2022 West Virginia Mine Drainage Task Force Symposium
Morgantown, West Virginia
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10+ Year Passive Treatment System Performance Evaluation

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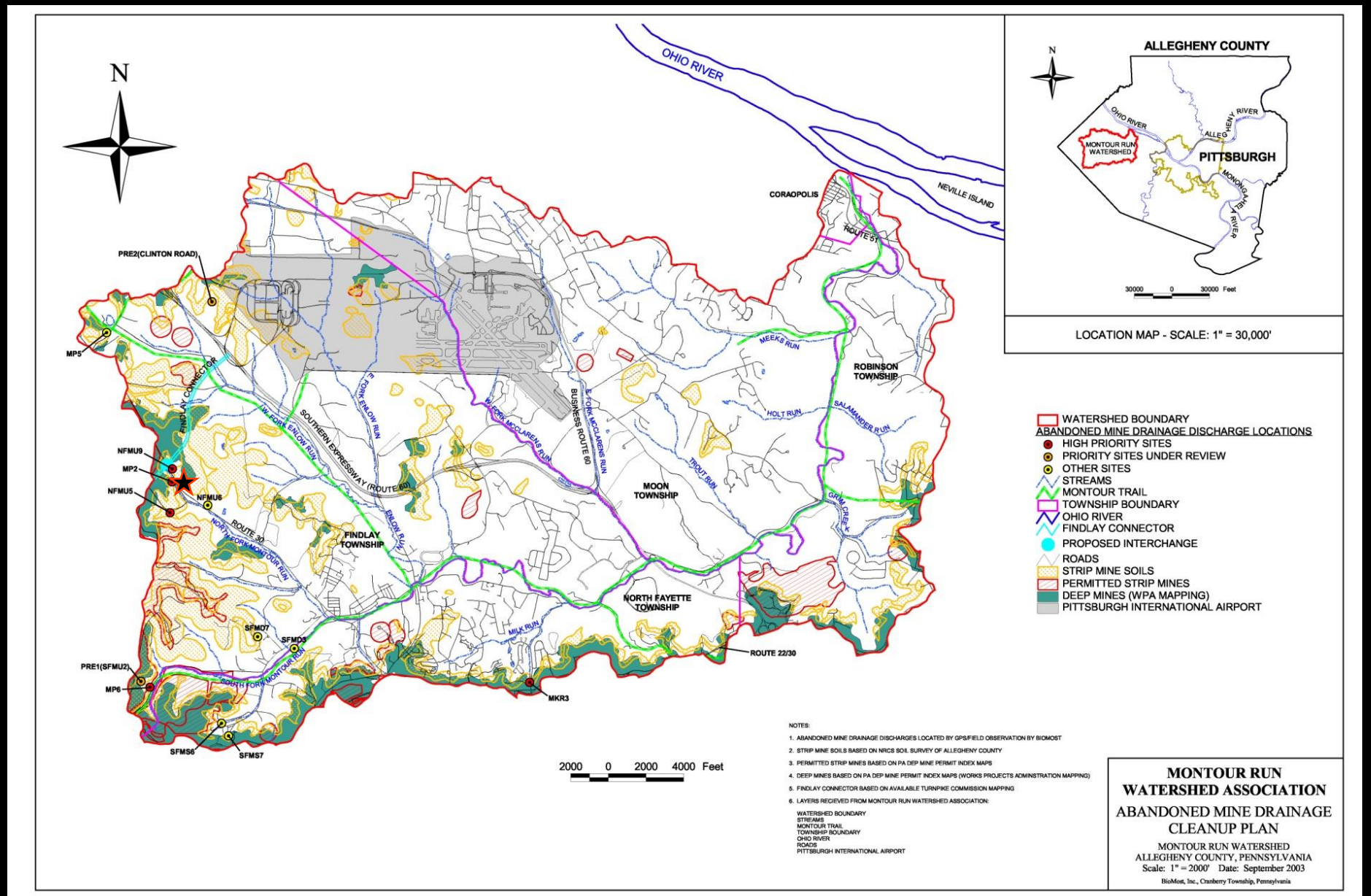
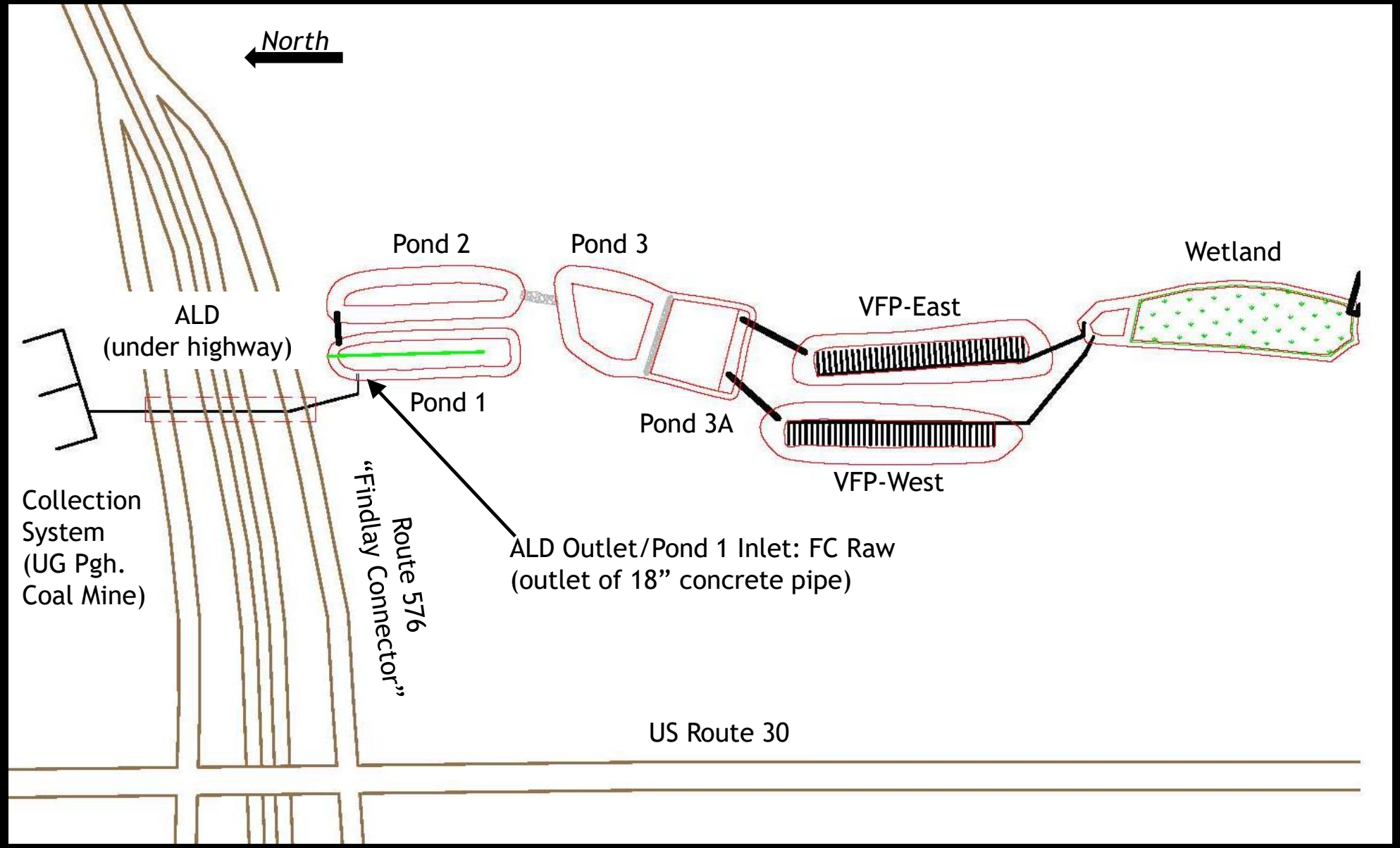
Special thanks to: Rich Beam PG Formerly of PA Dept. of Env. Protection, Bureau of Abandoned Mine Reclamation; Currently US Office of Surface Mining

mining & reclamation services

Montour Run Watershed



North Fork Montour Run Passive Treatment System



North Fork Montour Run Passive Treatment System

PA Turnpike & PADEP-BAMR Collection and ALD

Looking south towards future treatment expansion area

ALD under 18” open joint RCP Culvert bedded in non-calcareous river gravel overlain by geotextile

Weir Set at Pond 2 TO MEASURE FLOW

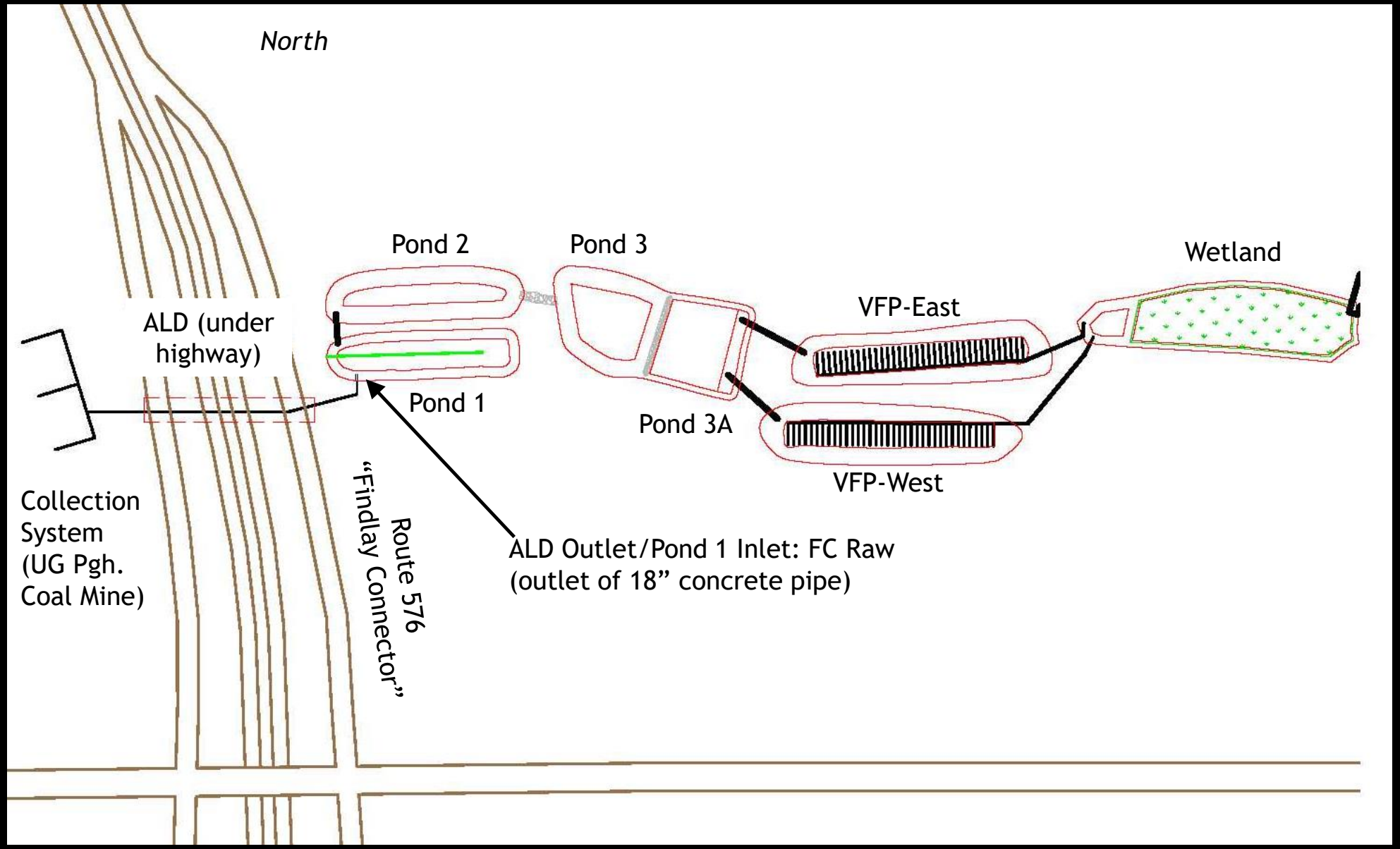
Weir Set at Pond 3 TO MEASURE FLOW

Pond 3 (Pre-Expansion) Monitoring Summary

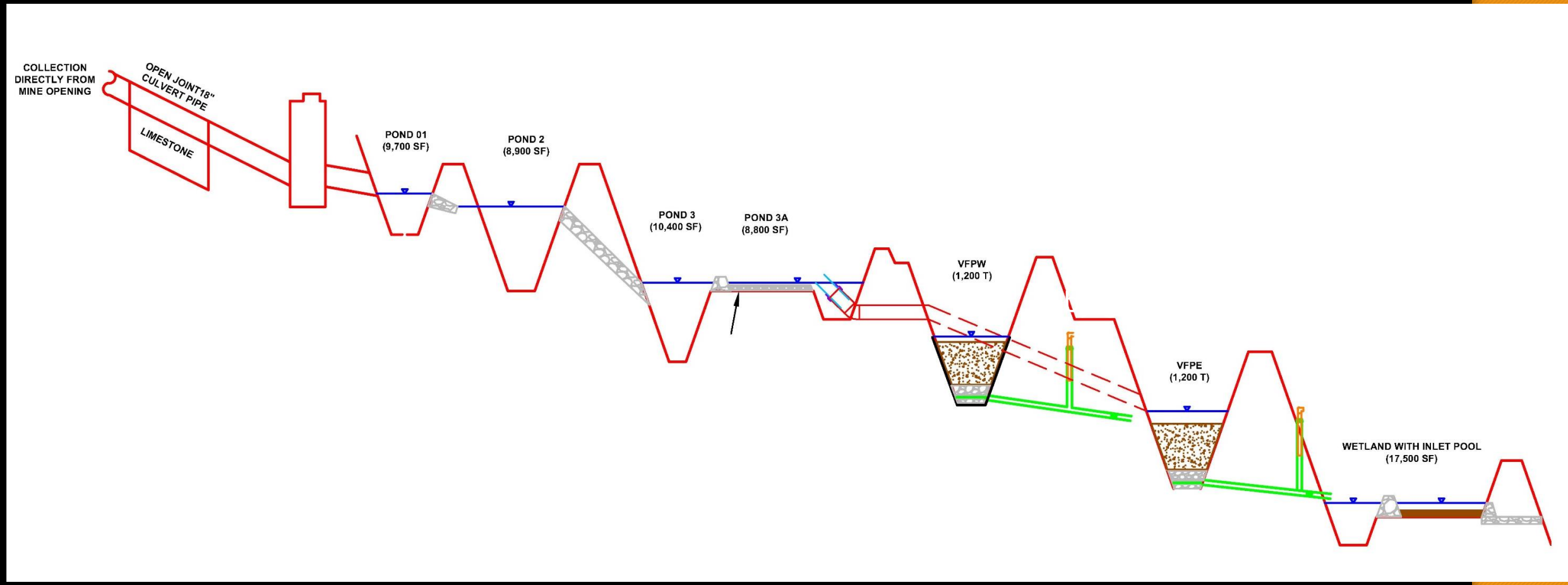
Date	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	Calc. Acidity mg/L$CaCO_3$	D.Fe mg/L	D.Mn mg/L	D.Al mg/L	(Hot) Acid Load lb/d	Calc. Acid Load lb/d	D.Fe Load lb/d
09/22/05	45	4.6	3.5	0	0	135	163	81	9	0	73	88	44
10/28/05	30	3.9	3.6	0	0	48	101	46	7	0	17	36	16
11/23/05	26	4.2	4.0	0	0	51	56	22	7	0	16	17	7
12/26/05	45	6.1	5.1	61	7	110	176	90	7	0	59	95	49
01/31/06	70	5.7	5.6	56	7	223	266	140	7	0	189	225	118
02/21/06	103	6.1	5.8	18	10	250	285	151	7	0	309	353	187
03/15/06	70	6.5	5.6	NM	12	186	250	134	6	0	157	212	113
05/25/06	76	4.8	3.8	NM	0	118	114	57	6	0	109	104	52
08/02/06	19	4.2	3.8	0	0	99	91	43	6	0	23	21	10
01/18/07	103	6.4	5.6	50	9	31	91	45	9	0	38	112	56
Minimum	19	3.9	3.0	0	7	31	56	22	6	0	16	17	7
Average	59	5.2	4.6	23	9	125	159	81	7	0	99	126	65
Median	58	5.2	4.6	9	9	114	138	69	7	0	66	100	50
Maximum	103	6.5	5.8	61	12	250	285	151	9	0	309	353	187
"Design"	*70/110*		*3.0*	*0*	*0*	*285*		*80*	*N/A*	*1*	*100/353*		*100 +/-*

Calculated acidity assumes all Ferrous iron. Design parameters average/maximum. Average pH not calculated from H-ion concentrations. Design Fe load is what was expected discharge from VFPs; It was assumed that about 1/2 of the iron load would be retained within the VFPs as either oxides or sulfides; wetland size was limited by budgetary and site constraints.al
Note, due to uncertainty of effectiveness of ALD, alkalinity not subtracted when calculating acidity.

North Fork Montour Run Passive Treatment System



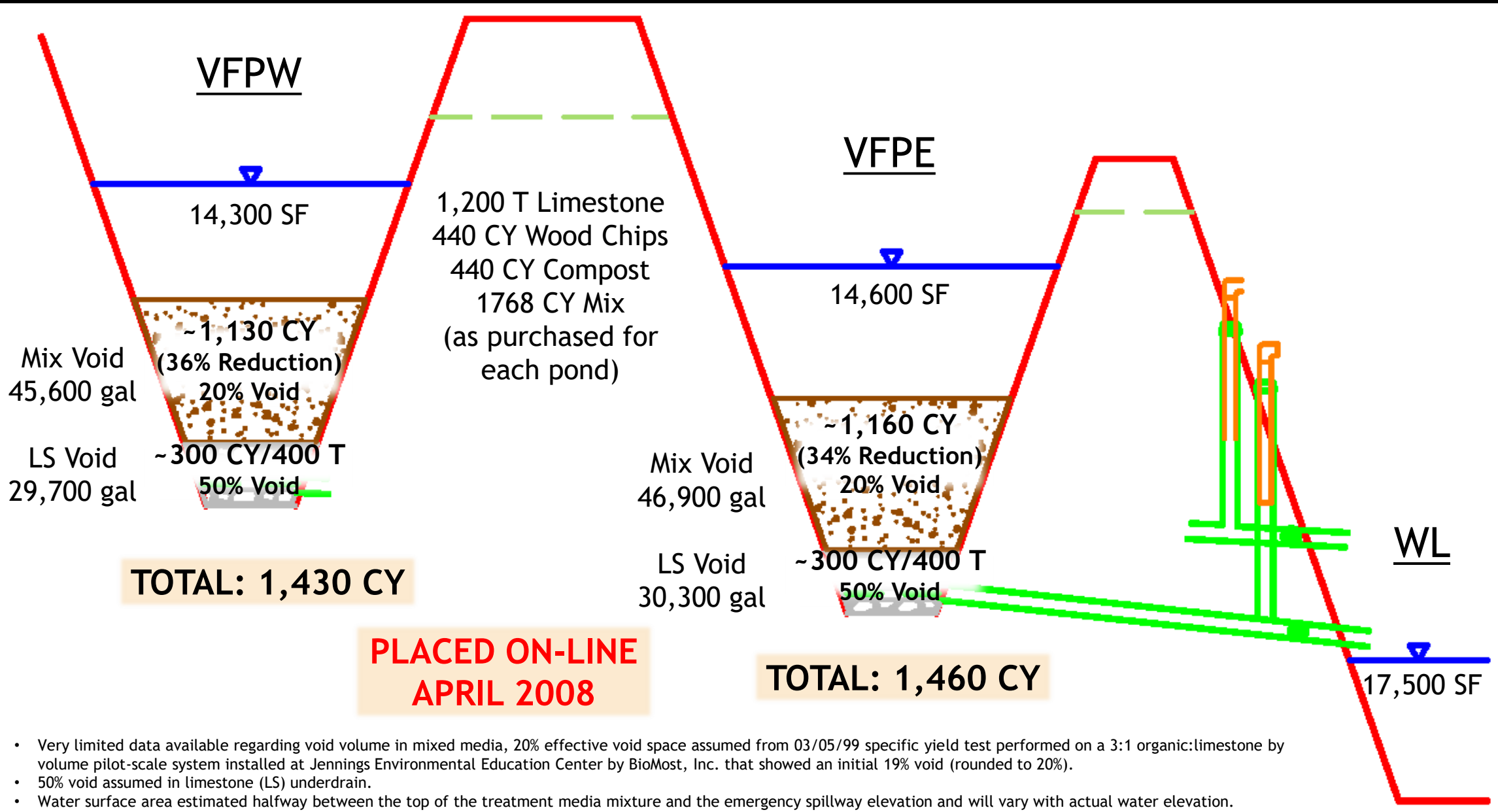
North Fork Passive Treatment System



Not shown: 3 trompes below wetland with aerator in Pond 2

Vertical Flow Pond Treatment Media & Underdrain

Vertical Flow Pond Treatment Media



- Very limited data available regarding void volume in mixed media, 20% effective void space assumed from 03/05/99 specific yield test performed on a 3:1 organic:limestone by volume pilot-scale system installed at Jennings Environmental Education Center by BioMost, Inc. that showed an initial 19% void (rounded to 20%).
- 50% void assumed in limestone (LS) underdrain.
- Water surface area estimated halfway between the top of the treatment media mixture and the emergency spillway elevation and will vary with actual water elevation.

VFP Performance Pre-2018

Design Flow:
70 gpm average (35 gpm per pond)
110 gpm maximum (55 gpm per pond)

VFP	Flow gpm	Lab pH s.u.	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L
WEST – Minimum	3	6.6	90	-373	<0.1	4.7	<0.1
WEST – Average	19	7.0	234	-172	4.5	6.0	0.1
WEST – Median	20	6.9	140	-93	5.1	6.2	<0.1
WEST – Maximum	56	7.7	580	-72	10.9	6.9	0.2
	At/Below Design			Consistently Alkaline			
EAST – Minimum	12	6.7	76	-192	0.2	4.8	<0.1
EAST – Average	30	7.1	149	-121	5.4	5.9	0.1
EAST - Median	32	7.2	151	-121	3.3	5.9	<0.1
EAST – Maximum	44	7.5	234	-54	18.7	7.2	0.2

AFTER FIRST YEAR OF OPERATION six samples collected: 06/01/09, 9/24/09, 11/28/09, 03/27/10, 05/15/12, 06/09/15. 580 mg/L lab alkalinity taken 9/24/09 with 3 gpm flow, field alk. was 582 mg/L. Additional data available on **www.datashed.org (datashed.org/water_quality_report/project-north-fork-montour-run/standard)**

2018 – THE. WETTEST. YEAR. EVER.

- 57.83 inches of rain in Pittsburgh
  - 19.64 inches above normal
  - 51% higher than normal

2018 (Year 10): The Discharge is Bad!

04/26/18 Wetland

- 5 pH
- 96 mg/L acid
- 56 mg/L Fe
- 6 mg/L Al

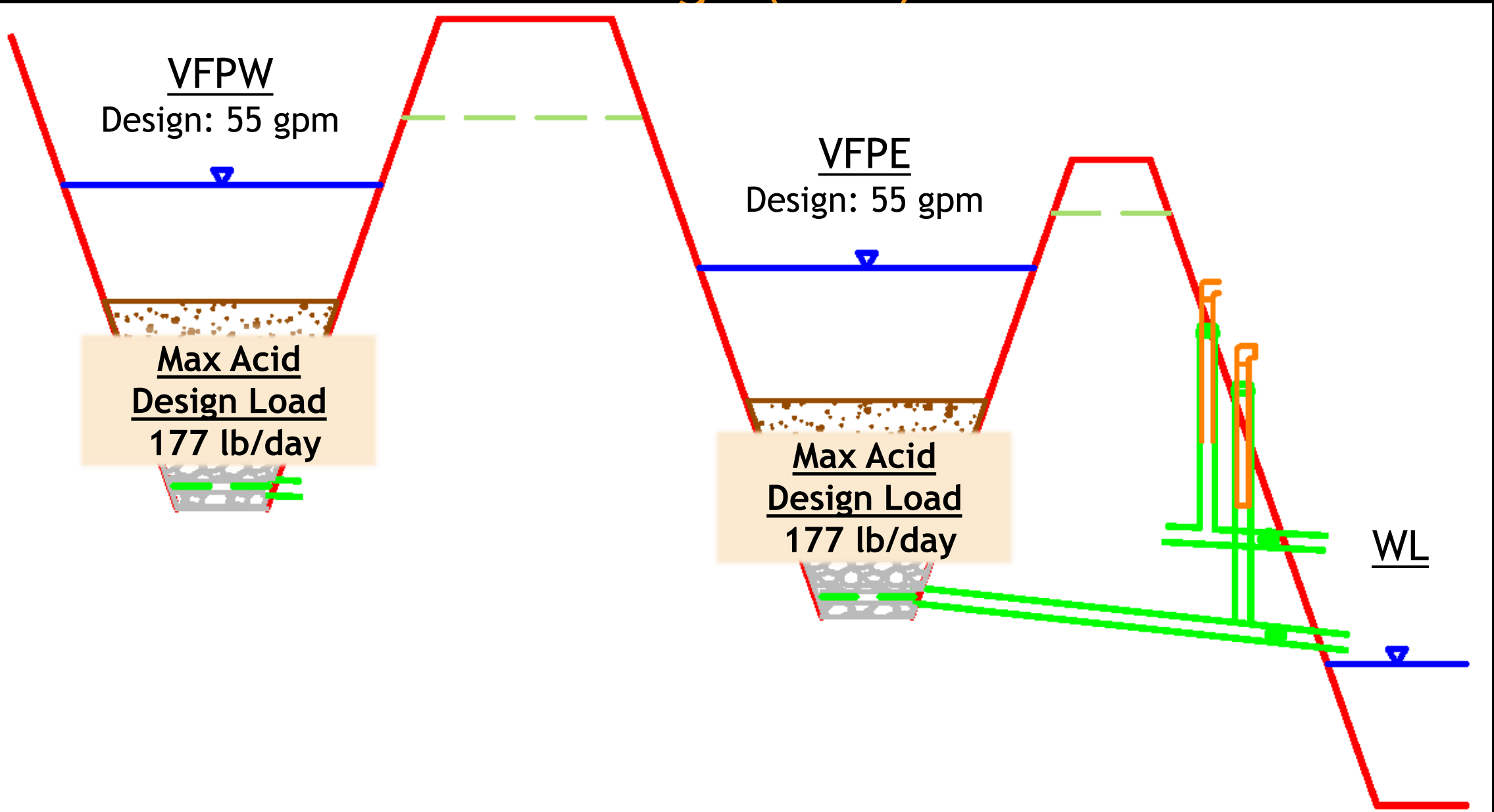
Don’t Panic!

Take Samples.

<u>04/26/18</u>

- How much acid was coming in?
- How much acid was going out?
- How much acid was removed?
- Check the **<u>Flow</u>** (Measure it!)

Vertical Flow Pond Design (Max)

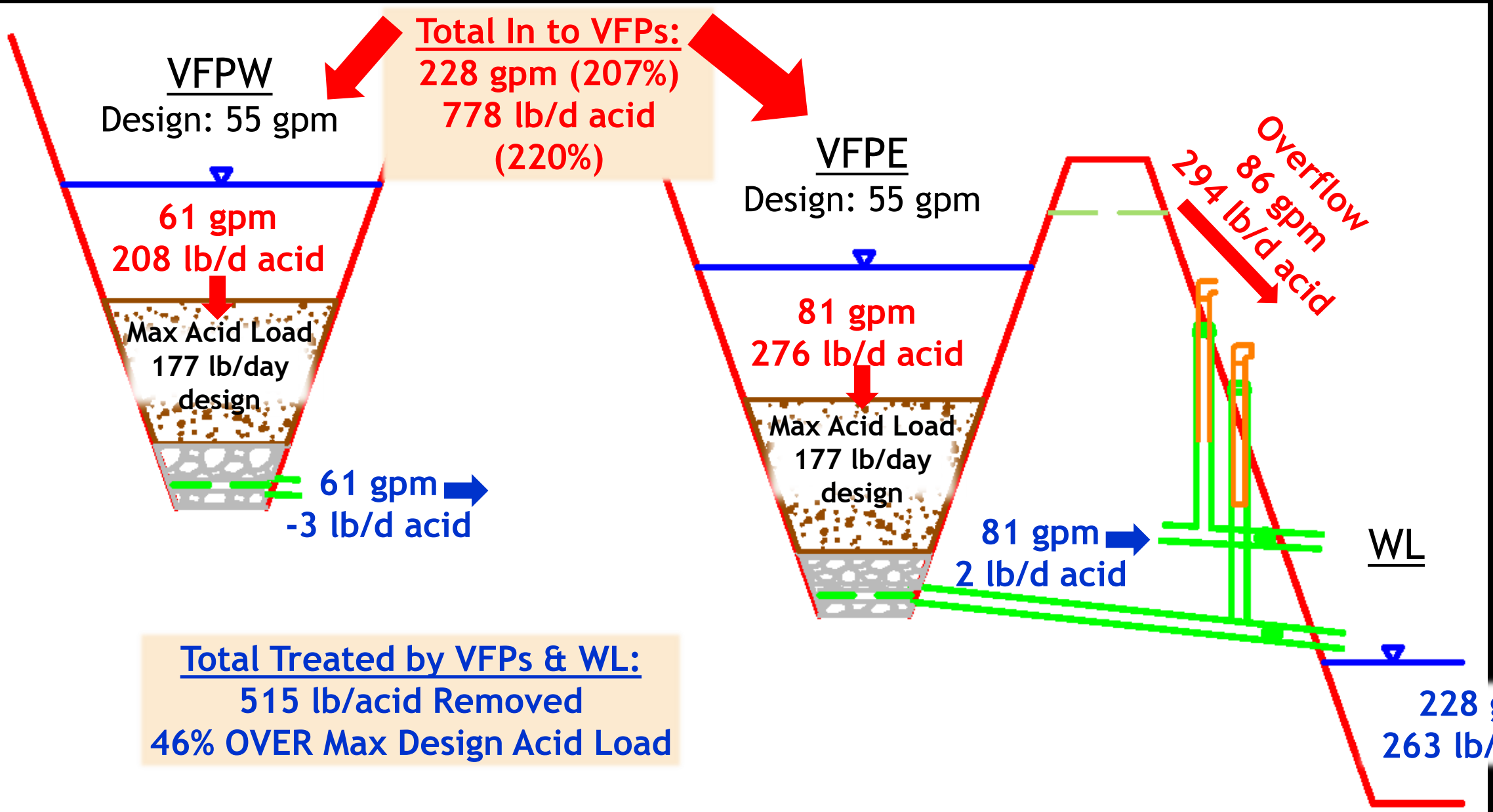


Monitoring Data: 04/26/18

Point	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L	Acid Load lb/d $CaCO_3$	Δ Acid Load lb/d $CaCO_3$	Fe Load lb/d	Δ Fe Load lb/d
FC Raw	228	4.4	3.95	0	0	316	121	7	27	865	-	332	-
Pond 2	228	4.5	3.91	3	0	295	107	7	23	809	-56	293	-38
Pond 3A	228	4.2	3.88	0	0	284	125	7	21	778	-31	343	+48
VFP-West	61	6.5	5.77	108	53	-4	44	7	2	-3	-211	32	-60
VFP-East	81	6.7	5.67	121	43	2	54	7	2	2	-275	53	-69
VFP-East Overflow	~86	4.1	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.
Wetland	228	6.2	5.08	33	3	96	56	7	6	263	-515	154	-188

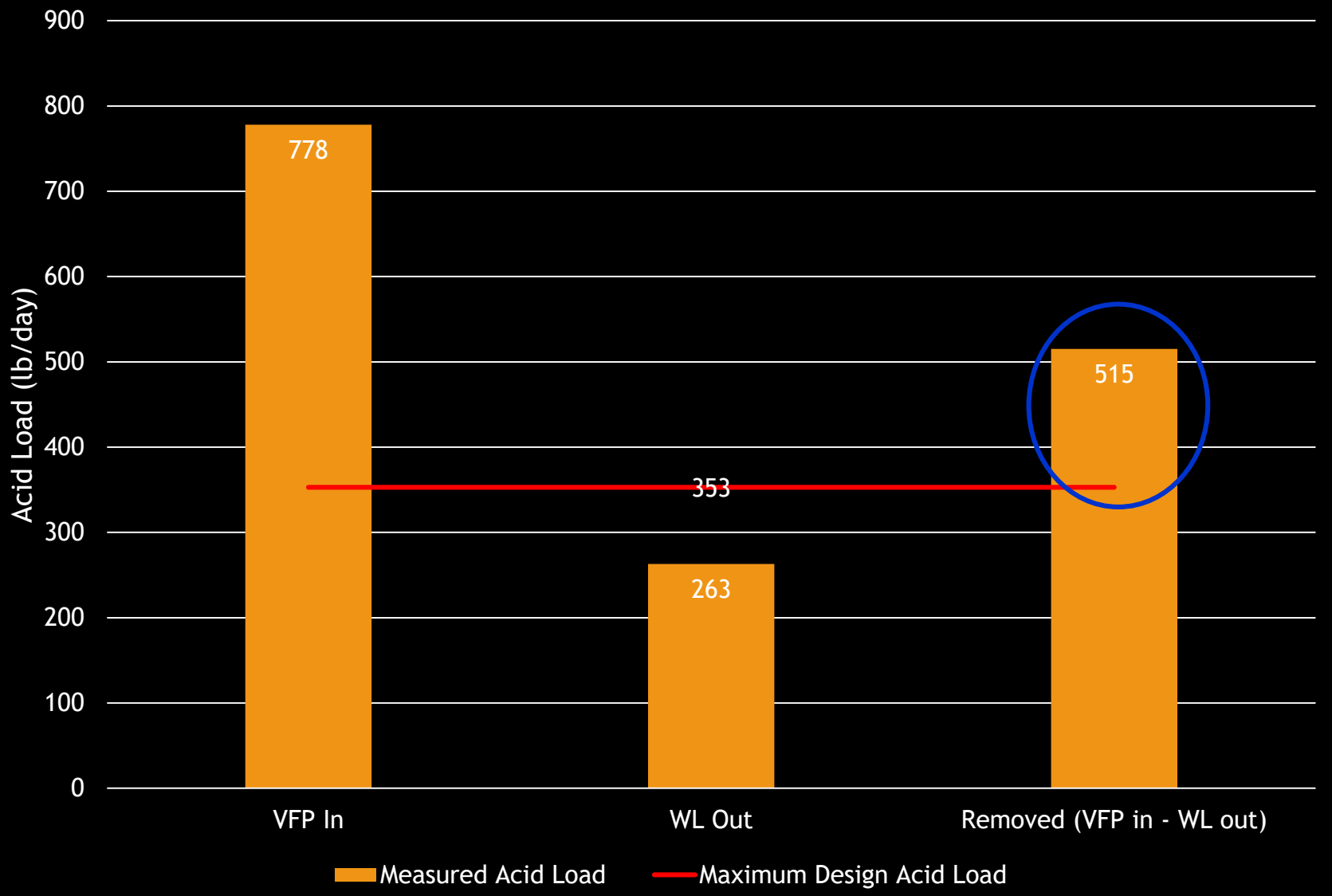
Pond 2 acid and iron change from FC Raw (Pond 1 not sampled). Wetland acid and iron change calculated from Pond 3A (Inflow to VFPs). VFP-East Overflow drains to Wetland.

Vertical Flow Pond Actual 4/26/18



Total Treated by VFPs & WL:
515 lb/acid Removed
46% OVER Max Design Acid Load

VFP(in) to WL(out) Performance 04/26/18



162 lb/day (46%) over design

VFP Performance: 04/26/18

Component	Flow Through Media gpm	Acid Neutralized lb/d	Theoretical LS/Organic Mixture HRT hr	LS/Organic Mixture Acid Neutralization Rate lb/d/CY	Theoretical Limestone Underdrain HRT hr	Total Theoretical HRT hr	Total Acid Neutralization Rate lb/d/CY	*Areal Acid Neutralization Rate $g/m^2/d$
VFP-West	61	211	12.5	0.19	8.3	20.8	0.15	72
VFP-East	81	275	9.7	0.24	6.2	15.9	0.19	92

Note: Total VFP-East inflow was 167 gpm with 86 gpm overflowing to wetland

HRT = Hydraulic Retention Time

“Total” HRT and Acid Neutralization Rate based on total volume of LS/Organic mixture and limestone underdrain.

*Areal Acid Neutralization Rate follows procedure described by Dr. Art Rose where a typical removal rate was found to be about 34 grams/square meter/day ($g/m^2/d$). Ref: Vertical Flow Systems Effects of Time and Acidity Relations, Proceedings of American Society of Mining and Reclamation, 2004. (https://www.asrs.us/wp-content/uploads/2021/09/1595-Rose.pdf)

System Performance: 04/26/18

"You don't know how small you can build something until you break it."

-Dr. Bob Nairn (pers. comm.)

- VFP-West effluent acidity: -4 mg/L
- VFP-East effluent acidity: 2 mg/L

Both VFPs effluents are almost exactly "neutral"
(i.e., 0 mg/L acidity)

(Is this the breaking point?)

System Performance: 04/26/18

- VFP-West Acid Load In/Out lb/d **208** to **-3** = 211 lb/d
- VFP-East Acid Load In/Out lb/d **276** to **2** = 274 lb/d
- Total Acid Neutralized in VFPs = 485 lb/d
- Max pre-construction calculated acid load: 353 lb/d
- 37% over "design" maximum load (based on only VFPs)
- System put on-line 04/29/08 (10 years)
  - Design life: 15 years

TAKE AWAY: Even with "bad" effluent the system did not fail…
…it is doing more than what it was designed to do.

But Will We Ever See Good Water Again…?

Monitoring Data: 06/06/18

Point	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L	Acid Load lb/d $CaCO_3$	Δ Acid Load lb/d $CaCO_3$	Fe Load lb/d	Δ Fe Load lb/d
FC Raw	149	5.4	5.27	49	27	230	124	7	9	412	-	222	-
Pond 1	149	5.3	5.17	23	16	220	117	7	5	394	-18	210	-13
Pond 2	149	5.4	4.68	8	2	222	102	7	3	398	+4	183	-27
Pond 3A West	75	4.1	3.61	0	0	217	92	7	4	196	-5	83	-9
Pond 3A East	74	4.0	3.64	0	0	224	96	7	4	199	+2	85	-5
VFP-West	75	6.7	6.21	92	59	13	47	7	1	11	-184	42	-41
VFP-East	74	6.5	6.55	183	136	-98	44	7	0	-87	-287	40	-46
Wetland	149	6.5	6.55	63	48	-20	17	7	0	-36	+40	31	-51

Wetland acid and iron load change calculated from mathematically combined VFP-West and VFP-East loads (-76 lb/d acid & 82 lb/d Fe) used as the inflow to the wetland (not shown above).

Monitoring Data: 10/23/18

Point	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L	Acid Load lb/d $CaCO_3$	Δ Acid Load lb/d $CaCO_3$	Fe Load lb/d	Δ Fe Load lb/d
FC Raw	83	5.2	5.77	96	76	105	86	5	3	105	-	86	-
Pond 3A	83	6.1	5.86	36	10	111	60	5	0	111	+6	60	-26
VFP-West	71	6.7	6.59	91	62	-44	13	5	0	-38	-133	11	-40
VFP-East	12	7.4	6.71	115	78	-61	16	4	0	-9	-25	2	-7
Wetland	83	7.0	6.78	74	58	-44	4	4	0	-43	+4	4	-9

VFP-West & East acid and iron load reductions calculated from the mathematically divided load from Pond 3A: VFP-West 95 lb/d acid & 51 lb/d Fe; VFP-East 16 lb/d acid & 9 lb/d Fe.
Wetland acid and iron load reductions calculated from mathematically combined VFP-West and VFP-East loads (-47 lb/d acid & 13 lb/d Fe) used as the inflow to the wetland (not shown above).

Monitoring Data: 04/22/20

Point	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity mg/L$CaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L	Acid Load lb/d $CaCO_3$	Δ Acid Load lb/d $CaCO_3$	Fe Load lb/d	Δ Fe Load lb/d
FC Raw	129	5.6	5.18	76	12	77	55	4	4	119	-	86	-
Pond 3A	129	6.4	5.67	32	4	74	42	4	1	115	-4	65	-9
VFP-West	93	6.7	7.05	57	65	-71	3	4	0	-80	-163	3	-44
VFP-East	28	7.0	7.31	90	110	-95	4	3	0	-32	-57	1	-13
VFP-East Overflow	8	6.6	5.59	20	2	74	28	4	0	7	0	3	-1
Wetland	129	6.4	7.36	74	69	-55	2	3	0	-85	+20	4	-3

VFP-West & East acid and iron load reductions calculated from the mathematically divided load from Pond 3A: VFP-West 83 lb/d acid & 44 lb/d Fe; VFP-East 25 lb/d acid & 14 lb/d Fe.
Wetland acid and iron load reductions calculated from mathematically combined VFP-West, East & Overflow loads (-105 lb/d acid & 7 lb/d Fe) used as the inflow to the wetland.

Monitoring Data: 03/09/22

Point	Flow gpm	Field pH s.u.	Lab pH s.u.	Field Alk. mg/L	Lab Alk. mg/L	(Hot) Acidity $mg/LCaCO_3$	T.Fe mg/L	T.Mn mg/L	T.Al mg/L	Acid Load lb/d $CaCO_3$	Δ Acid Load lb/d $CaCO_3$	Fe Load lb/d	Δ Fe Load lb/d
FC Raw	180	5.3	4.94	33	11	129	50	4	7	280	-	108	-
Pond 3A	180	5.4	5.14	19	4	111	45	4	4	239	-41	97	-11
VFP-West	102	7.0	7.0	149	114	-102	2	4	0	-125	-261	3	-52
VFP-East	48	6.7	7.0	167	116	-104	7	4	0	-60	-124	4	-22
VFP-East Overflow	30	6.0	5.1	12	2	83	30	4	1	30	-10	11	-5
Wetland	180	7.0	7.3	107	97	-87	1	3	0	-189	-33	1	-16

VFP-West & East acid and iron load reductions calculated from the mathematically divided load from Pond 3A: VFP-West 136 lb/d acid & 55 lb/d Fe; VFP-East 64 lb/d acid & 26 lb/d Fe.
Wetland acid and iron load reductions calculated from mathematically combined VFP-West, East & Overflow loads (-155 lb/d acid & 18 lb/d Fe) used as the inflow to the wetland.

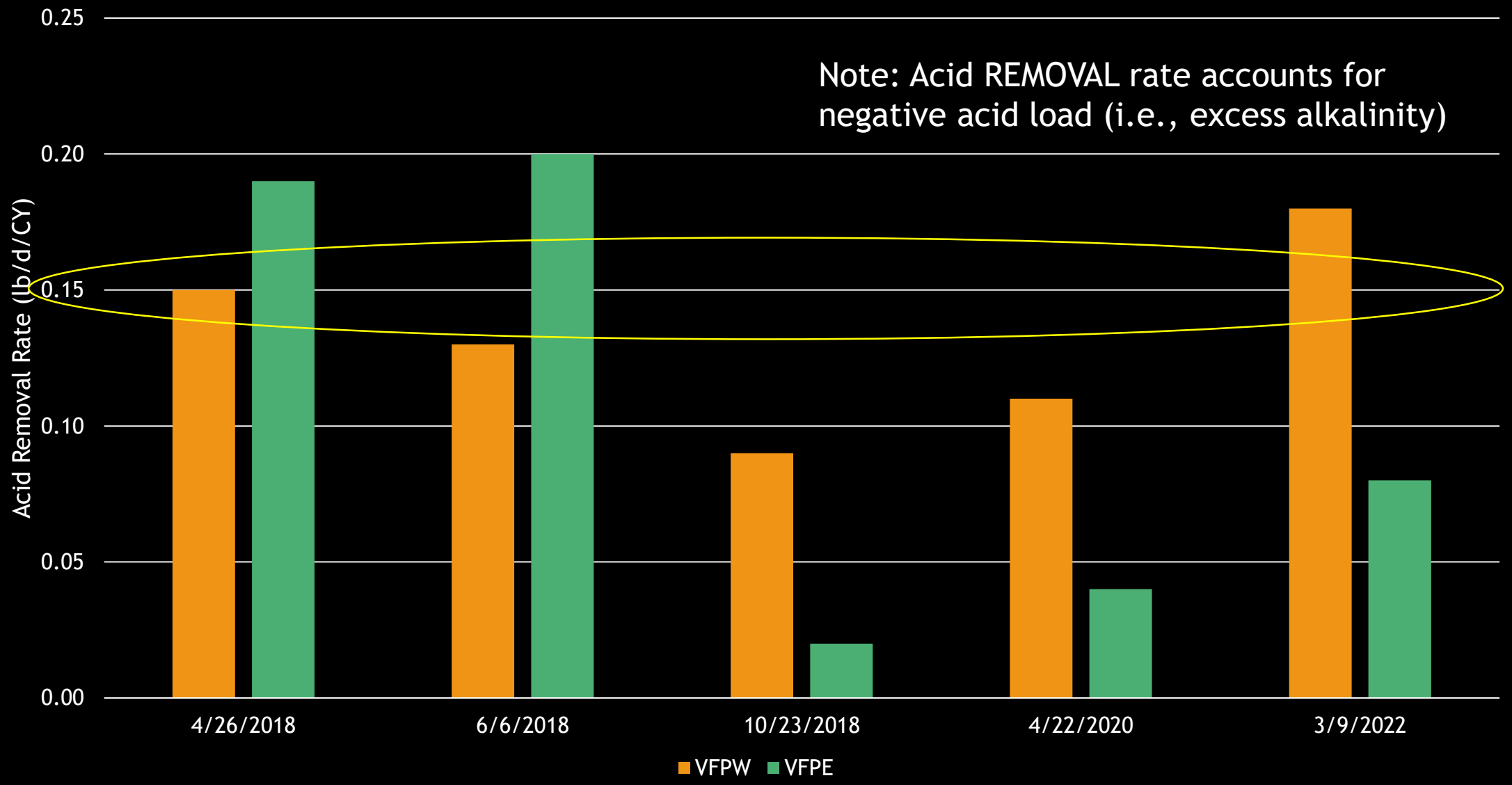
2018 VFP Performance

VFP	Flow Through Media gpm	Acid Neutralized lb/d	Theoretical LS/Organic Mixture HRT hr	LS/Organic Mixture Acid Neutralization Rate lb/d/CY	Theoretical Limestone Underdrain HRT hr	Total Theoretical HRT hr	Total Acid Neutralization Rate lb/d/CY	Areal Acid Neutralization Rate $g/m^2/d$
04/26/18 (Total Inflow = 228 gpm - 200% of Max Design Flow - 86 gpm overflow from VFPE; Pond 3A 778 lb/d acid)								
VFP-West	61	211	12.5	0.19	8.3	20.8	0.15	72
VFP-East	81	275	9.7	0.24	6.2	15.9	0.19	92
06/06/18 (Total Inflow = 149 gpm - 135% of Max Design Flow; Pond 3A 395 lb/d acid)								
VFP-West	75	184	10.1	0.16	6.7	16.8	0.13	63
VFP-East	74	287	10.6	0.25	6.8	17.4	0.20	96
10/23/18 (Total Inflow = 86 gpm - 78% of Max Design Flow; Pond 3A 11 lb/d acid)								
VFP-West	71	133	10.7	0.12	7.1	17.8	0.09	45
VFP-East	12	25	65.1	0.02	42.1	107.2	0.02	8

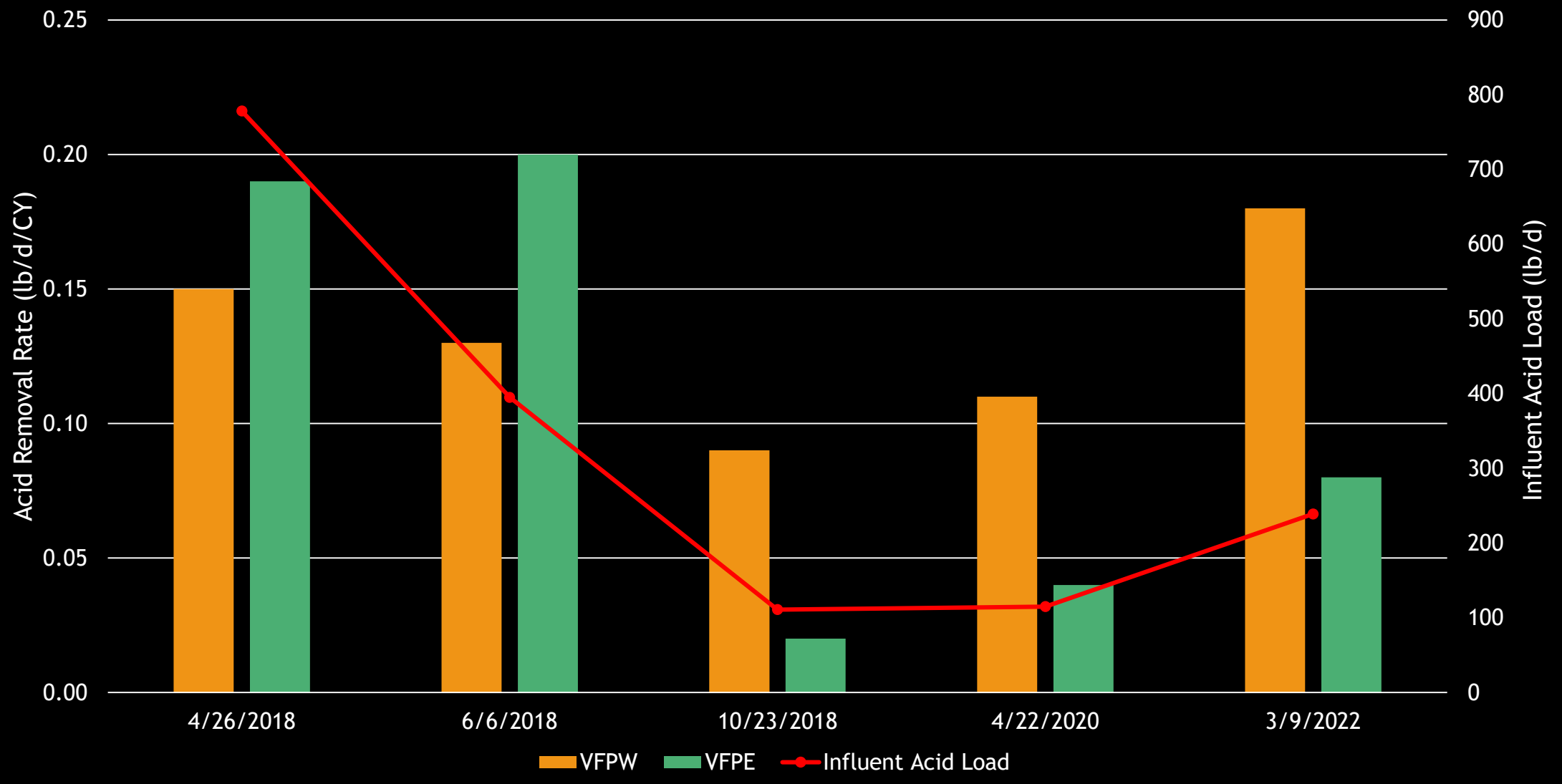
2020 & 2022 VFP Performance

VFP1	Flow Through Media gpm	Acid Neutralized lb/d	Theoretical LS/Organic Mixture HRT hr	LS/Organic Mixture Acid Neutralization Rate lb/d/CY	Theoretical Limestone Underdrain HRT hr	Total Theoretical HRT hr	Total Acid Neutralization Rate lb/d/CY	Areal Acid Neutralization Rate $g/m^2/d$
04/22/20 (Total Inflow = 129 gpm - 117% of Max Design Flow - 8 gpm overflow from VFPE; Pond 3A 115 lb/d acid)								
VFP-West	93	163	8.2	0.14	5.3	13.5	0.11	56
VFP-East	28	57	27.9	0.05	18.0	46.0	0.04	19
03/09/22 (Total Inflow = 180 gpm - 164% of Max Design Flow - 30 gpm overflow from VFPE; Pond 3A 116 lb/d acid)								
VFP-West	102	261	7.5	0.23	4.9	12.3	0.18	89
VFP-East	48	124	16.3	0.11	10.5	26.8	0.08	42

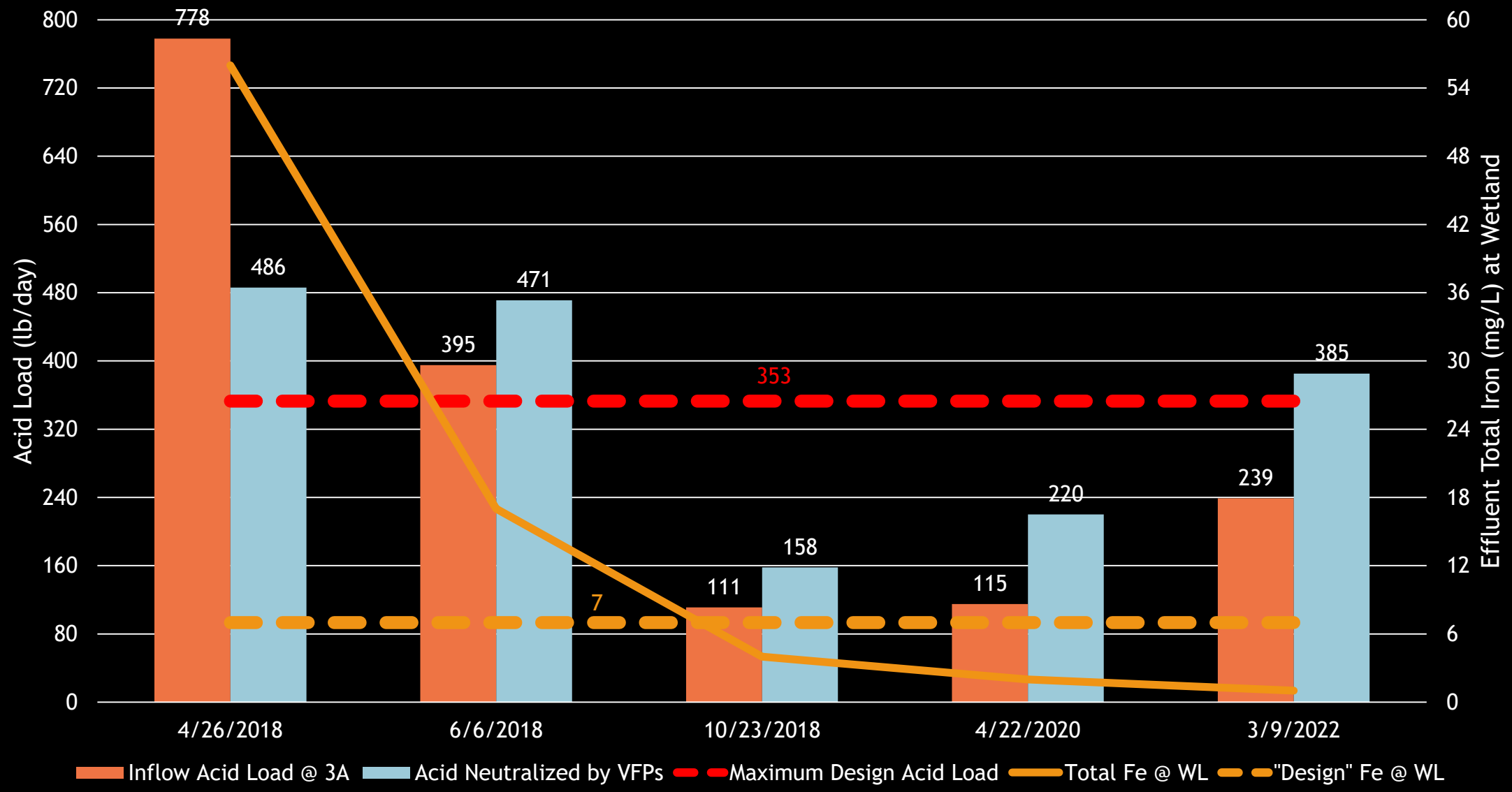
VFPW & VFPE Acid Removal Rate (lb/d/CY)



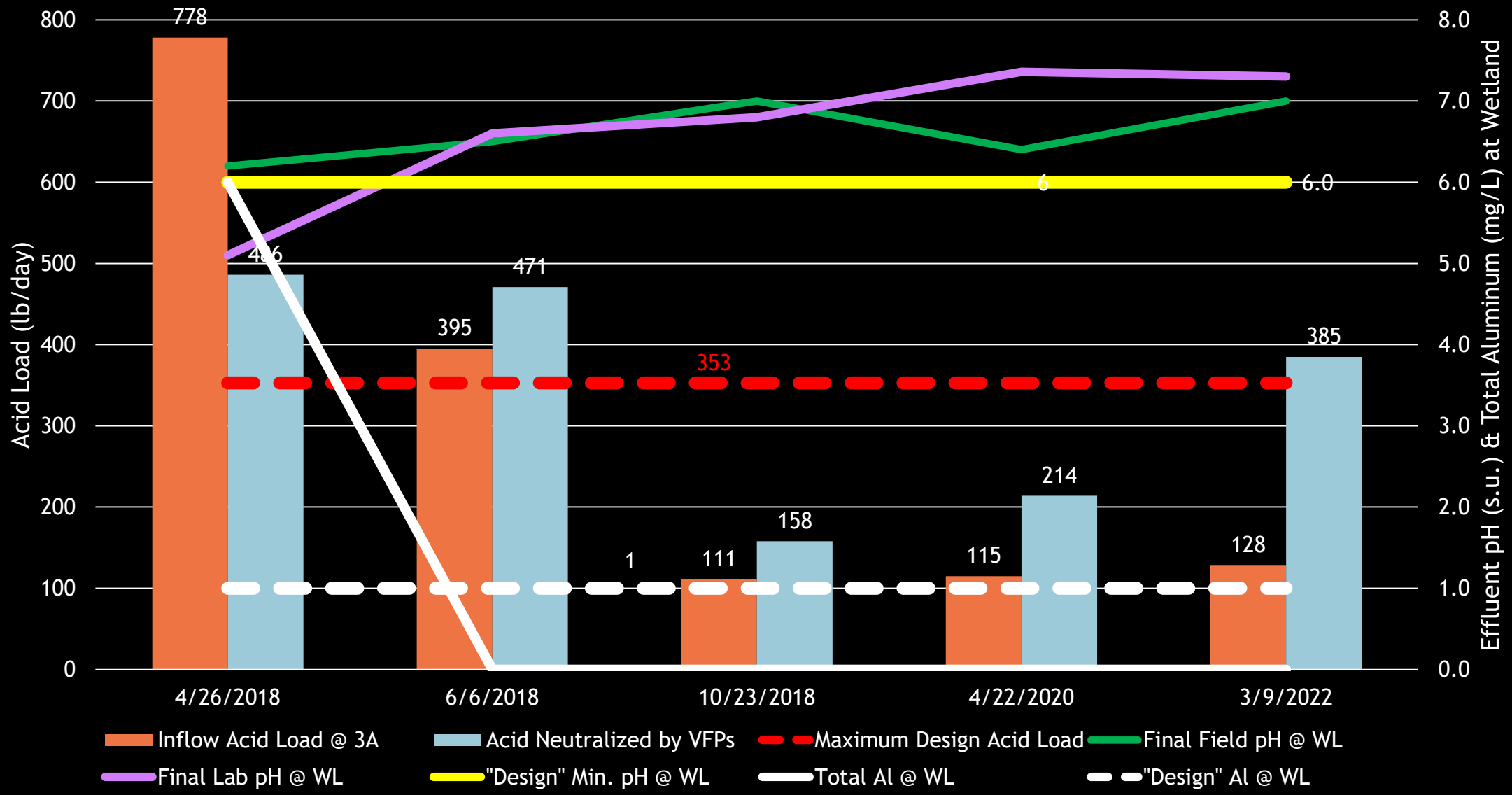
Acid Removal Rate & Influent Acid Load



Acid Load Treated vs. Final T.Fe



Acid Load Treated vs. Final pH & T.Al



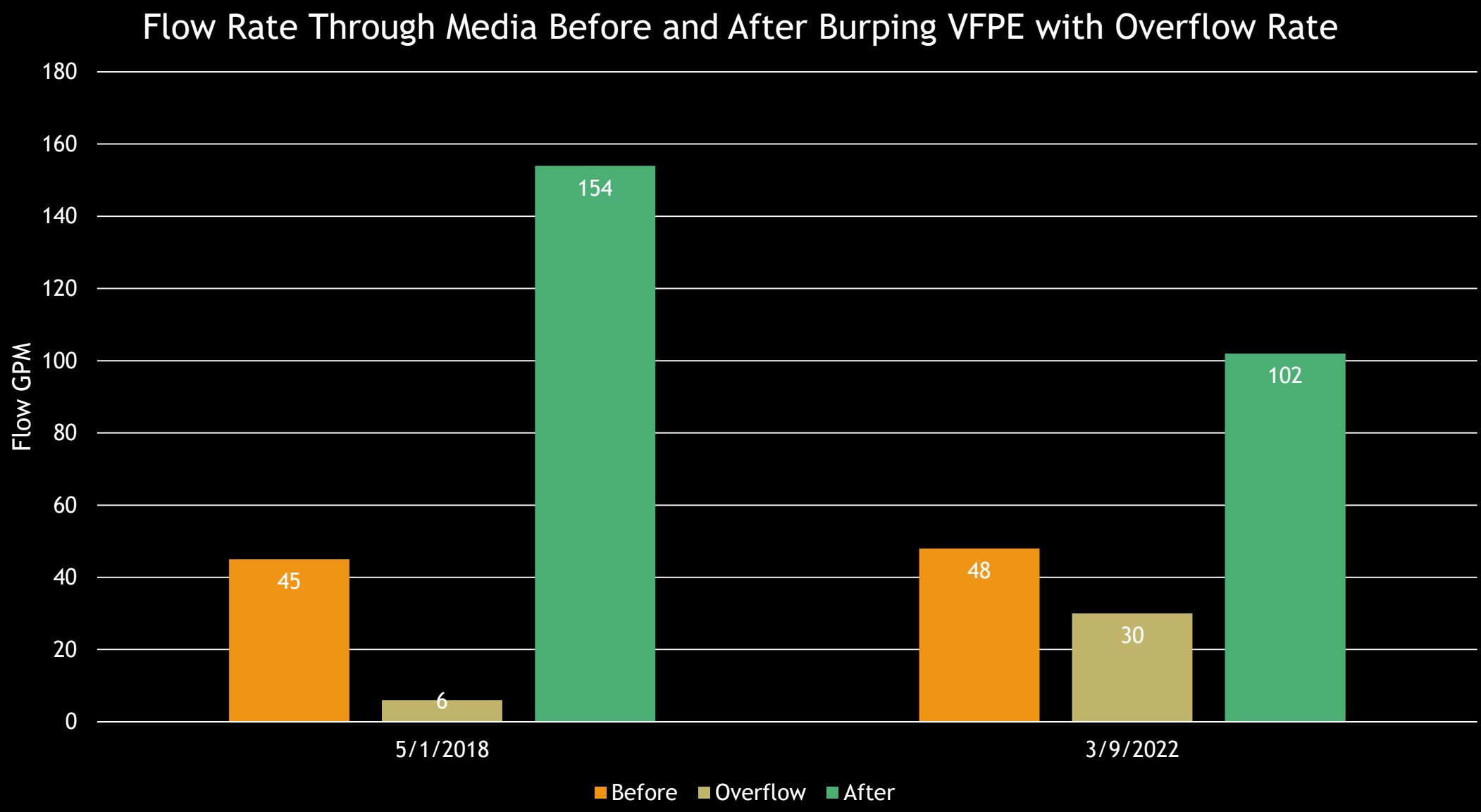
Does VFPE have Air Lock?

3/9/22 VFPE was flowing 48 gpm with about 30 gpm Overflow
The four drain valves were opened from about 1715-1724 (9 min)
Flow measured at 1746: 105 gpm
Flow measured at 1828: 102 gpm
Overflow decreased and almost ceased by 1828
Did ‘burping’ eliminate an air lock?
Is air lock related to temp / biological activity?

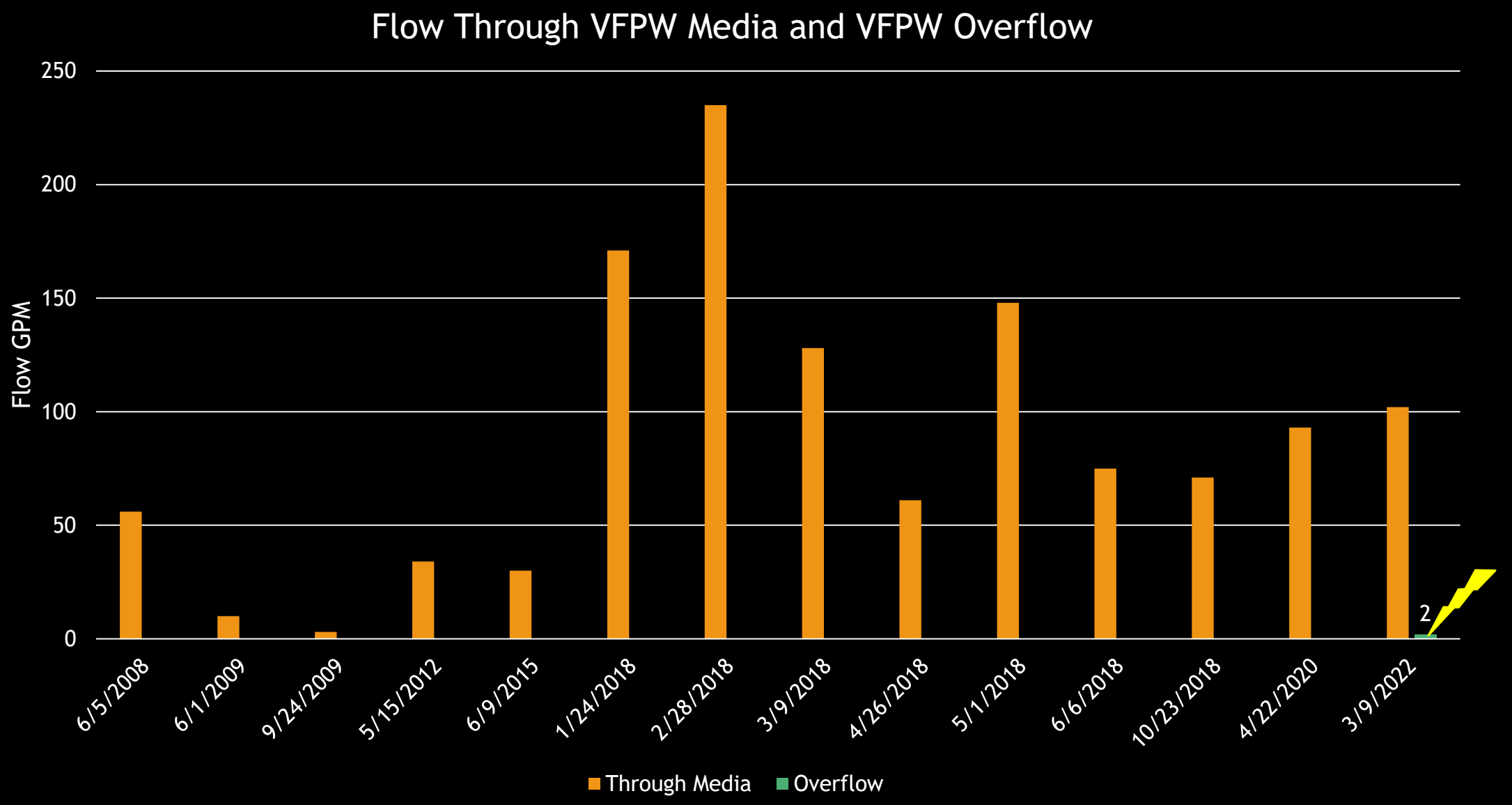
System was also burped on 5/1/18 (see next slide)

Time shown in military format

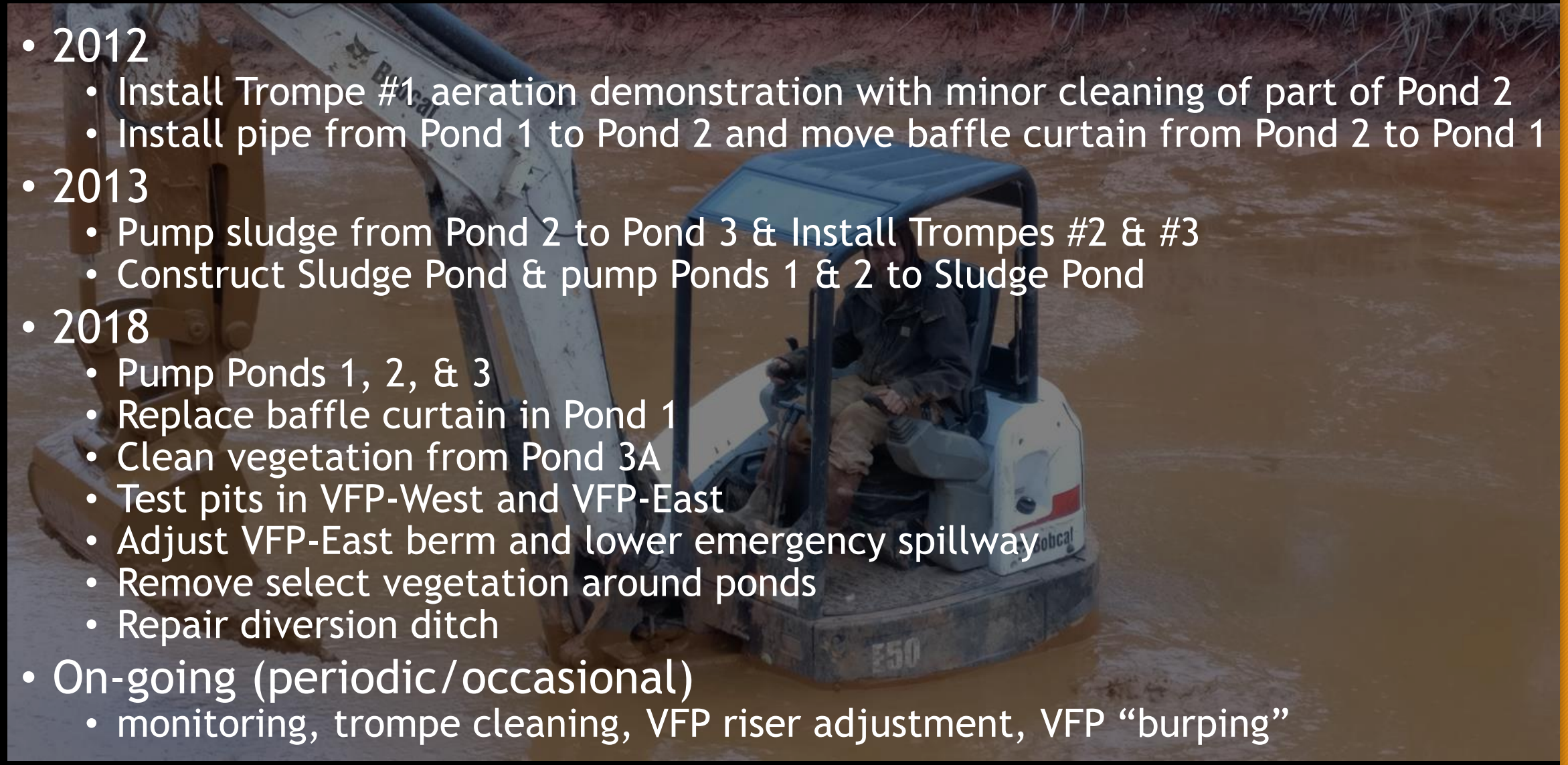
VFPE Potential Air Lock



VFPW Media Flow Capacity



Operation & Maintenance (First 14 years)



- 2012
  - Install Trompe #1 aeration demonstration with minor cleaning of part of Pond 2
  - Install pipe from Pond 1 to Pond 2 and move baffle curtain from Pond 2 to Pond 1
- 2013
  - Pump sludge from Pond 2 to Pond 3 & Install Trompes #2 & #3
  - Construct Sludge Pond & pump Ponds 1 & 2 to Sludge Pond
- 2018
  - Pump Ponds 1, 2, & 3
  - Replace baffle curtain in Pond 1
  - Clean vegetation from Pond 3A
  - Test pits in VFP-West and VFP-East
  - Adjust VFP-East berm and lower emergency spillway
  - Remove select vegetation around ponds
  - Repair diversion ditch
- On-going (periodic/occasional)
  - monitoring, trompe cleaning, VFP riser adjustment, VFP “burping”

Take Aways

- Effluent water quality is not necessarily an indicator of system performance
- Need to measure flow and calculate load when evaluating systems
- System expectations should be included in O&M Plan/As-built
  - Average and Maximum Design Flow
  - Average and Maximum Pollutant Load
    - Acid
    - Iron
    - Aluminum
    - Manganese
- Include design basis water monitoring data if possible

Thank you!

- Much thanks to the great folks at the Montour Run Watershed Association
- Thanks to OSM for Funding the Trompe Project
- Thanks to PADEP for O&M Funds/Assistance
- Thanks to the Rockwell Foundation for O&M Funds
- Thanks to Allegheny County Airport Authority (landowner)
- In memory of Bruce Leavitt, Inventor & Trompemaster