AN EVALUATION OF PASSIVE TREATMENT SYSTEMS RECEIVING OXIC NET ACIDIC MINE DRAINAGE

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Executive Summary

1. In a survey by the Bureau of Abandoned Mine Reclamation (BAMR) of DEP in 2009-10, a disturbing number of publically funded passive AMD treatments systems discharged acid effluent. This DEP survey defined "Failure" as discharging effluent with positive hot peroxide acidity. Effluent was acid not only at systems classified as High Risk using the earlier BAMR Risk Matrix, but also at Medium and Low Risk sites. The present followup investigation is intended to determine reasons for these failures and to compare characteristics of successful systems with the systems discharging acid water.

2. The current investigation consists of a more detailed study of 10 "failed" High Risk systems, 4 "failed" Medium Risk systems, 4 "failed" Low Risk systems and 5 successful Medium and High Risk systems, with most selected at random from sites designed since development of improved sizing guidelines in 2002. Available information on the design, construction and performance of the systems was collected, most were visited and sampled, and the systems were discussed with the local group and designers.

3. At 2 High Risk "failures" (AMD&Art, Webster), the design was poor and did not meet design standards known at the time they were designed. At 3 other sites (Metro, SX0-D6, Clinton Road), the design appears inadequate for the influent AMD, though at SX0-D6 the problem was insufficient space. At 2 sites (Avery, Klondike), problems during construction appear to have degraded system performance. Three sites (AMD & Art, Metro, Webster) have lacked maintenance that would have greatly improved their performance, and at 2 others (Avery, Yellow Creek 2A) the maintenance has been inadequate. At 6 systems (DeSale 1, Kalp, Yellow Cr. 2A, Bear Rock Run, Robbins, McKinley), the sample sites in the DEP survey did not represent the system performance or the use of a net acid failure criterion gave misleading results. At 2 sites (AMD &Art, Harbison-Walker 2), sampling is either lacking or inadequate.

4. At 11 of the 18 "failed" sites, the treatment systems removed 89 to 100% of the influent acidity in the 2008-13 period, and at most, the remaining acidity was Mn acidity which is not a serious problem. Two systems (Metro, Webster), both poorly designed for their influent AMD, accomplished very little treatment. Three systems (Klondike, Cessna, Robbins) removed moderate (69-73%) proportions of the influent acidity and at one (Avery) data is ambiguous on performance. Thus, although the systems were designated as "failures", more than half performed reasonably at removing acidity.

5. At 5 "failing" sites (DeSale 1, Finleyville, LR0-D2, SX0-D6, Robbins), the receiving streams

have essentially recovered and have fish because of the effectiveness of the investigated systems plus one or more other systems in the watershed. These streams are being considered for removal from the 303d list. At 2 other sites (MR Frog, Bear Rock Run), the stream appears to be largely recovered. Although an individual system may release slightly acidic water, the combined effects of several treatment systems in a watershed can lead to stream recovery.

6. The cost of acidity removal by passive systems, based on several studies and models, is generally less than the cost of removal by active systems. Most of the passive systems remove acidity for less than \$1000/ton (as $CaCO_3$). The median cost for the systems of this study is \$702/metric ton of acidity removed. Four systems with small flow have higher costs, but would be high for active systems also. In contrast, costs using lime or caustic are \$1200/ton and higher. Thus, treatment by passive systems that are well designed and constructed, and are well maintained is considerably less than the alternative. Also, active systems are not perfect and sometimes release water exceeding discharge standards. Another problem is funding of active systems – several State active treatment plants have been abandoned for lack of funds.

7. It is recommended that the State continue to provide funding for construction and maintenance of passive systems but oversight should be considerably improved to ensure good designs and preserve the value of the systems. Watershed Managers should be supported full time to monitor and coordinate treatment systems, and DEP staff should greatly increase their expertise in evaluation of passive systems so that proposals for passive treatment systems have adequate designs. Funding for repairs and renovations of passive systems, as by TAG grants and Quick Response programs, should continue and be improved. In this way, the state will spend funds for AMD treatment in the most effective manner.

8. The negative points in the DEP evaluation scheme for ranking passive treatment proposals should be eliminated or greatly reduced. This evaluation plan makes it almost impossible to fund treatment for discharges in the High Risk category. Instead, the DEP should carefully evaluate proposals and should conduct continuous oversight to ensure that successful systems are built and are maintained. The successful systems discussed here show that passive systems can be successful on even very acidic and metal-rich water.

Introduction

In 2009-10, the BAMR of PA Department of Environmental Protection (DEP) conducted an evaluation of passive treatment systems for acid mine drainage (AMD). The goal was to obtain data on which to base future plans and funding for remediation of mine drainage discharges treating acid AMD containing appreciable ferric Fe or Al. An incentive for the study was the failure of many passive systems to completely treat their influent AMD. Previous work had developed a "Risk Matrix" for evaluating passive systems of this type, and it was desired to further evaluate this matrix. Systems were classified as High, Medium or Low Risk depending on a combination of flow rate and sum of Fe and Al concentrations in the influent (Figure 1). High Risk systems were assigned large negative points in the evaluation system (BAMR, 2009). This evaluation system made funding for High Risk discharges nearly impossible to obtain from AML sources.

The study covered about 150 passive treatment sites in Pennsylvania that had been built by public funds, such as Growing Greener or EPA 319. Sites were sampled on 2 dates, once in a low flow period in fall 2009 and once in a higher flow period in spring 2010. As a simple criterion, the sites were considered "failures" if the hot peroxide acidity of the effluent at either sampling date was positive.

Figure 1. DEP Risk Analysis Matrix (2009)

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

Table 1. Numbers of Alkaline and Acid Sites in DEP 2009-10 Study

				All years	Post-2004				Pre-2004
Risk Level	**Total**	**Pre-2004**	**Post-2004**	**% "Failure'**	**Acid**	**Alkaline**	**Uncertain**	**% "Failure'**	**%"Failure"**
High	53	30	23	52	9	12	2	39	67
Medium	45	28	17	40	7	10	0	41	39
Low	39	15	24	26	6	16	2	25	27
"Failure" = positive effluent acidity									

A tabular summary of the results as evaluated by the committee is listed in Appendix A. Table 1 summarizes the results of the DEP study. According to the criterion of net alkalinity, about 52% of the High Risk systems were said to have "failed", and about 40% of the Medium and 26% of the Low Risk systems "failed". This level of "failure" was surprising and shocking, considering that numerous successful systems were known, and was the incentive for this further study. The high proportion of failures is particularly surprising in the Medium and Low Risk categories, and suggests serious problems in applying the concepts underlying passive treatment technology.

Examination of the data for different time periods shows that the High Risk systems built before 2004 have a much higher failure rate of 67%. Part of this difference is perhaps due to deterioration with increasing age, but some is certainly due to use of incorrect sizing criteria prior to about 2003. Rose and Dietz (2002) showed that the 12-20 hr. retention time guideline used for most systems up to that date was inadequate for many systems, and that an areal acidity loading of 25-40 $g/m^2/d$ gave much better results. Rose (2006) showed that many of the older failed systems were too small based on acidity loading. If only systems built in 2004 and later are considered, only 39% of High Risk systems “failed”, as did lower percentages of Medium and Low Risk systems.

Nevertheless, the very significant level of poor performance is discouraging, and leads to the question as to why so many systems are unsuccessful, and what can be done to improve the passive treatment technology.

In this study, a group of about 25 sites was chosen for more detailed investigation. The goal was to gain a better understanding of the causes for “failure” vs. success. The approach is to investigate “failed” systems to identify the cause of “failure” and to identify key factors in successful systems.

Selection of Systems for Study

The systems for study were chosen mainly from the list of 150 studied systems, based on the following guidelines:

1. Ten High Risk Failures, 5 Medium Risk Failures and 5 Low Risk Failures were sought.

2. Five High and Medium Risk Successes were selected to compare design and construction features with the failures.

3. Most of the chosen “failing” systems were from those constructed after 2003, on the basis that Rose and Dietz (2002) showed that the previous sizing guideline for vertical flow ponds (12-20 hrs. retention time in limestone) was not relevant, and that an areal acidity loading of 35-40 $g/m^2/d$ gave much better results. Systems less than about 5 years old were also avoided because of a short history.

4. Some attempt was made to include systems with Limestone Ponds and Bioreactors as well as Vertical Flow Ponds.

5. Systems were all from the bituminous districts, because the characteristics of very high high flow and much lower metal concentrations in the anthracite region seemed to complicate understanding.

The systems were chosen largely randomly from the group fitting the above characteristics, though with some attempt to select sites with a wide distribution in geography and designer. Some systems were rejected because there did not seem to be enough information available. The DeSale 1, Harbison-Walker 2 and McKinley systems, constructed before 2003, were included because they were thought to have been performing generally well, yet turned up on the “failure” list.

Table 2 lists the chosen systems. Only 4 Medium Risk and 4 Low Risk systems seemed to have good information and characteristics for study. The location of the sites is shown on a map of the state (Figure 2).

Some Definitions and Concepts

The following discusses some terms and concepts used in this report.

Acidity and Alkalinity The Acidity data used here are all hot peroxide acidity values as specified by the PA DEP for mine drainage studies (APHA 1998; USEPA, 1979). Negative acidity values are used rather than reporting zero if the contribution from the initial titration down to pH 4 exceeds the acidity titration to pH 8.2. All acidity concentrations are in mg/L of $CaCO_3$, though for brevity $CaCO_3$ is not stated in the tables. A positive acidity is “net acid”, and a negative acidity is “net alkaline”. This relation

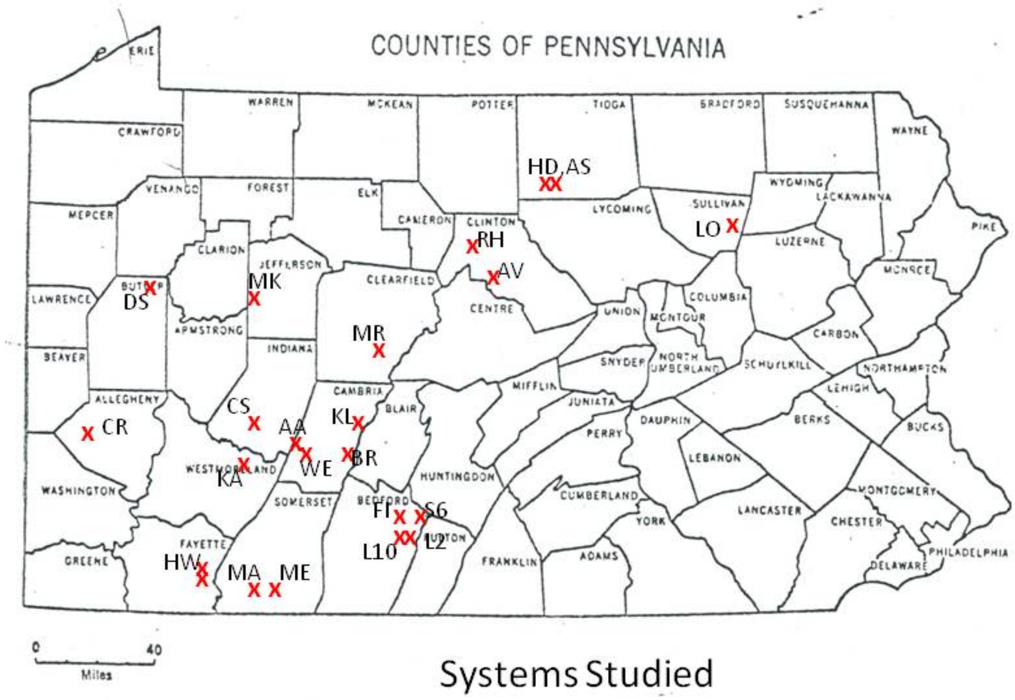

Figure 2. Location of passive systems studied. AA=AMD&Art, AS= Anna S, AV=Avery, BR=Bear Rock Run, CR=Clinton Road, CS=Cessna Run, DS=DeSale 1, FI=Finleyville, HD=Hunters Drift, HW=Harbison-Walker 1 & 2, KA=Kalp, KL=Klondike-1, LO=Loyalsock, L2=LR0-D2, L10=LR0D10, MA=Maust, ME=Metro, MK=McKinley, MR=MR Frog, RH=Robbins Hollow, WE=Webster.

Table 2. Sites Selected for Evaluation				
High Risk-Failure				
Site	County	Built	Effluent	Types
YELLOW CREEK 2A BIO RE/	Indiana	2002	Acid	Bioreactor
WEBSTER	Cambria	2004	Acid	2 VFP's
Finleyville	Bedford	2005	Acid	4 Ls beds, flushers
Kalp Discharge	Fayette	2007	Acid	Ls bed, 2 VFP's
Klondike KL-1	Cambria	2007	Acid	VFP
Avery Big Run	Centre	2005	Acid?	Ls bed, VFP
AMD & Art	Cambria	2004	Acid	Anoxic wetlands, VFP
Harbison Walker II	Fayette	2000	Acid	VFP's, LS beds, Wetlands
DeSale I	Butler	2000	Acid	2 VFP's, HFLB
Metro	Somerset	2003	Acid	2 VFP's
High Risk-Success				
Hunters Drift	Tioga	2004	Alk	4 VFP's
Maust	Somerset	1998	Alk	2 VFP's
Anna S	Tioga	2004	Alk	4 VFP's
Loyalsock C Vein #3	Sullivan	2005	Alk	1 VFP
Harbison Walker I	Fayette	1999	Alk	ALD, VFP
Medium Risk-Failure				
Longs Run LRO-D2	Bedford	2005	Acid	Upflow Ls bed, siphon
MR FrOG B	Clearfield	2008	Acid	Ls bed
Six Mile Run SXO-D6	Bedford	2008	Acid	VFP with siphon
Clinton Road	Allegheny	2004	Acid	2 VFP's
Low Risk -Failure				
Cessna Run	Indiana	2005	Acid?	2 upflow Ls beds
Robbins	Clinton	2005	Acid	2 Limestone beds
Bear Rock Run	Cambria	2009	Acid?	HFLB and wetland
McKinley	Jefferson	1996	Acid	VFP

reflects the fact the hot peroxide acidity procedure includes an initial step of titration down to pH 4 that amounts to an alkalinity titration; this initial "alkalinity" is then subtracted from the following acidity results to obtain the reported acidity value. Alkalinity is usually a lab measurement but may be a field measurement, and involves titration down to pH 4.5 or 4. Net acidity and alkalinity are not determined as the difference of acidity and alkalinity, in contrast to some state regulations.

Metal concentrations The reported metal concentrations are nearly all total concentrations, and may include some suspended Fe, Mn or Al precipitate.

Vertical Flow Pond A Vertical Flow Pond is a pond with a layer of limestone fragments in the bottom, overlain by an organic layer of compost and other materials, and then by water (Figure 3). An underdrain of perforated pipes lies in the limestone layer and allows AMD to flow down through the compost and limestone layers, and then out through the underdrain and a standpipe or water level control unit at a level slightly below the water level in the pond. The organic matter reduces the oxidation state of the AMD, removing O_2 and converting ferric iron to ferrous iron and possibly some SO_4 to H_2S, generating some alkalinity in the process. The limestone then acts to neutralize the remaining acidity and provide net alkalinity. This type is also called a SAPS (Successive Alkalinity Producing System) or a Vertical Flow Wetland. The Vertical Flow Pond may be flushable (see below).

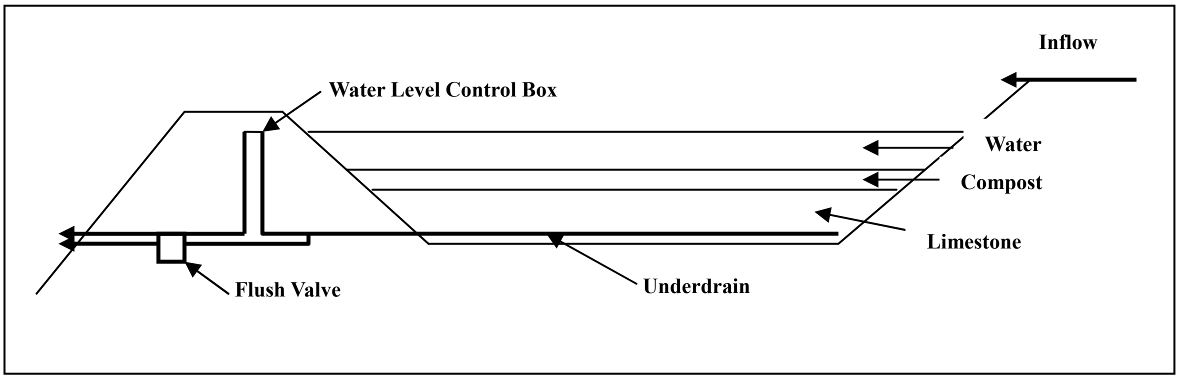

Figure 3. Diagram of Vertical Flow Pond.

Bioreactor A bioreactor is similar to a Vertical Flow Pond except that the limestone and compost are mixed into a single thick layer, possibly underlain by a thinner layer of limestone or sandstone containing the underdrain. This design appears to function better with high-Al AMD.

Limestone Pond or Limestone Bed This type of system is composed completely of limestone fragments. The AMD may flow in at the surface of the bed and out the bottom (downflow type) or flow in at the bottom of the bed (upflow type) and overflow from the top. Most limestone beds are flushable. An additional type of limestone bed is a Horizontal Flow Limestone Bed (HFLB), usually used to remove Mn after Fe and Al have been removed.

Flushable system Several types of flushing are possible. The purpose of flushing is to remove the accumulated Al and perhaps Fe precipitate that has accumulated in the limestone and possibly in the compost layers. The flushing may be manual, in which a large valve is manually opened on the underdrain every month or so. Tests indicate that manual flushing removes only 5% or less of the accumulating Al precipitate and is not very effective. A second technology is a siphon, which flushes when the water level in the limestone bed or pond reaches a maximum level, and flushes the system down several feet until the siphon breaks, flushing out precipitate from the limestone bed in the process. A third method is an automatic flushing system (Agridrain), which uses a small computer and a solar cell to time the opening of a large valve on the underdrain. Initial manual flushing systems were typically flushed only an hour or less, until obvious suspended material diminished. Some recent systems flush a limestone bed all the way to the bottom, to clean the entire limestone layer (Weaver et al., 2004).

Methods of Investigation and Data Sources

In general, the intent has been to acquire all the information that can be easily obtained on the sites. A primary source of information has been the Datashed website www.datashed.org. This database has provided information on location, date of construction, designer, responsible local group, current contacts, maps and diagrams of the system, sample points, water sampling data, reports on the system and other information. The website includes much data from sampling by the state, as well as by local groups. At most sites it includes the 2009 and 2010 sampling for the DEP survey. When the current project was first considered, there appeared to be major gaps in the data in Datashed, but that was almost completely remedied by the time work started seriously. This website is the source of much of the information listed on the SUMMARY SHEET for each project, as found in Appendix B.

Nearly all sites were visited during the project, between May and September 2013. DeSale 1 and McKinley were not visited during the study, but had been visited previously. Avery was not visited but is the subject of a recent report by Hedin Environmental.

At each site, the various ponds and other treatment units were inspected, field measurements of flow, pH, alkalinity, temperature, specific conductance and other water measurements were made at numerous points, and samples were collected for lab analysis from several points in the system. The samples were submitted and analyzed in the DEP labs for a suite of mine drainage parameters: pH, hot acidity, alkalinity, total Fe, Mn Al, SO_4, ferrous iron, total dissolved solids, and total suspended sediment. Flow was measured at previously installed weirs or with a bucket and stop watch method. At some sites it was difficult to obtain a good flow value, and more emphasis should be placed in designing systems so that flow can be easily measured at several locations.

For most sites, the local group was contacted and the site discussed with them, and with the engineer designing the site. Aspects of the design, problems, maintenance and operation were discussed with these people.

For each system, a SUMMARY SHEET was prepared with basic data on the 23 systems, including average influent and effluent water chemistry for the period 2008-2013 (Appendix B). Also in this Appendix are a short DESCRIPTION and discussion of the system and of its problems and crucial features, as well as a map of the system and its sample points, and the water quality data for the period 2008-2013. The 2008-13 period was considered to represent the medium-term functioning of the system.

In a few cases, the system can be classified as a success from the 2008-13 data, but one of the 2009-10 effluents was acid, so the classifications differ.

Discussion of Systems

Tables 3, 4 and 5 summarize evaluation of the "failed" systems. Table 3 highlights sources of problems at sites and rates overall performance and maintenance.

Table 3	Summary of Characteristics and Problems						
System	**Design**	**Constr.**	**Maint.**	**Sampling**	**Perform. (%*)**	**Stream**	**Type**
AMD & Art	**Poor**		**Lacking**	**Lacking**	**Unclear (??)**		AW,VFP
Avery		**Problems**	**Inadeq.**		**Unclear (100?)**		LS,VFP
DeSale 1			Good	**Misleading**	**Good (99)**	**Recov.**	VFP,HFLB
Finleyville			Good		**Good (91)**	**Recov.**	LS,VFP
Harb-Walk. 2			Fair	**Lacking?**	**Poor (??)**		VFP, LS
Kalp			Good	**Misleading**	**Good (100?)**	?	LS,VFP
Klondike 1		**Problems**	Good		**Fair (73)**		VFP
Metro	**Inadeq.**		**Lacking**		**Poor (18)**		VFP
Webster	**Poor**		**Lacking**		**Poor (37)**		VFP
Yellow Cr.			**Inadeq.**	**Misleading**	**Fair (100)**		Bio
Long Run LR0D2	Unclear		Good		**Unclear (92?)**	**Recov.?**	LS
Six Mile SX0D6			Good		**Fair (92)**	**Recov.?**	VFP
MR Frog	Unclear	Unclear	**Unclear**		**Fair (100?)**	**Recov.?**	LS. AW?
Clinton Road	**Inadeq.**		Fair		**Fair (100?)**		LS
Cessna Run			Fair		**Good (69)**	?	LS
Robbins			Good	**Misleading**	**Good (70)**	**Recov**	LS
Bear Rock Run			Fair	**Misleading**	**Good (100)**	**Recov**	LS
McKinley			Good	**Misleading**	**Good (89)**	**?**	VFP
*% acidity removal 2008-13							
BIO, bioreactor; VFP, vertical flow pond; AW, anoxic wetland; LS, limestone bed;							
	HFLB, horizontal flow limestone bed						

Table 4 summarizes available data on influent and effluent water chemistry. Note that for some systems, very little data exists for the period 2008-13. Also, some systems include two or more units, which are shown as weighted averages in this compilation. The data is derived from the more detailed compilations in Appendix B.

Table 5 briefly describes problems and accomplishments at the systems.

The writer had previously evaluated about 30 other passive treatment systems, and it was intended that some of these would be re-studied and discussed in this report, but time has not allowed this. The previous studies are discussed in Rose and Dietz (2002), Rose (2004), Rose (2006), and other papers.

Based on this information and that in Appendix B, the various types of problems degrading the performance of the systems are discussed.

Table 4.	Average chemistry of inflow and outflow of systems														
		Inflow						Outflow							
Site	Flow	pH	Acidity	Alkal.	Fe	Mn	Al	pH	Acidity	Alkal.	Fe	Mn	Al	N	Built
	gal/min		mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	mg/L		
High Risk "Failures"															
AMD & Art	210	3.3	352	0	17	2.2	31	6.6	-38	111	46	5.6	2.5	1	2004
Avery	190	2.9	355	0	40	66	19	7.2	-76	102	22	18	0.2	3	2004
DeSale 1	31	4	250	0	80	48	11	6.5	3	32	0.8	26	0.5	9	2000
Finleyville	303	3.1	149	0	2.5	1.6	14.5	5.2	14	10	0.5	0.8	4.6	7	2005
Klondike KL-1	24	3	357	0	120	37	2	3.8	98	0	13	28	1.3	60	2007
Harbison Walker 2	35	3.4	373	0	1.9	28	70	6.2	-96	30	2	23	2	1	2000
Kalp	460	3.1	164	0	22	1.8	10	6.3	-8.1	24	0.9	1.8	1.5	25	2007
Metro	53	3	629	0	120	18	49	2.8	516	0	60	38	38	3	2003
Webster	480	2.8	326	0	23	4.8	34	3.4	206	1	13	5	25	35	2004
Yellow Creek 2A	12	2.8	451	0	40	3.8	43	6.9	-192	228	7	2.7	1.1	21	2004/09
Low (L) and Med.(M) Risk "Failure"															
Bear Rock Run(L)	33	4.9	8		2.2	0.5	0.4	6.2	-14	11	0.2	0.4	0.2	3	1998
Cessna Run (L)	111	3.8	70	0	1	17	4	5.2	29	8	3	10	2.1	8	2005
Clinton Road (M)	27	2.9	423	0	8	8	47	5.3	-87	144	41	13	4	1	2006
Long Run LR0-D2 (M)	30	3.8	142	0	13	1.7	11	4.6	12	2	0.9	0.9	1.3	1	2005
McKinley 1 (L)	15	3.9	81	0	0.5	34	3.4	6.3	9	29	1.2	16	1.9	3	1996
MR Frog (M)	86	3.7	44	0	0.5	3.1	3.7	7.2	-68	94	0.9	0.4	0.4	3	2008
Robbins Hollow (L)	11	3.5	126	0	0.3	1.7	20	5.3	39	12	12	5	6	7	2005
Six Mile Run SX0-D6 (M)	23	3.1	366	0	51	2.5	32	5.3	29	8	3.4	1.8	3.2	5	2008
Successes															
Anna S (H)	203	3.3	113	0	5.1	7.7	10.4	7.3	-99	120	1.2	2.9	0.3	13	2004
Hunters Drift (H)	208	2.8	349	0	37	7	37	7.2	-95	116	0.4	2.7	0.2	15	2004
Harbison Walker 1 (H)	14	4.5	177	1	89	20	0	7.2	-12	27	0.2	8	0	3	1999
Longs Run LR0-D10	20	3.2	442	0	145	5.4	10.1	6.7	-61	104	6.6	3.3	0.3	3	2005
Loyalsock (M)	350	3.8	31		0.6	1	2.3	7.8	-46	55	0.3	0.8	0.3	6	1999
Maust	15	3.2	124	0	42	13	1.9	7.1	-54	69	0.2	2.8	0.1	11	1998

Systems with Design Problems

For 3 systems, the design of the system appears to be a major source of poor performance. The Webster system receives a very large flow (480 gal/min) of high-Al AMD (34 mg/L). The system was designed as two simple VFP's with no obvious provision for handling the very high Al. No real provision for flushing appears to have been incorporated, and no arrangements for routine flushing were made. Within 2 years the effluent was net acid, and after about 5 years the system ceased to treat significantly. Most water is now overflowing the two VFP's, rather than flowing thru them for treatment.

There is no indication that the compost contained limestone, which might have improved the performance. The system is inferred to be largely plugged with Al precipitate.

The sizing parameters for the AMD and Art system are unknown, but the single VFP is woefully undersized for the loading, which may be as high as 400 $g/m^2/d$. Probably the action of 3 anaerobic wetlands was assumed to handle much of the loading. The system has also suffered from almost complete lack of maintenance, leading to a blockage and breakage of the inflow system for several years.

The Harbison-Walker 2 system has at least 4 inflows, and does not seem to be designed for long-term treatment of these high-Al AMD discharges. Part of the time the system has successfully treated some of the discharges, but handling of the high Al in the AC discharges and treatment of the remaining discharges has been incomplete. Maintenance has also been inadequate.

Two other systems appear to have significant inadequacies in design. At Metro, the extremely high Al (49 mg/L) apparently was planned to be handled by flushing and recovery of the Al precipitate, but the mechanism for accomplishing this is unclear, and it was never implemented by the local group, the Southern Alleghenies Conservancy. At Clinton Road, two simple VFP's were built for Al-rich AMD (47 mg/L), but the systems do not capture a lot of the AMD in the small valley, and they were not flushed so are now partly plugged with Al and Fe precipitate. The plan was apparently to renovate the systems after about 7 years, but this has been only partially successful.

Systems with Construction Problems

The high-Fe Klondike KL1 system appears to suffer from compaction of the compost layer by equipment during construction and during rehab events. At flow rates more than about 20 gal/min, the system overflows. The compaction was caused by running tracked and wheeled vehicles over the compost. The result is short circuiting thru the non-compacted portion of the system. Plans are underway to remove the existing compost, rip the underlying limestone, and replace with new compost.

At Avery, considerable water flowed into the excavations during construction, resulting in placing lining in some ponds, but apparently the modifications were inadequate, and there is extensive subsurface flow of AMD beneath and around the system. Also, neither of the siphons at the site is operating properly. One is thought to have lost the air in the siphon owing to infrequent operation, and at the other, the underdrain leading to it is apparently too small to allow the siphon the operate long enough to draw down the water level before breaking the siphon.

Few details are available for MR Frog, but flushing and treatment at one of the two systems are inadequate, possibly because of leakage. The other system at the site is working well.

Maintenance Problems

Maintenance includes routine inspections and water sampling, flushing if required, and small to moderate rehab work if needed. At some sites, the maintenance has been excellent and has contributed to good performance of the systems. In Broad Top Township in Bedford County (Finleyville, SX0-D6, LR0-D2, LR0-D10), the township has consistently inspected and maintained their systems, and conducted repairs and modifications where needed. For example, it was found that in upflow limestone beds at several systems, if the perforated pipes of the inflow system were connected directly to the flushing pipes, the flush removed mainly water that was little treated. The underdrains were exposed and disconnected. Limestone in several beds was cleaned after a few years of service.

At Robbins Hollow, performance was monitored and one system was rebuilt because of poor performance. At Kalp, declining performance has led the local group to initiate repairs and rehab. At Klondike, several modifications to the system have been made or are underway. Most of the other systems studied have had some inspection and minor repairs. The Technical Assistance Grants (TAG) and Quick Response Programs have been crucial contributors to needed activities.

At several systems, lack of maintenance has been a source of significant problems. As noted, at Metro, no flushing or other work was done on a very high Al system. The Southern Alleghenies Conservancy is apparently the nominal local group, but has never been active in the required maintenance. At AMD & Art, the inflow grate was plugged with leaves, and the exposed inflow pipe was broken (by shooting?) for several years, so that no water reached the treatment system. The village of Vintondale was supposed to do maintenance. When visited in 2013, we encountered by accident two high school students who had repaired the blockage and pipe problems on their own, and re-started treatment. At Yellow Creek, a broken valve is apparently preventing flow to the 2B system. At Avery, the state, who designed and constructed the system, apparently has not recognized the need for renovations, and the local watershed group is no longer allowed into the site by the property owner.

Table 5. SUMMARY OF CAUSES FOR "FAILURE"

High Risk Systems

AMD & Art Maintenance and sampling have been lacking for many years. The inflow was blocked and broken for several years. A sample for this study suggests that the system may be capable of generating net alkaline water, though the VFP is considerably undersized.

Avery Much water flows under and around the system rather than through it, and neither siphon works properly, so that much acid and metal-rich water reaches the final HFLB. However, the final outflow (RDOUT) is net alkaline, for reasons that are not clear.

DeSale 1 After 13 years, this system removes essentially all Fe and Al and produces net alkaline water much of the time, or has mainly Mn acidity. The receiving streams have largely recovered and have fish. This system is erroneously classified as "failure".

Finleyville This system removes about 90% of acidity and 75% of Al from a large flow, and along with numerous other systems, greatly improves downstream conditions, to the point that it is close to removal from the 303d list. Modifications to improve performance are proposed.

Klondike KL-1 The system has removed about 75% of 400 mg/L acidity and 90% of 120 mg/L Fe. The problem appears to be short circuiting caused by compaction of compost by driving on it during construction. The compost will be replaced in 2013-14.

Harbison-Walker 2 This complex system with 4 high-Al discharges has apparently released net acid water from 2 of its discharges most of its history. The system does not seem to have been designed or maintained for its high-Al inflow.

Kalp The system has generated net alkaline effluent from 2007 to 2012, but recently has deteriorated, probably because of plugging the upflow limestone bed. Additional seepage into the final wetland appears to have been a cause for net acid final outflow in the DEP study. Rehab is underway.

Metro This High-Al system was not flushed by the local group and is accomplishing almost no treatment.

Webster This High-Al system was not designed to handle the Al, and has largely plugged, so that little treatment is being accomplished.

Yellow Creek 2A The Yellow Creek 2A system is generating net alkaline water, but lack of maintenance on the associated 2B system results in the combined outflow being acid.

Medium and Low Risk Systems

Bear Rock Run The single net acidic result for this system is probably in error, because calculated acidity from Fe, Mn, Al, pH and alkalinity shows negative acidity. The receiving stream appears to have recovered.

Cessna Run The system removes only about half the acidity from slightly acid inflow. However Cessna Run downstream appears OK.

Clinton Run The two VFP's partially treat part of the Al-rich AMD originating in this small watershed. The VFP's should be flushed to remove the accumulated precipitate, and have become partially plugged.

Long Run LR0-D2 The flow is small and intermittent. The system may leak so that the siphon rarely operates. The receiving stream is essentially recovered because of this and 12 other passive systems.

McKinley 1 This Low Risk system has generated net alkaline water most of the time for 17 years. Both samples in 2009-10 were net alkaline. The site was erroneously included in the "failure" list, possibly because of confusion with McKinley 2. It does need some rehab.

MR Frog Of the 2 systems at this site, System A with a flushed limestone pond generates net alkaline water. System B only partially treats a second small discharge, possibly because of leakage. Little information is available.

Robbins Hollow EB 10/15 The site contains 2 small discharges, of which the system treats EB10 to alkalinity, but the mixture with EB15 is slightly acid. However, 3 other nearby systems in the vicinity provide enough alkalinity that the Robbins Hollow stream is net alkaline.

Six Mile Run SX0-D6 This system treats more than 90% of the acidity in this discharge, and is as large as the site can accommodate. The stream has largely recovered and is being tested for removal from the 303d list.

Misleading Sampling

At several systems, misleading samples or erroneous analyses are responsible for the designation of "Failure". At Bear Rock Run, reported acidities of +6 and +8 in the 2009-10 effluent led to inclusion in the failure list. However, acidities calculated from pH, Fe, Mn, Al and alkalinity are both negative (-18 and -8), as is the sample taken for this study. Either the acidities or the metal, alkalinity and pH values are in error. This is a successful system.

At Yellow Creek and Robbins EB10/15, the collected samples are misleading because of multiple flows to the sample point. The effluent of Yellow Creek 2A is strongly net alkaline, but its effluent mixes with flow from 2B and possibly other sources, and the combined flow, currently untreated, is net acid. At the Robbins site, discharge 10 is treated satisfactorily, and mixes with untreated discharge 15, so that the combination is acid. However, the Robbins Hollow stream is net alkaline because of the alkalinity from 2 other nearby systems.

At McKinley 1, both the 2009-10 samples show net alkaline discharge, as do most previous samples. In the slightly acid samples on other dates, the remaining acidity is mainly from Mn. Possibly the McKinley 1 and 2 sites were confused in classifying the sites.

At Desale 1, the effluent from the HFLB is nearly always net alkaline, and any remaining acidity is mainly from Mn. Seaton Creek, the receiving stream, has recovered except for Mn values, and has fish for the first time in years.

Capture of Influent AMD and Leakage

A significant problem at several sites is incomplete capture of the AMD. These are typically discharges from surface mining in which the AMD seeps out at numerous spots. At Robbins, the EB10/15 system captures and treats the EB10 site but not the EB15 discharge, though the combined treatment of the 4 systems in Robbins Hollow releases net alkaline water to the stream. At AMD and Art, it appears that a second discharge adjacent to the treatment ponds is not treated and is responsible for some acid effluent. At Yellow Creek, part of the discharge is captured and piped to the 2A and 2B treatment systems, but it appears that much additional AMD is not being treated, and flows as a small stream into Yellow Creek. At the Clinton Road site, it appears that much of the AMD in the small valley seeps into the small stream and is not treated. At Kalp, the acidic result at the final wetland outflow appears to result from seeps that are not captured by the inflow system. At Avery, considerable AMD evidently flows under and around the treatment system. Water flowed into the excavations so the ponds were lined, but the liner was punctured to ameliorate up-bulging, so probably the ponds are leaking. At Harbison-Walker 2, the system has treated several of the 4 discharges part of the time, but not all of them. At MR Frog, one discharge is treated well, but the other smaller one does not seem to be flowing properly through the treatment ponds, and may be leaking.

At some of the above sites, such as Kalp, Avery and MR Frog, part of the problem may be leakage from the treatment ponds. Leakage appears to be a significant factor at Long Run LR0-D2. Other sites are known for which leakage turned out to be a problem.

Performance of Limestone Beds

Nine of the systems contain limestone beds as major parts of their treatment system (Avery, Finleyville, Harbison-Walker 2, Kalp, LR0-D2, MR Frog, Cessna, Robbins, Bear Rock Run). Several have multiple limestone beds. It was intended to evaluate the performance of the limestone beds in terms of design, especially sizing. However, the chemistry and flow records of essentially all these systems are incomplete, and it was concluded that useful results could not be obtained with the available data. In particular, flow data is lacking for many of the limestone bed systems, and amounts of limestone are not available for some. The lack of flow data is partly because most of these systems have flushing devices, and the flow is not uniform.

As a crude generalization, the data indicate that flushable limestone beds remove significant amounts of acidity and metals, but most apparently do not completely treat water to discharge standards.

A more detailed study of treatment by limestone beds is needed.

Performance of Treatment Systems

In Table 3, the percentage removal of acidity is listed, calculated from the 2008-13 averages in Table 4. As indicated by these results, 5 of the 23 systems have averaged 100% removal in the samples since 2008 (but only 1 to 3 samples for many), and 5 more systems have removed 89% or more of the acidity. Two sites (Metro and Webster) are very low in removal and can clearly be classed as failures. Three are in the 69 to 80% range and are doing considerable treatment but are disappointing and need modification. For three, good data are lacking.

Thus, of the 18 supposedly "failing" systems, 10 of the failures have removed 89% or more of the influent acidity, and 5 appear to have removed 100% of the influent acidity. Thus, I cannot consider them as failures.

Stream Recovery

The ultimate goal is recovery of the receiving streams to normal biota including fish. A watershed overview is preferable to focus on individual systems.

Seven receiving streams have essentially recovered as a result of the passive treatment systems. Bear Rock Run appears to have been restored for many years. Streams in the Broad Top area are largely recovered and are being studied for removal from the 303d list, after construction of more than a dozen passive systems including Finleyville, LR0D2, and SX0D6. Seaton Run and Slippery Rock Creek are largely recovered and have fish in many places as a result of the DeSale systems and others. Morgan Run is reported to have recovered in some sections as a result of MR Frog and several other systems. Upper Robbins Hollow Run is net alkaline as a result of the EB10/15 and other systems, and Middle Branch and Kettle Creek into which it runs is mostly recovered. Receiving streams at several other sites (Cessna Run, Kalp) appear to be in relatively good condition, or at least are significantly improved. The Klondike KL1 system flows into Little Laurel Run which is the focus of a Restoration Plan involving 4 other systems under design and construction.

Based on the above information, seven of the “failing” systems systems have brought their receiving streams back from degradation by AMD, and others will probably do so when the remaining discharges in the watershed are treated as part of ongoing plans. Also, it does not appear that perfect treatment is necessary for stream recovery. Evidence indicates that low Mn contents are not deleterious to biota, and many normal streams are slightly acid, such as pH near 5. More research is need on the practical limits allowing good recovery of stream biota.

Successful Treatment of High Risk AMD Discharges

Five net alkaline sites were sought from the High Risk category for comparison with the “failures”. The sites chosen were Hunters Drift, Anna S, Maust, Harbison Walker 1 and Loyalsock C Vein. As it turns out, Maust and Loyalsock systems were funded by coal operators rather than public funds. Also, these two probably fit the Medium Risk category rather than the High Risk, but when chosen were thought to be High Risk. However, all have been successful in releasing net alkaline water for an extended period.

Another High Risk Success is worth including, namely LR0-D10 in the Broad Top area. I was shown this site while visiting other sites in the area. The preconstruction flow and chemistry clearly fall in the High Risk category (Fe 145 mg/L, Al 10 mg/L). The flow enters the system in two places, and the worst one cannot now be sampled, but very high acidities are recorded in parts of the system, indicating that it is still entering. The system, composed of 2 limestone ponds and a VFP, discharges net alkaline water.

Table 4 lists the average inflow and outflow chemistry for 2008-13 for the successful systems. Four are High Risk influent and 2 are Medium Risk influent. The 2 Medium Risk systems have been in operation for 14 to 15 years with consistent net alkaline effluents. One High Risk system has been furnishing alkaline effluent for a similar time; the others 3 are 8 to 9 years old.

The Anna S and Hunters Drift systems are simple Vertical Flow Ponds receiving very acid and

Al-rich water. The distinctive design feature of these systems is the addition of about 25% fine limestone in the compost, and close inspection and sampling, which has led to replacement of the compost in 2013. On draining the systems, the compost was found to be thin (originally 1 ft, now less than 6 inches) and poor in organic component with a high residual of partly reacted limestone. At several other systems, the incorporation of fine limestone in compost has been found to be beneficial. Maust is another of the Successes which had limestone added and has been a long-term success (15 years). Another site at Glasgow treating very acidic (acidity 600 mg/L), high Al (50 mg/L) AMD was rebuilt in 2009 with limestone-amended compost, and in 2013 is still successfully treating a flow of 50 gal/min. Several experimental studies using limestone amended compost show superior results (Thomas and Romanek, 2002; Gusek and Wildeman, 2002; Rose, 2004). The added limestone apparently creates high-pH microenvironments on the limestone surfaces and precipitates Al as a coating that grows inward to the limestone fragment, rather than filling pore space and plugging flow.

The Harbison-Walker 1 system has an ALD as the initial unit in a low-Al AMD, but the effluent of the ALD is still acidic and Fe-rich (89 mg/L). This High Risk effluent is then treated by a VFP followed by a HFLB, with net alkaline effluent over 14 years.

The LR0-D10 system treats highly acidic AMD (acidity 440 mg/L) with very high Fe (145 mg/L) and moderate Al using mainly 2 limestone ponds plus a VFP. The system has been treating since 2005. The limestone was cleaned in 2012.

The Loyalsock system is an example of a high-flow system (350 gal/min) successfully treating AMD with low metals (0.6 mg/L Fe, 2.3 mg/L Al). This system has been operating for 14 years.

The success of these systems treating varied but strongly acid water demonstrates that passive systems that are properly designed, constructed and maintained can be successful. All were carefully designed, and most have been well maintained and renovated if necessary.

Economics of Passive Systems

A key question is the cost of treating by passive systems as compared to active systems. This question has been addressed by Ziemkiewicz et al. (2002), Skousen and Ziemkiewicz (2005) and Rose (2006). Rose (2006) estimated the cost per ton of acidity neutralized for a set of 22 passive systems. The cost of constructing each system was estimated by the AMDTreat computer program, and the amount of acidity removed was based on data for the performance of the systems. The median cost per ton of acid neutralized was about $300/T. For 19 of the 22 passive systems, the cost per ton is less than $1000. Three systems that had failed have higher considerably higher costs, and several lower cost systems on the list have since declined in performance or required renovations, but costs for most would be less than $1000/T. Hedin et al. (2010) cite projected 20-year costs of $403-618/ton of acidity for the High Risk

Anna S and Hunders Drift systems, including periodic replacement of the organic layer and other maintenance.

Table 6 shows the costs for the systems of this study. The cost values are the construction costs compiled by DEP and the flow and acidity for 2008-13 compiled for this study. A 20-year life is assumed. The median cost/ton of acidity removed is $702/metric ton. Seven systems have very high costs exceeding $1000/T. Three are failed or very poorly performing systems: Webster ($2086/T), Metro $2066/T) and Harbixon-Walker 2 ($1823/T). Four are relatively successful systems, based on the discussion above: Robbins ($5499/T), Bear Rock Run ($4905/T), Harbison-Walker 1 ($2469/T) and DeSale 1 ($1277/T). The problem for these is the small flow (11,14, 33 and 35 gal/min). An active system for these would also be expensive for such small flows.

For comparison, costs for active systems were estimated by Ziemkiewicz et al. (2002) as $1200-1500/ton for treatment with NaOH. An AMDTreat calculation for a hydrated lime system treating 200 gal/min with 200 mg/L acidity gives a cost of $1300/ton. This data shows clearly that most passive systems have costs that are lower than most active systems, even if renovations are required at a later date.

Another argument given against passive systems is lack of reliability. If an active system is maintained, it is implied that the effluent always meets discharge standards, and the chemical addition rate can be easily modified, whereas passive systems, lacking active maintenance and easy adjustment, are considered unreliable. In my experience this contrast is misleading. Many active systems fail part of the time.   At Brubaker Run, the lime system operated by Bender Coal Co. has released acidic metal-rich water on many occasions, and the simple caustic systems of Cooney Bros. sometimes don't operate.   At Glasgow, where both active and passive flow paths are present, the active flow path has released water with elevated Mn and Fe on many occasions, whereas the passive system has very consistently released good quality water meeting all the standards, including Mn. A new plant at Blandburg has occasionally released acid water because of temporary problems. At the new plant near Barnesboro, it is understood that the chemistry of influent AMD has changed so the plant is not as efficient as originally designed. For small to medium sized active systems without full time employees, it appears that active treatment systems commonly fail to operate successfully part of the time. Biota in a receiving stream are subject to erratic episodes of toxic water.

Long-term funding of active systems can also be a problem. For example, State systems at Hawk Run, Bennett Branch and elsewhere were built, operated for a few years, then closed down, apparently because of lack of funds. At a passive system, once built, the expenses are minor, but at an active system the major cost of chemicals, maintenance and sludge disposal continues its entire life and can be difficult to fund.   Any active plants should be funded with a trust fund that is completely adequate for a 20-25

Table 6. Costs for Systems						
System	Cost	Flow	Acidity in	Acidity ou	Tons/yr	Cost/T
	$	gal/min	mg/L	mg/L	Tons/yr	$/T
AMD & Art	346500	210	352	-38	163.8	106
Avery	1042491	190	355	-76	163.8	318
DeSale I	391000	31	250	3	15.3	1277
Finleyville	280000	303	149	14	81.8	171
Harbison-Walker 2	1196659	35	373	-96	32.8	1823
Kalp	1661407	460	164	-8	158.2	525
KL1	176385	24	357	98	12.4	709
Metro	495000	53	629	516	12.0	2066
Webster	4793000	480	326	206	115.2	2080
YELLOW CREEK 2A	225000	12	451	-192	15.4	729
High Risk-Success						
Hunters Drift	1363938	217	349	-95	192.7	354
Maust						NA
Anna S	1167928	203	113	-99	86.1	678
Loyalsock C Vein #3						NA
Harbison Walker I	261294	14	177	-12	5.3	2469
Long Run LR0-D10	82000	20	442	-61	20.1	204
Medium Risk-Failure						
Longs Run LRO-D2	49000	30	142	2	8.4	292
MR FrOG	381875	86	44	-68	19.3	991
Six Mile Run SXO-D6	99970	23	366	8	16.5	304
Clinton Road	253525	27	423	-87	27.5	460
Low Risk -Failure						
Cessna Run	171390	111	70	29	9.1	941
Robbins	210483	11	126	39	1.9	5499
Bear Rock Run	142430	33	8	-14	1.5	4905
McKinley	30000	15	81	9	2.2	694
					Average	1254
					Median	702

year life.

The magnitude of the AMD problem in PA is another consideration. There are thousands of AMD discharges in PA. Are we really going to build and maintain thousands of active treatment systems? The number of active treatment systems built by the state in the last 20 years is less than 10, and not all have been maintained. A well-designed and constructed passive system, once built, should operate for its lifetime of 20-25 years with little maintenance.

Recommendations for Successful Passive Treatment

The success of some recent (and older) passive systems in treating High Risk AMD indicates the the technology is capable of good treatment of very nasty AMD. The cost data indicates that successful passive systems are economically low cost compared to active systems. If we are to make significant headway on treating the thousands of AMD discharges that are contaminating thousands of miles of PA waterways, we must use the available funds in the most efficient way. The challenge for the State of Pennsylvania is to develop policies and procedures to build successful passive systems with the available funds. The following paragraphs recommend steps to achieve this goal.

1. Funding of passive systems from State funds such as Growing Greener should be continued, but with better oversight from the state level.

2. The positions of Watershed Manager in the several mining district offices should be restored in priority and strengthened, with the goal of providing assistance and expertise to watershed groups and ensuring much better design, construction and maintenance of passive systems. Currently, the Watershed Managers have become burdened with other tasks and are unable to accomplish the needed oversight.

3. It is clear that maintenance and renovation of passive systems is required for successful long-term performance. Funds should be provided for maintenance of passive systems, as in the current TAG grants and Quick Response funds. These funds should amount to 5 to 10 % of the budget for new passive systems. Such funds will ensure that money spent to build systems is supported to ensure that the systems continue to operate well, just as maintenance and modifications are done at active treatment plants.

4. It is essential that proposals for passive treatment systems be more thoroughly and critically evaluated by State employees. Currently, the State reviewers do not seem to have the knowledge to evaluate proposals, so that dubious designs are funded and constructed if submitted by a registered engineer. More emphasis should be placed on review by State staff who are familiar with the details of passive system technology, and who attend technical meetings where the problems are discussed. The evaluation should include the previous success record of the design engineer. The information acquired in the current study indicates that some experienced designers are able to consistently design and build successful systems, but that the designs of engineers inexperienced in the passive treatment field have frequently failed. The State should task these professionals with conducting continuing evaluations of the treatment systems in their region.

Conclusions

1. In a survey by DEP in 2009-10, a very disturbing number of passive treatments systems for AMD funded by public funds failed to release net alkaline water. Failure in this DEP survey was defined

as effluent with positive acidity. Effluent was acid not only at systems classified as High Risk using the earlier DEP Risk Matrix, but also at Medium and Low Risk sites. The present followup investigation was intended to determine reasons for this failure and to compare characteristics of successful systems with the systems discharging acid water.

2. The current investigation consisted of a more detailed study of 10 “failed” High Risk systems, 4 “failed Medium Risk systems, 4 “failed” Low Risk systems and 5 successful Medium and High Risk systems, with most selected at random from sites designed since development of improved guidelines in 2002. Available information on the design, construction and performance of the systems was collected, most were visited and sampled, and the systems were discussed with the local group and designers.

3. At 2 High Risk “failures” the design was poor and did not meet design standards known at the time they were designed. At 3 other sites, the design appears inadequate for the influent AMD, though at one site the problem was insufficient space. At 2 sites, problems during construction appear to have degraded system performance. Three sites have lacked maintenance that would have greatly improved their performance, and at 2 others the maintenance has been inadequate. At 7 systems, the sample sites in the DEP survey did not represent the system performance or the use of a net acid failure criterion gave misleading results.

4. At 10 of the 18 “failed” sites, the treatment systems removed 89% or more of the influent acidity in the 2008-13 period, and at most, the remaining acidity was Mn acidity which is not a serious problem. Two or 3 systems, all poorly designed for their influent AMD, accomplished very little treatment. Three systems removed moderate proportions of the influent acidity and at one data is lacking on performance. Thus, although the systems were designated as “failures”, more than half performed reasonably at removing acidity.

5. At 3 supposedly failing sites, the receiving streams have essentially recovered and have fish because of the effectiveness of the investigated systems plus one or more other systems in the watershed. At 4 other sites, the streams appear to be largely recovered and are being considered for removal from the 303d list. Although an individual system may release slightly acidic water, the combined effects of several treatment systems in a watershed can lead to stream recovery.

6. The cost of acidity removal by passive systems, based on several studies and models, is generally less than the cost of removal by active systems. Most of the passive systems remove acidity for less than \$1000/ton (as $CaCO_3$). The median cost for the systems of this study is \$702/metric ton of acidity removed. Four systems with small flow have higher costs, but would be high for active systems also. In contrast, costs using lime or caustic are \$1200/ton and higher. Thus, treatment by passive systems that are well designed and constructed, and are well maintained is considerably less than the alternative. Also, active systems are not perfect and sometimes release water exceeding discharge

standards. Another problem is the continued funding of active systems – several State active treatment plants have been abandoned for lack of funds.

7. It is recommended that the State continue to provide funding for construction and maintenance of passive systems but oversight should be considerably improved. Watershed Managers should be supported full time to monitor and coordinate treatment systems, and DEP staff should greatly increase their expertise in evaluation of passive systems. Funding for repairs and renovations of passive systems, as by TAG grants and Quick Response programs, should continue and be improved because it is clear that for good performance, passive systems do need maintenance and renovation over their lifetime.

8. The negative points in the DEP evaluation scheme for ranking passive treatment proposals should be eliminated or greatly reduced. This evaluation plan makes it almost impossible to fund treatment for discharges in the High Risk category. Instead, the DEP should carefully evaluate proposals and should conduct continuous oversight to ensure that successful systems are built and are maintained. The successful systems discussed here show that passive systems can be successful on even very acidic and metal-rich water.

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References

American Public Health Association, 1998, Standard Methods for the examination of water and wastewater (20th), American Public Health Association, Washington D.C., p 2-24-2-26.

Bureau of Abandoned Mine Reclamation, 2009, Acid Mine Drainage Setaside Program, Program

Implementation Guidelines: DEP Report, 66 p.

Gusek, J.J., and Wildeman, T.R., 2002, Passive treatment of aluminum-bearing acid rock drainage: Proceedings, 23rd WV Surface mine Drainage Task Force Symposium, Morgantown, WV, p. 78-86.

Hedin, R., Weaver, T., Wolfe, N., and Weaver, K., 2010, Passive Treatment of Acidic Coal Mine Drainage: The Anna S Mine Passive Treatment Complex: Mine Water and the Environment, v. 29, p. 165-175.

Hedin, R., Weaver, T., Wolfe, N. and Watzlaf, G., 2013, Effective Passive Treatment of Coal Mine Drainage: Manuscript of paper presented at the 2013 Meeting of the AML Conference, October 2013.

Kepler, D. and McCreary, E., 1997, Passive Aluminum Treatment Successes: Proceedings, 18th WV Surface Mine Drainage Task Force, Morgantown, WV.

Rose, A.W. and Dietz, J.M., 2002, Case studies of passive treatment systems: Proc. 2002 National Meeting, American Society of Mining and Reclamation, Lexington, KY, p. 776-797

Rose, A,.W., 2004, Vertical Flow Systems: Effects of time and Acidity Relations: Proceedings 2004 Annual Meeting, American Society of Mining and Reclamation, Morgantown, WV, p. 1595-1615.

Rose, A.W., 2006, Long-Term Performance of Vertical Flow Ponds – An Update: Proceedings, 7th International Conference on Acid rock Drainage, St. Louis, MO, publ. by American Society of Mining and Reclamation, p. 1704-1716.

Skousen, J. and Ziemkiewicz, P., 2005, Performance of 116 passive treatment systems for acid mine drainage: Proceedings, Annual Meeting, American Society of Mining and Reclamation, Breckenridge, CO, p 1100-1133.

Thomas, B.T. and Romanek, C.S., 2002,Acid rock drainage in a vertical flow wetland. 1. Acidity neutralization and alkalinity generation: Proceedings, National Meeting, American Society of Mining and Reclamation, Lexington, KY, p. 723-752.

US Environmental Protection Agency, 1979, Acidity, Method 305.1, in Methods for chemical analysis of water and wastes: EPA 600/4-79/020, Washinton, DC.

Weaver, K.R., Lagnese, K.M., Hedin, R.S., 2004, Technology and design advances in passive treatment system flushing: Proceedings, American Society of Mining and Reclamation, Morgantown, WV, p. 1974-1979.

Ziemkiewicz , P., Skousen, J. and Simmons, J., 2003, Long-term performance of passive and mine drainage systems: Mine Water and the Environment, v. 22, p. 118-129.

Zipper, C.E. and Skousen, J.G., 2010, Influent Water Quality Affects Performance of Passive Treatment Systems for Acid Mine Drainage: Mine Water and the Environment, v. 29, p. 135-143.

Project Name	Reviewer*	Flow	Fe	Al	Al+Fe	Const	Alkal.	Alkalinity	YrsNet Alk.	Rehabbed?	RehabYr	CapCost	Risk		# spls
Hubler Run Phase 1	BM	NotRep.	0.675	14	14.6	2004	Alk	Net Alkaline	8			$ 225,477	?		2
Avery big run	BM	NotRep.	41	19	60	2005	Acid?	Net Acidic?	6			$ 1,042,491	?		2
Tangascootack	BM	NotRep.	1.5	12	13.5	1996	Alk	Net Alkaline	16	?		$ 35,000	reported in		2
Boyce Park VFP 2	BM	12	8	53	61	2008	Alk	Net Akaline	2	Y	2010	$ 340,000	high		2
Finleyville	BM	237	3	17	20	2005	Acid	Net Acidic	net acidic ir	N		$ 280,635	high		2
JB 2	BM	120	90	12	102	2006	Var	fluc with mainteance		Y	2006 & 200	112,000 (2006)	high		3
Hamilton	BM	200	163	0.2	163.2	2003	Acid	Net Acidic	how net acidic in 2007			$ 331,800	High		1
Kalp Discharge	SS	497	90.5	17.3	107.8	2007	Acid	Acidic	a- reverts back & forth			$ 1,661,407	high		
LERMD20	SS	220	9.5	7.4	16.9	2004		? - no current data	2010 data				high		
Lowber	SS	1745	39	0.5	39.5	2004		? - no current data	2006-10 data				high		
Metro	SS	27	110	43	153	2002		? - no current data	aline 2009-10 data			$ 495,000	high		
North Fork Montour Run	SS	60	159	5.2	164	2008	Alk	Alkaline	2008-12 data	yes	n Restorati	$ 674,281	high		
Glenwhite Squatter Falls Pre-Trea	MES	51	88	1	89	2000	Acid	Net Acidic	0	Yes	Annually	$ 253,077	High		
Oven Run B VFP1	MES	174	53	35	88	1999	Acid	Net Acidic	1	Yes	2001	$ 1,101,948	High		
Oven Run B VFP2	MES	174	21	23	44	1999	Acid	Net Acidic	1.5	Yes	2001		High		
Cold Stream Site A VFP1	MES	105	63	33	99	1998	Net Acidic then Net Alkaline aft		5	Yes	2010	$ 394,072	High		
Cold Stream Site B	MES	12	71	36	107	1998	Acid	Net Acidic	5	No	na		High		
Little Mill Creek - Hanlon VFP1	MES	13	2	54	56	2002	Acid	Net Acidic	1	No	na	$ 505,371	High	ncludes Kotche	
Kyler VFP1	MES	155	14	11	25	2002	Acid	Net Acidic	8	No	na	$ 1,932,095	High	cludes ALD 1 8	
Kyler VFP2	MES	245	14	11	25	2002	Acid	Net Acidic	8	Yes	2012		High		
Backside Hayes VFP1	MES	250	15	6	21	2004	Acid	Net Acidic	3	?	?	$ 539,500	High		
Middle Branch VFP1	MES	20	24	94	118	2001	Acid	Net Acidic	1	No	na		High		
Middle Branch VFP2	MES	20	8	59	67	2001	Acid	Net Acidic	1	No	na		High		
AMD & ART VINTONDALE	JS	244	16	27	42	2004	Acid	NET ACIDIC	0			$ 346,500	HIGH		
BIG BERTHA	JS	6	133	0.76	134	1995	Acid	NET ACIDIC	UNKNOWN	NO		$ 30,000	HIGH		
BOGGS ROAD	JS	24	69	0.82	70	2004	Alk	NET ALKALINE	8	JNKNOWN		$ 101,776	HIGH		
DESALE PHASE I	JS	43	82	12	94	2000	Acid	NET ACIDIC	3	NO		$ 391,000	HIGH		
DESALE PHASE III	JS	12	107	29	136	2002	NET ACIDIC NOT SURE TREATING A		1	NO		$ 186,000	HIGH		
DENTS RUN 3895	JS	15	311	131	442	2008	Alk	NET ALKALINE	4	NO		$ 407,500	HIGH		
ERICO BRIDGE	JS	388	22	0	22	2003	Alk	NETALKALINE	11	NO		$ 866,000	HIGH		
GOFF STATION ST40/41	JS	130	33	10	43	2000	Alk	NET ALKALINE	12	NO		840,751*	HIGH		
GOFF STATION ST38/39	JS	10	107	41	148	2000	Alk	NET ALKALINE	12	NO		840,751*	HIGH		
HARBISON WALKER PHASE I	JS	11	188	1.2	189	1999	Alk	NET ALKALINE	13	NO		$ 261,294	HIGH		
HARBISON WALKER PHASE II	JS	??	2	80	82	2000	Acid	NET ACIDIC	UNKNOWN	NOT YET		$ 1,196,659	HIGH		
HOWE BRIDGE	JS	14	168	0.19	168.2	1991	Alk	NET ALKALINE		YES	2007	$ 221,000	HIGH		
FILSON 2 AND 3	JS	8	95	2	98	1995	Acid	NET ACIDIC		YES	B COST 96	$ 93,315	HIGH		
REM (ORCUTT/SMAIL) NORTHERN	JS	55	237	4	241	2005	Acid	NET ACIDIC	MADE NET	NO		$ 688,850	HIGH		
JENNINGS	JS	20	37	15	52	1997	Acid	NET ACIDIC	13	AB PRESENTLY		$ 125,780	HIGH		
WEBSTER	JS	400	21	35	56	2004	Acid	NET ACIDIC	2	NO		$ 4,793,000	HIGH		
YELLOW CREEK 1B	JS	20	20.1	30.4	50.6	2000	Acid	NET ACIDIC	2	YES	/2005 $26	$ 131,000	HIGH		
YELLOW CREEK 2A BIO REACTOR	JS	33	48	56	104	2002	Acid	NET ACIDIC	2	YES	/2005 $25,	$ 200,000	HIGH		
YELLOW CREEK 2B BIO REACTOR	JS	10	48	56	104	2004	Alk	NET ALKALINE	8	NO		$ 158,048	HIGH		
YELLOW CREEK 2C	JS	16	64.2	14.5	78.7	2003	Acid	NET ACIDIC	4	NO		$ 300,000	HIGH		
Anna S	TW	285	8.5	17.1	25.6	2004	Alk	Alkaline	8			$ 1,208,314	High		
Rattler A2-2	TW	71	72.3	25.6	97.9	2003	Alk	Alkaline	9			$ 366,150	High		
Rattler A2-3	TW	11	86.2	27.45	113.65	2003	Acid	Acidic	9			$ 150,179	High		
Rattler A2-4	TW	14	97	35.2	132.2	2003	Alk	Alkaline	9			$ 150,179	High		
Hunters Drift	TW	249	36.6	34.6	71.2	2004	Alk	Alkaline	8			$ 872,000	High		
Shamokin Creek Site 15	TW	442	29.2	6.02	35.22	2005	Alk	Alkaline	7			$ 544,150	High		

Mine drift	DC	30	32	29	61 A 67 D	2002	Acid	Net acidic	?	no		$	128,500	high	
Longs Run LR0-D10	DC	27.5	117	7	I.3 A 155.	2005	Alk	net alkaline	6	no		$	82,000	high	
Klondike KL-1	Dc	13	141	2	3.6 A 140.	2007	Acid	net acidic	0	no		$	176,385	high	
Shreves Run SX3-D6	DC	1.0 D	27	176 A	02.6 A 8.0	2007	Alk	net alkaline	4	no	cost above for bc			high	
Tangascootack NW	BM	30	1.1	0.21	1.31	2001	Alk	Net Alkaline	11					Low	2
Gray Run	BM	13.5	3.3	13	16.3	1997	Acid	Net Acidic	's net acidic in 2009			$	124,000	Low	2
Bear Rock Run	SS	17	1.81	0.3	2.13	2009		? - no current data	2009-10 data	no?		$	142,430	low	
Cessna Run	SS	105	in FE 0.8	3.8	4.6	2005		? - no current data	ot alkaline 2008-09 data			$	171,390	low	
McCaslin Road	SS	0.25	0.45	20.8	21.2	2009		? - no current data	no data					low	
McKinley 1	SS	1	0.5	3.4	3.9	1996	Acid	Acidic	2009-10 data			$	30,000	low	
McKinley 2	SS	10	0.07	11.6	11.7	1999		? - no current data	a ; not alkaline 2010			$	36,059	low	
Middle Branch -Two Mile Run R1	SS	11	0.3	11.4	11.7	2001	Alk	Alkaline	2009-12 data	yes	2007	$	234,267	low	
Morrow 1 & 2	SS	4	0.56	2.88	3.4	1998	Alk	Alkaline	2009-12 data	yes	?	$	39,000	low	
Permapress	SS	in flow - 4.6	0.12	6.2	6.3	2004	Alk	Alkaline	2006-12 data			$	231,700	low	
Robbins Hollow Complex - EB15	SS	6	0.3	20.1	20.4	2005	Acid	Acidic	aline 2009-12 data			$	210,483	low	
Wells Creek Onstead	SS	22	1.1	3.2	4.3	2004		? - no current data	009-2010 data			$	304,410	low	
Wells Creek Skeria #6	SS	60	0.5	2.5	3	2004		? - no current data	009-2010 data			$	192,868	low	
Glenwhite Coke Ovens VFP	MES	25	1	2	3	2001	Alk	Net Alkaline	11	No	na	$	767,360	Low	ludes Clearwa
Laurel Run Pyrolusite Bed	MES	14	4	7	11	1997	Alk	Net Alkaline	15	Yes	2012	$	121,722	Low	
BBWA3893	JS	15	3	8	11	2008	Alk	NET ALKALINE	T DATA FRO	NO		$	25,000	LOW	
BEAGLE	JS	2.4	0.38	3.2	3.5	1998	Alk	NET ALKALINE		yes	abcost $19	$	18,275	low	
COAL PIT RUN LOWER	JS	17	1.16	3.02	4	2005	Alk	NET ALKALINE	7	NO		$	140,000	LOW	
CONIFER EAST	JS	25	2	6	8	2002	Alk	ALINE NOT TREATING AI	10	NO		$	117,991	LOW	
HORTERT	JS	5.5	0.1	4.8	4.9	1999	Alk	NET ALKALINE	13	NO		$	113,457	LOW	
FOXHEAD INDUSTRIAL PARK	JS	2	EW TO INCLUDE			2009	Alk	NET ALKALINE		NO		$	192,000	LOW	
FILSON 1	JS	2	0.3	22	22.3	1995	Acid	NET ACIDIC		NO		$	45,011	LOW	
FILSON 4	JS	2	3	16	19	2000	Acid	NET ACIDIC		YES	EHAB @PR	$	76,380	LOW	
SR 109	JS	13.8	2.58	0.2	2.78	1998	Alk	NETALKALINE	12	NO		$	55,000	LOW	
TWO MILE RUN -EBCLARION	JS	20	0.1	2	3	2004	Alk	NET ALKALINE	8	NO		$	314,575	LOW	
YELLOW CREEK 1A	JS	10	1	24	25	1991	Alk	NET ALKALINE	7	YES	/2005 $26	$	131,000	LOW	
Miller Run 1	DC	95 A 25 D	0.11	1.1	1.21	2007	Acid	010 net acidic (only data	?	no		$	22,225	low	
Miller Run 2	DC	15 A 10 D	0.4 A	4.5 A	4.9 A	2006		2009 net alkaline 2010 net a	4	no		$	61,000	low	
Old never Sweat Mine	DC	29 A30 D	15 A <1.0	2.7 A 8 D	2.8 A 8 D	2007		2009 net alkaline 2010 net a	3	no		$	151,500	low	
MR FROG A	DC	80 A 75 D	.6 A <0.1	3.9 A 3.0 D	4.5 A 3.0 D	2008	Alk	net alkaline	3	no		$	381,875	low	
Longs Run LR0-D8	DC	5 A 1 D	08 A <1.0	.64 A 3.0 I	1.72 A 3 D	2004	Alk	net alkaline	7	no		$	15,000	low	
Longs Run LR0-D11	DC	7.2 A 5.0 D	.11 A 4.6	3.2 A 11.9	).3 A 16.5	2006		2009 net alkaline 2010 net a	4	no		$	11,000	low	
Longs Run LR0-D5	DC	26 A 11 D	16 A <1.0	4.2 A 5 D	4.4 A 5 D	2004	Alk	net alkaline	7	no		$	20,000	low	
Longs Run LR0-D3	DC	20 A 8 D	.6 A <1.0	1.6 A 12.0	3.2 A 12 I	2004	Alk	net alkaline	7	no		$	30,000	low	
Klondike KL-2	DC	109 A 166 D	.48 A 5.4	.11 A 1.6	.59 A 7.0	2007	Alk	net alkaline	4	no		$	405,107	low	
Shreves Run SX3-D4, D5	DC	14.1 D	I.2 A 2.4 I	77 A 15.9	97 A 18.3	2007	Alk	net alkaline	4	no		$	77,940	low	
Shreves Run SX3-D7,D8	DC	6.8 D	2.8 D	15.2 D	18 D	2007	Acid	net acidic	?	no		$	51,960	low	
solomon	DC	9.5 A	0.13 A	3.04 A	3.17 A	2000	Alk	net alkaline	10	no		$	161,373	low	
Benedict Mine Shoups Run	DC	27.5 A 23 D	57 A <1.0	0.75 A 1 D	1.32 A 1 D	2007	Alk	net alkaline	4	no		$	37,000	low	
Six Mile Run SX0-D2	DC	75 A 80 D	.13 A 0.4	.92 A 1.7	I.05 A 2.1 I	2008	Alk	net alkaline	3	no		$	156,239	low	
COAL PIT RUN UPPER	JS	25	4	6	10	2005	Alk	NET ALKALINE	7	NO		$	145,863	.OW-MEDIUM	
Boyce park VFP 1	BM	16	7	37	44	2008	Alk	Net Alkaine	4	N		$	340,000	Medium	3
Clinton Road	BM	23	7.2	40	47.2	2004	Acid	Net Acidic	2			$	253,525	Medium	23
Bear Run Large	SS	295	4.4	6.3	10.7	2000	Alk	Alkaline	2009-12 data			$	250,000	medium	
Bear Run Small	SS	56	4.3	4.8	9.1	2000	Alk	Alkaline	2009-12 data			$	250,000	medium	
Gallentine	SS	in flow - 100	in FE 42.3	in AL 1.4	43.7	2003		Alkaline (as of 2011)	l;not alkalin	yes	2008	$	362,719	medium	

Lamberts Run	SS	26	7.6	19.7	13.6	1998	Acid	Acidic	aline 2009-10 data			$ 193,000	medium	
Robbins Hollow Complex - NB	SS	2	18.2	17.4	35.6	2005	Alk	Alkaline	2009-12 data			$ 159,517	medium	
Rock Run	SS	40	40	<5	40	2009	Alk	Alkaline	2012 data			$ 333,500	medium	
Glenwhite Spaghetti Hole VFP	MES	98	1	7	8	2001	Acid	Net Acidic	9	No	na		Medium	
Glenwhite Squatter Falls Pyrolusi	MES	52	20	1	21	1999	Alk	Net Alkaline	13	Yes	Annually		Medium	
Bellwood Site A VFP	MES	54	6	7	13	2001	Alk	Net Alkaline	11	No	na	$ 503,970	Medium	Includes Site C
Rocky Ridge South - Joller (Roarin	MES	61	21	13	34	1998	Acid	Net Acidic	0	No	na	$ 731,564	Medium	
Rocky Ridge South - Joller (Roarin	MES	65	21	13	34	1998	Acid	Net Acidic	0.5	No	na		Medium	
Rocky Ridge South - Joller (Roarin	MES	103	10	7	17	1998	Acid	Net Acidic	2	No	na		Medium	
Cold Stream Site A VFP2	MES	105	7	2	9	1998	Alk	Net Alkaline	14	No	na		Medium	
NuMine VFLSB	MES	36	1	9	10	2003	Alk	Net Alkaline	9	No	na	$ 180,315	Medium	
Pine Glen East VFLSB	MES	400	0	3	3	2005	Alk	Net Alkaline	7	No	na	$ 856,677	Medium	
Little Mill Creek - Hanlon VFP2	MES	13	1	27	28	2002	Alk	Net Alkaline (70/30)	10	No	na		Medium	
Keystone Limestone UpFlow Ponc	MES	70	18	8	26	2002	Acid	Net Acidic	3	Yes	2006	$ 166,805	Medium	
Backside Hayes VFP2	MES	250	1	1	2	2004	Alk	Net Alkaline	8	?	?		Medium	
Sandy Run 10 VFP	MES	23	39	4	43	1999	Acid	Net Acidic	5	No	na		Medium	
Sandy Run 11 VFP	MES	25	6	2	8	1999	Alk	Net Alkaline	13	No	na		Medium	
Sandy Run 12 VFP	MES	36	11	9	20	1999	Alk	Net Alkaline	13	No	na		Medium	
BACK SIDE HAYES RUN VFWB	JS	110	10	6	16	2004	Acid	NET ACIDIC	6?	NO		539500*	MEDIUM	
BACK SIDE HAYES RUN VFWC	JS	49	17	6	23	2004	Acid	NET ACIDIC	8	NO			MEDIUM	
BBWA 3888	JS	47.8	0.56	7.78	8.3	2008	Alk	NET ALKALINE	4	NO			MEDIUM	
BOG	JS	50	5	3	8	2000	Alk	NET ALKALINE	12?	YES	ehab cost $	$ 76,380	MEDIUM	
CONIFER WEST	JS	25	30	10	40	1998	Alk	NET ALKALINE	8	YES	2011	$ 351,081	MEDIUM	
DESALE PHASE II	JS	68	26	10	36	2000	Acid	NET ACIDIC	3	NO		$ 449,342	MEDIUM	
ELBON, LITTLE TOBY CREEK	JS	36	21	15	36	2001	Alk	NETALKALINE	11	NO		$ 213,625	MEDIUM	
FILSON 5 AND 6	JS	30	49.5	0.4	50	1994	Alk	NET ALKALINE		YES	B COST $4	$ 135,000	MEDIUM	
LAUREL RUN #1	JS	57	9	10	19	2001	Alk	NET ALKALINE		NO		$ 450,000	MEDIUM	
LAUREL RUN #2	JS	70	48	1	49	2005	Alk	NET ALKALINE		NO		$ 287,021	MEDIUM	
PENN HILLS #2C VFR	JS	80	42	0	42	2002	Alk	NET ALKALINE	10	NO		$ 1,299,000	MEDIUM	
PENN HILLS #2A VFR	JS	62	42	0	42	2002	Alk	NET ALKALINE	10	NO			MEDIUM	
PENN HILLS #2B VFR	JS	80	42	0	42	2002	Alk	NET ALKALINE	10	NO			MEDIUM	
JOHNSON RUN JRU88/89	JS	24	16	10	26	2002	Alk	NET ALKALINE	10	NO		$ 407,000	MEDIUM	
RICHARDS 1	JS	25	17	13	30	1991	Acid	NET ACIDIC	???	YES	1999		MEDIUM	
RICHARDS 2A	JS	45	17	13	30	1999	Acid	NET ACIDIC	11	NO			MEDIUM	
RICHARDS 2B	JS	40	17	13	30	1999	Acid	NET ACIDIC	10	NO			MEDIUM	
Klondike	TW	194	4.43	7.6	12.03	1997	Alk	Alkaline	15			$ 500,000	Medium	
Arnot #2 Discharge #4	TW	214	1.04	4.86	5.9	1995	Alk	Alkaline	17			$ 127,594	Medium	
Bear Run Large	TW	295	4.47	6.34	10.81	2000	Alk	Alkaline	12			$ 250,000	Medium	
Bear Run Small	TW	56	4.32	4.81	9.13	2000	Alk	Alkaline	12			$ 250,000	Medium	
Oneida #3	TW	940	0.67	1.1	1.77	2009	Alk	Alkaline	3			$ 1,000,000	Medium	
Six Mile Run SXO-D6	DC	25	.2 A 59.6	.6 A 35.7	.8 A 95.3	2008	Acid	net acidic	1	no		$ 99,970	medium	
Mitchell Discharge	DC	58 A	7.2 A	22.7 A	29.9 A	2005	Acid	Net acidic	?	no		?	medium	
North Point SX0-D4 and D5	DC	35 A	10.7 A	7.25 A	18 A	1998	Alk	net alkaline	13	no		$ 70,000	medium	
MR TUFF Morgan Run	DC	196	9.2 A	5.9 A	15.1 A	2008	Alk	net alkaline	3	no		$ 395,880	medium	
MR FrOG B	DC	50 D	<0.1 D	9.0 D	9.0 D	2008	Acid	net acidic	1	no		cost above for bc	medium	
Longs Run LR0-D7	DC	6.5 A 3.0 D	31 A 13 D	.5 A 2.0 D	34.5 A 15 D	2006	Alk	net alkaline	5	no		$ 15,000	medium	
Longs Run LRO-D2	DC	30 A 8.0 D	3.2 A 30	.1 A 14.2 D	24.2 A 34.	2005	Acid	net acidic	?	no		$ 49,000	medium	
Six Mile Run SX2-D5	DC	40 A 20 D	.8 A 10.2	5.8 A 7.3 D	3.6 A 17.5	2007	Alk	net alkaline	4	no		$ 75,165	medium	
Six Mile RunSX3-D9/SX0-D16	DC	93 A 100 D	86 A 2.15	48 A 6.35	.34 A 8.5	2007	Alk	net alkaline	4	no		$ 277,495	medium	
JB 1 (diverting Raccoon Creek wat	BM					2006						$ 550,000	NA	

Project Name	Reviewer*	rage Flow (g	r design	r design	als (Al + F	Constructed		ent Currently Net Alkaline or N		uent Net Al	ehabed? **	ear Rehabe	Capital Cost	Matrix Design	# Samples
Daiva (ALD)														NA/ALD	
Little Hefren (ALD)														NA/ALD	
		Flow	Fe	Al	Fe+Al	Year									
Schnepp Road 1	SS	4	o inf dat	o inf data		1992	Acid		Acidic	aline 2009-12 data			$ 60,000		
Wells Creek Moore No. 7	SS	no flow data	6	3.5	9.5	2004		? - no	current data	not alkaline - 2010 data			$ 327,582		

* Reviewer initials: JS, TW, PM, BM, MS

** Effluent Currently Net Alkaline or Net Acidic - Please indicate whether system effluent is currently net acidic or net alkaline.

*** Years Net Alkaline - Please provide the number of years the treatment system discharged net alkaline water.

**** Rehabed? - Was the system rehabilitated? Y or N

APPENDIX B
Information on Systems

SUMMARY SHEET – AMD & Art

Name: AMD and Art County: Cambria

Latitude: 40°28'53"N Longitude: 78°54'31.3"W

Year Built: 2004

Risk Level: High

Designer: Bob Deason?. T Allen Comp of OSM? Contractor: Eugene Hutchinson

Local Group or person: Supposed to be Vintondale but maintenance entirely lacking; two teenagers have done some recent maintenance, Sampling by Stream Team.

Treatment types, Sequence: Collection pond, 3 anaerobic(?) wetlands, VFP, Settling pond, 2 wetlands

VFP

Area(water surface): 2010 m^2
Compost thickness: ?
Limestone thickness, size, quality: ?
Comments

Rehab, date and nature: Water flow restored by teenagers in June 2012

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 210 gal/min, pH 3.3, acidity 352, alk. 0, Fe 17, Mn 2.2, Al 31, SO_4 664 (N=15)

Average effluent 2008-13

Flow ??, pH 6.6, acidity -38, alkaklinity 111, Fe 46, Mn 5.6, Al 2.5, SO4 562 (N=1)

Loading (g acidity/day, g/m2/d): 100,000 to 900,000 g/day; 50 to 400 g/m2/d

References: Datashed, Signs along trail next to ponds.

Conclusions: Based on 1 recent sample, the system is apparently capable of generating alkaline water, partly from anaerobic wetlands. However, the VFP is greatly undersized for the inflow loading. No maintenance is being done: the inflow pipe was plugged and broken for some time. Only one outflow sample available.

AMD & Art, Vintondale, PA

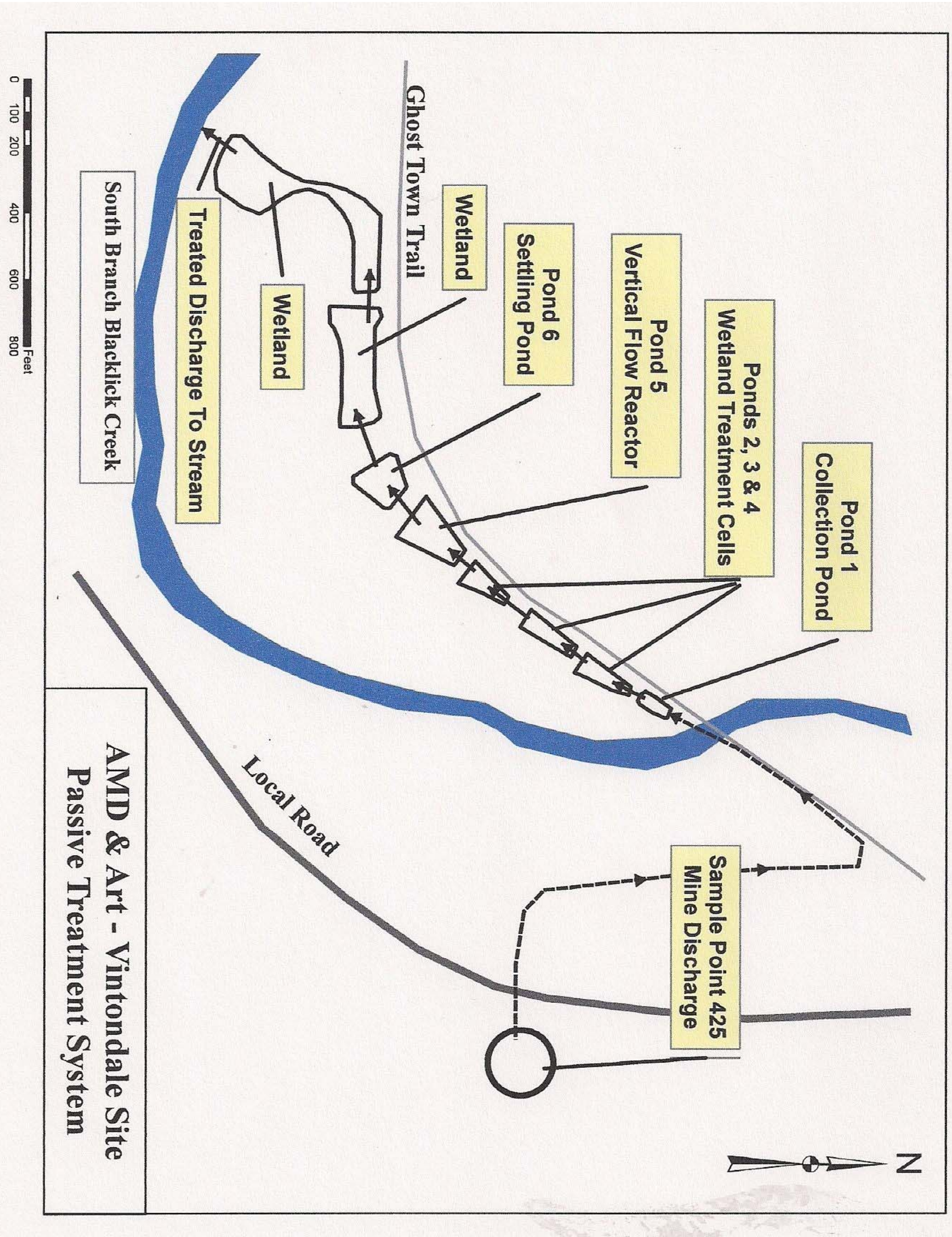
The AMD & Art treatment system is located at Vintondale, Cambria County, PA, along Blacklick Creek. The system treats the discharge of an abandoned mine on the opposite side of Blacklick Creek. The system was originally constructed in about 2001 and was modified in 2005 to repair leakage and problems from high Al. Flow has also been interrupted recently, as described below. The designer was Bob Deason of Earthtech. Funding and construction of the system was managed by AMD and Art Inc., a local non-profit organization. Input on artistic aspects of the design was by Dr. T. Allen Comp of US OSM. The system is described by a website, www.amdandart.info.

The system treats water reaching it through a long pipe from the abandoned Vintondale #3 mine on the opposite side of Blacklick Creek. The pipe crosses Blacklick Creek and feeds a pair of inflow pipes, followed by 6 ponds and 2 wetlands. The inflow is highly variable, ranging from 20 to 770 gal/min, with an average of 285 gpm at site 425, the inflow to the ponds (Table AA). Chemistry averages pH 3.1, acidity 397 mg/L, Fe 23 mg/L, Mn 2.5 mg/L, Al 34 mg/L and SO_4 732 mg/L.

The initial collection pond (Pond 1) is followed by 3 anaerobic wetlands (Ponds 2,3,4) with 4 ft. of pulverized limestone overlain by a foot of mushroom compost. Pond 5 is a vertical flow pond with an area of about 2000 m^2. The effluent flows out through a vertical perforated pipe into a settling pond, which flows to 2 large wetlands. Very little data is available on the outflow. The available data indicates that the effluent has been slightly to greatly net acidic, but a sample of the VFP outflow in this study was net alkaline.

Based on the area of the VFP, the system is greatly undersized, with areal loading to pond 5 averaging 148 $g/m^2/d$. The 3 preceding anaerobic wetlands should accomplish some treatment, but the amount is not documented. The system currently appears to leak from the last pond and the 2 wetlands – no outflow to Blacklick Creek could be found.

When visited on 7/8/13, two teenagers approached us. They say that the inflow from the mine into the pipeline was cut off for several years by plugging of the inflow grating and a break in the pipe, which is on the surface part of the way. In June 2013 they cleaned the inflow grating and put a “bandage” on the broken pipe, resulting in renewed flow into the system. Their actions were not part of any organized group – they were completely out of their own interest. The original agreements are said to involve the town of Vintondale for maintenance, but this is apparently lacking. The system badly needs a local or other group to monitor and maintain it, and to renovate it to be large enough to handle the load.



Prepared By The Blacklick Creek Watershed Association, 09/09

ID	Site	Date	Acidity	Alkalinity	Al	Ferrous	Flow	Fe	Mn	pH fld	pH Lab	Sp. Cond.	SO4	TSS
3709-535	BCSB-014	11/8/1973	1500	0			28.7	275.2			2.9		2224	
3711-535	BCSB-014	12/5/1973	4300	0			74.1	302.5			2.6		1700	
3713-535	BCSB-014	1/3/1974	900	0			198.4	226.8			2.8		950	
3715-535	BCSB-014	1/31/1974	604	0			179.5	128.7			2.8		675	
3717-535	BCSB-014	2/19/1974	700	0			74.1	163.7			2.7		775	
3719-535	BCSB-014	3/15/1974	800	0			355.9	78.5			2.8		550	
3721-535	BCSB-014	4/15/1974	550	0			208.2	119			2.7		725	
3723-535	BCSB-014	5/13/1974	620	0			162	108			2.8		650	
3725-535	BCSB-014	6/4/1974	600	0			153.5	112			2.6		725	
3727-535	BCSB-014	7/31/1974	900	0			24.7	152			2.6		1375	
3729-535	BCSB-014	8/19/1974	1100	0			18	346.5			2.6		1200	
3731-535	BCSB-014	9/10/1974	1400	0			46.7	129.5			2.6		400	
3839-541	425	6/23/1999	518	0	39.7	0.61		32.5	3.32		2.8	1,470	953.8	22
3841-541	425	4/12/2000	490	0	40.1	0.83		45.8	3.3		2.7		546	30
3843-541	425	7/12/2000	518	0	45.1	2.22		43.2	3.85		2.8		659	16
3845-541	425	10/16/2000	656	0	61.5	3.91		53.5	4.48		2.7		786	4
3847-541	425	2/13/2002	619.2	0	62.6	1.06		60.8	4.32		2.6	100	868	<2
3849-541	425	11/6/2002	583	0	50.7	0.81		37.1	3.49		2.7		927.4	4
3851-541	425	1/27/2003	552	0	45.4	0.96		40.5	3.98		2.6		927.2	30
3853-541	425	5/30/2003	457.6	0	34.4	0		26.9	2.94		2.7		697.6	10
3855-541	425	8/14/2003	453.2	0	39.5	0.69		32.1	3.51		2.7		788.8	4
3857-541	425	5/4/2004	274.2	0	21.9	0.46		15.2	2.28		2.8		501.5	4
3859-541	425	10/22/2004	387.8	0	28.9	0.53		18.4	2.44		2.7		610	<3
3861-541	425	4/25/2005	280.8	0	18.8	0.47	75.6	11.2	1.83		2.8		674.8	4
3863-541	425	7/26/2005	385.4	0	28.6	0.65		15.9	2.18		2.7		796.2	<3
3865-541	425	10/24/2005	438.6	0	38.2	0.61		18.9	2.8		2.8		762.8	<3
3867-541	425	4/20/2006	391.6	0	34.6	0.1		23.5	2.76		2.7		759.1	<3
3869-541	425	7/17/2006	372.4	0	27.1	1.17		17.1	2.26		2.7		770	4
3871-541	425	11/28/2006	389.6	0	32.5	1.02		25.2	2.66		2.8		769.9	4
3873-541	425	1/18/2007	286.6	0	19.1	0.79		17.2	1.8		2.8		612	<3
3875-541	425	4/30/2007	249.4	0	19.7	0.83	278.3	12	1.85		2.9		535.6	<3
3877-541	425	7/21/2007	423.4	0	33.1	1.29		18.2	2.41		2.7		812.9	6
3879-541	425	10/28/2007	481	0	38.8	1.27	26.9	22.3	2.77		2.6		930.5	4
3881-541	425	2/17/2008	297.8	0	21.3	0.71		14.2	1.83		2.8		670.6	<3
3883-541	425	5/4/2008	324.4	0	26.3	0.46		15.8	2.29		2.8		614.7	10
3885-541	425	11/2/2008	456.2	0	41.2	0.5		21.8	2.58		2.7		1029	8
3887-541	425	4/19/2009	340.6		28.8	0.73	181	18.2	2.24		2.6		653.8	<5
6339-541	425	9/23/2009	441.2	0	41	1.5		20.58	2.53		2.7		836.3	12
6341-541	425	4/1/2010	280.4	0	22.9	0.86		15.83	1.88		2.8		533.6	<5
6343-541	425	7/27/2010	422.6	0	37.4	1.08		20.45	2.53		2.7		877.8	6
6761-541	425	1/18/2011	450.2	0	39.8	0.86	47	26.43	2.59	2.49	2.7		843.4	10
6763-541	425	5/2/2011	196.2	0	15.9	0.48	770	9.96	1.42	2.39	3		486.8	8
6765-541	425	7/19/2011	369.2	0	35.5	0.75	20	17.81	2.34	2.46	2.7		701.8	<5
6767-541	425	10/31/2011	317.4	0	27.6	1.29	556	15.68	1.935		2.8		684.8	12
8251-541	425	5/1/2012	330	0		0.79	98	11.19	1.62		5.53		561.6	5
8310-541	425	8/9/2012	345	0		0.83	60	14.61	1.894		5.39		611.8	5
8371-541	425	11/26/2012	361.8	0		1.59	71.5	19.39	2.127		5.46		690.6	5
		7/8/2013	341.6	0	31.4	0.76	90	18.8	2.54	2.8	2.7	1760	166	5
Average 99-13			402.3	0.0	34.2	0.9	189.5	23.6	2.6	2.5	3.0	1110.0	712.6	9.3
Average 2008-13			351.6	0.0	30.8	0.9	210.4	17.4	2.2	2.5	3.3	1760.0	664.2	7.8

VFP outflow														
Pond 5 out		7/8/2013	-38	111	2.51	22.65		46.1	5.58	5.4	6.6	1160	562	64
	OUTFLOW?													
14711-290	KBLVI2	10/16/2000	398	0	40.9	2		32.1	3.7		2.9		723	10
15548-290	KBLVI2	3/2/2001	384	0	33.7			30.4	3.03		2.8		666	2
15550-290	KBLVI2	8/14/2003	180.2	0	23.3	1.76	425	5.83	3.42	3.6	3.6		820	30
16561-290	KBLVI2	10/22/2004	117.8	11.2	17.4	4.8		5.79	2.28		4.4		637.3	26
16562-290	KBLVI2	4/25/2005	159.4	0	15.3	1.32		6.41	1.73		3.4		656.6	6
16563-290	KBLVI2	7/26/2005	84.6	0.8	4.41	0.37		2.32	3.07		3.9		736.9	40
16564-290	KBLVI2	10/24/2005	-8	60.6	1.26	0.26		1.7	0.209		7		291.8	14
18723-290	KBLVI2	8/17/2010	-27.4	46.8	0.58			8.677	0.367	6.5	7		242.6	16

SUMMARY SHEET – Anna S

Name: Anna S County: Tioga

Latitude: 41º 37' 6" Longitude: 77º 18' 40"

Watershed: Babb Creek

Year Built: 2004

Risk Ranking: High

Designer: Hedin Environmental

Local Group or person: Babb Creek Watershed Association

Treatment types, Sequence: 2 discharges, 4 VFP's in parallel, Wetland, plus flush pond

VFP

Area(spillway level): 151,200 ft^2 = 14,050 m^2

Compost thickness: 1 ft. (50% mushroom compost, 3000 yd^3,25% wood chips, 25% fine limestone (2000 T)

Limestone thickness, size, quality: 3 ft., AASHTO #1, >90% $CaCO_3$, 16,200 T total

Comments

Rehab, date and nature:

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

S1: Flow 163 gal/min, pH 3.1, acidity 129 mg/L, Fe 5.8 mg/L, Mn 8.7 mg/L, Al 12.4 mg/L, SO_4 351 mg/L, N=12

S2: Flow 40 gal/min, pH 3.7, acidity 50 mg/L, Fe 2.4 mg/L, Mn 3.7 mg/L, Al 4.3 mg/L, SO_4 163 mg/L, N=11

Total inflow: Flow 203 mg/L, acidity 113 mg/L, Fe 5.1 mg/L, Mn 7.7 mg/L, Al 10.4 mg/L

Average effluent 2008-13

Flow 220 gal/min, pH 7.3, acidity -99 mg/L, alk. 120 mg/L, Fe 1.2 mg/L, Mn 2.9 mg/L, Al 0.3 mg/L, SO-4 301 mg/L, N=13

Loading (g acidity/day, g/m2/d): 126,000 g/d; 9 $g/m^2/d$

References: Datashed, Final report on Anna S and Hunters Drift Construction.

Conclusions: This High Risk system has released net alkaline water during its entire 9 years of operation. A key to its success is the addition of 25% limestone to the organic layer, and effective maintenance. Also, the receiving stream, Babb Creek, has recovered from the AMD at this site.

ANNA S SYSTEM

The Anna S sytem is located in Tioga County across the valley of Babb Creek from the village of Antrim. It treats the discharge from an abandoned underground mine and was constructed in 2004. The system drains into Babb Creek. The discharge ranks as High Risk in the DEP Risk Matrix, though only slightly above the Medium Risk level. The system is just north of the Hunter's Drift system.

The source is two discharges, S1 and S2. The combined flow and chemistry of the two are 203 gal/min with average acidity 113 mg/L, Fe 5.1 mg/L, Mn 7.7 mg/L and Al 10.4 mg/L. S1 is appreciably bigger than S2 in both flow and metals (see summary). The flow is conveyed by pipes to a distribution box for each discharge. Four VFP's in parallel treat the water. The S1 flow is distributed to all four VFP's, the S2 flow is distributed to VFP's 1 and 2. A bypass operates to divert high flows (>90th percentile) around the VFP's. The outflow of the VFP's flows in a ditch to a Wetland. Within each VFP, there is 3 feet of limestone (AASHTO#1, >90% $CaCO_3$) overlain by 1 foot of organic material composed of 50% spent mushroom compost, 25% wood chips and 25% fine limestone (AASHTO #10, >90% $CaCO_3$). An outflow underdrain lies at the base of the limestone, and a flush drain is one foot below the top of the limestone layer. The flushing valve is broken and the system has not been flushed recently

The system has released net alkaline water for the entire 9 years of operation, and all four VFP's have generated net alkaline water. The average acidity loading of the system was originally sized at 35 $g/m^2/d$ but the 2008-13 data indicates a lower loading of 9 $g/m^2/d$, largely because of decreases in discharge acidity and flow.

The receving stream, Babb Creek, has recovered from the AMD degradation and has been removed from the 303d list.

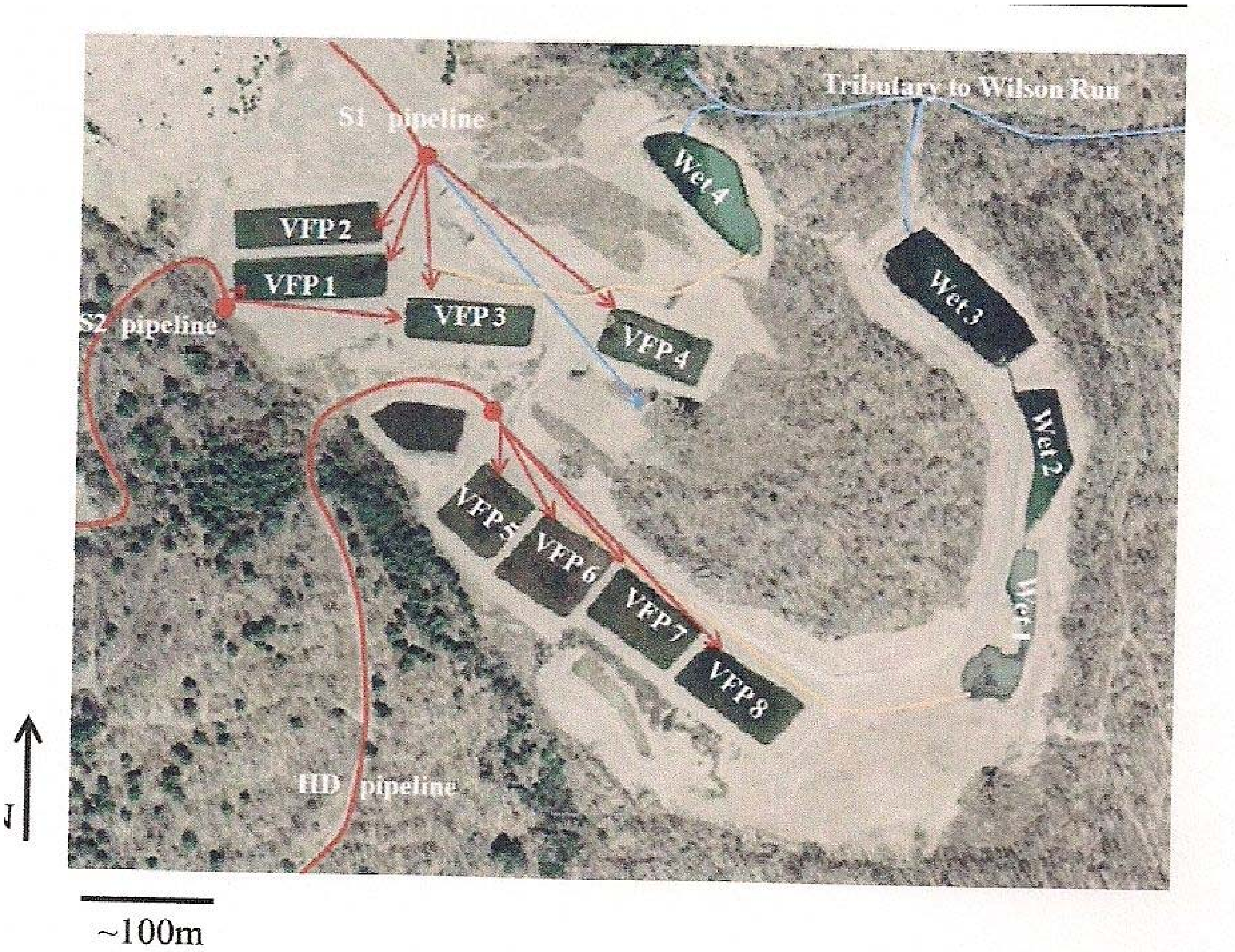


Figure AN1. The Anna S System treats the S1 and S2 discharges using VFP-1, -2, -3 and -4 plus Wetland Wet-4

ID	Site	Date	Acidity	Alkalinity	Al	Flow	Fe	Mn	pH fld	pH Lab	Sp. Cond.	SO4	TSS
			mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L
	AnnaS 1 Raw												
14016-419	50-46.4	12/16/1996	234	0	13.5		7.97	11.3		3	1188	312	2
14017-419	50-46.4	7/7/1997	238	0	15.5		9.35	14.3		3	1165	288	8
14359-419	50-46.4	6/13/2000	198	0	15.9	282	9.79	12		3	1198	389	12
16221-419	50-46.4	6/15/2004	164.6	0	12	500	6.83	9.26	4	2.9		291	3
16222-419	50-46.4	10/4/2004	287.2	0	20.2	500	16.4	9.67	4	2.9		393.8	22
16223-419	50-46.4	5/12/2005	168	0	10		5.37	8	2.4	3		401.1	3
16224-419	50-46.4	11/7/2005	164.4	0	1.72	100	0.557	3.83	3.5	3		409.9	3
17027-419	50-46.4	9/6/2006	166.8	0	12.89	359	6.632	9.32	3.5	3.1		341.1	3
2211-419	50-46.4	11/29/2006	153	-	8	328	10.1	8.3		3		366	
2213-419	50-46.4	11/27/2007				83							
2215-419	50-46.4	3/11/2008	120	-	12.4	368	6.4	7.1		3.2		322	
2217-419	50-46.4	6/30/2008	138	-	14.2		5.4	9.7		3		343	
2219-419	50-46.4	8/19/2008	151	-	17.6	99	5	10.7		3.1		412	
2221-419	50-46.4	12/8/2008	166	-	15.8	93	6.6	12.5		3		396	
6007-419	50-46.4	9/1/2009	164.6	0	19.3	117	7.64	9.52	3.3	3.06	937	297	8
6005-419	50-46.4	3/17/2010	139.36	0	14.02	342	8.52	3.69	3	3.04	923	371.7	7
8478-419	50-46.4	9/13/2010	134.64	0	14.89	10	9.41	10.3	3.4	2.91	991	385.9	4
8477-419	50-46.4	3/22/2011	42.2	0	3.18		0.32	7.13	4	3.82	503	251.1	5
8476-419	50-46.4	9/20/2011	126.96	0	9.63		3.97	11.1	3.1	3.06	841	382.4	5
7211-419	50-46.4	4/3/2012	124.57	0	8.26		5.48	7.29	3	3.08	747	363.9	0
8474-419	50-46.4	9/10/2012	118.8	0	9.28	42	3.64	8.68	3.2	3.16	870	361.2	5
8473-419	50-46.4	3/25/2013	121.6	0	10.01	315	7.21	6.68	4	3.15	753	325.1	5
AnnaS1		Average	158.2	0.0	12.3	235.9	6.8	9.1	3.4	3.1	919.6	352.5	5.9
		Av. 08-13	129.0	0.0	12.4	163.2	5.8	8.7	3.4	3.1	820.6	350.9	4.9
	AnnaS2 -Raw												
14016-421	50-46.6	12/16/1996	160	0	10.1		3.1	9.63		3.1	984	225	2
14359-421	50-46.6	6/13/2000	94	0	6.51	54	0.887	7.08		3.2	739	252	4
16221-421	50-46.6	6/15/2004	49.2	0	3.49	60	1.14	5.83	4	3.4		172.5	3
16222-421	50-46.6	10/4/2004	117.6	0	7.98	150	1.23	9.22	4	3.3		267.8	3
16223-421	50-46.6	5/12/2005	67	0	3.9		0.657	5.38	2.6	3.4		220.8	3
16224-421	50-46.6	11/7/2005	81.2	0	0.5	20	0.639	8.74	3.5	3.6		159.6	3
17027-421	50-46.6	9/6/2006	36	0	1.827	20	0.833	3.87	4	3.7		105.7	3
2211-421	50-46.6	11/29/2006	31	-	1.8	67	0.3	4		3.7		124	
2213-421	50-46.6	11/27/2007				18							
2215-421	50-46.6	3/11/2008	26	-	2.2	60	0.1	3.8		3.9		168	
2219-421	50-46.6	8/19/2008	36	-	2.7	6	0.8	5.5		3.6		137	
2221-421	50-46.6	12/8/2008	28	-	1.4	4	2.9	6.2		3.8		115	
6007-421	50-46.6	9/1/2009	157.2	0	19.91	7	7.8	9.37	3.4	3.04	941	411.3	7
6005-421	50-46.6	3/17/2010	17.05	0	1.5	46	0.27	6.89	4.5	4.02	288	104.4	1
8478-421	50-46.6	9/13/2010	25.74	0	1.03	150	0.2	5.18	3.6	3.82	249	101.5	3
8477-421	50-46.6	3/22/2011	162.4	ND	13.5		11.79	6.5	3.4	3.11	770	339.5	5
8476-421	50-46.6	9/20/2011	37.41	0	2.4		0.53	6.45	4	3.7	401	144.1	5
7211-421	50-46.6	4/3/2012	20.7	0	0.96		0.49	3.5	3.7	3.95	256	92.2	5
8474-421	50-46.6	9/10/2012	17	0	0.44	10	0.99	5.33	3.2	3.83	270	82.8	5
8473-421	50-46.6	3/25/2013	18.18	0	1.24		0.17	3.75	4	4.05	263	100.8	5
AnnaS2		Average	62.2	0.0	4.4	48.0	1.8	6.1	3.7	3.6	516.1	174.9	3.8
		Av. 08-13	49.6	0.0	4.3	40.4	2.4	5.7	3.7	3.7	429.8	163.3	4.5
	VFP1 out												
6007-1171	50-46.41	9/1/2009	-126.4	175.09	0.04	31	2.73	7.3	7	6.95	858	277.8	9
6005-1171	50-46.41	3/17/2010	-127.8	151.53	0.04	98	2.64	5.53	7	7.16	772	265.8	1
8477-1171	50-46.41	3/22/2011	-112.6	127.83	<0.04	85	3.8	6.74	7	7.05	696	237.3	10
8476-1171	50-46.41	9/20/2011	-81.99	99.16	0.04		7.14	6.44	7	6.41	630	236.6	18
7211-1171	50-46.41	4/3/2012	-98.7	128.45	0	54	2.45	3.7	7	6.96	698	262.8	12
8475-1171	50-46.41	9/11/2012	-157.2	226.19	<0.04	3	9.81	10.6	7	6.87	904	304.3	28
8473-1171	50-46.41	3/25/2013	-81.41	104.55	<0.10	75	3.85	3.75	7	7.16	672	225.9	10
16221-117	50-46.41	6/15/2004	-243.2	283.4	0.5	100	0.6	6.14	7.5	7.2		230.9	3

16222-117	50-46.41	10/4/2004	-76.8	174.6	0.5	100	0.3	10.1	7.3	7.2		472.3	3
16223-117	50-46.41	5/12/2005	-103.8	193.6	0.5		0.697	6.16	7.1	7.4		394.9	4
16224-117	50-46.41	11/7/2005	-42.4	138.8	0.588	100	3.85	7.38	7	7.1		361.8	4
17027-117	50-46.41	9/6/2006	-135	166.8	0.5	90	1.073	8.84	7	7.4		320	6
	VFP2 out												
6007-1173	50-46.42	9/1/2009	-128.4	188.64	0.28	29	16.86	8.1	7	6.62	884	297	18
6005-1173	50-46.42	3/17/2010	-131.9	164.06	0.04	72	12.29	7.4	6.8	7.03	896	344.2	18
8477-1173	50-46.42	3/22/2011	-112.2	122.38	<0.04	90	5.95	5.46	7	7.07	698	247.9	14
8476-1173	50-46.42	9/20/2011	-92.34	120.06	<0.04		14.77	8.73	7	6.45	730	260.3	26
7211-1173	50-46.42	4/3/2012	-99.7	134.04	0	26	3.74	5.1	7	6.64	747	2867	29
8475-1173	50-46.42	9/11/2012	-158.4	191.73	0.85	3	27.53	9.74	7	6.64	905	330.8	74
8473-1173	50-46.42	3/25/2013	-116.2	147.34	<0.10	75	6.84	4.28	7	7.16	742	264.5	15
16221-117	50-46.42	6/15/2004	-216.6	253.8	0.5	100	2.5	7.32	7.5	7.1		253.5	8
16222-117	50-46.42	10/4/2004	6.6	194.2	0.5	46.42	1.13	9.79	7.4	7.2		326.5	3
16223-117	50-46.42	5/12/2005	-99.6	184.8	0.5		3.02	6.1	6.8	7.4		324.4	8
16224-117	50-46.42	11/7/2005	-57.2	107.6	1.13	100	1.18	8.07	7	6.9		360.8	10
17027-117	50-46.42	9/6/2006	-124.8	151.4	0.5	92	5.78	9.1	7	7.1		325.1	12
	VFP3 out												
6007-1175	50-46.43	9/1/2009	-95.4	150.09	0.06	30	10.33	9.69	7	6.67	902	359.4	23
6005-1175	50-46.43	3/17/2010	-88.98	121.53	0.64	98	0.73	2.68	7	7.14	758	273.7	3
8477-1175	50-46.43	3/22/2011	-105.2	110.89	0.66	98	0.33	2.86	7	6.99	701	261.8	6
8476-1175	50-46.43	9/20/2011	-75.22	109.89	0.14	95	5.36	10.7	7	6.51	738	307.7	9
7211-1175	50-46.43	4/3/2012	-88.95	129.59	0.78	69	2.46	2.5	7	6.65	741	300.7	18
8475-1175	50-46.43	9/11/2012	-123	146.19	0.39	18	6.67	15.2	7	6.92	861	321.6	14
8473-1175	50-46.43	3/25/2013	-71.31	103.2	1.02	85	0.45	1.79	7	7.05	626	257.9	14
16221-117	50-46.43	6/15/2004	-162.8	197.2	0.5	100	0.3	7.88	7	7		287.7	3
16222-117	50-46.43	10/4/2004	-33.6	159.8	0.5	100	0.657	11	7.3	7.1		367.8	12
16223-117	50-46.43	5/12/2005	-84.2	171.8	0.5	100	1.04	7.7	7.4	7.3		416	3
16224-117	50-46.43	11/7/2005	-57	99.4	0.5	100	0.999	9.01	7	6.8		395.9	6
17027-117	50-46.43	9/6/2006	-110.4	136.8	0.502	92	5.58	7.8	7	7		317.3	10
	VFP4 out												
6007-1177	50-46.44	9/1/2009	-90.8	148.13	0.16	34	23.17	10.3	7	6.59	951	375.1	10
6005-1177	50-46.44	3/17/2010	-130	152.98	0.04	120	3.73	3.84	7	7.35	896	352.1	1
8477-1177	50-46.44	3/22/2011	-122.6	127.92	0.18	100	1.56	4.34	7	7.14	736	271.4	6
8476-1177	50-46.44	9/20/2011	-73.83	116.91	<0.04	75	20.28	12.6	7	6.37	863	376.5	29
7211-1177	50-46.44	4/3/2012	-72.64	115.22	0.6	60	1.36	3.9	7	6.73	764	341.4	10
8475-1177	50-46.44	9/11/2012	-107.8	123.03	<0.04	18	49.5	14	7	6.85	881	412.6	31
8473-1177	50-46.44	3/25/2013	-80.4	105.58	0.24	80	1.16	3.15	7	7.28	740	273.3	7
16221-117	50-46.44	6/15/2004	-185.6	204.8	0.5	100	0.3	7.6	7	7.1		318.2	3
16222-117	50-46.44	10/4/2004	-97.6	188.2	0.5	200	0.349	9.01	7.5	7.1		403.3	3
16223-117	50-46.44	5/12/2005	-94.2	178.4	0.5		0.832	7.63	7.2	7.1		403	6
16224-117	50-46.44	11/7/2005	-58.4	131	0.5	100	0.3	3.23	7	7.1		424.4	3
17027-117	50-46.44	9/6/2006	-122.2	162.8	0.5	94	2.64	6.64	7	7.2		327.1	8

	Final out												
16221-425	50-46.45	6/15/2004	-181.4	204.8	0.5	400	0.786	7.11	7.5	7.6		299.5	10
16222-425	50-46.45	10/4/2004	-61.4	154.8	0.5	425	0.344	9.08	8	7.5		362.5	4
2225-425	50-46.45	10/2/2004		171						7.3			
2227-425	50-46.45	10/28/2004		154						7.5			
2229-425	50-46.45	11/27/2004		137						7.3			
2231-425	50-46.45	12/29/2004		154						7.4			
2235-425	50-46.45	3/21/2005		150						7.4			
2237-425	50-46.45	4/23/2005		144						7.6			
16223-425	50-46.45	5/12/2005	-69	146.8	0.5	410	0.321	3.05	7.4	7.6		421.5	3
16224-425	50-46.45	11/7/2005	-62.2	91.8	3.95	400	4.1	7.3	7.5	7.3		360.1	3
17027-425	50-46.45	9/6/2006	-104	131	0.5	350	0.749	4.44	7	7.4		343.7	10
2211-425	50-46.45	11/29/2006	-83	89	0.2	395	0.4	2.2		7.1		322	
2239-425	50-46.45	4/24/2007		124						7.9			
2213-425	50-46.45	11/27/2007	-69	95	0.2	101	0.6	2.1		7.5		271	
2215-425	50-46.45	3/11/2008	-75	108	0.2	400	1.6	5.2		7		278	
2217-425	50-46.45	6/30/2008	-102	132	0.2		0.2	0.9		6.7		299	
2219-425	50-46.45	8/19/2008	-106	128	0.9	105		0.1		7.3		347	
2221-425	50-46.45	12/8/2008	-80	108	0.2	97	0.7	3.1		6.8		380	
2223-425	50-46.45	3/17/2009	-103	118			0.9	3.6		7		260	
6007-425	50-46.45	9/1/2009	-121.4	139.7	0.41	124	0.04	0.16	7.2	7.22	848	353.4	8
6005-425	50-46.45	3/17/2010	-119	145.8	0.04	388	1.52	3.14	7	7.93	807	289.4	1
8478-425	50-46.45	9/13/2010	-95.24	101.2	<0.04	150	<0.04	0.08	7	7.42	859	346.1	2
8477-425	50-46.45	3/22/2011	-111.6	117.28	0.16	373	1.27	4.31	8.5	7.51	701	239.4	5
8476-425	50-46.45	9/20/2011	-76.81	103.68	<0.04		4.52	8.12	7	6.66	711	260.3	9
7211-425	50-46.45	4/3/2012	-90.55	124.17	0.1	209	0.39	2.79	7.2	6.89	719	288.1	7
8475-425	50-46.45	9/11/2012	-119.2	136.47	<0.04	42	1.2	4.5	7.8	7.8	825	320.4	10
8473-425	50-46.45	3/25/2013	-83.43	105.24	0.1	315	0.41	1.84	7	7.83	689	251.3	13
		Average	-95.7	130.2	0.5	275.5	1.1	3.7	7.4	7.4	769.9	314.6	6.5
		Av. 08-13	-98.7	120.6	0.3	220.3	1.2	2.9	7.3	7.2	769.9	301.0	6.9
	Combined VFP												
2211-423	VFP1-4 c	11/29/2006	-89	111	0.3	395	2.4	8.6		7.2		376	
2213-423	VFP1-4 c	11/27/2007	-87	111	1	101	3.2	8.8		6.5		321	
2217-423	VFP1-4 c	6/30/2008	-118	153	0.3		3.1	7.4		6.7		292	
2219-423	VFP1-4 c	8/19/2008	-135	150	0.1	105	3.9	8.7		7		381	
2221-423	VFP1-4 c	12/8/2008	-89	119	0.1	97	3.2	8.4		6.8		332	
2223-423	VFP1-4 c	3/17/2009	-109	122			2.2	4.5				296	

SUMMARY SHEET - AVERY

Name: Avery County: Clinton

Latitude: 40° 10' 32" N Longitude: 77° 45' 5" W

Watershed: Middle Br., Big Run, tributary of Beech Creek

Risk Level: High

Year Built: 2004

Designer: BAMR (Helfrich)

Local Group or person: Beech Creek Watershed Assoc.

Treatment types, Sequence: Collection Pond, Flushable Upflow limestone bed, Settling pond, Vertical Flow Pond with siphon, Wetland, and Horizontal Flow Limestone Bed

Upflow Limestone Bed

3000 tons limestone; about 200 x 100 ft; about 3.5-4 ft. thick.

VFP

Area(water surface): 89,000 ft^2 = 8240 m^2

Compost thickness: 3 ft. (Hedin map)

Limestone thickness, size, quality: 2 ft.

Comments: 2 layers of underdrain, flusher on upper layer, flow limited on lower.

Rehab, date and nature: ULP pipes cleaned, 2006

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 190 gal/min*, pH 2.9, acidity 355, Fe 40 mg/L, Mn 66 mg/L, Al 19 mg/L, SO_4 1159 mg/L (N=3)(*Design flow; no recent flow data)

Average effluent 2008-13

Wetland in (=discharge from VFP): pH 4.5, acidity 116 mg/L, alk. 102(?), Fe 12 mg/L, Mn 56 mg/L, Al 9 mg/L, SO_4 1081 mg/L, N=3

Final out: pH 7.2, acidity -76# mg/L, alk. 102 mg/L, Fe 22 mg/L, Mn 18 mg/L, Al 0.2 mg/L, SO_4 1059 mg/L, N=3. (#5/20/10 calculated acidity is much higher)

Loading (g acidity/day, g/m2/d): 369,086 g/d; 44 $g/m^2/d$ assuming no treatment by ULP.

References: Datashed, Report by Hedin Environmental, 2008, Recommendations for the Avery Passive Treatment System, 6 p.; TMDL report for Beech Creek.

Conclusions: The system has a variety of problems from design and construction, so that the Mn removal bed is receiving major amounts of Fe and Al. However, the final outflow (RDOUT) shows net alkaline conditions. The location of major treatment is unclear. Neither siphon works, and much water bypasses the system either in the bypass channel or in the overburden.

AVERY SITE

The Avery passive system is located in Clinton County, on the Middle Branch of Big Run, a tributary of Beech Creek. The system was constructed in 2004. It treats the outflow from an abandoned surface mine. The system is on private property with gated access, and the owner is unwilling to allow access except to the DEP, which has a legal right to enter. As a result, I was unable to visit the site, and the present report is based mainly on a 2008 report by Hedin Environmental plus data in Datashed. However, the report provides a good picture of the system.

The system consists of a Collection Pond, an Upflow Limestone Pond (ULP) with siphon, a Settling Pond, a Vertical Flow Pond (VFP) with siphon flush, a Wetland, and a Horizontal Flow Limestone Bed (HFLB). There is also a Flush Pond to receive the outflow during flushing of the ULP and/or VFP (not clear which). The AMD flows into the bottom of the Upflow Limestone Pond, and the siphon flushes from the same perforated inflow pipes. The Hedin report indicates that the siphon flushes only a small amount of water at a flush, apparently because the underdrain is not able to furnish water to the siphon fast enough, so the siphon flow is broken. The Settling Pond, about 200 x 150 ft. receives the flow from the ULP. The Settling Pond is divided in two by a limestone dike, so that alkalinity is generated by flow through the limestone. From the Settling Pond, the flow is into the Vertical Flow Pond, which has 2 outlets that are apparently restricted so the pond gradually fills and then flushes through a siphon. This siphon does not flush but is constantly running at a slow rate, apparently because the siphon has lost its prime. The VFP outflow goes to a Wetland, and then to the HFLB for Mn removal. Apparently the flush water from at least one of the siphons flows into the Flush Pond, but the details are not clear.

Only limited data are available on the performance of the system. Almost no flow data is available. The report by the designer indicates that the design flow was 190 gal/min. Recent inflow chemistry averages pH 2.9, acidity 356 mg/L, Fe 40 mg/L, Mn 66 mg/L, Al 19 mg/L and SO_4 1159 mg/L, based on 3 analyses in 2009-12. The chemistry and flow apparently vary greatly, and a bypass channel is provided. During construction, appreciable flow into and out of the pond bottoms was a problem. The liner in the VFP pond was punctured in order to avoid bulges from upflowing water. Neither siphon is working properly, as noted above. The data clearly shows that the ULP and VFP are not treating the water completely, but at most times the HFLB is receiving acidic water with appreciable metals. At the time of the Hedin report, the HFLB was releasing net alkaline water. However, treatment of Fe and Al-bearing water will coat the limestone and result in failure at some point. Considerable water is bypassing the system, either through the bypass channel or through the unconsolidated zone beneath the system.

Recently, proposals for rebuilding are being developed.

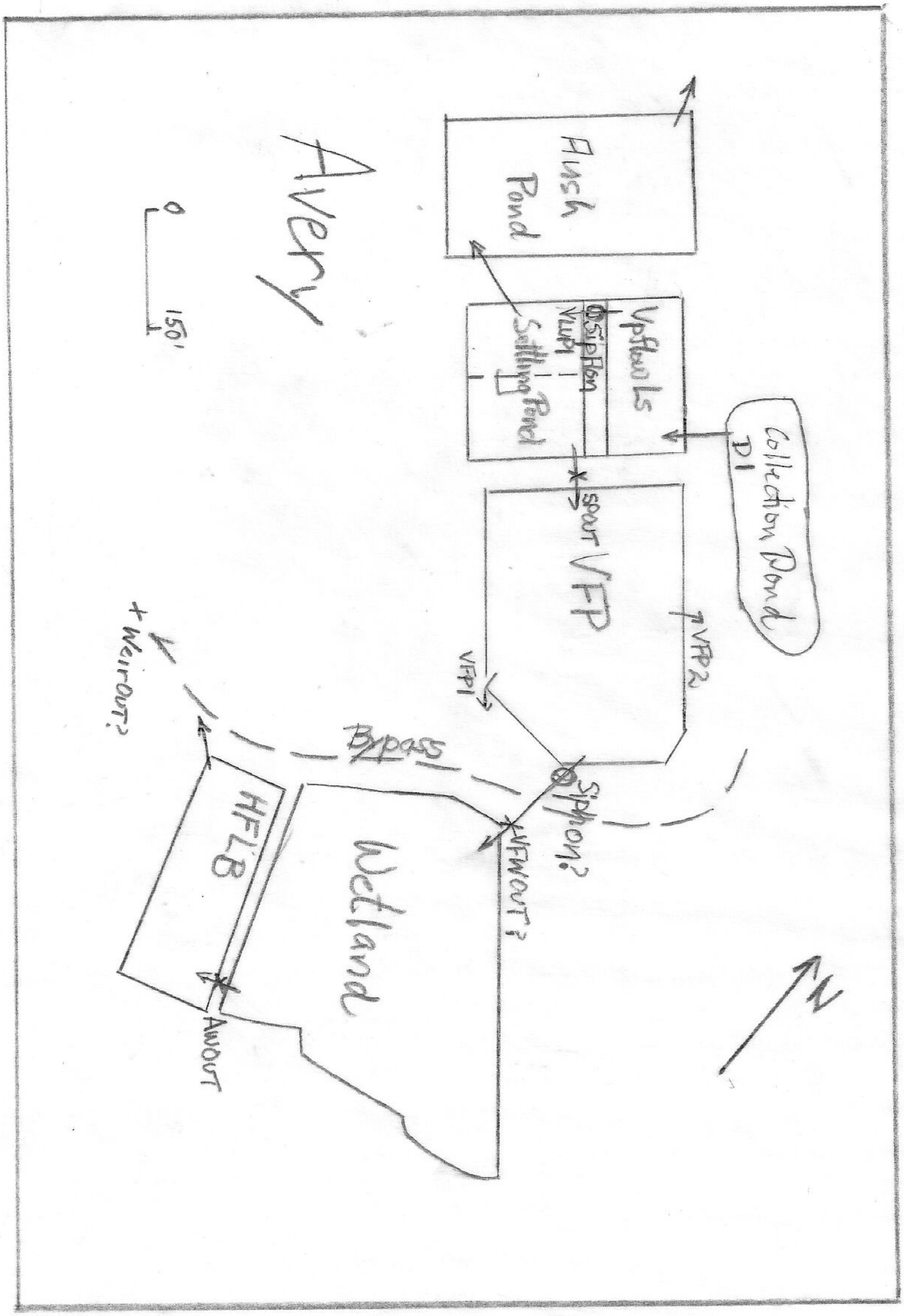

Avery
0
150'
Flush Pond
Settling Pond
Collection Pond
D1
VFP
VFP2
VFP1
Bypass
Siphon?
Weirout?
Wetland
HFLB
AWOUT
N

Table AV	Avery Site															
ID	Site	Date	Acidity	Alkalinity	Alkalinity	Al	Temp	Flow	Fe	Mn	pH fld	pH Lab	Spec.Co	Spec.Co	SO4	TSS
			mg/L	mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L			uS/cm	uS/cm	mg/L	mg/L
6195-1707	AWOUT	10/1/2009	-16.48	101	102.18	0.65			21.31	58.76	6.6	7.02		1957	1108.5	2
6193-1707	AWOUT	5/20/2010	202.18	0	ND	14.47			6.38	59.39	3.3	3.27		1837	1412.5	7
7275-1707	AWOUT	5/3/2012	161.99	0	ND	12.51	16.5		8.94	50.13	4.5-5.0	3.18	1219	1381	723.8	256
	Average		115.9	33.7	102.2	9.2	16.5		12.2	56.1	5.0	4.5	1219.0	1725.0	1081.6	88.3
6193-1703	BY-1	5/20/2010	359.63	0	ND	17.39			102.29	60.69	3.7	3.64		1983	1474	<1
7275-1703	BY-1	5/3/2012	284.97	0	ND	20.53	10.1		66.83	68.44	4.5-5.0	3.2	1344	1810	1096.4	7
	BY-1	11/16/2010	481		0	14.9			141	68		3.8			1419	20
6195-1693	D1	10/1/2009	273.96	0	ND	19.87			34.82	67.94	3.13	2.98		1935	1069.2	1
6193-1693	D1	5/20/2010	314.29	0	ND	18.24		0	48.22	69.02	3	3.06		2025	1222.8	3
	D1	11/16/2010	355		0	19.4			37.5	60.5		2.9			1186	<5
	Average		314.4	0.0	0.0	19.2			40.2	65.8	3.1	3.0		1980.0	1159.3	2.0
6195-1695	LUP1	10/1/2009	-0.8	27	11.43	0.23			0.11	3.14	6.5	6.45		1840	1125.7	1
6193-1695	LUP1	5/20/2010	154.54	0	ND	13.4			1.63	52.95	3.8	3.78		1707	1156.2	2
	LUP1	11/16/2010		3.2	17	<0.5			<0.3	18.5		7.1			1078	8
7275-1695	LUP1	5/3/2012	181.69	0	ND	15.78	20.2		3.43	66.24	5.0-5.5	3.41	1185	1697	1169.7	10
6195-1709	RDOUT	10/1/2009	-59.09	0	74.49	0.19			0.09	9.82	7.22	7.09		1950	1181.4	1
6193-1709	RDOUT	5/20/2010	-11.23	50	51.29	0.22			65.77	30	6.9	7.12		1744	1186.9	4
	RDOUT	11/16/2010	-157		179	<0.5			0.36	12.7		7.5			808	18
	Average		-75.8	25.0	101.6	0.2			22.1	17.5	7.1	7.2		1847.0	1058.8	7.7
6195-1697	SPOUT	10/1/2009	-66.73	76	82.46	<0.04			0.07	<0.02	8.13	7.52		1971	1282.4	3
6193-1697	SPOUT	5/20/2010	-90.48	105	98.69	0.08			<0.04	0.38	7.6	8.01		1800	1012.6	4
	SPOUT	11/16/2010	-73		85.8	<0.5			<0.3	<0.05		8.1			946	<5
7275-1697	SPOUT	5/3/2012	-92.14	70	103	0.11	19.4		0.27	15.31	7.5	7.78	1030	1566	852.1	6
6195-1701	VFR1	10/1/2009	358.99	0	ND	19.82			81.79	75.49	3	2.91		2167	1397.7	2
6193-1701	VFR1	5/20/2010	380.43	0	ND	14.59			72.06	68.06	3	3.06		2104	1381.7	1
	VFR1	11/16/2010	442		0	18.5			89.6	65.8		3.1			1401	12
7275-1701	VFR1	5/3/2012	236.61	0	ND	12.64	17.9		38.08	63.53	5	3.05	1376	1763	931.5	18
6195-1699	VFR2	10/1/2009	328.44	0	ND	19.74			81.08	75.02	2.97	2.93		2151	1319.2	1
6193-1699	VFR2	5/20/2010	347.98	0	ND	14.07			51.55	60.13	3.1	3.07		2092	1289.4	5
7275-1699	VFR2	5/3/2012	214.92	0	ND	11.75	18.8		34.31	57.44	3.5-4.0	2.97	1268	1591	949.8	34
	VFR2	11/16/2010	436		0	18.5			92.9	66.1		3.1			1418	8
6193-1705	VFROUT	5/20/2010	351.52	0	ND	17.46			6.53	68.59	3.7	3.61		1988	1566	2
6195-1717	Weir Out	10/1/2009		208							7.38					
7275-1717	Weir Out	5/3/2012	122.19	0	ND	11.52	18.9		1.14	47.88	5	3.6	106.1	1239	751.4	6

SUMMARY SHEET – BEAR ROCK RUN

Name: Bear Rock Run County: Cambria

Latitude: 40°25'09"N Longitude: 78°34'57"W

Year Built: 1998

Risk Level: Low

Designer: NRCS

Local Group or person: None?

Treatment types, Sequence: System 1: 2 Oxidation Ponds, Anaerobic wetland, Limestone Pond, Outflow wetland. System 2: 2 small wetland ponds with short limestone channel.

Rehab, date and nature:

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

System 1: Flow 33 gal/min, pH 4.9, Acidity 8 mg/L, Fe 2.2 mg/L, Mn 0.5 mg/L, Al 0.4 mg/L, SO_4 21 mg/L (N=3)

Average effluent 2008-13

System 1: Flow 28 gal/min, pH 6.2, acidity -14 mg/L (calc.), alk. 11 mg/L, Fe 0.2 mg/L, Mn 0.4 mg/L, Al 0.2 mg/L, SO_4 18 mg/L (N=3)

Loading (g acidity/day, g/m2/d):

References: Datashed. Report 1998 (see below).

Conclusions: The reported acidity in 2009-10 is probably in error: Calculated effluent acidity and the 2013 acidity is negative. The system is performing satisfactorily,.

BEAR ROCK RUN

The Bear Rock Run treatment system is located in Washington Twp., Cambria County, up-slope from the town of Lilly. The system drains into a small tributary of Bear Rock Run, which in turn runs into the Little Conemaugh River. The AMD is apparently from an abandoned underground mine. The Lilly water supply is on upper Bear Rock Run, but it does not appear that the treated discharge goes into the reservoir or water supply.

Two treatment systems are present at the site. The systems were built about 1996, rather than 2009 as reported in Datashed . The main one, System 1, consists of 4 pond-units, but the character of these is not evident. According to a report on the project apparently written about 1998 (Report, 1998), the first 2 ponds in this system are oxidation ponds, about 140 x 50 ft. . The oxidation ponds are followed by Pond 3, an anaerobic wetland, and then by pond 4, a limestone pond about 120 x 50 ft. The inflow in 2009-13 to this system (3 samples) averages pH 4.9, acidity 8 mg/L, Fe 2.2 mg/L, Mn 0.5 mg/L, Al 0.4 mg/L and SO_4 21 mg/L at a flow of 33 gal/min. The bottom of the first pond was covered with Fe precipitate, indicating that some Fe is being removed. The final outflow of System 1 in 2008-13 averages pH 6.2, acidity -14 mg/L, alkalinity 11 mg/L, Fe 0.2 mg/L, Mn 0.4 mg/L, Al 0.2 mg/L, SO_4 18 mg/L at a flow of 28 gal/min. The acidity listed is based on calculated acidity from Fe, Mn, Al, pH and alkalinity. However, the lab acidities for the 2009 and 2010 samples are positive, which resulted in the site being listed as failure in the DEP study.. Apparently the lab acidities/alkalinities or metal contents are in error Based on this data, the discharge is not very acid, the system is removing essentially all the metals, and is discharging net alkaline water..

The second smaller system consists of 2 very small wetland/ponds (~6 x 10 ft) connected by limestone channels. Possibly one of the ponds is an anaerobic wetland. The inflow (2 samples) averages pH 4.9, acidity 13 mg/L, Fe 1.4 mg/L, Mn 0.3 mg/L, Al 0.25 mg/L and SO_4 12 mg/L at a flow of 10 gal/min. The outflow averages pH 6.0, acidity -21 mg/L, Fe 0.4 mg/L, Mn 0.2 mg/L, Al 0.15 mg/L and SO_4 12 mg/L at a flow of 10 gal/min. This system satisfactorily treats the metals, and leaves negligible acidity (negative when using calculated acidity).

If the calculated acidities are accepted, these systems are performing very satisfactorily.

Reference

Final Report for Section 319h Funds, Bear Rock Run Habitat Improvement/Alkalinity Boosting Project, Washington Township, Cambria County, PA, 1998(?), 20p. Possibly by Cambria County Conservation District. Obtained from Donna Carnahan.

Datashed

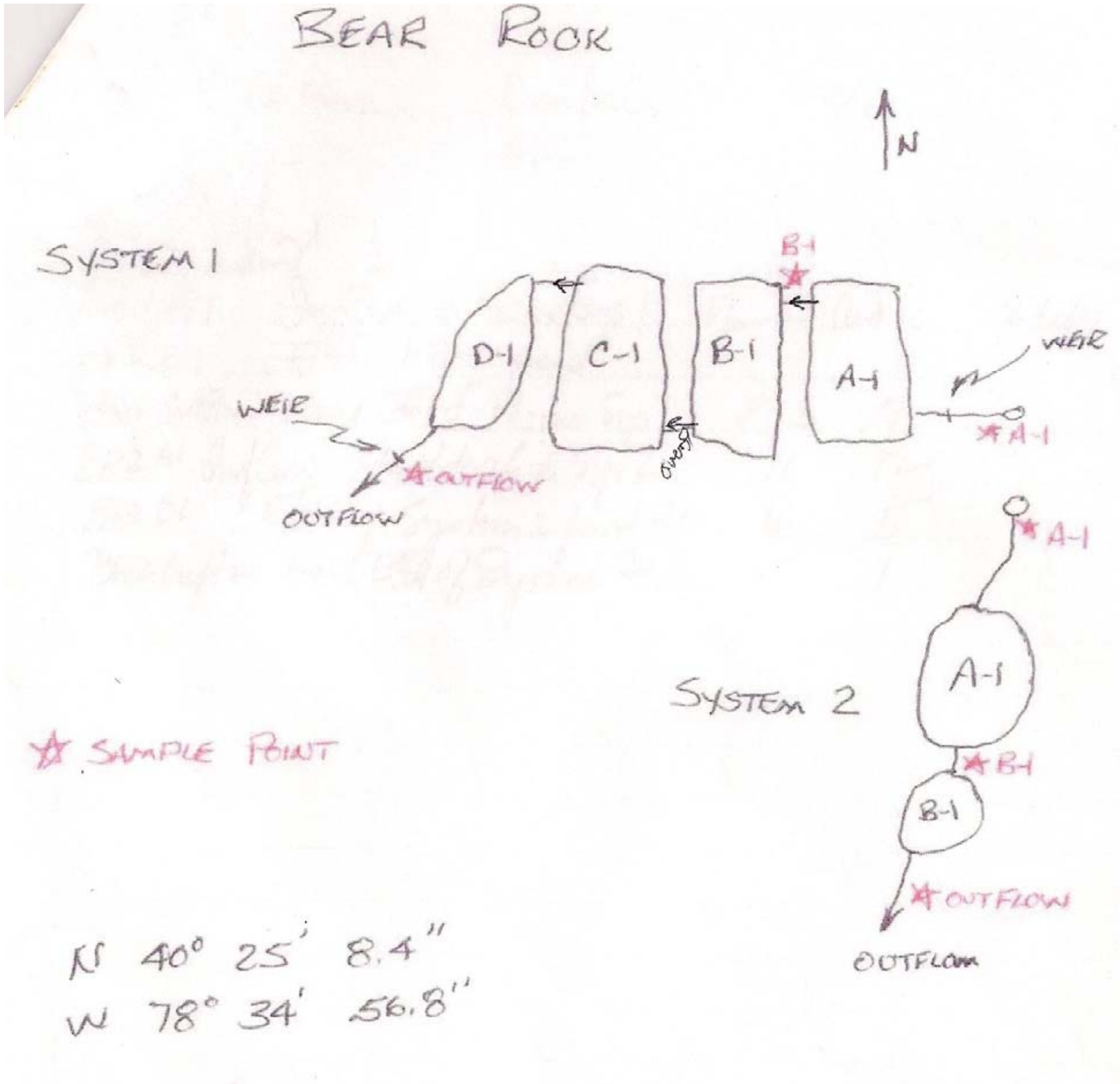


Figure 1. Sketch map of Bear Rock Run system (from Datashed). Ponds A1-D1 are about 120 to 140 ft. long.

Table BR1	Bear Rock Run														
ID	Site	Date	Acidity	Alkalinity	Al	T	Flow	Fe(tot.)	Mn	pH(fld)	pH(lab)	SPCond	SO4	TDS	TSS
	Outflow A		mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
5963-1643	BR1 Outfl	9/14/2009	6 (-18*)	20	0.1	17.5	6	0.11	0.38	6.03	6.47	68	21	42	<5
5961-1643	BR1 Outfl	4/23/2010	8 (-8*)	11	0.1	9.8	41	0.07	0.4	4.47	5.62	46	14		<5
0707-121	BR1 Outfl	7/15/2013	-15.4	1.8	0.5	20	38	0.3	0.37	5.6	6.4	62	20	38	5
		Average	(-14*)	10.9	0.2	15.8	28.3	0.2	0.4	5.4	6.2	58.7	18.3	40.0	5.0
			*calc. acidity												
	Inflow A1														
5963-1639	BR1A1	9/14/2009	13		0.4	11.6	6	2.97	0.7	5.8	5.1	62	19	36	<5
5961-1639	BR1A1	4/23/2010	12		0.4	6.5	41	1.46	0.4	5.12	4.72	47	23		<5
0707-120	BR1A1	7/15/2013	-2.2		0.5	10	52	2.3	0.5	5.8	5	70	20	78	5
		Average	7.6		0.43	9.4	33.0	2.2	0.5	5.6	4.9	59.7	20.7	57.0	
5963-1641	BR1B1	9/14/2009	13	0	0.5	16.4	6	0.47	0.72	4.48	4.5	72	21	34	5
5961-1641	BR1B1	4/23/2010	9		0.3	7.4	41	0.86	0.43	4.51	4.69	50	16		<5
707	BR1B1	7/15/2013								5		65			
5963-1649	BR2 Outfl	9/14/2009	(-24*)	27	0.2	15	2	0.65	0.16	6.8	6.86	60	14	42	<5
5961-1649	BR2 Outfl	4/23/2010	3 (-18*)	19	0.1	5.7	19	0.1	0.21	5.27	6.45	41	9		<5
		Average	(-21*)	23	0.15	10.4	10.5	0.375	0.19	6.035	6.655	50.5	11.5	42	
5963-1645	BR2A1	9/14/2009	16	0	0.3	13.2	2	2.71	0.51	5.46	4.58	56	16	30	<5
5961-1645	BR2A1	4/23/2010	9	7	0.2	5.6	19	0.11	0.14	4.29	4.93	31	8		<5
		Average	12.5	3.5	0.25	9.4	10.5	1.41	0.33	4.875	4.755	43.5	12	30	
5963-1647	BR2B1	9/14/2009	3	23	0.1	15	2	0.53	0.24	6.41	6.53	55	15	38	<5
5961-1647	BR2B1	4/23/2010	7	10	0.1	5	19	0.18	0.27	5.62	5.68	36	9		<5

CESSNA RUN

Name: Cessna Run County: Indiana

Latitude: 40°50’26”N Longitude: 78°55’14”

Year Built: 2005

Risk Level: Low (to Medium?)

Designer: Skelly and Loy – Terry Schmidt

Local Group or person: Indiana County Conservation District

Treatment types, Sequence: 3 systems

1. Open Limestone Channel
2. Disch 2: Pipe to Upflow Limestone Bed 1, Siphon outflow, Wetland 1, Outflow channel
3. Disch 3: Pipe to Upflow Limestone Bed 2, Siphon outflow, Settling Pond, Wetland 1, Outflow channel

Rehab, date and nature: None known

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Disch. 2: Flow 40 gal/min, pH 3.6, Acid. 67 mg/L, Fe 2.2 mg/L, Mn 16 mg/L, Al 2.8 mg/L, $SO_4$567 mg/L (N=8)

Disch. 3: Flow 71 gal/min, pH 3.9, acid. 70 mg/L, Fe 0.3 mg/L, Mn 19 mg/L, Al 4.4 mg/L, SO_4 613 mg/L (N=8)

Average effluent 2008-13

Final out: Flow 62 mg/L, pH 5.2, acid 29 mg/L, alk. 8 mg/L, Fe 3 mg/L, Mn 10 mg/L, Al 2.1 mg/L, SO_4 555 mg/L (N=8)

References: Datashed, Report in Datashed., Map from Skelly & Loy

Conclusions: This Limestone Bed system only removes about half the acidity from the slightly acid water, leaving a few mg/L Al and Fe. However, Cessna Run downstream is only slightly net acid (average 1 mg/L) and averages 24 mg/L alkalinity.

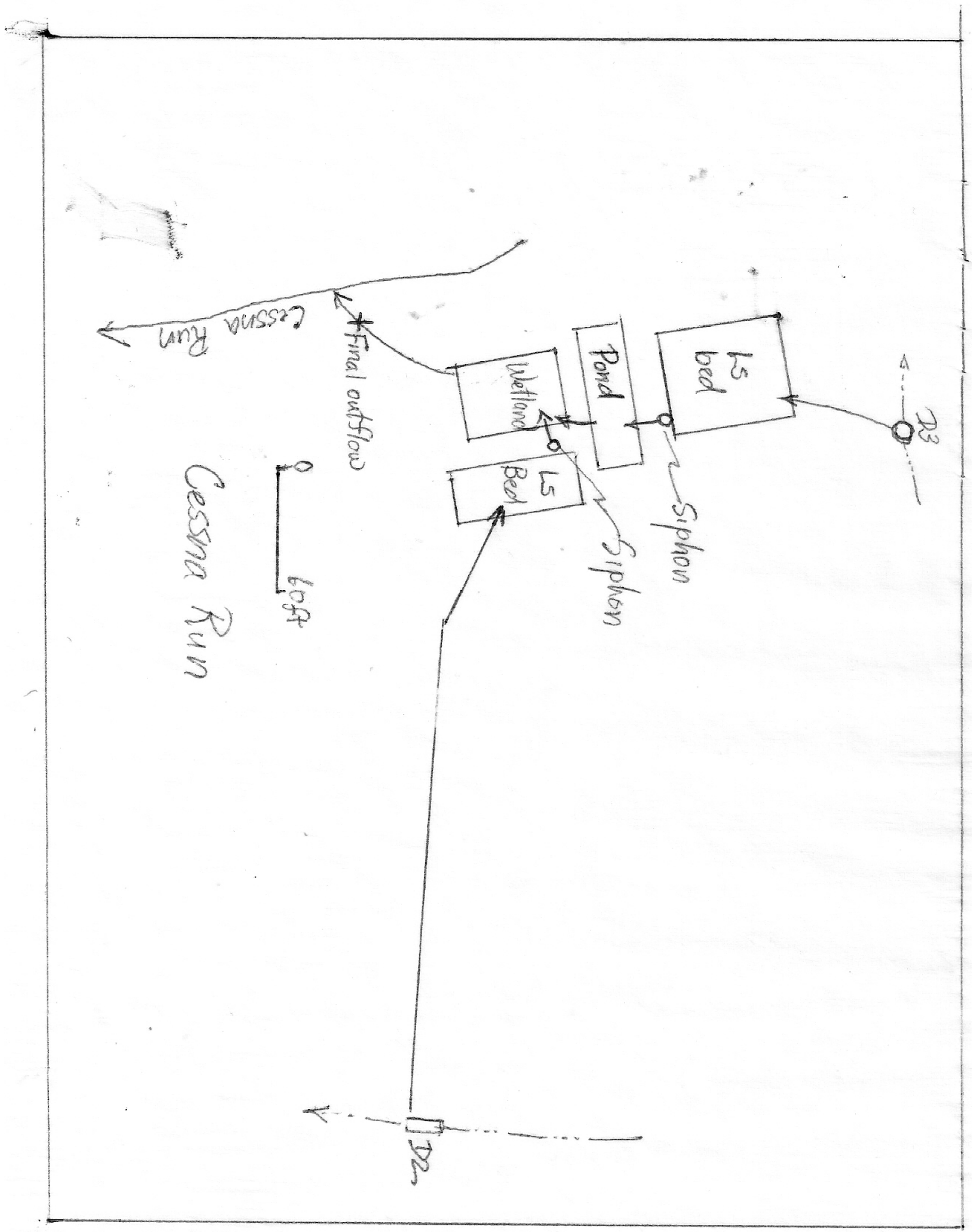
CESSNA RUN

The Cessna Run treatment system is located in Canoe Township, Indiana County about 7 miles south of Punxsutawney and 2 miles west of Smithport. It is in the watershed of Little Mahoning Creek, in the North Branch, also called Cessna Run. The source of the AMD is an abandoned underground mine uphill from the system.

Three discharges are treated by the treatment systems. Discharge 1 emerges along a road east of the main set of treatment systems, and is treated by a limestone channel extending along the road for several hundred feet. Discharge 2 is picked up in a grate along the margin of another road and transported about 400 feet downhill to its treatment, consisting of Upflow Limestone Bed 1 with dimensions of about 80 x 30 ft. The outflow of the limestone bed is a siphon which flushes to Wetland Pond 1 about 45 x 35 ft in area. This pond flows out a limestone-lined channel about 100 feet to the stream. Discharge 3 is a small stream just north of the treatment area. The stream flows into a grate and is piped to Upflow Limestone Bed 2, with dimensions of about 75 x 60 feet. Both limestone beds have stone sizes of less than 1 inch diameter. Limestone bed 2 discharges through a siphon to Pond 2, about 85 x 20 feet in dimensions. This pond in turn flows into Wetland Pond 1 and mixes with water from system 2.

Discharge 1 in the period 2007-09 had average pH 4.1, acidity 56 mg/L, Mn 14 mg/L and Al 3.7 mg/L at a flow of 19 gal/min (10 samples). No Fe data is reported for Cessna Run sites, except from the current study. The effluent from the limestone channel averages pH 6.2, acidity 7 mg/L, alkalinity 20 mg/L, Mn 5.5 mg/L, and Al 1.9 mg/L. Eight samples of Discharge 2 from 2008-13 averaged pH 3.6, acidity 67 mg/L, Fe 2.2 mg/L, Mn 16 mg/L, Al 2.8 mg/L at a flow of 40 gal.min. Ten samples of Discharge 3 averaged pH 3.9, acidity 70 mg/L, Fe 0.3 mg/L, Mn 19 mg/L, Al 4.4 mg/L at a flow of 71 gal/min. The outflow of treatment systems 2 and 3 averaged pH 5.2, acidity 29 mg/L, alkalinity 8 mg/L, Fe 0.3 mg/L, Mn 10 mg/L, and Al 2.1 mg/L with a flow of 62 gal/min. Based on this data, the system is doing a considerable amount of treatment but the effluent remains acid.

The adjacent stream has low or negative acidity and averages 24 mg/L alkalinity. It is large enough that the chemistry is probably little affected by the effluent. Numerous gas wells are present in the vicinity and may be responsible for at least as much stream load as the mine drainage.



LS bed
Pond
Wetland
LS Bed
Siphon
Siphon
Final outflow
Cessna Run
Cessna Run
60ft
D3
D2

Table CS	Cessna Run													
ID	Sample Site	Sample Dat	Acid.	Alk. Fld	Alk. Lab	Al	Flow (gal/	Fe	Mn	pH fld	pH lab	SO4	Cond.	TSS
154-192	Channel Efflu	1/22/2007	12		6	3.12	78		6.42	5.6	5.2			
155-192	Channel Efflu	6/6/2007	-10		29	3.06			4.76		6.9			
156-192	Channel Efflu	7/17/2007	-20		37	0.65			3.42		7.3			
276-192	Channel Efflu	4/23/2008	12		14	3.24			5.91		6.3			
277-192	Channel Efflu	7/25/2008	-1	15	29	0.35			4.87		6.7			
278-192	Channel Efflu	11/7/2008	-8	15	40	0.35	1.5		4.83		6.8			
279-192	Channel Efflu	1/27/2009	25	5	9	2.33	10		6.9	6	5.8			
280-192	Channel Efflu	4/17/2009	22	10	8	3.08	3		6.3	5.9	5.8			
281-192	Channel Efflu	7/27/2009	6	40	26	0.64	10		5.65	6.3	6.2			
282-192	Channel Efflu	12/15/2009	33	20	7	2.3	15		5.75	5	4.9			
	Channel Efflu	average	7.1	17.5	20.5	1.9	19.6		5.5	5.8	6.2			
276-265	CR1	4/23/2008	-1	25	22	0.59			2.27		6.6			
277-265	CR1	7/25/2008	-9	15	30	0.3			1.5		6.8			
278-265	CR1	11/7/2008	-13	15	38	0.11			0.97		6.9			
279-265	CR1	1/27/2009	1	10	23	0.51			2.34	6.6	6.4			
280-265	CR1	4/17/2009	3	10	21	0.48			1.67	6.5	6.6			
281-265	CR1	7/27/2009	-4	60	37	0.48			1.1	6.3	6.5			
282-265	CR1	12/15/2009	7	40	19	0.43			0.55	5	6.1			
276-266	CR2	4/23/2008	1	25	21	0.57			2.32		6.6			
277-266	CR2	7/25/2008	-6	15	29	0.84			1.86		6.8			
278-266	CR2	11/7/2008	-11	15	34	0.13			0.88		6.9			
279-266	CR2	1/27/2009	0	10	22	0.55			2.61	6.7	6.4			
280-266	CR2	4/17/2009	4	15	21	0.55			1.73	6.5	6.5			
281-266	CR2	7/27/2009	4	40	24	0.3			3.95	6.87	6.2			
282-266	CR2	12/15/2009	12	40	18	0.41			0.68	5	6.3			
	CR downstrea	Av. 2008-13	0.6	22.9	24.1	0.5			2.0	6.3	6.5			
154-191	Discharge D1	1/22/2007	39		1	<0.05	78		10.3	3.7	4.1			
155-191	Discharge D1	6/6/2007	47		0	3.66			14.8		3.9			
156-191	Discharge D1	7/17/2007	60		0	3.29			19		3.6			
276-191	Discharge D1	4/23/2008	46	15	4	3.49			10.3		4.4			
277-191	Discharge D1	7/25/2008	61	0	1	3.03			15.6		4.1			
278-191	Discharge D1	11/7/2008	71	0	1	4.4	1.5		22.1		4.1			
279-191	Discharge D1	1/27/2009	54	5	4	4.17	10		10.6	4.5	4.4			
280-191	Discharge D1	4/17/2009	55	0	2	3.74	1.5		10.3	4.4	4.1			
281-191	Discharge D1	7/27/2009	74	0	0	4.47	10		13.1	3.7	4			
282-191	Discharge D1	12/15/2009	51	20	2	2.89	15		9.61	3.5	4.2			
		Average	55.8	5.7	1.5	3.7	19.3		13.6	4.0	4.1			
154-193	Discharge D2	1/22/2007	62		0	1.81	163		11.9	3.4	3.7			
155-193	Discharge D2	6/6/2007	61		0	3.58			16.3		3.6			
156-193	Discharge D2	7/17/2007	70		0	2.63			17.3		3.3			
276-193	Discharge D2	4/23/2008	66		0	3.54			16		3.7			
277-193	Discharge D2	7/25/2008	75	0	0	2.17			16.2		3.5			
278-193	Discharge D2	11/7/2008	81	0	0	3.9			23.3		3.7			
279-193	Discharge D2	1/27/2009	72	0	0	3.39	20		16.9	4.1	3.9			
280-193	Discharge D2	4/17/2009	70	0	0	3.87	15		17.6	4	3.7			
281-193	Discharge D2	7/27/2009	90	0	0	2.38	5		17.3	3.7	3.4			
282-193	Discharge D2	12/15/2009	64	0	0	2.31	20		13.1	3.5	3.7			
0707-125	D2	7/17/2013	27		0	1.6	15	2.2	12.3	3.7	3.5	567	1180	5
		Average	67.1	0.0	0.0	2.8	39.7	2.2	16.2	3.7	3.6	567.0	1180.0	
154-194	Discharge D3	1/22/2007	58		0	7.87	115		14.7	3.5	4			
155-194	Discharge D3	6/6/2007	67		0	5.31			21.7		3.9			
156-194	Discharge D3	7/17/2007	90		0	6.36			28.7		3.7			
276-194	Discharge D3	4/23/2008	66		0	4.63			17.9		3.9			
277-194	Discharge D3	7/25/2008	74	5	0	4.67			24.1		3.8			
278-194	Discharge D3	11/7/2008	88	5	0	4.99	2		25		4			
279-194	Discharge D3	1/27/2009	84	5	2	5.58	115		20.1	4.3	4.2			
280-194	Discharge D3	4/17/2009	71	0	0	4.53	60		16.8	4.3	4			
281-194	Discharge D3	7/27/2009	96	0	0	5	60		23	3.7	3.8			
282-194	Discharge D3	12/15/2009	56	0	0	2.44	120		10.6	4	3.9			
0707-122	D3	7/17/2013	29		0	3.1		0.3	15.3	4.1	3.8	613	1200	5
		Av. 2008-13	70.5	2.5	0.25	4.4	71.4	0.3	19.1	4.1	3.9	613	1200	5
		Average	70.8	2.5	0.2	5.0	78.7	0.3	19.8	4.0	3.9	613.0	1200.0	
154-195	System Efflue	1/22/2007	-20		38	3.71	278		5.32	6.1	6.9			
155-195	System Efflue	6/6/2007	15		9	1.96			10.3		5.7			
156-195	System Efflue	7/17/2007	4		15	0.86			8.81		6.3			
276-195	System Efflue	4/23/2008	22		7	1.97			9.68		5.1			
277-195	System Efflue	7/25/2008	20	10	11	0.38			8.21		6.2			
278-195	System Efflue	11/7/2008	13	10	15	2.43	0.5		4.94		6.4			
279-195	System Efflue	1/27/2009	46	5	8	3.08	115		14.4	5.7	4.9			
280-195	System Efflue	4/17/2009	35	5	7	2.71	60		11.6	5.6	5			
281-195	System Efflue	7/27/2009	38	20	7	2.8	60		12.2	5	4.9			
282-195	System Efflue	12/15/2009	50	20	5	2.33	120		10.1	4	4.5			
0707-124	System Efflue	7/17/2013	6		0	1.42	15	0.3	8.6	4.6	4.5	555	1010	5
		Av. 2008-13	28.8	11.7	7.5	2.1	61.8	0.3	10.0	5.0	5.2	555.0	1010.0	5.0
		Average	20.8	11.7	11.1	2.2	92.6	0.3	9.5	5.2	5.5	555.0	1010.0	5.0

SUMMARY SHEET - Clinton Road

Name: Clinton Road County: Allegheny

Latitude: 40.495^{o} N Longitude: 80.2725^{o} W

Watershed: Enlow Run, tributary of Montour Run

Risk Level: Medium

Year Built: 2006

Designer: N A Water Systems

Local Group or person: Montour Run Watershed Association. Located on land of Pittsburgh Int. Airport

Treatment types, Sequence: 2 systems: Both with Inflow channels and pipes, VFP, Wetland

VFP

Area(water surface): 5000 +4500 = 9500 ft^2 = 880 m^2
Compost thickness: ?
Limestone thickness, size, quality: ?
Comments

Rehab, date and nature: System 1: Compost and limestone stirred 2012.
System 2: Compost stirred, 2012

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Unit 1: Flow 22 gal/min, pH 2.9, acidity 424 mg/L, Fe 9.2 mg/L, Mn 4.4 mg/L, Al 44 mg/L, SO4 1080 mg/L, N=16
Unit 2: Flow 5gal/min, pH 3.1, acidity 421 mg/L, Fe 6.7 mg/L, Mn 13 mg/L, Al 52 mg/L, SO_4 1503 mg/L, N=1

Average effluent 2008-13

Unit 1 Flow 20 gal/min, pH 5, acidity -87 mg/L alkal. 127 mg/L, Fe 46 mg/L, Mn 13 mg/L, Al 5 mg/L, SO4 1435 mg/L, N=1
Unit 2: Flow 5 gal/min, pH 6.7, acidity -87 mg/L, alkalinity 214 mg/L, Fe 20 mg/L, Mn 13 mg/L, Al <0.05 mg/L, SO_4 1610 mg/L, N=1

Loading (g acidity/day, g/m2/d): 51,000 + 11,500 = 62,500 g/d; 71 g/m^2/d

References: Datashed, reports from Watershed Assoc.

Conclusions: These systems have removed about 40% of the acidity from the AMD in this small watershed for 7 years. Both systems are somewhat plugged and require cleanout of precipitate and frequent flushing to remove Al and Fe precipitate. They also appear too small for complete treatment, and are not capturing all the AMD in the watershed.

Description – Clinton Road

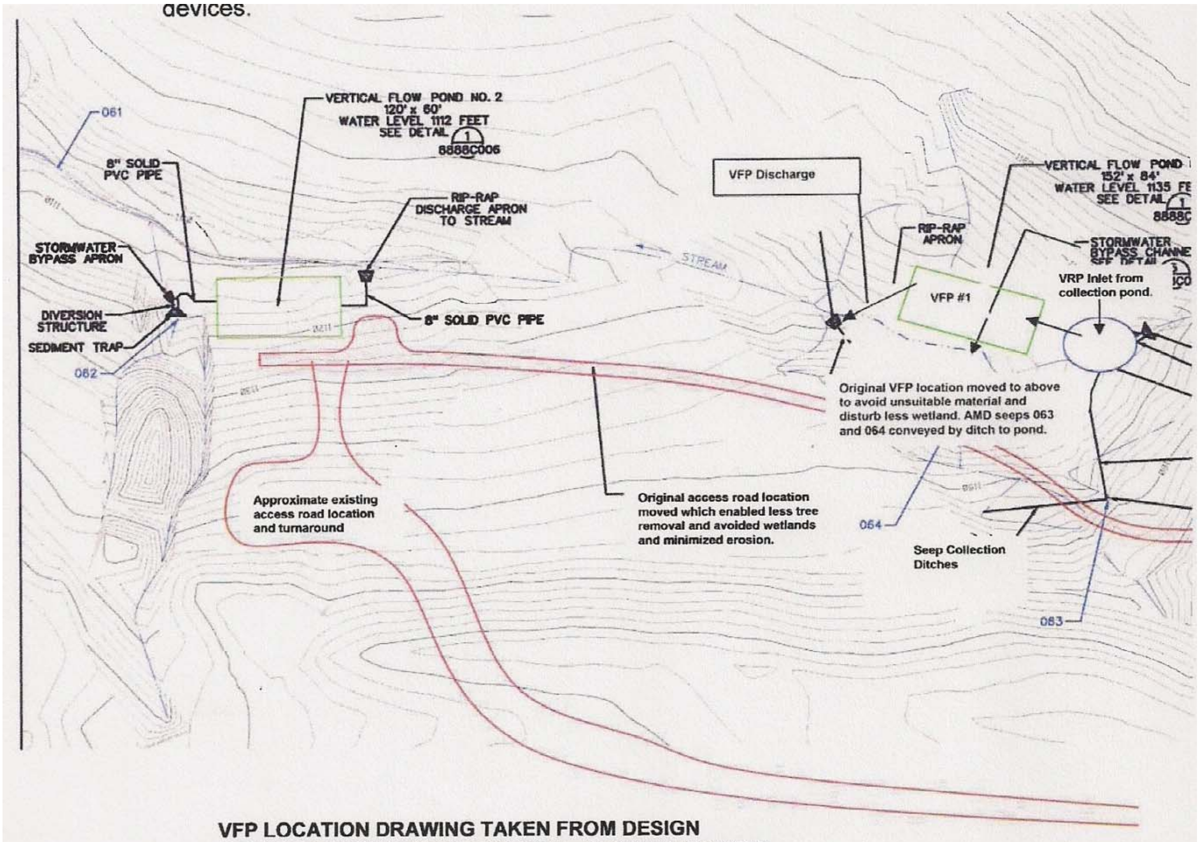
This system is located in Allegheny County on the property of the Pittsburgh International Airport. It treats the discharge from an abandoned underground coal mine and possibly a surface mine. The AMD is treated by 2 separate units, located along a small valley tributary to Enlow Run, a tributary in turn of Montour Run. They were constructed in 2006.

Unit 1 is composed of a small Collection Pond that receives water via a pipe from an upslope mine discharge, a Vertical Flow Pond, and a Wetland. The VFP is about 125 x 40 ft in size. Originally the compost apparently overlay the limestone, but recently the two were mixed in the process of restoring permeability and removing Fe precipitate. When visited, the surface of the limestone was largely dry and covered with Fe precipitate. AMD was flowing across the surface and percolating down at the south end of the pond. The report on the site shows two separate underdrains, but only one outflow was recognized and sampled. At Unit 2, the flow emerges from the base of an apparent spoil pile from an underground entry. It flows into a small collection pond, then into Vertical Flow Pond 2, and out via a pair of underdrains, only one of which was flowing appreciably at about 5 gal/min. In addition about 2 gpm was running out the overflow. The flow enters a small stream and wetland. The VFP 2 is about 100 x 45 feet in size. The limestone and compost of this pond was also stirred in 2012 to restore permeability, so that the compost and limestone are now mixed.

Sample site 61 is the small stream into which both systems flow. It still has considerable acidity and metals. The flow is considerably larger than the flow through the treatment systems, indicating that additional AMD sources are present in the small watershed.

Although the systems have partially treated considerable AMD, the systems are not as effective as they should be. Given the relatively high Al (44 mg/L), they should be set up with either automatic flushing or flushed manually on a monthly basis. They are currently partly plugged with the accumulated Fe and Al from 7 years of service. They are only partly treating the water.

devices.



VFP LOCATION DRAWING TAKEN FROM DESIGN DRAWING SHOWING THE GENERAL AS-CONSTRUCTED CONFIGURATION OF VFP #1 AND VFP#2 WITH THE MAJOR ASSOCIATED CONVEYANCE AND COLLECTION STRUCTURES (SEE DESIGN FOR ORIGINAL LAYOUT)

Table CR	Clinton Road														
ID	Site	Date	Acidity	Alkalinity	Al(D)	Al (T)	Temp	Flow	Fe	Mn	pH Fld	pH Lab	SO4	TDS	TSS
			mg/L	mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L			mg/L	mg/L	mg/L
	Outflow stream														
4995-400	61	3/31/2006	49.6	1.1	6.84	23.4		75	4.38	14.4		4.51	1340	2040	89
4997-400	61	6/20/2006	<1	62.2	<0.10	0.68		18	4.81	16.7		6.84	1450	2450	16
4999-400	61	9/28/2006	<1	74.1	<0.10	0.5		4	4.17	18.9		7.28	1500	2640	11
5001-400	61	12/11/2006	<1	42.4	<0.10	3.29		37.5	8.78	15.7		6.6	1520	2430	30
5003-400	61	3/21/2007	136	<1	21.3	21.6		180	1.75	8.17		4.5	985	1450	6
5005-400	61	6/28/2007	91.2	<1	9.31	13.3		24	6.32	19.4		4.55	1620	2630	19
5007-400	61	9/26/2007	35.1	<1	2.63	5.18		6	3.36	18.9		4.48	1660	2810	21
5009-400	61	12/14/2007	12	7	0.36	4.19		100	1.97	6.77		5.57	773	1150	24
5011-400	61	3/25/2008	225	<1	27.4	27.7		150	1.83	7.97		4.28	1070	1530	2
5013-400	61	6/19/2008	115	2	7.68	12		25	5.16	19.7		4.66	1400	2380	18
5015-400	61	9/23/2008	40	1	3.27	8.27		7.5	4	19.4		4.9	1950	2680	33
4985-400	61	3/9/2009	114	<1	15.4	15.8	5.9	50	0.83	10.7	4.84	4.58	1110	1800	2
4987-400	61	6/23/2009	60	<1	7.7	11.7	19.8	29.4	2.32	12.9	4.54	4.55	1150	1860	23
4989-400	61	9/21/2009	116	0	15.8	16	17.7	5.3	2.3	18.5	4.36	4.27	1480	2740	11
4991-400	61	12/15/2009	61	<1	3.58	6.99	3.9	28.5	2.69	11.2	5.39	4.99	1150	1800	18
4993-400	61	3/30/2010	227	<1	31	31.2	5.9	81.3	1.89	8.27	3.89	3.87	1080	1680	5
7207-400	61	9/2/2010	120	<1	13.4	14.2	21.4	2.7	2.74	20.4	3.79	3.94	1590	2880	11
7205-400	61	12/10/2010	271	<1	46.8	53.7	1.2	75.6	1.19	9.93	4.58	4.25	826	1870	4
7203-400	61	3/29/2011	488	<1	54.3	55.9	2.6	113.5	8.63	8.81	3.2	3.34	1490	1840	15
7201-400	61	6/27/2011	274	<1	34.9	36.4		17.7	3.7	15.1		3.26	1490	2180	<2
7199-400	61	9/22/2011	112	<1	14.6	14.8	18.9	6.8	3.52	17.3	3.8	3.93	1730	2350	7
7197-400	61	12/8/2011	108	<1	19.1	22	4.1	60	2.361	9.39	4.8	4.75	1730	1600	10
7195-400	61	3/27/2012	372	<1	25.4	26.2	5.4	55.3	1.941	10.2	4	3.95	1240	1630	13
Average	61		164.2	21.1	18.0	19.9	10.6	48.3	3.6	13.8	4.2	4.6	1368.2	2111.2	17.6
Av. 08-13	61		195.3	0.8	21.4	25.3	10.6	44.6	3.2	13.3	4.2	4.2	1374.3	2066.8	12.5
	Inflow, VFP1														
4995-399	66	3/31/2006	307	0	31.4	31.5		65	5.3	3.2		2.8	826	1150	<2
4997-399	66	6/20/2006	273	0	28.4	29.2		9	5.28	3.02		2.78	810	1320	2
4999-399	66	9/28/2006	336	0	36.1	36.2		4.5	5.07	2.64		3.02	1020	1630	5
5001-399	66	12/11/2006	345	0	34.5	35.5		6.8	4.52	3.06		3.2	1090	1520	<5
5003-399	66	3/21/2007	357	0	37.3	37.7		90	5.1	3.5		2.61	887	1250	<2
5005-399	66	6/28/2007	301	0	33.2	36.9		4.2	9.62	3.99		2.88	968	1520	5
5007-399	66	9/26/2007	352	0	36.5	41.4		2.1	6.86	3.89		2.91	1150	2100	5
5009-399	66	12/14/2007	345	0	33.8	35.9		18.8	5.13	2.64		2.73	968	1430	<2
5011-399	66	3/25/2008	348	0	32.4	32.6		75	5.21	2.94		3	857	1130	<2
5013-399	66	6/19/2008	367	0	32	33		6	5.41	3.51		2.9	908	1450	<2
5015-399	66	9/23/2008	320	0	38.8	38.8		1.7	5.58	3.66		3.1	1330	2060	<2
4985-399	66	3/9/2009	337	0	33.5	35.1	9.7	18.8	4.95	2.9	2.86	2.81	742	1290	<2
4987-399	66	6/23/2009	324	0	36.3	35.3	20.7	14.3	4.66	2.88	2.86	2.92	901	1350	4
4989-399	66	9/21/2009	364	0	47	47.8	18.2	1.9	6.64	4.34	2.97	2.94	1090	2280	3
4991-399	66	12/15/2009	376	0	42.8	43	8	6.5	4.52	2.8	2.95	3.12	1180	1850	2
4993-399	66	3/30/2010	477	<1	48.2	49.3	13.1	50	9.48	3.53	2.87	2.78	1080	1700	<2
7207-399	66	9/2/2010	404	<1	42.1	45.5	23.1	1.3	8.07	3.7	2.95	3.16	1150	2250	4
7205-399	66	12/10/2010	530	<1	81.1	71.8	9.2	37.5	7.12	4	2.74	2.84	1300	1790	2
7203-399	66	3/29/2011	830	<1	70.4	71.4	12.5	60	30.2	3.92	2.7	2.78	1330	1840	<2
7201-399	66	6/27/2011	386	<1	34.3	34.9		6.5	7.85	3.97		2.85	924	1410	<2
7199-399	66	9/22/2011	440	<1	47.6	47.8	20.1	1.9	6.29	4.27	3	3.04	1400	1980	4
7197-399	66	12/8/2011	339	0,1	39.1	40	10.6	27.3	7.27	4.31	2.8	2.86	912	1290	<2
7195-399	66	3/27/2012	522	<1	31.8	34	10	27.3	5.75	3.98	2.7	2.86	790	1110	6
0707-138	VFP1 in	8/28/2013	424	0		41.6	22	10	28.1	15.5	2.4	2.8	1378	2266	10
Average	VFP1 in		391.8	0.0	40.4	41.1	14.8	22.8	8.1	4.0	2.8	2.9	1041.3	1623.6	4.3
Av. 08-13	VFP1 in		424.3	0.0	43.8	43.9	14.8	21.6	9.2	4.4	2.8	2.9	1079.5	1690.4	4.4

4985-1025	Pond 1 - E.L.	3/9/2009					11	17.6			4.66				
4987-1025	Pond 1 - E.L.	6/23/2009					23.9	12.5			4.85				
4989-1025	Pond 1 - E.L.	9/21/2009					21.2	1			4.56				
4991-1025	Pond 1 - E.L.	12/15/2009					4.6	7			4.99				
4993-1025	Pond 1 - E.L.	3/30/2010					10.1	13			4.72				
7207-1025	Pond 1 - E.L.	9/2/2010					24.7	1.3			4.36				
7205-1025	Pond 1 - E.L.	12/10/2010					3.9	37.5			3.79				
7203-1025	Pond 1 - E.L.	3/29/2011					8.2	30			3.6				
7201-1025	Pond 1 - E.L.	6/27/2011						5.7				3.84			
7199-1025	Pond 1 - E.L.	9/22/2011					20	0.3			5.1				
7197-1025	Pond 1 - E.L.	12/8/2011					6.9	12.5			3.9				
7195-1025	Pond 1 - E.L.	3/27/2012					13.2	8.8			4.4				
4985-1027	Pond 1 - E.R	3/9/2009					10.6	12			4.56				
4987-1027	Pond 1 - E.R	6/23/2009					23.8	9.4			4.57				
4989-1027	Pond 1 - E.R	9/21/2009					21.4	3			4.36				
4991-1027	Pond 1 - E.R	12/15/2009					4.3	7.1			4.81				
4993-1027	Pond 1 - E.R	3/30/2010					10	12.5			4.44				
7207-1027	Pond 1 - E.R	9/2/2010					24.9	1.2			4.34				
7205-1027	Pond 1 - E.R	12/10/2010					3.9	14.3			3.67				
7203-1027	Pond 1 - E.R	3/29/2011					8.4	12.5			3.4				
7201-1027	Pond 1 - E.R	6/27/2011						4.5				3.61			
7199-1027	Pond 1 - E.R	9/22/2011					20.8	3.8			3.4				
7197-1027	Pond 1 - E.R	12/8/2011					7	20			3.7				
7195-1027	Pond 1 - E.R	3/27/2012					12.9	17.6			3.7				
0707-139	VFP1Out	8/28/2013	-87.2	126.6	4.7		21		45.93	12.5	5	6.4	1435	2378	42
0707-140	VFP2 in	8/28/2013	421	0		51.7	20	5	6.68	13	2.8	3.1	1503	2248	16
4985-1029	Pond 2 - E.L.	3/9/2009					6.8	9.7			5.03				
4987-1029	Pond 2 - E.L.	6/23/2009					22.2	5			4.75				
4989-1029	Pond 2 - E.L.	9/21/2009					20.3	1.3			4.4				
4991-1029	Pond 2 - E.L.	12/15/2009					6.7	4.1			4.92				
4993-1029	Pond 2 - E.L.	3/30/2010					8.6	17.7			4.31				
7207-1029	Pond 2 - E.L.	9/2/2010						0							
7205-1029	Pond 2 - E.L.	12/10/2010					3.5	15			4.54				
7203-1029	Pond 2 - E.L.	3/29/2011					8.5	1.5			4.5				
7201-1029	Pond 2 - E.L.	6/27/2011						0							
7199-1029	Pond 2 - E.L.	9/22/2011					19.4	1.5			6				
7197-1029	Pond 2 - E.L.	12/8/2011					8	11.5			5.3				
7195-1029	Pond 2 - E.L.	3/27/2012					11.3	10.3			4.2				
4985-1031	Pond 2 - E.R	3/9/2009					7.6	2.7			4.22				
4987-1031	Pond 2 - E.R	6/23/2009					21.3	1.3			5.7				
4989-1031	Pond 2 - E.R	9/21/2009					20.3	0.5			5.46				
4991-1031	Pond 2 - E.R	12/15/2009					8	0.6			6.08				
4993-1031	Pond 2 - E.R	3/30/2010					8.9	1.2			4.6				
7207-1031	Pond 2 - E.R	9/2/2010						0							
7205-1031	Pond 2 - E.R	12/10/2010					3.9	2.6			4.44				
7203-1031	Pond 2 - E.R	3/29/2011					7.6	0.1			4.5				
7201-1031	Pond 2 - E.R	6/27/2011						0							
7199-1031	Pond 2 - E.R	9/22/2011					19.3	0.3			6.1				
7197-1031	Pond 2 - E.R	12/8/2011					8.2	1.5			5.1				
7195-1031	Pond 2 - E.R	3/27/2012					12.3	0.4			4.6				
0707-141	VFP2 out	8/28/2013	-87	214	<0.05		21	5	19.8	12.5	5.5	6.7	1610	2626	12

4995-402	R-D	3/31/2006	13.8	9.7	<0.10	5.28		95	0.7	10.1		5.87	1010	1660	22
4997-402	R-D	6/20/2006	<1	24.2	<0.10	0.83		30	2.89	13.7		6.75	1310	2220	21
4999-402	R-D	9/28/2006	<1	77.6	<0.10	0.54		8	4.66	12.8		7.16	1210	2240	22
5001-402	R-D	12/11/2006	<1	53.5	<0.10	2.09		~40	7.86	10.1		6.9	1100	1870	16
5003-402	R-D	3/21/2007	3.84	4	2.27	7.34		300	0.36	3.55		5.5	566	1200	33
5005-402	R-D	6/28/2007	42.7	<1	3.36	7.1		60	2.27	14.4		4.92	1410	2270	29
5007-402	R-D	9/26/2007	<1	21.7	<0.10	0.66		20	0.91	15		6.54	1460	2460	7
5009-402	R-D	12/14/2007	<1	59	<0.10	0.26		600	0.32	2.2		6.68	404	982	6
5011-402	R-D	3/25/2008	114	<1	17.1	19		660	0.36	4.61		4.54	801	1300	23
5013-402	R-D	6/19/2008	102	2	4.58	7.1		50	1.1	16.9		4.86	1250	2150	16
5015-402	R-D	9/23/2008	<1	12	0.15	1.41		10	2.92	14		6.18	1490	2220	9
4985-402	R-D	3/9/2009	<1	30	0.28	2.52	4.9	180	0.34	3.95	6.6	6.6	623	2050	18
4987-402	R-D	6/23/2009	<1	18	0.11	5.1	16.9	50	0.78	10.1	6.15	6.08	887	1660	26
4989-402	R-D	9/21/2009	24	2	1.93	6.15	15.1	8	0.97	14.6	5.26	4.99	1330	2340	15
4991-402	R-D	12/15/2009	<1	67	<0.10	1.16	2	90	0.42	4.72	6.98	6.96	615	1320	8
4993-402	R-D	3/30/2010	66	<1	11.4	16	4.4	100	0.22	4.09	4.9	4.66	590	1620	35
7207-402	R-D	9/2/2010	5	6	0.29	2.47	17.2	5	0.49	11.8	5.69	5.84	1030	2150	7
7205-402	R-D	12/10/2010	160	<1	34.1	34.7	1.5	100	0.446	8.08	4.72	4.47	992	1660	5
7203-402	R-D	3/29/2011	306	<1	40.4	41.2	0.6	120	1.77	6.6	4.7	3.98	1020	1580	13
7201-402	R-D	6/27/2011	218	<1	25.4	27.9	15.7	20	0.717	13.1	4.4	4.22	1080	1940	7
7199-402	R-D	9/22/2011	2	6	0.55	6.33	16.5	12	1.25	9.27	5.6	5.48	1030	1650	24
7197-402	R-D	12/8/2011	<1	20	0.507	6.91	3	100	0.371	4.66	6.5	6.23	580	1070	23
7195-402	R-D	3/27/2012	132	<1	9.86	16.3	4.4	70	0.428	6.68	5	4.54	901	1370	37
4995-401	R-U	3/31/2006	<1	90.3	0.37	0.62		25	1.97	0.57		6.83	308	820	<2
4997-401	R-U	6/20/2006	<1	139	<0.10	0.12		2	3.01	2.88		6.94	181	678	12
4999-401	R-U	9/28/2006	<1	154	<0.10	0.11		3	1.92	2.38		6.82	217	718	9
5001-401	R-U	12/11/2006	<1	118	<0.10	0.36		~5	2.51	0.96		7.2	276	736	<5
5003-401	R-U	3/21/2007	<1	81.2	<0.10	<0.10		120	0.17	0.07		7.21	210	858	6
5005-401	R-U	6/28/2007	<1	136	<0.10	<0.10		1	1.46	2.27		6.97	181	728	3
5007-401	R-U	9/26/2007	<1	161	<0.10	<0.10		12	0.79	1.68		6.75	170	720	3
5009-401	R-U	12/14/2007	<1	92	<0.10	<0.10		150	0.23	0.09		7.04	166	734	<2
5011-401	R-U	3/25/2008	<1	92	<0.10	<0.10		120	0.22	0.12		7.33	259	806	2
5013-401	R-U	6/19/2008	<1	124	<0.10	<0.10		12	0.99	1.91		7.02	198	834	2
5015-401	R-U	9/23/2008	<1	149	<0.10	<0.10		2	1.02	2.05		6.85	276	824	3
4985-401	R-U	3/9/2009	<1	99	<0.10	<0.10	5.7	30	0.23	0.15	7.28	7.36	232	1510	4
4987-401	R-U	6/23/2009	<1	172	<0.10	<0.10	17.3	5	0.66	1.2	7.19	7.26	201	956	12
4989-401	R-U	9/21/2009	<1	145	<0.10	0.14	16.4	1	0.54	0.8	7.17	7.13	143	858	3
4991-401	R-U	12/15/2009	<1	133	<0.10	<0.10	1.9	50	0.58	0.33	7.21	7.22	201	820	6
4993-401	R-U	3/30/2010	,1	111	<0.100	0.18	5.3	15	0.47	0.15	7.04	7.26	216	1170	16
7207-401	R-U	9/2/2010	<1	174	<0.100	0.83	18.3	1	1.27	1.12	7.2	7.26	113	888	<2
7205-401	R-U	12/10/2010	<1	108	<0.100	0.119	1.6	15	1.34	0.78	6.18	7.03	189	731	18
7203-401	R-U	3/29/2011	<1	102	<0.100	<0.100	1.6	10	0.804	0.24	6.3	7.32	240	878	3
7201-401	R-U	6/27/2011	<1	178	<0.100	0.108		2	1.34	1.65	6.4	7.19	169	826	2
7199-401	R-U	9/22/2011	<1	182	<0.100	<0.100	16.6	1	0.784	1.63	6.7	6.67	206	768	5
7197-401	R-U	12/8/2011	<1	131	<0.100	<0.100	3.5	10	0.558	0.27	7.1	7.47	222	652	4
7195-401	R-U	3/27/2012	<1	143	<0.100	<0.100	5.9	5	0.557	0.45	6.9	7.44	268	812	7

SUMMARY SHEET – DeSale 1

Name: DeSale 1 County: Butler

Latitude: 41^o 8' 33"N Longitude: 79^o 49' 48" W

Watershed: Seaton Run, tributary of Slippery Rock Creek

Year Built: 2000

Designer: Tim Danehy, Biomost

Local Group or person: Stream Restoration Inc.

Treatment types, Sequence: 2 Vertical Flow Ponds in parallel, Settling Pond, Wetland, and Horizontal Flow Limestone Bed.

VFP

Area(water surface): 2 x 10,000 ft^2 = 1860 m^2
Compost thickness: 0.5 ft.
Limestone thickness, size, quality: 4 ft AASHTO #1, >90% $CaCO_3$
Comments: 2 layers of underdrain pipes.

Rehab, date and nature: ?

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 31 gal/min, pH 4.0, Acidity 250 mg/L, Fe 80 mg/L, Mn 48 mg/L, Al 11 mg/L, SO_4 1287 mg/L (N=9)

Average effluent 2008-13

Flow 31 gal/min, pH 6.5, Acidity 3 mg/L, Alkalinity 32 mg/L, Fe 0.8 mg/L, Mn 26 mg/L,Al 0.5 mg/L, SO_4 1010 mg/L, (N=9)

Loading (g acidity/day, g/m2/d): 42,400 g/d;, 23 $g/m^2/d$

References: Datashed and data from Stream Restoration Inc.

Conclusions: This system, after 13 years in operation, removes essentially all the Fe and Al, and produces net alkaline water much of the time, with remaining acidity being nearly all from Mn. Along with treatment by 2 other systems, Seaton Run, the receiving stream, has water with 25-60 mg/L alkalinity and very low Fe and Al at pH 6-7.

DeSale Phase 1

The DeSale 1site is located in Venango Township, Butler County about 2 miles west of the village of Eau Claire. It treats the discharge from an abandoned surface mine. The water flows into Seaton Run, a tributary of Slippery Rock Creek. Two other nearby treatment systems also discharge water to Seaton Run. The system was built in 2000, by the Stream Restoration Inc. group, and has been maintained by them since.

The discharge enters a Forebay from which it is distributed to 2 Vertical Flow Ponds in parallel. These ponds contain about 4 ft. of limestone (each has 1500 tons of AASHTO #1 limestone and 167 tons of #57 limestone) overlain by about 1 foot (158 yd^3) of mushroom compost. The limestone contains two layers of perforated underdrain pipe. The upper set are normal discharge pipes and the lower set are flush pipes. The flushing schedule is not recorded. From the VFP's the water flows to a Settling Pond (15,200 ft^2) and then to a Wetland (18,200 ft^2). From the wetland the final unit is Horizontal Flow Limestone Bed containing 1000 tons of limestone.

The inflow AMD is relatively high in acidity and metals (pH 4.0, acidity 250 mg/L, Fe 80 mg/L, Mn 48 mg/L and Al 11 mg/L) at a flow rate of 31 gal/min. The effluent of the VFP's is sometimes net acid, but most of the Fe and Al are removed, the acidity is mostly due to Mn and the pH is above 6. The two VFP's do not treat equally – the northern VFP commonly is higher in alkalinity. The acidity loading of the systems is about 24 g/m2/d. The HFLB completes treatment, discharging water with sometimes positive, sometimes negative acidity with very low Fe and Al but considerable Mn and pH above 6. The system has been treating reasonably for 13 years.

This system, in combination with the DeSale 2 and 3 systems, have greatly improved Seaton Run. From 2004-06 (the most recent readily available data), the pH at a downstream point has been uniformly above 6, with 25-60 mg/L of alkalinity and net negative acidity about half the time. Thus the treatment has significantly benefitted the streams.

Table DS	DeSale 1													
Site	Date	Acidity	Alk. fld	Alk. Lab	Al	Temp.	Flow	Fe	Mn	pH fld	pH Lab	Sp. Cond.	SO4	TSS
		mg/L	mg/L	mg/L	mg/L	C	gpm	mg/L	mg/L			uS/cm	mg/L	mg/L
RAW	8/12/1999	380.69		0	17.25		36	78.5	66.5		3.56	1842	1284.8	62
RAW	8/17/1999	286		0	14.8		36	77.2	62		3.5		1612.4	0
RAW	8/19/1999	438.67		0	14		36	76.5	66.75		3.39	1866	1478.3	8
RAW	8/20/1999	298		0	15.4			83.4	64.8		3.4		1449	10
RAW	9/2/1999	371.9		0	15.85	25	27	84	72.25	3.4	3.41	2221	1469.1	11
RAW	9/9/1999	310		0	17.6		20	92.5	68.9		3.1		124	12
RAW	10/5/1999	492.41		0	13.8	9	28	61.5	69.5	3.2	3.21	2078	1665.4	35
RAW	10/13/1999	408		0			24				3.2		1662	
RAW	11/12/1999	556		0	21	8	26	83.5	69	3.1	3.1	2197	1622.2	126
RAW	11/18/1999	443.31		0	17.3	5	24	94.8	84	4.8	3.09	2311	2358.1	41
RAW	12/8/1999	338.38		0	21.95	4	28	47.5	72.5	3.3	3.35	2156	2525.3	50
RAW	12/28/1999	274		0	20.4		30	59.3	64.9		3.4		1287.7	12
RAW	1/13/2000	305.76		0	13.65	4	60	48.1	57	3.5	3.48	1691	1722.2	26
RAW	1/20/2000	242		0	15.4		45	68.5	59.9		3.6		681	0
RAW	2/10/2000	356		0	14.1	9	40	66.8	56.1	3.8	3.5	1723	868.9	8
RAW	3/1/2000	224.32		0	10.05	11	50	29.9	43.05	3.7	3.42	1610	1095.6	16
RAW	3/8/2000	252		0			30				3.4			951
RAW	4/4/2000	267.55		0	8	10	28	45.8	39.7	4.2	4.01	1360	1198.6	23
RAW	4/25/2000	238		3.2	6.86		50	58.4	41		4		851	0
RAW	5/4/2000	229.4		0	7.89	12	20	64.9	41.25	4.1	4.05	1474	1278.4	5
RAW	5/25/2000	276		5	7.69		40	59.5	40.5		4.1		1043.5	0
RAW	6/15/2000	286		7	7.54		50	61.1	41.3		4.2		1055.2	0
RAW	6/26/2000	250.92		0	8.22	11	44	70.8	9.25	4.5	3.11	1641	1195	3
RAW	7/13/2000	408		5			30				4.1			
RAW	8/9/2000	292		5.6	11.5		40	92.9	55.9		4.1		1858.3	1.5
RAW	9/20/2000	392.7		0	13.3	11.7		133	73.78	4.08			1375	
RAW	9/28/2000	318		8.4	13			125	69.6		4.2		1427.2	4
RAW	10/18/2000	388		6.8	13.3			132	71.2		4.1		1440.7	10
RAW	10/31/2000	418.61		0	12.8	12	26	138	79.5	4.5	4.09	2205	2031.6	5
RAW	11/14/2000	488		3.8	14			142	75.3		4		1309.4	14
RAW	12/19/2000	440		3.4	13			128	63.8		4		1498	12
RAW	1/8/2001	395.04		0	57.75	11	34	113	73	4.3	4.07	2032	1652.4	4
RAW	1/17/2001	388		0	11			121	63.1		3.9		1141	14
RAW	3/29/2001	246		5.2	8.15			78.6	48.5		4.1		750	1.5
RAW	4/5/2001	280		4.8	8.42		54	81.8	49.9		4		947.9	6
RAW	4/20/2001	253.75		0	7.37	10	78	69.6	42.92	4.1	3.52	1496	1020.3	10
RAW	5/4/2001	184		0	7.79			71.7	45.7		3.7		1230	1.5
RAW	6/5/2001	283.97		0	8.67			66.8	48.25		3.29	1704	1063.4	10
RAW	6/19/2001	407.4		0							3.8		858	1
RAW	7/11/2001	422.6		0	10.8			104	64.4		3.9		1310.1	28
RAW	8/30/2001	434.8		0	11.9			118	67.7		3.7		1357	12
RAW	10/18/2001	669.2		0	14.6			148	78.5		3.8		1510	1.5
RAW	2/14/2002	388		9.4	9.78			95.9	56.8		4.2		720.1	4
RAW	3/13/2002	372.2		0	9.24			115	70.3		3.7		1048	18
RAW	4/30/2002	318		1.6	9.89			73.1	47.9		4		898.1	15.9
RAW	7/25/2002	266.6		0	11.9			83.5	55.3		3.7		1647.5	20
RAW	10/8/2002	578		0	15.6			127	74.3		3.9		1395	16
RAW	3/14/2003	247.2		12.4	9.53			66.8	46.3		4.6		963.5	6
RAW	6/17/2003	257		0							3.8		1037.3	14
RAW	9/16/2003	306.8		1.8	10.3			62.3	42.2		4		975.1	1.5
RAW	10/29/2003	318.6		0	12			80.1	50.3		3.9		1061.7	12
RAW	3/30/2004	190		6.8	10.2			44	35		4.2		796	1.5
RAW	6/4/2004	290.8		0							3.8		942.9	10
RAW	8/27/2004	218.4		0							4		841.8	10
RAW	11/4/2004	282.6		2.6	12.1			68.1	43.3		4		909.2	1.5
RAW	3/29/2005	223		8	9.71			46.4	35.9		4.2		975.6	1.5
RAW	6/9/2005	301.4		0							3.9		968.6	8
RAW	8/19/2005	381.6		1.8	13.7			105	61.9		4		1189.3	1.5
RAW	11/3/2005	433.6		3.6	12.7			106	53.7		4		1351	4
RAW	2/9/2006	209.44		0	9.31	10		70.2	43.61	4.44	4.38	1526	1231.8	8
RAW	3/8/2006	261.69		0	8.02	10		81	46.64	4.23	4.24	1596	1042.6	6
RAW	3/21/2006	222.2		9	7.95			55.1	36.8		4.4		888	4
RAW	6/21/2006	334		0							4.1		1045	4
RAW	9/7/2006	302.8		7.2	10.3			71.4	43.8		4.1		1122.6	1.5
RAW	11/2/2006	253		0	8.55			60.4	38.6		3.9		859.3	4
RAW	8/6/2008	275.41	0	0	15.9	12.4	25	85.4	49.43	3.92	3.64	1667	965.7	3
RAW	11/12/2008	368.39	0	0	11.42	11.1	13	100	55.07	4.12	3.78	1938	1292.9	20
RAW	3/31/2009	192.63	0	0	9.33	10.1	55	71.9	41.2	4.26	3.43	1561	712.2	2
RAW	6/25/2009	205.97	0	0	7.9	12.3	35	63.2	41.73	4.16	4.34	1544	926.9	3
RAW	6/29/2009	205.97	0	0	7.9	12.3	35	63.2	41.73	4.16	4.34	1544	926.9	3
RAW	9/16/2009	268.8	0	0	11.1	12.2	20	80.1	48.8	4.11	4.22	1723	1275	10
RAW	12/14/2009	310.95	0	0	15.6	10.8	27	104	59.96	4.1	3.97	1916	1394.8	2
RAW	4/15/2010	199.72	0	0	7.99	10.7	40	84.3	39.5	4.38	3.49	1666	1278.4	4
RAW	5/22/2012	222.88		0	9.85			69	50.32		4.11	1471	1124.7	<5
	Min	184	0	0	6.86	4	13	29.9	9.25	3.1	3.09	1360	124	0
	max	669.2	0	12.4	57.75	25	78	148	84	4.8	4.6	2311	2525.3	951
	median	299.7	0	0	11.42	10.8	34.5	78.5	55.07	4.11	3.9	1697.5	1165.2	7
	Avg	322.2	0	1.65405	12.52	10.58	35.7	83.2	54.95	4.018	3.8259	1777.107	1209.9	25.1
	Avg 06-12	255.59	0	1.08	10.08	11.19	31.3	75.7	45.51	4.188	4.0293	1650.182	1072.5	5.32
	Avg 08-13	250.1	0.0	0.0	10.8	11.5	31.3	80.2	47.5	4.2	3.9	1670.0	1099.7	5.9

Forebay S	2/9/2006	187.13			11.2	3		54.8	42.7	3.88	3.57	1543	1182.4	10
Forebay S	3/8/2006	280.03			9.2	8		72.6	45.4	3.72	3.54	1622	1075.6	20
Forebay S	8/6/2008	255.71	0	0	14.79	24.8	15	21.7	49.45	3.14	3.03	1785	728.5	3
Forebay S	11/12/2008	344.55	0	0	11.02	6.5	12	68.4	52.62	3.17	3.1	2080	1562.2	16
Forebay S	3/31/2009	168.16	0	0	8.86	10	30	36.8	34.58	3.56	3.33	1561	775.2	1
Forebay S	6/25/2009	201.19	0	0	8.4	25.4	24	38.4	40.84	3.35	3.27	1645	853.3	10
Forebay S	6/29/2009	201.19	0	0	8.4	25.4	24	38.4	40.84	3.35	3.27	1645	853.3	10
Forebay S	9/16/2009	248.2	0	0	10.4	20.5	15	57.9	49.03	3.33	3.23	1881	1246.9	16
Forebay S	12/14/2009	275.97	0	0	10.19	7.6	17	71	46.79	3.52	3.08	1989	1237.9	14
Forebay S	4/15/2010	151.7	0	0	7.88	17.5	30	51.4	36.27	3.69	3.17	1676	1090.6	17
Forebay S	5/22/2012	193.83	0	0	10.17			18.9	24.95		3.11	1636	922.2	7
	Min	151.7	0	0	7.88	3	12	18.9	24.95	3.14	3.03	1543	728.5	1
	max	344.55	0	0	14.79	25.4	30	72.6	52.62	3.88	3.57	2080	1562.2	20
	median	201.19	0	0	10.17	13.75	20.5	51.4	42.7	3.435	3.23	1645	1075.6	10
	Avg	227.97	0	0	10.05	14.87	20.9	48.2	42.13	3.471	3.2455	1733	1048	11.3
VFP-N	6/26/2000			147.98	0.23	20		7.89	38.3	6.7	7	1674	1255.3	8
VFP-N	10/31/2000		150	159.4	0.56	13	26	14.9	72	6.8	6.68	2246	1657.9	26
VFP-N	4/20/2001	25.17		51.76	1.68	11		22.4	43.35	6.4	6.15	1512	1028.2	3
VFP-N	6/5/2001	2.04		91.03	0.72			18.5	41.75		6.44	1620	971.6	13
VFP-N	8/6/2008	49.64	112	57.2	1.61	24.6	10	47.5	45.31	6.43	6.04	1672	949.1	8
VFP-N	11/12/2008	24.03	181	135.06	0.17	14.7	1	59.8	37.58	6.75	6.31	1822	1173.5	15
VFP-N	3/31/2009	1.19	53	39.19	2	9.7	25	1.13	26.54	6.19	6.47	1287	620.6	2
VFP-N	6/25/2009	-5.17	79	56.89	1.76	24.3	11	2.35	31.41	6.35	6.43	1381	740	12
VFP-N	6/29/2009	-5.17	79	56.89	1.76	24.3	11	2.35	31.41	6.35	6.43	1381	740	12
VFP-N	9/16/2009	-76.2	156	149.59	0.2	22.1	5	6.18	31.09	6.6	6.67	1566	880.8	12
VFP-N	12/14/2009	20.5	92	73.95	1.35	7	10	0.08	41.22	6.7	6.56	1685	1159.9	7
VFP-N	4/15/2010	-44.69	82	61.27	1.58	15.3	12	5.5	26.84	6.42	6.57	1357	972.1	19
	Min	-76.2	53	39.19	0.17	7	1	0.08	26.54	6.19	6.04	1287	620.6	2
	max	49.64	181	159.4	2	24.6	26	59.8	72	6.8	7	2246	1657.9	26
	median	1.615	92	67.61	1.465	15.3	11	7.04	37.94	6.43	6.455	1593	971.85	12
	Avg	-0.866	109.3	90.0175	1.135	16.91	12.3	15.7	38.9	6.517	6.4792	1600.25	1012.4	11.4
VFP-S	6/26/2000			181.01	0.2	21		5.59	33.4	6.7	7.14	1698	1330.7	11
VFP-S	10/31/2000	22.64	146	141.48	0.35	13	26	23.2	74	6.8	6.69	2225	1732.6	32
VFP-S	1/8/2001	12.59		211.68	0.36	6		73.3	76.5	6.3	6.57	2230	1486.3	21
VFP-S	4/20/2001	12.59		44.86	0.8	11		35.4	43.4	6.6	6.1	1540	1020.3	17
VFP-S	6/5/2001			92.39	0.74			18.1	40.1		6.43	1619	1077.5	10
VFP-S	8/6/2008	68.36	98	27.15	2.55	23.7	15	25.4	43.6	6.49	6.07	1668	1048.4	3
VFP-S	11/12/2008	159.18	10	0.1	10.11	10	12	18	53.34	5.17	4.51	1869	1292.9	16
VFP-S	3/31/2009	94.92	0	0	7.35	9.9	30	13.8	34.55	4.13	4.01	1413	1284.6	46
VFP-S	6/25/2009	1	59	45.45	1.06	27.5	24	3.59	34.22	6.72	6.67	1535	892.9	1
VFP-S	6/29/2009	1	59	45.45	1.06	27.5	24	3.59	34.22	6.72	6.67	1535	892.9	1
VFP-S	9/16/2009	50.2	70	37.82	2.01	21.1	15	12.3	46.25	6.51	6.35	1694	1168	18
VFP-S	12/14/2009	80	18	21.2	8.47	6.1	17	16.2	49.24	5.27	5.88	1787	1264.8	94
VFP-S	4/15/2010	3.14	31	19.36	3.45	18.1	28	1.53	31.59	6.25	6.42	1517	1070.9	19
VFP-S	5/22/2012	48.36		6.74	4.29			6.43	51.43		5.38	1499	979.1	30
	Min	1	0	0	0.2	6	12	1.53	31.59	4.13	4.01	1413	892.9	1
	max	159.18	146	211.68	10.11	27.5	30	73.3	76.5	6.8	7.14	2230	1732.6	94
	median	35.5	59	41.34	1.535	15.55	24	15	43.5	6.5	6.385	1643.5	1122.8	17.5
	Avg	46.165	54.56	62.4779	3.057	16.24	21.2	18.3	46.13	6.138	6.0636	1702.071	1181.6	22.8

WL	6/26/2000			161.17	0.21	33		0.92	15.65	7.9	7.51	1923	1488.9	10
WL	9/6/2000				0	14.8		0.33	52.48	7.3			1359	
WL	9/20/2000		110		0	15.7		0.27	50.12	7.44			1263	
WL	9/29/2000				1.29	12.5		18	14.79	7.3	7.04		18.25	
WL	10/10/2000		172		0.74			23.4	12.75	7.34	7.13		1431.6	
WL	10/23/2000				0.18	8.4		6.34	17.52	7.59			1618	
WL	10/31/2000		110	116.09	0.24	12	26	0.21	52.5	7	7.24	2258	1941.9	9
WL	11/24/2000				0.2	1.9		5.51	46.64	7.06	6.98		1597.7	
WL	12/29/2000					0.4		3.45	72.52	6.87			1497.6	
WL	1/8/2001	34.31		102.82	0.21	0		3.32	67.5	6	6.52	2186	1410.8	13
WL	1/26/2001	37.4			0.28	0.1		7.18	48.4	6.44	6.46		1043.7	
WL	3/20/2001					12.3				7.2				
WL	4/20/2001	7.71		57.62	0.11	9		1.62	41.24	6.7	6.61	1575	1154	10
WL	6/5/2001	30.19		61.01	0.08			0.3	33.05		7.27	1576	1035.1	30
WL	3/28/2007	40.59	2	4.07	0.94	14.3	150	0.02	31.73	5.43	5.48	1343	698.3	3
WL	4/26/2007	35.28	11	11.18	0.56	14.1	100	0.24	31.98	6.25	6.15	1381	757.9	4
WL	5/23/2007	-26.66	30	19.75	0.27	20	60	0.18	34.96	6.32	6.3	1426	563.9	2
WL	8/6/2008	45.9	27	25.2	0.04	25.5	25	0.24	30.95	6.55	6.16	1580	987.8	1
WL	11/12/2008	85.69	13	4.91	1.08	4.8	13	0.23	39.43	6.14	5.61	1856	1173.5	2
WL	3/31/2009	49.55	8	2.16	2.41	4.7	55	0.16	29.05	5.38	4.99	1349	683.6	1
WL	6/25/2009	-8.36	25	23.06	0.04	25.7	35	0.04	13.76	6.4	6.43	1506	819.3	7
WL	6/29/2009	-8.36	25	23.06	0.04	25.7	35	0.04	13.76	6.4	6.43	1506	819.3	7
WL	9/16/2009	-7.8	26	21.74	0.09	17.8	20	0.05	13.76	6.24	6.35	1722	1061	3
WL	12/14/2009	22.91	16	35.55	10.83	1.6	27	8.99	27.17	6.44	6.47	1681	1010.1	3
WL	4/15/2010	-0.2	15	18.31	0.08	19.4	40	<0.04	21.62	6.25	6.18	1492	1090.6	9
WL	5/22/2012	23.48		21.95	<0.04			0.29	47.34		6.35	1466	1055.1	<5
	Min	-26.66	2	2.16	0	0	13	0.02	12.75	5.38	4.99	1343	18.25	1
	max	85.69	172	161.17	10.83	33	150	23.4	72.52	7.9	7.51	2258	1941.9	30
	median	26.835	25	23.06	0.21	12.5	35	0.3	31.98	6.495	6.43	1575	1061	5.5
	Avg	22.602	42.14	41.7441	0.866	12.77	48.8	3.39	34.43	6.664	6.46	1636.824	1103.2	7.13

HFLB	5/25/2000			146	0		25	4.63	11.3		7.2		1413.4	0
HFLB	6/15/2000			180	0		50	3.64	10.7		7		927	4
HFLB	6/26/2000			170.86	0.21	24	38	3.86	13.75	7.6	7.39	1896	1609.4	15
HFLB	7/13/2000			186	0		30	4.9	26.1		7.2		1037.6	12
HFLB	9/6/2000				0	19.4	23	0.44	140.4	7.22			1510	
HFLB	9/20/2000		110			15.6	25	0.82	42.55	7.13			1321	
HFLB	9/28/2000			118	0.25		24	0.15	42.8		6.7		1275	1.5
HFLB	10/18/2000			110	0.25		30	0.71	46		7		1391.8	32
HFLB	10/23/2000					11.5		0.29	51.97	7.07			1415	
HFLB	10/31/2000		106	113.41	0.28	10	24	0.25	52.25	7.3	7.32	2261	1568.2	10
HFLB	11/14/2000			110	0.25		20	0.35	50.5		7		1260.7	10
HFLB	12/19/2000			110	0.25		40	0.61	47.5		6.9		1618.8	10
HFLB	12/29/2000				0	0.8	35	0.89	68.27	6.85			1489.4	
HFLB	1/8/2001			121.43	0.22	1	32	0.75	67.5	6.8	6.92	2124	1380.5	5
HFLB	1/17/2001			120	0.25		32	0.73	53.9		6.7		1282	10
HFLB	3/20/2001					6.6	47			6.97				
HFLB	3/29/2001			90	0.25		90	0.47	21.5		6.5		1162	4
HFLB	4/5/2001			108	0.25		56	0.48	11.3		7		1072.9	8
HFLB	4/20/2001			97.72	0	10	72	0.42	8.43	7	7.04	1661	1177.6	8
HFLB	5/4/2001			106	0.25		70	0.83	15.9		6.9		1044.7	8
HFLB	6/19/2001			106	0.25		30	0.75	34.2		6.9		1274.4	12
HFLB	7/11/2001			102	0.25		36	1.35	38		6.8		1181	6
HFLB	8/30/2001			96	0.25		15	1.74	45.1		6.7		1285	10
HFLB	10/18/2001			102	0.25		9	0.82	37.5		7		1700.2	16
HFLB	2/14/2002			68	0.25		48	0.78	34.4		6.6		948.1	1.5
HFLB	3/13/2002			78	0.25		60	0.7	25.1		6.5		1286.4	6
HFLB	4/30/2002			66	0.25		80	0.32	14.4		6.3		712.6	10
HFLB	7/25/2002			78	0.25		40	0.45	28.2		7		1610.2	4
HFLB	10/8/2002			68	0.25		24	0.6	43.7		7.2		1513.1	10
HFLB	3/14/2003	35.6		42	0.545		90	1.87	35.8		6.4		974	4
HFLB	6/17/2003	29		52.2	0.25		50	0.68	26.8		6.2		971.8	8
HFLB	9/16/2003			65.4	0.25		50	1.09	24.1		6.8		909.9	1.5
HFLB	10/29/2003			56.8	0.724		40	1.9	27.2		6.7		1034.4	4
HFLB	3/30/2004	51		11	4.47		80	0.7	33		5		849.6	6
HFLB	11/4/2004	-16		89.6	0.25		40	0.31	9.42		7		834.2	1.5
HFLB	3/29/2005	102		10.8	3.85		50	0.15	33.6		5		976.3	1.5
HFLB	6/9/2005	-17.4		120.6			40				7.1		1107.8	6
HFLB	8/19/2005	-46.4		121.6	0.25		20	1.52	30.6		7		1214.7	1.5
HFLB	11/3/2005	-19.8		80.6	0.25		25	0.43	17.5		6.9		1306.5	4
HFLB	3/21/2006	-46.6		73	0.25		40	0.15	10.1		6.8		931.1	4
HFLB	6/21/2006	-80.4		94			30				7.5		953.4	6
HFLB	9/7/2006	-69.2		87.6	0.25		40	0.15	2.75		7.2		991.2	1.5
HFLB	11/2/2006	-11.8		39.8	0.578		50	0.47	0.111		7		943.4	4
HFLB	3/28/2007	16.63	17	17.57	0.53		150	0.02	25.69	6.29	6.2	1368	856.1	4
HFLB	4/26/2007	7.25	27	21.48	0.23	13.1	100	0.18	30.58	6.51	6.37	1392	705.6	3
HFLB	5/23/2007	-28.22	55	37.56	0.23	20	60	0.05	20.28	6.49	6.49	1447	615.3	2
HFLB	8/6/2008	5.91	56	51.96	0.07	25.6	25	0.04	24.3	6.69	6.69	1553	995.6	4
HFLB	11/12/2008	39.6	30	25.58	0.53	5.8	13	0.77	33.7	6.32	6.21	1855	1167.8	2
HFLB	3/31/2009	32.44	12	5.43	2.03	3.8	55	0.45	26.63	5.88	5.87	1376	632.1	2
HFLB	6/25/2009	-25.47	47	42.31	0.22	26.4	35	0.04	28.93	6.68	6.65	1483	926.9	11
HFLB	6/29/2009	-25.47	47	42.31	0.22	26.4	35	0.04	28.93	6.68	6.65	1483	926.9	11
HFLB	9/16/2009	-26.2	54	44.3	0.13	17.4	20	1.64	14.2	6.4	6.64	1734	1246.9	7
HFLB	12/14/2009	29.58	26	9.45	0.05	2.5	27	1.56	24.16	6.556	6.56	1702	1010.1	6
HFLB	4/15/2010	-10.78	35	24.58	<0.04	18.2	40	0.76	18.38	6.52	6.82	1500	1238.8	3
HFLB	5/22/2012	5.97		39.43	<0.04			1.63	38.53		6.5	1474	945.9	5
	Min	-80.4	12	5.43	0	0.8	9	0.02	0.111	5.88	5	1368	615.3	0
	max	102	110	186	4.47	26.4	150	4.9	140.4	7.6	7.5	2261	1700.2	32
	median	-11.29	47	79.3	0.25	13.1	40	0.69	28.57	6.685	6.8	1526.5	1134.9	5.5
	Avg	-2.865	47.85	79.1676	0.44	13.58	43.6	0.95	31.7	6.748	6.7204	1644.313	1143.2	6.53
	Avg 06-12	-11.673	36.91	41.0225	0.409	15.92	48	0.53	21.82	6.456	6.6344	1530.583	942.94	4.72
	Avg 08-13	2.8	38.4	31.7	0.5	15.8	31.3	0.8	26.4	6.5	6.5	1573.3	1010.1	5.7

SUMMARY SHEET – FINLEYVILLE

Name: Finleyville (SX3-D1, SX3-D2, SX3-D3) County: Bedford

Latitude: 40° 9' 12" N Longitude: 78° 11' 8" W

Watershed: Six Mile Run

Year Built: 2005

Risk Level: High

Designer: Skelly and Loy

Local Group or person: Broad Top Township

Treatment types, Sequence: 3 Discharges. D1: Limestone channel, limestone bed 3, settling pond 2, flushing limestone bed 4 (siphon), settling pond 3. D2: Flushing limestone bed 1 (siphon), Settling pond 1, upflow limestone bed 2 with siphon, and into final settling pond 3 with D1 system. D3: Flows into one side of Limestone Bed 4 and mixes with D1 system.

VFP

Area(water surface):
Compost thickness:
Limestone thickness, size, quality:
Comments

Rehab, date and nature: Limestone stirred and some limestone added; Additional modifications planned.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.)

Average influent 2008-13

D1: Flow 180 gal/min, pH 3.1, Acidity 149, Alk. 0, Fe 2.5, Mn 1.6, Al 14.5, SO_4 350 (N=4)
D2: Flow ?? , pH 3.4, acidity 159, alk. 0, Fe 1.1, Mn 1.1, Al 16.3, SO_4 453 (N=2)
D3: ?? Not easily sampled.

Average effluent 2008-13

Flow 303 gal/min, pH 5.2, acidity 31 (calc. 14), alk. 10, Fe 0.5, Mn 0.8, Al 4.6, SO_4 350 (N=7)

References: Datashed, Report by Skelly and Loy, 2013, Report by Skelly and Loy, 2005. Information from Broad Top Twonship.

Conclusions: The system is removing about 90% of the acidity and 75% of the Al from a large Al-rich flow, and greatly improving downstream conditions. Modifications are proposed to improve performance to a net alkaline condition.

Finleyville (SX3-D1,D2,D3)

The Finleyville system treats three discharges near the headwaters of Shreves Run, a tributary of Six Mile Run, in Broad Top Township, Bedford County. The system was constructed in fall and winter 2005-6 using funding from Growing Greener and OSM. The pre-construction chemistry of the discharges is as follows:

	Flow	pH	Acidity	Alkalin.	Fe	Mn	Al	SO4
	Gpm		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
D1	120	3.1	172	0	3.2	1.8	15	410
D2	42	3.0	163	0	3.6	1.9	15.2	
D3	64	3.2	137	0	0.8	1.6	13.4	
Total	226	3.1	159	0	2.6	1.7	14.5	
Outflow	163	6.2	14	20	0.5	0.7	3.7	Average from combined outflow, variable.

As indicated, Al is the major metal contaminant, and the flow is relatively large.

The total treatment system is diagrammed on Figure FI. The D1 discharge, the largest, is treated by a sequence of ponds. The initial flow is controlled so that a maximum of about 150 gpm flows into the treatment system, with the occasional excess bypassing to the final pond (Settling Pond 3). The D1 discharge normally goes first to Limestone Bed #3, containing 880 tons of limestone. This bed/pond is manually flushed occasionally. The outflow flows into Settling Pond #2, and then to Limestone Bed #4, which contains 3850 tons of limestone (recently stirred and supplemented). This pond does most of the treatment. Discharge D3 enters this limestone pond in one corner of the Limestone Bed 4. The treated water from D1 and D3 flows out through two underdrain systems to Settling Pond #3. The east underdrain system, receiving mainly D1 water, discharges through a automatic dosing siphon. The west underdrain, receiving mainly D3 water, discharges through an inline structure. Manual flushing of this limestone pond is also provided.

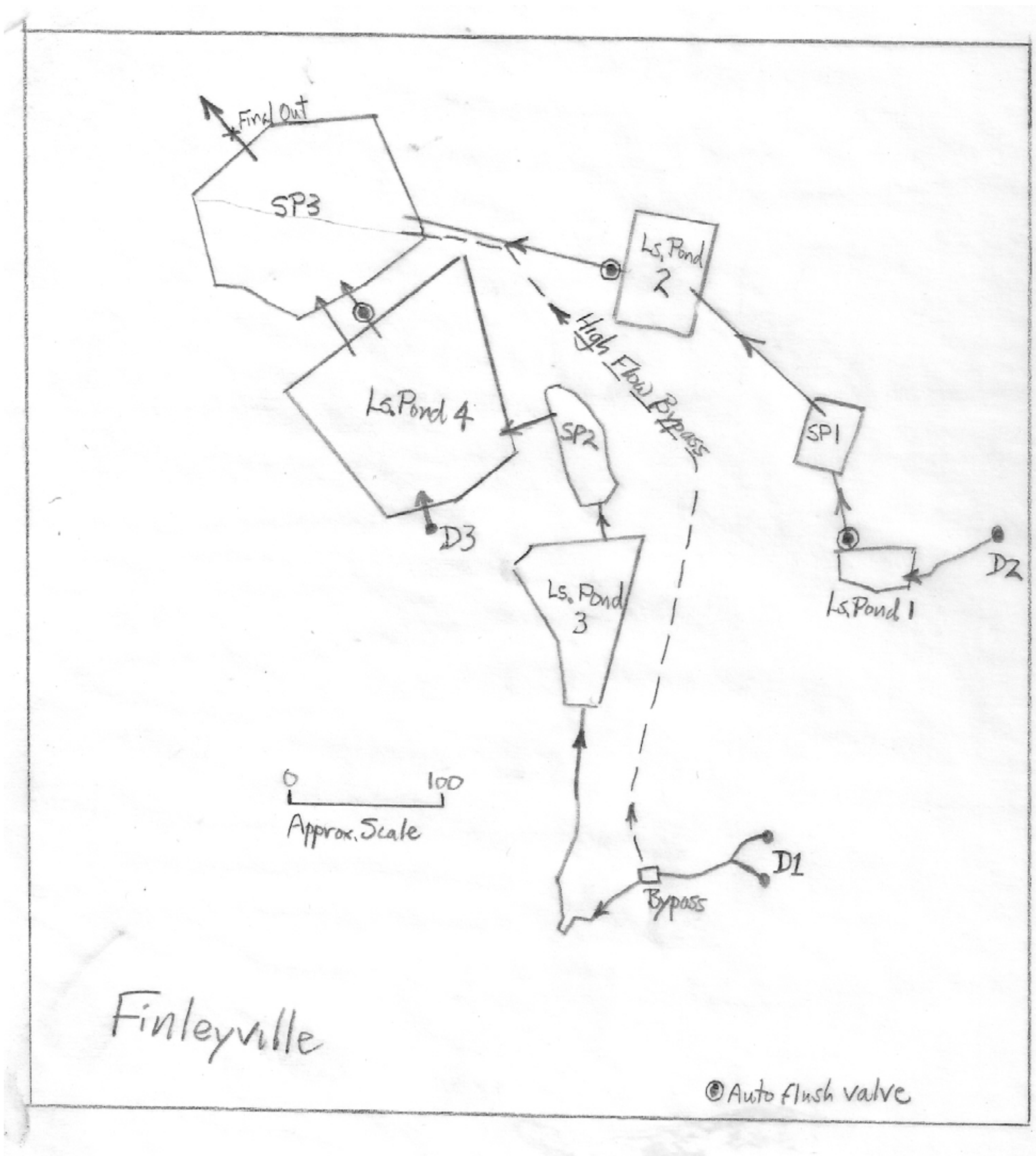
The D2 discharge is treated by a largely separate system. The initial unit is Limestone Bed #1 containing 220 tons of limestone in a 4-foot deep layer. The outflow of this pond is a siphon flowing to Settling Pond #1. This overflows thru a perforated riser to Limestone Bed #2 with 780 tons of limestone in a 4-foot layer. A siphon releases the water from the underdrain of this pond into Settling Pond #3, where it combines with the flow from D1 and D3.

The chemistry of the outflow is somewhat variable, as indicated in Table FI. On most sampling occasions the acidity is slightly positive, Al reduced by about 75%, and Fe and Mn are less than 1 mg/L, with a pH near 6. However, treatment does not generally generate water with negative acidity. An appreciable amount of the Al is in suspension, given the appreciable suspended solid and the pH near 6.

An extensive field evaluation in March 2013 brought out a number of problems with the components of the system, and recommended a number of modifications. At a high flow of about 800 gal/min at that time, the outflow acidity was 39 mg/L with 5 mg/L Al and <1 mg/L Fe and Mn at pH 7. One problem was buildup of debris on the limestone beds, leading to water levels above the limestone and short circuiting flow along the surface. Debris around the vertical perforated outflow pipes of the Settling Ponds led to consistent high water levels rather than slow drainage of flush events, and short retention times in the settling ponds. Some flushing siphons were apparently either leaking flow all the time, or not flushing completely. A series of recommendations were made for cleaning, baffles, and investigations or replacement of siphons, with an estimated cost of $50,000 plus work by Broad Top Township, and continuing O&M.

The chemistry of Shreves Run and Six Mile Run has markedly improved as a result of construction of about 6 passive systems on Shreves Run and many on Six Mile Run. The combined stream is being considered for removal from the 303d list. Six Mile Run at Defiance was net alkaline on 2 occasions in 2010-11 with pH near 7, Fe and Mn less than 0.5 mg/L and Al about 1 mg/L. Shreves Run at its mouth had average pH of 5.8, acidity 11 mg/L, Fe 0.4 mg/L and Al 2.5 mg/L in 2010-2013.

Macroinvertebrates are improving. This result indicates that the combined passive systems in the watershed are being effective.



Site	Date	Acidity	Alkalinity	Al	Flow	Fe	Mn	pH Fld	pH Lab	Sp.Cond.	SO4	TSS
Discharge D1		mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L
SX3-D1	1/10/2001	228	0	22.5	100	5.8	2.48		3		653	<3
SX3-D1	3/29/2001	108	0	7.2	1000	3.12	1.06		3.2		230	<3
SX3-D1	5/14/2001	122	0	9.95	174	2.28	1.3		3.2		341	<3
SX3-D1	7/31/2001	188	0	17.1	52	2.37	2.1	3	3.1	1290	446	<3
SX3-D1	9/26/2001	212	0	18.2	30	2.35	2.19	3.2	3.1	1420	291	<3
SX3-D1	11/19/2001				23			3		1450		
SX3-D1	5/29/2002				103			3.1		840		
SX3-D1	6/18/2003				175			3.3		670		
SX3-D1	5/14/2004				280			2.8		750		
SX3-D1	11/23/2004				200			3.1		1100		
SX3-D1	11/16/2005				42			3.1		1180		
SX3-D1	3/28/2006	151	0	12.5		4.4	1.32		3.1			6
SX3-D1	9/23/2009	216	0	22.2		2.62	2.25	3.05	3	1280	556	<5
SX3-D1	4/26/2010	125	0	11.8		1.98	1.25	3.49	3.1	955	344	<5
SX3-D1	3/13/2013	126	0	11.1	269	3.1	1.2		2.97	910	321	
SX3-D1	6/25/2013	129	0	12.8	90	2.2	1.53	2.8	3.2	1004	326	5
Average		160.5	0.0	14.5	195.2	3.0	1.7	3.1	3.1	1070.8	389.8	5.5
Average 2008-13		149.0	0.0	14.5	179.5	2.5	1.6	3.1	3.1	1037.3	386.8	5.0
SX3-D1A1B	9/23/2009	211	0	21.7		2.26	2.21	3.04	3.1	1250	553	<5
SX3-D1A1B	4/26/2010	126	0	12.1		3.82	1.33	3.59	3.1	961	336	<5
Outflow, LS Pond 3												
SX3-D1A1C	9/23/2009	169	0	19.3	15	1.47	2.06	2.48	3.5	1070	550	<5
SX3-D1A1C	4/26/2010	112	0	12.4		3.28	1.31	3.68	3.2	885	339	5
SX3-D1A1C	6/25/2013	114	0	12.3		1.94	1.47	3.4	3.3	958	298	5
SX3-DA1D	9/23/2009	158	0	20.6		1.54	2.17	3.53	3.5	1070	550	<5
SX3-DA1D	4/26/2010	111	0	12		3.19	1.28	3.61	3.2	867	342	<5
SX3-D1A1E	9/23/2009	16	25	7.78	60	0.17	0.9	5.8	5.6	1020	541	23
SX3-D1A1E	4/26/2010	42	0	3.95		0.14	0.55	4.05	3.9	405	149	<5
Discharge D2												
SX3-D2	9/23/2009	206	0	21.4		2.59	2.15	3.09	3	1280	561	<5
SX3-D2	4/26/2010	111	0	11.2		1.96	1.23	3.65	3.2	943	346	<5
	Average D2	158.5	0	16.3		2.3	1.7	3.4	3.1	1111.5	453.5	
SX3-D2A2B	9/23/2009	177	0	21		1.77	2.12	3.35	3.3	1120	559	<5
SX3-D2A2B	4/26/2010	98	0	10.3		2.57	1.14	3.8	3.3	851	341	5
SX3-D2A2C	9/23/2009	88	8	12.5		0.75	1.23	4.26	4.4	1010	566	<5
SX3-D2A2C	4/26/2010	70	0	9.51		1.09	1.08	4.04	3.8	730	333	<5
Final Outflow												
F	5/8/2007	8	2	1.97		0.25	0.57	6.8	6.02	540	306	11
F	7/30/2007	-48	60	0.78	120	0.06	0.23	8	6.71	940		<4
F	2/29/2008	42		7.03		1.29	0.87		4.5	592		<4
F	6/16/2008				120			5.9		560		
SX3-D1,D2,D3F	9/23/2009	30	11	2.25	75	0.16	1.02	5.15	5.3	997	539	6
SX3-D1,D2,D3F	4/26/2010	40	6	6.54	400	0.68	0.84	4.73	4.7	612	300	10
F	5/22/2012							7.42		600		
F	3/13/2013	39	0	5.1	818	0.54	0.7		4.87	545	264	
F	6/25/2013	2.4	21	2.05	100	0.06	0.74	5.4	6.6	694	300	6
Average		16.2	16.7	3.7	272.2	0.4	0.7	6.2	5.5	676	381.7	9
Average 2008-13		30.7	9.5	4.6	302.6	0.5	0.8	5.7	5.2	657.1	350.8	7.3

SUMMARY SHEET – Harbison-Walker 1

Name: Harbison Walker I County: Fayette

Latitude: 40°50' 33" N Longitude: 79° 29' 35" W

Year Built: 1999

Risk Level: High

Designer: Biomost, Tim Danehy

Local Group or person: Ohiopyle Park?

Treatment types, Sequence: ALD, Settling Pond, VFP, Settling Pond, Wetland

VFP

Area(water surface): 230 m^2
Compost thickness: None?
Limestone thickness, size, quality:
Comments: Said to be auto-flushing

Rehab, date and nature:

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

	Flow	pH	Acid.	Alk.	Fe	Mn	Al	N
Average discharge (1999)	11	4.2	361	0	190	26	1.2	6
Average VFP influent 2008-13	14	4.5	177	1	89	20	0.0	4
Average VFP effluent 2008-13	10	6.3	16	44	15	18	0.0	3
Average final effluent 2008-13	10	7.2	-12	27	0.2	8	0.0	3

Loading (g acidity/day, g/m2/d): 11,260 g/d, 49 $g/m^2/d$ (or 15497 g/d inflow to VFP; 67 $g/m^2/d$)

References: Datashed

Conclusions: This High Risk system composed of an ALD followed by a VFP and an HFLB has released net alkaline water for the 14 years it has been in operation.

Harbison-Walker I

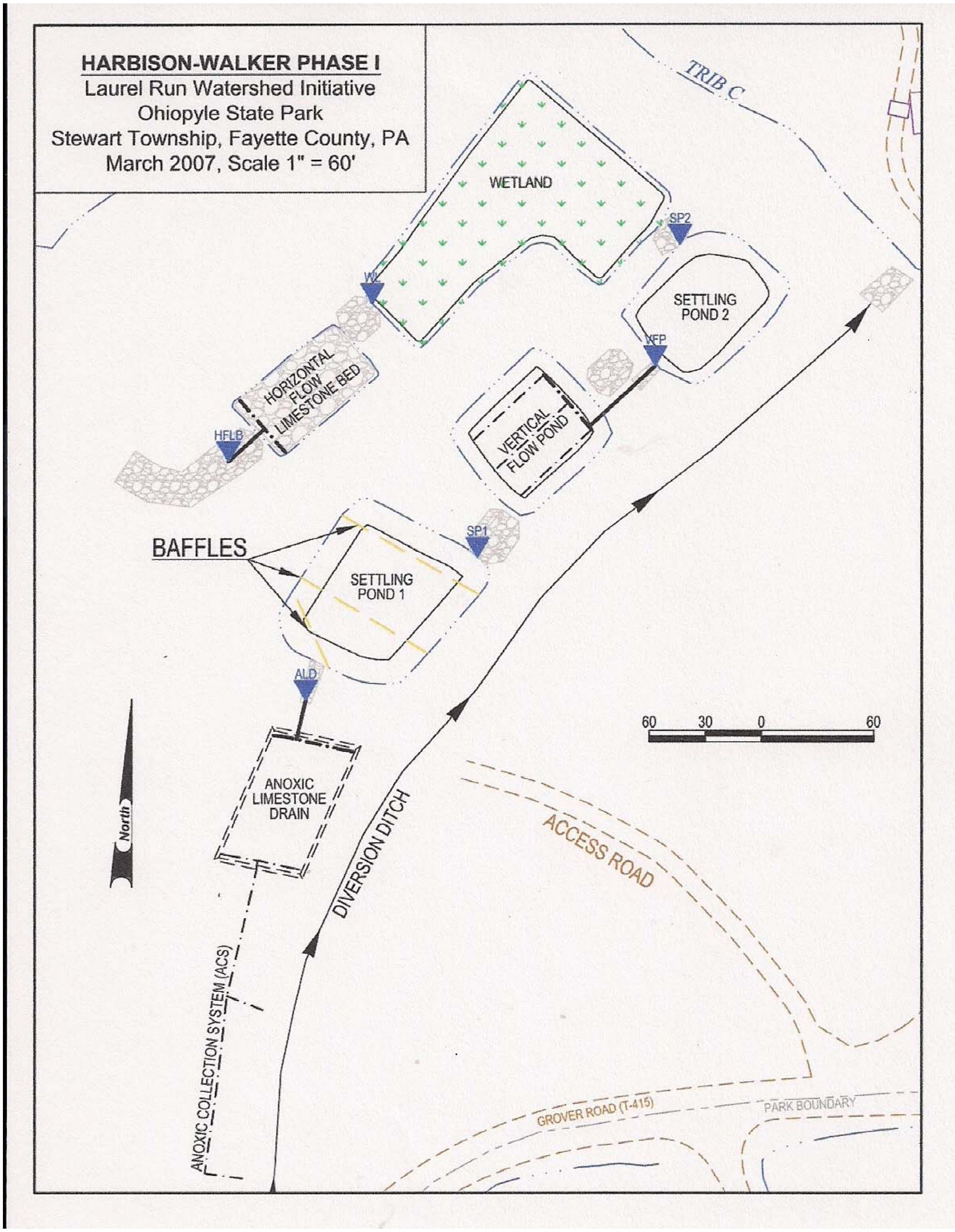
The Harbison-Walker Phase I system is located in Ohiopyle State Park, Fayette County about 2 miles south of Ohiopyle. The system is in the watershed of Laurel Run, a tributary of Meadow Run which flows into the Youghigheny River. The system is adjacent to the Harbison-Walker II system which is just down the valley. It was built in 1999.

The system drains AMD from an abandoned underground clay mine. The system is composed of an initial subsurface collection system, an anoxic limestone drain (ALD), Settling Pond 1, Vertical Flow Pond, Settling Pond 2, a wetland, and a Horizontal Flow Limestone Bed (HFLB). According to Datashed, the VFP is a limestone-only unit, with no compost. No H_2S smell was noted at the VFP effluent, as expected for a limestone-only system. The inflow to the system cannot currently be sampled, but sampling prior to construction showed pH 4.2, acidity 361 mg/L, Fe 190 mg/L, Mn 26 mg/L, and Al 1.2 mg/L. A flow of about 11 gal/min is typical. Outflow since 2008 averages pH 7.2, acidity -12 mg/L, Fe 0.2 mg/L, Mn 8 mg/L and Al 0 mg/L at 11 gal.min.

The system is generally releasing net alkaline water with negligible Fe and Al, and minor Mn. The ALD accomplishes about half the treatment, and the VFP most of the remainder, with the HFLB adding the final alkalinity. The performance does seem to have decreased in the last few years, as indicated by lower alkalinity in the effluent, but the final outflow is still net alkaline after 14 years. The decreased performance is in both the ALD and the VFP. The loading to the VFP is about 50 $g/m^2/d$ (based on the original inflow).

Table HW1		Harbison-Walker Phase 1														
ID	Site	Date	Acidity	Alk Fld	Alk. Lab	Al	Temp	Flow	Fe	Mn	pH fld	pH Lab	Sp.Cond.	SO4	TDS	TSS
			mg/L	mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
4155-635	12/13 Raw	3/1/1999	326.24		0	0.74			172.5	22.25		3.58	1492	1353		4
4145-635	12/13 Raw	10/15/1999	394		8	0.6			215	27.1		5.6	1460	110		0
4147-635	12/13 Raw	10/18/1999	401		4	0.7			212	26.4		5.1	1440	1100		12
4149-635	12/13 Raw	10/20/1999	409		0	1.3			218	29		3.9	1570	1100		0
4153-635	12/13 Raw	11/9/1999	270.48		0	3.4	11		162.8	26.3	4.7	3.12	1739	1167		15
4151-635	12/13 Raw	11/19/1999	367.08		0	0.65	11		160.5	26.05	4.9	3.78	1625	851.8		5
	ALD out															
4151-623	ALD	11/19/1999	114.66		111.14	0.12	10	10	146.8	21.1	6.7	6.2	1660	1608		52
4173-623	ALD	12/17/1999	182		128	0			184	23.4		6.2		958.6		80
4157-623	ALD	1/17/2000	195.3		75.13	0	9		146.8	20.75	7	6.17	1607	864.1		38
4161-623	ALD	1/25/2000	198		142	0		10	186	22.7		6.3		984		104.1
4175-623	ALD	3/30/2000	191.84		13.7	0	10	11	148.8	18.5	6.6	5.38	1391	1109		68
4177-623	ALD	4/28/2000	195.2		76.92	0.05	10	11	86.6	17.65	6.4	6.2	1438	744.4		18
4181-623	ALD	6/8/2000	211.15		48.41	0.04	13	12	172	18.25	6.3	5.91	1501	787.5		63
4187-623	ALD	9/7/2000	162.59		172.45	0.09	13	10.81	173.8	19.2	6.4	6.09	1474	889		22
4163-623	ALD	10/24/2000	181.97		99.55	0.07	11	11.5	175.8	19.5	6.7	6.2	1532	995		36
4169-623	ALD	12/15/2000	242.18		90.47	0.04	9	11.98	155.8	18.5	6.7	6.21	1530	884.6		5
4159-623	ALD	1/23/2001	205.03		78.78	0.17	9	9.65	180.3	20.6	6.6	6.22	1502	867.5		16
4179-623	ALD	5/29/2001	182.91		82.06	0.07	11	12	135.8	19.15	6.5	6.21	1436	816.9		10
4183-623	ALD	9/21/2001	178.6		16.07	0.05	14	8	134	18.35	6.7	5.8	1372	882.6		47
4185-623	ALD	9/23/2004	173.4		68.8	0.25		20	158	17.8	6.3	6		786.2		94
4165-623	ALD	10/27/2004	205.2		86.4	0.25	11	10	143	16.6	6.71	6.2		736.3		76
4167-623	ALD	11/28/2004	179.4		114.8	0.25	10	10	156	19.7	6.55	6.2		739.8		58
4171-623	ALD	12/16/2004	200.8		111	0.25	9	12	146	17.2	6.57	6.2		935.9		24
4143-623	ALD	10/20/2009	169.04	178	52.78	0.04	12.1	10	174	24.19	6.45	5.94	1475	988.3	1032	112
5227-623	ALD	4/29/2010	163.28	182	20.86	0.04	10	11	193	20.72	6.5	5.51	1409	867.4		104
7279-623	ALD	6/5/2012	149.45	160	44.39	<0.04	12.8	11	172	27.15	6.29	5.74	1378	916.7		110
		Average	184.1	173.3	81.7	0.1	10.8	11.2	158.4	20.1	6.6	6.0	1478.9	918.1	1032.0	56.9
		Average 200	160.6	173.3	39.3	0.0	11.6	10.7	179.7	24.0	6.4	5.7	1420.7	924.1	1032.0	108.7
4189-633	HFLB	12/10/1999	0		173.58	0.27			1.9	2.66	7.5	7.27	1723	1245		7
4173-633	HFLB	12/17/1999	0		164	0			4.9	7.3		7.2		784.5		0
4157-633	HFLB	1/17/2000	0		135.63	0.07	2		3.95	15.8	7	7.1	1573	958.2		14
4161-633	HFLB	1/25/2000	0		144	0		10	3.3	21.5	7	6.7		113.9		4
4175-633	HFLB	3/30/2000	0		115.7	0	18	11	1.07	11	7.4	7.59	1173	726		7
4177-633	HFLB	4/28/2000	0		125.7	0.16	23	11	1.2	4.25	7.6	7.52	1198	563.1		13
4181-633	HFLB	6/8/2000	0		121.07	0.07	18	12	4.03	11.55	7.5	7.15	1219	512.3		3
4187-633	HFLB	9/7/2000	0		142.81	0.15	18	10.81	0.98	8.46	7.2	7.12	1291	722.6		9
4163-633	HFLB	10/24/2000	0		89.07	0.86	13	11.5	0.9	1.84	7.3	7.14	1349	861		4
4169-633	HFLB	12/15/2000	0		98.15	0.1	2	11.98	2.23	4.79	6.8	6.82	1281	617.3		1
4159-633	HFLB	1/23/2001	0		116.62	0.09	1	9.65	3.95	20.15	6.5	6.64	1346	762.5		9
4179-633	HFLB	5/29/2001	0		75.49	0.2	17	12	1.11	1.87	7	7.04	1221	609.8		3
4183-633	HFLB	9/21/2001	0		82.36	0.04	18		1.84	2.27	7.3	7.28	1163	616.4		1
4185-633	HFLB	9/23/2004	-45		83	0.25			1.87	4.35	7.3	7.1		618.3		12
4165-633	HFLB	10/27/2004	-63.2		82.6	0.25	12		2.06	2.22	7.04	7.2		606.6		6
4167-633	HFLB	11/28/2004	-45.8		80	0.25	6		2.08	1.29	7.13	7.3		578.1		1.5
4171-633	HFLB	12/16/2004	-42		73	0.25	2		1.45	0.716	7.14	7		661		1.5
4143-633	HFLB	10/20/2009	-1.21	18	13.64	0.04	13.1	10	0.09	6.89	7.34	6.24	1187	734.5	831	4
5227-633	HFLB	4/29/2010	-10.82	11	33.91	0.04	16.5	11	0.3	6.75	6.9	6.46	1217	654.2		1
7279-633	HFLB	6/5/2012	-23.88	30	34.43	<0.04	17.9	8	0.23	11.16	7.26	6.43	1165	669.8		6
		Average	-11.6	19.7	99.2	0.2	12.3	10.7	2.0	7.3	7.2	7.0	1293.3	680.7	831.0	5.4
		Average 200	-12.0	19.7	27.3	0.0	15.8	9.7	0.2	8.3	7.2	6.4	1189.7	686.2	831.0	3.7

4189-625	SP1	12/10/1999	216.3		0	0.51			82.25	18.8	6	3.18	1497	980.9		39
4173-625	SP1	12/17/1999	184		28	0			97.8	21.6		5.8		955.1		28
4157-625	SP1	1/17/2000	229		16.09	0	3		84.9	21.4	6	5.85	1478	1034		15
4161-625	SP1	1/25/2000	214		46	0			122	23.9		6		854		10
4175-625	SP1	3/30/2000	207.06		2.14	0	11	11	81.25	18.2	6.2	4.88	1286	929.1		29
4177-625	SP1	4/28/2000	192.1		1.56	0.05	13	11	68.4	17.15	6	4.74	1276	763		3
4181-625	SP1	6/8/2000	181.43		0	0.09	17	12	70.75	17.05	5.7	3.78	1362	707.9		37
4187-625	SP1	9/7/2000	192.37		48.84	0.07	15	10.81	88.5	19.65	5.8	5.16	13.03	851.2		11
4163-625	SP1	10/24/2000	208.9		8.25	0.06	11	11.5	91.75	19.15	5.8	5.61	1360	905.7		6
4169-625	SP1	12/15/2000	238.91		20.81	0.06	5	11.98	98.25	18.55	6	5.91	1400	823.5		3
4159-625	SP1	1/23/2001	222.29		49.19	0	5	9.65	155.5	19.65	5.9	6.04	1355	1010		9
4179-625	SP1	5/29/2001	197.58		3.71	0.22	20	12	72.5	18.15	6	5.25	1275	726.3		2
4183-625	SP1	9/21/2001	199.2		0	0.15	16		68	18.45	4.7	4.08	1285	815.2		2
4143-625	SP1	10/20/2009	201.2	2	1.88	0.04	11.8	10	98.26	22.37	5.25	4.97	1382	882.9	927	6
5227-625	SP1	4/29/2010	198.02	0	0	0.04	16	11	94.11	19.64	4.5	4.11	1330	809.7		4
7279-625	SP1	6/5/2012	162.38	5	3.12	<0.04	16.8		87.08	22.16	5.15	5.1	1220	867.3		<5
	SP1	7/29/2013	145.2		0	<0.5	22	20	78.5	17.1	5.2	4	1240	675.6	1250	6
		Average	199.4	2.3	13.5	0.1	13.0	11.9	90.6	19.6	5.6	5.0	1250.6	858.3	927.0	13.1
		Average 200	176.7	2.3	1.3	0.0	16.7	13.7	89.5	20.3	5.0	4.5	1293.0	808.9	1088.5	5.3
4173-629	SP2	12/17/1999	0		146	0			9.5	10.3		6.9		835		0
4157-629	SP2	1/17/2000	0		93.49	0.09	3		18.6	18.4	7	6.67	1490	920.6		23
4161-629	SP2	1/25/2000	0		138	0			26.6	23.5		6.6		962		7.9
4175-629	SP2	3/30/2000	0		101.51	0.23	12	11	4.1	14	7.6	7.67	1216	916.7		16
4177-629	SP2	4/28/2000	0		106.15	0.09	15	11	2.32	13.05	7.4	7.41	1242	694.8		3
4181-629	SP2	6/8/2000	0		98.02	0.1	19	12	1.65	16	7.7	7.22	1266	548.5		7
4163-629	SP2	10/24/2000	0		59.74	0.06	12	11.5	4.1	16	6.8	6.82	1330	898.2		1
4169-629	SP2	12/15/2000	1.22		40.79	0.05	2	11.98	4.31	21.45	6	6.21	1280	701.3		5
4159-629	SP2	1/23/2001	11.57		12.17	0.04	1	9.65	30.1	18.7	6.1	5.43	1296	800		16
4183-629	SP2	9/21/2001	0		76.92	0.12	19		2.57	14.75	7.2	7.34	1264	643.1		4
4143-629	SP2	10/20/2009	6.43	25	21.88	0.04	11.5	10	2.72	15.9	6.68	6.48	1276	744.2	893	5
5227-629	SP2	4/29/2010	-18.51	9	27.86	0.04	17	11	2.83	19.66	6.7	6.6	1266	691.6		3
7279-629	SP2	6/5/2012	6.97	27	29.51	<0.04	18.8		5.45	20.72		6.15	1216	787.1		6
		Average	0.6	20.3	73.2	0.1	11.8	11.0	8.8	17.1	6.9	6.7	1285.6	780.2	893.0	7.5
		Average 200	-1.7	20.3	26.4	0.0	15.8	10.5	3.7	18.8	6.7	6.4	1252.7	741.0	893.0	4.7
4189-627	VFP	12/10/1999	0		150.65	0.27			9.5	9.7	7.5	7.1	1575	1232		30
4173-627	VFP	12/17/1999	0		134	0			13.6	12.9		6.8		935.2		0
4157-627	VFP	1/17/2000	0		89.18	0	4		22.5	19.85	7	6.63	1490	1059		35
4161-627	VFP	1/25/2000	0		136	0			30.9	25.5		6.6		905		16
4175-627	VFP	3/30/2000	0		104.79	0	9	11	6.53	14.75	6.8	6.98	1272	978.7		31
4177-627	VFP	4/28/2000	0		101.97	0.12	14	11	5.5	14.7	6.8	6.89	1249	620.4		4
4181-627	VFP	6/8/2000	0		103.02	0.07	18	12	1.9	15.35	6.8	7.01	1215	526.8		6
4187-627	VFP	9/7/2000	0		116.16	0.09	20	10.81	14.75	17.7	6.8	6.77	1248	722.6		17
4163-627	VFP	10/24/2000	0		65.6	0.11	13	11.5	19.8	17.35	7	6.62	1306	816.3		15
4169-627	VFP	12/15/2000	22.74		79.65	0.08	3	11.98	40	19.05	7	6.48	1416	899.9		23
4159-627	VFP	1/23/2001	27.61		92.97	0	2	9.65	71.25	20.05	6.7	6.51	1370	942.5		14
4179-627	VFP	5/29/2001	0		51.82	0.23	17	12	20.25	15.85	6.9	6.47	1275	726.3		4
4183-627	VFP	9/21/2001				0.35			19.3	17.5	6.9	20				
4143-627	VFP	10/20/2009	21.51	55	50.4	0.04	9.9	10	0.34	20.37	6.63	6.45	1365	836.3	955	11
5227-627	VFP	4/29/2010	2.7	20	53.9	0.04	13.5	11	16.96	17.31	6.4	6.5	1321	801.8		1
7279-627	VFP	6/5/2012	28.86	58	44.48	<0.04	20.6	8	22.64	17.95	6.51	6.23	1303	873.5		8
	VFP	7/29/2013	13.6		28.4	<0.5	23		19.1	15	6	6.2	1080	644	1050	32
		Av. 2008-13	16.7	44.3	44.3	0.0	16.8	9.7	14.8	17.7	6.4	6.3	1267.3	788.9	1002.5	13.0
4173-631	WL	12/17/1999	0		196	0			6.9	9.1		7.2		1071		4
4157-631	WL	1/17/2000	0		128.35	0.11	2		13.45	19.2	7.2	6.81	1717	1090		12
4161-631	WL	1/25/2000	0		134	0			21.3	23.4		6.6				871
4175-631	WL	3/30/2000	0		112.66	0.11	15	11	2.45	12.3	7.8	7.94	1187	735.9		12
4177-631	WL	4/28/2000	0		138.94	0.16	19.5	11	0.78	8.02	7.6	7.34	1236	682.4		9
4181-631	WL	6/8/2000	0		134.55	0.14	14	12	1.54	13.8	7.4	7.14	1292	534		10
4187-631	WL	9/7/2000	0		161.81	0.13	20	10.81	0.73	17.05	7.3	7.35	1296	760.4		7
4163-631	WL	10/24/2000	0		65.26	0.15	12	11.5	0.47	15.25	7	7.07	1309	935.5		2
4169-631	WL	12/15/2000	2.44		45.79	0.12	2	11.98	5.81	15.6	6.3	6.38	1392	861.7		7
4159-631	WL	1/23/2001	10.56		17.08	0.09	0	9.65	17.2	19.35	5.9	5.67	1264	852.5		12
4179-631	WL	5/29/2001	0		40.91	0.22	20	12	0.33	8.67	6.7	6.79	1211	609.8		1
4183-631	WL	9/21/2001	0		49.07	0.09	17		0.51	2.49	6.8	6.74	1180	664.3		3
4143-631	WL	10/20/2009	-2.81	22	20.77	0.04	14.7	10	0.34	12.26	7.03	6.45	1233	786.3	863	4
5227-631	WL	4/29/2010	-11.44	14	19.22	0.04	20	11	0.36	13.68	7.3	6.51	1252	683.6		<1
7279-631	WL	6/5/2012	-26.07	47	40.91	<0.04	17.3	8	1.11	18.33	7.13	6.46	1210	731.5		<5


HARBISON-WALKER PHASE I
Laurel Run Watershed Initiative
Ohiopyle State Park
Stewart Township, Fayette County, PA
March 2007, Scale 1" = 60'
TRIB C
WETLAND
SP2
WL
SETTLING POND 2
VFP
HORIZONTAL FLOW LIMESTONE BED
HFLB
VERTICAL FLOW POND
BAFFLES
SP1
SETTLING POND 1
ALD
60 30 0 60
North
ANOXIC LIMESTONE DRAIN
DIVERSION DITCH
ACCESS ROAD
ANOXIC COLLECTION SYSTEM (ACS)
GROVER ROAD (T-415)
PARK BOUNDARY

SUMMARY SHEET – Harbison-Walker Phase 2

Name: Harbison-Walker 2 County: Fayette

Latitude: 39° 50' 39" Longitude: 79° 29' 30"

Year Built: 2000

Risk Level: High

Designer: Biomost, Tim Danehy

Local Group or person: Ohiopyle State Park?

Treatment types, Sequence: 4+ discharges. Discharge A+C: 2 VFP's in parallel, Flush pond, Settling Pond-Wetland, Outflow to stream. Discharge B1: VFP, Settling Pond, Wetland, (into B3 system). Discharge B3: Collection Ponds, VFP (mixes with B1 flow), Settling Pond/Wetland, Hor. Flow Ls. Bed. There are additional interconnections of the B1 system (see map).

VFP

Area(water surface): 18,000 ft^2 (ACVFPS) = 1670 m^2
Compost thickness:
Limestone thickness, size, quality:
Comments

Rehab, date and nature: Some rehab?

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

AC discharge: Flow 35 gal/min, pH 3.4, Acidity 373 mg/L, Fe 1.9 mg/L, Mn 28 mg/L, Al 70 mg/L, SO4 1354 mg/L, N=2 (1995-2004: Flow 82 gal/min, acidity 470 mg/L, pH 3.4, Fe 1.6 mg/L, Mn 39 mg/L, Al 59 mg/L, SO4 1328 mg/L, N=71)

Average effluent 2008-13

ACSPWL: Acidity -96 mg/L, alkalinity 30 mg/L, pH 6.2, Fe 2 mg/L, Mn 23 mg/L, Al 2 mg/L, SO4 1216 mg/L, N=1)(in 2013, effluent treated with Na_2CO3 after this outflow)
HFLB: Acidity 62, pH 3.4, Fe 1.7mg/L, Mn 16 mg/L, Al 6.6 mg/L, SO4 811 mg/L, N=1

Loading (g acidity/day, g/m2/d): 71,400 g/d; 43 $g/m^2/d$ into ACVFPS.

References: Datashed, Previous data.

Conclusions: This complex system with 4 high-Al discharges and interconnected treatment systems has apparently released net acid water from its 2 discharges most of the time, but only 2 sets of data for 2008-2013 are available. The system does not seem to have been designed for high Al, or routinely flushed, as a high-Al system should be.

The Harbison-Walker II system is located in Ohiopyle State Park, Fayette County about 2 miles south of Ohiopyle. The system is in the watershed of Laurel Run, a tributary of Meadow Run which flows into the Youghigheny River. The system is adjacent to the Harbison-Walker I system which is just up the valley. It was built in 2000.

The system is complex, with 3 main discharges and 17 ponds and units (Figure HW). The source of the AMD is a combination of clay and coal mining. The A and C discharges flow into 2 Vertical Flow Ponds, followed by a Flush Pond, Settling Pond-Wetland 1, Wetland 2 and outflow into the stream. Valves in the system allow water from Wetland 1 to be diverted into the B system. The B1 discharge flows to B1VFP, along with possible flow from the A system, then to Settling Pond B1SP and then a Wetland (B1WL1). From the latter the B flow passes thru 2 wetlands and into a VFP (B1B3VFP) which also receives the B3 discharge. The ouflow of this VFP flows to a a wetland and a Horizontal Flow Limestone Bed, from which it exits in a final discharge. An additional complexity is that outflow from ACVFPS was being treated with Na Carbonate briquettes when the site was visited on 7/26/13. Sodium Carbonate was also apparently being used on Discharge B1. ACVFPN was drained and not in use.

Very little recent data is available on Datashed for this system.

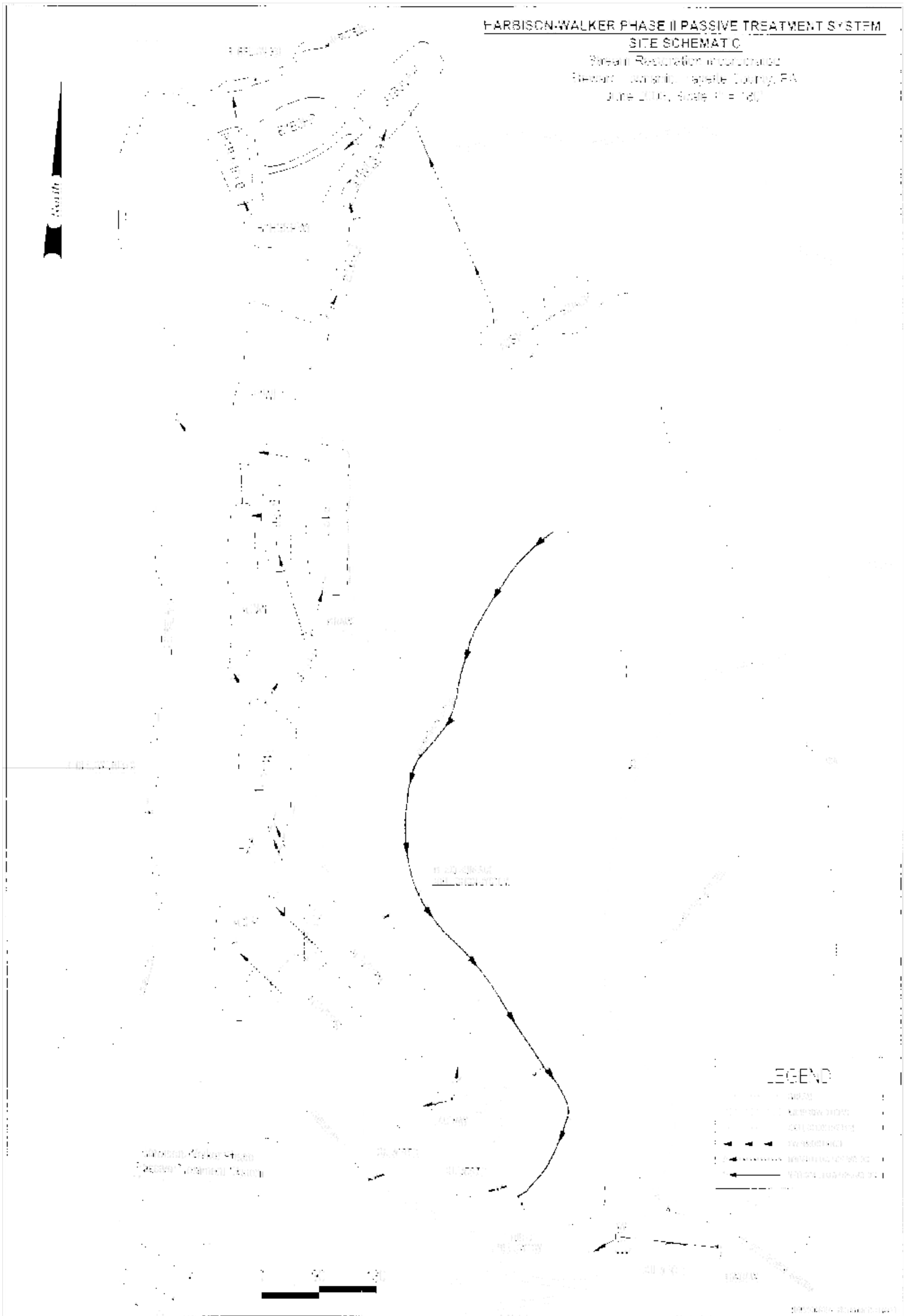

HARBISON-WALKER PHASE II PASSIVE TREATMENT SYSTEM
SITE SCHEMATIC
LEGEND

Table HW2	Harbison-Walker 2														
ID	Site	Date	Flow	Acidity	Alkalinity	Al	Fe	Ferrous	Mn	pH fld	pH Lab	Sp.Cond.	SO4	TDS	TSS
			gal/min	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
7281-23233	ACRAW	6/5/2012		362.98	ND	80.72	1.92		23.29		3.44	1932	1404.3		5
		7/29/2013	35	382	0	59.6	1.9	0.59	33	3.5	3.3	1590	1304	2014	10
		Average	35	372.5	0.0	70.2	1.9	0.6	28.1	3.5	3.4	1761.0	1354.2	2014.0	7.5
7281-23229	ACSPWL	6/5/2012		-95.52	29.82	2	0.08		22.95		6.19	2078	1216.1		10
7281-23231	ACVFPS	6/5/2012		305.07	ND	75.41	0.93		38.61		4.41	1772	1385.8		<5
		7/29/2013	60	242	0	42.9	0.88	0.58	25.8	4.2	4.3	1420	1075	1740	8
7281-23223	B1B3HFLB	6/5/2012		62.29	ND	6.58	0.4		15.89		3.76	1342	811.7		<5
7281-23227	B1WL3	6/5/2012		100.5	ND	7.23	1.75		21.06		3.36	1589	898.2		<5

SUMMARY SHEET – Hunters Drift

Name: Hunters Drift County: Tioga

Latitude: 41° 37' 6" Longitude: 77° 18' 40"

Watershed: Babb Creek

Risk Level: High

Year Built: 2004

Designer: Hedin Environmental

Local Group or person: Babb Creek Watershed Assoc.

Treatment types, Sequence: Collection pond, 4 VFP's in parallel, 3 Wetlands in series

VFP

Area(water surface): 160x185+200x185+250x150+260x130=138,000 ft^2 = 12,800 m^2

Compost thickness: One foot (50% mushroom compost, 25% wood chips, 25% AASHTO#10 limestone)

Limestone thickness, size, quality: 3 ft of AASHTO #1, >90% $CaCO_3$(18,500 T)

Comments: Compost very thin and low in organics in 2013; being replaced.

Rehab, date and nature: Compost layer currently being replaced (2013).

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 227 gal/min, pH 2.8, Acid. 349 mg/L, Fe 37 mg/L, Mn7 mg/L, Al 37 mg/L, SO4 568 mg/L, N=15

Average effluent 2008-13

Flow 208 gal/min, pH7.2, Acid. -95 mg/L, alk. 116 mg/L, Fe 0.4 mg/L, Mn 2.7 mg/L, Al 0.2 mg/L, SO4 497 mg/L, N=15

Loading (g acidity/day, g/m2/d): 433,000 g/d; 34 $g/m^2/d$

References: Datashed, Hedin et al., 2010, Passive treatment of Acidic Coal Mine Drainage: The Anna S Mine passive treatment complex: Mine Water and the Environment, v. 29, p. 165-175.

Conclusions: This High Risk system has now successfully treated AMD with moderate to high metals over a 9 year period. The inclusion of considerable limestone in the compost appears to be a key aspect of the design. Hover, the compost has now deteriorated and is being replaced. The receiving stream has recovered from the AMD degradation and has been removed from the 303d list.

HUNTERS DRIFT

The Hunter Drift system is located in Tioga County across the valley of Babb Creek from the village of Antrim. The system treats the discharge from an abandoned underground mine. It is immediately south of the Anna S treatment system, and close to the Mitchell experimental system. The system was constructed in 2004.

The system consists of a pipeline from the mine, a collection pond, four vertical flow ponds in parallel, a flush pond and three wetlands in series. A distribution box at the outflow of the collection pond discharges approximately equal flows to each of the 4 VFP's. High flows are bypassed around the system. The VFP's contain 3 feet of AASHTO#1 limestone (>90% $CaCO_3$, total 18,500 T) overlain by one foot of organic material, consisting of 50% spent mushroom compost, 25% wood chips and 25% fine limestone (AASHTO #10, >90% $CaCO_3$). An underdrain system located in the bottom of the limestone layer flows out through a water level control box from each VFP into a channel leading to the wetlands. The VFP's contain a flush valve that opens the underdrain to rapid flow into the flush pond. The perforations in the underdrain are sized for effective flushing according to the method of Weaver et. al. (2004).

Influent to the system in 2008-13 has averaged 227 gal/min with pH 2.8, Acidity 349 mg/L, Fe 37 mg/L, Mn7 mg/L, Al 37 mg/L, and SO4 568 mg/L based on 15 samples. Outflow from the final wetland has averaged 208 gal/min, pH7.2, Acidity -95 mg/L, Alkalinity 116 mg/L, Fe 0.4 mg/L, Mn 2.7 mg/L, Al 0.2 mg/L, and SO4 497 mg/L from 15 samples. Each of the 4 VFP's has released consistently net alkaline effluent over this period. The combined outflow of the VFP's, prior to entering the wetland, is similar to this value. Most of the metals removed by the treatment are apparently retained in the VFP's. The systems were occasionally flushed initially but have not been flushed for most of its history.

In 2012, after 8 years of service, changes in treatment behavior suggested that the compost layer was decreasing in effectiveness. The systems were drained, and the compost layer was found to be thin and the organic matter was bleached and decreased in abundance. The organic matter is currently being replaced.

The receiving stream, Babb Creek, has recovered from the AMD degradation and has been removed from the 303d list.

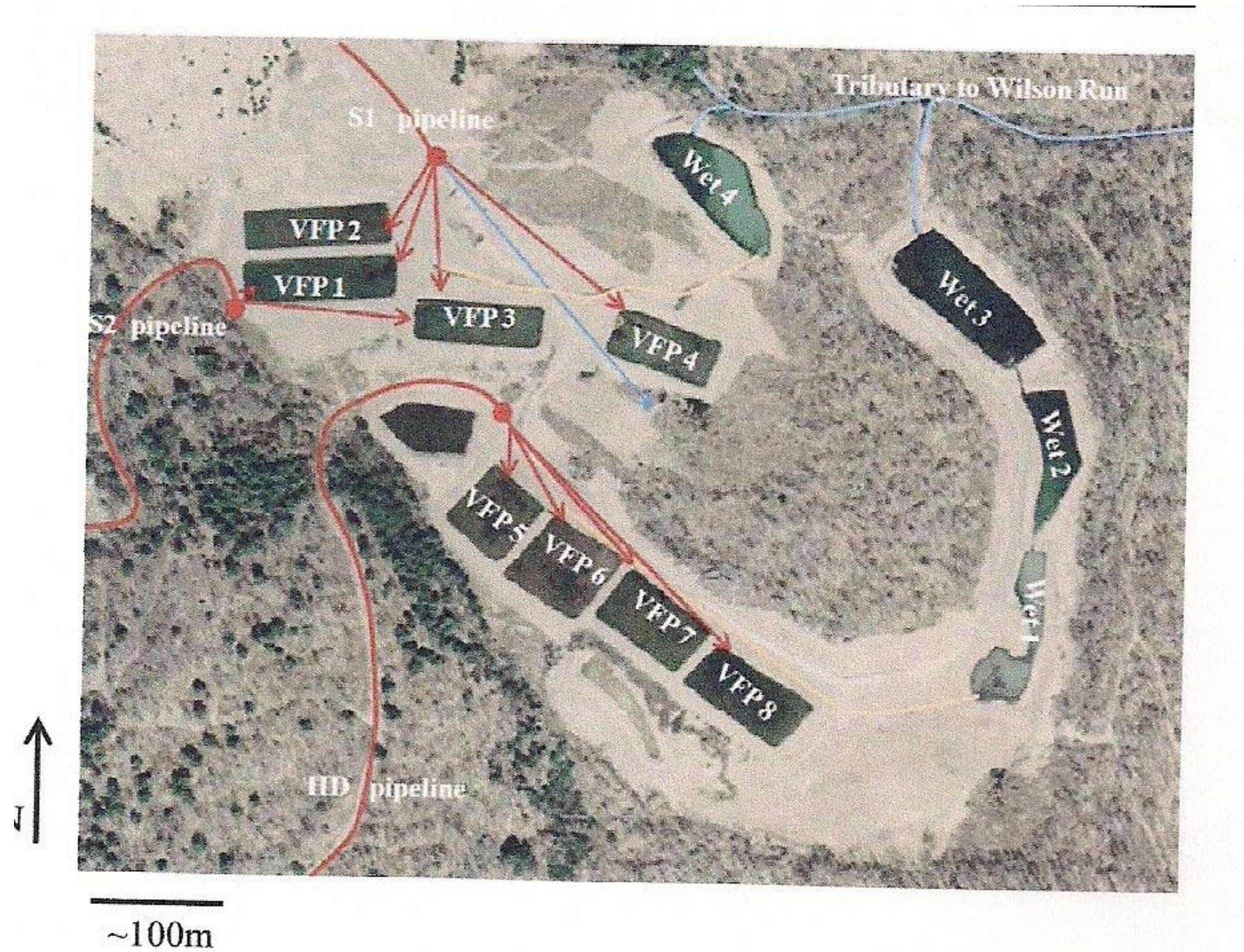


Figure HD1. Hunters Drift is VFP-5, -6, -7, -8 and Wetland Wet-1, -2 and -3. The site to the N is the Anna S site.

Table HD	Hunters Drift												
ID	Site	Date	Acidity	Alkal. Lab	Al	Flow	Fe	Mn	pH fld	pH Lab	Sp.Cond.	SO4	TSS
	RAW		mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L
14020-114	22-48.2	12/16/1996	282	0	22.7		23.2	5.98		2.9	1218	165	2
14021-114	22-48.2	7/7/1997	462	0	29.9		36.3	9.33		2.8	1465	470	4
14022-114	22-48.2	7/17/1997	466	0	40.6	100.9	50.9	13		2.8	1525	515	8
14360-114	22-48.2	6/13/2000	338	0	27.7	246	27.4	7.36		2.9	1355	284	10
16229-114	22-48.2	6/15/2004	315	0	26.4	450	22	6.65	4	2.8		465.9	4
16230-114	22-48.2	10/4/2004	299.4	0	21.3	400	18	6.35	4	2.8		346.3	3
16231-114	22-48.2	5/12/2005	269.2	0	18.9		16.6	5.02	2.4	2.9		427.8	3
16232-114	22-48.2	11/7/2005	341.8	0	18.3	400	20.5	4.21	3	2.8		568.5	3
17030-114	22-48.2	9/6/2006	390.8	0	26.2		27.3	5.43	4	2.8		540.6	3
5239-1147	22-48.2	11/29/2006	278	-	16.9	393	22	6.3		2.8		473	
5241-1147	22-48.2	7/25/2007	373		30.9	93	44.2	8.8		2.8		719	
5243-1147	22-48.2	9/11/2007	436	-	38	78	53.3	9.5		2.8		495	
5245-1147	22-48.2	11/27/2007	458	-	55.3	171	55.3	8.4		2.8		641	
5247-1147	22-48.2	12/12/2007	436	-	40.2	177	49.6	7.5		2.8		518	
5249-1147	22-48.2	2/25/2008	336	-	37.9		22.6	6.6		2.9		448	
5251-1147	22-48.2	3/11/2008	254	-		384	27.9	3.4		2.9		350	
5253-1147	22-48.2	6/30/2008	329	-	36.5		32	7.9		2.8		484	
5255-1147	22-48.2	8/6/2008	405	-	50.3	119	38.9	8.4		2.8		653	
5257-1147	22-48.2	8/19/2008	408	-	61.9	94	45.5	9.8				618	
5259-1147	22-48.2	10/3/2008	479	-	49.5	83	72.3	9.6		2.9		785	
5261-1147	22-48.2	10/31/2008	504	-	48.5		60.1	9		3		835	
5995-1147	22-48.2	9/1/2009	431.6	0	36.37	195	51.46	7.15	3.2	2.79	1400	751.7	2
5993-1147	22-48.2	3/17/2010	278.91	ND	25.82	510	33.5	3.35	2.5	2.72	1147	491.7	2
8467-1147	22-48.2	9/13/2010	424.12	0	49.53	200	34.07	9.52	3.9	2.65	1568	802.5	2
8466-1147	22-48.2	3/22/2011	190.4	0	14.57		14.96	3.44	3	2.89	820	307.6	5
8464-1147	22-48.2	9/20/2011	298.9	0	24.14		25.22	7.22	3	2.81	1050	539.5	5
7229-1147	22-48.2	4/3/2012	240.99	ND	18.29		18.51	5.06	2.9	2.87	1048	387.9	5
8462-1147	22-48.2	9/10/2012	397.4	0	47.4	80	51.51	8.9	3.2	2.91	1464	701.1	5
8461-1147	22-48.2	3/25/2013	249.67	0	24.09	380	21.97	4.49	4	2.88	987	368.1	7
		Average	357.7	0.0	33.5	239.7	35.1	7.2	3.3	2.8	1253.9	522.5	4.3
		Avrage 08-13	348.5	0.0	37.5	227.2	36.7	6.9	3.2	2.8	1185.5	568.2	4.1
	VFP5 out												
16229-114	22-48.25	6/15/2004	-233.2	263.2	0.5	100	0.3	5.43	7	7		370.8	3
16230-114	22-48.25	10/4/2004	-63.8	223	0.5	100	0.796	4.45	7.5	7.1		435.8	4
16231-114	22-48.25	5/12/2005	-150.6	214	0.5		0.3	0.05	6.7	7		518.6	3
16232-114	22-48.25	11/7/2005	-108	191.4	0.5	100	8.37	5.26	7	6.9		498.2	14
17030-114	22-48.25	9/6/2006	-129.2	178	0.5	70	15.35	6.554	7	6.7		421.5	22
5995-1149	22-48.25	9/1/2009	-80.2	191.21	0.15	57	47.49	6.68	6.8	6.49	1241	610.7	25
5993-1149	22-48.25	3/17/2010	-95.65	135.78	1.19	135	5	3.81	6.5	7.03	1031	461.2	15
8467-1149	22-48.25	9/13/2010	-135.04	179.57	0.19	50	49.48	7.75	6.8	6.33	1430	744.8	16
8466-1149	22-48.25	3/22/2011	-122.4	136.34	0.76	177	1.83	3.3	7	7.08	861	338.5	7
8464-1149	22-48.25	9/20/2011	-78.8	117.64	0.23		22.96	5.91	6.5	6.38	887	386	42
7229-1149	22-48.25	4/3/2012	-95.12	153.22	0.13	62	1.3	2.52	7	6.6	905	432.9	9
8463-1149	22-48.25	9/11/2012	-71.8	144.7	0.55	18	54.43	2.28	6.5	6.47	1314	726	61
8461-1149	22-48.25	3/25/2013	-108.47	150.4	0.3	90	0.73	1.62	7	7.03	942	348.2	8
		Average	-113.3	175.3	0.5	87.2	16.0	4.3	6.9	6.8	1076.4	484.1	17.6
		Average 08-1	-98.4	151.1	0.4	84.1	22.9	4.2	6.8	6.7	1076.4	506.0	22.9
	VFP6 out												
16229-115	22-48.26	6/15/2004	-246.6	291.4	0.5	100	0.3	4.46	7	7.1		338.6	3
16230-115	22-48.26	10/4/2004	-138.2	223.4	0.5	100	0.3	5.85		7.2		393.2	3
16231-115	22-48.26	5/12/2005	-170.6	213.8	0.5		0.403	4.36	6.8	7.1		445.1	3
16232-115	22-48.26	11/7/2005	-170	208	0.5	100	24.4	0.558	7	7		499.2	6
17030-115	22-48.26	9/6/2006	-158	203	0.5	68	8.174	7.166	7	6.8		444.8	12
5995-1151	22-48.26	9/1/2009	-96.8	179.53	0.41	48	41.95	7.27	6.8	6.49	1254	599.4	11
5993-1151	22-48.26	3/17/2010	-151.9	180.85	<0.04	120	6.32	3.24	6.8	7.15	1135	484.6	26
8467-1151	22-48.26	9/13/2010	-113.06	178.75	<0.04	50	59.95	9.01	6.8	6.39	1434	739.5	13
8466-1151	22-48.26	3/22/2011	-164.6	170.87	<0.04	100	1.39	3.11	7	7.21	941	368.3	5
8464-1151	22-48.26	9/20/2011	-84.58	126.79	0.1		24.1	6.22	7	6.39	904	384.8	30
7229-1151	22-48.26	4/3/2012	-124.77	161.88	0.08	77	0.78	2.2	7	7.29	880	386.4	10
8462-1151	22-48.26	9/10/2012	-89.2	148.66	0.17	36	50.56	12.61	6.5	6.45	1277	674.1	69
8461-1151	22-48.26	3/25/2013	-114.13	156.62	0.24	95	0.53	1.19	7	7.09	1001	350.4	6
		Average	-140.2	188.0	0.4	81.3	16.9	5.2	6.9	6.9	1103.3	469.9	15.2
		Average08-1	-117.4	163.0	0.2	75.1	23.2	5.6	6.9	6.8	1103.3	498.4	21.3

8464-1151	22-48.26	9/20/2011	-84.58	126.79	0.1		24.1	6.22	7	6.39	904	384.8	30
7229-1151	22-48.26	4/3/2012	-124.77	161.88	0.08	77	0.78	2.2	7	7.29	880	386.4	10
8462-1151	22-48.26	9/10/2012	-89.2	148.66	0.17	36	50.56	12.61	6.5	6.45	1277	674.1	69
8461-1151	22-48.26	3/25/2013	-114.13	156.62	0.24	95	0.53	1.19	7	7.09	1001	350.4	6
		Average	-140.2	188.0	0.4	81.3	16.9	5.2	6.9	6.9	1103.3	469.9	15.2
		Average08-1	-117.4	163.0	0.2	75.1	23.2	5.6	6.9	6.8	1103.3	498.4	21.3
	VFP7 out												
16229-115	22-48.27	6/15/2004	-219.8	291.6	0.5	100	0.3	4.15	7.3	7.2		297.2	8
16230-115	22-48.27	10/4/2004	-91	224.2	0.5	100	0.549	5.26	7.3	7.2		381.5	3
16231-115	22-48.27	5/12/2005	-150	207.2	0.5	100	2.17	4.49	7.3	7.1		439	6
16232-115	22-48.27	11/7/2005	-137.6	196	0.5	100	5.46	5.29	7	7		508	10
17030-115	22-48.27	9/6/2006	-133	181.6	0.5	72	16.47	6.685	7	6.7		437.9	18
5995-1153	22-48.27	9/1/2009	-69.2	147.33	0.26	44	63.8	6.21	7	6.36	1224	644.5	15
5993-1153	22-48.27	3/17/2010	-116.82	150.36	0.72	120	3.98	5.14	6.5	7.01	1073	469	1
8467-1153	22-48.27	9/13/2010	-68.71	162.98	0.16	50	32.49	7.4	7	6.44	1482	776.2	11
8466-1153	22-48.27	3/22/2011	-129.8	141.11	0.55	120	1.22	2.87	7	7.07	859	358.7	5
8464-1153	22-48.27	9/20/2011	-61.89	106.55	0.42		30.87	6.14	7	6.32	902	391.9	30
7229-1153	22-48.27	4/3/2012	-93.73	133.05	1.08	74	0.64	2.55	7	7.22	845	376.5	8
8463-1153	22-48.27	9/11/2012	-61.8	139.17	1.87	24	52.81	12.06	6.5	6.45	1309	749.1	72
8461-1153	22-48.27	3/25/2013	-101.81	141.41	0.5	95	0.72	1.66	7	6.94	892	365.9	11
		Average	-110.4	171.0	0.6	83.3	16.3	5.4	7.0	6.8	1073.3	476.6	15.2
		Average08-1	-88.0	140.2	0.7	75.3	23.3	5.5	6.9	6.7	1073.3	516.5	19.1
	VFP8 out												
16229-115	22-48.28	6/15/2004	-208	287	0.5	100	0.3	4.08	7	7.2		352	4
16230-115	22-48.28	10/4/2004	-147.8	209	0.5	100	0.854	6.45	7.5	6.9		351.3	4
16231-115	22-48.28	5/12/2005	-133.4	195.2	0.5	100	4.67	5.01	7.4	7		450.7	8
16232-115	22-48.28	11/7/2005	-126.8	190.4	0.5	100	7.61	5.37	6.7	6.9		525	10
17030-115	22-48.28	9/6/2006	-102	161.8	0.544	70	22.27	6.763	7	6.6		427.4	20
5995-1155	22-48.28	9/1/2009	-18	116.88	0.28	46	83.12	6.48	7	6.24	1238	490.8	13
5993-1155	22-48.28	3/17/2010	-46.65	77.14	5.22	135	8.26	5.3	6	6.55	969	467.7	17
8467-1155	22-48.28	9/13/2010	-76.23	160.57	1.17	50	89.63	7.95	6.8	6.42	1391	660.9	14
8466-1155	22-48.28	3/22/2011	-122	140.83	0.06	100	0.27	2.73	7	7.69	859	328.7	5
8464-1155	22-48.28	9/20/2011	-36.82	103.8	1.84		26.27	5.16	6.5	6.27	943	449.4	23
7229-1155	22-48.28	4/3/2012	-69.85	117.27	0.06	81	0.82	3.52	7	6.96	824	361.1	26
8461-1155	22-48.28	3/25/2013	-139.78	183.14	<0.10	100	6.99	3.32	7	7.06	1005	337.2	23
		Average	-102.3	161.9	1.0	89.3	20.9	5.2	6.9	6.8	1032.7	433.5	13.9
		Av. 08-13	-72.8	128.5	1.4	85.3	30.8	4.9	6.8	6.7	1032.7	442.3	17.3
	Wetland out												
16229-115	22-48.29	6/15/2004	-144.8	242	0.5	400	0.698	1.95	8	8.5		425.3	48
16230-115	22-48.29	10/4/2004	-130.8	189.8	0.5	420	0.829	3.45	7.9	7.7		302.5	3
5263-1157	22-48.29	10/2/2004		188						7.6			
5265-1157	22-48.29	10/28/2004		171						7.8			
5267-1157	22-48.29	11/27/2004		188						7.4			
5269-1157	22-48.29	12/29/2004		171						7.4			
5271-1157	22-48.29	3/21/2005		157						7.4			
5273-1157	22-48.29	4/22/2005		171						7.9			
16231-115	22-48.29	5/12/2005	-109.4	159	0.5	400	0.3	0.543	7.5	7.8		422.6	8
16232-115	22-48.29	11/7/2005	-133.8	174.8	0.5	400	0.3	0.05	7.2	7.7		491.8	3
17030-115	22-48.29	9/6/2006	-139.4	160	0.5	280	0.3	0.88	7	7.3		399.4	3
5239-1157	22-48.29	11/29/2006	-131	141	0.4	393	0.6	2.5		7.4		396	
5275-1157	22-48.29	4/24/2007		126						7.9			
5241-1157	22-48.29	7/25/2007		95		93				7			
5245-1157	22-48.29	11/27/2007	-98	107	0.2	171	0.4	3.2		7.3		490	
5247-1157	22-48.29	12/12/2007	-115	133	0.8		0.8	5.2		7.3		507	
5249-1157	22-48.29	2/25/2008	-145	158	0.9		0.5	3.7		7.4		142	
5251-1157	22-48.29	3/11/2008	-87	123	0.5	400	0.9	3.8		7.1		429	
5253-1157	22-48.29	6/30/2008	-79	100	0.2		0.1	0.3		6.7		440	
5277-1157	22-48.29	8/8/2008	-94	123	0.2	119		1.2		7		504	

5245-1157	22-48.29	11/27/2007	-98	107	0.2	171	0.4	3.2		7.3		490	
5247-1157	22-48.29	12/12/2007	-115	133	0.8		0.8	5.2		7.3		507	
5249-1157	22-48.29	2/25/2008	-145	158	0.9		0.5	3.7		7.4		142	
5251-1157	22-48.29	3/11/2008	-87	123	0.5	400	0.9	3.8		7.1		429	
5253-1157	22-48.29	6/30/2008	-79	100	0.2		0.1	0.3		6.7		440	
5277-1157	22-48.29	8/8/2008	-94	123	0.2	119		1.2		7		504	
5257-1157	22-48.29	8/19/2008	-79	104		51		0.3		7.5		594	
5259-1157	22-48.29	10/3/2008	-86	112	0.4	83	0.1	0.4		6.9		837	
5261-1157	22-48.29	10/31/2008	-59	61	0.1	40	0.2	0.3		7.4		683	
5279-1157	22-48.29	12/8/2008	-120	149	0.1	145	0.7	4		7		893	
5281-1157	22-48.29	3/17/2009	-134	146			0.4	2.9		7.2		416	
5995-1157	22-48.29	9/1/2009	-100.8	122.05	0.05	195	0.32	1.41	7.2	7.24	1164	562.5	4
5993-1157	22-48.29	3/17/2010	-101.53	128.17	0.14	510	0.75	3.47	7	7.63	1004	451.4	<1
8467-1157	22-48.29	9/13/2010	-82.37	86.3	<0.04	200	0.5	2.92	7.2	7.11	1322	537.1	3
8465-1157	22-48.29	4/19/2011	-93.4	120.25	0.05		0.15	2.02	7.5	7.24	743	280.5	5
8464-1157	22-48.29	9/20/2011	-74.03	90.89	0.05		0.14	1.35	7.5	6.85	874	370.6	5
7229-1157	22-48.29	4/3/2012	-88.36	121.3	<0.04	294	0.08	0.81	7.4	7.04	842	391.9	5
8463-1157	22-48.29	9/11/2012	-83.4	96.53	<0.04	78	0.48	5.29	8	7.93	1169	555.6	6
8461-1157	22-48.29	3/25/2013	-111.5	135.58	<0.10	380	0.12	1.15	7	7.78	895	355.9	13
		Average	-104.8	137.9	0.3	252.6	0.4	2.1	7.4	7.4	1001.6	475.1	8.8
		Av. 08-13	-95.2	116.3	0.2	207.9	0.4	2.1	7.4	7.2	1001.6	496.7	5.9

SUMMARY SHEET - KALP

Name: Kalp County: Fayette

Latitude: 40^o 2' 48" N Longitude: 79^o 23' 56" W

Watershed: Indian Creek

Year Built: 2007

Risk Level: High (?- No good flow data)

Designer: NRCS

Local Group or person: Mountain Watershed Association

Treatment types, Sequence: Upflow limestone bed, settling pond, 2 VFP's in parallel, settling pond, wetland

VFP

Area(water surface): 2*(325 x 130) = 84,500 ft^2 = 7850 m^2
Compost thickness: None
Limestone thickness, size, quality: ?
Comments: Caustic tank currently at site during renovations

Rehab, date and nature: 2013 work on inflow system.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

	Flow(gpm)	pH	Acidity	Alk.	Fe	Mn	Al	SO_4	
Average influent 2008-13:	103* (460*)	3.1	164	0	22	1.8	10	508	N=25
Average effluent 2008-13:	82	6.3	-8.1	24	0.9	1.8	1.5	547	N=25

*Flow data very incomplete, from earlier period.

Loading (g acidity/day, g/m2/d): 422,900 g/d total; 304,600 into vfp's; 39 $g/m^2/d$

References: Datashed

NRCS, 2000, Indian Creek: Watershed Plan and Environmental Assessment (on Datashed).

Conclusions: The system generated net alkaline effluent (SB2) from 2007 to 2012, but in the last few months only 75 to 90% of acidity is removed. The upflow limestone bed appears nearly plugged with Fe precipitate. Rehab is underway. Additional seepage may enter the wetlands and affects samples at the final wetland outlet.

Kalp

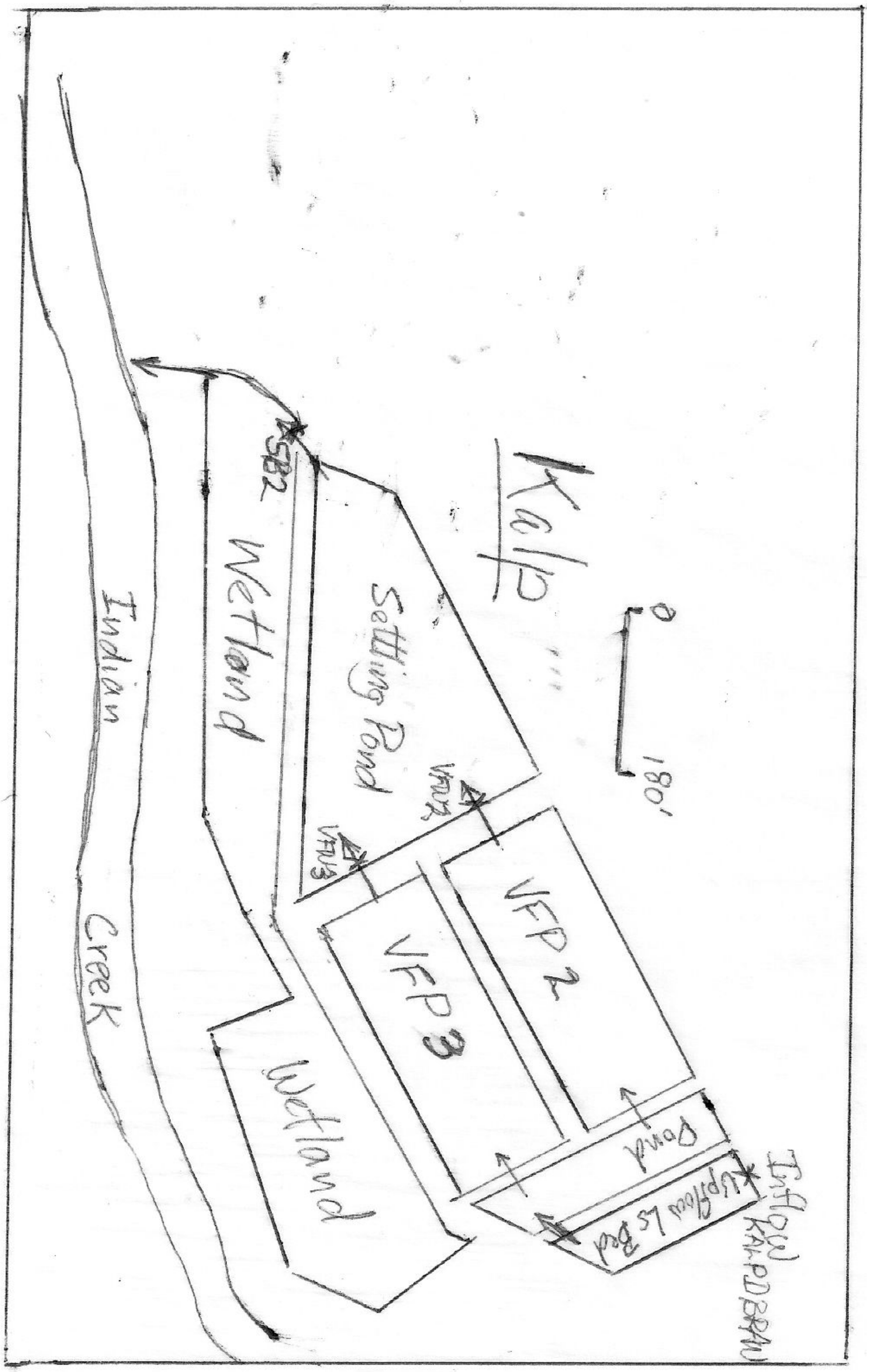
The Kalp discharge is located in Saltlick Township, Fayette County near the village of Melcroft in the Indian Creek Watershed. It treats the discharge from the abandoned underground Melcroft Mine. The discharge is the largest of about a dozen discharges in the Indian Creek watershed, as determined in an assessment conducted in 2000. The system was built in 2007 and started operation late in the year. The construction and management of the treatment system is under the direction of the Mountain Watershed Association. The system was designed by the NRCS, with input from PA BAMR, and funding of $1.6 million from AMD Setaside funds.

The AMD is collected from the underground mine pool and flows in pipes into the base of an upflow limestone bed. The influent since 2008 averages pH 3.1, acidity 164 mg/L, 22 mg/L Fe, 1.8 mg/L Mn and 10 mg/L Al. Earlier analyses of the mine discharge were much more acid and metal-rich. Mainly earlier flow data indicates a flow of 460 gal/min, but flow appears highly variable and recently may be <100 gal/min. A portion of the flow is sprayed onto the berm, presumably to aerate it. The effluent of the upflow limestone bed passes through a baffled settling pond and is split into two parallel vertical flow ponds. The ponds are limestone only, with no compost and have siphons according to Datashed, but no siphons were evident when the site was visited. The effluent from the VFP's flows to a large settling pond, and then into a wetland.

When visited on 7/29/13, a plastic tank labeled as caustic was present in the inflow area. The hose from this tank disappeared in vegetation and may be flowing into the underground mine pool. Watershed members indicate this is temporary while work is done on the inflow structures. Another feature of note is that the water level in the outflow control structures of the VFP's was several feet lower than the water level in the VFP's, suggesting that they may be partially plugged (or that the siphons had recently operated?).

The system released net alkaline water from the Settling Pond (SB2) most of the time until mid 2012. The effluent is more alkaline in the summer and fall, and can be acid in other parts of the year. Flow data is very sporadic, so it is not possible to tell if the performance is related to flow. About 40% of the Fe is evidently being removed by the upflow limestone bed. The acidity loading to the VFP's is about 39 $g/m^2/d$, and the VFP's treat at about 31 $g/m^2/d$, assuming an average flow of 460 gal/min.

The system is clearly removing most of the acidity and metals, and with current rehab may regain its original success. The samples in the DEP study in 2009-2010 appear to have been taken from the final wetland outlet (COMBOUT), and probably include additional seepage into the wetland. The available maps do not show where this sample point is located.


Kalp
0
180'
Settling Pond
Wetland
Indian Creek
VFP 2
VFP 3
Wetland
Pond
Upflow LS Bed
Inflow

ID	Site	Date	Acidity	Alkalinity	Al	Ferrous	Flow	Fe	Mn	pH fld	pH lab	Sp.Cond.	SO4	TDS	TSS
			mg/L	mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
17704-181	COMBOUT	1/24/2008	181.2	0	10.3	3.38		26.5	1.93		3.1	1252	490.9		6
17705-181	COMBOUT	3/12/2008	36.8	0	2.455	0.71		5.322	1.94		4.4	1044	639.3		18
17706-181	COMBOUT	6/24/2008	-32.2	51	0.576	0.24		1.437	2.088		7	1106	494.4		12
17707-181	COMBOUT	10/1/2008	-52.2	60.4	0.244	0.12		0.506	1.9		7.3	1203	721.4		10
17708-181	COMBOUT	12/30/2008	-13.6	23.6	0.864	0.14		0.508	1.74		6.8	1017	421.7		6
17709-181	COMBOUT	3/5/2009	63.2	0	4.993	0.99		12.8	1.872		3.5	1123	566.1		18
17710-181	COMBOUT	4/10/2009	19.4	0.4	2.467	0.59		4.085	2.001		5.1	1033	578.5		10
17711-181	COMBOUT	5/18/2009	60.8	0	4.35			8.393	1.857		3.5	1062	426.6		12
17712-181	COMBOUT	7/17/2009	0.2	9	1.632	1.28		5.137	1.417		6.6	1076	512.2		16
17713-181	COMBOUT	9/3/2009	-16	20	0.2	0.12		0.207	2.213		6.9	1108	524.4		5
17714-181	COMBOUT	10/28/2009	32	0	5.51	0.24		1.02	1.89		4.7	1011	555.3	894	
18533-181	COMBOUT	2/4/2010	57.6	0	6.495	0.6		5.037	2.09		3.7	991	496.6	830	6
18562-181	COMBOUT	4/8/2010	47.4	0	4.599	0.69		4.951	1.717		4	1002	517.2		5
18651-181	COMBOUT	6/17/2010	-0.8	10.4	1.724	0.26		2.223	1.372		6.1	1042	510.3		6
18767-181	COMBOUT	10/21/2010	-87.2	99	0.2	0.16		0.561	2.085		7.2	932	338.1		8
18805-181	COMBOUT	12/29/2010	-29.6	42.4	0.473	2.5		2.706	1.258		6.7	768	295.8	564	
18849-181	COMBOUT	3/9/2011	22	0	2.689	0.48		1.596	1.343		4.9	965	462	784	5
18911-181	COMBOUT	5/23/2011	21.2	0	4.121	0.42		2.954	1.345		4.9	901	468.9	830	10
18983-181	COMBOUT	8/10/2011	38.4	0	3.868	1.8		5.748	2.611		4.8	1024	561.5	952	18
19035-181	COMBOUT	11/2/2011	50	0	3.708	0.77		3.154	1.459		3.7	1003	579.5	752	6
19103-181	COMBOUT	2/15/2012	38.2	0	3.608	0.49		2.185	1.269		3.9	934	446.1		
19184-181	COMBOUT	5/16/2012	29.2	0	3.184	0.78		2.97	1.383		4.2	973	455.3		
19233-181	COMBOUT	8/22/2012	51	0	6.848	0.18		0.554	2.23		4.5	1087	570		
19284-181	COMBOUT	12/5/2012		0	6.561	0.57		1.351	1.503		4.1	957	438.1		
		Average	22.5	13.2	3.4	0.8		4.2	1.8		5.1	1025.6	502.9	800.9	9.8
17182-181	KALPDBRA	3/21/2006	226	0	14.4	46.3		50.6	2.08		3.3		620.5		3
17183-181	KALPDBRA	3/31/2006	836	0	43.2	287.63		243	2.74		3.3		1113		12
17184-181	KALPDBRA	4/3/2006	753.8	0	39.6	244.46		211	2.62		3		1243		3
17185-181	KALPDBRA	4/12/2006	893.6	0	53	27.67	1000	243.8	2.92	4	3.3		1425		3
17186-181	KALPDBRA	4/18/2006	827	0	41	302.36	1000	250	2.89	4	3.3		1367		8
17187-181	KALPDBRA	4/27/2006	792.4	0	49.5	257.82		290	3.66		3.2		1209		3
17188-181	KALPDBRA	5/1/2006	628	0	33.7	207.78		190	2.84		3.2		981.2		4
17189-181	KALPDBRA	5/5/2006	612	0	29.3	202.93		182	2.7		3.2		1142		10
17190-181	KALPDBRA	5/11/2006	569.6	0	23.5	178.59	390	161	2.6		3.2		1083		3
17191-181	KALPDBRA	5/18/2006	500	0	24.54	161.35		149.1	2.601		3.1		964.3		3
17192-181	KALPDBRA	5/24/2006	475	0	21.7	152.5		130	2.23		3		965.3		8
17193-181	KALPDBRA	5/31/2006	430.6	0	19.5	128.03		121	2.39		3.1		843.6		4
17194-181	KALPDBRA	6/5/2006	412	0	17.2	124.36		96.1	1.81		3.1		966.5		3
17195-181	KALPDBRA	6/9/2006	407.8	0	17.3	119.28		107	2.14		3.1		846.8		10
17196-181	KALPDBRA	6/16/2006	419	0	16.5	114.29		98.2	2.05		3		797.9		18
17197-181	KALPDBRA	6/30/2006	383	0	15.2	105.46		90	1.89		2.9		930.3		12
17198-181	KALPDBRA	7/12/2006	366.6	0	15.5	96.1		94.3	2.21		3		805.1		3
17199-181	KALPDBRA	7/18/2006	340	0	16.4	90.65	364	103.5	2.27		3	1520	730.9		10
17200-181	KALPDBRA	7/28/2006	345	0	14.2	85.7		83.4	2.02		3		755.3		6
17201-181	KALPDBRA	8/7/2006	353.4	0	13.8	81.86		82.5	2.18		3		820.7		3
17202-181	KALPDBRA	8/18/2006	335.6	0	13.7	85.98		79.1	1.83		2.9		888.2		10
17203-181	KALPDBRA	9/22/2006	360	0	12.8	90.96		87.1	1.99		2.9		907.1		18
17204-181	KALPDBRA	10/20/2006	335.6	0	15.863	72.63	246	100.3	2.485		3.1		802.6		3
17205-181	KALPDBRA	11/3/2006	305.2	0	14.2	59.3	262	82.6	2.276		3	1482	779.5		10
17875-181	KALPDBRA	1/19/2007	269.6	0	11.7	32.69	375	64.7	2.105		3.1	1400	682		12
17876-181	KALPDBRA	3/8/2007	255	0	11.7	14.86	450	45.4	1.9		3	1301	582.4		20
17877-181	KALPDBRA	4/25/2007	224	0	11.5	15.77	600	40.2	1.81		3.1	1285	624.6		2
17878-181	KALPDBRA	5/16/2007	244.6	0	13.1	29.04	1000	50.7	1.826		3.1	1342	604.5		2
17879-181	KALPDBRA	6/22/2007	318	0	13.7	58.67		75.9	1.97		3		806.8		18
17880-181	KALPDBRA	8/8/2007	271.6	0	12.6	31.16		68.8	2.02		3.1	1402	602.9		12

17881-181	KALPDBRA	9/27/2007	262.2	0	11.8	29.12		61.8	2.069		3.1	1387	619.9		20
17882-181	KALPDBRA	12/27/2007	239.8	0	11.9	8.04	200	41.1	1.893		3	1308	521.5		2
17704-181	KALPDBRA	1/24/2008	192.6	0	10.8	2.7		29.8	1.993		3	1272	477.7		6
17705-181	KALPDBRA	3/12/2008	199.2	0	11.5	2.91		28.8	1.681		3	1233	618.3		2
17708-181	KALPDBRA	12/30/2008	213	0	10.3	26.63		64	1.73		2.8	1377	535.2		5
17709-181	KALPDBRA	3/5/2009	180.4	0	9.497	3.18		23.27	1.719		3	1249	590.8		5
17710-181	KALPDBRA	4/10/2009	164	0	10.07	1.69		17.7	1.928		3	1223	480.3		5
17711-181	KALPDBRA	5/18/2009	167.6	0	9.992	2.51	75	18.5	1.829		3	1184	482.2		5
17712-181	KALPDBRA	7/17/2009	188.4	0	8.563	10.55		35.2	1.774		3	1201	428.1		6
17714-181	KALPDBRA	10/28/2009	202.2	0	9.82	7.97		34	1.84		3.1	1222	522.9	970	
18533-181	KALPDBRA	2/4/2010	156.2	0	8.812	1.2	35	15.6	1.658		3.1	1146	449.4	824	5
18562-181	KALPDBRA	4/8/2010	152.6	0	9.94			11	1.717		3.1	1181	470.5		5
18651-181	KALPDBRA	6/17/2010	155.2	0	9.97	3.08		20.1	1.775		3.1	1183	484.8		5
18767-181	KALPDBRA	10/21/2010	197	0	10.4	5.06		30	1.958		3.1	1366	592.6		10
18805-181	KALPDBRA	12/29/2010	180.6	0	9.99	1.69		19.9	2.108		3	1349	581.8	884	
18849-181	KALPDBRA	3/9/2011	137	0	9.89	0.75		8.089	1.691		3.1	1230	466.3	816	5
18911-181	KALPDBRA	5/23/2011	114.2	0	7.491	0.71		6.271	1.36		3.2	1063	477	850	5
18983-181	KALPDBRA	8/10/2011	243.6	0	15.6	13.66		34.2	1.947		3.1	1320	589.6	1154	10
19035-181	KALPDBRA	11/2/2011	135.4	0	8.742	1.59		11	1.636		3.2	1155	482.8	790	5
19103-181	KALPDBRA	2/15/2012	106.4	0	8.383	1.35		8.161	1.684		3.3	1035	415.4		
19146-181	KALPDBRA	4/25/2012	113.8	0	7.11	0.64		10.5	1.56		3.2	1059	453.4		
19184-181	KALPDBRA	5/16/2012	124.4	0	8.175	5.68		13.1	1.687		3.3	1137	456		
19233-181	KALPDBRA	8/22/2012	284.2	0	20.2	25.99		56.7	2.014		3.1	1311	621.7		
19284-181	KALPDBRA	12/5/2012	119	0	8.211	0.71		10.8	1.619		3.1	1129	496.6		
19306-181	KALPDBRA	2/21/2013	121.6	0	9.1			6.576	1.7		3.2	1051	458		5
19307-181	KALPDBRA	3/11/2013	109.2	0	8.482	1.76		6.834	1.467		3.2		527.1	770	5
0707-127		7/29/2013	155	0	9.9	2.49		35	1.7	3.1	3.1	1320	546	1082	
	Average		317.6	0.0	16.2	66.7	461.3	76.0	2.0	3.7	3.1	1255.2	714.7	904.4	7.2
	Average 2008-13)		164.5	0.0	10.0	5.4	55.0	22.2	1.8	3.1	3.1	1208.2	508.2	904.4	5.5
17882-291	SB1	12/27/2007	90.2	0	7.391	0.57	180	9.26	2.015		3.5	1194	603.5		14
17704-291	SB1	1/24/2008	70.4	0	8.185	0.64		8.212	2.077		3.6	1148	560.5		22
17705-291	SB1	3/12/2008	121.4	0	8.702	0.8		16.1	1.744		3.3	1162	563		18
17706-291	SB1	6/24/2008	147.6	0	7.944	5.82		25.6	1.831		3.2	1199	492.3		16
17707-291	SB1	10/1/2008	134.4	0	8.26	1.24		23.4	1.9		3.1	1267	671.5		12
17708-291	SB1	12/30/2008	131.6	0	8.27	0.89		16.7	1.77		3.2	1099	420.3		5
17709-291	SB1	3/5/2009	141.6	0	9.053	1.09		16.56	1.75		3.1	1231	590.7		5
17710-291	SB1	4/10/2009	101.6	0	8.743	0.94		10.5	1.896		3.3	1153	527.3		18
17711-291	SB1	5/18/2009	125.2	0	9.267			11.3	1.876		3.2	1157	439.6		5
17712-291	SB1	7/17/2009	114	0	7.287	2.22		13.1	1.939		3.1	1208	473.8		10
17713-291	SB1	9/3/2009	123.8	0	7.932	0.95		14.5	1.94		3	1246	506.7		8
17714-291	SB1	10/28/2009	126.4	0	10.7	0.94		19.8	1.95		3.2	1228	542.8	902	
18533-291	SB1	2/4/2010	140.6	0	8.462	0.74		15.5	1.688		3.2	1135	485.2	848	5
18562-291	SB1	4/8/2010	102.6	0	8.374	0.51		5.955	1.655		3.4	1071	493.5		5
18651-291	SB1	6/17/2010	113.8	0	8.184	0.75		10.5	1.667		3.2	1173	514.8		6
18767-291	SB1	10/21/2010	144.8	0	9.38	0.89		19.6	1.916		3.2	1382	609.9		22
18805-291	SB1	12/29/2010	132.6	0	9.26	0.72		14	1.926		3.2	1295	594.5	940	
18849-291	SB1	3/9/2011	102.6	0	7.959	0.61		5.834	1.508		3.3	1191	496	826	5
18911-291	SB1	5/23/2011	75.4	0	7.053	1.18		2.899	1.425		3.6	1016	511.9	814	5
18983-291	SB1	8/10/2011	183.4	0	14.7	3.05		15.9	1.908		3.1	1342	606.2	1104	5
19035-291	SB1	11/2/2011	101.6	0	8.151	0.55		7.648	1.686		3.3	1123	589.8	756	5
19103-291	SB1	2/15/2012	67.2	0	6.457	0.75		4.878	1.518		3.6	980	457.3		
19184-291	SB1	5/16/2012	75.4	0	5.376	1.69		2.891	1.762		3.4	1042	454		
19233-291	SB1	8/22/2012	254.4	0	18.9	4.49		41.4	2.007		3.1	1379	631.2		
19284-291	SB1	12/5/2012	111.4	0	7.83	1.03		9.87	1.59		3.2	1120	502.5		
		Average	121.4	0.0	8.9	1.4	180.0	13.7	1.8		3.3	1181.6	533.6	884.3	10.1

17882-291	SB2	12/27/2007	-45.8	71.8	0.446	0.43	180	1.198	1.639		7.7	1231	658.7		10
17704-291	SB2	1/24/2008	-38.8	52.6	0.766	0.15		1.01	2.13		7.1	1204	595.1		18
17705-291	SB2	3/12/2008	-0.8	23.4	0.579	1.19		1.479	2.796		6.6	1086	633.6		4
17706-291	SB2	6/24/2008	-31.4	51	0.615	0.16		1.294	2.121		6.8	1106	485.1		10
17707-291	SB2	10/1/2008	-50.6	59.6	0.319	0.12		0.501	1.9		7.1	1204	717.8		6
17708-291	SB2	12/30/2008	-11.6	22.4	0.931	0.1		0.485	1.79		6.8	1020	424.4		10
17709-291	SB2	3/5/2009	-20.2	29.2	0.884	0.26		0.832	1.841		6.9	1098	576.1		10
17710-291	SB2	4/10/2009	-16.4	27.6	0.63	0.13		0.216	1.964		7	1075	575.6		10
17711-291	SB2	5/18/2009	-11.8	24.2	0.279			0.653	1.739		7	1019	443.8		5
17712-291	SB2	7/17/2009	-38.2	44.4	0.2	0.09		0.357	1.323		7.4	1117	517.5		5
17713-291	SB2	9/3/2009	-13.4	17	0.2	0.1		0.124	2.311		6.7	1105	510.7		5
17714-291	SB2	10/28/2009	43.8	0	6.11	0.24		1.16	2.04		4.4	1071	575.1	960	
18533-291	SB2	2/4/2010	31.6	0	4.969	0.47		1.516	2.106		4.7	964	506.9	822	5
18562-291	SB2	4/8/2010	-28.2	41.6	0.22	0.35		0.843	1.78		7.4	1039	541.8		5
18651-291	SB2	6/17/2010	-27.2	37.8	0.212	0.1		0.398	1.329		6.9	1081	536.9		5
18767-291	SB2	10/21/2010	-7.8	14.2	0.646	0.17		0.386	1.777		6.3	1186	640.7		10
18805-291	SB2	12/29/2010	5.4	6.4	1.687	0.29		0.473	1.695	6.12	5.6	1104	612	988	
18849-291	SB2	3/9/2011	-1	10.2	1.068	0.41		1.811	1.249		6.4	989	464.3	822	5
18911-291	SB2	5/23/2011	-59.2	66.2	0.284	0.14		0.617	1.217		7.4	982	489.2	916	5
18983-291	SB2	8/10/2011	-11.6	28.6	0.611	1.23		2.807	2.981		6.6	1094	641.2	1030	6
19035-291	SB2	11/2/2011	10.4	1.6	1.043	0.51		0.614	1.397		5.8	979	598	808	5
19103-291	SB2	2/15/2012	-3.8	9.6	0.907	0.16		0.282	1.09		6.2	950	474.5		
19184-291	SB2	5/16/2012	-20.8	27.2	0.513	0.2		0.377	1.409		6.9	1015	485.7		
19233-291	SB2	8/22/2012	49.8	0	6.942	0.11		0.569	2.292		4.4	1096	571.2		
19284-291	SB2	12/5/2012	42.2	0	5.168	0.61		1.165	1.12		4	995	497.2		
0707-130	SB2	7/29/2013	7	8.2	0.81	1.53	82	3.03	1.85	5.2	5.6	1030	569	936	14
Average	SB2		-9.6	26.0	1.4	0.4	180.0	0.9	1.8	6.1	6.4	1070.8	551.6	906.6	7.3
Average 2008-13			-8.1	24.1	1.5	0.4	82.0	0.9	1.8	5.7	6.3	1064.4	547.3	910.3	7.5
17882-291	VFW1	12/27/2007	93.2	0	7.649	1.86	180	15.2	2.008		3.5	1223	599.7		22
17704-291	VFW1	1/24/2008	79.2	0	8.811	1.15		12.7	2.192		3.5	1165	548.5		32
17705-291	VFW1	3/12/2008	122.8	0	9.078	1.56		18.7	1.801		3.3	1158	509.9		16
17706-291	VFW1	6/24/2008	144	0	8.036	12.5		27.4	1.872		3.2	1176	476.1		18
17707-291	VFW1	10/1/2008	138.2	0	8.68	3.74		28.3	1.93		3.1	1242	608.4		14
17708-291	VFW1	12/30/2008	47.4	0	8.31	2.2		17.3	1.77		3.2	1100	403.2		5
17709-291	VFW1	3/5/2009	132.6	0	8.458	1.33		15.81	1.73		3.1	1215	589.6		5
17710-291	VFW1	4/10/2009	109.2	0	8.797	1.15		12.6	1.875		3.3	1169	522.6		18
17711-291	VFW1	5/18/2009	126.6	0	8.601			14.1	1.735		3.2	1154	444.9		6
17712-291	VFW1	7/17/2009	109.2	0	6.891	6.95		22.4	1.915		3.1	1193	476.9		42
17713-291	VFW1	9/3/2009	116.6	0	7.694	2.58		22	1.92		3.1	1222	533.3		34
17714-291	VFW1	10/28/2009	134.8	0	10.5	1.89		25.1	1.97		3.2	1228	588.4	946	
18533-291	VFW1	2/4/2010	142	0	8.625	0.82		14.4	1.701		3.2	1139	494.1	846	5
18562-291	VFW1	4/8/2010	96	0	8.279	0.66		6.97	1.619		3.4	1085	510.4		8
18651-291	VFW1	6/17/2010	115.4	0	9.12	2		15.4	1.767		3.2	1169	501.6		16
18767-291	VFW1	10/21/2010	139.8	0	9.57	1.75		22.2	1.929		3.2	1383	627.3		24
18805-291	VFW1	12/29/2010	132.2	0	8.8	0.86		14.5	1.943		3.2	1290	588.8	962	
18849-291	VFW1	3/9/2011	106.2	0	8.38	0.52		6.181	1.546		3.3	1193	493.2	812	5
18911-291	VFW1	5/23/2011	74.4	0	7.083	0.9		4.801	1.446		3.6	1007	503.9	814	10
18983-291	VFW1	8/10/2011	197.2	0	14.5	5.63		26.4	1.976		3.1	1383	631	1190	36
19035-291	VFW1	11/2/2011	105.8	0	8.434	0.82		8.658	1.737		3.3	1127	579.9	800	8
19103-291	VFW1	2/15/2012	72.8	0	6.802	0.68		5.402	1.602		3.5	1012	451.5		
19184-291	VFW1	5/16/2012	77.8	0	7.399	3.42		7.95	1.974		3.5	1077	475.4		
19233-291	VFW1	8/22/2012	256.4	0	19.2	17.02		46.6	2.001		3.1	1370	644.4		
19284-291	VFW1	12/5/2012	112	0	7.947	1.01		13.2	1.57		3.2	1118	494.2		
17882-291	VFW2	12/27/2007	-32.6	53	0.419	0.17	120	0.401	1.503		7.5	1153	600.5		4
17704-291	VFW2	1/24/2008	-50.2	60.8	0.607	0.07		0.202	2.344		7.2	1217	614.6		8
17705-291	VFW2	3/12/2008	-14	32.2	2.793	0.13		1.001	1.955		6.5	1109	681.8		14
17706-291	VFW2	6/24/2008	-45	61.4	3.021	2.83		4.263	2.139		6.8	1122	417.5		26
17707-291	VFW2	10/1/2008	-32.8	46.8	3.64	0.42		1.63	2.03		6.4	1179	706.4		24
17708-291	VFW2	12/30/2008	-11.6	23	3.83	0.18		2.08	1.7		6.2	1002	405		20
17709-291	VFW2	3/5/2009	20.2	0.8	5.95	0.72		5.782	1.687		5.1	1090	588.1		26
17710-291	VFW2	4/10/2009	0.8	13.8	3.902	0.43		1.135	1.738		6.1	1056	564.7		22
17711-291	VFW2	5/18/2009	2.4	14.6	4.348			4.972	1.838		6.3	1023	442.1		22

17712-291	VFW2	7/17/2009	-37.2	47.4	2.128	14.63		14.5	2.44		6.4	1154	552.7		36
17713-291	VFW2	9/3/2009	-2	24.2	4.154	8.72		10.9	2.16		6.2	1113	519.3		16
17714-291	VFW2	10/28/2009	53.6	0	6.21	3.16		5.21	1.91		4.3	1083	630.8	952	
18533-291	VFW2	2/4/2010	51	0	6.222	2.18		4.772	1.772		4.3	968	514.5	828	5
18562-291	VFW2	4/8/2010	-25.2	39.6	2.434	2.8		3.483	1.702		7	1051	579.2		10
18651-291	VFW2	6/17/2010	1.2	16.6	4.963	7.53		6.031	1.742		5.9	1068	550.5		24
18767-291	VFW2	10/21/2010	23.8	0.4	6.271	0.38		4.146	1.848		4.9	1157	611.8		30
18805-291	VFW2	12/29/2010	33.4	0.4	6.605	0.31		2.151	1.575		4.9	1137	616.9	958	
18849-291	VFW2	3/9/2011	-18.4	31.2	2.508	1.38		2.194	1.31		6.4	1023	483.5	818	16
18911-291	VFW2	5/23/2011	-29.6	57.2	1.412	16.26		17.3	2.325		6.8	962	519.1	874	10
18983-291	VFW2	8/10/2011	8.2	51.2	4.305	23		22.7	2.664		6.5	1082	625.7	1030	16
19035-291	VFW2	11/2/2011	28.4	0	5.655	2.99		3.764	1.688		4.9	970	603.1	794	18
19103-291	VFW2	2/15/2012	13.2	1.8	4.674	0.48		1.827	1.414		5.1	952	489.1		
19184-291	VFW2	5/16/2012	73.4	0	6.487	1.35		4.271	1.855		3.4	1094	454.7		
19233-291	VFW2	8/22/2012	142.8	0	15	4.17		24.4	2.054		3.3	1259	614.2		
19284-291	VFW2	12/5/2012	49.4	0	6.803	3.2		19	1.497		3.7	1022	490		
		7/29/2013	53.4	0	6.8		22	9.6	1.9	4.4	4.8	1010			30
		Average	9.9	22.2	4.7	4.1	120.0	6.8	1.9		5.7	1079.1	555.0	893.4	18.3
17882-291	VFW3	12/27/2007	-41.4	65.2	0.714	0.56	60	0.613	1.343		7.4	1140	544.9		2
17704-291	VFW3	1/24/2008	-53	65.2	0.661	0.47		0.737	2.063		7.2	1259	626.2		12
17705-291	VFW3	3/12/2008	-36.6	57.2	1.546	0.1		0.37	2.479		7	1145	637.4		12
17706-291	VFW3	6/24/2008	-26.2	47.2	3.534	5.95		7.312	2.015		6.6	1098	484		34
17707-291	VFW3	10/1/2008	-50.4	59.2	2.66	2		3.21	2.14		6.6	1190	705.3		24
17708-291	VFW3	12/30/2008	-17.4	29.8	3.46	0.19		1.89	1.83		6.4	1008	437		18
17709-291	VFW3	3/5/2009	-39	52.4	2.519	0.3		1.233	2.083		6.8	1158	603.3		24
17710-291	VFW3	4/10/2009	-11.4	27.4	3.968	0.25		1.927	1.871		6.4	1073	566		20
17711-291	VFW3	5/18/2009	-7	25.8	3.877			3.362	1.839		6.5	1036	446.6		28
17712-291	VFW3	7/17/2009	-33.8	45.2	2.737	7.49		8.005	2.078		6.6	1135	522.4		26
17713-291	VFW3	9/3/2009	17.4	1.8	5.105	4.23		5.272	1.987		5.2	1094	532.6		8
17714-291	VFW3	10/28/2009	50.8	0	6.06	2.54		4	1.98		4.2	1089	630.2	960	
18533-291	VFW3	2/4/2010	31.2	0	6.715	0.34		2.482	2.143		4.8	954	526.6	836	8
18562-291	VFW3	4/8/2010	-45	58	1.336	2.96		4.482	1.795		7.2	1084	573		10
18651-291	VFW3	6/17/2010	-69.2	81.8	2.379	0.18		7.96	2.021		6.6	1148	535.3		12
18767-291	VFW3	10/21/2010	-92.4	99.8	0.762	0.22		0.976	1.874		6.7	1302	650.3		6
18805-291	VFW3	12/29/2010	-18.2	30.8	4.45	0.47		1.216	1.789		6.1	1151	607.6	978	
18849-291	VFW3	3/9/2011	7.2	6.2	3.765	0.3		1.171	1.371		5.7	993	493	822	8
18911-291	VFW3	5/23/2011	-78.4	82.8	0.913	0.74		0.825	1.06		7	1033	526.2	938	8
18983-291	VFW3	8/10/2011	4.2	22	7.745	2.91		4.534	2.643		6.1	1081	618.1	1050	18
19035-291	VFW3	11/2/2011	18.6	0.6	4.992	0.21		0.601	1.317		5	991	610.4	816	12
19103-291	VFW3	2/15/2012	-6.4	15.2	4.589	0.22		1.353	1.013		6	965	477.8		
19184-291	VFW3	5/16/2012	75.6	0	6.958	1.61		3.374	1.798		3.4	1091	468.6		
19233-291	VFW3	8/22/2012	2	22	8.319	3.45		5.17	2.488		6	1162	624.7		
19284-291	VFW3	12/5/2012	24.4	0	4.498	0.29		1.671	0.986		4.7	995	495.3		
0707-128	VFW3	7/29/2013	18	2.4	6.1	4.6	60	5.5	2.5	4.9	5.1	960			20
		Average	-14.5	34.5	3.9	1.7	60.0	3.0	1.9		6.1	1089.8	557.7	914.3	15.3

SUMMARY SHEET - KLONDIKE KL1

Name: Klondike KL1 County: Cambria

Latitude: 40^o33' 08" N Longitude: 78^o 29' 49" W

Watershed: Little Laurel Run, Clearfield Creek

Risk Level: High

Year Built: 2007

Designer: John Foreman

Local Group or person: Clearfield Creek Watershed Association

Treatment types, Sequence: Oxidation channel and ponds, settling pond, VFP, Settling Pond, Wetland

VFP

Area(water surface): 9700 ft^2 (900 m^2)
Compost thickness: 1 ft, with 25% wood chips and 10% fine limestone
Limestone thickness, size, quality: 2 ft, AASHTO #1 (3 in.diam), >86% $CaCO_3$, 686 T
Comments

Rehab, date and nature: Fe on compost removed, minor addition of compost-limestone 2008, 2012, Oxidation ponds added 2009.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 14 gal/min, pH 3.0, Acidity 357 mg/L, Fe 120 mg/L, Mn 37 mg/L, Al 2 mg/L, SO_4 1003 mg/L, (N=29)

Average effluent 2008-13

Flow 24 gal/min, pH 3.8, acidity 98 mg/L, Fe 13mg/L, Mn 28 mg/L, Al 1.3 mg/L, SO_4 844 mg/L, (N=60)

Loading (g acidity/day, g/m2/d): 26,300 g/d, 27.5 $g/m^2/d$

References: Klondike Final Report, later reports and data.

Conclusions: The system is removing about 75% of the nearly 400 mg/L acidity, and about 90% of the 120 mg/L Fe, but releases net acidic water. Overflow is observed at flow exceeding about 25 gal/min. The problem is interpreted to be short circuiting caused by compaction of the compost by equipment at the time of construction, and during 2 episodes of removing Fe precipitate from the compost. The compost will be replaced in 2013 and the limestone ripped to increase permeability.

Klondike KL1

The Klondike KL1 system is located in Dean Township, Cambria County near the village of Ashville. The system is in the watershed of Little Laurel Run, which flows into Clearfield Creek. The project was constructed by the Clearfield Creek Watershed Association, and is being maintained by them. It was constructed in 2007 to treat a small discharge of very acid and Fe-rich water from a combination of abandoned underground and surface mines. The discharge released about 69 lb/d of acidity, 22 lb/d of Fe and 0.6 lb.d of Al. A treatment system for a nearby second discharge, KL-2, was constructed as part of the same project.

The KL1 discharge before construction was averaging 15 gal/min containing pH 3.3 with acidity 417 mg/L, Fe 141 mg/L, Mn 30 mg/L and Al 3.8 mg/L. The original system as constructed consisted of an inflow channel, a settling pond (55 x 85 ft, 6-9 ft. deep), a vertical flow pond, an outflow settling pond (63 x 74 ft, 6-9 feet deep) and a wetland (Figure 1). The VFP was sized for 25 year life with an acidity loading of 35 $g/m^2/d$. It has an area of 125 x 78 ft. with 2 ft of limestone (AASHTO #1, 686 T) overlain by 1 foot of compost consisting of mushroom compost plus 25% wood chips and 10% fine limestone. The water depth over the compost is 4.5 ft.

Monitoring in 2008 showed that the effluent of the system had acidities of 31 to 66 mg/L, increasing to 137 mg/L in June 2008, with appreciable Fe. Also, it was noted that the VFP overflowed during times of increased flow during the winter-spring. The system was drained, and about an inch of Fe precipitate was observed covering the compost. This was removed by a combination of hand work and a small scraper. In 2008, two small oxidation ponds were built preceding the inflow pond, to remove Fe by low-pH oxidation. In 2011, a slag bed was constructed using water from a small stream to mix with the outflow pond. Unfortunately, the small stream dries up in the late summer and the inflow can freeze in winter, so it only operates part of the year. An experiment using crab-shell waste was conducted at the site by researchers at Penn State. Iron precipitate was removed again in 2012, using a small tracked scraper. Overflow continues in winter-spring.

Despite these modifications, the system continues to treat the water only partially, removing about 75% of the acidity and 90% of the Fe. The problem is believed to be compaction of the compost by the mechanized equipment, so that only about half the bed is open to flow. Replacement of the compost and ripping of the underlying limestone is planned.

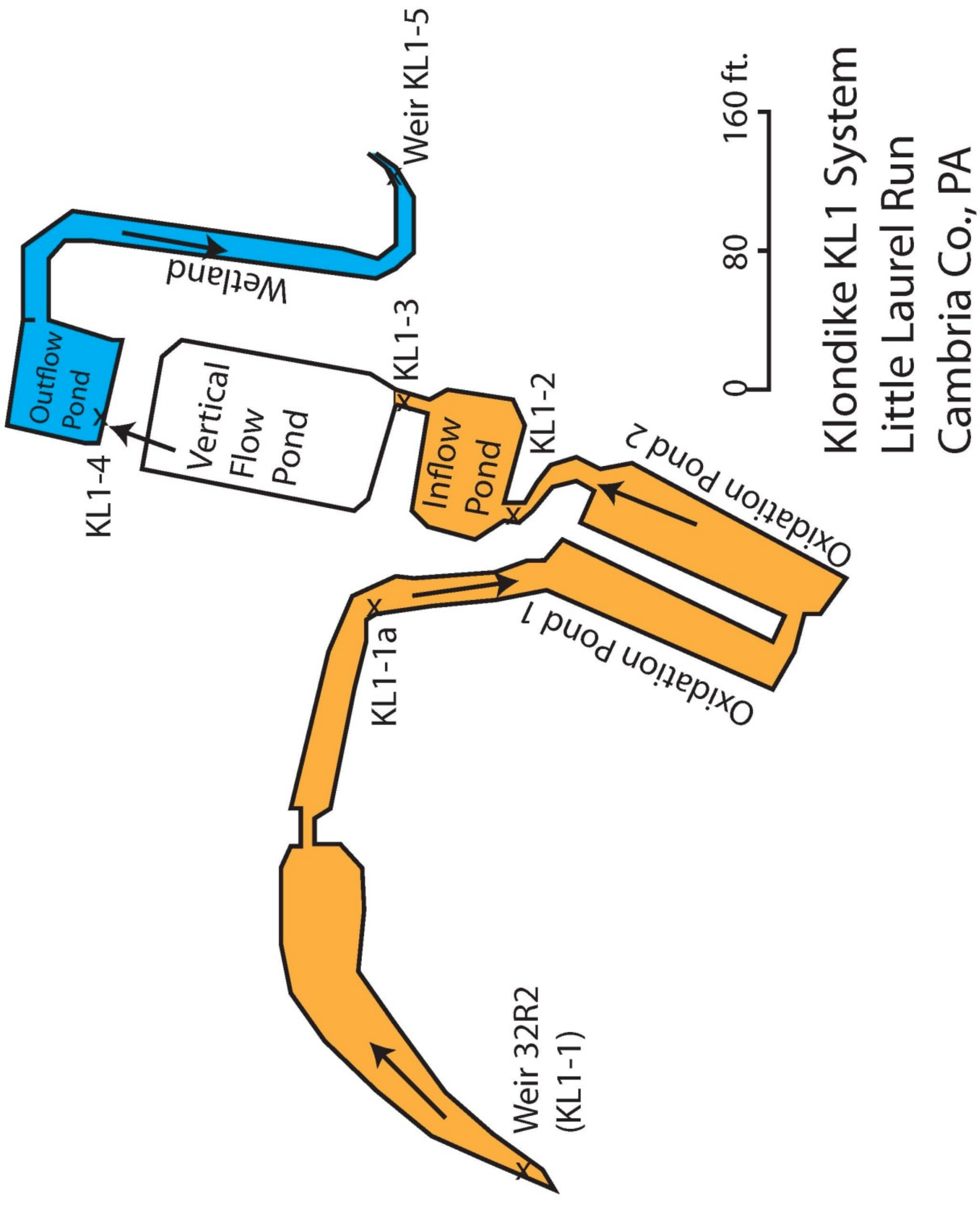

Klondike KL1 System
Little Laurel Run
Cambria Co., PA
0
80
160 ft.
Weir KL1-5
Wetland
Outflow Pond
KL1-4
Vertical Flow Pond
KL1-3
Inflow Pond
KL1-2
Oxidation Pond 2
Oxidation Pond 1
KL1-1a
Weir 32R2
(KL1-1)

Table KL	Klondike KL1											
Date	Flow	pH field	pH lab	Cond.lab	Temp.	Alk(lab)	Acidity	Fe T	Mn T	Al T	SO4	TSS
Inflow (32R2)	gal/min			uS/cm	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
12/18/2007	~15	3.28	2.8	2030		0	406	157.0	42.70		1231	10
3/18/2008	28	2.7	3.1	1650		0	333	134.0	41.10	3.24	894	7
4/15/2008	~20	2.5	3									
5/6/2008	17	3.3	3	1960	16	0	387				1040	16
5/20/2008	22	3.1	2.4		11	0	285					
6/20/2008	12	2.92	3	2050		0	422	142.0	42.20	2.46	1090	<5
8/14/2008	7				21							
9/25/2008	5											
10/21/2008	5	3.14			9							
11/18/2008	2	3.05	3	2580	3	0	502	211.0	52.60	2.04	1401	9
12/16/2008	9	3.19	3.1	2300	2.6	0	543	199.0	50.00	1.63	1360	<5
1/20/2009	9	3.28	3.2	1770	0.9	0	362	77.8	24.00	1.43	1010	6
2/17/2009	12	3.21	3.1	1860	6.8	0	312	113.0	35.40	2.42	949	9
8/17/2009	6	3.28	3	2070	23	0	440	138.0	38.70	1.90	1160	10
8/25/2009	7	3.19	3.1	2210	20	0	446	154.0	41.80	1.93	1211	8
9/15/2009	7	3.13	3	2170	16	0	489	163.0	44.10	2.01	1238	<5
10/20/2009	10	3.1	2.9	2110	11.9	0	444	161.0	42.30	1.81	1190	<5
11/8/2009		3.1		2040		0	385	146.0	45.30	1.91	1063	8
3/18/2010	28	2.58	3.2	1320	10.7	0	216	63.5	23.70	2.32	668	<5
6/13/2010	17	3.1	3	1910	18	0	323	104.0	36.60	2.32	903	7
7/20/2010	9	3.89			15			>100				
9/21/2010	6											
3/15/2011	25	2.81	3.1	1410	7.1	0	246	72.3	26.50	2.26	740	5
4/17/2011	38	2.93	3	1420	12.3	0	183	25.9	22.00	2.87	588	5
6/21/2011	12	2.7	2.9	1760	22	0	278	82.1	31.40	1.71	860	<5
7/19/2011	10	2.9	3	1940	17	0	356	112.5	37.72	1.90	995	<5
9/20/2011	17	3.4	3.1	1570	12	0	289	91.3	32.34	2.51	886	6
2/21/2012	22	3.2	3.2	1650	6	0	286	101.5	29.90	1.53	860	11
6/19/2012	15	3	3.2		15	0	279	88.2	30.50	1.39	796	8
10/16/2012	15	2.85	3.1	1940		0	401	136.2	38.40	1.06	1172	7
Av 2007-13	14	3.1	3.0	1896.4	12.6	0.0	358.9	121.5	36.8	2.0	1013.3	8.3

Date	Flow	pH fld	pH lab	Sp.Cond.	Temp.	Alk(lab)	Acidity	Fe T	Mn T	Al T	SO4	TSS
	gal/min			uS/cm	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KL1-5	Final outflow from wetland											
12/18/2007		6.4	7.2				-35	6.7	40.20		1092	35
1/15/2008		6.8					32					
2/19/2008		5.4			1.0		66					
3/18/2008		5.2	6.2	1430		44	34	15.9	28.80	0.45	788	29
4/15/2008		5.6		1440		54	26					
5/6/2008		5.9	7.3	2780	24.0	58	31				984	13
5/20/2008		5.5		1440	11.0		45					
6/20/2008		3.6		1600		0	137	24.3	34.40	0.17	1030	14
7/8/2008		3.4										
11/18/2008		6.1	3.7	2300	3.4	0	72	32.4	17.60	0.22	1459	56
12/16/2008		6.6	5.2	1820	1.4	12	82	41.2	37.60	0.29	1148	55
1/20/2009		6.1	5.0	1720	6.1	9	108	17.3	19.10	0.12	1060	45
2/17/2009	20	5.9	4.1	1310	2.6	2	71	28.6	26.90	0.37	731	45
3/17/2009	17	5.3		1330	14.0		87					
3/20/2009	13	5.8	5.2	1390	6.1	9	74	5.8	31.10	0.17	891	8
4/21/2009	25	5.4	5.7	1370	12.0	8	66	9.5	31.80	0.29	935	<5
5/20/2009	10	5.9		1410			83	6.0				
6/16/2009	9	3.4	3.5	1580	23.0	0	99	3.8	34.20	0.26	1064	<5
6/18/2009	28	3.5	3.3	1580		0	116	20.5	32.30	0.21	1005	19
7/30/2009	17	3.3	3.3	1590	27.0	0	136	10.2	32.50	0.45	976	9
8/17/2009	4	3.3	3.2	1600	28.1	0	125	3.8	34.30	0.76	1062	<5
8/25/2009	4	3.3	3.2	1670	26.5	0	145	3.5	36.30	0.64	1015	<5
9/15/2009	5	3.2	3.2	1720	21.9	0	146	4.6	33.40	0.81	1095	11
10/20/2009	13	3.3	3.3	1610	12.1	0	150	13.7	35.80	1.70	1021	16
11/8/2009			3.5			0	91	7.5	40.80	0.69	906	16
12/15/2009	35	3.8	3.5	1510	3.7	0	135	18.3	32.30	1.61	878	19
1/19/2010	22	3.0	3.3		4.1	0	133	29.5	31.10	1.63	88?	38
3/18/2010	61	2.8	3.2	990	17.6	0	121	0.5	1.86	0.88	512	29
4/23/2010	20	3.6	3.5	1250	16.8	0	81	7.5	27.20	1.36	806	10
6/13/2010	22	3.0	3.2	1370	24.0	0	131	9.1	32.70	1.12	811	6
7/20/2010	28	3.1		1946	26.0							
9/21/2010	1	6.4	7.2	700	20.2	262	-97	11.2	18.70	0.67	1064	255
11/16/2010	35	3.6	3.8	1130		0	75	4.6	20.24	3.53	679	13
12/21/2010	6	2.8	3.2	1620	1.2	0	156	24.7	29.70	2.78	859	12
1/18/2011	8	3.0	3.2	1570	6.0	0	128	40.8	51.80	3.16	862	12
3/15/2011	35	2.9	3.2	980	7.3	0	119	18.3	18.60	3.05	568	<5
3/15/2011	39	2.9	3.1	1020	6.9	0	124	18.4	18.80	3.08	561	<5
4/17/2011	72	2.8	3.1	980		0	115	17.2	17.30	2.65	510	5
5/21/2011	39	2.9	3.2	1100	20.0	0	107	5.6	20.44	1.80	680	<5
6/21/2011	13	2.6	3.1	1200	28.0	0	126	13.8	25.53	1.13	778	6
7/19/2011	8	2.9	3.0	1870	28.0	0	180	18.6	29.42	1.52	967	<5
9/9/2011	56	3.1	3.1	1360	19.0	0	137	12.5	23.70	3.02	644	<5
9/20/2011	28	3.5	3.4	1170	18.0	0	91	3.6	20.72	3.12	574	6
10/18/2011	28	3.5	3.3	1200	14.0	0	115	7.0	25.10	3.16	640	6
11/15/2011	28	3.3	3.2	1300	8.7	0	104	7.3	20.80	2.50	583	8
12/13/2011	25	3.5		1490	3.8							
1/9/2012	22	4.0		1550	2.8							
2/21/2012	22	3.1	3.1	1590	2.6	0	145	19.0	25.50	2.27	782	5
3/20/2012	28	2.6	3.0	1450	16.0	0	161	12.7	27.20	2.15	726	<5
4/17/2012	22	2.7	3.0	1460	11.0	0	173	11.8	32.33	2.47	937	<5
6/19/2012	20	2.7	3.0		13.0	0	115	5.8	24.70	1.50	700	8
8/12/2012		3.6	3.6			0	62	0.7	28.54	0.16	967	<5
8/21/2012	9	4.1	3.9	1390	12.0	0	54	1.3	30.62	0.14	984	<5
9/18/2012	35	5.1	5.6	1090	18.0	9	65	2.2	26.77	0.08	1002	<5
10/16/2012	15	4.8	6.0	1150	11.0	16	64	2.2	33.00	0.09	1001	<5
12/14/2012	20	4.2	3.2	1170	3.5	0	125	9.6	31.96	1.51	858	11
1/15/2013	39	3.0	3.0	1160	1.8	0	138	26.9	23.55	1.44	680	6
2/19/2013	28	4.1		1210	0.5							
4/20/2013	25	2.9										
5/21/2013	22	3.3	3.6			0	78	1.7	21.63	1.08	624	<5
6/18/2013	35	3.6			20.0	0	66	22.8	25.22	1.81	549	<5
7/16/2013	22	3.3	3.6	1280	25.0	0	65	1.2	21.63	0.59	594	<5
8/20/2013	13	3.4	3.7	1540	22.0	0	71	1.2	30.82	0.64	906	<5
Av 2007-13	23	4.0	3.9	1437.9	13.0	10.3	97.5	13.1	28.2	1.4	866.8	25.8

SUMMARY SHEET –Loyalsock

Name: Loyalsock (White Ash #3, C Vein) County: Sullivan

Latitude: 41^o 27' 34" N Longitude: 76^o 21' 58 W

Watershed: Loyalsock Creek

Risk Level: Medium

Year Built: 1999

Designer: BAMR

Local Group or person: Corey Richmond, Sullivan Co. Conservation

Treatment types, Sequence: Vertical flow pond, Settling pond

VFP

Area(water surface): 39,000 ft^2 (3630 m^2)
Compost thickness: 1.5 ft.
Limestone thickness, size, quality: 5 ft, AASHTO #3
Comments: No H2S smell

Rehab, date and nature: None known

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.
Average influent 2008-13: pH 3.8, Acid. 31, Fe 0.6, Mn 1.0, Al 2.3 (N=6)

Average effluent 2008-13: pH 7.8. Acid. -46, Alk. 55, Fe 0.3, Mn 0.8, Al 0.3
flow: 350 gpm

Risk Level: Medium (high flow)

Loading (g acidity/day, g/m2/d): 59,400 g/d; 16.3 g/m^2/d

References: Datashed

Conclusions: This Medium Risk treatment system is performing well, releasing net alkaline water from a high-flow (350 gpm) but low metals discharge. The VFP is nearly twice the size needed for good treatment, but may have been sized for retention time.

Loyalsock (White Ash #3, C Vein)

This Medium Risk treatment system is located in Sullivan County about 1 mile south of the village of Mildred. The system treats the outflow of an abandoned underground mine. It consists of an inflow structure, a pipe to the vertical flow pond, and a settling pond. The system was built in 1999, and designed by the PA BAMR office in Wilkes Barre. The effluent enters Loyalsock Creek.

The AMD flows from a vertical pipe about 3 ft. in diameter at one end of a roofed enclosure. Presumably this flow is from the underground mine. A small pond about 15 feet in length is beneath the roof and limited by a large stainless steel V-notch weir. However, water is flowing under the weir and into a large pile of rocks which presumably covers the opening of a pipeline to the VFP about 50 feet away. This conduit flows beneath a ditch that contains surface water. The flow emerges from an 8 inch pipe into the VFP which is about 350 feet long and 115 feet wide. According to the design drawing, this pond contains 1.5 feet of spent mushroom compost and 5 feet of AASHTO #3 limestone, underlain by an underdrain system. The flow emerges from a pipe at the south end of the VFP into a settling pond about 250 x 90 feet in dimension. The outflow of this pond flows to Loyalsock Creek a few hundred feet away. The inflow to the system averages pH 3.6, acidity 31 mg/L, Fe 0.6 mg/L, Mn 1 mg/L and Al 2.3 mg/L, based on 6 samples since 2008. Outflow is pH 7.8, acidity -46 mg/L, alkalinity 55 mg/L, Fe 0.3 mg/L, Mn 0.8 mg/L, and Al 0.3 mg/L. Based on an approximate flow measurement made at the visit, the flow is about 350 gal/min. No flow measurements are recorded in the Datashed database, but Todd Wood of BAMR reports 300-400 gal/min. Treatment is thus very satisfactory. The VFP may have been designed on retention time in the limestone; the areal acidity loading is 18 $g/m^2/d$.

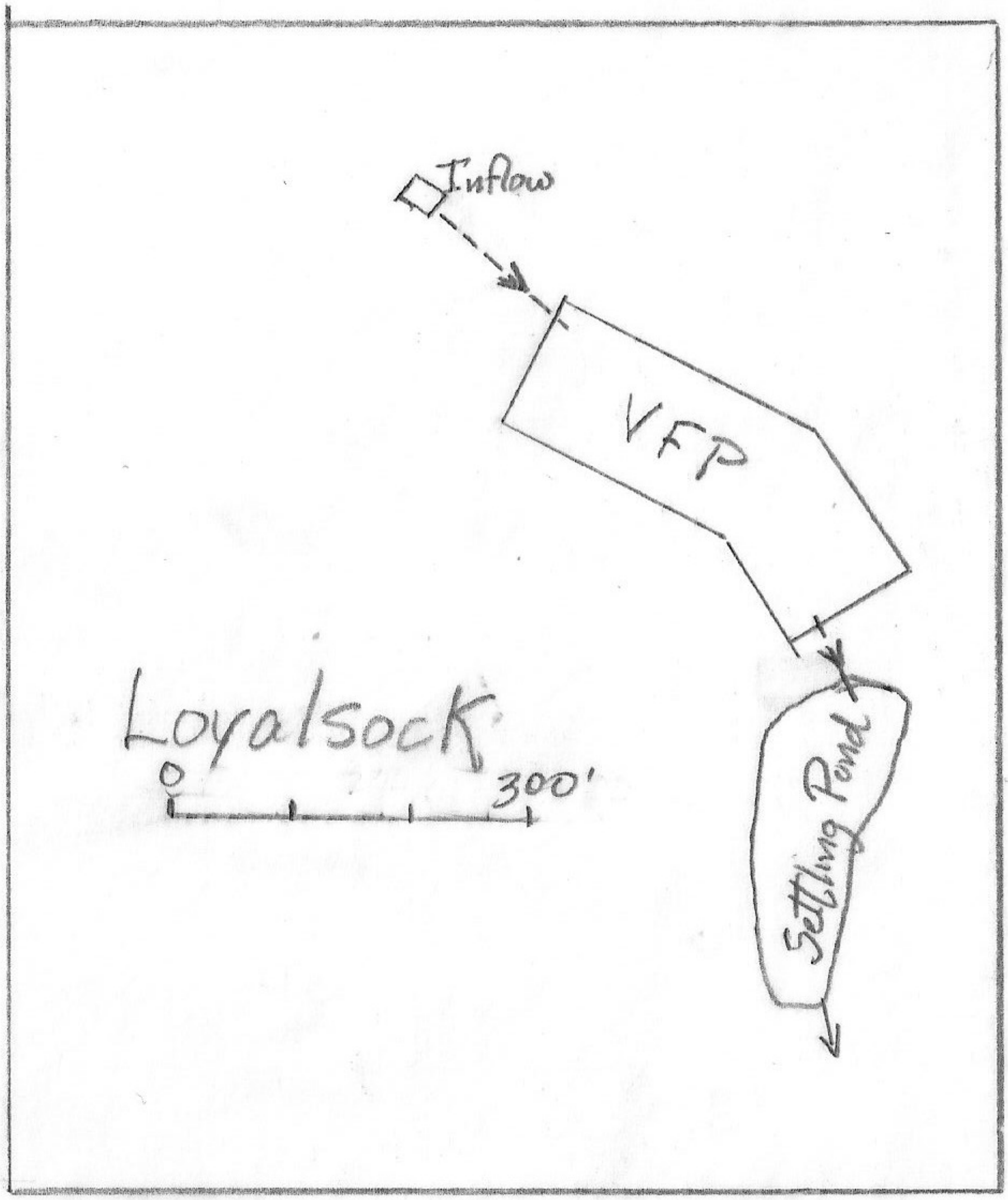

Inflow
VFP
Loyalsock
0
300'
Settling Pond

Table LS	Loyalsock													
ID	Site	Date	Acidity	Alkalinity	Al	Ferrous	Flow	Fe	Mn	pH fld	pH Lab	SO4	TSS	Sp.Cond
			mg/L	mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			mg/L	mg/L	uS/cm
	Inflow													
14071-293	CV01	8/6/1998	40	0	2.92	1.14		1.43	1.33		3.7	76	2	
14072-293	CV01	8/13/1998	38	0	3.09	1.02		1.36	1.53		3.8	70	8	
14073-293	CV01	9/10/1998	42	0	3.63	1.2		1.88	1.84		3.7	65	2	
14074-293	CV01	10/13/1998	40	0	3.35	1.02		1.35	2.43		3.8	66	2	
14075-293	CV01	11/12/1998	52	0	4.73	1.44		2.17	2		3.7	92	2	
14076-293	CV01	12/10/1998	54	0	5.39	1.5		2.49	2.27		3.7	97	22	
14544-293	CV01	1/26/1999	42	0	2.99	0.23		0.677	1.21		3.6	59	44	
14545-293	CV01	2/22/1999	36	0	2.68	0.38		0.558	1.08		3.7	45	2	
14546-293	CV01	3/29/1999	34	0	2.3	0.1		0.414	1.04		3.8	47	2	
14547-293	CV01	12/15/1999	40	0	2.98	0.07		0.81	1.16		3.8	63	2	
14548-293	CV01	2/23/2000	44	0	3.8	0.42		0.732	1.45		3.6	74	14	
14549-293	CV01	3/23/2000	32	0	2.42	0.2		0.394	1.19		3.7	53	4	
14550-293	CV01	4/26/2000	30	0	2.29	0.15		0.477	1.19	3.56	3.7	51	2	
14551-293	CV01	5/30/2000	34	0	2.28	0.25		0.401	1.06		3.7	52	2	
14552-293	CV01	7/5/2000	38	0	2.66	0.62		0.845	1.28		3.7	45	2	
14553-293	CV01	7/27/2000	40	0	3.14	0.6		1.52	1.54		3.7	60	14	
14554-293	CV01	8/30/2000	46	0	4.16	0.98		1.8	1.91		3.6	70	2	
14555-293	CV01	9/28/2000	50	0	4.59	0.58		1.18	1.9		3.7	67	2	
14556-293	CV01	11/2/2000	0	52	0.277	0.211		0.184	2.41		7.1	107	38	
14557-293	CV01	12/7/2000	42	0	3.53	0.066		0.859	1.46		3.6	57	2	
15274-293	CV01	1/18/2001	38	0	3.04	0.663		1.25	1.27		3.7	54	2	
15275-293	CV01	2/27/2001	38	0	3.11	0.28		0.69	1.28		3.7	49.2	10	
15276-293	CV01	3/29/2001	36	0	2.99	0.32		0.572	1.23		3.7	58.8	2	
15277-293	CV01	5/3/2001	32	0	2.44	0.37		0.764	1.19		3.7	52	6	
15278-293	CV01	6/5/2001	42	0	2.79	0.72		1.45	1.37		3.7	49.6	22	
15279-293	CV01	7/24/2001	50.8	0	3.68	0.81		1.25	1.66		3.7	66.9	2	
15280-293	CV01	10/3/2001	100.2	0	4.11	0.35		0.617	1.83		3.6	43.8	6	
15281-293	CV01	11/1/2001	52.6	0	3.97	0.47		2.63	1.66		3.6	60.1	34	
15282-293	CV01	2/6/2002	73.2	0	3.12	0.33		0.5	1.31		3.6	70	2	
15283-293	CV01	5/8/2002	59	0	3.04	0.12		0.587	1.32		3.6	62.7	2	
15284-293	CV01	6/4/2002	40.8	0	3.21	0.53		0.963	1.47		3.7	58.1	4	
15285-293	CV01	8/15/2002	42.4	0	3.08	0.97		1.95	1.62		3.7	78.2	2	
15286-293	CV01	10/1/2002	63	0	3.7	0.18		0.89	2.17		3.7	85.8	2	
15287-293	CV01	11/21/2002	76	0	2.83	0.18		0.455	1.25		3.6	58.6	2	
15288-293	CV01	4/2/2003	61	0	2.05	0.5		0.521	1.07		3.7	53.8	8	
15289-293	CV01	7/8/2003	0	49.2	0.685	0.03		0.068	0.477		7	72.4	2	
15290-293	CV01	10/7/2003	55.4	0	2.606	0.49		0.705	1.287		3.6	58.9	2	
16382-293	CV01	6/7/2004	47.2	0	2.25	0.52		0.759	1.11		3.7	52.5	2	
17130-293	CV01	5/16/2006	30.6	0	2.42	0.32		0.557	1.028		3.8	63.3	2	
17736-293	CV01	8/23/2007	42.2	0	2.89	1.58		2.46	1.53		3.7	95	2	
17737-293	CV01	8/19/2009	30.8	0	2.043	0.28		0.499	0.846		3.7	47.9	5	
18603-293	CV01	4/14/2010		0	1.653	0.38		0.576	0.707		3.8	44.4	12	
18808-293	CV01	11/10/2010	37.4	0	2.784	0.33		0.522	1.069		3.7	73.6	5	
18993-293	CV01	8/22/2011	31.2	0	1.905	0.23		0.345	0.825		3.9	55	5	
19251-293	CV01	10/4/2012	23.2	0	3.016	0.59		1.132	1.451		3.9	86	5	
	CV01	8/14/2013								3.2				290
		Av.(2008-13)	30.7	0.0	2.3	0.4		0.6	1.0		3.8	61.4	6.4	

	VFP out												
14547-293	CVCF	12/15/1999	5.2	7.8	1.11	0.05		0.42	0.58		6.1	40	2
14548-293	CVCF	2/23/2000	10.2	3.2	2.08	0.14		0.491	0.983		5.3	61	30
14549-293	CVCF	3/23/2000	22	0	1.79	0.27		0.341	0.921		4	47	2
14550-293	CVCF	4/26/2000	11	2.6	1.53	0.28		0.376	0.973		5	47	6
14551-293	CVCF	5/30/2000	0	54	0.2	0.25		0.278	1.31		7.4	74	18
14552-293	CVCF	7/5/2000	0	52	0.337	0.18		0.432	1.57		7.1	69	2
14553-293	CVCF	7/27/2000	0	64	0.2	0.27		0.409	1.08		7	83	12
14554-293	CVCF	8/30/2000	0	60	0.206	0.44		0.79	1.06		7.1	90	8
14555-293	CVCF	9/28/2000	0	44	0.2	0.24		0.348	1.75		6.7	114	6
14556-293	CVCF	11/2/2000	0	30	0.897	0.24		0.421	1.5		6.7	88	32
14557-293	CVCF	12/7/2000	0	30	0.568	0.099		0.191	1.4		6.7	95	6
15274-293	CVCF	1/18/2001	0	38	0.477	0.127		0.26	0.889		6.8	83	2
15275-293	CVCF	2/27/2001	8.6	5.4	1.64	0.11		0.463	1.03		5.9	56.2	16
15276-293	CVCF	3/29/2001	11.8	2	1.79	0.18		0.343	0.859		4.8	61.3	10
15277-293	CVCF	5/3/2001	0	26	0.773	0.09		0.296	0.513		6.7	65.5	2
15278-293	CVCF	6/5/2001	0	54	0.342	0.09		0.55	0.692		7	20	24
15279-293	CVCF	7/24/2001	0	56	0.993	0.15		1.07	1.29		7	90.2	4
15280-293	CVCF	10/3/2001	69.8	1	2.79	0.24		0.562	1.39		4.6	45.9	18
15281-293	CVCF	11/1/2001	47.2	0	2.32	0.07		0.847	1.1		4.2	62.3	60
15282-293	CVCF	2/6/2002	58.6	0	2.53	0.27		0.45	1.11		3.9	63.8	12
15283-293	CVCF	5/8/2002	51.2	1.6	2.2	0.05		0.538	1.21		4.7	54.4	6
15284-293	CVCF	6/4/2002	0	30	1.14	0.06		0.408	0.656		6.6	60.1	10
15285-293	CVCF	8/15/2002	0	76	0.2	0.02		0.356	0.183		7.3	77.3	6
15286-293	CVCF	10/1/2002	0	48	0.2	0.02		0.265	0.704		7.4	77.2	2
15287-293	CVCF	11/21/2002	55.6	3	1.52	0.05		0.222	0.783		5.6	53.3	2
15288-293	CVCF	4/2/2003	30	8	0.876	0.04		0.14	0.431		6.3	39.4	10
15289-293	CVCF	7/8/2003	0	43.6	0.362	0.02		0.042	0.292		7.5	73.3	6
15290-293	CVCF	10/7/2003	0	24.8	0.643	0.03		0.045	0.409		7.2	65	2
16382-293	CVCF	6/7/2004	-10.8	41.6	0.527	0.03		0.093	0.24		7.6	54.8	4
17130-293	CVCF	5/16/2006	0.8	3.6	1.286	0.12		0.325	0.658		6.2	41.6	58
17736-293	CVCF	8/23/2007	24	16.2	1.51	0.12		0.507	1.03		7	65.1	4

	Outflow													
14547-293	CVSP	12/15/1999	0	70	0.266	0.23		0.604	0.323		7.3	91	2	
14548-293	CVSP	2/23/2000	0	54	0.294	0.15		0.321	0.609		7.1	94	12	
14549-293	CVSP	3/23/2000	0	68	0.231	0.41		0.373	0.635		7.3	58	8	
14550-293	CVSP	4/26/2000	0	66	0.2	0.27		0.222	0.865	7.31	7.5	56	2	
14551-293	CVSP	5/30/2000	0	60	0.2	0.22		0.162	1.4		7.6	86	12	
14552-293	CVSP	7/5/2000	0	58	0.237	0.19		0.318	1.67		7	75	2	
14553-293	CVSP	7/27/2000	0	78	0.2	0.14		0.103	1.78		7	103	16	
14554-293	CVSP	8/30/2000	0	68	0.2	0.08		0.107	1.59		7.6	98	2	
14555-293	CVSP	9/28/2000	0	48	0.31	0.24		0.284	2.21		6.7	122	6	
14556-293	CVSP	11/2/2000	0	52	0.236	0.15		0.154	1.83		7.2	120	24	
14557-293	CVSP	12/7/2000	0	40	0.514	0.088		0.117	1.62		6.8	95	2	
15274-293	CVSP	1/18/2001	0	46	0.404	0.098		0.12	1.16		6.8	98	2	
15275-293	CVSP	2/27/2001	0	46	0.384	0.06		0.156	1.04		7.1	80	2	
15276-293	CVSP	3/29/2001	0	40	0.371	0.04		0.104	0.698		6.7	79.4	2	
15277-293	CVSP	5/3/2001	0	48	0.236	0.08		0.188	0.488		7.2	74.5	6	
15278-293	CVSP	6/5/2001	0	66	0.2	0.09		0.282	0.39		7.3	20	26	
15279-293	CVSP	7/24/2001	0	78	0.2	0.15		0.522	1.07		7.1	98.2	2	
15280-293	CVSP	10/3/2001	0	54	0.2	0.14		0.71	1.13		7	89.6	2	
15281-293	CVSP	11/1/2001	0	58	0.2	0.02		0.384	0.734		6.8	93	38	
15282-293	CVSP	2/6/2002	0	48	0.422	0.05		0.27	0.63		6.8	77.2	14	
15284-293	CVSP	6/4/2002	0	62	0.2	0.03		0.394	0.827		7.7	61	2	
15285-293	CVSP	8/15/2002	0	82	0.2	0.08		0.716	0.987		8.6	78.9	8	
15286-293	CVSP	10/1/2002	0	56	0.214	0.02		0.55	1.52		7.5	82.2	2	
15287-293	CVSP	11/21/2002	0	20	0.989	0.03		0.085	0.734		6.6	71.4	4	
15288-293	CVSP	4/2/2003	0	20	0.746	0.02		0.038	0.461		6.6	60.5	2	
15289-293	CVSP	7/8/2003	0	46.4	0.395	0.02		0.03	0.405		7.1	84.7	2	
15290-293	CVSP	10/7/2003	0	27.4	0.77	0.03		0.07	0.476		6.9	71.2	6	
16382-293	CVSP	6/7/2004	-13.6	44.4	0.363	0.02		0.033	0.202		7.5	58.1	2	
17130-293	CVSP	5/16/2006	-38.2	44.2	0.2	0.04		0.08	0.324		7.9	57.7	2	
17736-293	CVSP	8/23/2007	-44.8	116.8	0.2	0.22		1.25	4.75		7.9	52	2	
17737-293	CVSP	8/19/2009	-71.8	82.4	0.2	0.08		0.545	1.037		7.8	56.4	5	
18603-293	CVSP	4/14/2010		58	0.2	0.05		0.32	0.274		7.8	54.9	10	
18808-293	CVSP	11/10/2010	-20.6	31.4	0.617	0.25		0.48	1.562		7.3	67.1	5	
18993-293	CVSP	8/22/2011	-34	50.4	0.2	0.04		0.196	0.534		7.9	48.4	5	
19251-293	CVSP	10/4/2012	-59	51.2	0.2	0.03		0.201	0.77		8	79.6	5	
	CVSP	8/14/2013								6				290
		Average(100	-46.4	54.7	0.3	0.1		0.3	0.8	6.0	7.8	61.3	6.0	290.0

14547-293	CVTC	12/15/1999	0	84	0.2	0.6		0.593	0.389		7.6	87	2	
14548-293	CVTC	2/23/2000	0	58	0.395	0.34		0.05	0.674		7.2	91	18	
14549-293	CVTC	3/23/2000	0	72	0.2	0.42		0.371	0.69		7.4	67	2	
14550-293	CVTC	4/26/2000	0	64	0.2	0.28		0.198	0.858	7.38	7.7	70	2	
14551-293	CVTC	5/30/2000	32	0	2.26	0.33		0.421	1.04		3.7	60	10	
14552-293	CVTC	7/5/2000	0	64	0.2	0.18		0.148	1.74		7.1	79	2	
14553-293	CVTC	7/27/2000	38	0	3.08	0.66		1.49	1.5		3.7	61	10	
14554-293	CVTC	8/30/2000	0	78	0.2	0.11		0.096	2.05		7.1	118	6	
14555-293	CVTC	9/28/2000	0	54	0.221	0.36		0.339	2.58		6.7	132	10	
14556-293	CVTC	11/2/2000	50	0	4.16	0.58		1.09	1.76		3.6	68	14	
14557-293	CVTC	12/7/2000	0	38	0.505	0.071		0.118	1.69		6.7	113	12	
15274-293	CVTC	1/18/2001	0	50	0.42	0.138		0.132	1.22		6.8	106	2	
15275-293	CVTC	2/27/2001	0	46	0.403	0.14		0.127	1.11		7.1	103	8	
15276-293	CVTC	3/29/2001	0	44	0.455	0.13		0.092	0.853		6.6	88.6	2	
15277-293	CVTC	5/3/2001	0	48	0.358	0.24		0.268	0.734		6.9	80.7	2	
15278-293	CVTC	6/5/2001	0	70	0.261	0.69		0.553	1.06		6.9	20	24	
15279-293	CVTC	7/24/2001	0	82	0.2	1.11		1.09	1.58		7	109	4	
15280-293	CVTC	10/3/2001	0	58	0.254	1.38		1.14	1.54		6.9	96.1	2	
15281-293	CVTC	11/1/2001	0	64	0.344	0.58		0.729	1.16		6.8	127	36	
15282-293	CVTC	2/6/2002	0	48	0.551	0.26		0.32	0.69		6.7	79.6	4	
15283-293	CVTC	5/8/2002	0	70	0.2	0.46		0.448	0.833		7.2	69.7	2	
15284-293	CVTC	6/4/2002	0	56	0.296	0.52		0.574	1.03		7.1	67.8	8	
15285-293	CVTC	8/15/2002	0	86	0.2	0.86		1	1.44		7	87.3	6	
15286-293	CVTC	10/1/2002	0	50	0.4	0.02		0.601	1.83		7.4	99.8	4	
15287-293	CVTC	11/21/2002	0	20	1.19	0.02		0.087	0.751		6.6	79.3	2	
15288-293	CVTC	4/2/2003	0	20.2	0.826	0.02		0.034	0.491		6.6	67.6	2	
15289-293	CVTC	7/8/2003	51.8	0	2.47	0.45		0.814	1.27		3.7	54.2	2	
15290-293	CVTC	10/7/2003	0	27.8	0.935	0.05		0.086	0.502		6.7	82.2	2	
16382-293	CVTC	6/7/2004	-12.4	47.4	0.382	0.02		0.034	0.212		7.4	66.4	6	
17130-293	CVTC	5/16/2006	-36.8	41.4	0.2	0.05		0.057	0.292		7.6	62.1	2	
17736-293	CVTC	8/23/2007	-17.4	110.2	0.2	2.76		4.2	7.49		7.2	73.6	2	
	CVTC	8/14/2013								5.6				297

SUMMARY SHEET, Broad Top LR0-D2

Name: LR0-D2 County: Bedford, Broad Top Township

Latitude: 40°8.63” Longitude: 78°11.467”

Watershed: Longs Run

Risk Level: Low

Year Built: 2005

Designer: Skelly and Loy

Local Group or person: Broad Top Township

Treatment types, Sequence: Limestone bed(inflow to bottom), Siphon, Settling pond, Settling pond

VFP

Area(water surface):
Compost thickness:
Limestone thickness, size, quality:
Comments

Rehab, date and nature: Siphon disconnected from inflow to Limestone Pond.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.)

Average influent 2008-13:
Flow 30 gal/min, pH 3.8, Acidity 142, Alk. 0, Fe 13, Mn 1.73, Al 11, SO_4 269 mg/L (N=1)

Average effluent 2008-13:
Flow 30 gal/min, pH 4.55, acidity 25 (12 calc), alk. 2, Fe 0.9, Mn 0.93, Al 1.34, SO_4 87 (N=1)

Loading (g acidity/day, g/m2/d):

References: Broad Top township, 2007, Final Report for PADEP Grant #4100021654, Longs Run Regional AMD remediation Project, Phase 2, 10 p plus maps, photos, tables.

Conclusions: The flow is small and intermittent. The system may leak slightly so that the siphon only rarely flushes. The receiving stream is essentially recovered based on this and 12 other treatment systems.

Longs Run LR0-D2

The LR0-D2 system treats a small AMD discharge in the headwaters of Longs Run, Broad Top Township, Bedford County. The system is one of 13 systems constructed in Longs Run to treat AMD discharges. The project was accomplished by Broad Top Township using funds from an DEP-EPA 319 grant of $234,119 for this discharge and several others.

The discharge is small and intermittent. According to pre-construction sampling in 2001, the discharge flows at about 8 gpm with pH 3.6, acidity 270 mg/L $CaCO_3$, Fe 30 mg/L, Mn 2.1 mg/L, and Al 14.2 mg/L (based on 2 samples plus 4 occasions when the discharge was not flowing). The source of this discharge is an abandoned underground mine on the east side of Enid Mountain Road. The discharge is piped across the road to the treatment system. The system consists of a limestone pond about 110 x 30 feet, containing 300 tons of limestone (>90% $CaCO_3$) as a layer about 2.5 feet thick. The fragment size is not recorded, but is probably AASHTO #1. The AMD flows into the limestone bed in the bottom of the bed. A 6-inch layer of compost was added to the top of the limestone to maintain Fe solubility. The bed drains through a siphon that flushes water and Al-Fe precipitate into a settling pond. The treated water flows out through a control structure into another small pond and then down into Longs Run.

Data on the performance of the system is limited. The Final Report of the project indicates that outflow pH is 5.7, with 1.58 mg/L Fe, <0.02 mg/L Al and 20 mg/L alkalinity (calculated effluent acidity of -17 assuming no Mn). At the time of the first DEP sampling in 9/24/09, the system was not flowing. At the second sampling on 4/27/10, it is recorded as flowing 30 gpm with pH 4.55, Fe 0.9 mg/L, Mn 0.93 mg/L, Al 1.34 mg/L, acidity 25 mg/L, alkalinity 2 mg/L. Note that the calculated acidity for the preceding data is 10 mg/L, not 25 as reported. At the time of my visit on 6/25/13, the system was not flowing, and the settling pond was completely dry.

The reason for the net acid condition is not clear. It appears that some flow may leak from the limestone bed, despite the addition of a liner after original construction. Probably the flow is so low that the water does not circulate through the limestone, though there was water above the limestone when visited in 2013. Perhaps the siphon does not operate often enough to clear out the Al and Fe precipitate.

Recent tests of the chemistry and macroinvertebrates in Longs Run indicate that the stream has largely recovered from AMD, as a result of the 13 treatment systems in the watershed. The very small loading of the treated LR0-D2 discharge appears to be negligible in the overall.

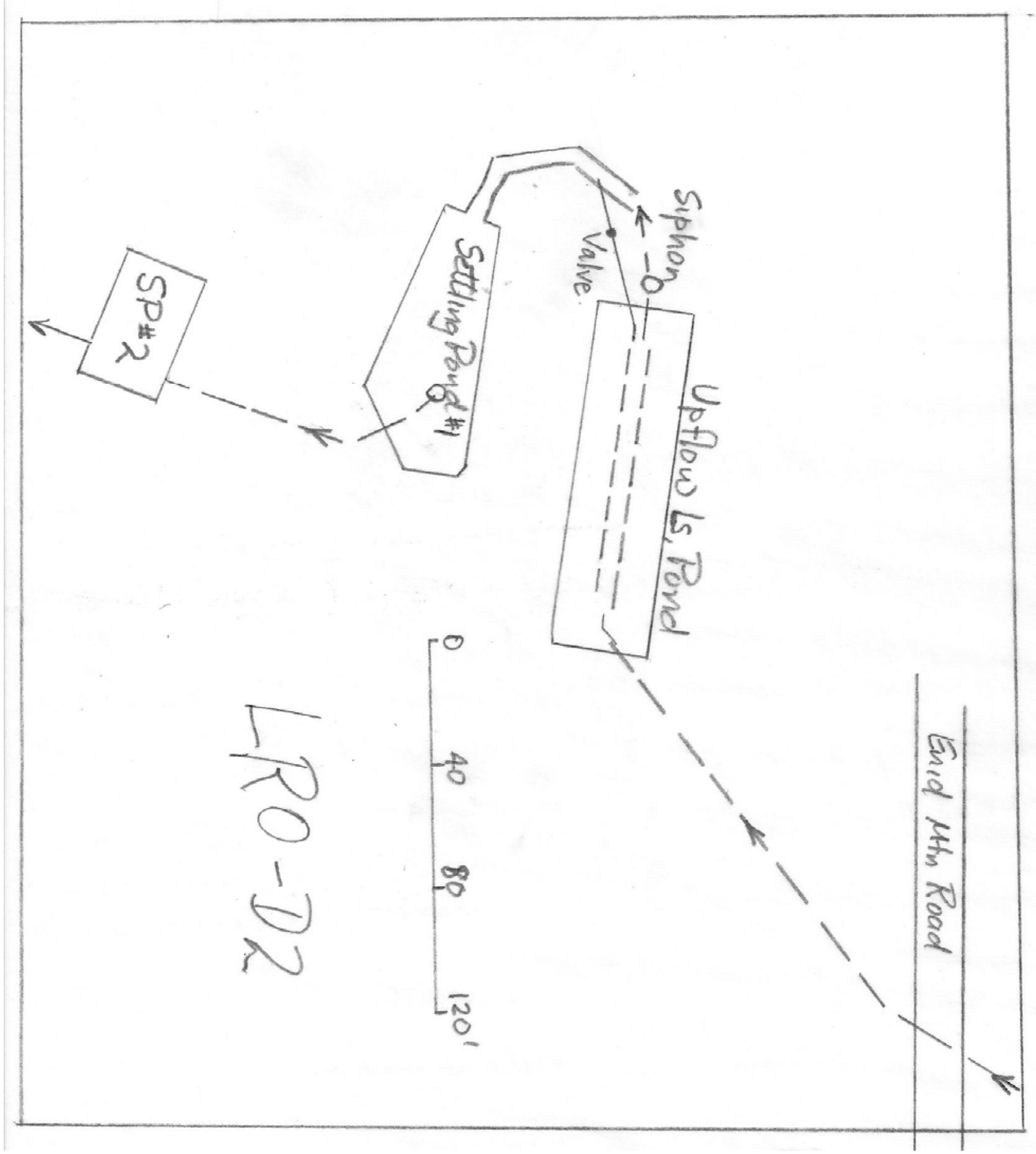

Siphon
Valve
Settling Pond #1
SP#2
Upflow Ls Pond
Enid Mtn Road
0
40
80
120'
LRO-D2

	Table LR	**Longs Run LR0-D2**											
ID	Site	Date	Acidity	Alkalinity	Al	Flow	Fe	Mn	pH fld	pH Lab	Sp.C.	SO4	TSS
			mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L
	<u>Inflow</u>												
	LR0-D2	3/29/2001	236	0	11	20	28	1.4		2.8		226	
	LR0-D2	5/14/2001	304	0	17	4	31	2.8		2.9		290	
	LR0-D2	5/30/2002				6			2.9				
	LR0-D2	6/18/2003				7.5			3.5				
	LR0-D2	6/29/2004				1			3.7				
	LR0-D2	6/22/2005				0			4.1				
	LR0-D2	12/28/2007							6.7		180		
6053-1075	LR0-D2	9/24/2009				0							
6051-1075	LR0-D2	4/27/2010	142	0	11	30	13.2	1.73	3.8	3.1	835	269	7
	<u>Ls. Pond Outflow</u>												
6053-1077	LR0-D2 B	9/24/2009				0							
6051-1077	LR0-D2 B	4/27/2010	79	0	10.2	30	16.7	2.06	4.37	3.6	681	269	31
	<u>Outflow</u>												
6053-1079	LR0-D2 C	9/24/2009				0							
6051-1079	LR0-D2 C	4/27/2010	25	2	1.34	30	0.9	0.93	4.55	4.2	236	87	<5
	Lro-D2C	6/25/2013				0							

SUMMARY SHEET – Long Run LR0-D10

Name: Longs Run LR0-D10 County: Bedford

Latitude: 40°8' 38" N Longitude: 78° 13' 27'W

Watershed: Longs Run

Risk Level: High

Year Built: 2005

Designer: Skelly and Loy

Local Group or person: Broad Top Township

Treatment types, Sequence: Limestone Pond 1 (40 tons) , Siphon, Settling Pond 1, Additional discharge, Vertical Flow Pond, automatic flusher, Settling Pond/Aerobic Wetland, Limestone Pond 2 (635 tons) , Settling Pond 2, outflow to Longs Run.

VFP

Area(water surface): 2400 ft^2 = 225 m^2
Compost thickness: 1 ft.
Limestone thickness, size, quality: 2 ft thick, 320 tons
Comments

Rehab, date and nature: Limestone cleaned 2012.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Uncertain; second discharge into VFP not measured. Preconstruction: Flow 13 gal/min, pH 3.2, acidity 442 mg/L, Fe 145 mg/L, Mn 5.4 mg/L, Al 10.1 mg/L

Average effluent 2008-13

Flow 20 gal/min, pH 6.7, acidity -61, alkal. 104 mg/L, Fe 6.6* mg/L, Mn 3.3* mg/L, Al 0.3 mg/L, SO_4 711 mg/L, N=3 (*15 mg/L TSS)

Loading (g acidity/day, g/m2/d):

References: Datashed, Final report, Longs run Project Phase II, 2007; Field observations.

Conclusions: This system, treating extremely Fe-rich AMD with some Al, has successfully removed the metals and acidity for 8 years with minimal maintenance (limestone cleaning). It is one component of a set of many passive systems that have restored Long Run.

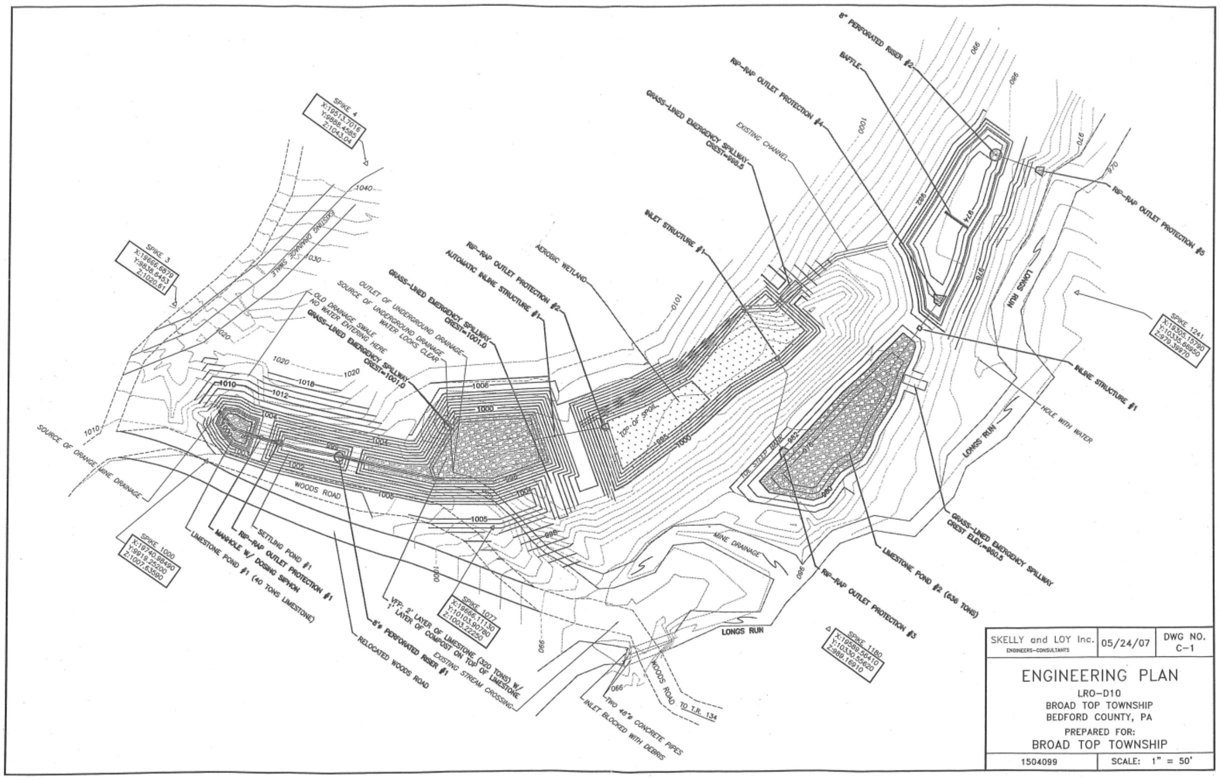
Longs Run LR0-D10

This system is located in Broad Top Township, Bedford County, near the village of Kearney. It is in the watershed of Longs Run, which flows to Sandy Run and into the Juniata River. The system was built in 2005. The AMD drains from an abandoned underground mine, and a spoil pile. The initial flow is into a small limestone bed containing about 40 tons of limestone and out through a siphon discharge into Settling Pond 1. This Settling Pond flows to a Vertical Flow Pond, which also receives an additional apparently larger and more metal-rich flow. The VFP has about 320 tons of limestone in a 2 ft. layer, overlain by a foot of compost. The VFP has an automatic flusher that flushes about once a week to Settling Pond/Wetland 2. This pond flows into Limestone pond 2, with 635 tons of limestone. This pond can be manually flushed. Outflow goes to the final Settling Pond, and then is discharged to Longs Run.

Data on the flow and chemistry is limited, but the preconstruction discharge was 13 gal/min with an acidity of 442 mg/L, Fe 145 mg/L, Mn 5 mg/L and Al 10 mg/L. Samples in 2009-10 show similar chemistry for the VFP where the second discharge enters. As with other systems with siphons and automatic flushers, information on average flow and chemistry is somewhat ambiguous, but all data show the final outflow is net alkaline.

According to the local group, the limestone was cleaned in 2012. The system is considered very successful.

Table LR-D10		Longs Run LR0-D10											
ID	Site	Date	Acidity	Alkal.	Al	Flow	Fe	Mn	pH Fld	pH Lab	Sp.Cond.	SO4	TSS
			mg/L	mg/L	mg/L	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L
	Inflow												
	LR0-D10	Preconst.	442	0	10.1	13	145	5.4		3.2			
6085-1113	LR0-D10	9/24/2009	110	0	1.43	5	26.9	4.7	3.69	3.2	1840	1041	12
6083-1113	LR0-D10	4/28/2010	57	0	2.34	50	7.09	1.3	4	3.4	497	176	9
		6/25/2013				10			2.6				
		Average	203	0	4.6	19.5	59.7	3.8	3.4	3.3	1168.5	608.5	10.5
6085-1115	LR0-D10B	9/24/2009	454	0	9.8	5	200	5.55	3.95	2.9	1510	783	14
6083-1115	LR0-D10B	4/28/2010	17	5	0.29	50	0.86	0.18	4.93	4.7	77	23	8
6085-1117	LR0-D10C	9/24/2009	341	0	7.5	5	149	5.37	3.8	3	1540	789	43
6083-1117	LR0-D10C	4/28/2010	178	0	5.74	50	102	3.47	4.62	3	1070	505	18
6085-1119	LR0-D10D	9/24/2009	356	0	8.34	5	96.8	5.32	3.92	2.8	1660	795	14
6083-1119	LR0-D10D	4/28/2010	194	0	5.43	50	84.9	3.71	3.85	3	1170	555	13
6085-1121	LR0-D10E	9/24/2009	-57	115	3.28	5	40.4	5.17	6.06	6	1520	792	84
6083-1121	LR0-D10E	4/28/2010	20	16	4.11	50	2.57	4.37	5.51	5.9	759	409	11
	Outflow												
6085-1123	LR0-D10F	9/24/2009	-66	116	<0.05	5	4.71	2.76	6.81	6.2	1560	812	9
6083-1123	LR0-D10F	4/28/2010	-56	92	0.28	50	8.53	3.86	7	7.1	1200	611	20
		6/25/2013				5			6.4				
		Average	-61	104	0.28	20	6.62	3.31	6.7	6.65	1380	711.5	14.5


SKELLY and LOY Inc.
ENGINEERS-CONSULTANTS
05/24/07
DWG NO. C-1
ENGINEERING PLAN
LRO-D10
BROAD TOP TOWNSHIP
BEDFORD COUNTY, PA
PREPARED FOR:
BROAD TOP TOWNSHIP
1504099
SCALE: 1" = 50'

SUMMARY SHEET - MAUST

Name: Maust County: Somerset

Latitude: 39^o 48' 27" N Longitude: 79^o 7' 50" W

Watershed: Casselman

Risk Level: Medium (or high if flow is higher)

Year Built: 1998

Designer: Hedin Environmental (Bond Forfeiture funding)

Local Group or person: None?

Treatment types, Sequence: Sediment Pond, VFP1, Pond/Wetland 1, VFP2, Wetland 2

VFP

Area(water surface): 125 x 125 + 110 x 110 = 27,700 ft^2 = 2580 m^2
Compost thickness:
Limestone thickness, size, quality:
Comments

Rehab, date and nature: Minor inlet repairs.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 15 gal/min, pH 3.2, Acidity 124 mg/L, Fe 42 mg/L, Mn 13 mg/L, Al 1.9 mg/L, SO4 529 mg/L, N=11

Average effluent 2008-13

pH 7.1, Acidity -54 mg/L, Alk. 69 mg/L, Fe 0.2 mg/L, Mn 2.8 mg/L, Al 0.1 mg/L, SO_4 351 mg/L, N=11

Loading (g acidity/day, g/m2/d): 10,180 g/d; 4.0 $g/m^2/d$ (15 $g/m^2/d$ for 1998-2006 data)

References: Rose (2002, 2006); Recent data from DEP.

MAUST

The Maust system is located in Elklick Township, Somerset County about 5 miles NW of Salisbury. It is in the watershed of Elklick Creek, a tributary of the Casselman River. It treats AMD from an abandoned surface mine. It was built in 1998 using bond funds.

The system consists of a Sediment Pond, VFP1about 125 feet square, a Settling Pond/Wetland, VFP 2 about 110 feet square, and a final Wetland-Pond. The 2008-13 inflow averages 15 gal/min at pH 3.2, Acidity 124 mg/L, Fe 42 mg/L, Mn 13 mg/L, Al 1.9 mg/L, SO4 529 mg/L, N=11. For 1997-2006 inflow average 47 gal/min, with acidity 154 mg/L, Fe 24 mg/L and Al 3 mg/L (Rose, 200x). The effluent in 2008-2013 averages pH 7.1, acidity -54 mg/L, alk. 69 mg/L, Fe 0.2 mg/L, Mn 2.8 mg/L, Al 0.1 mg/L, SO_4 351 mg/L for 11 samples. These flows and metal loadings classify the system as Medium Risk. The system has released net alkaline water during its entire life. Minor maintenance has been done.

A key design feature of the system is that the compost contained fine limestone (Hedin, final report; Rose, 2002). The areal acidity loading is relatively low.

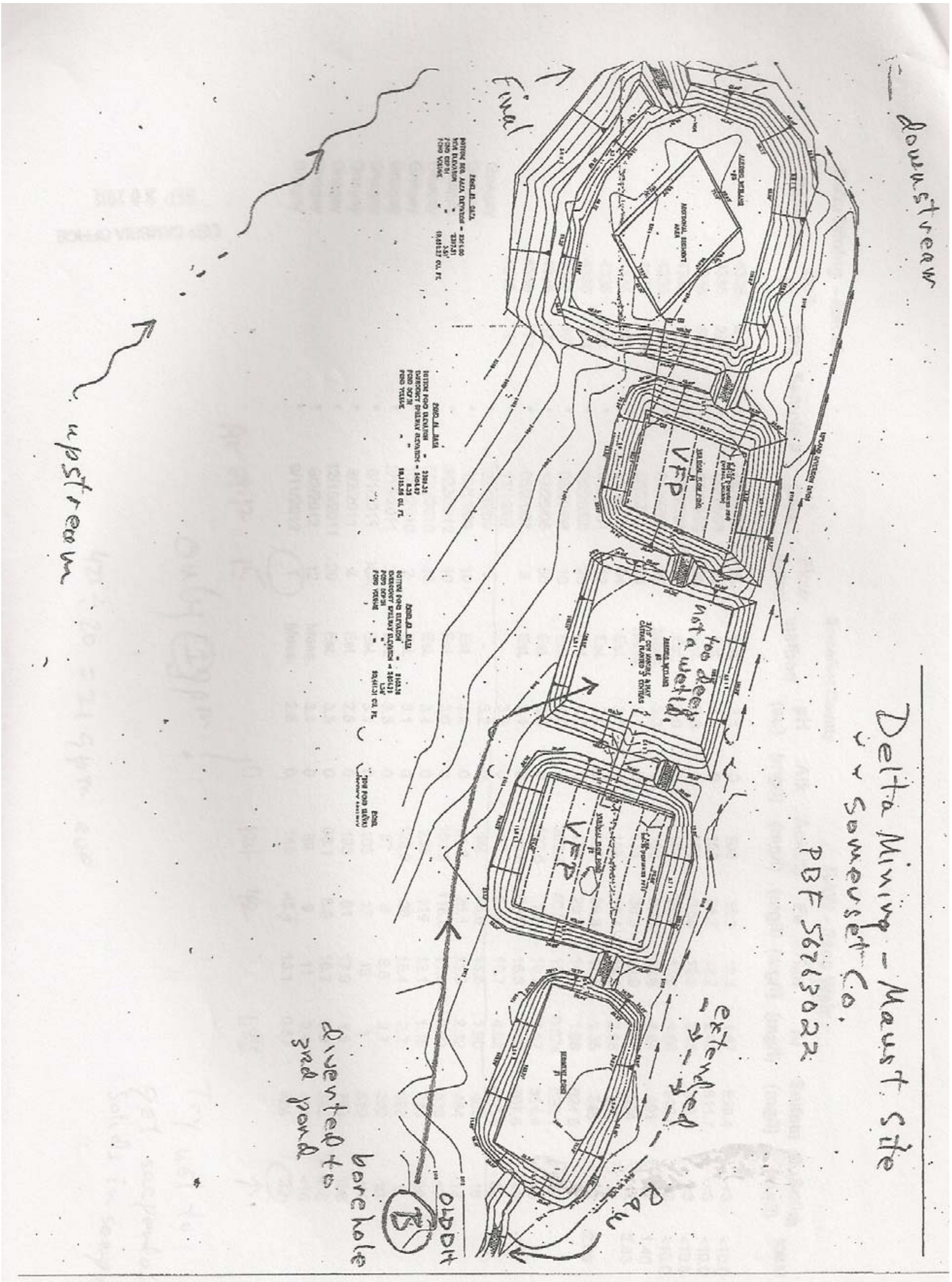

Delta Mining - Maust Site
Somerset Co.
PBF 56763022
downstream
upstream
Final
VFP
too deep
not a wetland
VFP
extended
Raw
borehole
diverted to
3rd pond
OLD DIT
B

Table MA	Maust									
Site	Date	Flow	pH	Acidity	Alkalinity	Fe	Mn	Al	SO4	TSS
Raw	8/7/1998	5	3.1	206	0	36	16	1.87	829	<3
Raw	8/18/1998	26	3.1	158	0	22	13	2.05	612	<3
Raw	4/20/1999	60	3.3	104	0	9.6	12	2.48	373	<3
Raw	7/8/1999	3	3	174	0	31	18	1.86	820	<3
Raw	1/10/2000	22	3.3	108	0	9.1	14	4.84	391	<2
Raw	6/23/2000	34	3.1	174	0	30	21	2.44	524	<2
Raw	6/4/2001	34	3.1	138	0	16	14	2.58	433	4
Raw	8/20/2001	12	3	163	0	40	18	1.35	546	<2
Raw	6/20/2006	25	3	173	0	29	14	1.68	625	4
Raw	8/30/2006	10	3	203	0	40	14	0.62	630	6
Raw	12/26/2006	50	3.3	122	0	16	11	2.17	364	<3
Raw	6/21/2007	3	3.1	243	0	54	16	1.99	707	<3
Raw	12/19/2007		3.3	90	0	5.5	11	4.02	410	52
Raw	9/30/2009		3.2	99	0	34	14	1.9	463	16
Raw	12/11/2009	10	3.2	91	0	26	12	2.32	484	13
Raw	3/22/2010	40	3.6	151	0	115	12	0.03	538	17
Raw	5/20/2010	30	3.4	235	0	119	13	1.16	764	28
Raw	10/4/2010	2	3.1	124	0	26	15	2.2	628	5
Raw	2/19/2011	20	3.3	67	0	6	8.5	2.7	282	10
Raw	6/1/2011		3.1	105	0	17	13	3	510	<10
Raw	8/2/2011	4	2.8	193	0	51	18	1.5	790	106
Raw	12/15/2011	20	3.3	68	0	8.8	11	2.9	395	<10
Raw	5/2/2012	12	3.1	89	0	9	11	2.4	436	<10
Raw	9/11/2012	1	2.8	145	0	45	13	0.57	524	33
Raw	Average	20.1	3.2	142.6	0.0	33.1	13.9	2.1	544.9	24.5
Raw	Av. 08-13	15.4	3.2	124.3	0.0	41.5	12.8	1.9	528.5	28.5
Final out	8/7/1998	2.2	7.8	0	268	0.41	4.5	<0.5	338	<3
Final out	8/18/1998	22	7.5	0	258	0.36	5.1	<0.5	303	<3
Final out	9/24/1998	12.5	7.3	0	230	<0.3	5.5	<0.5	232	<3
Final out	4/20/1999	60	6.8	0	82	<0.3	3.2	<0.5	298	<3
Final out	7/8/1999	1.1	7.3	0	238	<0.3	14.2	<0.5	441	8
Final out	1/10/2000	22	6.7	0	82	0.18	7.7	0.4	550	14
Final out	6/23/2000	34	7	0	154	0.18	18.5	<0.2	623	<2
Final out	6/4/2001	34	7	0	108	<0.3	5.5	<0.5	421	8
Final out	8/20/2001	12.4	7.1	0	148	0.22	10.7	<0.2	385	12
Final out	6/20/2006	25	7.6	-81	102	<0.3	2.5	<0.5	424	4
Final out	8/30/2006	10	8.2	-158	166	0.52	9.5	<0.5	249	50
Final out	12/26/2006	60	7.9	-17.2	67	0.31	2.8	<0.5	269	<3
Final out	6/21/2007	2	7,3	-75.2	105	0.35	4.5	<0.5	386	<3
Final out	12/19/2007	25	7.5	-48	66	<0.3	4.4	<0.5	379	<3
Final out	9/30/2009		7.3	-67	93	0.06	6	0.1	194	<6
Final out	12/11/2009		7.1	-12.8	28	0.12	2.1	0.03	334	2
Final out	3/22/2010		7.4	-52	60	0.24	2.4	0.03	293	3
Final out	5/20/2010		6.9	-46	64	0.19	1.9	0.03	576	2
Final out	10/4/2010	10	7.1	-69	81.8	0.08	2.3	0.03	418	1
Final out	2/19/2011		7.2	-68	82	0.19	3.3	0.07	328	<10
Final out	6/1/2011		7.1	-63	81	0.29	3.6	<0.03	292	<10
Final out	8/2/2011		7	-63	73	0.54	3.9	0.07	409	<10
Final out	12/15/2011		6.7	-53	59	0.06	0.7	0.12	345	<10
Final out	5/2/2012		7.5	-51	63	0.12	1	0.06	346	<10
Final out	9/11/2012		6.9	-51	77	0.34	3.8	<0.03	321	18
Final out	Average	22.1	7.2	-39.0	113.4	0.3	5.2	0.1	366.2	11.1
Final out	Av. 08-13	10	7.1	-54.2	69.3	0.2	2.8	0.1	350.5	5.2

SUMMARY SHEET – McKinley 1

Name: McKinley 1 County: Jefferson

Latitude: 41° 11' 36" N Longitude: 79° 9' 49"W

Watershed: Little Mill Creek

Risk Level: Low

Year Built: 1996

Designer: Damariscotta

Local Group or person: Mill Creek Coalition

Treatment types, Sequence: VFP, Settling Pond

VFP

Area(water surface): 600 m^2
Compost thickness: 0.5 ft
Limestone thickness, size, quality: 1.3 ft.
Comments

Rehab, date and nature: None?

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 15* gal/min, pH 3.9, Acidity 81 mg/L, Fe 0.5 mg/L, Mn 34 mg/L, Al 3.4 mg/L, SO_4 701 mg/L

Average effluent 2008-13

Flow 15* gal/min, pH 6.3, Acidity 9 mg/L#, Alkal. 29 mg/L, Fe 1.2 mg/L, Mn 16 mg/L, Al 1.9 mg/L, SO_4 555 mg/L, N=3

*Average Inflow in 96-97; very little flow data since
2012 sample is net acid due to Mn; 2009-10 samples net alkaline.

Loading (g acidity/day, g/m2/d): 6600 g/d; 11 $g/m^2/d$

References: Datashed, Demchak thesis at Clarion Univ., Info from Terry Morrow in early 2000's.

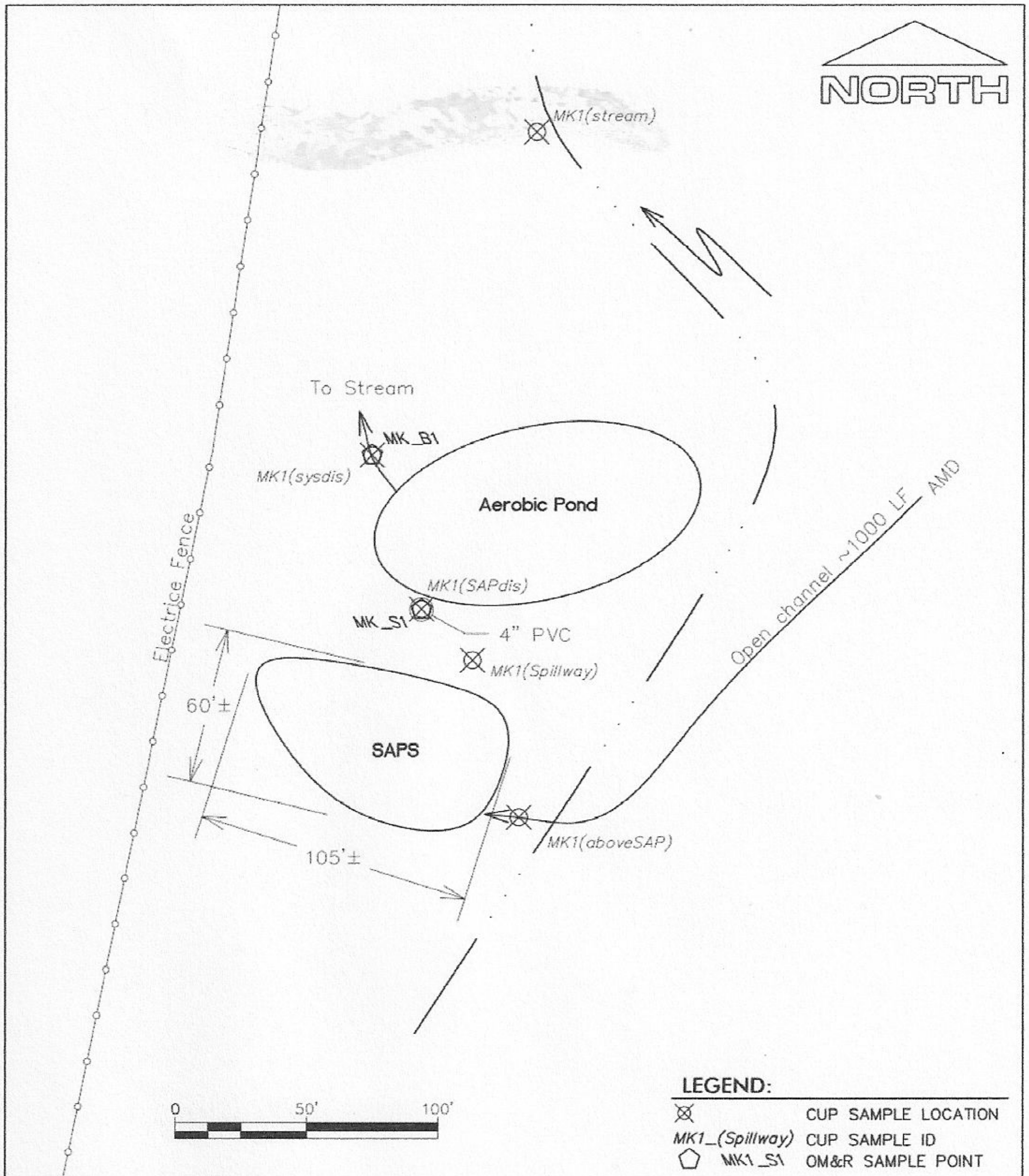
Conclusions: This Low Risk system has generated net alkaline water most of the time since construction in 1996. Both samples in the DEP survey were net alkaline, though the summary table shows it as net acid, - possibly confusion with McKinley 2. Also, the net acid sample in 2012 is nearly all Mn acidity.

McKinley 1 System

This Low Risk system is located in Jefferson County about 2 miles east of Corsica, and west of Brookville. The system is in the Little Mill Creek watershed. It was constructed in 1996. It consists of an inflow pipe from an abandoned surface mine, a Vertical Flow Pond, and a Settling Pond.

The inflow water, based on 3 samples in 2009-12, averages pH 3.9, acidity 81 mg/L, Fe 0.5 mg/L, Mn 34 mg/L, and Al 3.4 mg/L. Almost no flow data is available for this period; flows in 1996-2004 average 14 gal/min. Effluent in 2008-12 averages pH 6.3, Acidity 9 mg/L, alkalinity 29 mg/L, Fe1.2 mg/L, Mn 16 mg/L, Al 1.9 mg/L. Two of the 3 effluent analyses are net alkaline; the third is high in Mn, and most of the acidity is from Mn. Effluent analyses in 1996-2005 are similar: most are net alkaline but some are acid with high Mn. On many occasions, a large fraction of the Mn is removed in the VFP, which is not expected.

In 2009, after 13 years in service, the McKinley system was said to be worn out. However, 4 years later it continues to accomplish significant treatment, though it probably needs maintenance and renovation. The cost of the system was only $30,000.



Project No.: 05-009 Drawing No.: 05-001 By: TSG 8/17/05 Chkd: JMD 9/14/05	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	Figure McKinley 1-1 Existing McKinley 1 Treatment System & OM&R Sample Points Union Township Jefferson County, PA

Table MCK		McKinley 1													
ID	Site	Date	Acidity	Alkal. Fld	Alkal. Lab	Al	Temp	Flow	Fe	Mn	pH fld	pH lab	Sp. Cond.	SO4	TSS
			mg/L	mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L				mg/L	mg/L
4205-689	MK1(SAPdis)	9/15/2009	-24.12	148	71.29	0.04	21.2	1	2.75	19.58	6.65	6.82	1115	516.4	11
5039-689	MK1(SAPdis)	4/12/2010	-37.44		58.91	0.04	9.8		0.33	0.76	6.2	7.28	1203	600.9	8
7249-689	MK1(SAPdis)	5/3/2012	-24.28	96	92.15	<0.04	12.3		11.95	40.7	5.82	6.95	1605	1099.1	16
4205-691	MK1(source)	9/15/2009	93.06	0	0	0.68	15.6	1	1.31	34.28	3.69	3.56	1473	696.7	6
5039-691	MK1(source)	4/12/2010	72.32	0	ND	2.56	9		0.18	33.88	3.9	3.87	1291	663.8	1
7249-691	MK1(source)	5/3/2012	79	1	ND	6.93	10.6		0.06	34.22	4.34	4.32	1139	743.8	<5
		Average	81.5	0.3		3.4	11.7	1.0	0.5	34.1	4.0	3.9	1301.0	701.4	3.5
4205-693	MK1(sysdis)	9/15/2009	-15.48	56	26.21	0.04	21.6	1	0.09	2.27	6.3	6.61	809	377.1	6
5039-693	MK1(sysdis)	4/12/2010	-3.14	15	21.68	4.55	16		1.85	14.53	6.29	6.61	1031	505.8	5
7251-693	MK1(sysdis)	5/13/2012	46.37	16	8.49	1.18	20.2		1.53	32.29	4.82	5.73	1253	783.3	6
		Average	9.3	29.0	18.8	1.9	19.3	1.0	1.2	16.4	5.8	6.3	1031.0	555.4	5.7

SUMMARY SHEET: METRO

Name: Metro County: Somerset

Latitude: 39°46'53"N Longitude: 79°04'58"W

Watershed: Coal Run

Year Built: 2003

Risk Level: High

Designer: Damariscotta (Doug Kepler)

Local Group or person: Southern Alleghenies Conservancy, Somerset County Conservation Dist.

Treatment types, Sequence: System 1: VFP 1- Settling Pond 1- Settling Pond 2- Wetland
System 2: VFP 2 – Settling Pond 1 – Settling Pond 2 - Wetland

VFP

Area(water surface): VFP 1: 160 x 100 = 16,000 ft^2 = 1490 m^2
VFP 2: 225 x 60 = 13,500 ft^2 = 1250 m^2

Compost thickness:

Limestone thickness, size, quality:

Comments

Rehab, date and nature: None known.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

A1source : Flow 23 gal/min, pH 2.9, acid. 629 mg/L, Fe 120 mg/L, Mn 18 mg/L, Al 49 mg/L, SO_4 1369 mg/L, conductance 2600 (N=3)

A2 source: Flow ~30 gal/min, pH 3.1, conductance 4600 (N-1 field data)

Average effluent 2008-13

Flow 84 gal/min, pH 2.8, acidity 516 mg/L, Fe 60 mg/L, Mn 38 mg/L, Al 38 mg/L, SO_4 2230 mg/L, (N=3)

Loading (g acidity/day, g/m2/d): VFP 1: 46 g/m2/d VFP 2: Insufficient data

References: Datashed

Conclusions: The design probably intended manual flushing for the very high Al content, but no flushing or maintenance has been done, according to Len Lichvar. The system is accomplishing almost no treatment. No good data is available on the A2 source, which appears the worst.

Metro

The Metro system is located in Elklick Twp., Somerset County about 1.4 miles northwest of the village of Boynton. The system flows into Coal Run, a tributary of the Casselman River. The system was built in 2003 to treat 2 discharges from underground mines.

One discharge, A1, emerges in a small valley and had pre-construction chemistry of pH 2.7, Fe 290 mg/L, Mn 30 mg/L and Al 90 mg/L at a design flow rate of 85 gal/min. Three samplings in 2009-2013 average pH 2.9, acidity 629 mg/L, Fe 120 mg/L, Mn 18 mg/L, Al 49 mg/L and SO_4 1370 mg/L at an average flow of 28 gal/min. Little data is available on the second discharge, but on 7/15/13 it was flowing at about 30 gal/min with pH 3.1 and conductance 4600 uS/cm, a higher conductance than A1 at 2600 uS/cm. This is extremely bad water.

The passive system has 2 branches. The A1 discharge flows down a short channel and over a weir into Vertical Flow Pond 1. This pond has an area of 1490 m^2. No information is available on its construction, but it is presumed to have compost and limestone layers drained by perforated pipes, and to be intended to be manually flushed periodically. At the time of the visit, an estimated 40 gal/min was emerging at B1 from 4 pipes into Settling Pond 1. The pH of the underdrain outflow was 2.8, slightly lower than the pH 3.2 of discharge A1. The surface of this settling pond was covered with floating Fe precipitate. Appreciable Fe was evidently being removed as a result of oxidation.

Discharge 2 emerges from a couple of pipes on the north side of the small valley, evidently from an underground mine. Its flow was estimated as 30 gal/min and had pH 3.1 with conductance of 4600 uS/cm. This discharge flows into a Vertical Flow Pond 2 with an area of 1250 m^2. The pipe outflow from the VFP2 underdrain had a pH of 3.2 with a conductance of 3800. This outflow enters Settling Pond 1 and mixes with the outflow of VFP 1.

The combined flow discharges from Settling Pond 1 into Settling Pond 2 at C1with pH 2.8. Settling Pond 2 then flows into a wetland. The outflow from Settling Pond 2 was 51 gal/min with pH 2.7. Much Fe is precipitating throughout this set of ponds, and in the following wetland and its outflow. The final outflow has a pH of 2.6 and an acidity of 516 mg/L. Although the system is undoubtedly removing some metals, it is not accomplishing much neutralization of acidity.

The VFP's were presumably designed to be flushed manually, but there was no evidence of routine visits – weeds were high and little indication of access. An email from Len Lichvar of Somerset County Conservation District indicates that no maintenance has been done. Along the road at the bottom of the system is a pavilion with 8 troughs that were evidently designed to dry precipitate. The method of obtaining the precipitate is not clear. A small flow comes into the troughs from a pipe, and some contained Fe precipitate, but the flow is small compared to the above passive system.

The chemistry of the inflow to this system is extremely high in metals. The areal acidity loading of 46 $g/m^2/d$ is high, but should provide some treatment. However, unless the Al is flushed from the system, it is not expected to treat for more than a short time before plugging with Al, as appears to have happened.

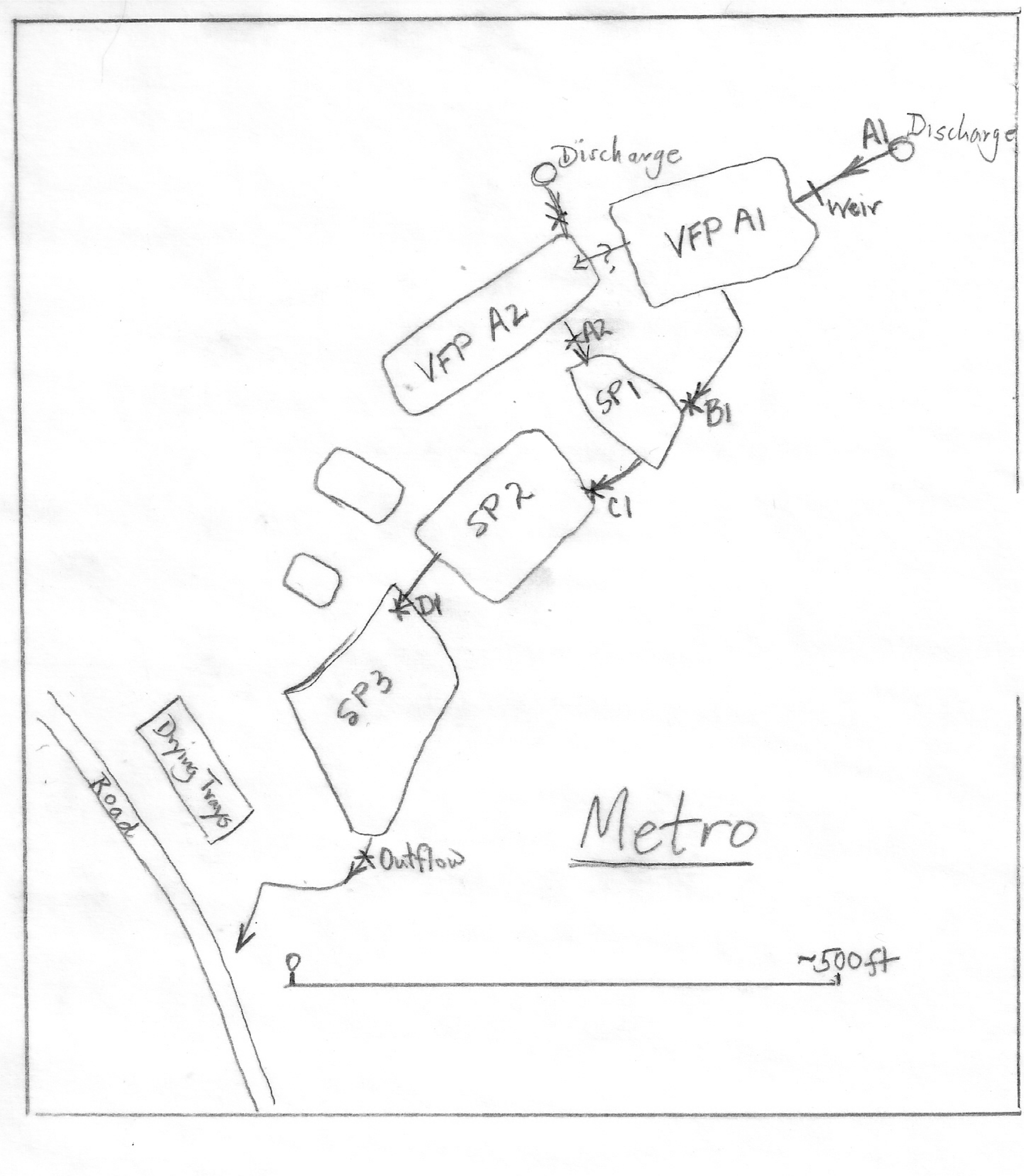

A1
Discharge
Discharge
Weir
VFP A1
VFP A2
A2
SP1
B1
SP2
C1
D1
SP3
Drying Trays
Road
Outflow
Metro
~500ft

Table MT	Metro													
Site	Date	Acidity	Alkalinity	Al	Temp	Flow	Fe	Mn	pH fld	pH Lab	Sp.Cond.	SO4	TDS	TSS
		mg/L	mg/L	mg/L	C	gal/min	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
PA37A1	9/8/2009	780	0	59.3	12.1	18	166	22	4.8	2.85	2780	1450	2700	<5
PA37A1	3/29/2010	330	0	27	10.1	34	54.8	12.9	2.29	3.03	1860	986		<5
A1	7/15/2013	776	0	59.9	12	18	139.5	20.3	3.2	2.8	2600	1672		14
Average	Inflow A1	628.7	0	48.7	11.4	23.3	120.1	18.4	3.4	2.9	2413.3	1369.3	2700.0	14.0
PA37A2	9/8/2009	10	0	68.1	19.4	9	139	63.8	4.58	2.8	4560	1590	4750	6
PA37A2	3/29/2010	490	0	66.7	11.3	110	114	39.9	1.88	2.63	3840	2380		<5
A2	7/15/2013				20	50			3.2			3800		
PA37B1	9/8/2009	450	0	50.6	19.5	9	39.4	21	4.68	3.05	2670	1670	2610	<5
PA37B1	3/29/2010	390	0	43.8	9.7	10	39.7	20.9	2.63	3.2	2470	1600		10
B1	7/15/2013				24				3.9			2100		
PA37C1	9/8/2009	570	0	57	19.3	20	50.2	31.6	4.8	2.92	3120	1930	3150	12
PA37C1	3/29/2010	710	0	56.5	9.6	160	85	32.9	2.23	2.84	3280	2130		<5
c1	7/15/2013				30	28			2.8		3400			
PA37D1	9/8/2009	480	0	47.4	20.2	20	80.6	39.1	5.44	3.47	3300	2160	3580	<5
PA37D1	3/29/2010	700	0	56.2	9.4	160	83.2	33.2	2.64	2.86	3240	2140		5
D1	7/15/2013				30	51			2.7		2500			
Outlet	9/8/2009	530	0	38	19.2	20	68.3	45	4.95	2.93	3610	2110	3700	8
Outlet	3/29/2010	500	0	41.8	9	180	61.8	28.2	2.64	2.99	2800	1810		<5
Final out	7/15/2013	520	0	33.7	30	51	51.1	41.5	3.2	2.6	3500	2760		20
Average	Outflow	516.7	0.0	37.8	19.4	83.7	60.4	38.2	3.6	2.8	3303.3	2226.7	3700.0	14.0

SUMMARY SHEET – MR FROG

Name: MR Frog County: Clearfield

Latitude: 40°53'15" N Longitude: 78°21'33" W

Watershed: Morgan Run, Tributary of Clearfield Creek

Risk Level: Medium (or low?)

Year Built: 2008

Designer: Jen Demchak; Alder Run Engineering.

Local Group or person: Morgan Run Watershed Association, Clearfield County Cons. Dist.

Treatment types, Sequence: System A: equalization basin, Limestone pond with auto flusher, Settling pond, Wetland.

System B: Limestone pond with flusher, Settling pond, Settling pond, Wetland.

VFP

Area(water surface):
Compost thickness:
Limestone thickness, size, quality:
Comments

Rehab, date and nature:

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent System A, 2008-13

Flow 80 gal/min, pH 3.7, acidity 41 mg/L, Fe 0.5 mg/L, Mn 3.0 mg/L, Al 3.6 mg/L, SO_4 102 mg/L,(N=3)

Average effluent System A, 2008-13

Flow 35 mg/L, pH 7.3, acidity 71 mg/L, alk. 97 mg/L, Fe 0.9 mg/L, Mn 0.3 mg/L, Al0.26 mg/L, SO_4 56 mg/L (N=2)

Average influent system B, 2008-13

Flow 6 gal/min, pH 3.9, acidity 78 mg/L, alk. 0, Fe 0.9 mg/L, Mn 4.3 mg/L, Al 4.4 mg/L, SO_4 176 mg/L, (N=3)

Average effluent system B, 2008-13

Flow 1 gal/min, pH 4.6, acidity 35 mg/L, alk. 3 mg/L, Fe 0.1 mg/L, Mn 3.5 mg/L, Al 3.5 mg/L, SO_4 172 mg/L (N=3).

Loading (g acidity/day, g/m2/d):

References: Datashed

Conclusion: System A at this site, consisting of a limestone pond with an automatic flusher, very successfully treats the larger flow at the site (35-80 gpm). System B, consisting of a limestone pond with automatic flusher, only partially treats the second small discharge. The details of the design are unclear.

Morgan Run Frog

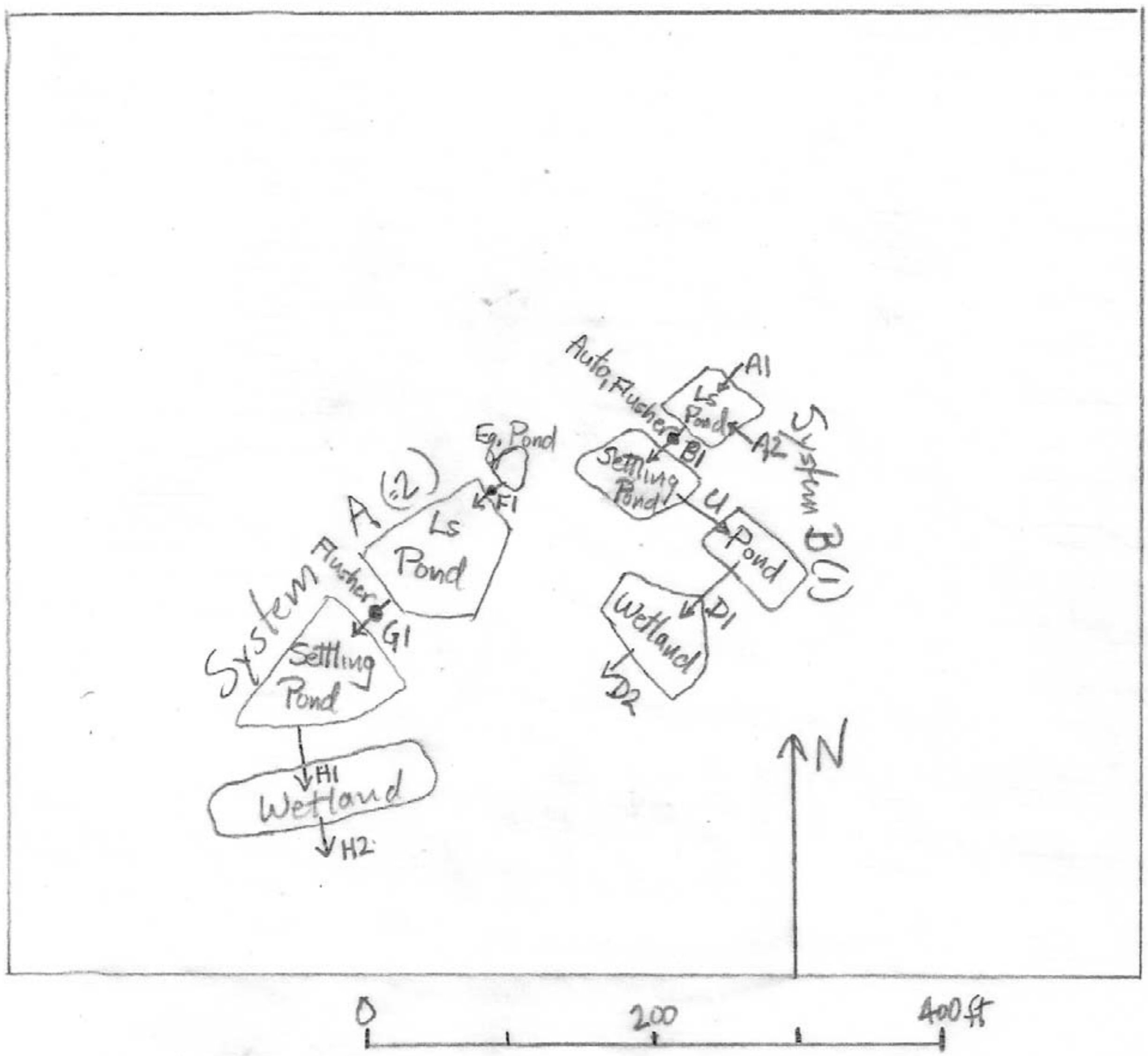
The MR Frog treatment system is located in Decatur Township, Clearfield County, at the headwaters of Morgan Run, a tributary of Clearfield Creek. The system treats two discharges derived from surface and underground mining in the vicinity. The system was constructed in 2008 under the supervision of the Clearfield County Conservation District. Two separate systems are present at the site. System A consists of an equalization pond, a limestone pond with automatic flusher, a settling basin and a wetland. System B consists of an upflow limestone bed with automatic flusher, a settling pond and 2 wetlands (one is anaerobic?).

System A, the larger of the two, treats the flow into a small equalization basin. Inflow to this system, based on 3 samples, has pH 3.7, acidity 44 mg/L, Fe 0.23 mg/L, Mn 3 mg/L, Al 3.6 mg/L and SO_4 95 mg/L at a flow rate of 80 gal/min. The limestone pond has an area of about 7000 ft^2, with xx tons of limestone in a layer x ft thick. After flowing through the settling pond, the outflow is pH 7.7 with acidity of -71 mg/L, Fe 0.9 mg/L, Mn 0.24 mg/L, Al 0.23 mg/L and SO_4 59 mg/L.

The flow and chemistry into System B is not determinable because it flows in below the surface of the upflow limestone pond at two points. The limestone pond has an area of about 4500 ft^2, and has an automatic flusher on the outflow. The water then passes thru a settling pond and a wetland. Outflow of system B (2 samples) has pH 4.5, acidity 44, Fe 0.07 mg/L, Mn 3.5 mg/L, Al 5.7 mg/L and SO_4 187 mg/L at flow of a few gal/min. This system does not appear to be treating the water properly. A possible reason is that the inflow is through the bottom of the limestone pond, and the outflow during flushing is also through the bottom, so that much AMD does not circulate through the limestone. Another possible reason is that the limestone pond is leaking, so that the system rarely flushes. Another reason, suggested by Michelle Merrow of Alder Run Engineering, is that the original discharge was eliminated by reclamation, and another discharge, apparently larger, was piped to the site.

More information is needed for a good evaluation.

Table	Table MR	MR Frog														
ID	Site	Date	Acidity	Alkal fld	Alkal.Lab	Al	Temp.	Flow	Fe	Mn	pH fld	pH Lab	Sp. Cond.	SO4	TDS	TSS
			mg/L	mg/L	mg/L	mg/L	C	gal/mi	mg/L	mg/L			uS/cm	mg/L	mg/L	mg/L
	System B (1)															
6141-1471	PA259A2	10/21/2009	70	5	0	14.5	16.5	1	2.01	4.32	3.76	3.8	410	162	245	5
6139-1471	PA259A2	4/26/2010	102	0	0	16.3	9.4	-	0.45	5.16	3.32	3.9	456	219	345	<5
8387-1471	PA259A2	5/15/2012	62	0	0	7.74	12	10	0.16	3.55	3.93	3.9	341	147		0
	Inflow A2	Average	78	1.7	0.0	12.8	12.6	5.5	0.9	4.3	3.7	3.9	402.3	176.0	295.0	2.5
6141-1473	PA259B1	10/21/2009	6	10	19	0.71	14.5	2	0.43	0.74	6.19	6.2	375	172	248	<5
6139-1473	PA259B1	4/26/2010	47	<10	6	7.51	10.8	-	0.11	3.91	4.27	4.6	447	237	357	6
6141-1475	PA259C1	10/21/2009	6	10	18	0.51	14.8	2	0.37	0.63	6.42	6.2	345	162	223	5
8387-1475	PA259C1	5/15/2012	33	0	5	3.25	17		0.07	2.77	4.74	4.6	332	149		0
6141-1477	PA259D1	10/21/2009	6	5	16	0.45	13.3	2	0.33	0.57	6.56	6.3	339	154	218	6
6139-1477	PA259D1	4/26/2010	46	<10	6	7.24	11.1	-	0.14	3.91	4.31	4.6	459	235	358	5
8387-1477	PA259D1	5/15/2012	52	0	3	6.36	16		0.12	3.13	4.43	4.4	332	149		0
	D1	7/8/2013	41		0	5.65			0.3	3.11		4.4		136	288	5
	Final out, System 1															
6139-1479	PA259D2	4/26/2010	42	0	5	5.9	10.9	-	0.13	3.79	4.39	4.6	447	226	338	<5
8387-1479	PA259D2	5/15/2012	46	0	4	5.45	16		0	3.19	4.51	4.4	333	148		0
	D2	7/8/2013	16		1.2	1.94		1	0.3	3.6	5.3	4.9	380	142	282	5
Average	Outflow 1	Average	34.7	0.0	3.4	4.4	13.5	1.0	0.1	3.5	4.7	4.6	386.7	172.0	310.0	2.5
	System A (2)															
6141-1481	PA259F1	10/21/2009	44	0	0	3.68	13.5	70	0.71	2.89	3.8	3.7	309	100	156	<5
6139-1481	PA259F1	4/26/2010	42	0	0	4.09	9	90	0.49	3.3	3.39	3.7	313	112	179	<5
8387-1481	PA259F1	5/15/2012	36	0	0	3.06	11		0.23	2.76	3.88	3.7	277	95		0
	A inflow	Average	40.7	0.0	0.0	3.6	11.2	80.0	0.5	3.0	3.7	3.7	299.7	102.3	167.5	0.0
6141-1483	PA259G1	10/21/2009	-13	15	36	0.22	18.1	70	0.2	0.04	7.26	6.6	232	75	144	9
6139-1483	PA259G1	4/26/2010	-46	60	64	0.49	12.7	-	0.34	0.02	5.78	7.6	351	116	234	8
8387-1483	PA259G1	5/15/2012	-63	85	81	0.49	13		0	0.4	6.31	7.2	364	95		0
6141-1485	PA259H1	10/21/2009	-115	40	146	0.3	16.5	70	1.72	0.46	8.84	7.4	431	21	300	85
6139-1485	PA259H1	4/26/2010						0								
8387-1485	PA259H1	5/15/2012	-27	55	48	0.23	18		0	0.03	6.54	7.3	301	92		0
	H1	7/8/2013									5.6					
	A outflow settling pon		-71	47.5	97	0.265	17.25	35	0.86	0.245	7.23	7.35	366	56.5	300	42.5
6139-1487	PA259H2	4/26/2010						0								
8387-1487	PA259H2	5/15/2012	-66	85	83	0.16	16		1.02	0.83	6.53	7.2	302	55		0
Average	A outflow	Average	-66	85	83	0.16	16		1.02	0.83	6.53	7.2	302	55		0



Morgan Run MR Frog
from Google Earth

SUMMARY SHEET – Robbins Hollow

Name: Robbins Hollow EB 10/15 County: Clinton Co.

Latitude: 41^{o} 20' 20"N Longitude: 77^{o} 50' 46"

Watershed: Robbins Hollow, tributary to Kettle Creek

Year Built: 2005

Risk Level: Low (to Medium)

Designer: Hedin Environmental

Local Group or person: Kettle Creek Chapter Trout Unlimited

Treatment types, Sequence: Pipe from source, 2 Limestone beds in parallel, Settling Pond.

VFP

Area(water surface): 6400 ft^2 = 600 m^2
Compost thickness: None
Limestone thickness, size, quality:
Comments

Rehab, date and nature:

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 0 to 12 gal/min, pH 3.5, Acidity 126 mg/L, Fe 0.3 mg/L, Mn 1.7 mg/L, Al 20 mg/L, N=4

Average effluent 2008-13 (includes mixing with EB10)

Flow 11 gal/min, pH 5.3, acidity 39 mg/L, alk. 12 mg/L, Fe 12 mg/L, Mn 5 mg/L, Al 6 mg/L, N=7

Loading (g acidity/day, g/m2/d):

References: Datashed, Information from Hedin Environmental and Trout Unlimited.

Conclusions: The EB 10/15 site contains 2 small discharges, of which the system treats EB 15, but not EB10. However, 3 other nearby systems treat their discharges and provide sufficient alkalinity that Robbins Hollow stream is net alkaline and is recovering.

Robbins Hollow EB 10/15

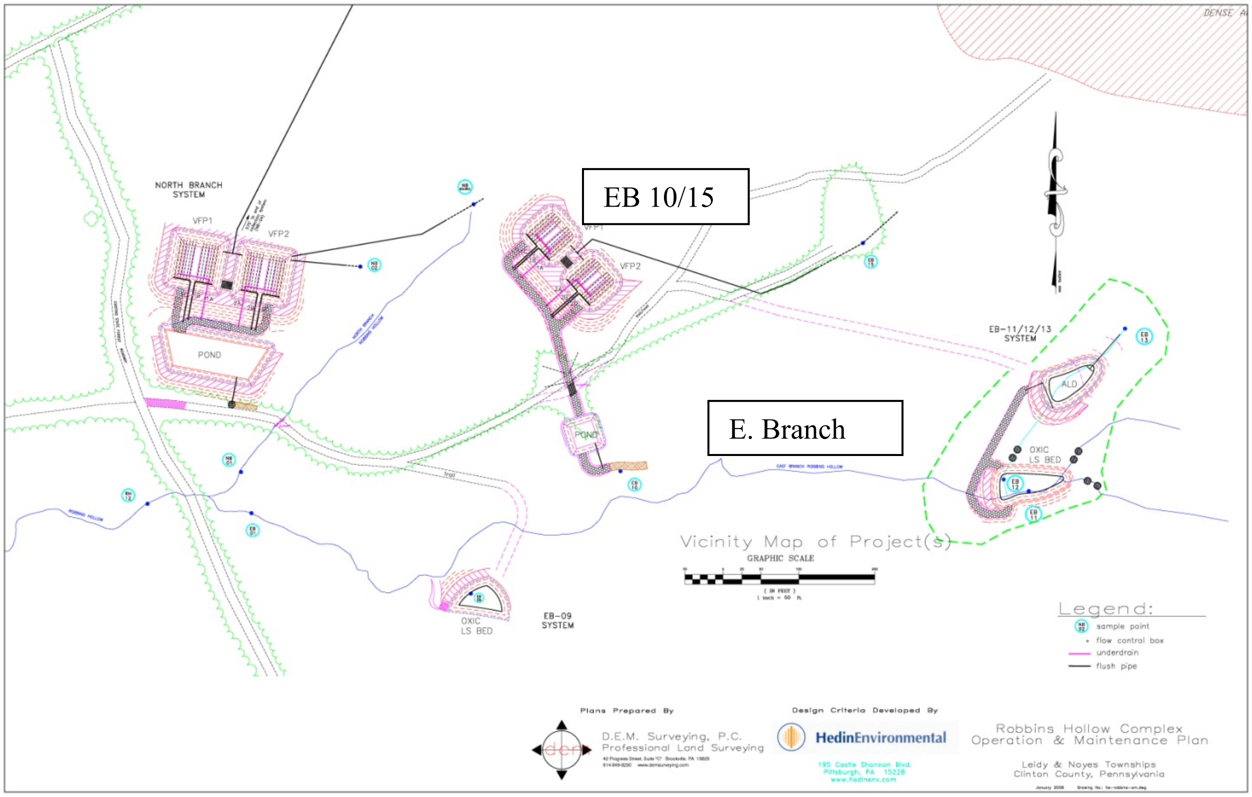
Robbins Hollow is a tributary of Kettle Creek in Clinton County. This group of sites treats a group of discharges in the headwaters of Robbins Hollow, originating from abandoned strip mines. Three main groups of treatment systems are in the vicinity: Robbins Hollow NB, Robbins Hollow EB 10/15 and Robbins Hollow EB 11/12/13 (Figure 1). An additional small limestone bed treats RH EB 09. The treatment systems were constructed in 2005.

The system in question treats water from discharge EB15. Compiled chemical data is listed in Table 1. Based on 4 samples in 2009-12, this discharge has highly variable flow (0 to 11.5 gal/min) of high-Al water (average Al 20 mg/L, Fe 0.3 mg/L, Mn 1.7 mg/L at pH 6 with acidity 126 mg/L). Treatment of this water in the 2 downflow limestone beds released net alkaline water in 2006 (4 samples); no data is available for the limestone bed outflow more recently but the effluent is probably net alkaline. The flow from the limestone beds goes to a settling pond, into which the untreated EB10 discharge also flows. The effluent from this pond is commonly net acid. Average chemistry of the effluent since 2009 is pH 5.3, acidity 39 mg/L, alkalinity 12 mg/L, Fe 12 mg/L, Mn 5 mg/L and Al 6 mg/L at an average flow of 11 gal/min. Evidently, the chemistry is dominated by the EB10 water most of the time. When there is significant flow from the EB 15 discharge, the treated water dominates over the untreated EB 10 water and the effluent is net alkaline.

Despite the commonly net acid effluent from the EB10/15 system, the stream samples of the East Branch Robbins Hollow a short distance downstream were net alkaline in the 4 samples collected in 2006 and 2012. This stream also receives the outflow of the EB 11/12/13 system and the EB 9 system, and the combination of the three systems evidently results in net alkalinity downstream. No good data seems to be available on the effluent of the other two systems.

In addition to the net alkaline condition of the East Branch at its junction with the North Branch (which receives the effluent of the North Branch System), the combined Robbins Hollow stream is also net alkaline (sample site RH12) and the stream appears clean for about a mile downstream, until it receives another small discharge. Therefore, although the effluent from the EB10/12 system is commonly net acid, the overall effect of the 4 systems results in a net alkaline condition for about a mile downstream.

Sample Site	Sample Dat	Source	Flow	pH Field	pH Lab	Acidity	Alkalinity	Alkalinity	Temp	Fe	Mn	Al	Specific C	Specific C	SO4	TSS
			gpm			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	uS/cm	uS/cm	mg/L	mg/L
EB15 discharge																
EB15	10/8/2009	Import	0													
EB15	4/13/2010	Import	0.5	3.7	3.5	128.38	0	ND	42	0.34	1.49	21.14		376	168.5	1
EB15	6/14/2010	Import		3.5	3.53	135.2		ND	51	0.35	1.75	20.65		388	150.2	25
EB15	4/20/2012	Import	11.5	3.5	3.48	115.22	0	ND	9.7	0.26	1.72	18.57	403	322	149.7	< 5
Average			4.0	3.6	3.5	126.3	0.0		34.2	0.3	1.7	20.1	403.0	362.0	156.1	13.0
VFP outflows																
EB10/15VFPBou	1/12/2006		<1	6.9	7.63	-90		108		0.2	0.1	0.3		350	83	4
EB10/15VFPAou	1/12/2006		3	6.79	7.75	-64		78		0.1	0	0.8		301	74	2
EB10/15VFPout	10/26/2006		drip	7.04	6.5	-67		86		0.1	0	0.4		244	24	3
EB10/15VFPout	11/24/2006		5.5	6.51	6.78	-48		66		0.2	0.2	1.8		378	112	1
EB10/15VFPout	1/3/2007		<1	6.71	6.78	-70		80		<0.04	<0.02	0		413	135	1
EB10/15 VFP1 O	10/8/2009	Import	0													
EB10/15 VFP1 O	4/13/2010	Import	drip													
EB10/15 VFP1 O	4/20/2012	Import														
EB10/15 VFP2 O	10/8/2009	Import	0													
EB10/15 VFP2 O	4/13/2010	Import	drip													
EB10/15 VFP2 O	4/20/2012	Import														
Average			2.125	6.79	7.088	-67.8		83.6		0.15	0.075	0.66		337.2	85.6	2.2
EB10/15 outflow																
EB10/15Final	6/15/2006		7.5	4.6	4.69	37		1		5.1	3.1	4.5		492	235	23
EB10/15Final	3/22/2006			4.27	4	92		ND		21.3	5.2	7.3		673	330	1
EB10/15Final	1/22/2006			4.6	5.05	24		2		8.8	3.1	4.5		425	209	24
EB10/15Final	10/26/2006			4.83	4.31	28		ND		4.7	3	3.8		442	183	5
EB10/15Final	11/24/2006		12.9	4	4.99	19		2		3	2.1	3.7		369	175	1
EB10/15Final	1/3/2007		6.8	4.35	4.51	60		0		15.5	3.7	6		543	255	5
EB10/15 Final	10/8/2009	Import	0													
EB10/15 Final	4/13/2010	Import	drip	5.4												
EB10/15 Final	6/14/2010	Import		5.3	5.23	30.99		9.56	68	8.81	3.56	3.05		582	275.6	13
EB10/15Final	8/12/2010		Base		3.67	68		ND		6.9	7.6	6.5		950	412	8
EB10/15 Final	4/20/2012	Import		5.5	5.27	90.74	20	6.9	14	30.29	10.03	19.32	927	1021	677.3	280
EB10/15 Final	1/13/2013	NW	30	6.1	6.64	-7.27		21.8		1.6	0.77	1.37		219	69.7	5
EB10/15 Final	4/8/2013	NW	2.2	6.1	5.9	14.5		10.05		10.9	2.87	2.07		475	223	19
Average			9.9	5.0	4.9	41.5	20.0	6.7	41.0	10.6	4.1	5.6	927.0	562.8	276.8	34.9
average 2009-13			10.7	5.7	5.3	39.4	20.0	12.1	41.0	11.7	5.0	6.5	927.0	649.4	331.5	65.0
Stream, mouth of EB																
EB01	6/19/2002		120		3.8	27.0		0.0		1.1	1.2	1.5			73.0	
EB01	7/25/2002		8	3.2	3.2	88.0		0.0	16.9	5.3	9.2	3.9		907.0	511.0	
EB01	8/27/2002		2.5	2.9	3.0	171.0		0.0	18.0	14.3	17.3	6.5		1516.0	766.0	
EB01	9/30/2002		3.5	3.0		168.0				12.9	15.0	8.9		1403.0	655.0	
EB01	10/28/2002		6.5													
EB01	1/30/2003		25	3.7	3.6	52.0				3.3	4.8	4.1		543.0	260.0	
EB01	3/21/2003		300		4.4	11.0		0.0		0.5	0.6	0.9		97.0	29.0	
System constructed																
EB01	1/12/2006			7.2	6.8	-13.0		18	7.3	1.7	1.1	0.7		175.0	56.0	
EB01	3/22/2006			7.1	6.3	-9.0		14.0	2.7	2.8	1.2	1.1		223.0	87.0	
EB01	10/26/2006			6.9	6.1	-10.0		20.0	8.4	1.9	1.0	0.5		200.0	63.0	
EB01	4/20/2012	Import	14.5	5.75	6.48	-7.36	20	35.52	14.4	2.36	1.74	0.63	344	358	143.6	< 5
Robbins Hollow Stream below EB, NB																
RH12	4/20/2012	Import	22.7	5.25	6.34	-4.58	20	31.76	15.1	3.13	2.27	3.2	410	433	178.4	7


EB 10/15
NORTH BRANCH SYSTEM
VFP1
VFP2
POND
VFP1
VFP2
POND
E. Branch
EB-11/12/13 SYSTEM
ALD
OXIC LS BED
OXIC LS BED
EB-09 SYSTEM
Vicinity Map of Project(s)
GRAPHIC SCALE
Legend:
sample point
flow control box
underdrain
flush pipe
Plans Prepared By
D.E.M. Surveying, P.C.
Professional Land Surveying
Design Criteria Developed By
HedinEnvironmental
195 Castle Shannon Blvd.
Pittsburgh, PA 15228
www.hedinenv.com
Robbins Hollow Complex
Operation & Maintenance Plan
Leidy & Noyes Townships
Clinton County, Pennsylvania

SUMMARY SHEET – Six Mile Run SX0-D6

Name: SX0-D6 County: Bedford Broad Top Township

Latitude: 40° 9.85' N Longitude: 78° 12.24 W

Watershed: Six Mile Run

Risk Level: High

Year Built: 2008

Designer: Skelly and Loy

Local Group or person: Broad Top Township

Treatment types, Sequence: Settling pond, Vertical Flow Pond (Automatic Flusher), Settling Pond

VFP

Area(water surface): 585 m^2
Compost thickness: 1.5 feet
Limestone thickness, size, quality: 3 feet, AASHTO #1 (980 Tons, >80% $CaCO_3$)
Comments: Automatic flusher set to flush down to compost twice a week (10 minute flush)

Rehab, date and nature: None

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 23 gpm, pH 3.1, acidity 366 mg/L, alkalinity 0, Fe 51 mg/L, Mn 2.5 mg/L, Al 32 mg/L, SO_4 692 mg/L, N=5.

Average effluent 2008-13

Flow 23 gal/min, pH 5.3, acidity 29 mg/L, alkalinity 8 mg/L, Fe 3.4 mg/L, Mn 1.8 mg/L, Al3.2 mg/L, SO_4 478 mg/L, N=5.

Loading (g acidity/day, g/m2/d): 26,000 g/d; 45 g/m2/d

References: Broad Top Township, 2009, Six Mile Run – SX0-D6 AMD Remediation Construction Project: Final report for DEP Growing Greener Grant ME# 4100039590. 8 p plus drawing.

Conclusion: The system is treating most but not all of the acidity and metals from this High Risk discharge. The size is too small but is as large as the site will accommodate. The receving stream has largely recovered and is being tested for removal from the 303d list.

Six Mile Run SX0-D6

The SX0-D6 system is located on Six Mile Run about a half mile upstream from Coaldale in Broad Top Township, Bedford County. The AMD discharges from an abandoned and caved mine opening on the north side of Six Mile Run. Based on sampling between 2001 and 2007, the discharge averaged 13 gpm with pH 3.2, acidity 412 mg/L, 59.6 mg/L Fe, 2.7 mg/L Mn and 35.7 mg/L Al. Similar inflow data are obtained in 2008-13 (Table 1). The acidity loading is 29,300 g/d based on this dataset, though with considerable variability. Ernest Fuller reports that when the entry was excavated, the flow considerably increased, and probably increased loading.

The discharge flows into a small sandstone-filled pond as a capture area. From this it flows into a lined vertical flow pond with a water surface area of 585 m^2. The pond contains 3 feet of AASHTO #1 limestone overlain by 1.5 feet of mushroom compost. The normal outflow is an automatic flusher which flushes the system for 10 minutes twice a week. The 10-minute flush is timed to lower the water to the compost, but not below it. The flush goes into a settling pond which releases water gradually to the adjacent stream.

The available outflow data indicates that the system removes most of the Fe, Al and acidity but frequently the outflow is still net acidic (Table 1). The system was built as large as could be accommodated in the area available. A calculation of the loading in g/m2/d indicates a loading of about 45 $g/m^2/d$, which exceeds the recommended value of 35 g/m2/d. Based on this sizing criterion, the system is somewhat undersized, and is performing about as well as this sizing criterion would predict.

Six Mile Run is largely recovered from AMD as a result of this and several other passive systems on it. It is being tested for removal from the 303d list.

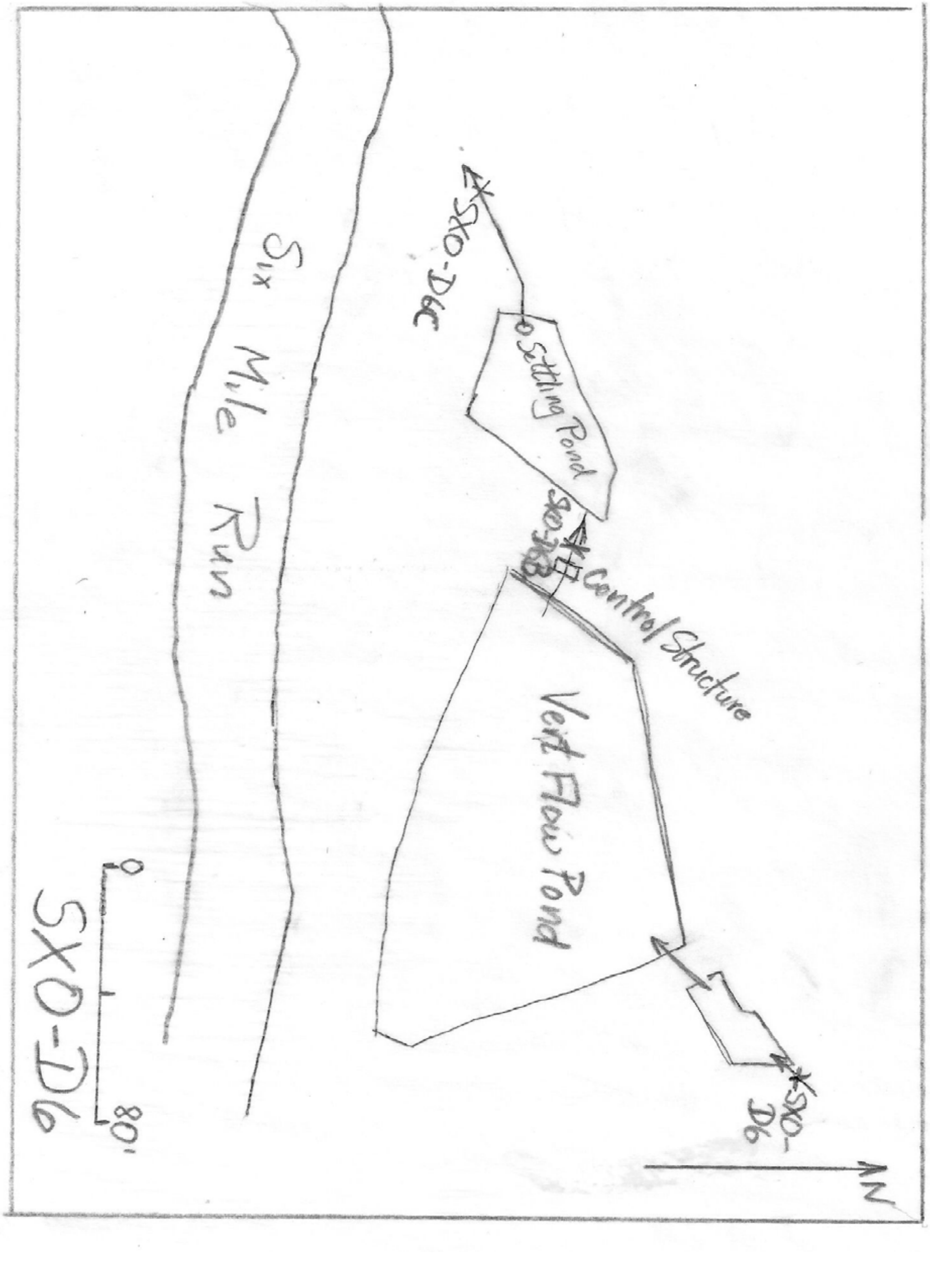

SXO-D6
0
80'
Six Mile Run
SXO-D6C
Settling Pond
SXO-D6B
Control Structure
Vert Flow Pond
SXO-D6
N

Table SX-1	SX0-D6											
Site	Date	Flow	SpCond	pH fld	pH lab	Acidity	Alkalinity	Fe	Mn	Al	SO4	TSS
		gal/min	us/cm			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Inflow(D6)	2001-07	13			3.2	412	0	59.6	2.7	35.7		
	11/25/2008				3.1	731	0	152	4.5	55.6	1213	<5
	6/29/2009	36	870	6?								
	9/22/2009	10	1510	2.98	2.9	334	0	27.3	2.2	31.9	693	<5
	4/27/2010	40	1170	3.54	3	189	0	11.1	1.72	21.2	475	<5
	6/25/2013	18	850	2.7	3.2	166	0	6	1.35	17	390	5
	Average	23.4	1100	3.1	3.1	366.4	0.0	51.2	2.5	32.3	692.8	5.0
VFP out(D6B)	9/22/2009	10	1110	5.02	4.4	112	7	19.6	2.34	18.5	653	47
	6/25/2013		670	6.3	5	40.8	1.8	14.7	1.31	9.5	367	46
Final out(D6C)	8/5/2009				6	-6.4	19.8	2.83	1.74	1.71		
	8/19/2009				5.45	10	0	2.04	2.07	1.53		
	9/22/2009	10	1130	4.62	4.4	64	5	5.16	2.34	4.87	647	10
	4/27/2010	40	839	5.27	6	9	15	5.27	1.43	1.25	410	11
	5/22/2012		680	4.46								
	6/25/2013	18	850	3.6	4.5	70	0	1.8	1.3	6.7	378	6
	Average	22.7	874.8	4.5	5.3	29.3	8.0	3.4	1.8	3.2	478.3	9.0

SUMMARY SHEET – Webster

Name: Webster County: Cambria Municipality: Nanti Glo

Latitude: 40°28' 00" Longitude: 78° 50' 3.36"

Watershed: Blacklick Creek

Risk Level: High

Year Built: 12/2004

Rehab, date and nature: No significant rehab

Designer: Tom Gray, GAI.

Local Group or person: BAMR, Cambria County Conservation

Treatment types, Sequence: VFP (2), Wetland pond

VFP

Area(water surface) VFP A 3.8 acres VFP B 3.8 acres
Compost thickness: 12 in.
Limestone thickness, size, quality: 2.5 ft., AASHTO No 1, >85% CaCO3 equiv.
Comments: Compost may be thinner in some areas.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13:
pH 2.85, Alk. 0, Acid. 326, Fe 23, Mn 4.8, Al 34, SO4 525, N=34
Average effluent 2008-13
Flow 480 gpm, pH 3.37, Alk. 0.9, Acid. 206, Fe 13, Mn 5.2, Al 25, SO4 557, N=35

Loading (g acidity/day, g/m2/d): Area is 7.6 acres (30757 m^2). Acidity loading is 738,000 g/d (326 mg/L acidity and 480 gal/min) giving an areal loading of 24 $g/m^2/d$.

Conclusions: The system is largely plugged, with most water overflowing from VFP's. Despite the high Al (34 mg/L), the design has no provision for automatic flushing and no manual flushing has been done or was evidently planned for.

Webster Discussion

The Webster passive system is located in the town of Nanti Glo, Cambria County. Latitude-longitude are 40^{o}28'00"N, 78^{o}50'3.36"W. It treats the discharge from a large underground mine to the west. Flow since 2008 averages 280 gal/min with pH 2.85, acidity 326 mg/L $CaCO_3$, Fe 23 mg/L, Mn 4.8, Al 34 mg/L and SO_4 525 mg/L for 35 samples. The inflow enters VFP A at one side. Some AMD in VFP A flows out the other side into VFP B. Underdrains and overflows of both VFP's flow out into a large wetland/settling pond to the north. Each VFP has 2 separate underdrain systems (outflows W1, W1W, W2, W2E). The final outflow from the wetland (OUT1) flows to the East Fork of Blacklick Creek. The system started treating water in 12/04.

The system was designed by Tom Gray of GAI Consultants. Bob Hedin apparently provided some input to the design, but did not evaluate the final design. The overall project was supervised by the US Army Corps of Engineers.

The VFP's were designed with 2.5 feet of limestone (AASHTO #1, >85% $CaCO_3$ equivalent) overlain by 1 foot of compost. Malcolm Crittenden reported comments that the compost may have been thinner than 1 foot in places. The average acidity loading (480 gpm, 326 mg/L acidity) is 738,000 g/d, on a VFP area of 7.6 acres (30760 m^2) to give an areal loading of 24 $g/m^2/d$. The system was probably designed with the older sizing criterion based on retention time in the limestone, rather than an areal acidity loading.

As seen on the attached graph and data table, the system generated net alkaline water from 12/04 until about 10/06. Since then the effluent has been net acid.

When visited on 5/28/13, the two outflows from VFP A (W1, W1W) indicated some treatment but not to net alkaline state, at flow rates estimated at less than 25 gpm. Most of the water was overflowing. At VFP B, most of the water was flowing across the overflow. About 30 gpm was emerging from each of the two underdrains, but with very little treatment. The overflow channel was partly eroded, and if not repaired, will probably fail and drain VFP B in the next year. The total flow from OUT1 at this time was 717 gal/min.

The probable cause of poor treatment is almost certainly plugging and coating of the limestone by the high Al concentration. Exhaustion of the compost has been suggested but if true, is a subsidiary problem. A slight H_2S smell was noted from W1 outflow, indicating that some compost is still active.

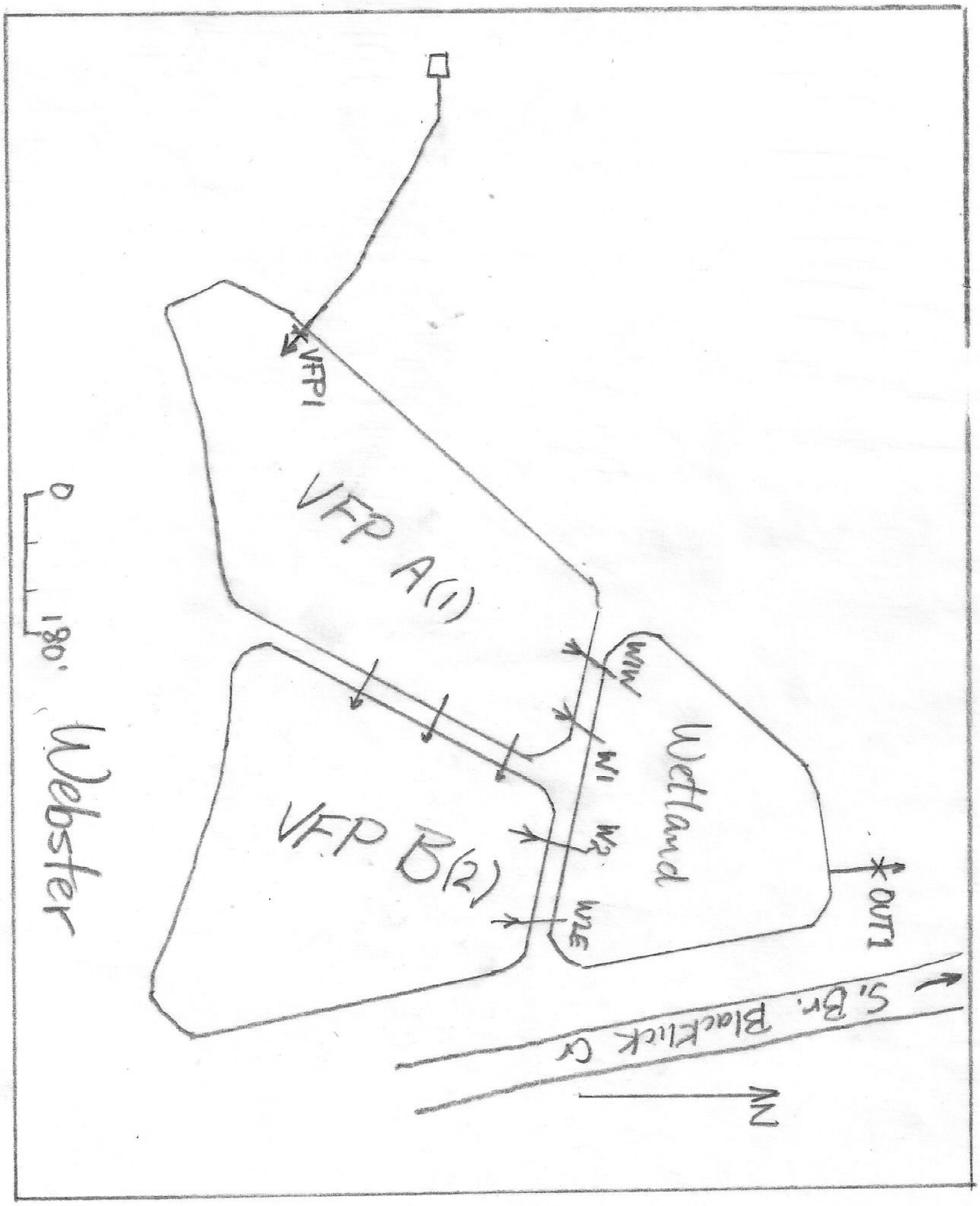
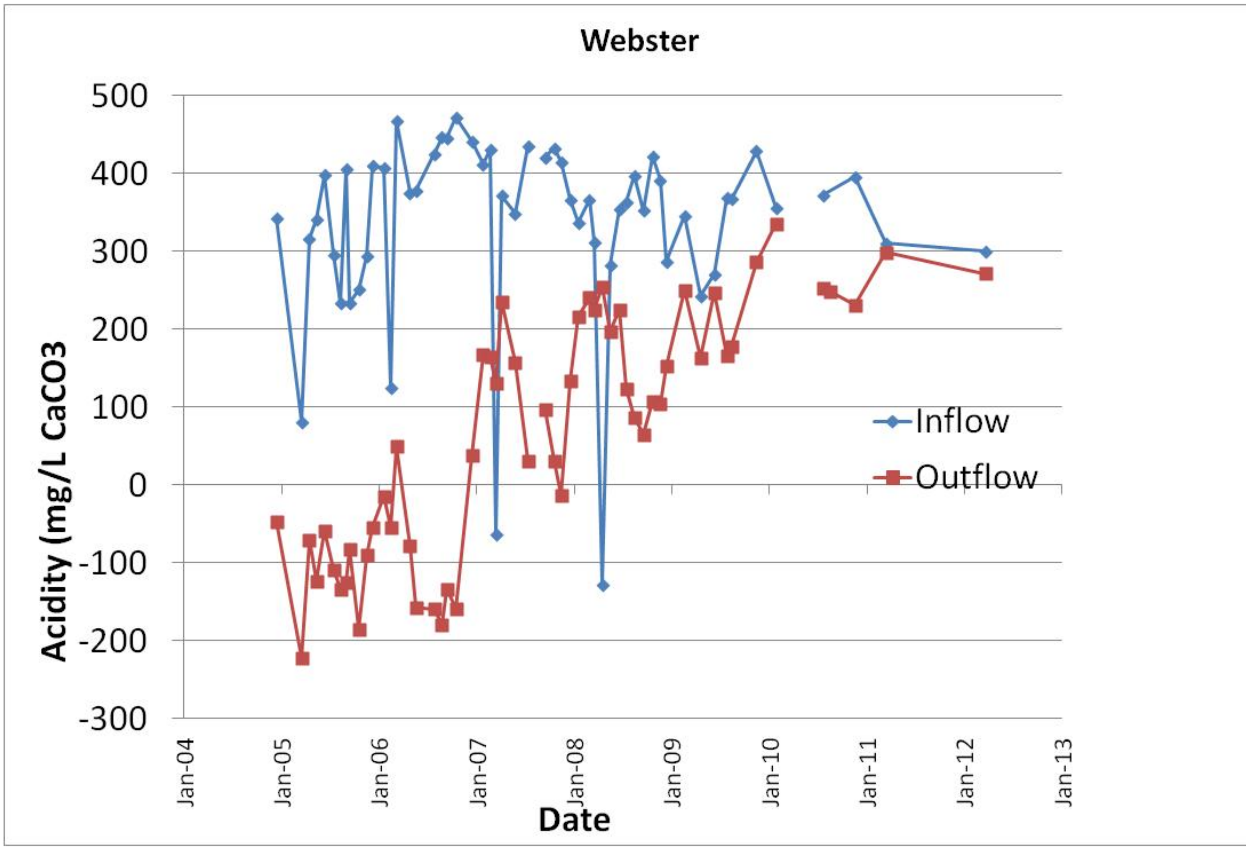

VFP1
VFP A(1)
VFP B(2)
Wetland
Webster
W1W
W1
W2
W1E
OUT1
S. Br. Blacklick Cr.
N
0
180'

Table WB		Webster												
MP_ALI	COLL	SSEQ	DTE_COLL	FLOW	Metho	PH(lab)	Alkalinity	Acidity	Fe	Ferrous	Mn	Al	SO4	TSS
VFP1	7329	601	1/17/2008			2.8	0	337.2	0.582		0.238	0.717	439.9	4
VFP1	7329	601	2/27/2008			2.8	0	367.2	24.9		5.7	34.3	553.4	<2
VFP1	7329	601	3/19/2008			2.8	0	311.8	19.7		5.25	30.5	444.4	<2
VFP1	7329	601	4/17/2008			2.8	0	-127.4	22.4		4.95	28.2	475.4	6
VFP1	7329	601	5/15/2008			2.9	0	283.4	18		3.78	26.1	426.3	<5
VFP1	7329	601	6/19/2008			2.9	0	354.8	28.4		5.28	35.2	514.6	<5
VFP1	7329	601	7/15/2008			2.8	0	363.2	29.5		5.348	35.8	580.5	<5
VFP1	7329	601	8/13/2008			2.9	0	397.2	24.9		5.34	40	568.6	<5
VFP1	7329	601	9/18/2008			2.9	0	352.8	22.9		5.1	33.7	594.2	20
VFP1	7329	601	10/22/2008			2.9	0	423.2	25.6		5.68	46.5	584.2	6
VFP1	7329	601	11/18/2008			2.9	0	391.6	23.7		5.25	43.4	539.8	<5
VFP1	7329	601	12/11/2008			3	0	287.2	17.3		3.514	30.7	497.2	8
VFP1	7329	601	2/19/2009			2.8	0	346.6	20.9		5.199	31.8	607.3	<5
VFP1	7329	601	4/20/2009			2.8	0	243.4	22.8		4.96	34.5	456.3	<5
VFP1	7329	601	6/11/2009			2.8	0	270.6	25.2		4.9	36	450.5	<5
VFP1	7329	601	7/27/2009			2.9	0	369.8	23.7		5.29	38.7	511.2	6
VFP1	7329	601	8/14/2009			2.8	0	367.4	22.2		5.16	41.1	537.5	6
VFP1	7329	601	11/13/2009			2.8	0	429.2	30.6		5.45	45.6	542.9	<5
VFP1	7329	601	1/27/2010			2.9	0	356	23		4.378	30.7	519.4	<5
VFP1	7329	601	4/14/2010			2.8	0		26.6		5.362	36	509.2	<5
VFP1	7329	601	7/21/2010			2.8	0	372.6	23.7		5.108	33.3	605.8	8
VFP1	7329	601	11/16/2010			2.9	0	396.6	26.9		4.664	43	664.3	<5
VFP1	7329	601	3/15/2011			2.9	0	311.2	19.5		4.786	29.1	460	<5
VFP1	7329	601	3/21/2012			2.9	0	300	17.4		4.454	28.3	510.5	<5
VFP1=Inflow			Average (2008-13)			2.85	0.00	326	22.5		4.8	33.9	524.7	
OUT1	7329	604	12/18/2007			4.3	7.6	133.8	7.78		4.61	19.2	493	4
OUT1	7329	604	1/17/2008			3.2	0	216.2	14.1		5.33	25.8	581.3	12
OUT1	7329	604	2/27/2008			3.2	0	241	16.2		5.58	28.1	601.2	8
OUT1	7329	604	3/19/2008			3.1	0	225.4	14.3		5.4	24.4	483.9	12
OUT1	7329	604	4/17/2008			3.1	0	254.6	15.16		5.264	29.97	597.9	<5
OUT1	7329	604	5/15/2008			3.2	0	197.2	10.7		4.33	23	569.7	12
OUT1	7329	604	6/19/2008			3.2	0	225.2	11.2		5.26	27.2	594.8	<5
OUT1	7329	604	7/15/2008			3.5	0	123.4	7.339		5.699	15.8	530	28
OUT1	7329	604	8/13/2008			3.9	0	87.4	2.14		5.54	10.7	643.5	14
OUT1	7329	604	9/18/2008			3.9	1.2	65.4	6.169		5.69	8.595	738.8	34
OUT1	7329	604	10/22/2008	61	Meas	3.9	1	108.2	5.18		5.65	16.9	736.3	16
OUT1	7329	604	11/18/2008	75	Meas	4.5	9	104.4	9.46		5.601	15	544	8
OUT1	7329	604	12/11/2008	171	Meas	4.4	10.6	152.6	13.9		4.688	22.6	55	18
OUT1	7329	604	2/19/2009	639	Meas	3.1	0	250.2	16		5.045	26.2	555	<5
OUT1	7329	604	4/20/2009	476	Meas	3.1	0	163.2	17.8		5	30.3	516.9	12
OUT1	7329	604	6/11/2009	311	Meas	3.1	0	247.8	16.2		5.13	29.7	504.5	10
OUT1	7329	604	7/27/2009	200	Meas	3.5	0	166.2	8.06		5.57	23.3	563.2	20
OUT1	7329	604	8/14/2009	230	Meas	3.4	0	178.4	8.91		5.32	25.4	583.6	16
OUT1	7329	604	11/13/2009	225	Meas	3.2	0	286.6	13.9		5.33	37.1	595.1	<5
OUT1	7329	604	1/27/2010	1250	Meas	3	0	335.2	21.8		4.733	32.7	540.6	<5
OUT1	7329	604	4/14/2010	600	Meas	3	0		24.5		5.186	33.3	569.2	10
OUT1	7329	604	7/21/2010	246	Meas	3.3	0	252.6	8.726		5.125	29.4	602.2	18
OUT1	4301	168	8/17/2010			3.2	0	249.6	10.3		5.347	30.9	629.5	24
OUT1	7329	604	11/16/2010			3.4	0	231.8	8.194		4.916	29.6	658.3	<5
OUT1	7329	604	3/15/2011	1650	Meas	2.9	0	299.2	19.2		4.528	28.8	465.9	<5
OUT1	7329	604	3/21/2012	576	Meas	3	0	271.8	17.7		4.06	27.8	476.1	<5
OUT1	707	4	5/28/2013	716	Meas	2.9	0	278.4	18.2	2.7	4.1	27.7	533	<5
		Average(2008-13)		495.07		3.35	0.8	208.5	12.9	2.7	5.1	25.4	556.5	16.0



Webster
Acidity (mg/L CaCO3
500
400
300
200
100
0
-100
-200
-300
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Date
Inflow
Outflow

SUMMARY SHEET - Yellow Creek 2A

Name: Yellow Creek 2A County: Indiana

Latitude: 40° 33.84' N Longitude: 79° 7.55'

Watershed: Yellow Creek, tributary of Blacklick Creek

Risk Level: High

Year Built: 2004

Designer: L. Robert Kimball

Local Group or person: Blacklick Creek Watershed Association

Treatment types, Sequence: Pipe from source, Collection Pond, Vertical Flow Reactor (modified to Bioreactor 2009), Settling pond, Polishing wetland.

VFP

Area(water surface): 1390 m^2

Compost thickness: Initial 1 foot, later increased.

Limestone thickness, size, quality: originally 3 feet, shown as 1.5 feet in 2009 plan

Comments: The discharge was originally measured (2003) at 10 to 60 gpm with pH 3.3, acidity 285 mg/L CaCO, Fe 33 mg/L, Mn 3.7 mng/L and Al 32 mg/L. The flow was divided with the 2B system at about this time. In about 2005 the system started to go acid. By 2009, the 2A system had problems with siltation and permeability and was no longer completely treating the discharge. It was rebuilt into a bioreactor in about 2009. Since then it has generated net alkaline water, but the 2B system releases net acid water or is not connected about half the time, so the final outflow is commonly net acid.

Rehab, date and nature: 2009; Converted to SRB by removal of previous organic layer and replaced with mix of the removed organic material plus 200 T of limestone (1A, 90% $CaCO_3$), 10 T hardwood chips, and 5 T of timothy hay; shown as 4.5 feet thick in 2009 plan.

Data (flow, pH Alkalinity, Acidity, Fe, Mn, Al, no. of spls.) Attach table.

Average influent 2008-13

Flow 12 gpm, pH 2.8, Acidity 451, alkalinity 0, Fe 40.5, Mn 3.8, Al 42.6, SO4 699, N = 22

Average effluent 2008-13

Flow 6 gpm, pH 6.9, acidity -192, alkalinity 228, Fe 6.9, Mn 2.7, Al 1.1, SO4 460, TSS 29, N=21

Loading (g acidity/day, g/m2/d): 14,800; 10.6

References: 2005 report at Indiana meeting; Datashed; emails from Blacklick Creek Watershed.

Conclusions: The Yellow Creek 2A system is generating net alkaline effluent from highly acid and Al-rich influent. However, the 2009-10 samples were collected from the combined outflow with Yellow Creek 2B, which is not currently functioning, apparently due to lack of maintenance on an inflow valve, and the combined flow is net acid.

Yellow Creek 2A-2B Description

The Yellow Creek 2A system is located in Center Township, Indiana County, PA about 7 miles south of the town of Indiana. The system is on the east side of Yellow Creek a few hundred yards west of highway PA 954. The Yellow Creek 2A system along with the 2B system treats part of the flow from the abandoned Ruth underground mine. The discharge flows typically at about 10 to 15 gal/min with average chemistry of pH 2.8, acidity 451 mg/L, Fe 40.5 mg/L, Mn 3.8 mg/L, Al 42.6 mg/L and SO_4 699 mg/L. The flow from the mine travels through a ¾ mile long pipeline to a splitter valve from which in recent years 5 to 10 gal/min flows to the 2A system and the remainder to 2B or bypasses the system. The systems were constructed in 2002-4 and apparently went on line in late 2004.

The flow from the 2A side of the splitter valve flows to the 2A Collection Pond. From this most of the flow goes to the 2A Treatment Pond, which since 2009 is a bioreactor with a surface area of about 1400 m^2. A small overflow from the Collection Pond to the Settling Pond was noted at the visit on 6/13. The 2A Treatment Pond originally contained 3 feet of limestone overlain by 1 foot of compost. However, by 2009 the outflow had turned acid and the pond was suffering from siltation and plugging. The pond was converted to a bioreactor. In about 2009 the compost layer was removed and mixed with 200 T of 1A limestone (90% $CaCO3$), 10 T of hardwood wood chips and 5 t of timothy hay. A cross section in 2009 shows 1.5 feet of limestone and 4.5 feet of compost mix. Outflow from the bioreactor emerges from a pipe and flows into a Settling Pond. The average chemistry in 2008-13 is pH 6.9, acidity -192 mg/L, alkalinity 228 mg/L, Fe 6.9 mg/L, Mn 2.7 mg/L, Al 1.1 mg/L, and SO4 460 mg/L. The outflow from the Settling Pond flows to a Polishing Wetland and then through a pipe under the road to emerge and flow to Yellow Creek.

The 2B flow from the splitter valve flows through a pipe to the 2B Treatment System, which is a vertical flow reactor. Details of construction are not available, but were probably similar to the original 2A design (limestone overlain by compost). In 2009, 20 tons of 1A limestone was added along with 15 tons timothy hay, apparently on top of the compost layer. The effluent from the 2B system flows into the Collection pond and mixes with the 2A outflow. Currently the splitter valve is broken and no flow is going to the 2B system (Dennis Remy email); it is apparently bypassing to the Wetland.

Table 1 and Figure 2 show the performance of the 2A system. The effluent of the 2A system has been consistently net alkaline on all but 2 sampling dates since 2004 (average 54 mg/L negative acidity), with flows mostly in the 5 to 10 gal/min range. However, the final outflow below the road averages +115 mg/L acidity. Apparently the combination of the small overflow from the Collection Pond plus the flow from the 2B side are making the total system outflow net acidic.

The available data does not clearly indicate the total flow from the Judy Mine or the splitter valve, so a complete appraisal of the sizing of the combined system is not possible. However, the 2A system appears to be performing very well at its current flow rate, despite very acid, Al-rich influent. A significant problem is that the Blacklick Creek Watershed Association is unable to accomplish the necessary maintenance, such as repair of the splitter valve. The system is being sampled regularly by the Stream Team. An overall restoration plan for Yellow Creek has not been located, but the stream has numerous other treatment systems nearby, and appears to be precipitating Fe.

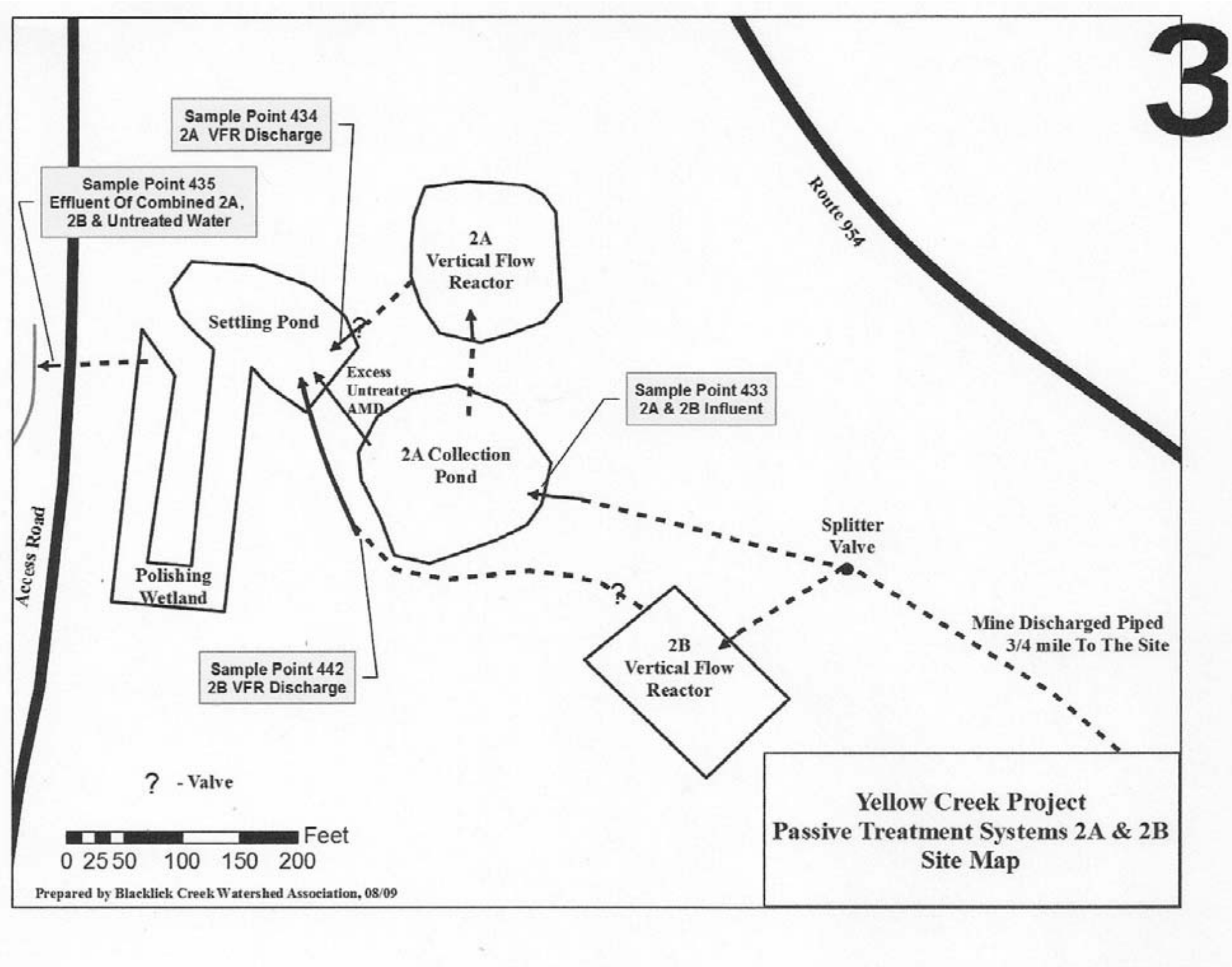

3
Sample Point 434
2A VFR Discharge
Sample Point 435
Effluent Of Combined 2A,
2B & Untreated Water
2A
Vertical Flow
Reactor
Route 954
Settling Pond
Excess
Untreated
AMD
Sample Point 433
2A & 2B Influent
2A Collection
Pond
Splitter
Valve
Access Road
Polishing
Wetland
Mine Discharged Piped
3/4 mile To The Site
2B
Vertical Flow
Reactor
Sample Point 442
2B VFR Discharge
? - Valve
Feet
0 25 50 100 150 200
Yellow Creek Project
Passive Treatment Systems 2A & 2B
Site Map
Prepared by Blacklick Creek Watershed Association, 08/09

Table YC-1	Yellow Creek 2A data											
ID	Sample Si	Date	Acidity	Alkalinity	Al	Ferrous	Flow	Fe	Mn	pH Lab	SO4	TSS
			mg/L	mg/L	mg/L	mg/L	gal/min	mg/L	mg/L		mg/L	mg/L
Inflow to Yellow Creek 2A Treatment Pond (Site 433)												
11973-511	433	12/17/2002	730.6	0	64.3	2.44		103	4.68	2.7	747.4	16
11974-511	433	1/17/2003	543.4	0	33.3	3.67		46	2.38	2.8	782.1	2
11975-511	433	2/26/2003	500.4	0	41.7	2.48		54.8	3.34	2.8	786.6	6
11976-511	433	3/18/2003	373.2	0	31	3.02		37.9	3	2.8	554.5	10
11977-511	433	4/24/2003	501.2	0	41.2	2.37		54.9	3.42	2.8	670.3	2
11978-511	433	5/29/2003	574	0	48	21.75		59	3.45	2.7	797.8	2
11979-511	433	6/24/2003	520	0	45	18.17		55.3	3.53	2.8	696.9	2
11980-511	433	7/31/2003	474.8	0	38.9	3.8		45.8	2.92	2.7	619.5	2
11981-511	433	8/28/2003	470.8	0	44.7	2		46.8	3.81	2.8	731.1	8
11982-511	433	10/30/2003	625.6	0	57.3	3.13		68.4	3.948	2.7	772	12
11983-511	433	11/30/2003	399.8	0	34.6	2.17		43.7	3.51	2.8	571.6	2
12931-511	433	1/25/2004	545.8	0	46.8	2.6		54.8	4.02	2.8	710.5	2
12932-511	433	2/29/2004	391.4	0	32.8	2.8		40.9	3.4	2.9	475.3	44
12933-511	433	3/28/2004	322.2	0	28.9	10.17		33.6	2.83	2.9	517.2	8
12934-511	433	4/28/2004	363.4	0	32.2	4.44		37.7	2.94	2.9	536.5	2
12935-511	433	5/26/2004	398.4	0	32.8	1.75		32.5	2.87	2.8	427.6	2
12936-511	433	8/1/2004	534	0	46.3	16.28		48.5	3.29	2.7	791.5	3
12937-511	433	9/12/2004	817.6	0	58.2	2.19		81.7	3.27	2.7	1046.5	3
12938-511	433	10/3/2004	880.2	0	74.7	1.98		99.7	4.25	2.7	985.6	3
12939-511	433	10/24/2004	1080.4	0	99.6	1.94		135	5.32	2.6	1015.7	4
12940-511	433	12/5/2004	774	0	65.8	2.79		82.3	3.95	2.7	867.6	8
12941-511	433	1/2/2005	575.2	0	50	1.82		60.1	3.51	2.7	772.7	3
12942-511	433	1/26/2005	460	0	36.8	0.81		45.8	3.05	2.8	664.7	10
12943-511	433	3/3/2005	478.8	0	35.3	2.08		43.3	2.72	2.8	790.2	3
12944-511	433	4/28/2005	584.8	0	47.8	4.53		59.5	3.42	2.8	986.6	3
12945-511	433	5/31/2005	733.6	0	67.8	2.4		71.4	3.97	2.6	300	4
12946-511	433	7/27/2005	1380.4	0	118	2.73		130	5.86	2.6	1500	15.9
12947-511	433	9/30/2005	1252	0	113	4.01		110	8.65	2.7	1836.2	4
12948-511	433	11/2/2005	651.4	0	47.6	2.06		71.2	6.14	2.9	1144	3
12949-511	433	12/4/2005	494.2	0	49.6	4.36		47.6	4.55	2.9	711	3
10262-511	433	1/4/2006	572	0	58.66	2.44			4.041	2.8	863	3
10263-511	433	3/9/2006	478	0	40.3	4.89			3.74	2.8	762.3	3
10264-511	433	4/10/2006	473	0	41.7	4.49			3.84	2.8	774.1	4
10265-511	433	5/10/2006	471.4	0	45.12	3.45			4.276	2.8	764.5	3
10266-511	433	6/6/2006	381.6	0	42.5	3.12			3.8	2.9	692.1	3
10267-511	433	7/11/2006	538.4	0	54.88	2.73			4.711	2.7	882.2	3
10268-511	433	8/9/2006	570.4	0	58.22	5.82			5.648	2.7	989.5	3
10269-511	433	9/11/2006	502.6	0	42.2	2.1			3.54	2.8	781.1	3
10270-511	433	10/3/2006	579	0	59.18	2.13			5.205	2.7	921.8	3
10271-511	433	11/14/2006	435.2	0	40.78	2.05			4.011	2.8	643.6	3
10272-511	433	12/14/2006	420.6	0	33.5	1.69			3.71	2.8	665.8	3
10044-511	433	1/4/2007	481.8	0	49.19	2.21		32.6	3.891	2.8	764.6	3
10011-511	433	2/20/2007	504	0	46.4	1.17		38.8	4.19	2.8	766	3
9997-511	433	3/21/2007	270	0	24.3	1.05		19.3	2.46	3	510.8	4
9974-511	433	4/19/2007	334	0	27.38	0.97		28.23	2.791	2.9	604.7	3
9944-511	433	5/24/2007	453.2	0	42.8	3.32		38.3	4.04	2.8	629.3	3
9910-511	433	6/25/2007	720.4	0	56.2	1.18		45.3	5.42	2.7	976.2	12
9896-511	433	7/25/2007	805.4	0	64.9	5.08		59.1	6.45	2.6	1315.5	8
9873-511	433	8/28/2007	424	0	40.3	2.7		28.8	3.46	2.8	680.4	4
9853-511	433	9/26/2007	635.6	0	50.4	2.08		29.3	3.59	2.6	924.4	10
9831-511	433	10/29/2007	664.2	0	53.8	1.48		35.5	4.66	2.7	1092.6	3
9818-511	433	11/20/2007	622.2	0	64	2.04		46.6	5.35	2.8	951	3
9789-511	433	12/19/2007	329.6	0	29.5	2.48		24.9	2.55	2.8	514.1	3
9772-511	433	1/17/2008	375.4	0	36.96	2.56		30.36	2.992	2.8	505.9	3
9732-511	433	3/11/2008	301.4	0	24.84	1.6		27.44	2.238	2.9	492.3	3
9702-511	433	4/23/2008	381.8	0	36.32	1.48		33.52	3.602	2.8	577.3	5
9679-511	433	5/29/2008	327.8	0	34.65	0.7		31.89	3.604	2.9	498.1	5

9637-511	433	7/17/2008	489.4	0	48.2	1.04		39.72	4.205	2.7	873.7	5
9597-511	433	8/21/2008	859.6	0	85.65	1.21		73.42	6.324	2.7	1241.7	5
9543-511	433	10/30/2008	863.2	0	85.23	1.66		77.86	6.924	2.8	1193.6	10
9470-511	433	12/30/2008	342.2	0	30.98	2.1		29.47	2.45	2.8	616.2	5
9461-511	433	1/30/2009	363	0	31.5	2.05		28.3	3.08	2.9	587.8	5
9433-511	433	3/18/2009	393.2	0	39	1.64		34.56	3.774	2.8	528.1	5
9375-511	433	5/26/2009	391.4	0	35.07	0.65		31.04	3.618	2.8	530.1	12
9315-511	433	7/28/2009	562.4	0	53.07	1.01		47.66	4.738	2.8	913.4	5
9262-511	433	9/28/2009	488.2	0	49.46	2.86		41.43	4.339	2.8	727.6	5
8745-511	433	12/20/2010	436.8	0	43.19	2.1	23		3.373	2.8	897.8	5
8766-511	433	1/24/2011	471.8	0	49.28	1.88			3.726	2.8	794.9	8
8811-511	433	4/11/2011	215.8	0	0.5	1.32			0.084	3	379.9	5
8828-511	433	5/23/2011	235	0	21.49	1.25			2.164	3	431.1	5
8874-511	433	7/27/2011	767.8	0	73.35	2.87			5.014	2.7	1052.9	5
8927-511	433	10/24/2011	371.4	0	30.14	1.01			4.343	2.9	560.8	5
8972-511	433	1/11/2012	202.6	0	18.39	2.16			2.1	3	428.6	5
9165-511	433	11/26/2012	627	0	63.66	1.9	6.67		6.114	2.8	913.1	5
		6/21/2013	447	0	45.5	1.7	6	34.7	4.9	2.7	647	8
			533.5	0.0	47.6	3.1	14.8	51.9	3.9	2.8	768.9	5.5
		Average200	450.6	0.0	42.6	1.7	11.9	40.1	3.8	2.8	699.6	5.6
Outflow of Yellow Creek 2A Treatment Pond (Site 434)												
11973-513	434	12/17/2002	373.8	0	44.2	9.66		50	5.95	3.2	1194.2	70
11974-513	434	1/17/2003	435.8	0	42.4	1.21		50.6	3.61	3	833.8	8
11975-513	434	2/26/2003	388.2	0	37.5	3.15		45	3.53	3	833.7	2
11976-513	434	3/18/2003	257	0	25.3	4.09		25	3.03	3.1	608.4	10
11977-513	434	4/24/2003	333	0	33.3	3.17		35.6	3.405	3	631.6	26
11978-513	434	5/29/2003	363	0	39.3	10.63		34.2	3.54	3	837.3	30
11979-513	434	6/24/2003	189	5.4	25.9	16.47		30.5	3.64	4.1	861.5	48
11980-513	434	7/31/2003	216	0	26	14.91		24.7	3.2	3.7	678.4	38
11981-513	434	8/28/2003	153.4	10.8	23.8	9.93		22.5	3.53	4.4	722.2	8
11982-513	434	10/30/2003	295.8	0	37.4	2.39		32	4.18	3.3	878.6	54
11983-513	434	11/30/2003	194.6	0	24.8	4.32		24.9	3.72	3.5	662	42
12931-513	434	1/25/2004	265.6	0	29.8	2.18		31.3	3.61	3.1	680.4	50
12932-513	434	2/29/2004	243	0	26.7	0.05	50	26.8	3.62	3.2	702.4	16
12933-513	434	3/28/2004	167.4	0	24	2.1		16.2	2.96	3.5	535.5	8
12943-513	434	3/3/2005	76.6	17.2	16.3	11.22	60	16.2	3.6	4.8	650.1	64
12944-513	434	4/28/2005	-10	66.8	10.5	7.19	20	9.37	3.46	6.1	835.4	36
12945-513	434	5/31/2005	-5.8	107.4	13.4	10.05	20	9.75	4.41	6.1	300	54
12947-513	434	9/30/2005	-212.4	429	1.18		5	60.3	6.42	6.4	1375.3	40
12948-513	434	11/2/2005	-197.4	374.8	1.21		10	35.7	4.63	6.6	1324.2	10
12949-513	434	12/4/2005	-87	265.2	0.5	21.35	25	27.6	4.9	6.8	822.4	16
10262-513	434	1/4/2006	-186	253.2	0.5		15		4.902	6.8	878.1	20
10263-513	434	3/9/2006	-13	97	8.37	2.25			3.72	6.3	757.6	40
10264-513	434	4/10/2006	-45.6	129.2	7.4	1.02	15		3.67	6.3	741.9	34
10265-513	434	5/10/2006	-66.4	150.8	8.602		12		4.944	6.3	708.4	38
10266-513	434	6/6/2006	-135.8	167	4.49	10.39	8		3.48	6.5	584.5	4
10267-513	434	7/11/2006	-180.4	210	2.606	19.17			4.669	6.5	570.3	4
10268-513	434	8/9/2006	-198.6	232.2	0.88		4		4.52	6.4	627.4	4
10269-513	434	9/11/2006	-186	233.6	2.82		5		3.3	6.7	523.3	24
10270-513	434	10/3/2006	-134.6	167.4	5.416		5		3.879	6.7	545.2	20
10271-513	434	11/14/2006	-115.4	156.2	5.377	0.88	6		2.976	6.7	466.3	16
10272-513	434	12/14/2006	53.4	140	3.59	0.42	9		2.39	6.8	474.2	4
10044-513	434	1/4/2007	-71.2	142.6	4.205	0.47	9	1.016	2.957	6.6	560.9	8
10011-513	434	2/20/2007	-128.8	157.6	3.12	0.38	9	0.74	2.38	6.8	566.3	14
9997-513	434	3/21/2007	-147.4	173.2	2.08	0.43	9	0.949	1.88	6.9	561.3	18
9974-513	434	4/19/2007	-153.8	182.8	1.278	0.27	9	0.618	1.238	7	396.6	3
9944-513	434	5/24/2007	-311.6	242.6	1.81	2.8	6	4.66	3.01	6.7	504.2	10
9910-513	434	6/25/2007	-114.6	238.6	0.5	10.43	3	9.64	4.97	6.7	581.8	8

9896-513	434	7/25/2007	-21	245.6	0.5	14.88	2	14	4.8	6.5	623.9	24
9873-513	434	8/28/2007	-204.6	340.2	0.5	10.57	5	10.4	4.62	6.7	394	6
9853-513	434	9/26/2007	-103.8	293.6	0.547	20.25	7	16.2	4.36	6.6	518.4	14
9831-513	434	10/29/2007	-77.2	271	1.04	9.73	5	9.53	3.91	6.8	713.5	4
9818-513	434	11/20/2007	-302.2	225.2	3.57	3.01	6	4.2	3.8	6.6	700.4	44
9789-513	434	12/19/2007	-162.2	180	3.06	1.06	8	1.6	2.55	6.8	552.9	6
9772-513	434	1/17/2008	-145.8	162.4	2.522	0.41	8	1.385	1.694	7.3	446.8	8
9732-513	434	3/11/2008	-139.8	164.6	1.752	0.3	10	0.711	1.133	7.2	442.5	3
9702-513	434	4/23/2008	-163	184.2	1.703	0.44	10	0.673	1.039	6.9	350.9	5
9679-513	434	5/29/2008	-162.4	204.8	2.183	1.2	8	1.777	1.619	7.1	432.4	12
9637-513	434	7/17/2008	-190.6	227.8	2.36	9.2	6	9.1	3.104	6.8	442.7	16
9597-513	434	8/21/2008	-215.4	268	3.569	15.95	4	17	6.749	6.5	591.8	28
9543-513	434	10/30/2008	-241.8	284.4	1.743	12.39	3	12.64	5.938	6.8	732.8	38
9470-513	434	12/30/2008	-213.6	233	0.667	1.46	5	1.566	2.571	6.8	867.8	8
9461-513	434	1/30/2009	-200	217.8	0.838	0.41	5	0.776	1.2	7.1	687.6	8
9433-513	434	3/18/2009	-190.2	213	0.892	0.24	6	0.392	0.861	7.2	401.6	5
9375-513	434	5/26/2009	-227	253.6	0.668	2.32	6	2.459	1.319	7	449.4	10
9262-513	434	9/28/2009	-196.8	241.2	0.5	17.36	2.07	18.08	5.332	6.5	504.8	5
8745-513	434	12/20/2010	-160.2	195	0.5	47.69			4.856	6.7	638.6	58
8766-513	434	1/24/2011	-162.6	248.4	0.5	44.95	5.5		4.73	7	566.1	38
8811-513	434	4/11/2011	-149	181.6	0.5	16.11	8		0.055	6.9	303.9	38
8828-513	434	5/23/2011	-183.2	211.2	0.5	20.54	7.5		2.181	6.9	231.3	40
8874-513	434	7/27/2011	-244.4	329.6	0.5	46.4	2		2.592	6.8	380.6	74
8927-513	434	10/24/2011	-201	290.2	0.5	64.17	6		2.024	6.8	302	96
8972-513	434	1/11/2012	-165.8	166.8	0.5	28.57	2		1.323	7	189.4	48
9165-513	434	11/26/2012	-271.4	294.4	0.5	48.98	2.61		2.926	6.9	386.4	24
		6/25/2013	-216	222	0.5	1.4	5	23.3	2.7	6.9	305	46
		Average	-56.4	167.2	9.1	10.9	9.6	17.0	3.4	6.0	612.1	25.1
		Average(200	-192.4	228.3	1.1	18.1	5.6	6.9	2.7	6.9	459.7	29.0
Final outflow of Yellow Creek 2A and 2B (site 435)												
11973-515	435	12/17/2002	302	0	38.9	10.5		28.4	6.45	3.4	1085.5	28
11974-515	435	1/17/2003	26.8	22.4	5.39	3.42		5.21	3.71	5.4	676	28
11975-515	435	2/26/2003	364.8	0	36.7	2.91		43.5	3.55	3	792.3	18
11976-515	435	3/18/2003	238.4	0	25.9	5.39		23.6	3.19	3.2	599.9	20
11977-515	435	4/24/2003	226.2	0	27.8	3.03		16.3	3.735	3.2	671.4	26
11978-515	435	5/29/2003	229.6	0	216	0.46		6.84	3.93	3.5	798.6	12
11979-515	435	6/24/2003	107.8	10.4	3.64	2.96		6.29	4.38	4.5	680.1	18
11980-515	435	7/31/2003	191.6	0	21.6	1.06		4.62	3.54	3.7	705.6	16
11981-515	435	8/28/2003	4.4	62.8	2.36	5.72		12.1	4.21	6.2	692.2	24
11982-515	435	10/30/2003	98.8	10.4	13.1	7.91		10.7	4.81	4.5	866.8	16
11983-515	435	11/30/2003	40	10.6	5.36	4.77	45	6.01	4.15	5.1	632.7	20
12931-515	435	1/25/2004	116.6	0	14.8	3.71		14.1	4.58	3.9	699.7	12
12932-515	435	2/29/2004	132.4	6.4	18.9	0.06		12.5	3.58	4.2	608.7	8
12933-515	435	3/28/2004	114.6	8.6	18	3.83		5.99	3.23	4.3	551.9	10
12938-515	435	10/3/2004	273.2	0	36.9	2.88	40	2.75	4.32	3.5	687.5	3
12939-515	435	10/24/2004	173.4	1.8	26	0.88	20	2.55	5.17	4	830.9	6
12940-515	435	12/5/2004	609.8	0	56.4	8.86	75	65.3	4.88	2.9	804.7	6
12941-515	435	1/2/2005					60					
12943-515	435	3/3/2005	32.2	22.6	1.43	8.94		8.36	3.86	6.1	640.5	16
12950-515	435	3/30/2005	221	0	29	5.9		12.1	3.8	3.4	640.7	6
12944-515	435	4/28/2005	114.6	0	14.6	3.06		4.08	4.45	3.8	808.6	3
12945-515	435	5/31/2005	55	8.8	1.68	3.04		3.31	5.02	4.8	300	6
12947-515	435	9/30/2005	-130.4	206.8	0.5	0.12		0.325	0.069	7.8	1168.4	8
12948-515	435	11/2/2005	-145.8	249	0.5	0.12		0.305	1.82	7.6	1285.7	3
12949-515	435	12/4/2005	33	20	4.59	3.39		4.09	5.99	5.5	877.8	12
10262-515	435	1/4/2006	148.4	2.2	19.64	17.5			6.141	4	844.9	4
10263-515	435	3/9/2006	-45.2	81.8	0.5	1.24			5.268	6.6	705	6
10264-515	435	4/10/2006	-25.6	71	0.5	0.16			4.74	6.9	831.5	8
10265-515	435	5/10/2006	50.6	8.2	3.225				6.64	4.6	740.7	4

10266-515	435	6/6/2006	29.4	4.4	3.2	0.77			4.63	4.2	571.3	3
10267-515	435	7/11/2006	19.2	5.4	0.5	2.91	6		6.334	4.3	667.3	6
10268-515	435	8/9/2006	-97.8	114.6	0.5	0.14			3.88	7.3	605.5	3
10269-515	435	9/11/2006	66	8.6	7.81	0.14			5.67	4.6	627	3
10270-515	435	10/3/2006	68.8	6.6	9.576	0.18			6.564	4.2	671.8	3
10271-515	435	11/14/2006	177.8	0	25.32	0.24			4.95	3.6	553.2	3
10272-515	435	12/14/2006	77.8	5.6	4.61	0.29			3.82	4.3	492.7	3
10044-515	435	1/4/2007	191.2	0	26.5	1.33		4.41	4.96	3.6	582.2	
10011-515	435	2/20/2007	82.4	7.6	16	1.41		2.7	4.34	4.3	505.6	8
9997-515	435	3/21/2007	183.8	0	19	2.2		10.1	2.86	3.2	477.4	15.9
9974-515	435	4/19/2007	84	6.6	10.94	2.12		2.606	3.398	4.2	536.6	3
9944-515	435	5/24/2007	75.4	0	6.61	3.23		4.77	4.36	3.7	504	6
9910-515	435	6/25/2007	27	27.4	0.5	2.62		2.62	4.61	6.7	708	8
9896-515	435	7/25/2007	5.4	58.8	0.5	0.37		0.723	4.79	7.5	768.2	10
9873-515	435	8/28/2007	134.4	0	18	1.58		2.43	4.92	3.8	581.5	3
9853-515	435	9/26/2007	90.4	0	5.79	1.58		1.95	5.48	3.8	710.4	20
9831-515	435	10/29/2007	38.2	18.6	0.5	0.17		0.3	5.62	6.8	749.5	3
9818-515	435	11/20/2007	-60	9.4	4.29	0.46		0.586	6.38	4.8	722.7	6
9789-515	435	12/19/2007	304.6	0	29.8	1.65		22.8	3.01	3	513	3
9772-515	435	1/17/2008	292.8	0	35.58	1.44		23.66	3.648	3	514.4	3
9732-515	435	3/11/2008	265.2	0	23.94	1.6		25.08	2.55	3	478.2	3
9702-515	435	4/23/2008	157.6	0	20.26	0.37		1.42	3.799	3.4	473.1	5
9679-515	435	5/29/2008	153.4	0	21.28	0.5		1.899	3.508	3.4	454.7	5
9637-515	435	7/17/2008	104.2	0	11.57	0.3		1.618	4.803	3.5	578.7	5
9597-515	435	8/21/2008	21.8	0	0.938	0.07		0.339	5.632	3.9	673.9	5
9543-515	435	10/30/2008	4.2	20.6	0.5	0.04		0.3	5.113	6.8	633.9	8
9470-515	435	12/30/2008	272.2	0	28.08	1.45		21.24	2.795	3	624.4	5
9461-515	435	1/30/2009	225.8	0	23	0.46		12.2	3.43	3.2	568.7	5
9433-515	435	3/18/2009	119.8	0	25.77	0.43		4.369	3.707	3.2	501.7	5
9375-515	435	5/26/2009	181	0	18.99	4.54		6.965	3.412	3.3	497	6
9315-515	435	7/28/2009	7.8	12.8	0.5	1.49		2.151	4.562	6.2	620.8	5
9262-515	435	9/28/2009	54	3.4	7.374	0.13		0.3	4.392	4.1	446.3	5
8745-515	435	12/20/2010	224.2	0	29.24	0.62			4.287	3.3	744.5	10
8811-515	435	4/11/2011	169.6	0	0.5	0.85			0.054	3.1	342.1	5
8828-515	435	5/23/2011	134.2	0	13.71	1.73			1.888	3.2	309.5	5
8874-515	435	7/27/2011	41	0	0.5	3.45	3		2.513	3.8	338.7	8
8927-515	435	10/24/2011	51.6	1.4	5.196	0.12	60		3.473	4	320.5	5
8972-515	435	1/11/2012	35.2	6.2	4.643	0.05	20		4.017	4.4	240.2	5
9165-515	435	11/26/2012	158.4	0	26.49	0.18	3.5		4.279	3.6	551.6	5
		6/21/2013	136.4	0	19.3	0.19		2.1	3.5	3.3	365	6
		Average	115.7	16.5	16.9	2.3	33.3	9.3	4.2	4.4	633.1	8.5
		Average 200	133.8	2.1	15.1	1.0	21.6	7.4	3.6	3.7	489.4	5.4
Outflow of Yellow Creek 2B Treatment pond (Site 442)												
11978-529	442	5/29/2003	0	563.4	0.2	0.17		0.073	2.61	6.8	368.8	2
11980-529	442	7/31/2003	0	595	0.2	0.08		0.053	2.81	6.9	320.5	20
11981-529	442	8/28/2003	0	369.8	0.2	0.19		0.141	4.13	6.7	602.3	4
11982-529	442	10/30/2003	0	257.4	0.66	14.56		13.3	4.53	6.6	833.4	26
11983-529	442	11/30/2003	0	210.8	0.2	4.23	20	4.58	2.97	7	517	2
12931-529	442	1/25/2004	0	229.2	0.2	6.89		6.77	4.8	6.7	741.7	22
12932-529	442	2/29/2004	-100	218.6	0.2	9.62	20	8.94	3.43	6.8	571.2	16
12933-529	442	3/28/2004	-99.4	224.6	0.2	2.99	20	3.15	2.61	7.1	448.6	18
12934-529	442	4/28/2004	-100	294.8	0.2	3.67		3.56	2.54	6.9	414.8	12
12935-529	442	5/26/2004	-96.8	402.4	0.2	3.98		2.51	2.75	6.8	374.3	14
12936-529	442	8/1/2004	-179.4	349.8	0.5	2.91		2.01	3.88	6.7	551.8	4
12937-529	442	9/12/2004	-90.6	339.2	0.5			10.9	4.15	6.5	807.7	10
12938-529	442	10/3/2004	-203.2	300	0.5	8.8	20	7.38	3.47	6.8	610.5	6
12939-529	442	10/24/2004	-104	275.2	0.5	46.08	20	40.7	5.94	6.5	905.2	28
12940-529	442	12/5/2004	-67	257.2	0.534	50.25	6	42.5	5.03	6.6	912.8	18
12941-529	442	1/2/2005	-128	253.4	0.5		4	24	3.62	6.6	829.6	24

12942-529	442	1/26/2005	-136	198.6	0.5	10.65	15	11.7	2.05	6.8	314.6	24
12943-529	442	3/3/2005	-132.4	206.2	0.5	16.7	15	13.8	2.53	6.9	575	14
12944-529	442	4/28/2005	-145.4	260.2	0.5	17.09	10	15	2.61	6.9	625.4	16
12945-529	442	5/31/2005	-159.4	302.2	0.583	20.86	9	18.8	3.45	6.7	300	22
12946-529	442	7/27/2005	-204.4	418.6	1.39		10	26.4	5.84	6.5	1292.3	28
12947-529	442	9/30/2005	-380.4	523.8	1.62	13.9	4	11.7	6.75	6.6	1376.2	24
12948-529	442	11/2/2005	-184.4	376	1.51		6	14.9	6.97	6.5	1460.3	6
12949-529	442	12/4/2005	-110	247.8	1.21	13.74	3	13.2	6.07	6.8	848.8	10
10262-529	442	1/4/2006	-38.2	134.8	4.619				4.581	6.5	767.1	16
10263-529	442	3/9/2006	-16.2	164	2.06	21.01	15		3.67	6.7	682	22
10264-529	442	4/10/2006	-57	171	1.58	29.63	15		3.79	6.4	693.5	16
10265-529	442	5/10/2006	-106	174	2.111	23.81	15		3.902	6.5	674.2	14
10266-529	442	6/6/2006	-180.8	206.4	1.4	10.01	15		2.87	6.9	510.9	4
10267-529	442	7/11/2006	-215.2	232	1.718	11.26	10		4.012	6.8	524.5	16
10268-529	442	8/9/2006	-200.2	277.8	2.014		12		4.286	6.8	592.6	8
10269-529	442	9/11/2006	-194.2	224.4	2.95	5.34	12		3.84	6.8	648.2	16
10270-529	442	10/3/2006	-156	187.2	5.347		10		4.91	6.9	704.5	24
10271-529	442	11/14/2006	-108.6	146.8	4.065	12.81	10		3.867	6.6	538.6	28
10272-529	442	12/14/2006	15.8	140.8	3.62	12.34	12		3.3	6.8	528.6	10
10044-529	442	1/4/2007	-23.4	138.6	5.617	14.59	12	17.15	3.853	6.7	645.8	42
10011-529	442	2/20/2007	-94	148	4.45	15.71	9	18.5	3.98	6.7	620.3	28
9997-529	442	3/21/2007	-103.4	145.8	1.6	11	12	10.7	2.45	6.8	412.3	32
9974-529	442	4/19/2007	13.4	46.6	8.823	15.15	60	19.5	3.198	6.1	571	38
9944-529	442	5/24/2007	31	57.4	12.6	22.5	20	22.8	3.34	5.9	622.6	56
9910-529	442	6/25/2007	18.6	106	14.3	17.88	12	15.8	5.13	6.2	764	68
9896-529	442	7/25/2007	82.8	70.8	17.8	19.01	12	17.1	5.73	6	925.9	46
9873-529	442	8/28/2007	53.4	33	17.2	14.98	30	15.7	4.03	5.6	660.5	76
9853-529	442	9/26/2007	55.2	50.4	22.3	18.28	6	15	3.85	5.6	829.9	82
9831-529	442	10/29/2007	96.2	17.4	24.6	13.47	7	13.8	4.86	5.1	918.1	72
9818-529	442	11/20/2007	25.2	50.4	20.5	16.16	5	21.1	5.73	5.7	837.3	84
9789-529	442	12/19/2007	27.6	36.8	12.8	16.98	5	21.8	3.81	5.8	598.4	50
9772-529	442	1/17/2008	22	100	5.569	13.04	4	13.99	2.829	6.8	497.7	26
9732-529	442	3/11/2008	-89	115.2	1.611	5.86	5	5.865	1.65	7	325.2	6
9702-529	442	4/23/2008	-59	100.6	5.634	16.31	6	15.92	2.289	6.7	446.1	48
9679-529	442	5/29/2008	0.4	47	10.06	7.83	30	9.194	2.492	6.3	412	16
9637-529	442	7/17/2008	-100	170.4	9.14	13.21	5	12.49	2.705	6.6	496.7	42
9543-529	442	10/30/2008	54.6	35.4	30.12	15.81	3	18.46	5.932	5.6	924.7	154
9470-529	442	12/30/2008	-41.6	81.6	7.375	9.37	4	11.45	3.415	6.4	518	40
9461-529	442	1/30/2009	-35.6	76.4	7.06	6.46	4	9.17	2.51	6.5	396.1	38
9433-529	442	3/18/2009	-60.4	76.8	2.514	8.92	2	10.37	1.88	7	393	12
9315-529	442	7/28/2009	88.2	13.4	20.64	17.98	15	21.61	4.535	4.9	727	72
9262-529	442	9/28/2009	145.2	12.8	26.82	17.07	12	27.47	5.266	4.5	678.3	52
8766-529	442	1/24/2011	455.4	0	46.14	1.84			3.553	2.8	754.2	5
8811-529	442	4/11/2011	-100	116.8	0.5	2.07	5		0.06	7	128	5
8828-529	442	5/23/2011	186	0	17.27	3.15			1.819	3	360.6	5
8927-529	442	10/24/2011	-69.4	98	6.493	4.16	10		2.109	6.7	369.9	32
8972-529	442	1/11/2012	2.2	38.6	7.95	6.29	15		3.508	6.3	502.9	40
9165-529	442	11/26/2012	-197.8	217.8	1.1	0.43			1.866	7	319.8	24