

Long-term Effectiveness of Three Passive Systems Treating Acidic, High-metal, Abandoned Coal Mine Discharges near De Sale, Pennsylvania



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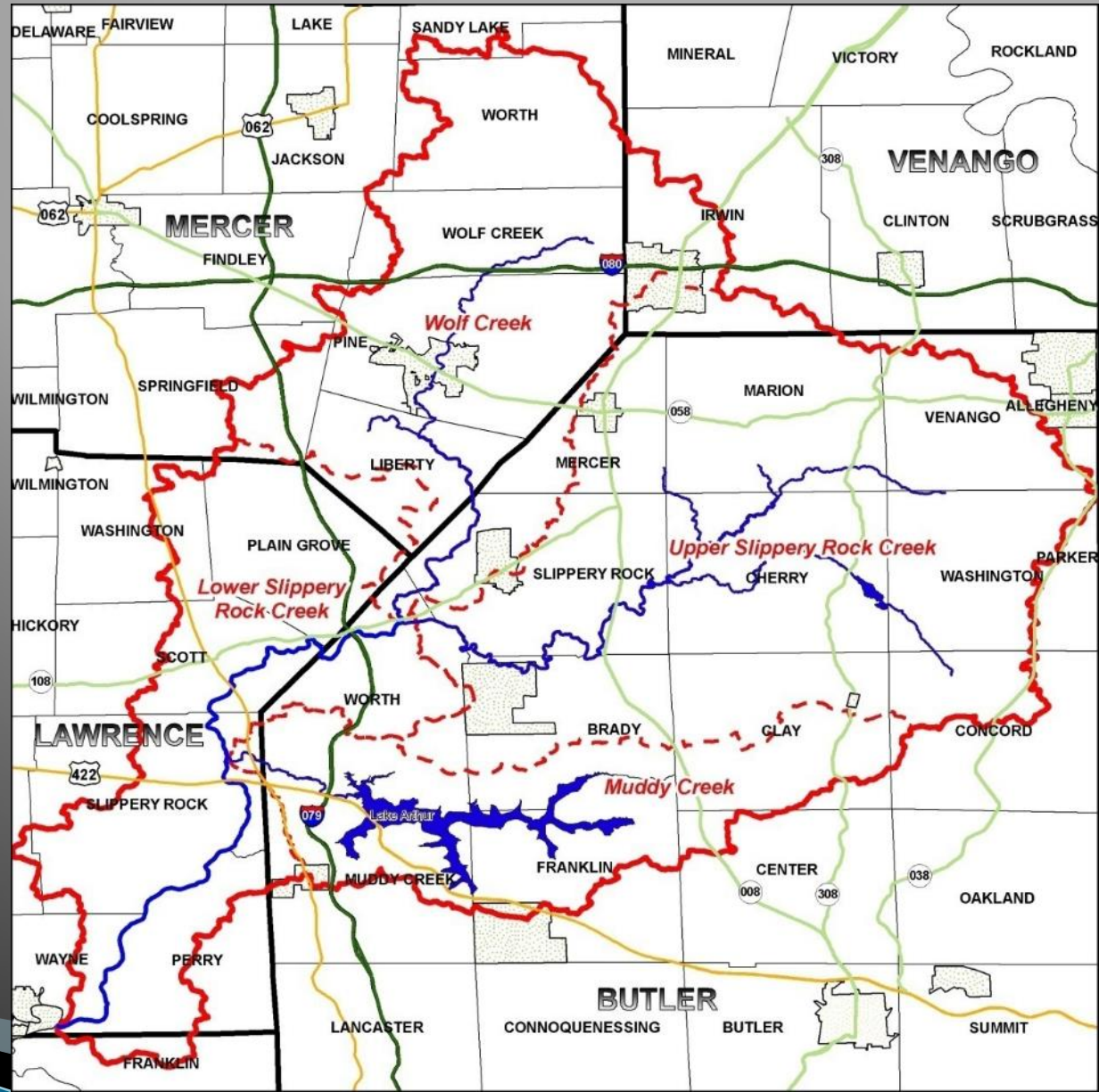
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Slippery Rock Creek Watershed

The watershed is
~410 square miles
and covers areas
of 5 counties:

- ▶ Beaver
- ▶ Butler
- ▶ Lawrence
- ▶ Mercer
- ▶ Venango

With 38
municipalities

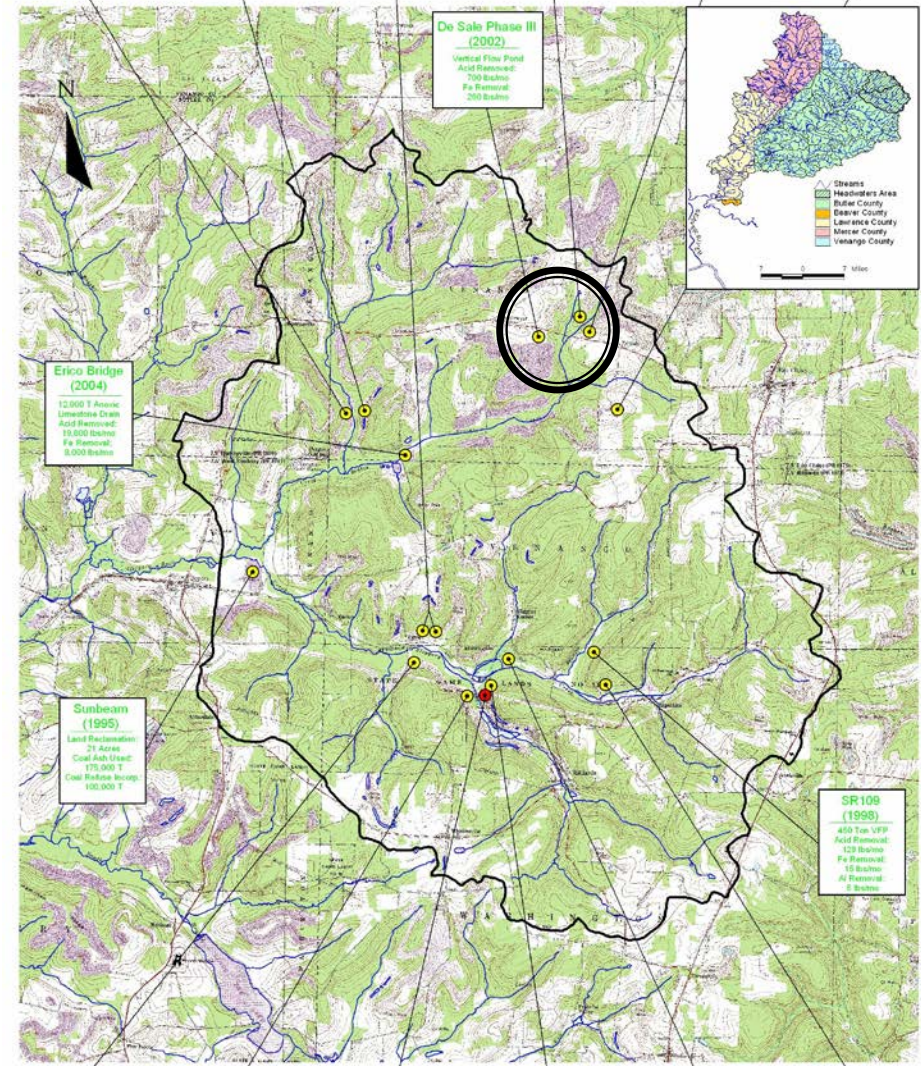


SLIPPERY ROCK CREEK TARGET AREA

Passive Treatment Installations

- ▶ 18 Passive Treatment Systems (PTS) have been built in the Slippery Rock Creek Watershed

Goff Station (2001) Four Vertical Flow Systems Acid Removed: 7,239 lbs/yr Fe Removed: 417 lbs/yr Al Removed: 367 lbs/yr Soil Microbiolium Naturally-Forming Wetlands	Brookville Pit (2002) Land Reclamation: 20 Acres Coal Ash Used: 200,000 Tons Coal Refuse Incorporated: 94,000 T	Ferris Complex (1997) Four Vertical Flow Systems Acid Removed: 12,732 lbs/yr Fe Removed: 437 lbs/yr Al Removed: 372 lbs/yr	DeSole Phase II (2001) 4,400 Ton VFF Acid Removed: 5,561 lbs/yr Fe Removed: 249 lbs/yr Al Removed: 210 lbs/yr	DeSole Phase I (2000) 3,300 Ton VFF Acid Removed: 5,371 lbs/yr Fe Removed: 1,129 lbs/yr Al Removed: 325 lbs/yr	Chernicky (1998) Land Reclamation: 50 Acres Coal Ash Utilization Abandoned Open Pits Reclaimed
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SR81 (2002) 1,392 Ton A&D Acid Removed: 173 lbs/yr Fe Removed: 23 lbs/yr	SR96 (2002) 708 Ton A&D Acid Removed: 292 lbs/yr Fe Removed: 70 lbs/yr	SR89 (2004) 3,100 Ton VFF Acid Removed: 7,127 lbs/yr Fe Removed: 1,189 lbs/yr Al Removed: 190 lbs/yr	Big Bertha (1996) 900 Ton A&D Acid Removed: 540 lbs/yr Fe Removed: 740 lbs/yr	SR101A (1996) 800 Ton A&D Acid Removed: 1,044 lbs/yr Fe Removed: 900 lbs/yr	SR114 (1995) 1,450 Ton A&D Acid Removed: 3,289 lbs/yr Fe Removed: 2,568 lbs/yr
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- COMPLETED PROJECT
- PROJECT UNDER CONSTRUCTION
- ▭ Headwaters Study Area
- ▬ Stream

2000 0 2000 4000 Feet



De Sale Restoration Area



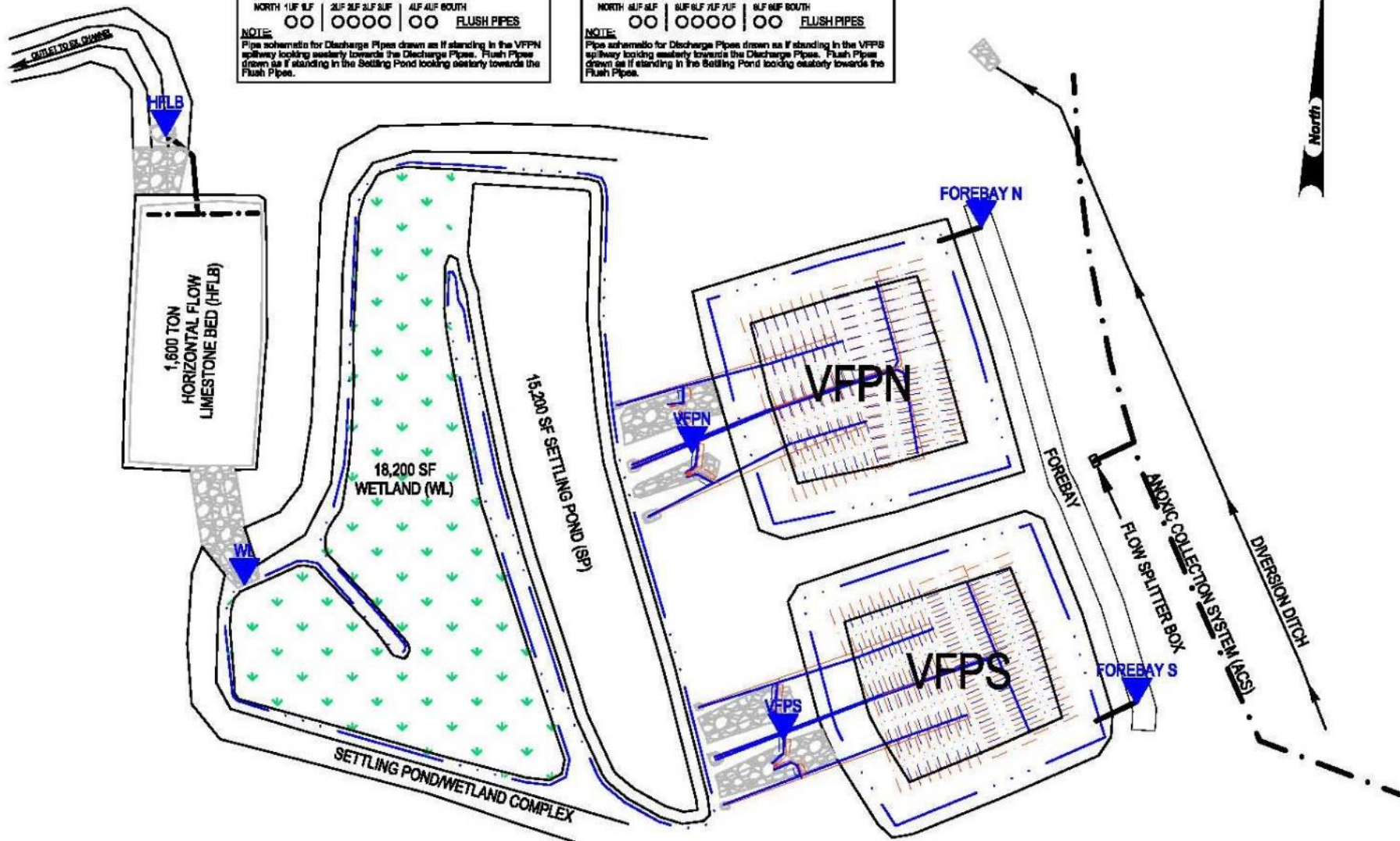
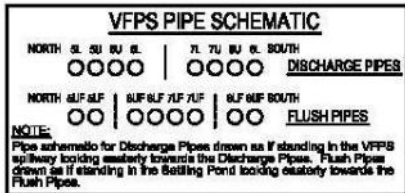
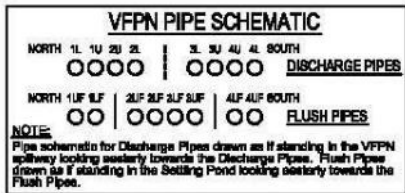


De Sale Phase 1

	Flow (gpm)	pH (s.u.)	Acid (mg/L)	Alk (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Raw	36	4.1	319	NA	82	55	12

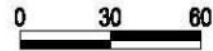
Table 1 – Risk Analysis Matrix for Category (4) Passive Treatment Systems

Risk Analysis Matrix				
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	< 25 gpm	≥ 25 < 50 gpm	≥ 50 < 100 gpm	≥ 100 < 200 gpm
< 5 mg/L	Low	Low	Low	Low
≥ 5 but < 15 mg/L	Low	Medium	Medium	Medium
≥ 15 < 25 mg/L	Low	Medium	Medium	Medium
≥ 25 < 50 mg/L	Medium	Medium	Medium	High
≥ 50 mg/L	High	High	High	High
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	≥ 200 < 400 gpm	≥ 400 < 800 gpm	≥ 800 < 1600 gpm	≥ 1600 gpm
< 5 mg/L	Medium	Medium	Medium	High
≥ 5 but < 15 mg/L	Medium	High	High	High
≥ 15 < 25 mg/L	High	High	High	High
≥ 25 < 50 mg/L	High	High	High	High
≥ 50 mg/L	High	High	High	High

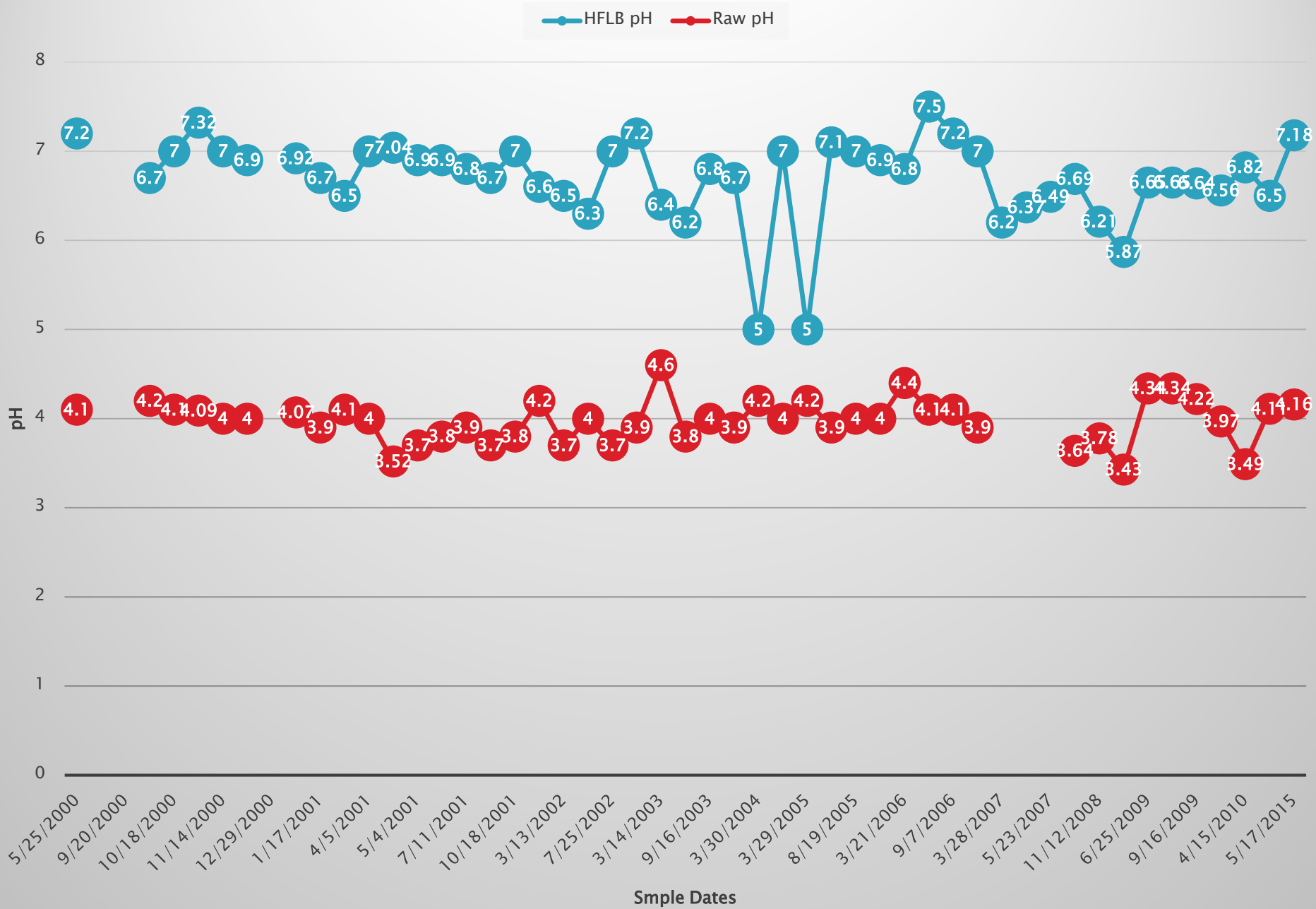


DE SALE RESTORATION AREA - PHASE I

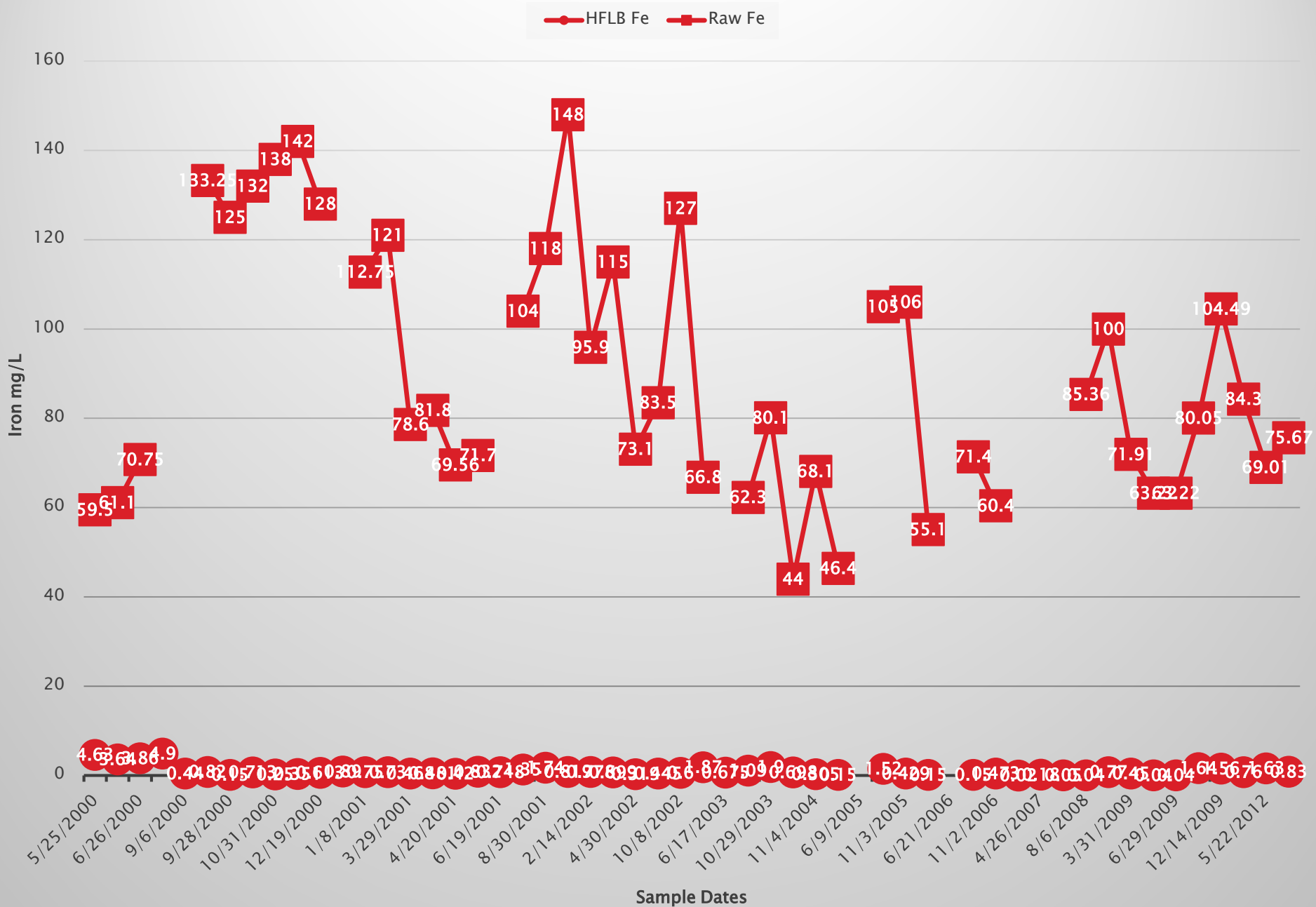
Stream Restoration Incorporated
 Venango Township, Butler County, PA
 January 2007, Scale 1" = 60'



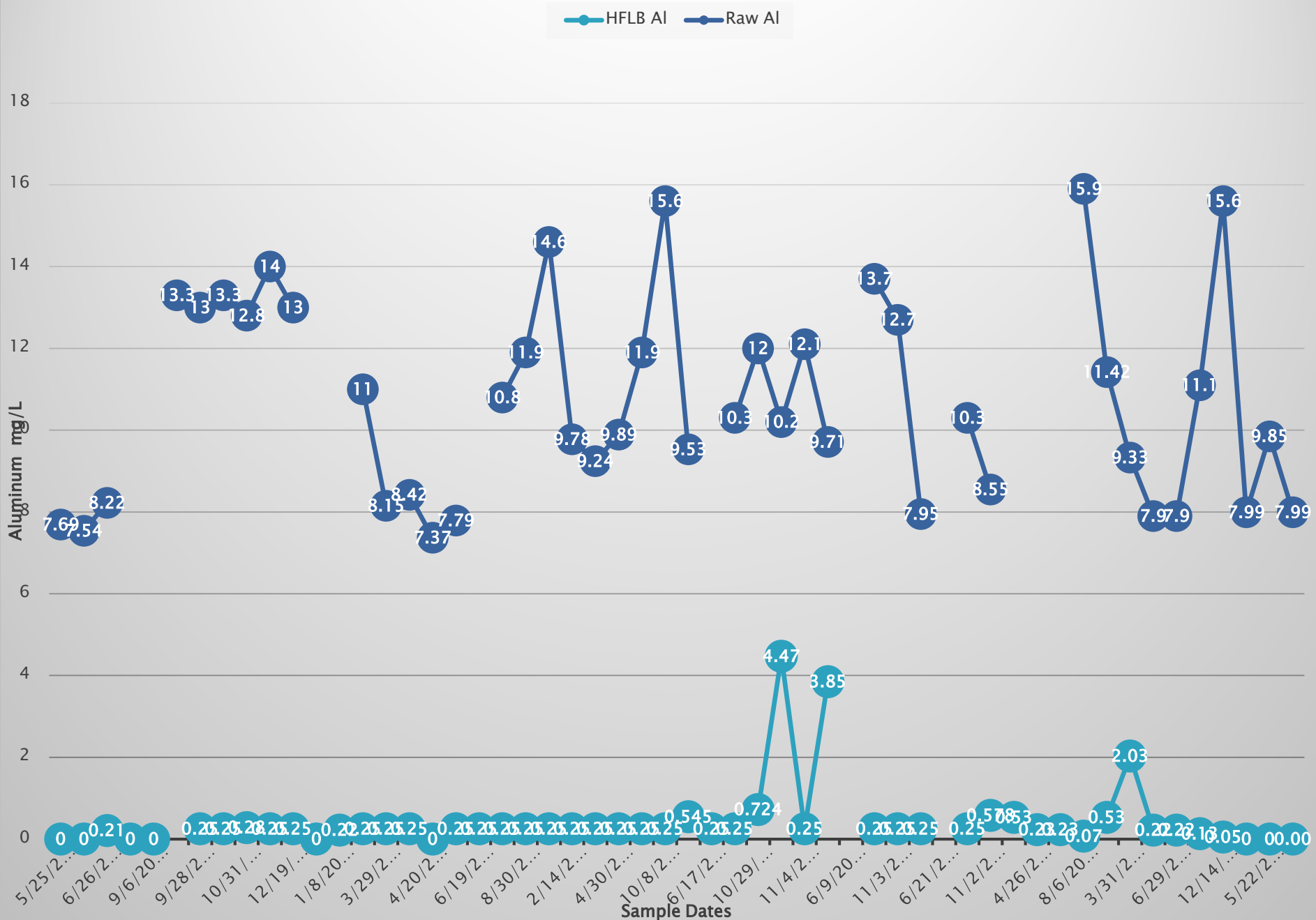
De Sale 1 pH (2000–2015)



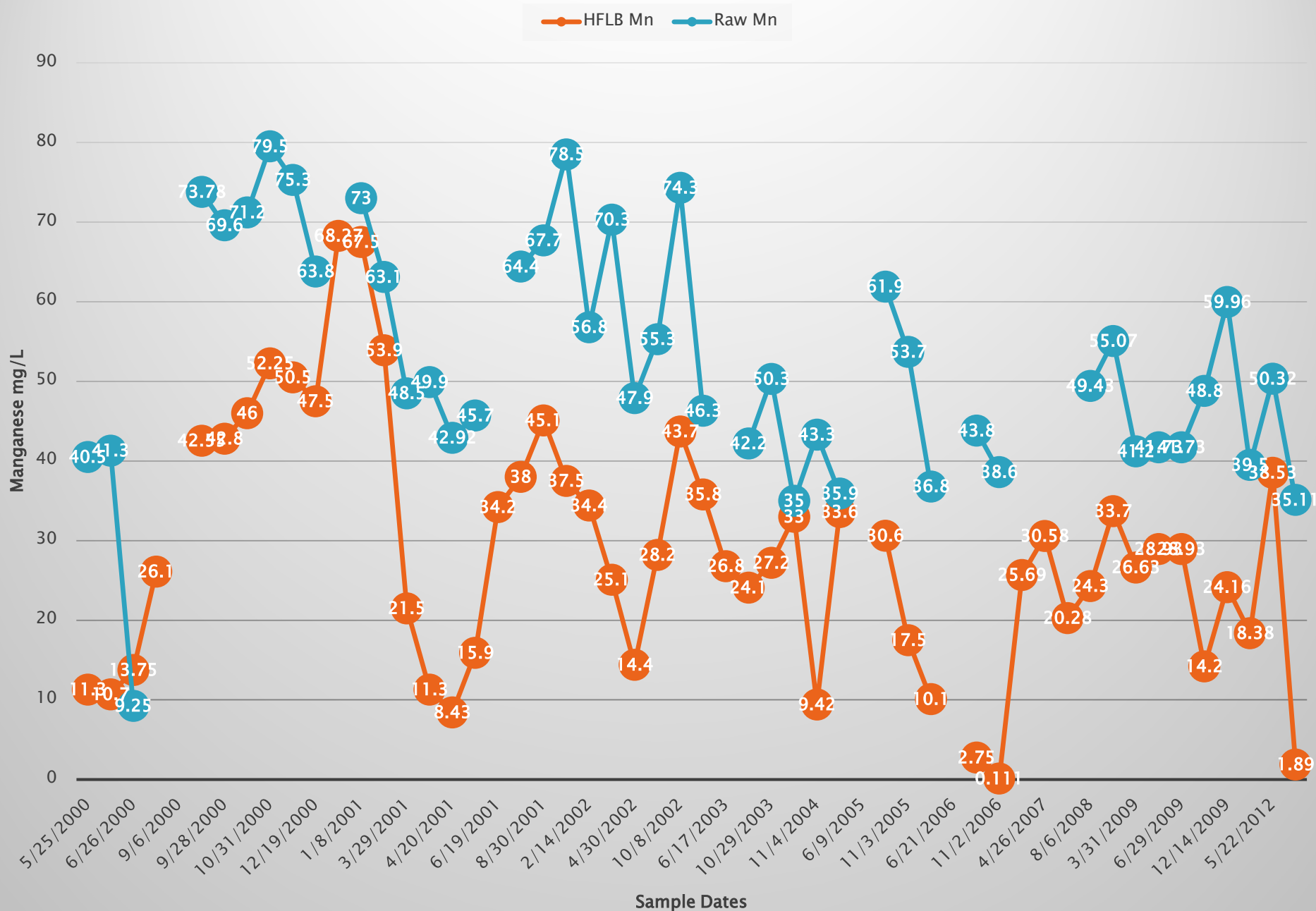
De Sale 1 Total Iron mg/L (2000 – 2015)



De Sale 1 Total Aluminum mg/L (2000 – 2015)



De Sale 1 Total Manganese mg/L (2000–2015)



De Sale Phase 1

	Flow (gpm)	pH (s.u.)	Acid (mg/L)	Alk (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Raw	36	4.1	319	NA	82	55	12
Forbay N	10	3.3	201	NA	20	40	11
Forbay S	21	3.4	228	NA	48	42	10





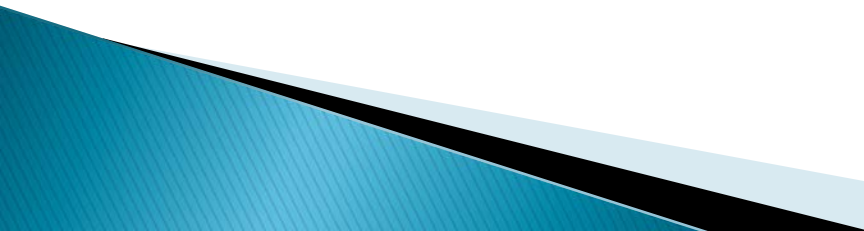
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De Sale 1 O&M & Upgrades

Upgrades

- Installed Forebay
- Replaced VFP Outlet Pipes to adjustable peri-pipes
- Inlet & Outlet pools in HFLB

O&M

- ▶ Flushing/Backflushing
 - ▶ Cleaning out low pH iron from pipes
 - ▶ Removed low pH iron from top of VFPs
 - ▶ Stirred top layer of VFP treatment media
 - ▶ Stirred HFLB
- 

De Sale Phase 1

Constructed 1999 (17 Years Old)

Cost \$391,000

Upgrades Cost ~\$10,000

O&M Costs ~\$8,000

Volunteer = \$?

O&M Annualized ~\$500/year

	Flow (gpm)	pH (s.u.)	Acid (mg/L)	Alk (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Raw	36	4.1	319	NA	82	55	12
Treated	44	6.6	-2	81	1	31	<1

DE SALE RESTORATION AREA - PHASE II

Stream Restoration Incorporated
 Venango Township, Butler County, PA
 January 2007, Scale 1" = 120'



DISCHARGE PIPES

PIPE #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LAYER	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
QUADRANT	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
VFH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

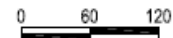
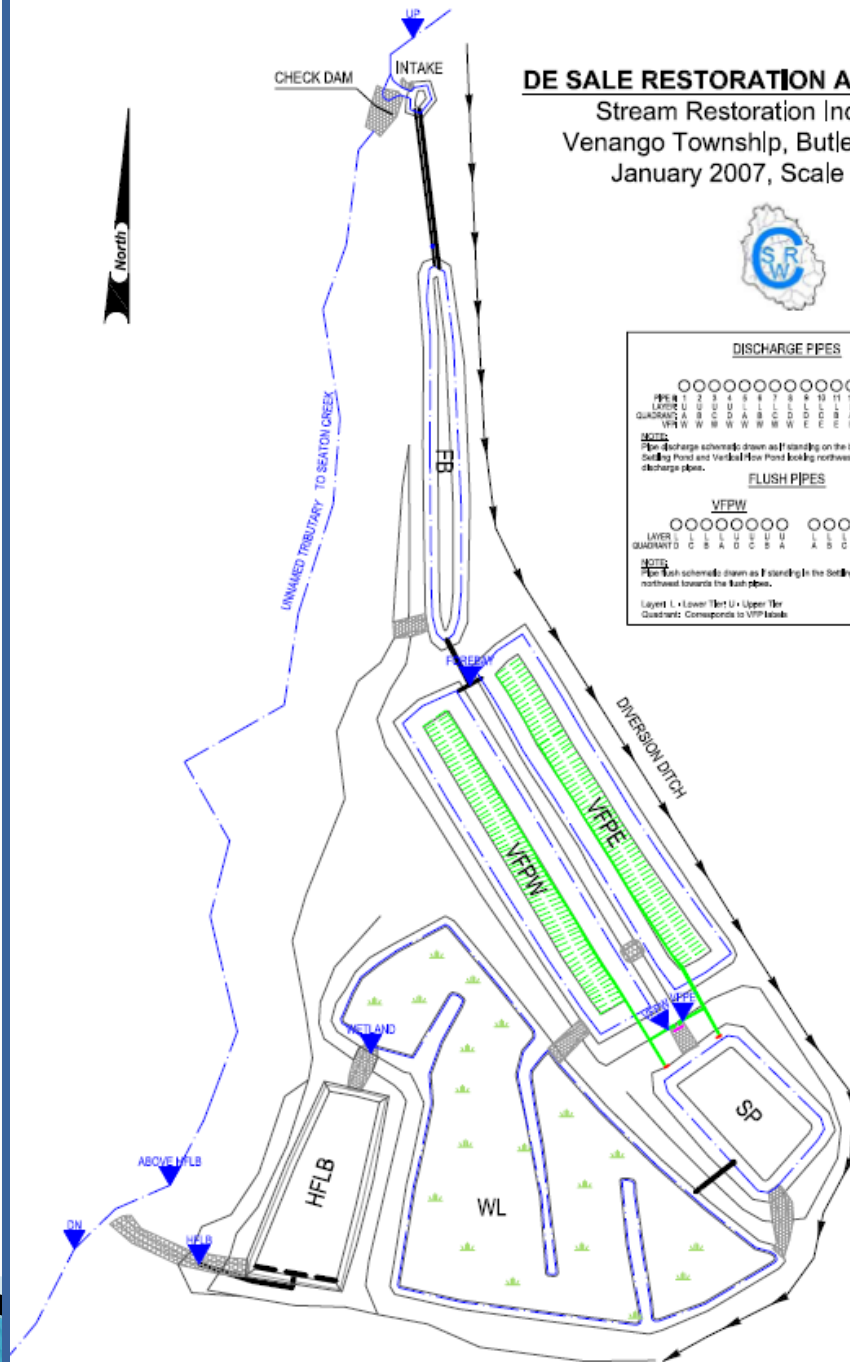
NOTE:
 The discharge schematic is drawn as if standing on the berm between the Settling Pond and Vertical Flow Pond looking northwest towards the discharge pipes.

FLUSH PIPES

VFPW										VFPE									
LAYER	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
QUADRANT	C	B	A	D	C	E	C	E	A	A	B	C	D	A	D	C	E	C	E

NOTE:
 The flush schematic is drawn as if standing in the Settling Pond looking northwest towards the flush pipes.

Layer L = Lower Tier U = Upper Tier
 Quadrant: Corresponds to VFP labels



ACCESS ROAD

De Sale Phase 2

	Flow (gpm)	pH (s.u.)	Acid (mg/L)	Alk (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Raw	135	3.2	257	NA	26	55	10
Treated	135	6.3	-1	74	<1	25	<1

Table 1 – Risk Analysis Matrix for Category (4) Passive Treatment Systems

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Risk Analysis Matrix				
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	< 25 gpm	≥ 25 < 50 gpm	≥ 50 < 100 gpm	≥ 100 < 200 gpm
< 5 mg/L	Low	Low	Low	Low
≥ 5 but < 15 mg/L	Low	Medium	Medium	Medium
≥ 15 < 25 mg/L	Low	Medium	Medium	Medium
≥ 25 < 50 mg/L	Medium	Medium	Medium	High
≥ 50 mg/L	High	High	High	High
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	≥ 200 < 400 gpm	≥ 400 < 800 gpm	≥ 800 < 1600 gpm	≥ 1600 gpm
< 5 mg/L	Medium	Medium	Medium	High
≥ 5 but < 15 mg/L	Medium	High	High	High
≥ 15 < 25 mg/L	High	High	High	High
≥ 25 < 50 mg/L	High	High	High	High
≥ 50 mg/L	High	High	High	High

DIPPIN' &
FLIPPIN'



09.06.2007 14:42



Opportunity!

Clean Stone

Clogged Stone

9/10/2007 15:30

De Sale II- Vertical Flow Pond



De Sale II– History/Maintenance

- ▶ WL outlet cleared of vegetation
- ▶ HFLB stone re-leveled
- ▶ VFP outlet spillway cleared of vegetation buildup



De Sale II– Recent Maintenance

- ▶ Forebay pipe inlet clogged



De Sale II-Forebay



De Sale II- Vertical Flow Pond



De Sale II- Vertical Flow Pond



De Sale II– Recent Maintenance

- ▶ VFP performance decreased



O&M– De Sale II

Pre- and Post- O&M Effluent Field Water Quality Data



Parameter	Pre- O&M	Post- O&M
pH	6.0	6.9
alkalinity	20	~70
Fe (mg/l)	4-8	0.5 - 1

Total metals mg/L, acidity and
alkalinity as CaCO₃ mg/L

Constructed 2000 (16 Years Old)
Cost \$411,000
Upgrades Cost ~\$6,000
O&M Costs ~\$40,000
Volunteer = \$?
O&M Annualized ~\$2,900/year

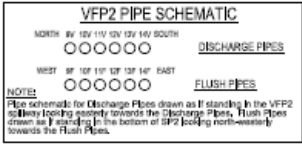
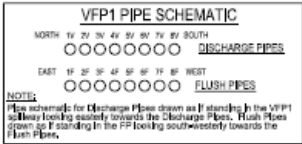
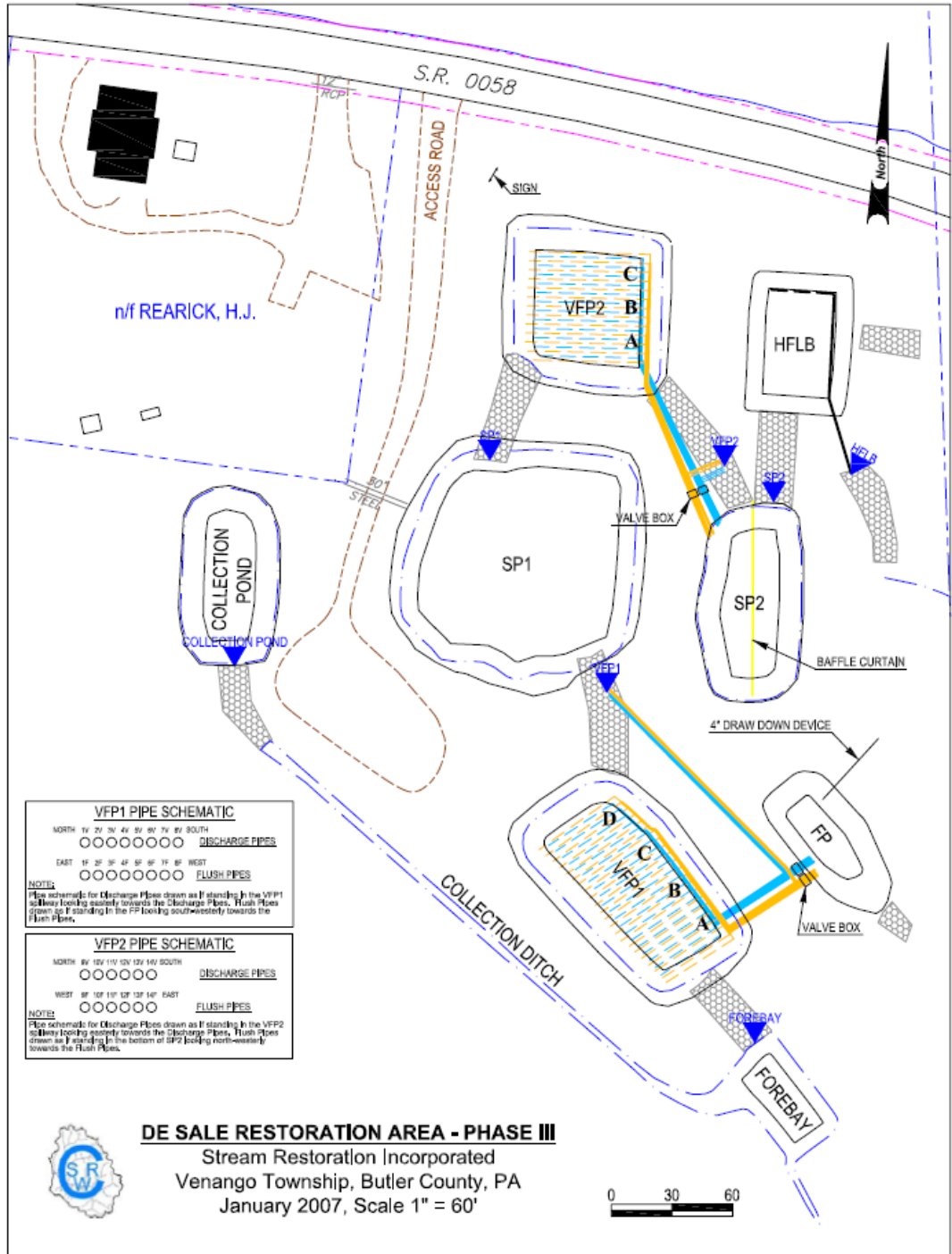


De Sale Phase 3

	Flow (gpm)	pH (s.u.)	Acid (mg/L)	Alk (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
Forebay	12	3.1	509	NA	107	107	29
Treated	13	6.9	30	64	<1	53	<1

Table 1 – Risk Analysis Matrix for Category (4) Passive Treatment Systems

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≥ 15 < 25 mg/L	Low	Medium	Medium	Medium
≥ 25 < 50 mg/L	Medium	Medium	Medium	High
≥ 50 mg/L	High	High	High	High
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	≥ 200 < 400 gpm	≥ 400 < 800 gpm	≥ 800 < 1600 gpm	≥ 1600 gpm
< 5 mg/L	Medium	Medium	Medium	High
≥ 5 but < 15 mg/L	Medium	High	High	High
≥ 15 < 25 mg/L	High	High	High	High
≥ 25 < 50 mg/L	High	High	High	High
≥ 50 mg/L	High	High	High	High



DE SALE RESTORATION AREA - PHASE III
 Stream Restoration Incorporated
 Venango Township, Butler County, PA
 January 2007, Scale 1" = 60'

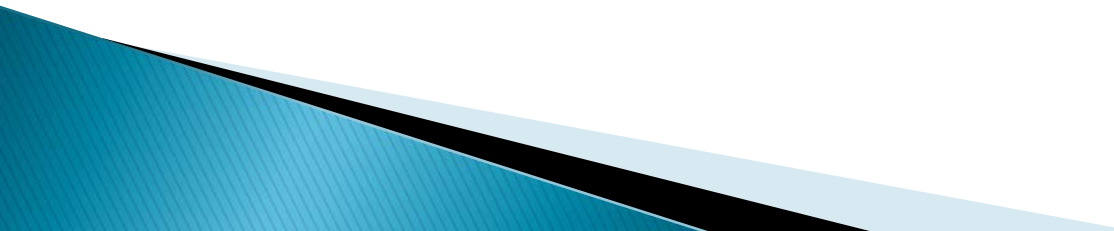


De Sale Phase 3

Constructed 2002 (~14 Years Old)

10/14/2002 14:37

De Sale 3 O&M

- ▶ Replace baffle curtain
 - ▶ Vegetation over growth
 - ▶ Flushing of VFPs
 - ▶ Removed Fe off of VFP & stirred VFP
 - ▶ Backflushed & Stirred HFLB
 - ▶ Fixed access road entry
- 

VFP1 Maintenance



VFP1 Maintenance



Access Road Maintenance



De Sale Phase 3

Constructed 2002 (14 Years Old)

Cost \$213,000

Upgrades Cost ~\$0

O&M Costs ~\$7,000

Volunteer = \$?

O&M Annualized ~\$500/year

Seaton Creek

	48		19.1		68.1	
	1995	2015	1996	2015	1995	2015
pH	5.2	7.1	4.5	7.4	6.0	7.3
Alk	11	30	7	69	18	47
Acid	89	-19	63	-54	10.2	-31
T. Fe	1.0	0.6	5.6	1.0	1.0	1.1
D. Fe		0.2		0.7		0.2
T. Mn	21.9	2.7	15.7	1.0	9.6	2.8
D. Mn		2.6		1.0		2.8
T. Al	6.1	<0.1	1.0	<0.1	0.6	<0.1
D. Al		<0.1		<0.1		<0.1



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Take Home Message

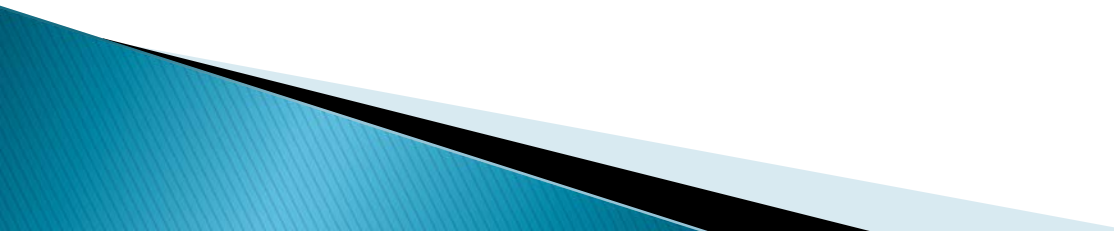
- ▶ High Risk (High Metal) AMD can be passively treated **IF**
 - Good Design
 - Sufficient Site Conditions
 - Area
 - Elevation Change
 - Proper Construction
 - Maintained

Take Home Message

- ▶ Passive treatment is not maintenance free;
- ▶ Like a car, regular inspections and occasional maintenance are needed for a treatment system to reach it's design life;



Take Home Message

- ▶ Poor water quality does not always mean the system is a failure or has reached its design life;
 - ▶ Treatment performance can often be restored through maintenance activities that rejuvenate the system instead of replacing the treatment media or rebuilding the system and thus saving money;
- 

Questions?

