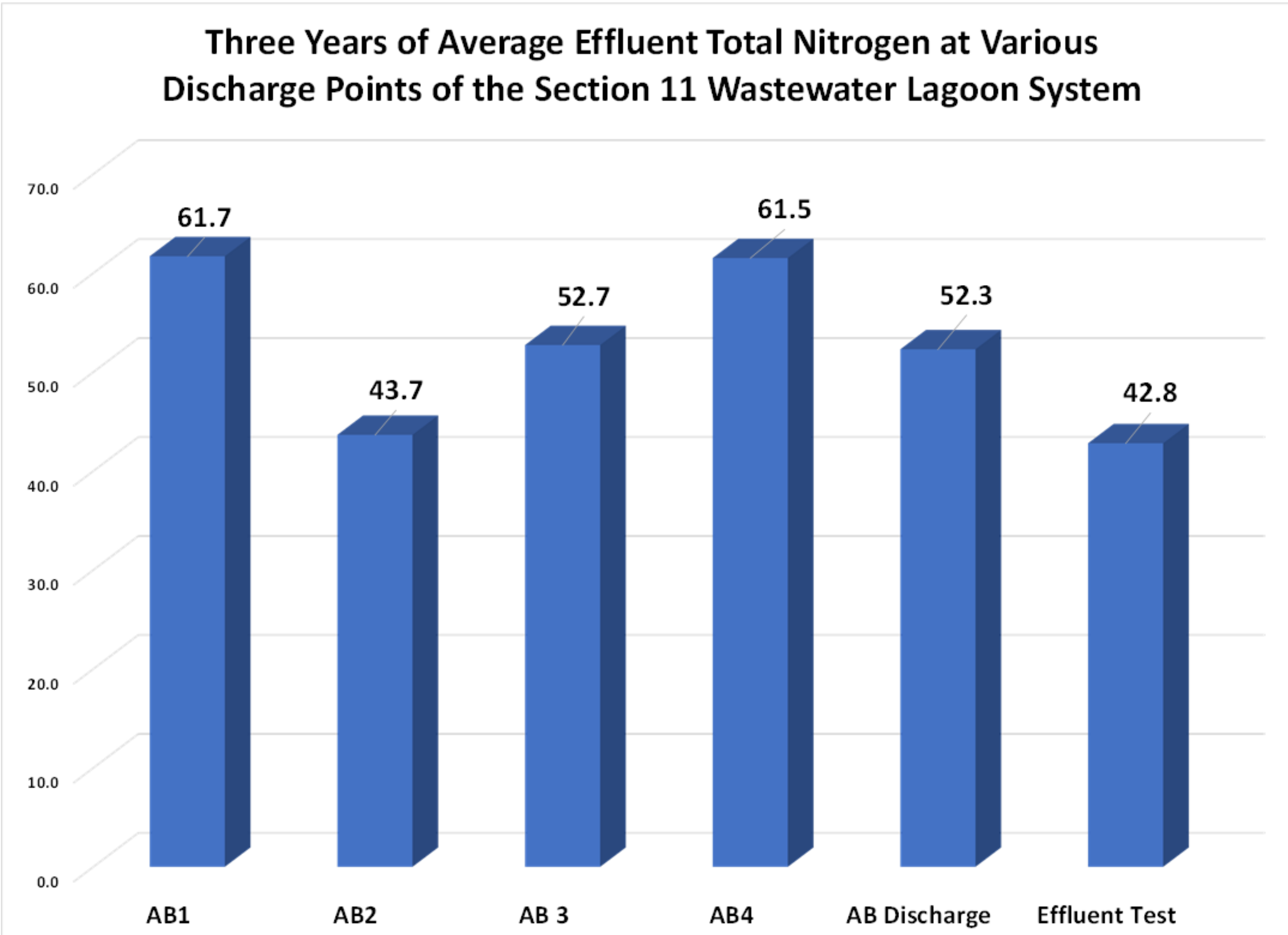

Dissolved Oxygen Concentrations Over the Past Three Years in
AERATION BASIN # 2
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
5/13/2018
6/11/2018
8/14/2018
9/3/2018
9/23/2018
10/12/2018
10/31/2018
11/11/2018
11/21/2018
12/1/2018
12/11PM
12/21PM
1/2/2019
1/12/2019
1/23/2019
2/3/2019
2/22/2019
3/15/2019
4/4/2019
4/25/2019
5/15/2019
6/4/2019
6/24/2019
7/14/2019
8/3/2019
8/23/2019
9/12/2019
10/2/2019
10/24/2019
11/15/2019
12/7/2019
12/27/2019
1/17/2020
2/8/2020
3/3/2020
3/24/2020
4/13/2020
5/3/2020
5/23/2020
6/12/2020
7/2/2020
7/22/2020
8/11/2020
8/31/2020
9/20/2020
10/10/2020
10/30/2020
11/19/2020
12/9/2020
12/29/2020
1/18/2021
2/8/2021
2/28/2021
3/20/2021
4/10/2021
4/30/2021
5/20/2021
6/12/2021


Dissolved Oxygen Concentrations Over the Past Three Years for
AERATION BASIN # 3
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
5/13/2018
6/11/2018
8/14/2018
9/3/2018
9/23/2018
10/12/2018
10/31/2018
11/11/2018
11/21/2018
12/1/2018
12/11PM
12/21PM
1/2/2019
1/12/2019
1/23/2019
2/3/2019
2/22/2019
3/15/2019
4/4/2019
4/25/2019
5/15/2019
6/4/2019
6/24/2019
7/14/2019
8/3/2019
8/23/2019
9/12/2019
10/2/2019
10/24/2019
11/15/2019
12/7/2019
12/27/2019
1/17/2020
2/8/2020
3/3/2020
3/24/2020
4/13/2020
5/3/2020
5/23/2020
6/12/2020
7/2/2020
7/22/2020
8/11/2020
8/31/2020
9/20/2020
10/10/2020
10/30/2020
11/19/2020
12/9/2020
12/29/2020
1/18/2021
2/8/2021
2/28/2021
3/20/2021
4/10/2021
4/30/2021
5/20/2021
6/12/2021

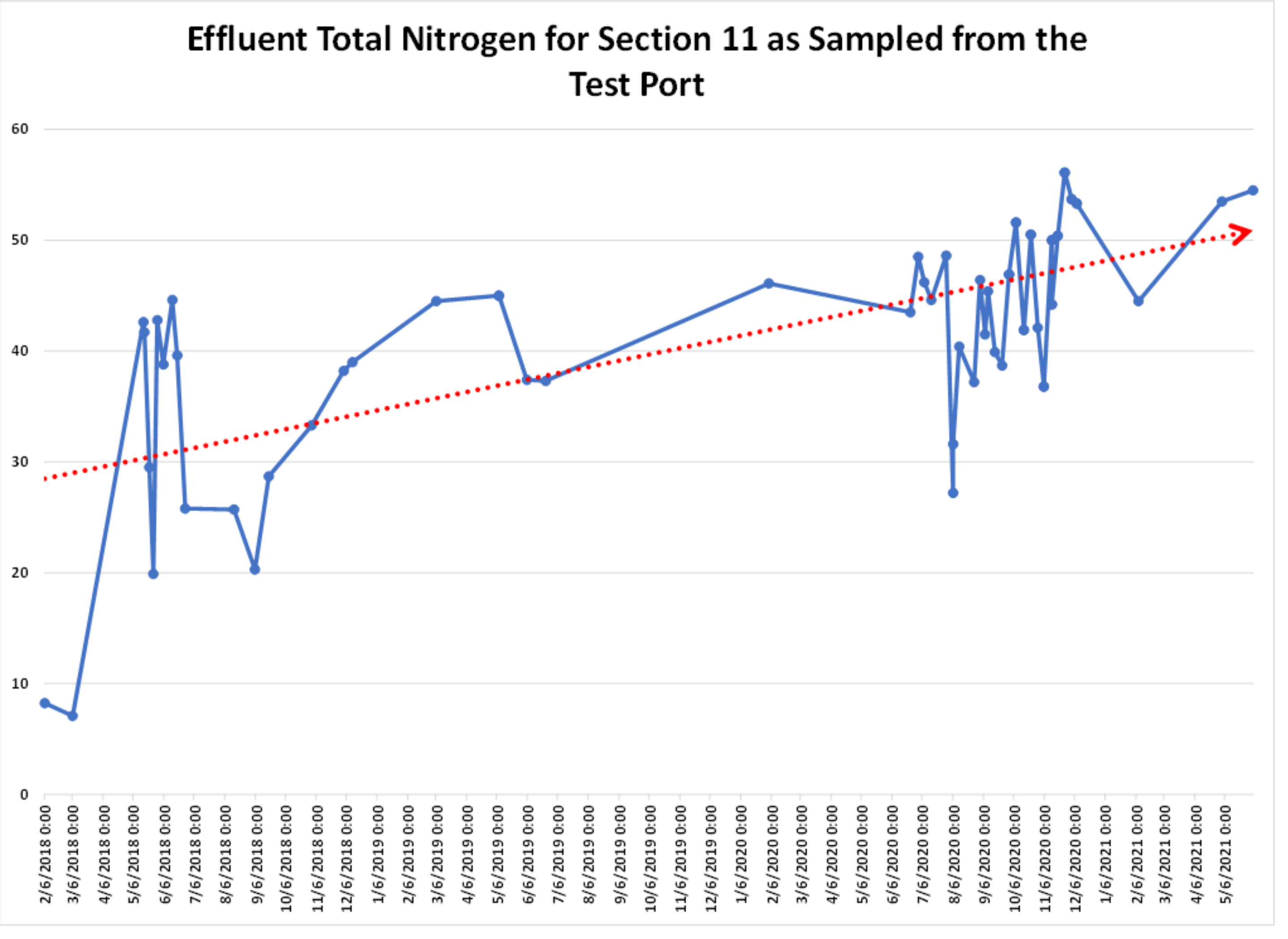

Three Years of Monthly Average Dissolved Oxygen Concentrations Grouped by Month
2.50
2.00
1.50
1.00
0.50
0.00
2.22
0.89
0.86
0.91
1.90
1.03
0.75
0.78
1.28
1.06
0.59
0.85
1.09
1.00
0.71
0.75
1.01
0.87
0.67
0.70
0.88
0.83
0.50
0.61
0.92
0.77
0.54
0.57
0.64
0.53
0.47
0.46
0.74
0.67
0.59
0.61
0.71
0.59
0.55
0.48
1.08
0.87
0.89
0.97
1.87
0.85
1.21
1.38
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average of AERATION 1
Average of AERATION 2
Average of AERATION 3
Average of AERATION 4



Three Years of Effluent Ammonia Concentrations
60.00
50.00
40.00
30.00
20.00
10.00
0.00
5/18/2018
7/18/2018
9/18/2018
11/18/2018
1/18/2019
3/18/2019
5/18/2019
7/18/2019
9/18/2019
11/18/2019
1/18/2020
3/18/2020
5/18/2020
7/18/2020
9/18/2020
11/18/2020
1/18/2021
3/18/2021
5/18/2021



Three Years of Average Effluent Total Nitrogen at Various Discharge Points of the Section 11 Wastewater Lagoon System
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
61.7
43.7
52.7
61.5
52.3
42.8
AB1
AB2
AB 3
AB4
AB Discharge
Effluent Test



Effluent Total Nitrogen for Section 11 as Sampled from the Test Port
60
50
40
30
20
10
0
2/6/2018 0:00
3/6/2018 0:00
4/6/2018 0:00
5/6/2018 0:00
6/6/2018 0:00
7/6/2018 0:00
8/6/2018 0:00
9/6/2018 0:00
10/6/2018 0:00
11/6/2018 0:00
12/6/2018 0:00
1/6/2019 0:00
2/6/2019 0:00
3/6/2019 0:00
4/6/2019 0:00
5/6/2019 0:00
6/6/2019 0:00
7/6/2019 0:00
8/6/2019 0:00
9/6/2019 0:00
10/6/2019 0:00
11/6/2019 0:00
12/6/2019 0:00
1/6/2020 0:00
2/6/2020 0:00
3/6/2020 0:00
4/6/2020 0:00
5/6/2020 0:00
6/6/2020 0:00
7/6/2020 0:00
8/6/2020 0:00
9/6/2020 0:00
10/6/2020 0:00
11/6/2020 0:00
12/6/2020 0:00
1/6/2021 0:00
2/6/2021 0:00
3/6/2021 0:00
4/6/2021 0:00
5/6/2021 0:00

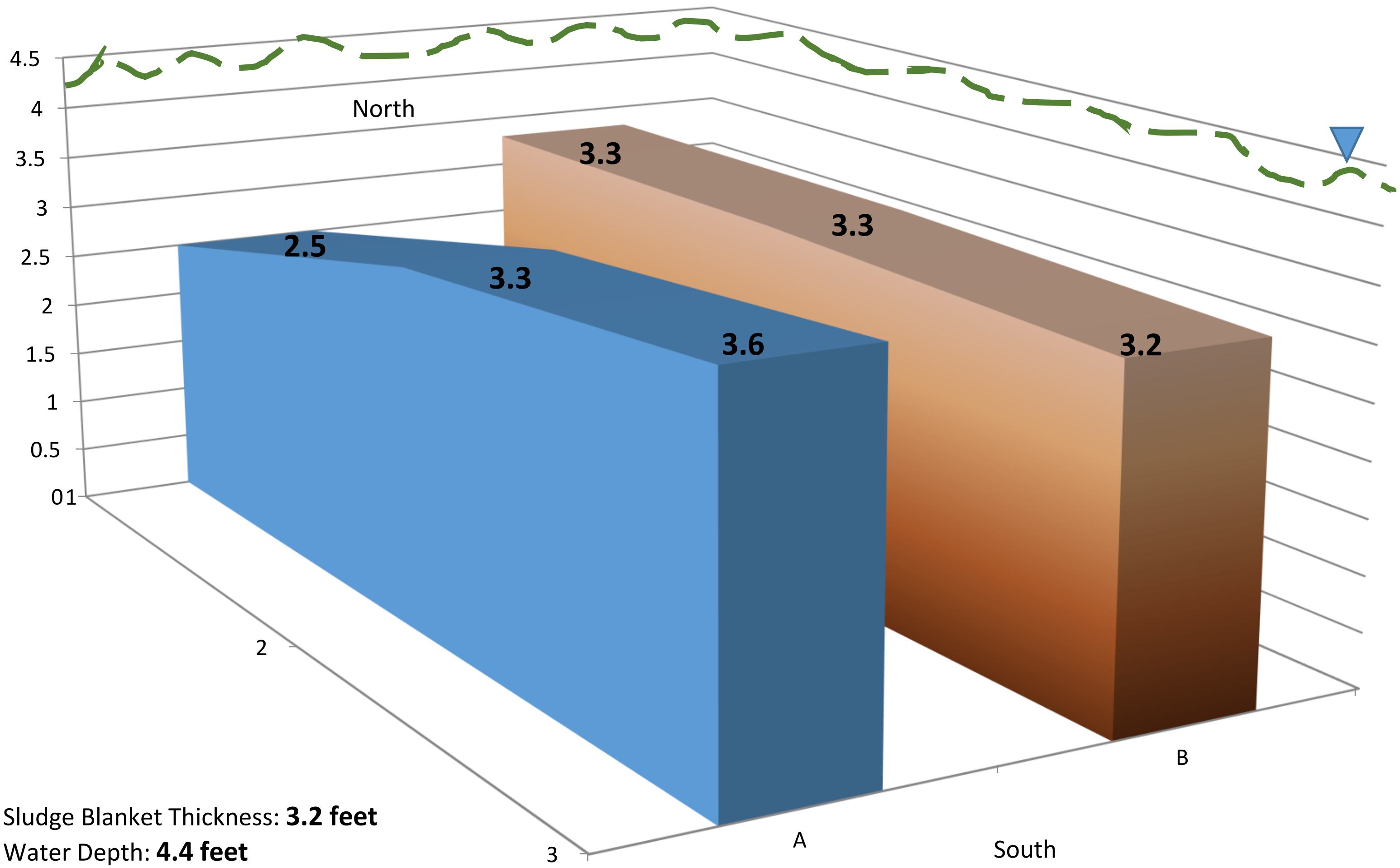
Sludge at the Effluent Structure

In a 43 Year Old Lagoon System

Marsing
Idaho


Midway
© 2013 Google
Google earth

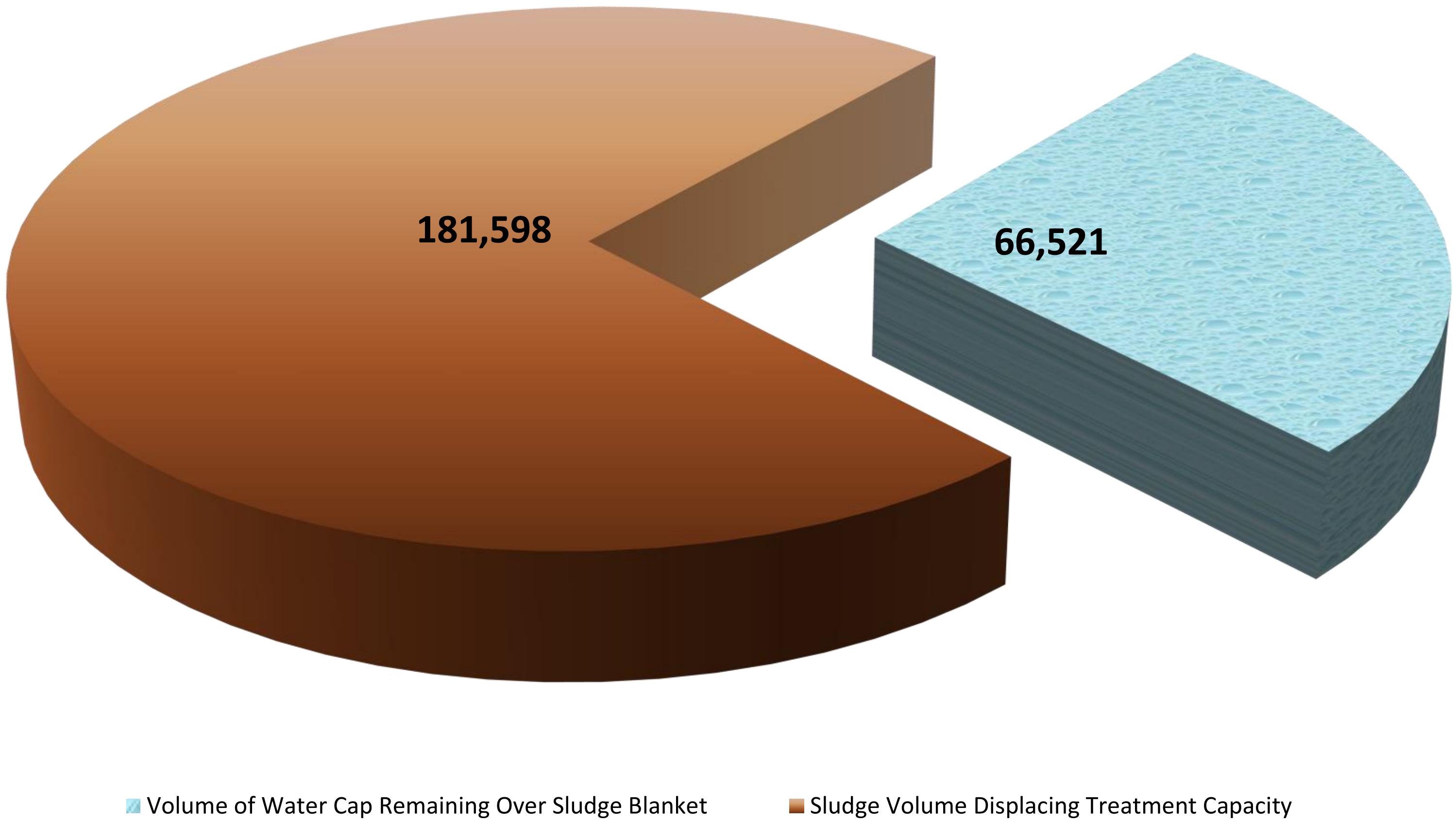
Sludge Blanket Profile for Cell # 3 of the [redacted] STP



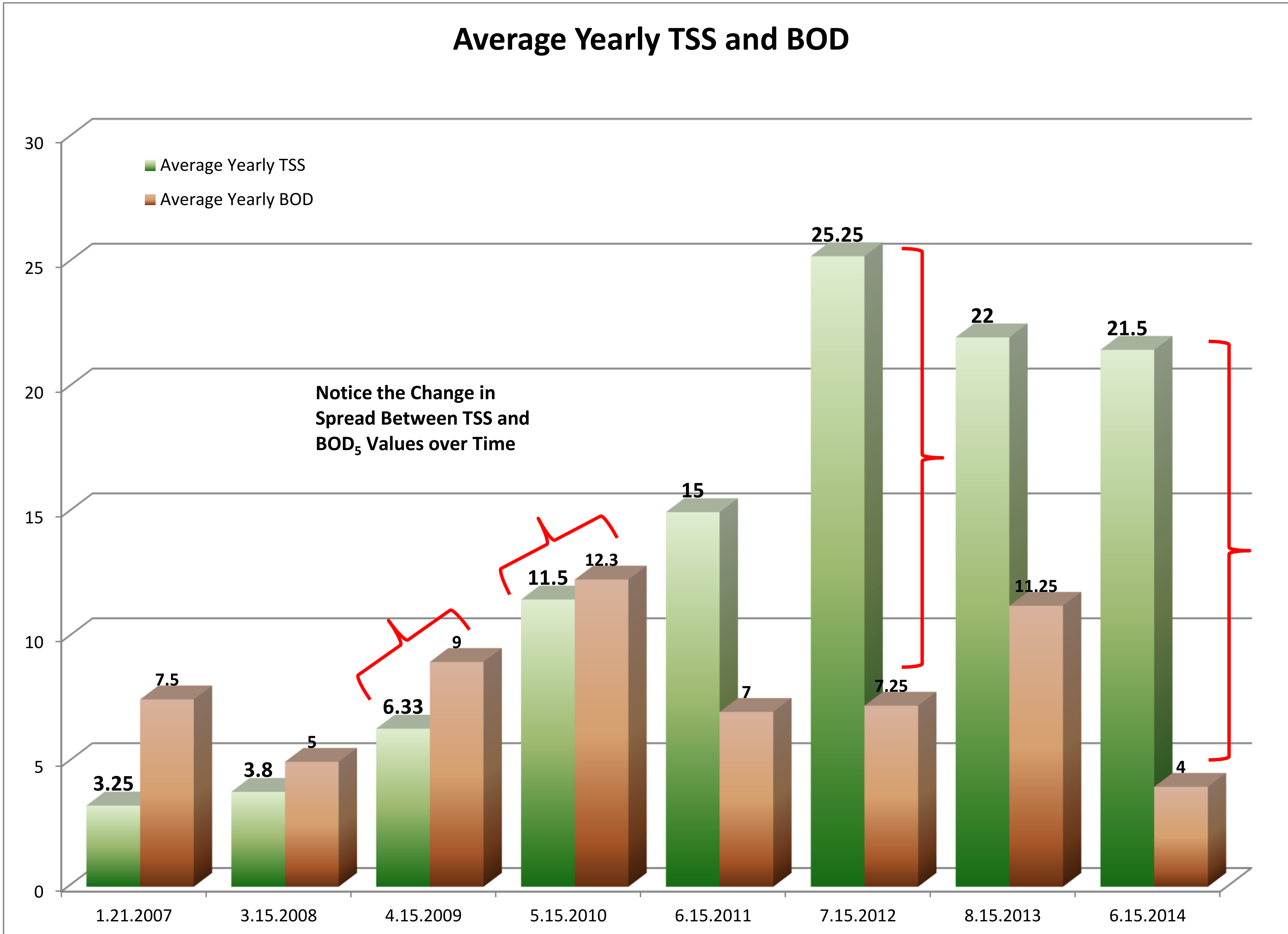
Average Sludge Blanket Thickness: **3.2 feet**
Average Water Depth: **4.4 feet**
Average Clearwater Cap Over Top of Sludge: **1.2 feet**
Volume of Sludge: **181,598 gallons**
Estimated Mass of Sludge Based on 20.3% Total Solids: **154 dry tons**
Sampled on: **4/1/2014**

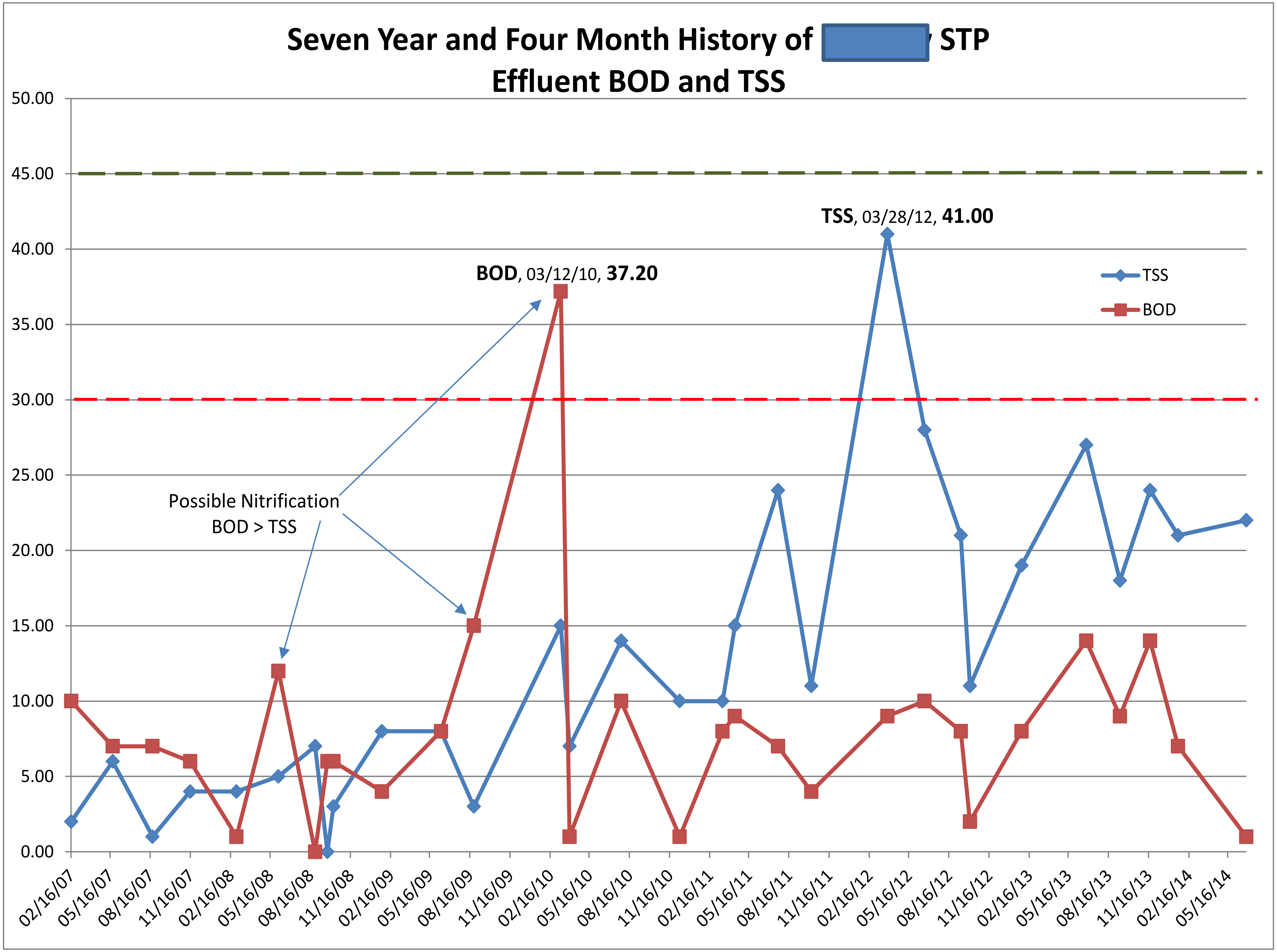
73% of this Treatment Cell's Capacity is Occupied by Sludge

Cell # 3's Diminished Treatment Capacity



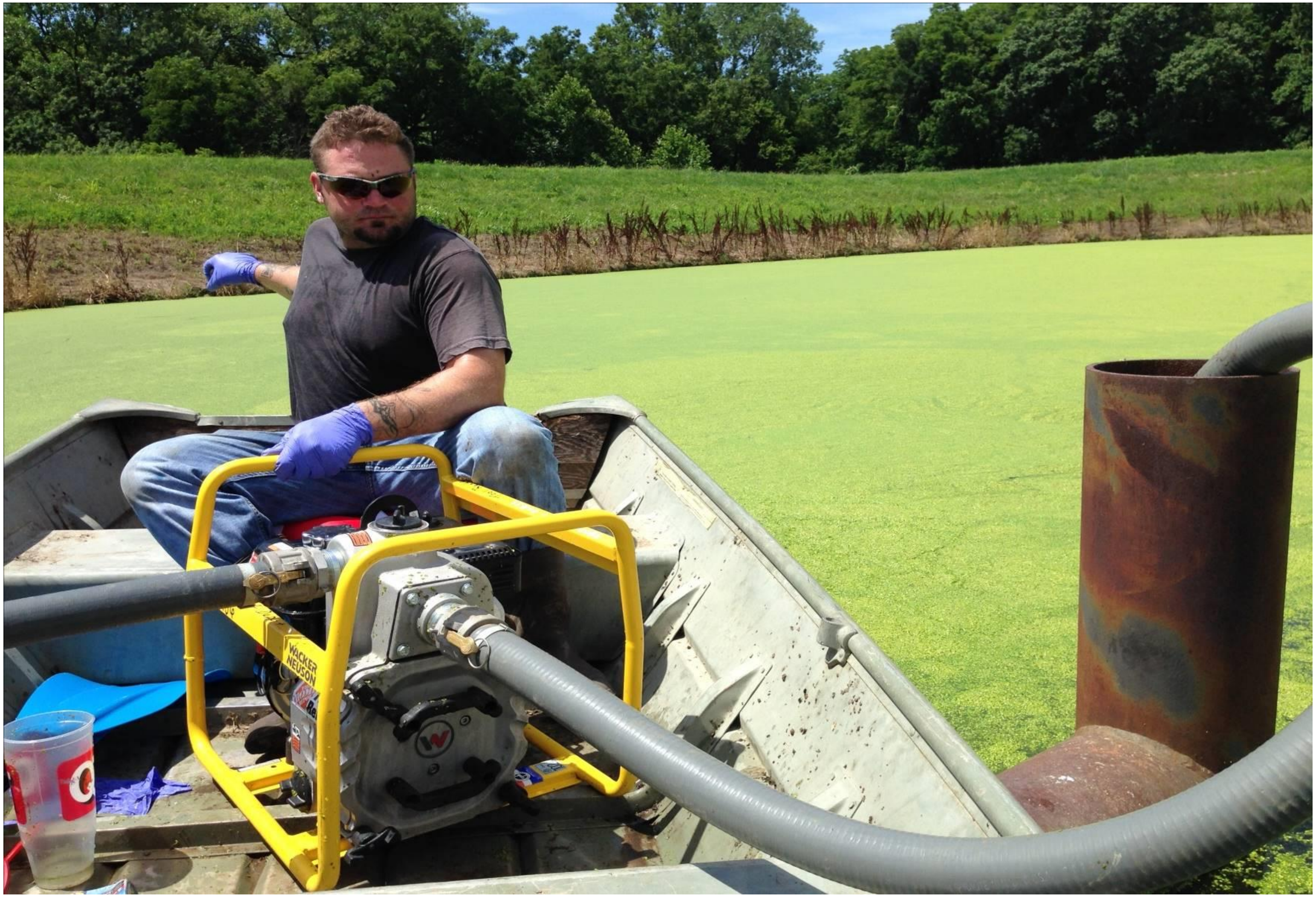
73% of Cell # 3's Treatment Capacity is Occupied by Sludge


Average Yearly TSS and BOD
Average Yearly TSS
Average Yearly BOD
Notice the Change in Spread Between TSS and BOD_5 Values over Time
30
25
20
15
10
5
0
3.25
7.5
3.8
5
6.33
9
11.5
12.3
15
7
25.25
7.25
22
11.25
21.5
4
1.21.2007
3.15.2008
4.15.2009
5.15.2010
6.15.2011
7.15.2012
8.15.2013
6.15.2014



Seven Year and Four Month History of [redacted] STP
Effluent BOD and TSS
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
TSS, 03/28/12, 41.00
BOD, 03/12/10, 37.20
TSS
BOD
Possible Nitrification
BOD > TSS
02/16/07
05/16/07
08/16/07
11/16/07
02/16/08
05/16/08
08/16/08
11/16/08
02/16/09
05/16/09
08/16/09
11/16/09
02/16/10
05/16/10
08/16/10
11/16/10
02/16/11
05/16/11
08/16/11
11/16/11
02/16/12
05/16/12
08/16/12
11/16/12
02/16/13
05/16/13
08/16/13
11/16/13
02/16/14
05/16/14

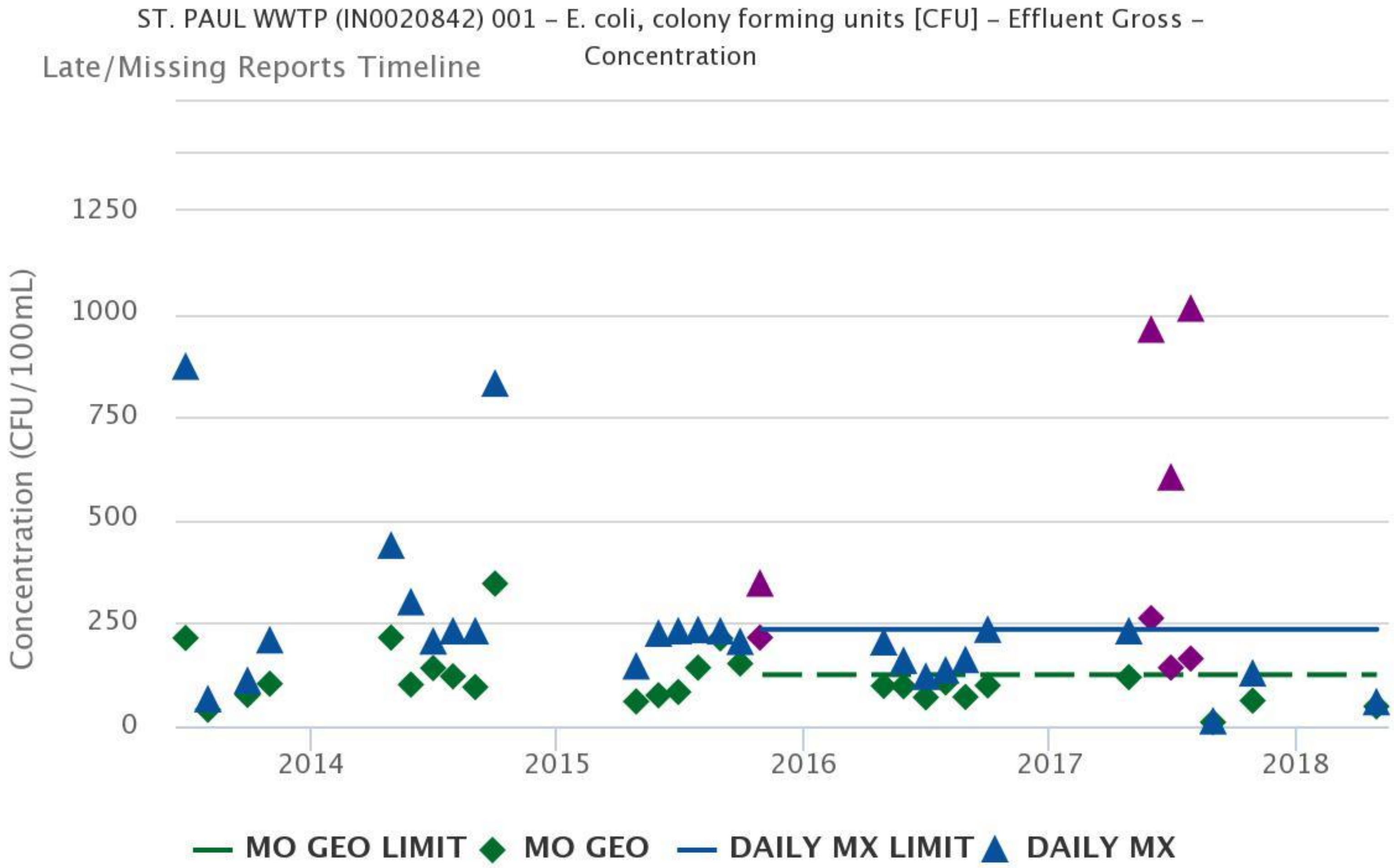
Cleaning Sludge from an Effluent Structure



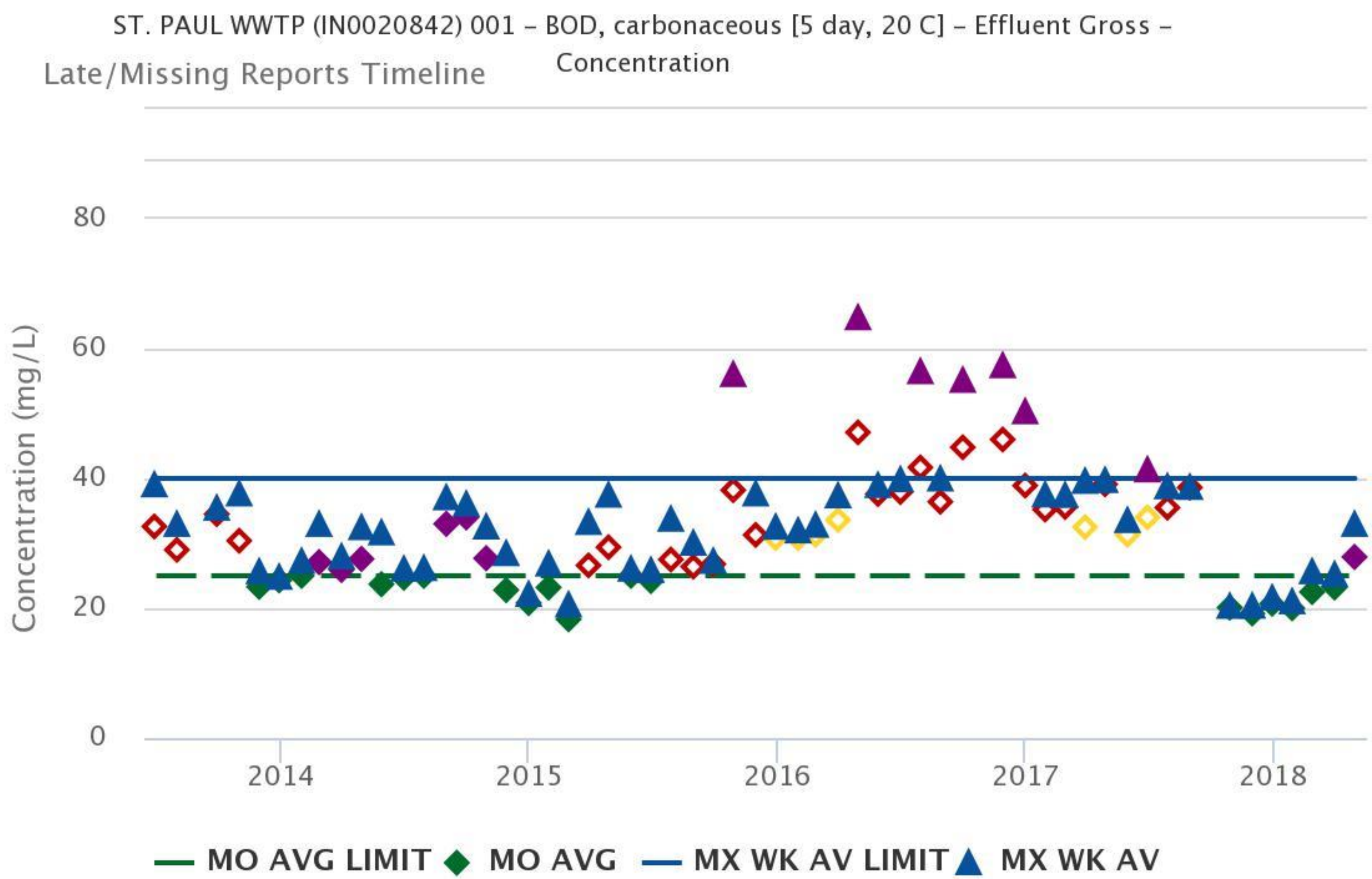
Cleaning an Effluent Structure

Three Feet of Sludge at the Effluent Structure

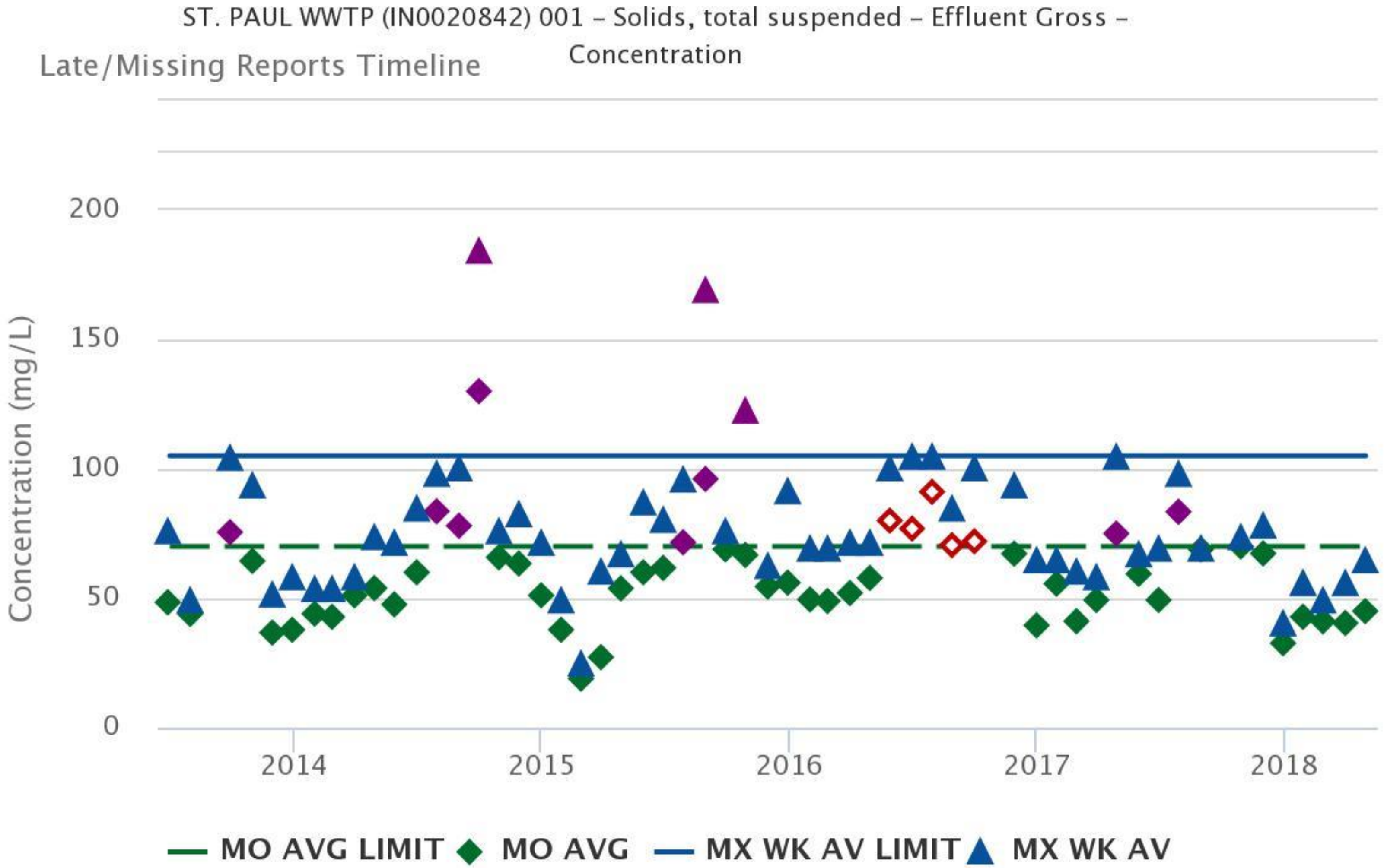
Sludge Removal at St Paul, IN Effluent Structure



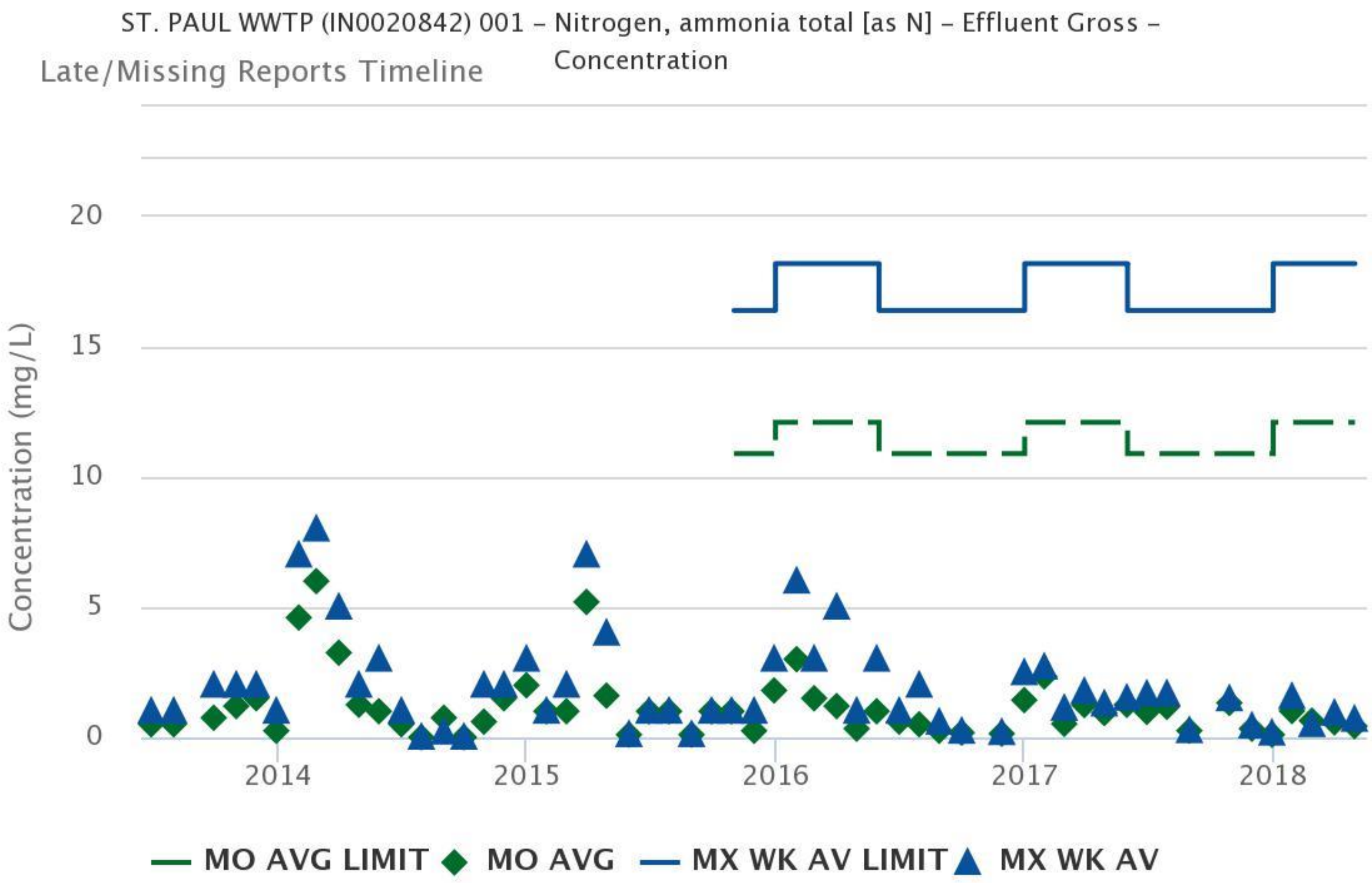
ST. PAUL WWTP (IN0020842) 001 – E. coli, colony forming units [CFU] – Effluent Gross – Concentration
Late/Missing Reports Timeline
Concentration (CFU/100mL)
1250
1000
750
500
250
0
2014
2015
2016
2017
2018
MO GEO LIMIT
MO GEO
DAILY MX LIMIT
DAILY MX


ST. PAUL WWTP (IN0020842) 001 - BOD, carbonaceous [5 day, 20 C] - Effluent Gross - Concentration
Late/Missing Reports Timeline
Concentration (mg/L)
0
20
40
60
80
2014
2015
2016
2017
2018
MO AVG LIMIT
MO AVG
MX WK AV LIMIT
MX WK AV

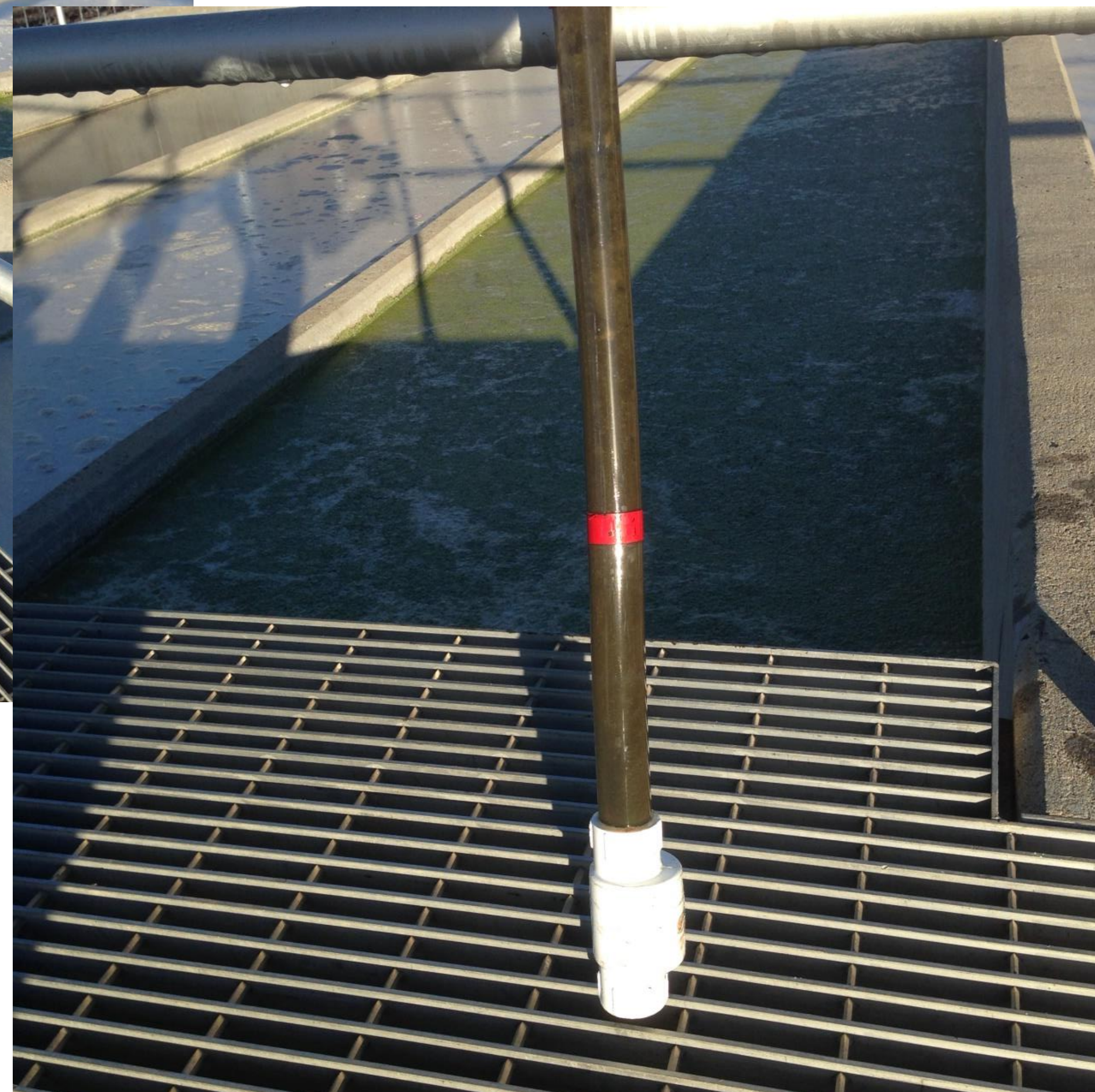
Late/Missing Reports Timeline



Late/Missing Reports Timeline



These accumulated Solids Can Affect Permit Results



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

The effluent structure is too close to the surface and pulls duckweed, scum, and litter into the CCC

The Effluent Structure with Three Feet of the Water Cap Drained

Steven M. Harris
H&S Environmental, LLC
www.lagoonops@gmail.com
www.lagoonops.com
1 (480) 274-8410

Case # 3

- The Cause of Odors, Popping

Oxygen Demand Comes from Several Different Sources in a Lagoon

Oxygen Demand comes from:

- Influent BOD_5
- The sediment layer
- Nitrification
- Algae Respiring at Night

City of XXXX Arizona

- Engineers Using Text Book Methods Determined there was Enough Aeration for the System = **_36,000 lbs. lbs O_2/day**

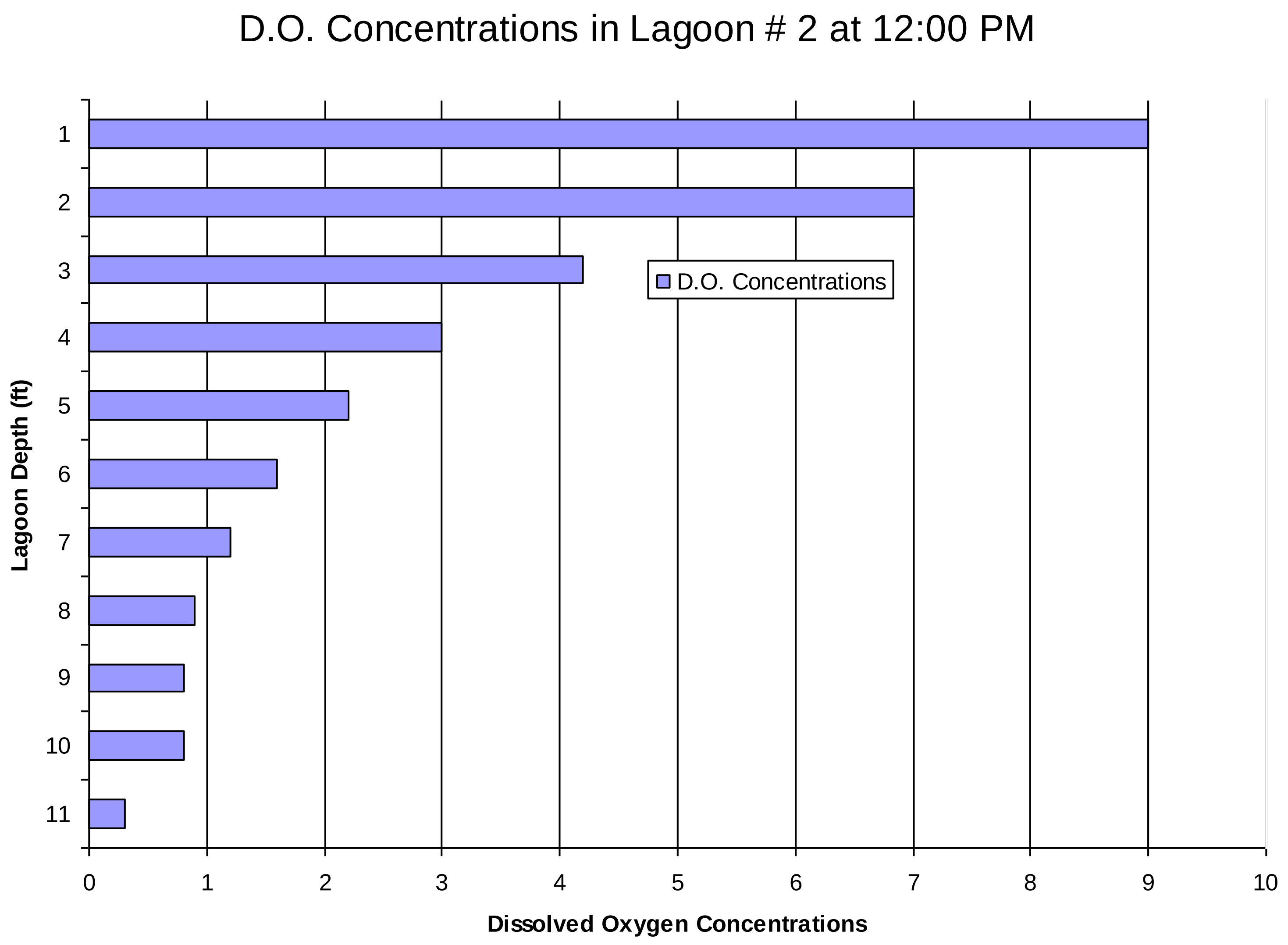
- D.O. Testing at Different times During the Day and Sediment O_2 Demand Calculations Showed a Total Demand of: **46,555 lbs O_2/day**

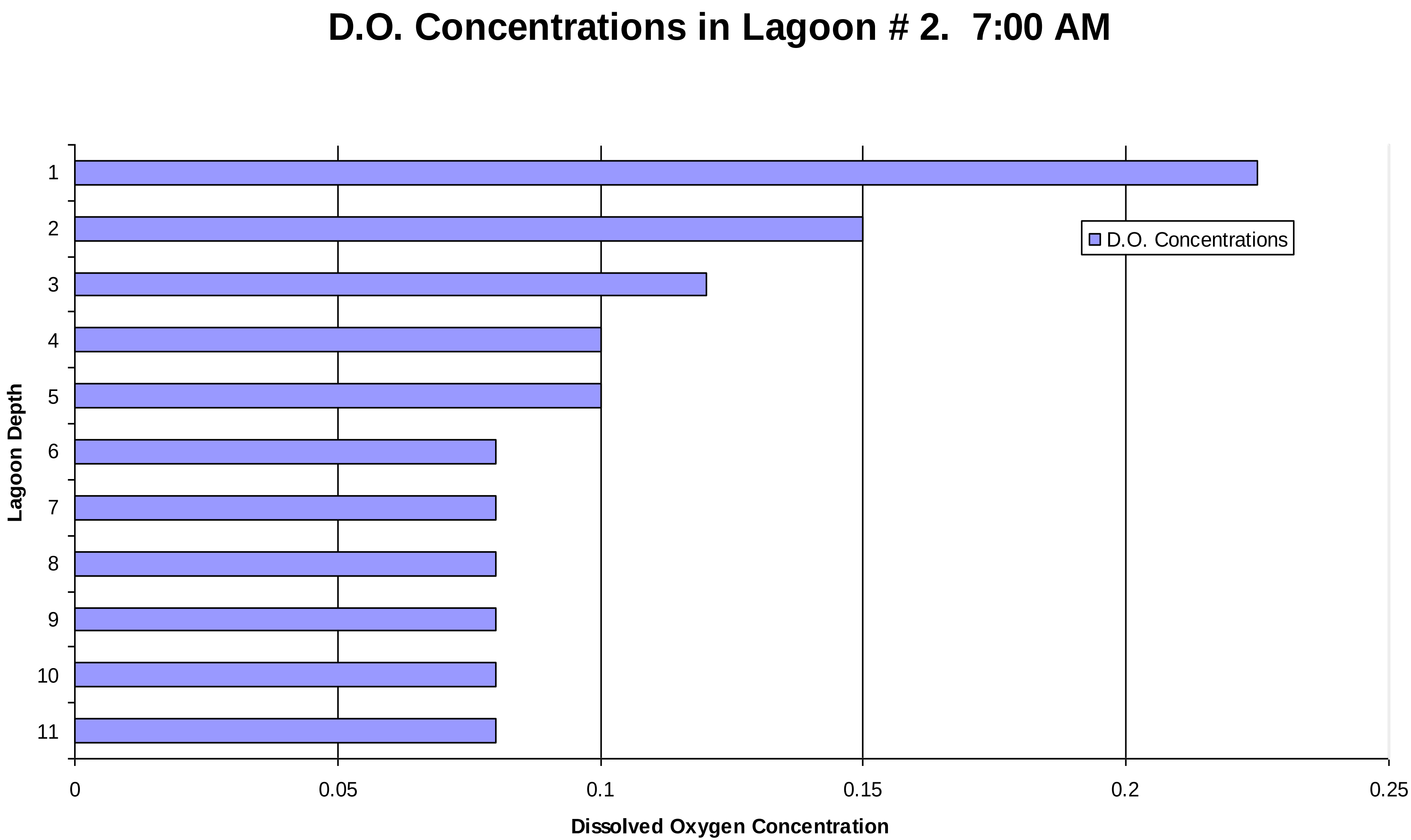
Xxxxx WWTF, xxxx, AZ

Rising “popping” sludge

- Rising Sludge
- Color Changes
- Odors

D.O. Profiles of the XXXXX Lagoon at Different Times During the Day




D.O. Concentrations in Lagoon # 2. 7:00 AM
D.O. Concentrations
Lagoon Depth
1
2
3
4
5
6
7
8
9
10
11
0
0.05
0.1
0.15
0.2
0.25
Dissolved Oxygen Concentration

Sedimen Oxygen Demand

Ro_2 in Kg O_2/hr = 4.16 x 10 $^{-5}$ ABo_2 where:

(Rich, 1999)

- Ro_2 = benthal oxygen demand rate in KgO_2/hr
- A = Area of sludge water interface in m^2
- Bo_2 = Unit rate of benthal oxygen demand in g $O_2/m^2/d$

Sediment O_2 demand in the City of Chandler, AZ was calculated to require an additional:

<u>12,929 lbs O_2/day</u>

If you put this sludge in a BOD bottle and ran a BOD_5, what do you think would happen?

Why would it be any different in your pond system?

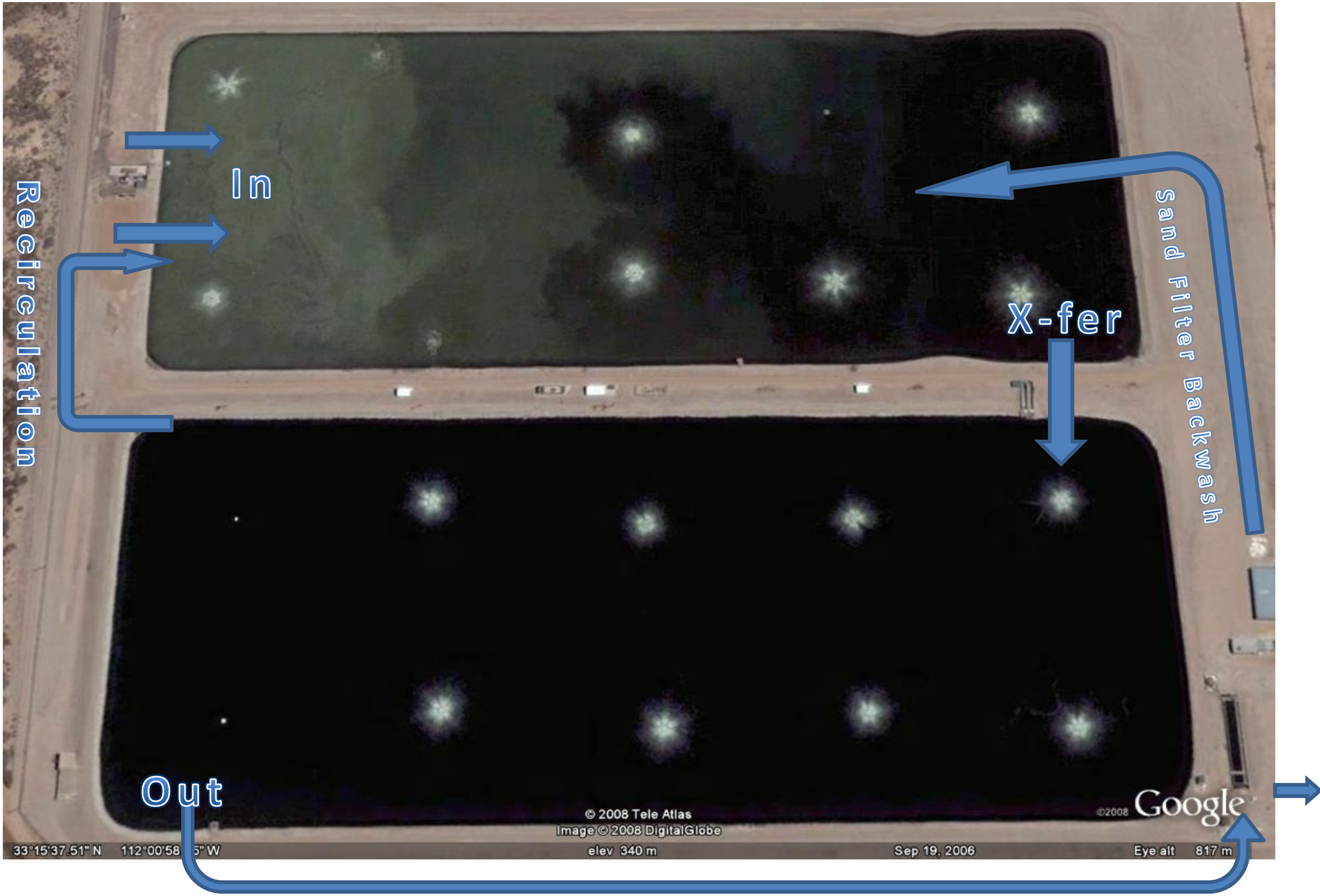
Older Less Efficient Aerators

Sludge Profiling Project

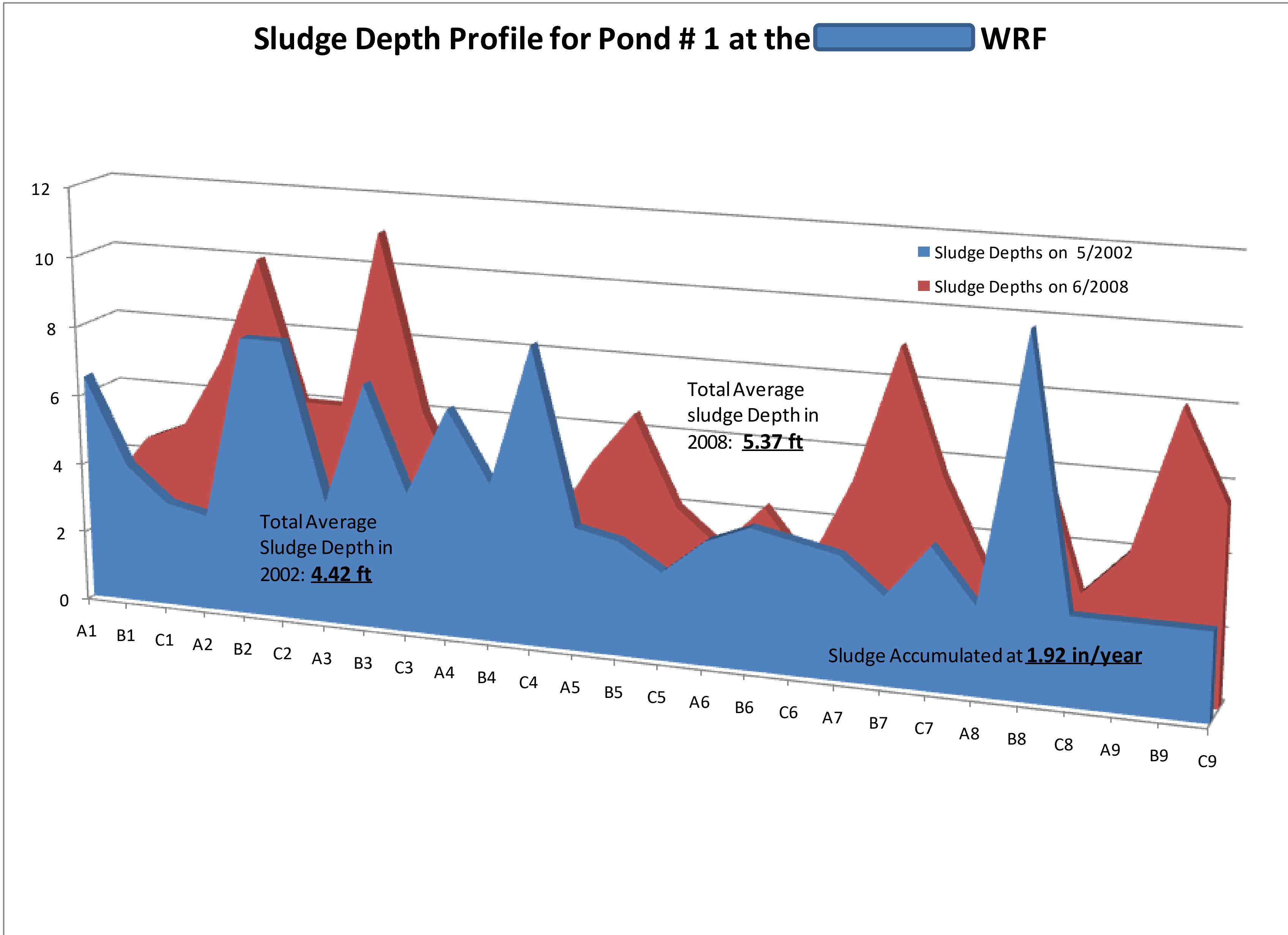
xxxxxx, AZ

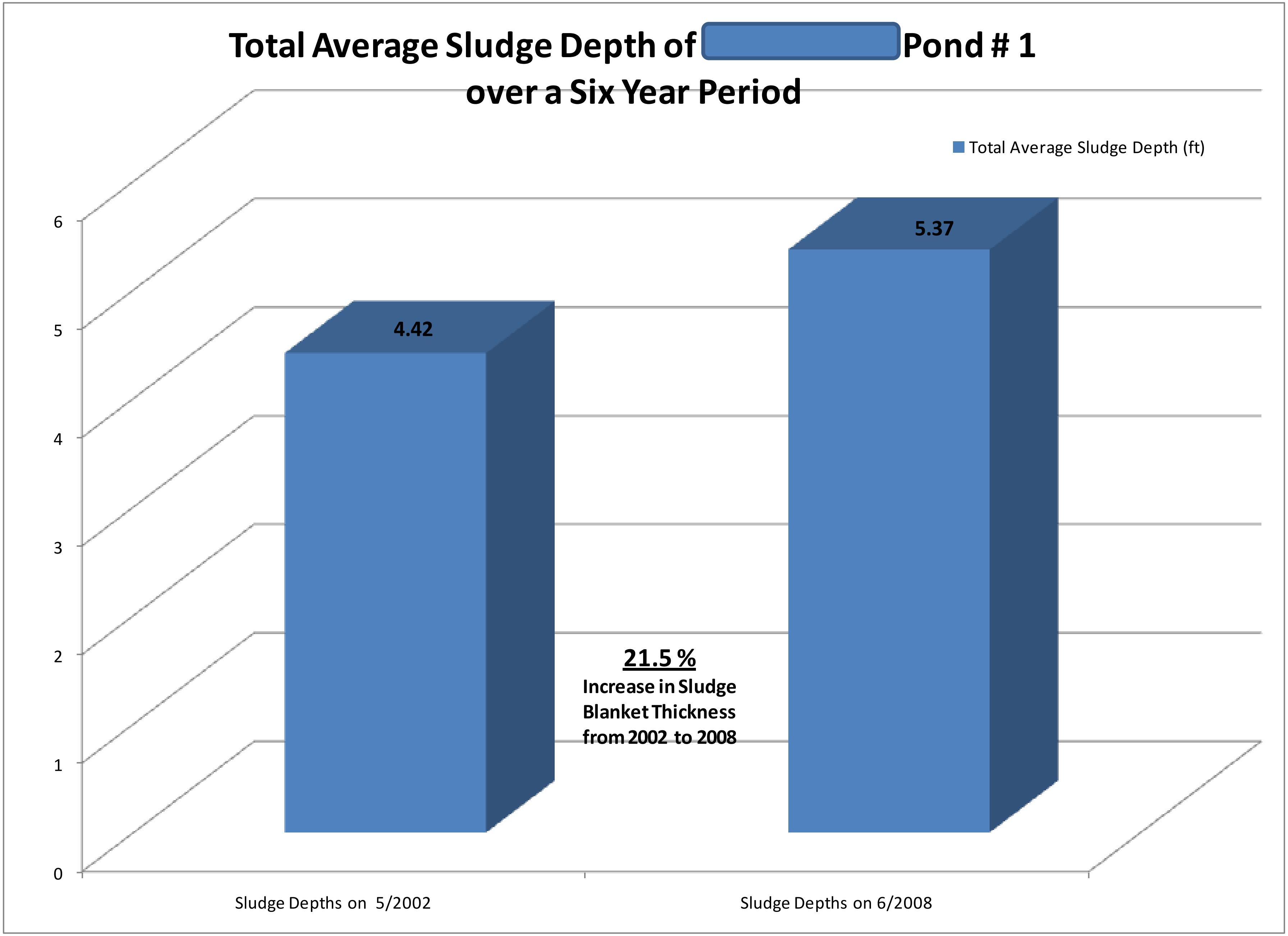
XXXXXX

- Average Daily Flow: 7 MGD
- Storage Capacity: Pond 1   84,235,092 gallons
  Pond 2   86,185,831 gallons
- Operating depth: 14 feet
- Theoretical Retention Time: 12 days each
- 16 splashing aerators 3 directional mixers and recirculation
- Water reused for crop irrigation and golf course
- Built in 1970's never desludged

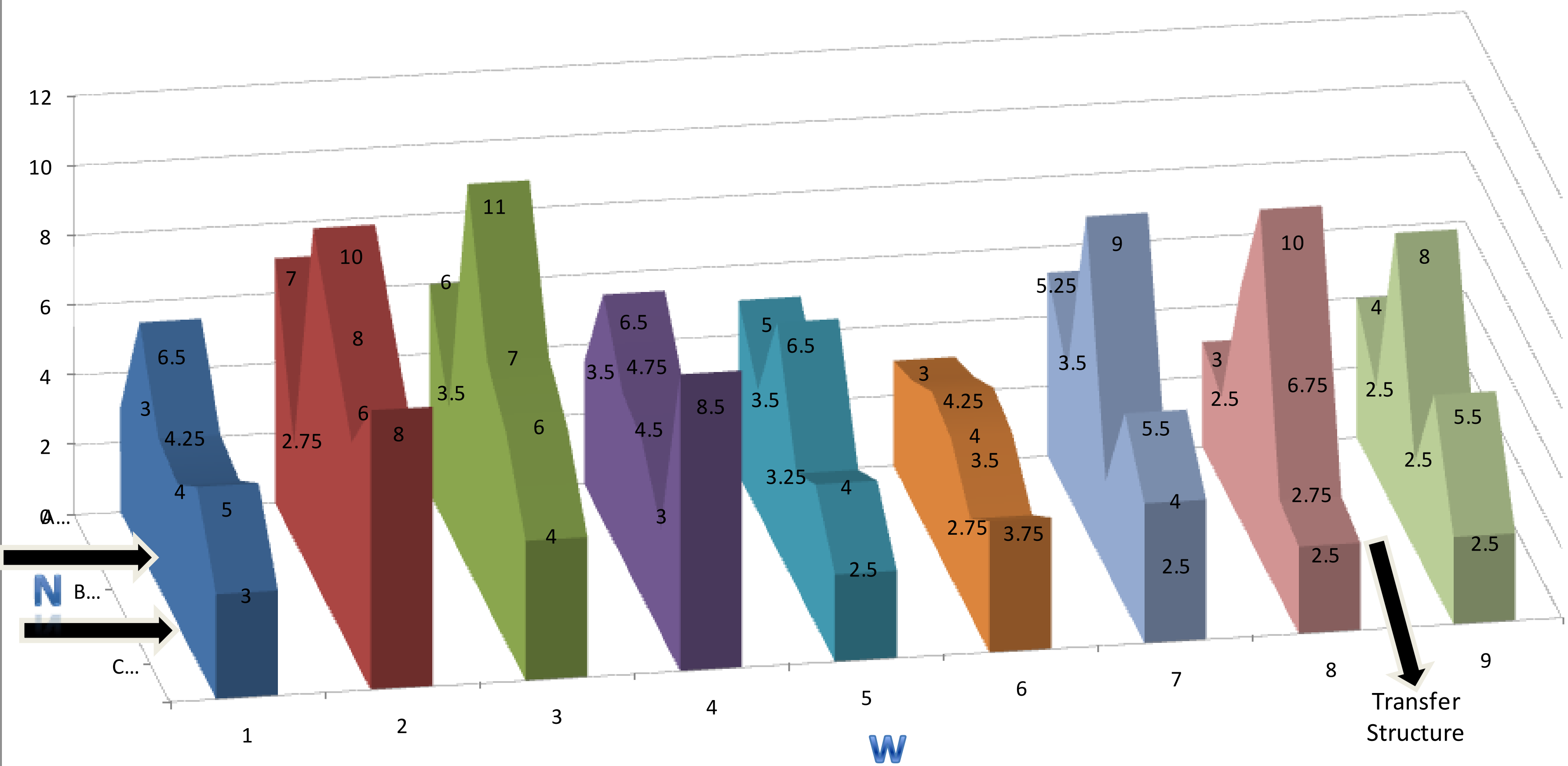

In
Recirculation
X-fer
Sand Filter Backwash
Out
© 2008 Tele Atlas
Image © 2008 DigitalGlobe
©2008 Google
33°15'37.51" N
elev 340 m
Sep 19, 2006
Eye alt 817 m

Profiling XXXXXXX
40 Sample Points / 20 Core Samples


Sludge Depth Profile for Pond # 1 at the [redacted] WRF
12
10
8
6
4
2
0
A1
B1
C1
A2
B2
C2
A3
B3
C3
A4
B4
C4
A5
B5
C5
A6
B6
C6
A7
B7
C7
A8
B8
C8
A9
B9
C9
Sludge Depths on 5/2002
Sludge Depths on 6/2008
Total Average sludge Depth in 2008: 5.37 ft
Total Average Sludge Depth in 2002: 4.42 ft
Sludge Accumulated at 1.92 in/year

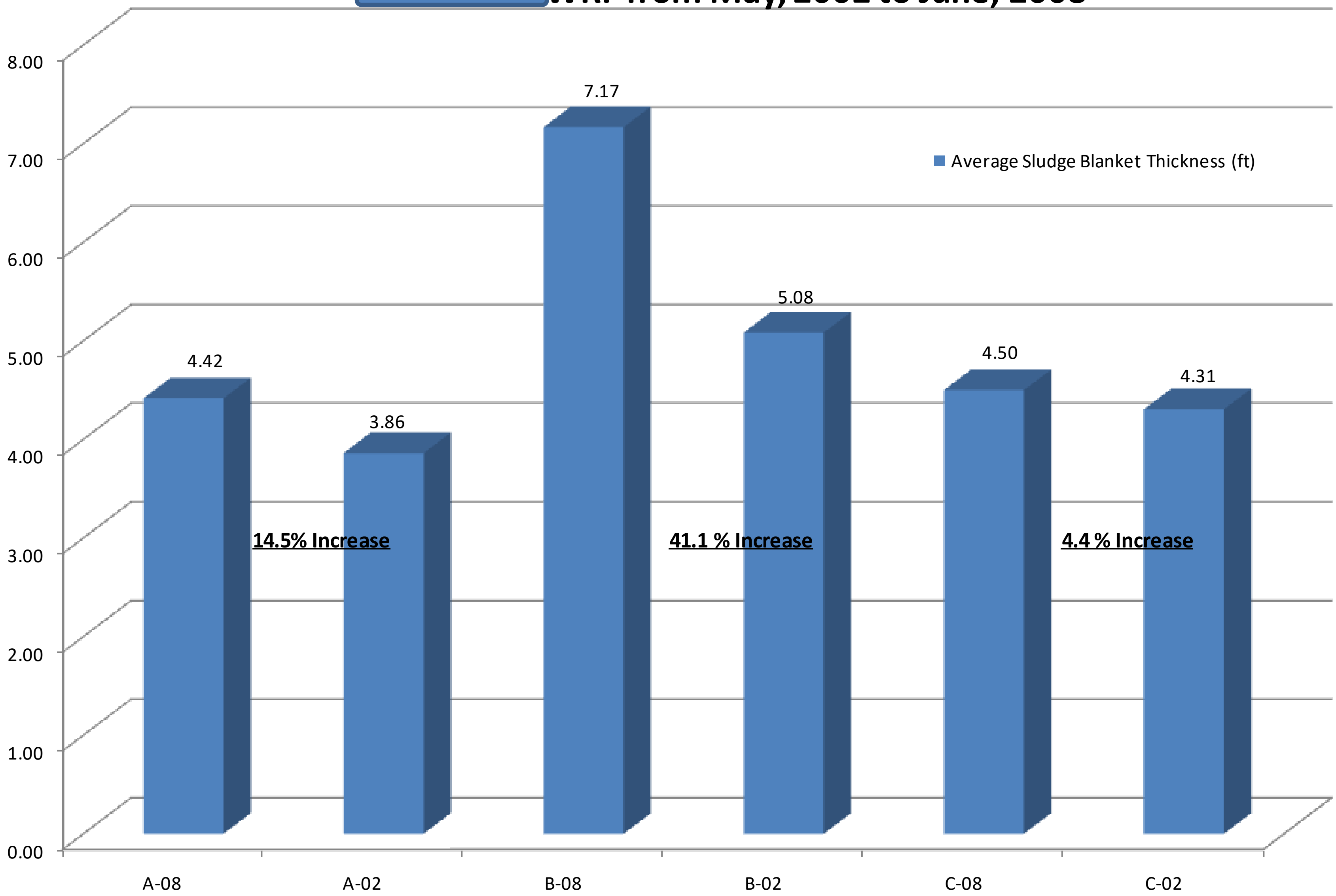

Total Average Sludge Depth of [redacted] Pond # 1
over a Six Year Period
Total Average Sludge Depth (ft)
6
5
4
3
2
1
0
4.42
5.37
21.5 %
Increase in Sludge
Blanket Thickness
from 2002 to 2008
Sludge Depths on 5/2002
Sludge Depths on 6/2008

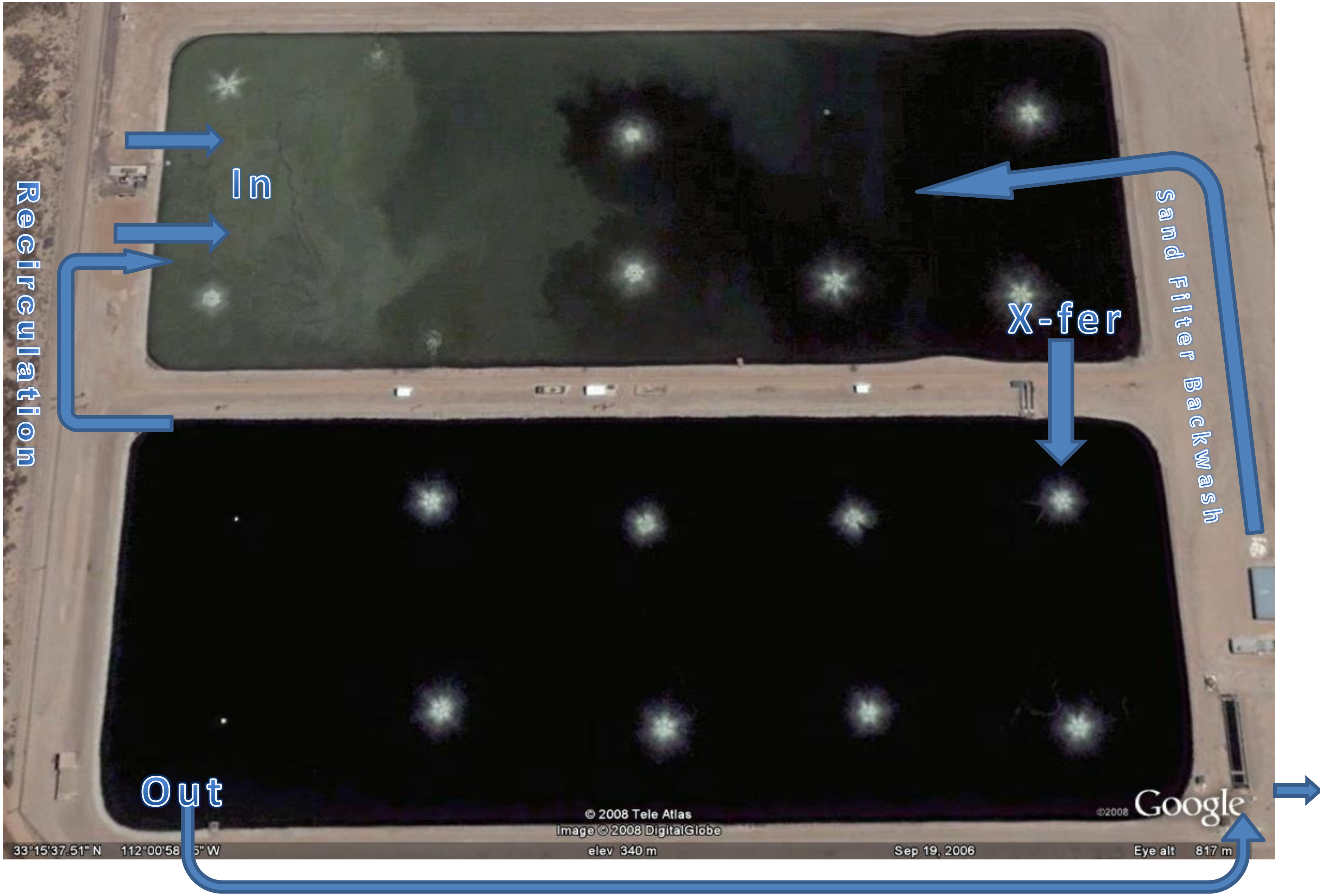
Pond # 1 Sludge Blanket Profile of the [redacted] Water Reclamation Facility



Sampled on June 12, 2008

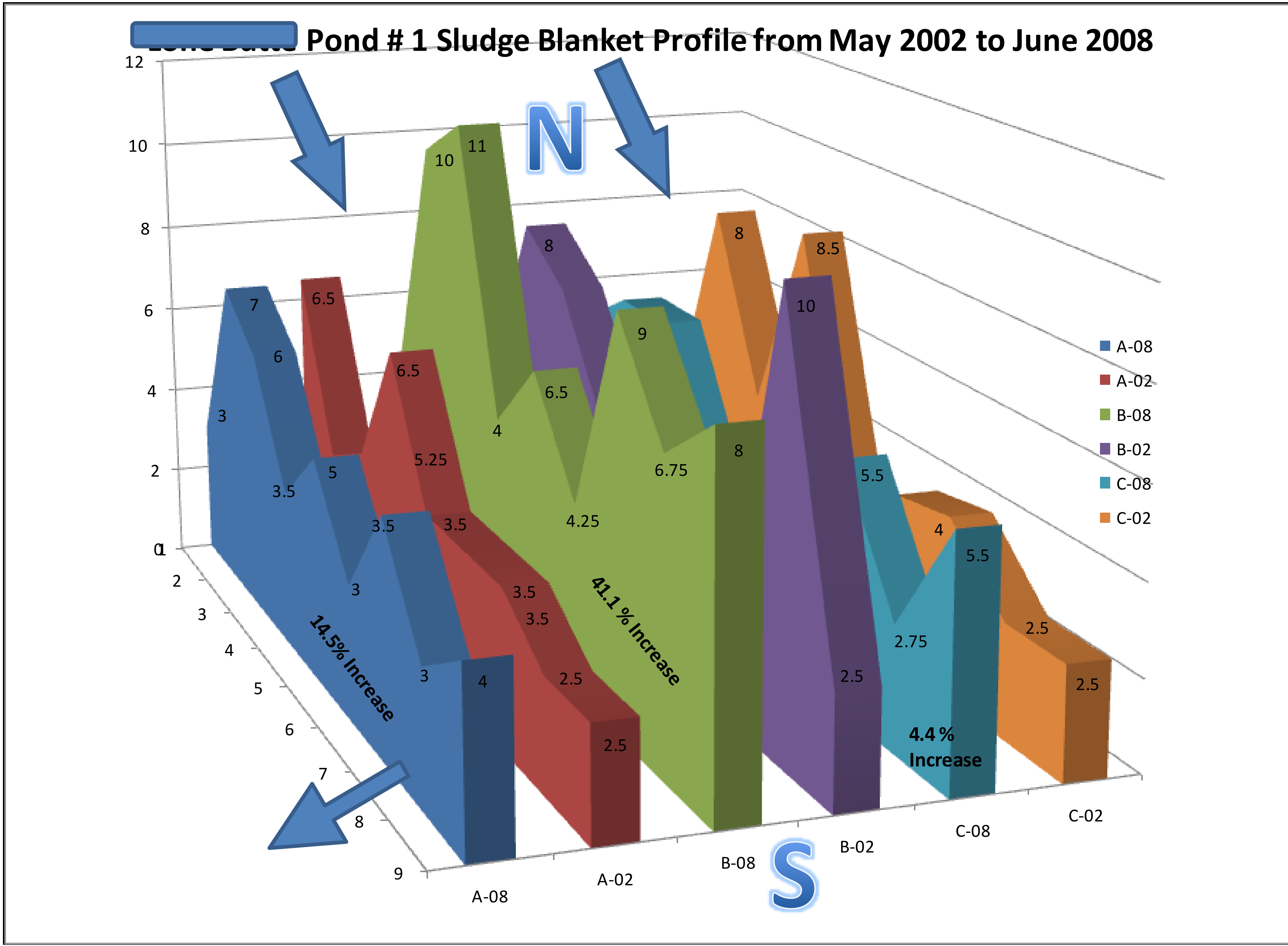
A Six Year Look at Sludge Blanket Thickness for Pond # 1 at [redacted] [redacted] WRF from May, 2002 to June, 2008

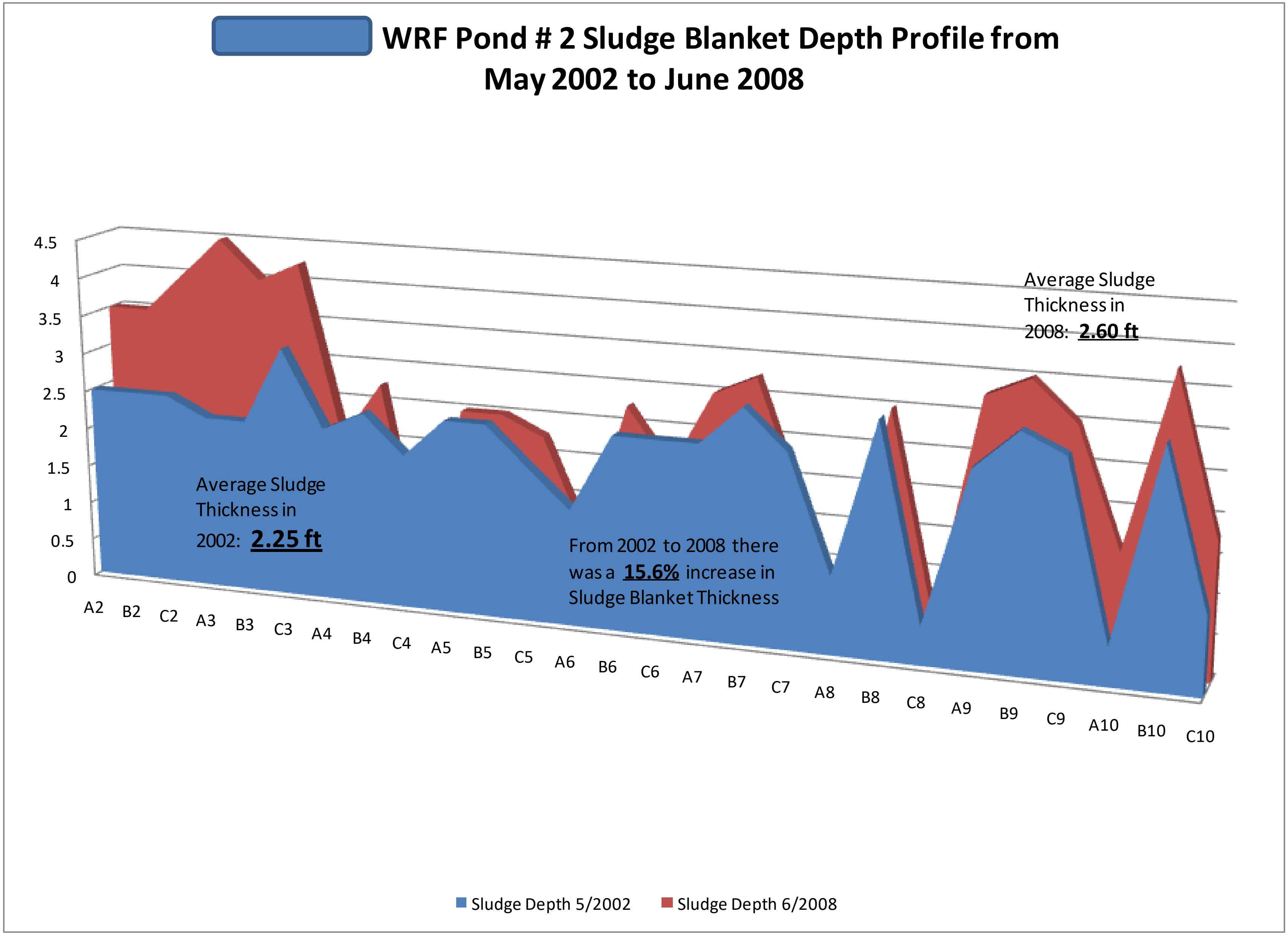


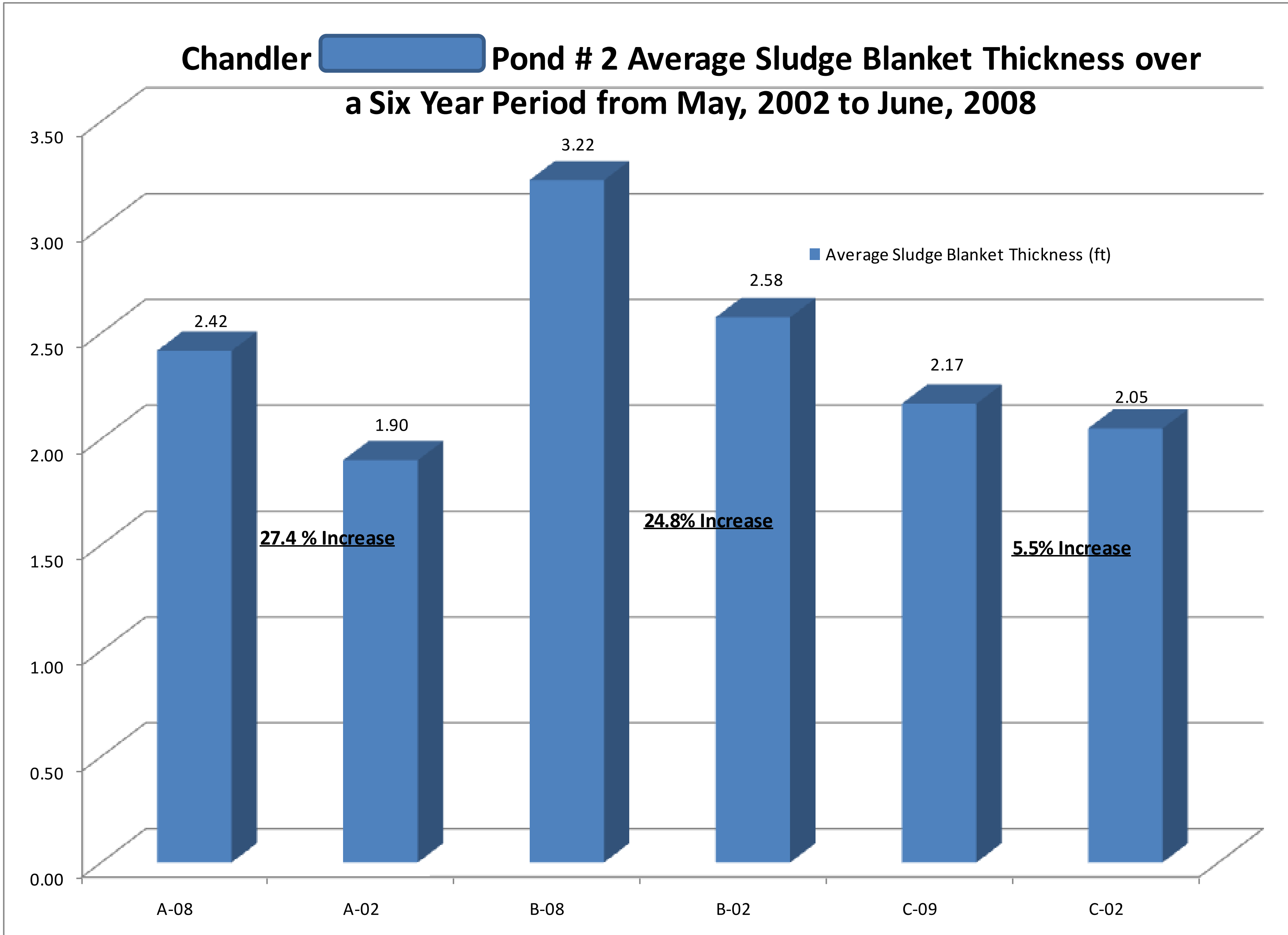


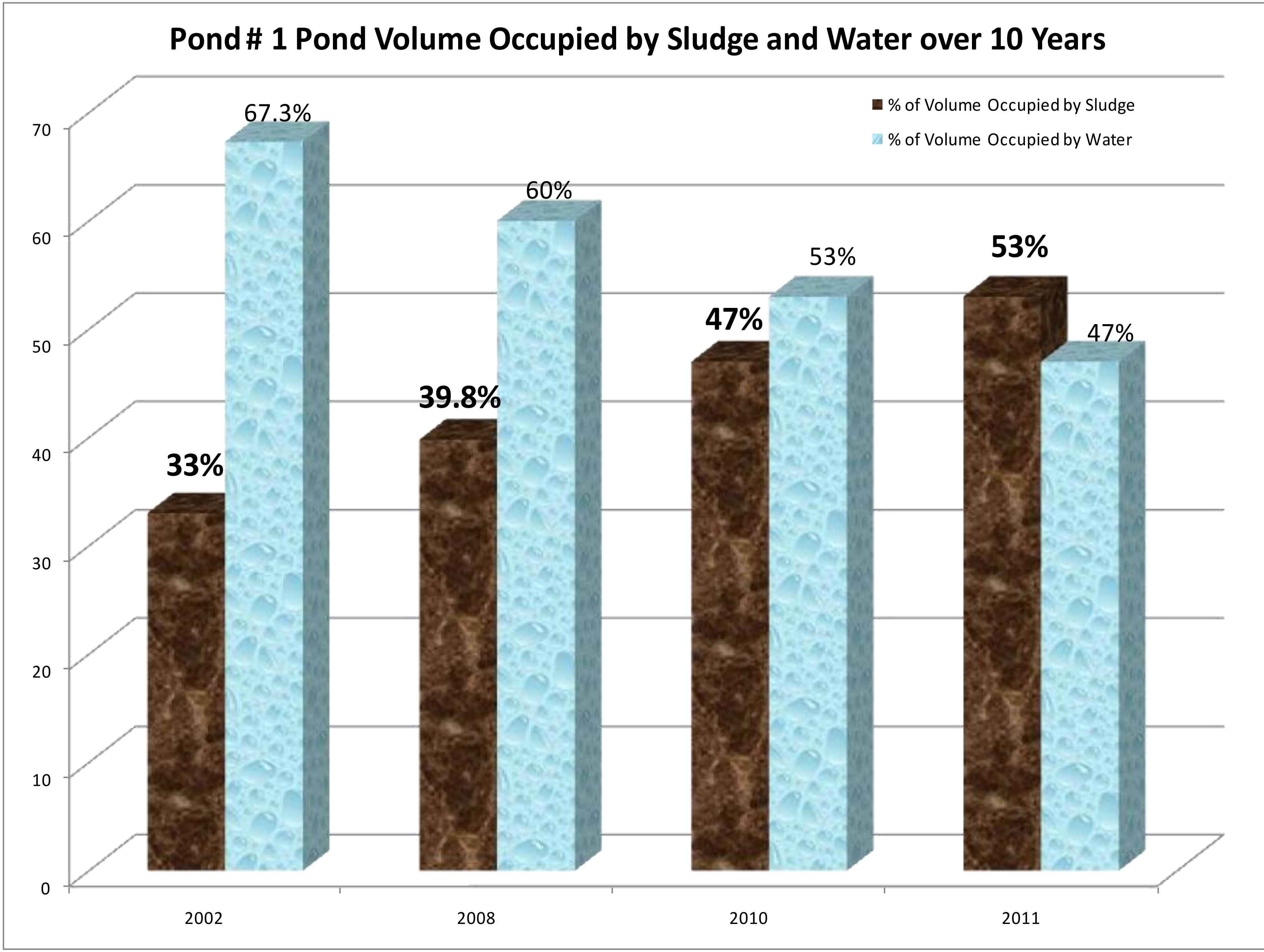
In
Recirculation
Sand Filter Backwash
X-fer
Out
© 2008 Tele Atlas
Image © 2008 DigitalGlobe
©2008 Google
33°15'37.51" N
elev 340 m
Sep 19, 2006
Eye alt 817 m

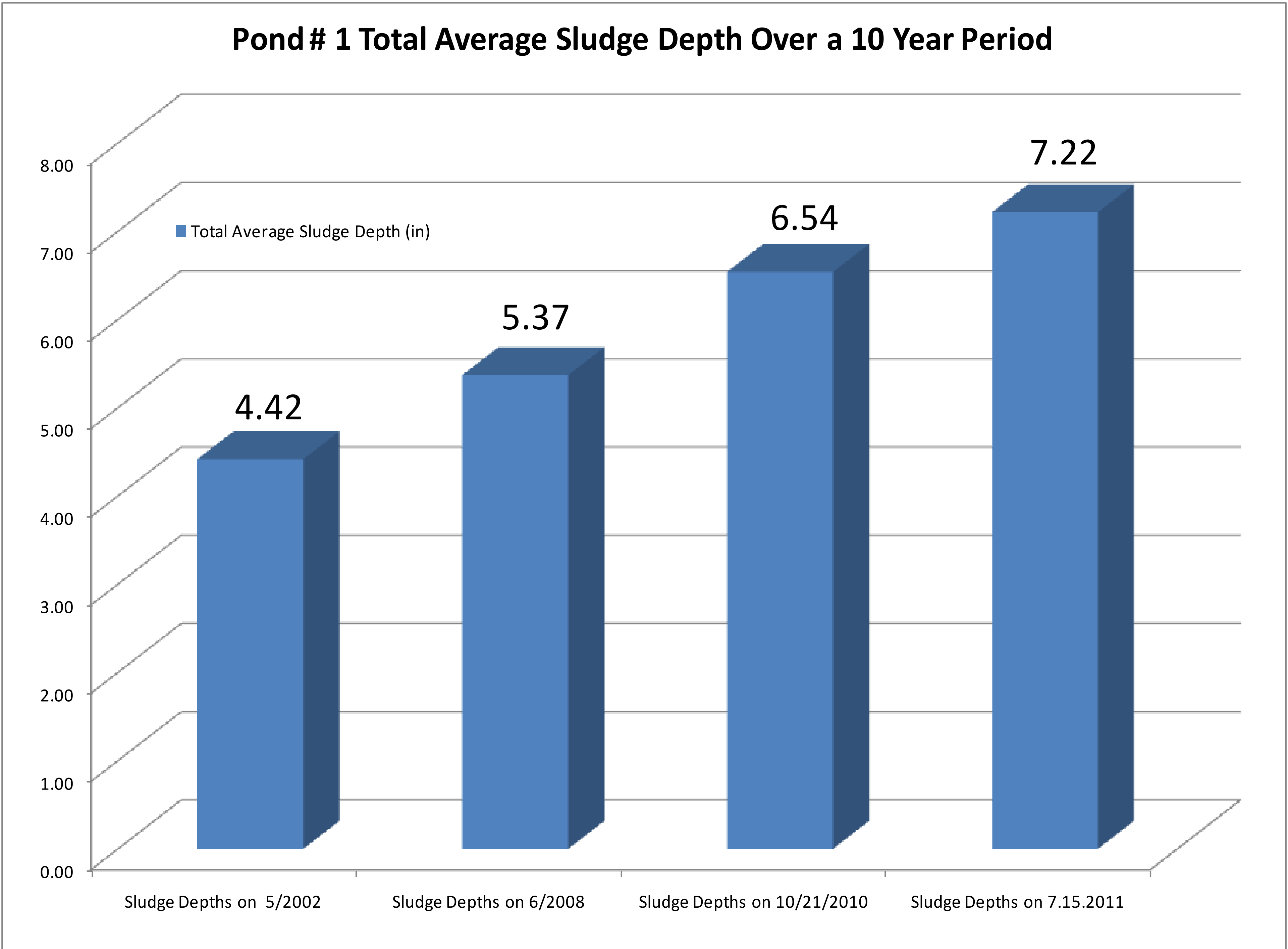
Backwash from the Dyna Sand filters and the Traveling Bridge Filter are backwashed back into the lagoon system

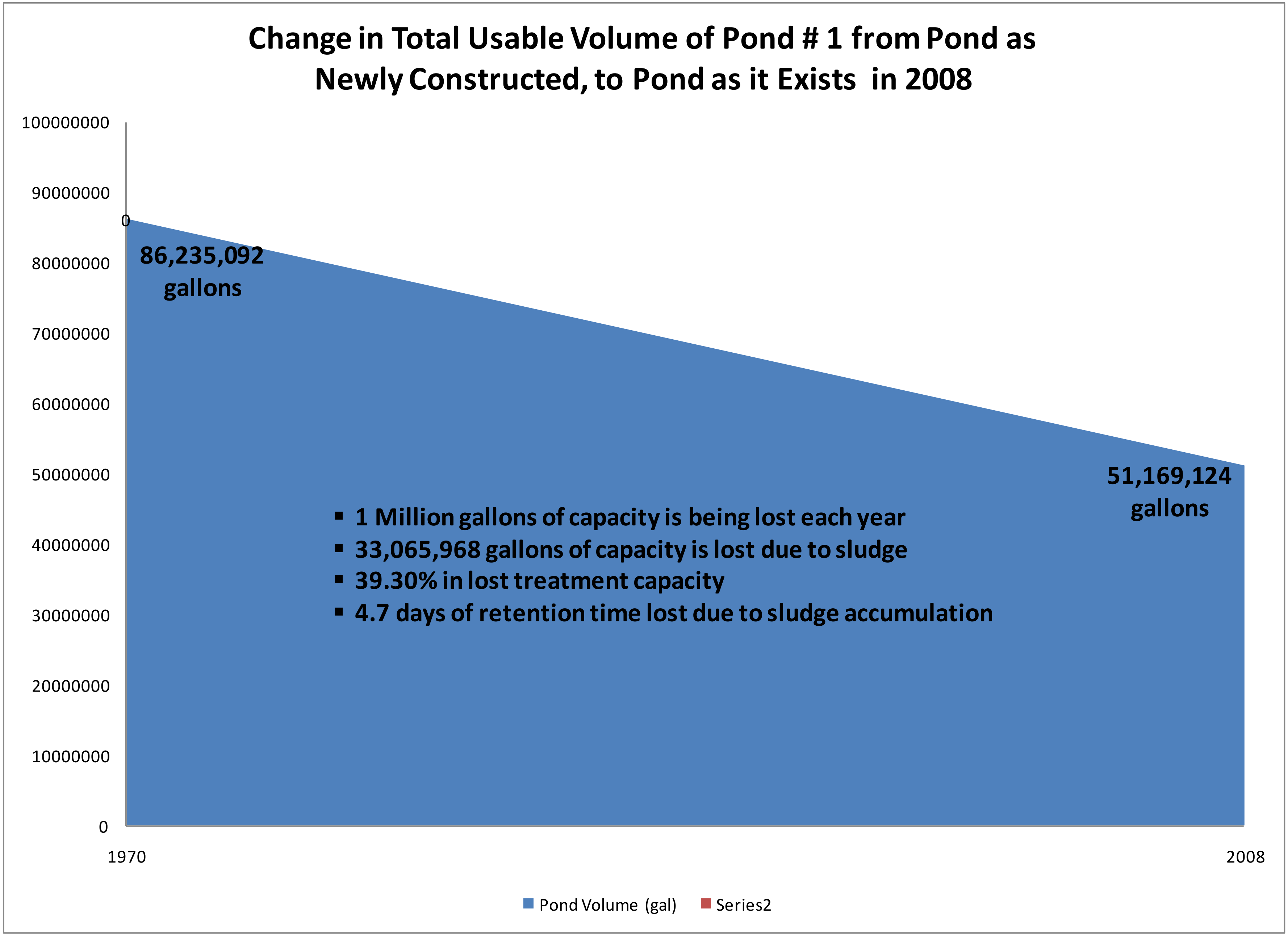

Pond # 1 Sludge Blanket Profile from May 2002 to June 2008
N
S
14.5% Increase
41.1 % Increase
4.4 % Increase
A-08
A-02
B-08
B-02
C-08
C-02
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
7
6
3
3.5
5
3.5
3
3
4
6.5
6.5
5.25
3.5
3.5
3.5
2.5
2.5
10
11
4
6.5
4.25
9
6.75
8
8
10
2.5
8
8.5
5.5
2.75
4
5.5
2.5
2.5


WRF Pond # 2 Sludge Blanket Depth Profile from May 2002 to June 2008
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
A2 B2 C2 A3 B3 C3 A4 B4 C4 A5 B5 C5 A6 B6 C6 A7 B7 C7 A8 B8 C8 A9 B9 C9 A10 B10 C10
Average Sludge Thickness in 2002: 2.25 ft
Average Sludge Thickness in 2008: 2.60 ft
From 2002 to 2008 there was a 15.6% increase in Sludge Blanket Thickness
Sludge Depth 5/2002
Sludge Depth 6/2008

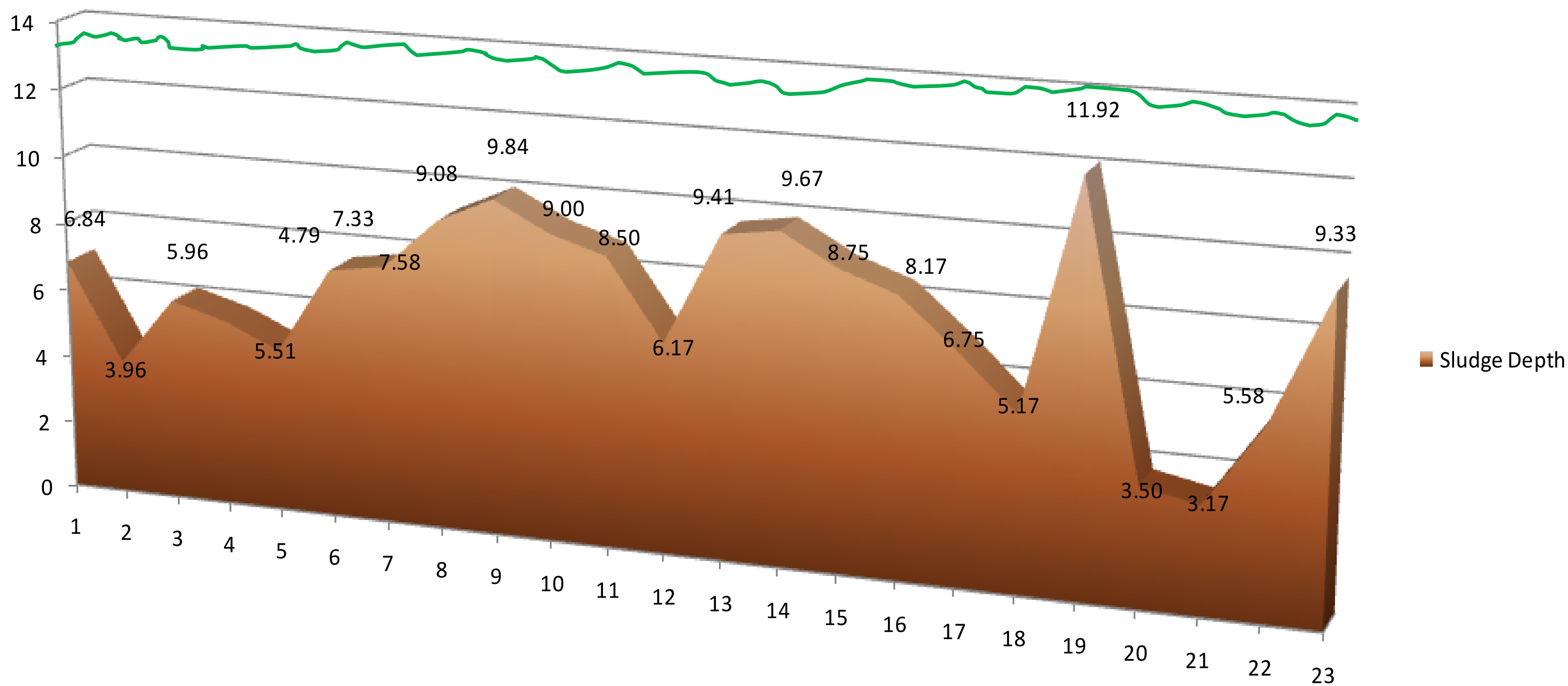

Chandler
Pond # 2 Average Sludge Blanket Thickness over a Six Year Period from May, 2002 to June, 2008
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.42
1.90
3.22
2.58
2.17
2.05
Average Sludge Blanket Thickness (ft)
27.4 % Increase
24.8% Increase
5.5% Increase
A-08
A-02
B-08
B-02
C-09
C-02


Pond # 1 Pond Volume Occupied by Sludge and Water over 10 Years
% of Volume Occupied by Sludge
% of Volume Occupied by Water
70
60
50
40
30
20
10
0
67.3%
60%
53%
53%
47%
47%
39.8%
33%
2002
2008
2010
2011


Pond # 1 Total Average Sludge Depth Over a 10 Year Period
Total Average Sludge Depth (in)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
4.42
5.37
6.54
7.22
Sludge Depths on 5/2002
Sludge Depths on 6/2008
Sludge Depths on 10/21/2010
Sludge Depths on 7.15.2011


Change in Total Usable Volume of Pond # 1 from Pond as Newly Constructed, to Pond as it Exists in 2008
100000000
90000000
80000000
70000000
60000000
50000000
40000000
30000000
20000000
10000000
0
0
86,235,092 gallons
51,169,124 gallons
1 Million gallons of capacity is being lost each year
33,065,968 gallons of capacity is lost due to sludge
39.30% in lost treatment capacity
4.7 days of retention time lost due to sludge accumulation
1970
2008
Pond Volume (gal)
Series2

Pond # 1 Sludge Depth Profile taken on 7.15.2011



Average Water Depth: 13.6 feet
Average Sludge Depth: 7.22 feet
Pond Volume Occupied by Sludge: 53%

Sludge at 14 Ft. on 9/28/2012

Why is loss of retention time so important to the effluent quality of lagoons?

“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

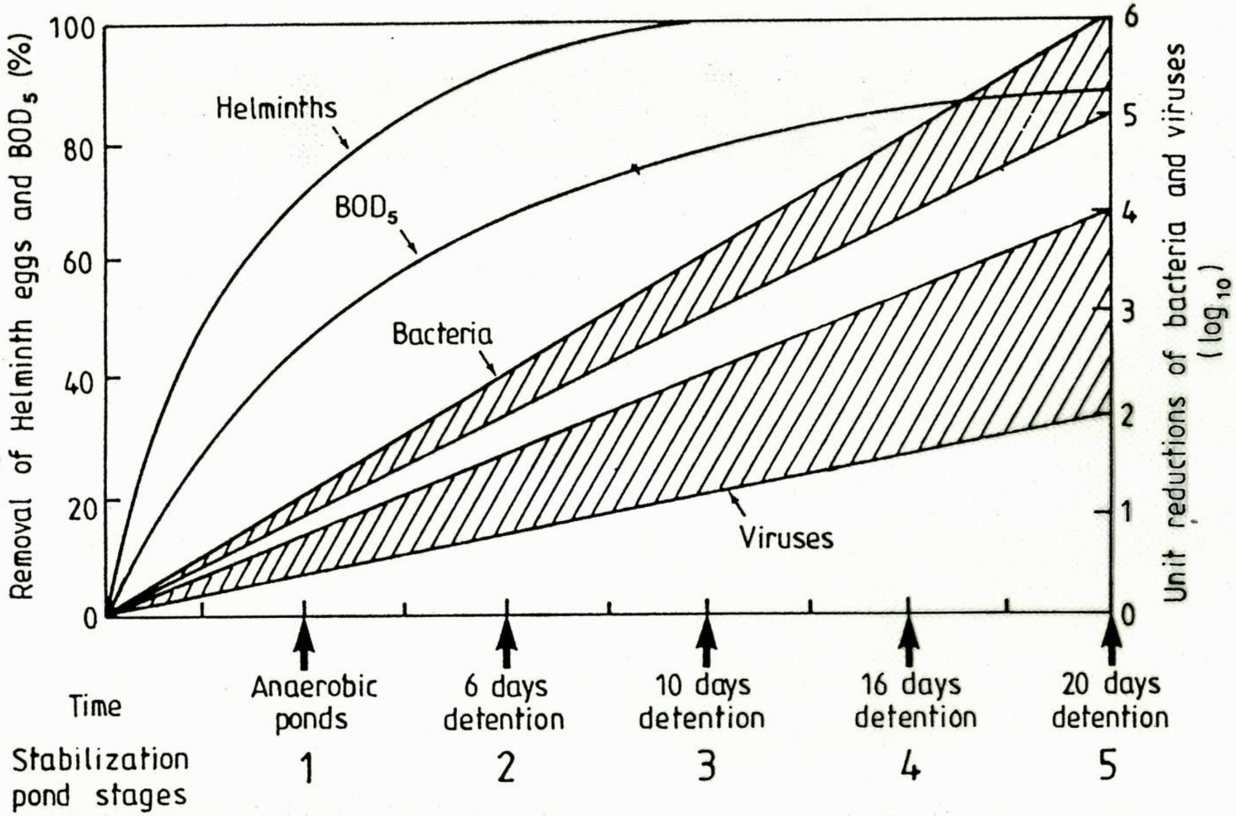


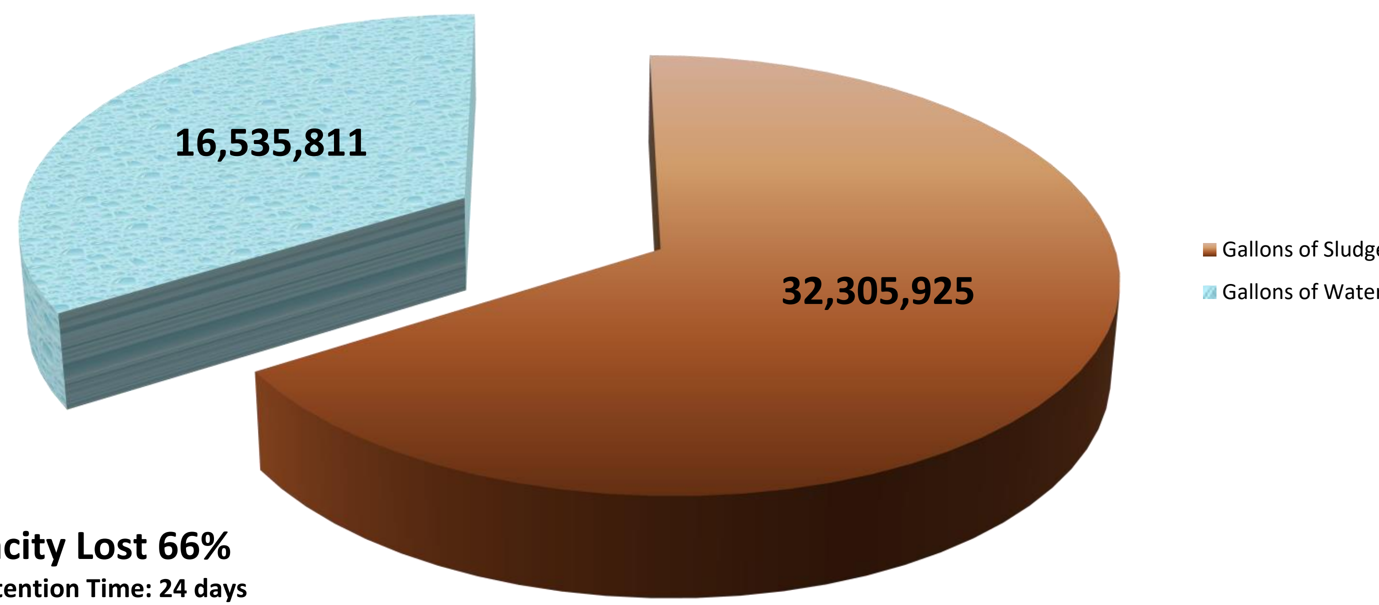
Figure 10.2 Generalised curve for the removal of organic material and excreted pathogens across a waste stabilisation series, for temperatures in excess of 20 °C. (From *IRCWD News*, **23**, 1985. Reproduced by permission of the International Reference Centre for Waste Disposal.)

Hydraulic retention time in a pond is critical because it effects the following:

- 1. Nitrogen removal
- 2. Pathogen destruction and inactivation
- 3. Algae growth
- 4. BOD/COD removal

Capacity Reduction / Days Lost

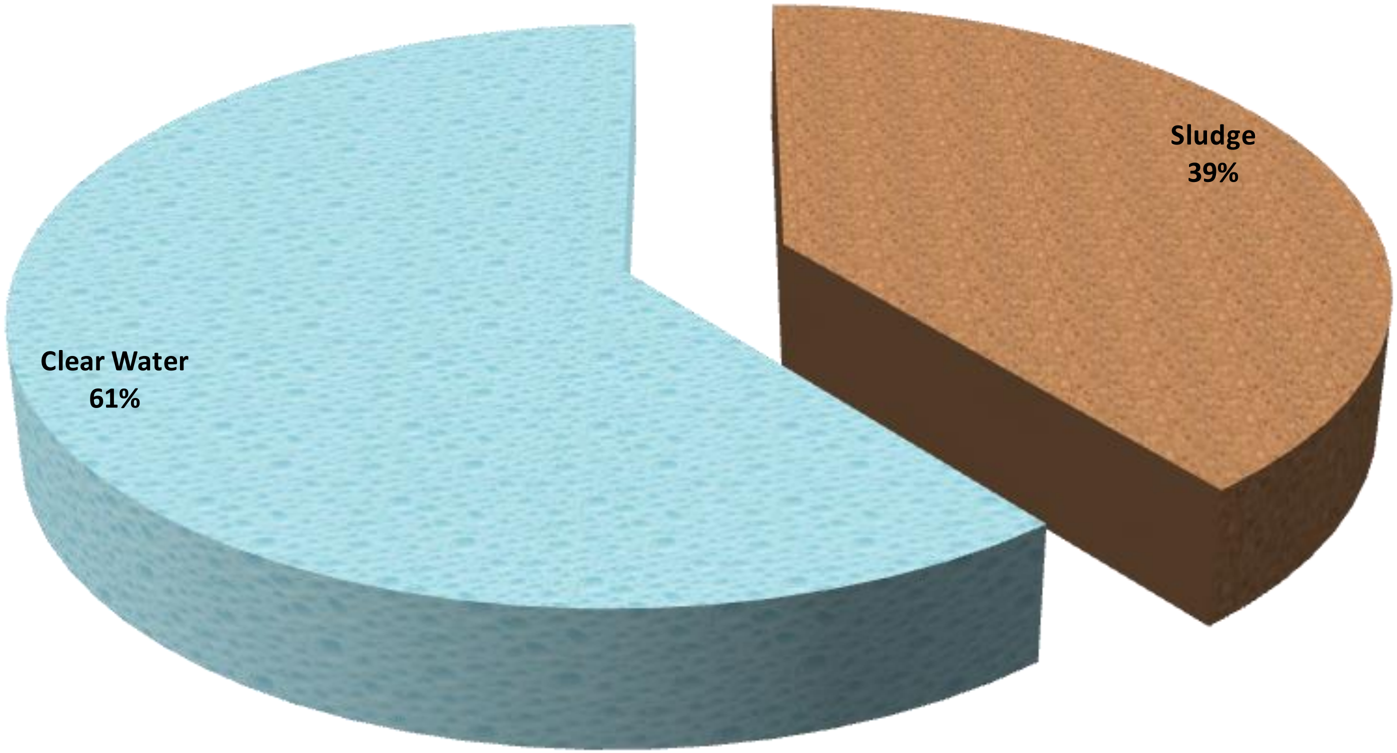
Treatment Capacity Displaced by Sludge in Cell # 1 of the
Wastewater Stabilization Pond System



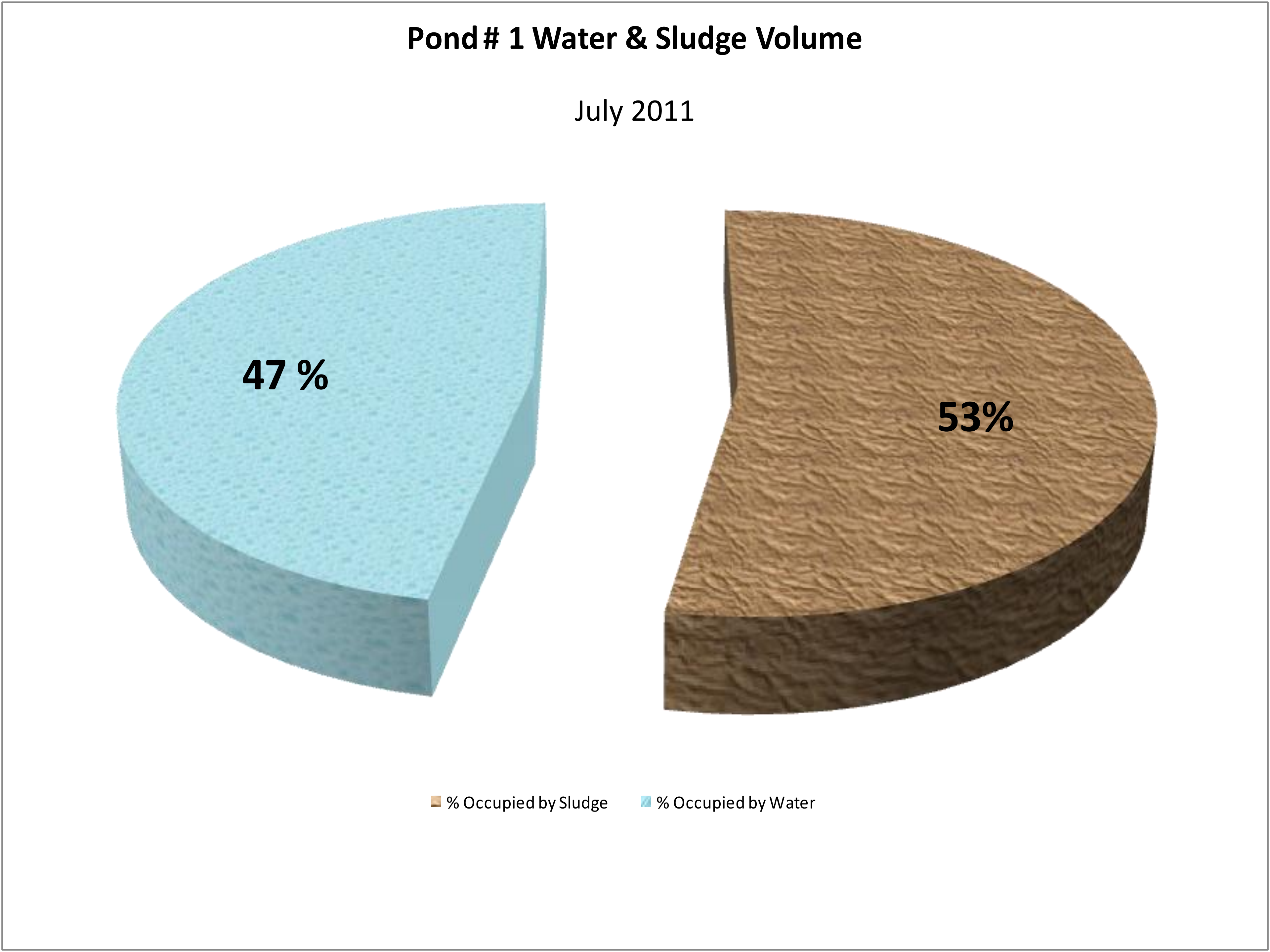
Capacity Lost 66%

Old Retention Time: 24 days
New Retention Time 8.27 days
Average Water Depth: **6 feet**
Average Sludge Depth: **3.966 feet**
Volume of Sludge: **32,305,925 gallons**
Estimated Mass of Sludge: **10,104** dry tons
Date Profiled: July 20, 2011

Capacity in Pond # 1 as of 6/12/2008

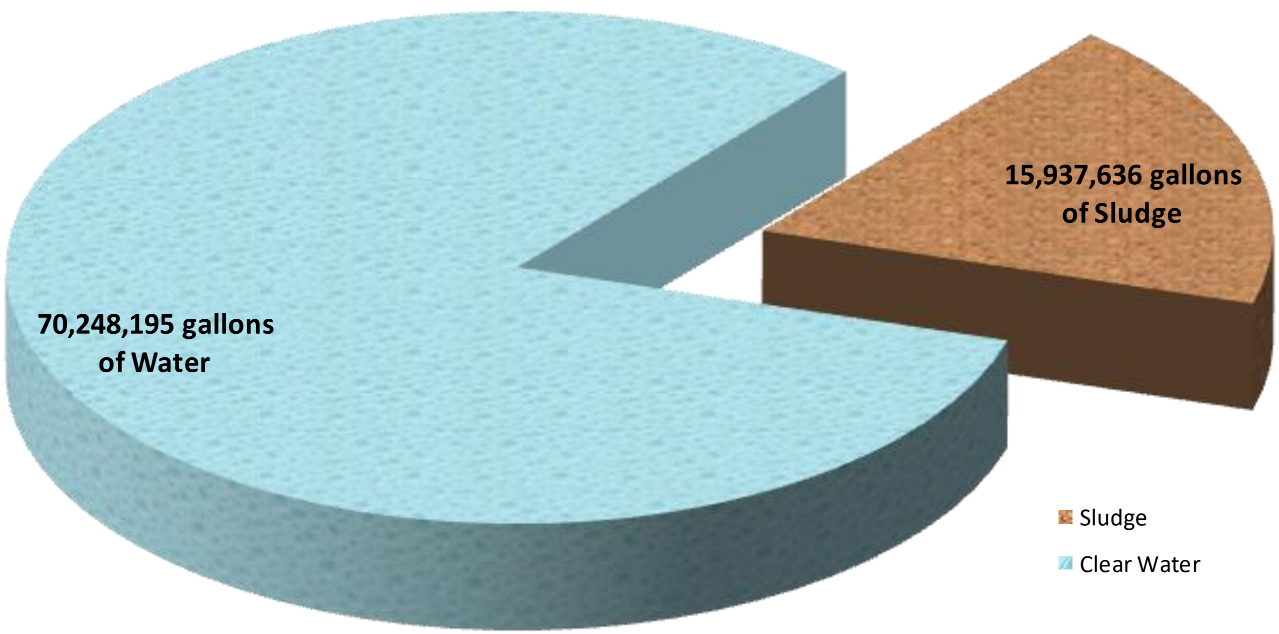


- 1 Million gallons of capacity is being lost each year
- 33,065,968 gallons of capacity is lost due to sludge
- 39.30% in lost treatment capacity
- 4.7 days of retention time lost due to sludge accumulation

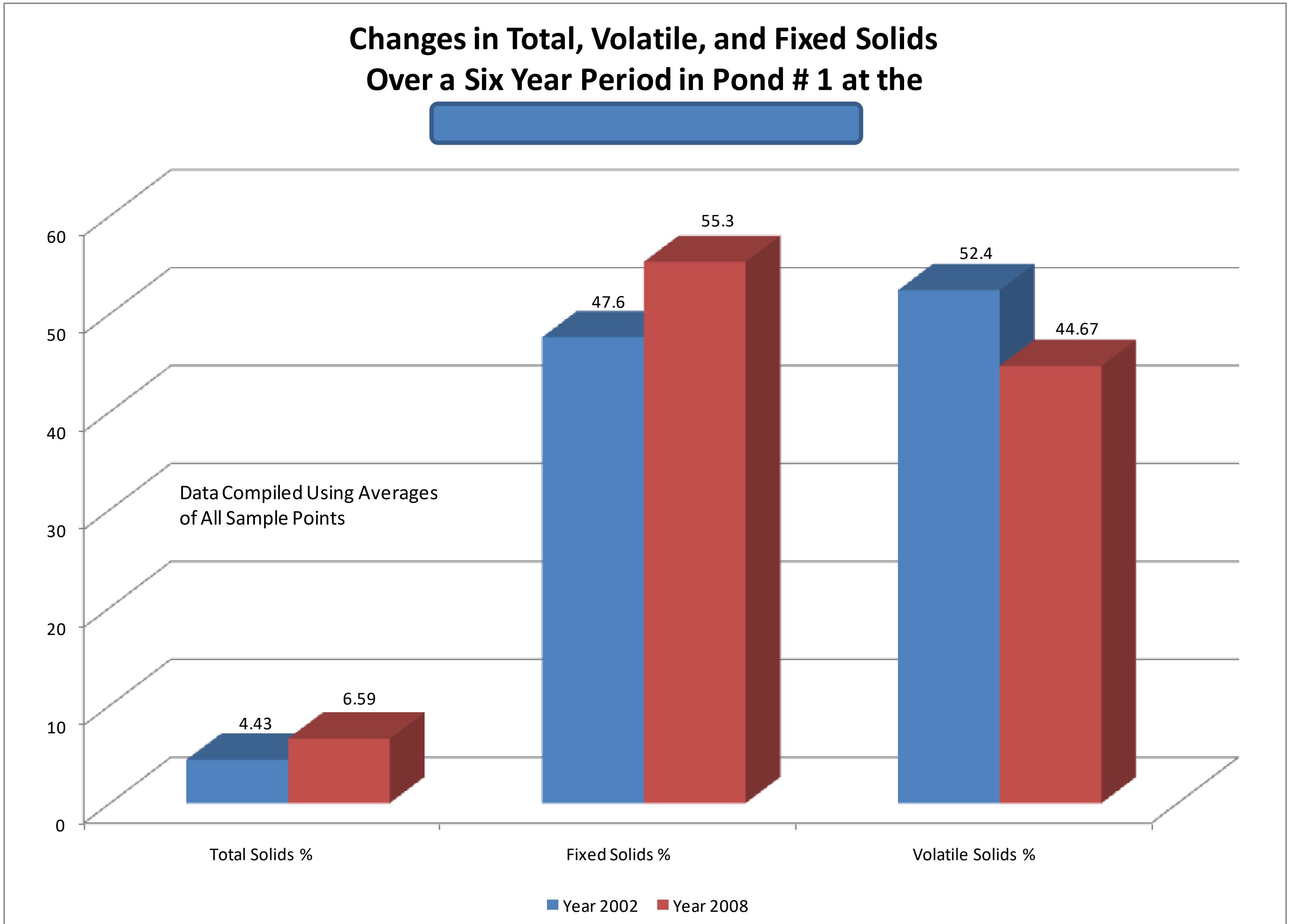

Pond # 1 Water & Sludge Volume
July 2011
47 %
53%
% Occupied by Sludge
% Occupied by Water

Current Capacity in Pond # 2

- Pond volume lost to sludge: 18.50%
- Sludge has displaced .35 million gallons of capacity each year
- Pond # 2 has lost 2 days of retention time since it came on line



Adding and Moving Aerators Helps Destroy Volatile Solids



- On the average, suspended sediments (mixed sediments) consume as much as 4.96 mg O_2/day which is 900 times more than unmixed sediments.

- As sediments are mixed, respiration rates can increase by 300 times (D.Chabir, 2000).

Summary

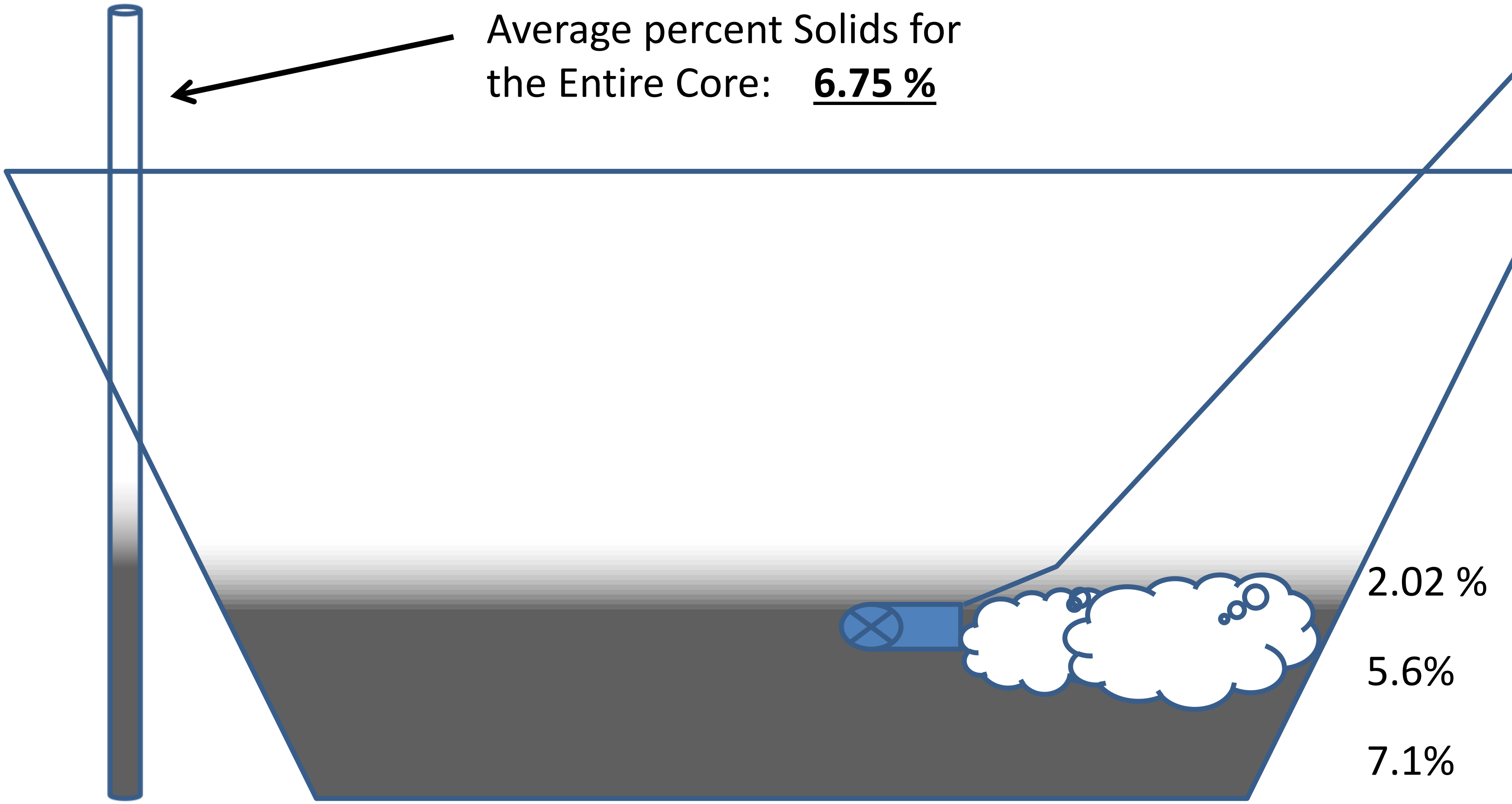
Pond # 1	May-02	Jun-08	Net Increase	Net Decrease from 2002 to 2008	Overall Decrease
Tons of Dry Solids	4,679	8,098	3419 dry tons		
Average Sludge Depth (ft)	4.42	5.37	.95 ft		
Average Total Solids (%)	5.9	6.25	0.35%		
Total Pond Volume with No Sludge	84,235,092 gal.	84,235,092 gal.	0.00%	0.00%	
Useable Pond Volume	57,018,783 gal.	51,169,124 gal.		5,849,659 gal.	
Pond Volume Lost to Sludge	27,215,309 gal	33,065,968 gal			33,065,968 gal. volume lost
% Pond Volume Lost to Sludge	32.30%	39.30%		7.00%	39.30%
Theoretical Retention Time No Sludge	12 days	12 days			1 million gallons of capacity is lost each year
Retention Time with Sludge	8.14 days	7.3 days		.84 days	4.7 days

Pond # 2	May-02	Jun-08			
Tons of Dry Solids	1551	2511	960 dry tons		
Average Sludge Depth (ft)	2.25	2.6	.35 ft		
Average Total Solids (%)	2.6	3.66	1%		
Total Pond Volume with No Sludge	86,185,831 gal	86,185,831 gal	0%		
Useable Pond Volume	72,393,646 gal	70,248,195 gal		2,145,451 gal	
Pond Volume Lost to Sludge	13792185 gal	15,937,636 gal.		2,145,451 gal.	15,937,636 gal
% Pond Volume Lost to Sludge	16%	18.5%		2.50%	18.50%
Theoretical Retention Time No Sludge	12.3 days	12.3 days			.35 million gallons of capacity is lost each year
Retention Time with Sludge	10.04 days	10.3 days		.26 days	2 days

Solids Concentration Changes with Changing Sludge Depths

40 Sample Points / 20 Core Samples

Solids Concentration Changes with Changing Sludge Depths

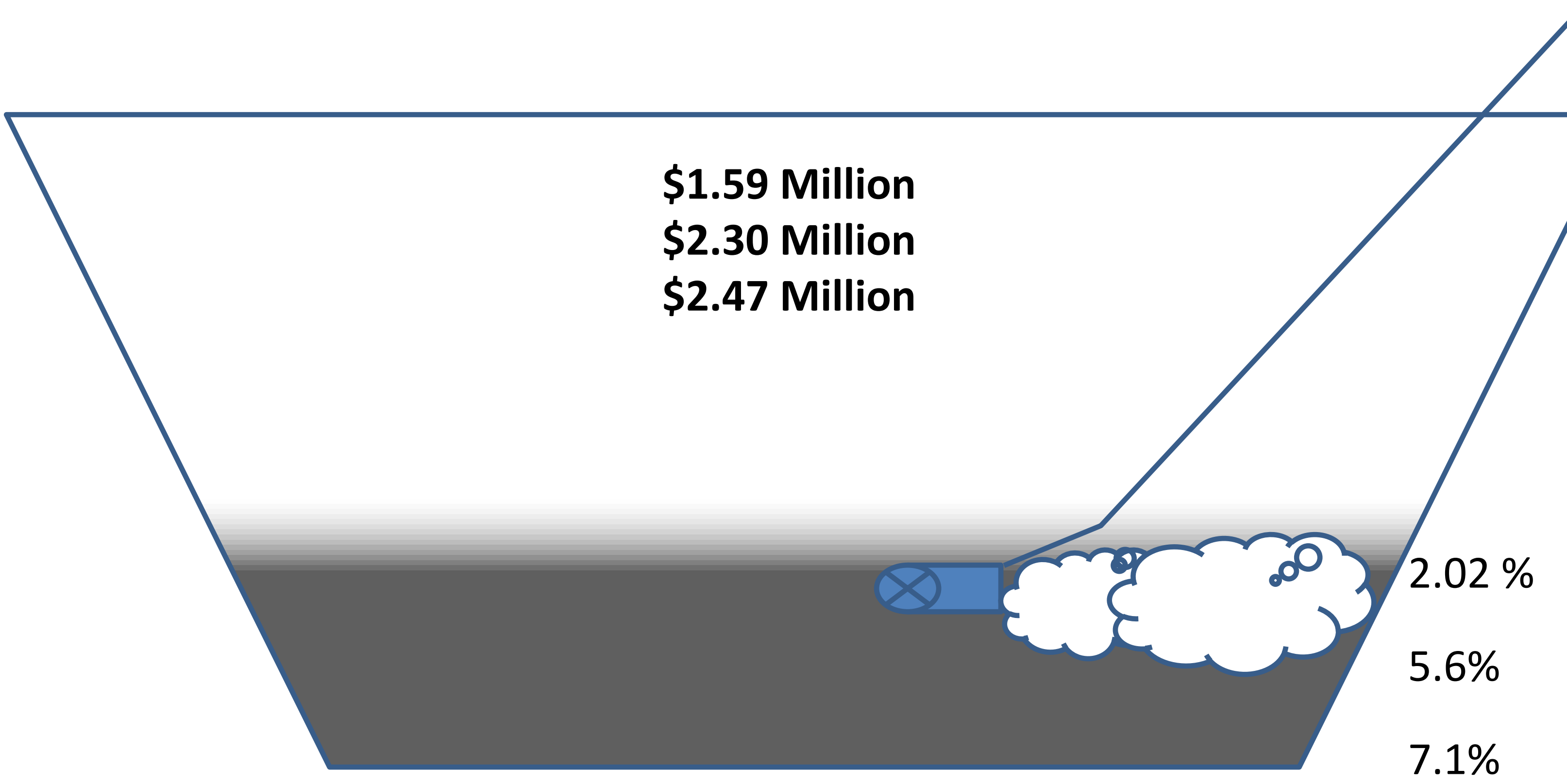


Solids Concentration Changes with Changing Sludge Depths

1470’ x 560’ x 5.5’ sludge x 7.48 gal/ft^3 x 8.34 lbs/gal x .045 % solids x 1/2000 = **<u>6,355 dry tons</u>**

1470’ x 560’ x 5.5’ sludge x 7.48 gal/ft^3 x 8.34 lbs/gal x .065 % solids x 1/2000 = **<u>9,179 dry tons</u>**

1470’ x 560’ x 5.5’ sludge x 7.48 gal/ft^3 x 8.34 lbs/gal x .070 % solids x 1/2000 = **<u>9,886 dry tons</u>**



Questions to Think About

- What if you are paying by the gallon for sludge removal and the dredge does not move fast enough?
- What if you are paying by time and the dredge does not move fast enough?
- What if you are paying by the job and the dredge only get the upper 50 to 60% of the sludge blanket?