MILL CREEK COALITION

Passive Treatment System
Operation, Maintenance & Replacement Plan

Project Summary Report
FINAL REPORT

December 29, 2006

Prepared by:
The EADS Group, Inc.
Dietz-Gourley Consulting, LLC

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FINAL REPORT

PREPARED FOR:

THE MILL CREEK COALITION
OF CLARION & JEFFERSON COUNTIES

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Clarion University – Biology Department
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Headwaters Charitable Trust
NRCS - *National Resources Conservation Service*
DEP - *Department of Environmental Protection*
OSM - *Office of Surface Mining*
WPCAMR - *Western Pennsylvania Coalition for Abandoned Mine Reclamation*
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EXECUTIVE SUMMARY

The project involved preparation of a Comprehensive Operation, Maintenance, and Replacement Plan for the AMD treatment systems throughout the Mill Creek Watershed. The Mill Creek Watershed is located in Jefferson and Clarion Counties and covers 35,800 acres. Over 20 AMD treatment systems have been constructed in this watershed. The Mill Creek Coalition currently bears the responsibility for operating and maintaining 17 of these systems. These systems are of varying ages and use a variety of passive treatment technologies. This study was undertaken to provide: 1) a comprehensive study of the existing systems to determine their current status; 2) recommendations regarding operation, maintenance and/or replacement of the existing systems, if needed; and 3) development of a Geographic Information System (GIS) for management of historic and future data and for the rapid assessment of the systems based on key assessment parameters.

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INTRODUCTION

Since the early 1990s, the Mill Creek Coalition (MCC) and their various supporting partner organizations and agencies have been working to address non-point sources of Acid Mine Drainage (AMD) within the Mill Creek Watershed. This watershed has a long history of mining which has left over 60 areas of identifiable AMD pollution to Mill Creek and its tributaries. As a result of this past mining and close proximity of Clarion University, the Mill Creek Watershed was one of the test grounds for developing passive AMD treatment technologies as well as development of grassroots watershed groups. Treatment efforts such as the Howe Bridge system were developed using cooperative partnerships, grassroots volunteerism, and unique treatment ideas. Generally these early systems were constructed as experimental efforts without the sizing guidance and design approaches that have developed since these early efforts.

In 1999, the Mill Creek PL-566 Watershed Plan was created to identify and prioritize the major AMD sites within the Mill Creek Watershed. The plan identified 58 sites for treatment at an estimated construction cost of over $6,000,000. Including development of systems before the creation of the Watershed Plan, over $2,000,000 of private, state, and federal money has been invested in treatment system construction. The Pennsylvania DEP - Bureau of Abandoned Mine Reclamation has also expended funds in developing their own treatment systems within this watershed. Additional funds have been spent in alkaline addition land liming, well plugging, and other efforts. The Mill Creek Coalition has direct responsibility for the operation and maintenance of 18 treatment systems, summarized in Table Intro-1.

Table Intro-1. Summary of Mill Creek Coalition Passive Treatment Systems

Site Name	Year Built	System Type
Howe Bridge	1991 *Modified in 2002*	ALD/Aerobic Pond/SAPS
Schnepp Road 1/2	1992	ALD/Settling Ponds/SAPS
Alder Bog	1992	Open Limestone Channel
Filson 5/6	1994	ALDs/Aerobic Ponds/SAPS
Filson 1/2/3	1995-2001	SAPS
McKinley 1	1996	SAPS/Aerobic Pond
Beagle Site	1998	Aluminator ®
Morrow 1	1998	ALD/Aerobic Pond
McKinley 2	1999	SAPS/Aerobic Pond
Bog Site	1999	SAPS
Daiva	2001	ALD/Aerobic Pond
Simpson 1	2000	ALD/Aerobic Pond
Filson 4	2000	SAPS/Settling Pond/ALD
REM	2005	SAPS/Settling Pond/ALD

Over the last 15 years, the restoration effort has grown from a few heavily studied systems to a large watershed treatment effort, the scope of which has become hard for a volunteer organization to assess. This is not from lack of effort. The Mill Creek Coalition has been very proactive in keeping records of water sampling and analysis in and around their existing systems. They have continued to form partnerships and move forward with the implementation of their watershed plan. Yet while this plan is very clear about the need for O&M and the responsibility of its sponsors to perform these tasks, it makes little provision for a comprehensive look at watershed wide maintenance efforts.

The analysis and assessment of the existing treatment systems in the watershed, combined with a structured method of organizing existing and future data is needed to provide continued management of the treatment systems and continued restoration in Mill Creek. The Mill Creek Coalition, as well as state and federal agencies, require a comprehensive "snap shot" analysis/assessment of the existing systems, a methodology to evaluate the systems in the future, and a tool to provide long range planning for maintenance and replacement of installed systems.

This OM&R plan has been developed to assist the Mill Creek Coalition and partners in evaluating existing conditions of the passive treatment systems, determine current OM&R needs, and provide a tool for future planning of OM&R needs for existing systems and systems installed in the future. The following tasks were conducted as part of this OM&R project:

Data Gathering & Evaluation - Various sources of information including historical sampling data, design information and summary reports were organized, summarized and evaluated.

On-Site System Assessment – Field evaluation, sampling and analysis were conducted at each system to determine current conditions and identify operation "triggers" to be used to determine current and future operating conditions for the purpose of planning OM&R activities.

Treatment System Evaluation - Information from the on-site inspections were combined with previously collected existing information. Each system was assessed with respect to historical water quality and field assessment. The field assessment and historical data were used to develop "triggers" to assess passive treatment conditions and the initiation of various OM&R activities.

Geographic Information System (GIS) – Information was assembled and organized into a database and GIS format to provide ease of access to historical information, the input of future water quality data, and provide a graphic/picture representation of the systems in the watershed and their current condition with respect to OM&R activities.

The following report is summarized in three sections following the above tasks. They are:

Treatment Unit Evaluation. A summary of the field evaluation and basis for selection of operation "triggers" that will initiate various OM&R activities. It must be stated the purpose of the triggers is to determine what level of OM&R activities are required at each passive treatment site and not as a measure of the success of a passive treatment system installation. It should also be understood, many of the older systems were "cutting-edge" approaches and were installed with little or no past design guidance, which has been, in part, developed based on the installations in this watershed.

Geographic Information System Summary. A summary of the process used to develop the GIS, the data and information contained in the GIS, and a brief user guidance description.

Individual Treatment System Recommendations. A summary of the individual treatment systems containing the following information:

- Treatment system design information (e.g., photographs, plan views, descriptions, and materials);
- Historical water quality data for systems and/or units (in tables or graphs);
- Treatment system/unit field evaluation;
- Performance evaluation analysis (e.g., underdrain Eh, ALD effluent alkalinity, iron removal, solids accumulation, etc.);
- Suggested operation procedures (e.g., flushing procedure, etc.);
- Maintenance issues and recommendations;
- Innovations and modifications for future revitalization/replacement; and
- A costing for maintenance, revitalization and/or replacement.

The Alder Bog Treatment System and the REM Treatment System were not evaluated as part of this study. Alder Bog was excluded because it is an open limestone channel. REM was excluded because the treatment system went online in late 2005.

Treatment Unit Evaluation

A number of different types of passive treatment technologies have been used in the various systems constructed by the Mill Creek Coalition (MCC). The treatment technologies include:

- Anoxic Limestone Drains (ALD)
- Successive Alkalinity Producing System (SAPS)
- Aerobic Ponds/Wetland

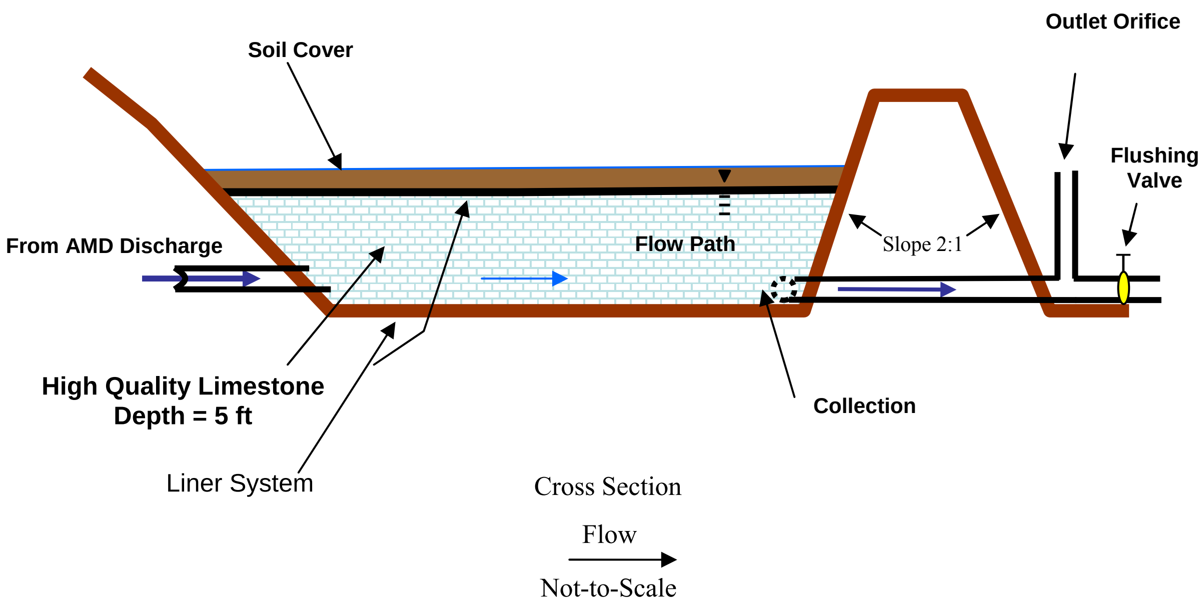
The passive treatment systems and unit technologies were evaluated for a number of water quality parameters during a field evaluation conducted in July 2005. The passive treatment system field evaluation focused on the individual treatment units within a system and not on the overall performance of the system. The purpose of the individual treatment unit evaluation was two-fold. Firstly, the treatment units were evaluated to determine current conditions of the systems and whether OM&R of the treatment units was needed. Secondly, the evaluation examined various parameters with the intent of identifying simple methods and criteria for the MCC to evaluate through their field sampling to provide a snapshot of the passive treatment units and any required OM&R by the MCC. The following sections discuss the passive treatment technologies, the various water quality parameters examined, and the basis for selection of the parameters to be included in future field sampling and the criteria to be included in the GIS application.

Anoxic Limestone Drain (ALD)

An Anoxic Limestone Drain (ALD) is a buried channel or bed of limestone containing a three to five foot depth of limestone. A typical cross-section is shown in Figure TUE-1. The channel configuration is the most common configuration in treatment systems constructed by the MCC. Newer MCC systems use a buried basin design equipped with influent distribution piping and outlet collection piping to create more uniform distribution of the mine drainage and improved contact with the limestone.

A category of mine drainage, known as anoxic mine drainage, is fed into the ALD and alkalinity is generated. The water quality criteria for anoxic mine drainage in the bituminous coal region for use of an ALD include: 1) little or no oxygen (dissolved oxygen less than 0.5 mg/L); 2) pH greater than 5 with initial alkalinity (typically greater than 10 mg/L); 3) iron predominately as ferrous iron (> 95%); and 4) mine drainage with net acidity. Low aluminum (<1 mg/L) can also be included as a criteria, but should be captured in the pH criteria due to pH-dependent solubility of aluminum.

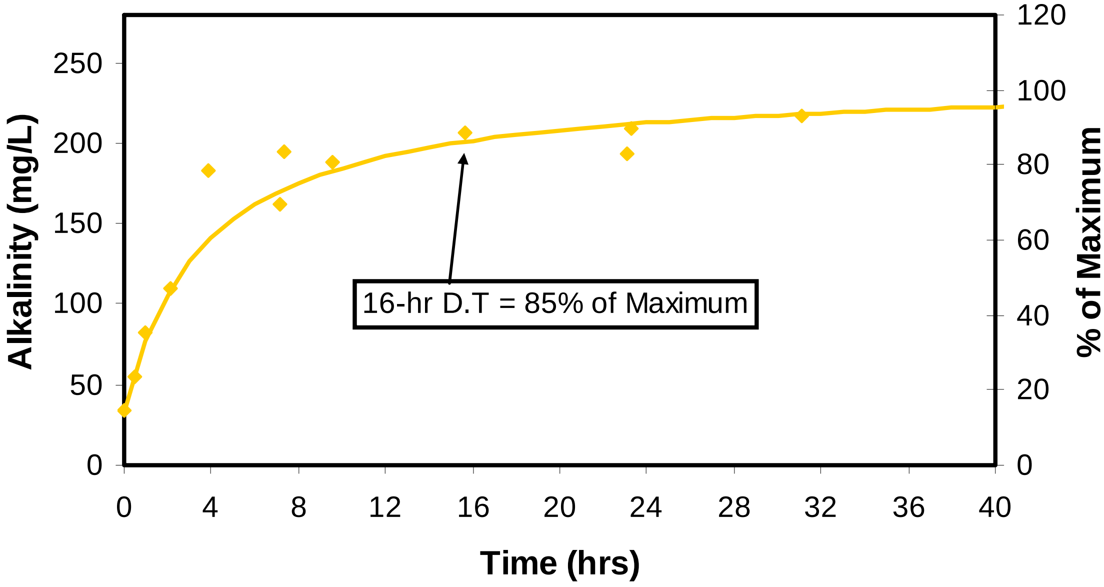
Figure TUE-1: Conceptual Anoxic Limestone Drain (ALD) Cell



Sizing for an ALD is typically based on: 1) water detention time (e.g., 16 hours) in the limestone, 2) plus an additional volume of limestone to provide 20 to 25 years of operational life. However, it should be understood the volume added for longevity is typically much greater than the detention time volume. This additional volume increases the detention time in the ALD to durations that are much greater than 16 hours and, in fact, approach detention times generating the maximum alkalinity possible.

Cubitainor studies on a number of discharges, including Howe Bridge, have been used to develop the design criteria for ALDs. An example of a cubitainor study is shown in Figure TUE-2. The results show alkalinity increasing with detention time and approaches maximum alkalinity after about 30 hours. The recommended 16-hour detention time was based on a reasonable detention time to approach the maximum alkalinity (80 and 90 percent of the maximum alkalinity possible). However, upon system start-up, most ALD will be at the maximum alkalinity due to the limestone added for longevity, which typically results in a start-up detention time in excess of 40 hours.

Figure TUE-2. Cubitainor study showing relationship of detention time to percent of maximum alkalinity produced.



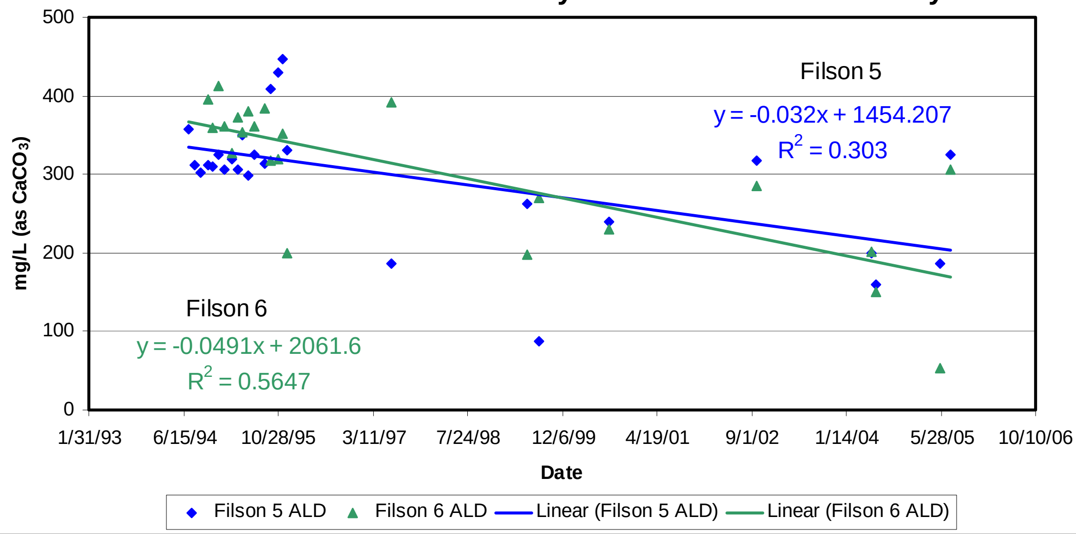
A newer design approach involves using a deterministic kinetic model that can predict alkalinity produced in an ALD for any contact time and temperature condition as long as the maximum alkalinity is known, or can be calculated from raw water chemistry. The latter is not possible because existing ALD do not permit sampling of the influent water. The ALD kinetic equation is:

(1) $$A_t = A_{Max} - [(A_{Max} - A_o)^{-1} + (k \times SA \times t)]^{-1}$$

where A_t is the Alkalinity at any time (t), A_o is the Alkalinity at initial time (t=0), A_{Max} is the Maximum alkalinity (t = ∞), k is the Reaction Rate, SA is the Surface Area of the limestone, and t is time. The reaction rate can be adjusted for site specific temperature conditions based on activation energy (E_a). This design approach is represented by the continuous line shown on Figure TUE-2.

The effects of long term operation on an ALD alkalinity and detention time are shown in Figure TUE-3 by examining the Filson 5/6 ALDs. The Filson 5/6 ALDs have been in operation for more than ten years and provide a good basis for evaluation. The effluent alkalinity has decreased by more than 100 mg/L over time in both ALDs as the limestone is consumed and/or preferential flow paths have developed. This equates to a decrease in ALD detention time and effluent alkalinity. Iron solids may gradually accumulate in the ALD causing a coating over the limestone and subsequently reducing dissolution thereby resulting in a lower effluent alkalinity.

Figure TUE-3. Evaluation of Anoxic Limestone Drains (ALD) at Filson 5/6 Passive Treatment System - ALD Outlet Alkalinity



The field evaluation was conducted to evaluate the conditions of the ALD in the Mill Creek Watershed and identify simple field methods to determine the current operating conditions and criteria on which to base future OM&R efforts for ALDs. Field parameters used to examine operating conditions of an ALD included:

- Effluent Dissolved Oxygen – measures whether dissolved oxygen is entering the ALD, which could cause premature failure through oxidation of ferrous iron and accumulation of iron oxides.
- Effluent Eh – (redox potential) a measure of whether there are oxidizing conditions within the ALD and is similar, but more sensitive than dissolved oxygen.
- Effluent to Influent Iron – determines whether iron is being removed in the ALD, but requires the ability to measure influent to an ALD (typically not incorporated in ALD systems).
- Effluent Ferrous Iron to Ferric Iron – determines whether particulate iron is in the discharge, which would reflect ferrous iron oxidation. This is difficult to determine due to the filtration of particulate iron oxide within the ALD.
- Percent (%) Maximum Alkalinity – comparison of current ALD effluent alkalinity to the maximum alkalinity in order to evaluate remaining effective detention time in the ALD.

The final evaluation parameter required a determination of the maximum alkalinity that can be produced by the ALD. This was determined by collecting an ALD effluent sample into a limestone cubitainor and measuring the alkalinity on the cubitainor water after greater than 40 hours detention at greater than 20°C. The temperature was chosen to increase the reaction rates and ensure the reaction time was adequate to approach the maximum alkalinity (> 98% of actual maximum alkalinity).

Table TUE-1 summarizes the field measurements taken from the ALDs as part of this study. Dissolved oxygen (DO), redox potential (Eh), and ferrous iron to total iron were relatively insensitive and did not provide insight to the current operating conditions of the ALD. In comparison, the percent (%) Maximaum Alkalinity values determined from ALD effluent alkalinity and cubitainor results ranged from 57 to 104 %. The 57% values are from two of the oldest ALDs constructed in the early 1990s and the 104% is from a system constructed in 1998, indicating the parameter is directly correlated to the age of the ALD. It is also well founded in the kinetics of dissolution representing the remaining effective detention time of the ALD (see Figure TUE-2).

Table TUE-1. Summary of results from ALD field evaluation conducted on July 14 and 15, 2005 as part of the MCC OM&R Plan.

Site	DO mg/L	Eh mV	Total Iron mg/L	Fe^{2+} Iron mg/L	Effluent Alkal. mg/L	Effluent pH	Cubitainor Alkal. mg/L	Cubitainor pH	% Max. Alkal.
Howe Bridge	0.24	-16	199.0	196.0	148	6.34	260	6.55	57
Filson 5	0.17	-6	35.8	35.8	280	6.48	340	6.67	82
Filson 6	0.20	+7	51.5	51.5	250	6.38	340	6.65	73
Schnepp 1	0.28	+12	82.5	81.0	143	6.27	250	6.74	57
Morrow 1	0.15	-5	8.3	8.4	214	6.86	206	7.01	104
Filson 4	0.16	+84	23.2	23.4	169	6.11	282	6.60	60
Simpson	0.28	-49	50.0	47.4	228	6.42	297	6.74	77

Using the kinetic model as a basis of the remaining detention time in the ALD (or effective detention time in the case of preferential flows and iron oxide solids accumulation), criteria were developed on which to assess the ALD for planning purposes. The two levels of detention time evaluation were based on 1) a value of 80% that reflects slightly less than 16 hours detention time, and 2) a value 60% that reflects a detention time of approximately 4 hours. One other parameter was used in the evaluation of ALDs to assist in determining whether a low ALD maximum alkalinity (< 85%) was of concern and requiring initiating planning activities. This is related to the relationship between acidity and alkalinity. A calculated alkalinity demand (AD) representing the acidity of iron and manganese plus additional excess alkalinity was used for this evaluation and was calculated as follows:

(2) $$AD\ (mg/L) = 25 + 1.8 \times (Total\ Iron + Total\ Manganese)$$

As long as this calculated required alkalinity is less than the ALD effluent alkalinity, then there is adequate alkalinity for metal removal to continue in the remaining treatment units. If the required alkalinity exceeded the ALD effluent alkalinity, the subsequent treatment units would be affected by the ALD performance. The ALD criteria developed for the OM&R planning levels are:

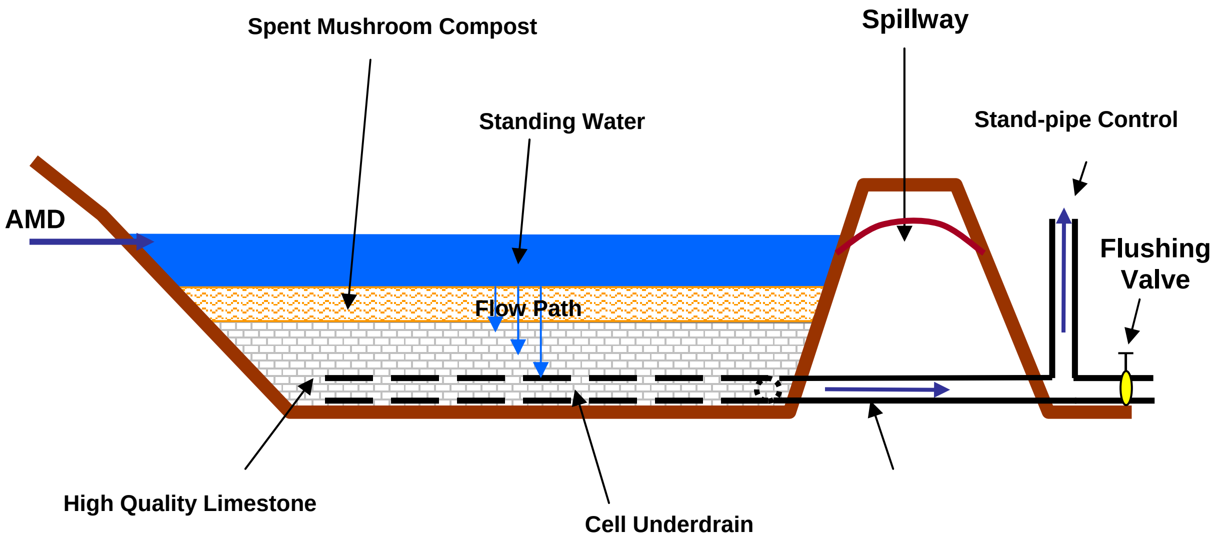
- ***Satisfactory Effectiveness*** - the ALD has an effluent alkalinity greater than 80% of the maximum alkalinity value.
- ***Moderate Effectiveness*** - the ALD is operating between 60% and 80% of the maximum alkalinity value and with an alkalinity demand (AD) less than the ALD effluent alkalinity.
- ***Reduced Effectiveness*** - the ALD is operating at less than 80% of the maximum alkalinity value and with a required alkalinity greater than the effluent alkalinity.

Successive Alkalinity Producing System (SAPS)

A Successive Alkalinity Producing System (SAPS) is a biological filtration/reactor system used to treat AMD with low pH (<5), net acidic water chemistries, and varying concentrations of metals, primarily iron and aluminum. This system is also known as an Anaerobic Vertical Flow Wetland (AVFW), Reducing Alkalinity Producing System (RAPS), Sulfate Reducing Bioreactors (SRB), and Aluminator®.

A typical cross-section, as shown in Figure TUE-4, shows a SAPS with standing water overlying compost and limestone substrate layers and water collection system (underdrain) located in the limestone layer to direct water through the substrates. The substrates affect treatment performance through biological and chemical reactions. The piping system collects the treated water and discharges it via a pipe to additional treatment units or a discharge channel. In the case of the Mill Creek Watershed passive treatment systems, all the SAPS designs are similar in design and consist of: 1) 3 to 4 feet of standing water, 2) a ½ foot layer of organic substrate (e.g., mushroom compost), 3) a 3 to 4 foot layer of high quality limestone, and 4) an underdrain piping and valve or stand-pipe to control water levels in the SAPS. It is important to note the underdrain designs do not regulate flow through the systems, but are merely in place to control water levels. On a broader scale, a SAPS may contain varying depths of water and substrates, with water depths from ½ to 4 feet depth, organic substrate from ½ to 5 feet, and limestone from 1 to 5 feet.

Figure TUE-4: Conceptual Successive Alkalinity Producing System (SAPS)



Cross Section

Flow

Not-to-Scale

There is a number of design criteria used to size a SAPS. The SAPS design basis for the systems in the Mill Creek Watershed is an 8 or 16 hour detention time in the limestone bed. This designed detention time is consistent with past sizing approaches for SAPS units that vary the detention time in the limestone layer between 4 and 32 hours. However, a study by Rose and Dietz (2002) examining over 30 SAPS found this past detention time design criteria may not provide effective long term treatment, particularly for AMD with acidity greater than 100 mg/L. Rose and Dietz recommended a surficial acidity loading sizing criteria of 25 grams of acidity per square meter of treatment area based on a daily loading (gr/day/m^2). Other new design approaches involve sizing based on biological sulfate reduction, known as sulfate reducing bioreactors (SRB), which result in similar sizing as the surficial acidity loading approach. Differences exist between SAPS and an AVFW/SRB; an AVFW/SRB contains a deeper layer of organic material (1½ to 3 feet).

The field evaluation of MCC passive treatment systems was conducted to evaluate the conditions of the SAPS and identify simple field methods to evaluate the current operating conditions and determine criterion on which to base future OM&R efforts for SAPS. In addition, the Long Valley AVFW (two units), located in the Schrader Creek Watershed (Bradford County, Pennsylvania) was included in the survey to provide a comparison. The Long Valley AVFW has been in operation since 1996 with little or no operational concerns over the period. Field parameters used to examine operating conditions of a SAPS included:

- Effluent Dissolved Oxygen – measures whether dissolved oxygen is present in the effluent of the SAPS. The organic layer is intended to remove oxygen and prevent ferrous iron oxidation in the limestone layer.
- Sulfide – a measure of the sulfide (H_2S, HS^-, S^{-2}) in effluent water to determine if sulfate reduction is occurring in the SAPS substrate and is a measure of how reducing the environment is within the SAPS.
- Effluent pH – a measure of the acidity level within the SAPS which provides an evaluation of whether the conditions are adequate to neutralize/consume influent hydrogen ion acidity.
- Effluent Eh – (redox potential) a measure of oxidizing and reducing conditions within the SAPS. It provides an evaluation of whether there are conditions adequate to reduce ferric iron to ferrous iron and sulfate to sulfide.
- Effluent Ferrous Iron to Ferric Iron – determines whether ferric iron is in the discharge, indicating oxidation is occurring within the limestone layer of the SAPS. This is difficult to determine due to the filtration of particulate iron oxide by the limestone.
- Effluent Alkalinity – a measure of the dissolution of calcite in the limestone layer. It provides an estimate of the decomposition of the organic layer. Calcite solubility is related to carbon dioxide concentration, produced by decomposition, in the water.

A number of parameters represented above focus on the reducing/oxidizing (redox) environment within the SAPS. This is important because providing a reducing environment is necessary to prevent accumulation of iron oxide solids in the limestone layer. This can be understood by the redox reaction of iron in the following general equation:

$$Fe^{3+} + H^+ + e^- + C_{org} \leftrightarrow Fe^{2+} + \tfrac{1}{2}H_2O + CO_2 \tag{3}$$

The equilibrium Eh for this reaction is near 0 mV at pH 6. Sulfate reduction to sulfide is represented by the following general equation:

$$SO_4^{2-} + 9H^+ + 8e^- + C_{org} \leftrightarrow HS^- + 4H_2O + CO_2 \tag{4}$$

The equilibrium Eh for this reaction is approximately -70 mV at pH 6.6. Also note that both equations indicate hydrogen ion is consumed and carbon dioxide is produced in the reduction reactions. This indicates an adequate Eh to prevent iron oxidation within the substrate would be less than 0 mV and to have sulfate reduction, the Eh would be less than -50 mV. The reduction reactions would also promote increased substrate pH through the consumption of hydrogen ions and greater solubility of calcite/limestone (as indicated by alkalinity) through the production of carbon dioxide. The former would directly affect aluminum concentration by removal in the organic substrate instead of the limestone layer.

Table TUE-2 summarizes the field measurements taken from each SAPS as part of this study. Dissolved oxygen (DO) was found to be low at all SAPS except McKinley 2; measured dissolved oxygen of 6.4 mg/L. Dissolved oxygen concentrations at a number of other SAPS were greater 0.2 mg/L, suggesting these SAPS are not anaerobic. As a comparison, the Long Valley AVFW in the Schrader Creek Watershed had values less than 0.10 mg/L, which is probably the threshold for detection of dissolved oxygen and the level representing interference by sulfide. Eh (redox potential) measured in the Mill Creek SAPS units ranged from +120 to -70 mV. The positive values represent oxidizing conditions and negative values represent reducing conditions in the SAPS. Positive Eh were found at SAPS with known operational concerns. The Long Valley AVFW had lower Eh ranging from -87 to -115 mV, reflective of strongly reducing conditions and conditions conducive to sulfate reduction.

Table TUE-2. Summary of results from SAPS field evaluation conducted on July 14 and 15, 2005 as part of the MCC OM&R Plan.

Site		DO mg/L	Eh mV	pH	Sulfide mg/L	Alkal. mg/L	Total Iron mg/L	Fe^{2+} Iron mg/L
Beagle	--	No Flow						
Bog – SAPS1	L	0.10	-22	6.55	<0.05	129	16.80	16.80
	R	0.12	-20	6.51	0.05	125	19.80	20.40
Bog – SAPS2	L	0.05	-69	6.98	0.15	105	5.25	5.08
	R	0.09	-65	6.86	0.08	105	5.20	5.03
Filson 1 – *SAPS 1*	--	No Flow						
Filson 1 – *SAPS 2*	--	No Flow						
Filson 1 – *SAPS new*	L	0.08	-17	6.45	0.10	131	39.6	41.6
	R	0.55	+120	5.62	<0.05	24	8.5	8.6
Filson 2	--	0.13	+117	5.80	<0.05	54	44.4	43.6
Filson 3	L	0.12	+37	5.92	0.15	82	78.5	79.5
	R	No Flow						
Filson 4	L	0.12	+25	5.99	0.11	114	40.2	41.2
Filson 5 SAPS	L	0.09	-90	6.68	0.10	194	35.8	36.8
	R	0.07	-70	6.67	<0.05	197	34.2	33.2
Howe Bridge 1	L	0.07	-67	6.62	<0.05	128	72.0	73.0
	R	0.20	-56	6.53	0.05	116	71.0	68.0
Howe Bridge 2	L	0.25	-29	6.63	<0.05	94	22.5	22.0
	R	0.36	-11	6.52	<0.05	80	9.3	7.8
McKinley 1	--	No Flow						
McKinley 2	--	6.40	+39	5.92	<0.05	30	4.68	4.68
Schnepp 1	--	0.18	+31	5.93	<0.05	62	51.80	51.40
Long Valley-*AVFW1*	L	0.07	-87	7.16	0.12	144	1.48	1.56
	R	0.09	-100	7.17	0.50	140	0.90	0.91
Long Valley-*AVFW2*	L	0.06	-115	7.08	1.10	195	0.44	0.45
	R	0.09	-110	7.07	1.30	198	0.50	0.43

L & R indicate the outfall pipe (looking upstream)

The pH found in the SAPS units varied from slightly less than 6 to near neutral pH. A pH less than 6 was found at the majority of the Filson 1/2/3 SAPS, McKinley 2 SAPS and Schnepp 2 SAPS; all with known operational concerns. As a comparison, both Long Valley AVFWs had effluent pH near neutrality. In the MCC SAPS units, only the Bog SAPS 2 had a pH near neutrality. Sulfide was not found in the majority of the Mill Creek SAPS units and where found, was at levels less than 0.2 mg/L. As a comparison, both the Long Valley AVFWs had detectable sulfide with values exceeding 0.50 mg/L at three out of the four underdrain outlets. Alkalinity was detected in all the MCC SAPS units, ranging from 20 to 200 mg/L. The lower alkalinities were found at those with operational concerns. The Long Valley AVFWs typically had slightly higher alkalinity than found in MCC SAPS units with alkalinity ranging between 150 and 200 mg/L. Only the Filson 5 SAPS had similar high alkalinity and this SAPS received an alkaline influent (based on MCC data). Ferrous and total iron was similar at all SAPS units indicating little or no ferric iron is present. The absence of ferric iron does not preclude iron oxidation in the SAPS as any ferric iron would be precipitated and filtered by the substrates at the pH found in the SAPS effluent.

The results of the field analyses and survey to evaluate operational parameters identified several parameters that may be useful in evaluating operating conditions in a SAPS. The parameters that varied with effluent quality and known operational concerns were pH, Eh, alkalinity, and sulfide. While pH is a good indicator of effluent quality, it may not prove to be an indicator of SAPS health due to the range of parameters that can affect pH; these include carbon dioxide concentration, calcite dissolution, and metal hydrolysis. Alkalinity is also an indicator of SAPS performance and based on the equations above, may be an indicator of SAPS health. The reactions show alkalinity is produced and would be proportional to the amount of reduction of ferric iron and sulfate within the SAPS. However, alkalinity may also be a function of inorganic precipitation reactions (e.g., aluminum and ferric iron) that can enhance limestone solubility and produce high alkalinity concentrations from the formation of hydrogen ion and subsequent carbon dioxide upon reaction with limestone. Therefore, alkalinity alone may not prove to be an indicator of SAPS health. Sulfide is an indicator of biological sulfate reduction and may be a good indicator of SAPS health. However, depending on iron concentrations in the water and pH levels, sulfide may not found be due to the formation of metal sulfides. Eh (redox potential) is a parameter predicting the relative oxidizing and reducing conditions within the SAPS. It represents a value that is a mixture of all oxidized forms (e.g., ferric iron and sulfate) to their reduced forms (e.g., ferrous iron and sulfide). As a result, Eh can provide a picture of the conditions within the organic layer of the SAPS.

It should be understood the intent of the organic layer depth (typically only 6 inches) was to reduce any ferric iron to ferrous iron and prevent accumulation of iron oxides in the limestone. The organic layer of the SAPS was not to provide biological sulfate reduction for metal removal and alkalinity production. The reducing environment needed to provide this protection is a reducing condition where sulfate reduction is initiated and some sulfide is produced. This reducing environment would provide greater certainty that all the ferric iron has been reduced since sulfide would react with ferric iron and reduce it to ferrous iron. Based on these requirements and the observations in the Mill Creek SAPS units, as well as the Long Valley Run AVFW, Eh can be used to assess the health of the SAPS where: 1) an Eh of less than 0 mV representing the absence of oxygen and conditions conducive to the reduction of ferric iron to ferrous iron; and 2) an Eh of less than -50 mV representing conditions in which biological sulfate reduction is initiated. The above redox conditions assume a slightly acidic pH condition.

The use of Eh as an assessment tool for SAPS was not possible until recently with the availability of ORP field pens. This is because the Eh was only able to be measured in the laboratory and, as a result, required sample collection using complex field sampling and handling techniques and laboratory analysis in a closed chamber system. Even with careful sample handling and laboratory processing, analysis could result in significant error. The new inexpensive field pens permit direct measurement in the underdrain outlets, thus preventing the historic measurement issues.

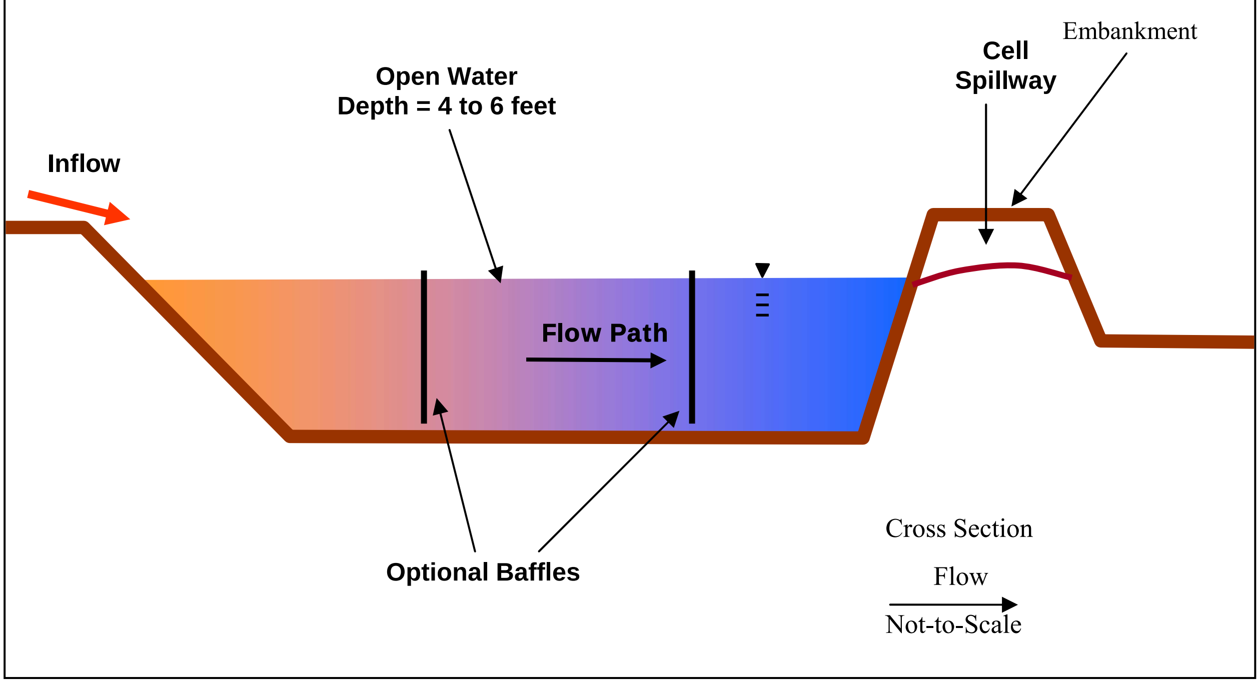
Based on the above evaluation the SAPS criteria developed for the OM&R effectiveness levels are:

- ***Satisfactory Effectiveness*** - the SAPS has an underdrain outlet Eh of less than -50 mV.
- ***Moderate Effectiveness*** – the SAPS has an underdrain outlet Eh of 0 mV to -50 mV.
- ***Reduced Effectiveness*** – the SAPS has an underdrain outlet Eh of greater than 0 mV.

Aerobic Pond/Wetland

Aerobic Ponds/Wetlands are shallow to deep water (1 to 5 feet) ponds used for metal removal. Shallow water depth wetlands can contain emergent vegetation that may enhance the metal removal process. In the Mill Creek Watershed, aerobic ponds are used in conjunction with ALD and SAPS units to remove iron from the mine water. A cross-section of a typical aerobic pond is shown in Figure TUE-5. Aerobic ponds are either sized based on detention time (typically 24 hours) or based on iron removal (10 or 20 grams per day per square meter) depending on their application.

Figure TUE-5: Conceptual Aerobic Pond



Iron removal from AMD is a three step process involving ferrous iron oxidation, ferric iron hydrolysis, and settling of particulate ferric iron hydroxides. The controlling step in iron removal in aerobic ponds/wetlands is the rate of ferrous iron oxidation (Dempsey *et al* 2001).

This oxidation step is an abiotic process, known as homogeneous ferrous iron oxidation, which is a solution based reaction. The ferrous iron oxidation reactions involve soluble ferrous iron species (Fe^{2+}, $FeOH^+$, $Fe(OH)_2°$), which will be cumulatively described as dissolved ferrous iron.

Homogeneous ferrous iron oxidation (HoFIO) occurs in the presence of oxygen by the following stoichiometric equation.

(5) $$\mathbf{Fe(II)_{\mathit{diss}} + \tfrac{1}{4}O_2 + \tfrac{1}{2}H_2O \rightarrow Fe(III)_{\mathit{diss}} + \tfrac{1}{2}OH^-}$$

The oxidation is followed by rapid hydrolysis/precipitation, over a broad range of pH (typically from 2.5 to 12), according to the following stoichiometric equation:

(6) $$\mathbf{Fe(III)_{\mathit{diss}} + 3H_2O \rightarrow Fe(OH)_{3(\mathit{s})} + 3H^+}$$

Among the dissolved species involved in the HoFIO, the oxidation of $Fe(OH)_2^o$ dominates when the pH is between 5.5 and 8 (Millero *et al.* 1987). Stumm & Lee (1961) examined the oxidation rate of dissolved ferrous iron at pH between 6.5 and 8.0 and described the following rate equation for ferrous iron oxidation.

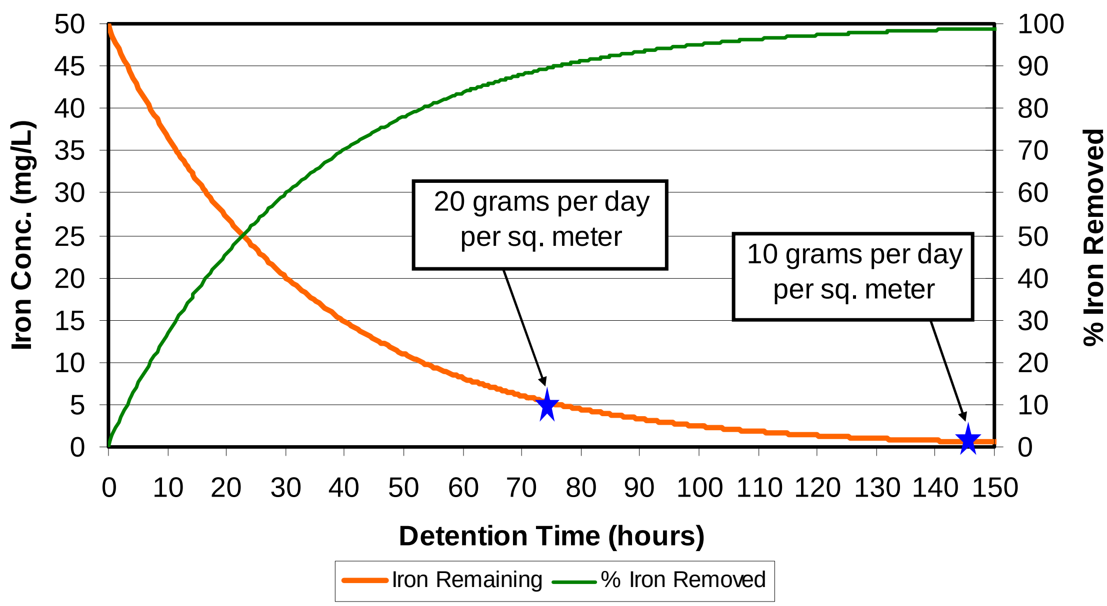
(7) $$\textbf{Homogeneous rate} = (-d[\mathrm{Fe(II)}]/dt) = k_{Ho}\,[\mathrm{Fe(II)}][\mathrm{DO}]\{\mathrm{H}^+\}^{-2}$$

The equation is only valid for the pH range between 5.5 to 8 where the oxidation of $Fe(OH)_2^o$ dominates the homogeneous oxidation of Fe(II). $\mathbf{k_{Ho}}$ is the homogeneous oxidation rate constant and $\mathbf{\{H^+\}}$ is the hydrogen ion concentration (calculated from pH). The concentrations are expressed in molar units. The square on the hydrogen ion concentration shows that pH is an important control on ferrous iron oxidation. A 0.2 pH unit change from 6.3 to 6.5 results in a tripling of the oxidation rate. Stumm and Morgan (1996) reported an oxidation rate constant (k'_{Ho}) of $8.0 \times 10^{13}\ L^2 min^{-1} atm^{-1} mol^{-2}$ at 20°C where the rate was expressed in terms of $\{OH^-\}^2$ and $P_{O2,}$ which corresponds to $k_{Ho} = 9.3 \times 10^{-14}\ M\ s^{-1}$ when expressed in terms of $\{H^+\}^{-2}$ and [DO]. Dempsey *et al.* (2001) reported an estimated activation energy (E_a) of 237 kJ/mol, which shows the importance of temperature on the oxidation rate. The activation energy equates to a doubling of the rate for every 5°C (9°F) change in temperature, reflecting the importance of water temperature (and season) on iron oxidation and removal.

A simulated ferrous iron oxidation curve using the abiotic ferrous iron oxidation equation for the conditions indicated is depicted in Figure TUE-6. This figure indicates it takes approximately 55 hours to achieve 80% removal, 80 hours to achieve 90% removal and 150 hours to achieve 99% removal. As a comparison, the 10 and 20 grams of iron removed per day per square meter ($gr/day/m^2$) yield detention times (assuming a 4 feet pond depth) of 146 and 73 hours, respectively. This provides evidence that iron removal in aerobic ponds is controlled by ferrous iron oxidation. Unlike the fixed removal rates (10 and 20 $gr/day/m^2$), the homogeneous oxidation equation reflects remaining detention times in the pond, based on the amounts of solids that have accumulated in the pond and or the effects of short-circuiting. It also shows the oxidation equation may be a more useful design tool, as the size will adjust according to discharge and expected pond chemistry (e.g., pH and influent iron concentration).

Figure TUE-6. Homogeneous ferrous iron oxidation as a function of detention time

pH = 6.5, DO=7 mg/L, T=11^{o}C



The field evaluation was conducted to evaluate the conditions of the aerobic ponds and identify simple field or analysis methods to evaluate the current operating conditions and determine criteria on which to base future OM&R efforts for aerobic ponds. Field parameters used to examine operating conditions of aerobic ponds included:

- Influent/Effluent Dissolved Oxygen (DO) – an important parameter for ferrous iron oxidation in the aerobic pond. The dissolved oxygen concentration could provide an evaluation of whether gas transport (atmospheric oxygen to dissolved oxygen) is adequate to maintain needed levels of ferrous iron oxidation.
- Influent/Effluent pH – a measure of hydrogen ion activity; a controlling factor in ferrous iron oxidation. A comparison of both provides insight to the effectiveness of iron removal.
- Influent/Effluent Ferrous Iron, Total Iron and Ferric Iron – the form of iron is determined to separate soluble ferrous iron from particulate ferric iron in order to evaluate ferrous iron oxidation.
- Influent/Effluent Alkalinity – evaluates consumption of alkalinity as a result of removal of iron, which is known to be 1.8 mg/L of alkalinity consumed for every 1 mg/L of ferrous iron removed.
- Influent/Effluent Temperature – temperature is an important factor in ferrous iron oxidation with the rate increasing with increasing temperature.

The parameters listed focus on the oxidation of ferrous iron and removal of iron from the aerobic ponds. The focus is limited to iron because this is the primary/sole objective of the aerobic ponds in the Mill Creek Watershed at this point in time.

Table TUE-3 summarizes the field measurements taken from the aerobic ponds as part of this study. Dissolved oxygen (DO) was found to increase across all settling ponds. However, several of the ponds (Howe Bridge and Filson 6) had measured outlet dissolved oxygen of less than 50% saturation, indicating ferrous oxidation is limited by the lower dissolved oxygen. Temperature increased across all aerobic ponds reflecting the warm season in which the survey was conducted. This warm weather temperature results in faster oxidation, 5 to 10 times faster, than would occur during cooler seasons when heating of the water is not as great and/or water temperatures decrease. The pH increased and decreased across aerobic ponds and depends on the initial alkalinity and the acidity released by the ferrous iron as it is oxidized and precipitated (there is 1.8 mg/L of acidity for every 1 mg/L of ferrous iron oxidized and removed). The decrease in pH can be observed across the Howe Bridge Pond 1, which removed 90 mg/L of ferrous iron and showed a decrease in pH by 0.5 units and an associated alkalinity decrease of over 100 mg/L. As a comparison, the Morrow aerobic pond showed a pH increase to greater than 7, but still had alkalinity greater than 200 mg/L. Total and ferrous iron decreased across all aerobic ponds. The decreases reflect the importance of ferrous iron oxidation in the removal of iron in aerobic ponds. Iron removal between ponds varied between 25 to 97%.

Table TUE-3. Summary of results from aerobic pond field evaluation conducted on July 14 and 15, 2005 as part of the MCC OM&R Plan.

Site		DO mg/L	Temp °C	pH	Cond µS	Alkal. mg/L	Total Iron mg/L	Fe^{2+} Iron mg/L
Howe Bridge 1	--	Full of Solids						
Howe Bridge 2	In	0.20	10.1	6.34	1227	148	199.0	196.0
	Out	2.40	22.0	5.82	1094	23	125.0	106.0
Filson 4	In	0.12	18.6	5.99	1307	114	40.2	41.2
	Out	8.20	28.0	3.95	1296	0	2.0	1.1
Diava	In	6.50	11.7	6.17	735	63	16.2	16.3
	Out	6.90	15.7	6.22	748	61	12.0	9.6
Simpson	In	0.28	13.5	6.42	980	228	50.0	47.4
	Out	7.00	25.8	6.86	891	135	1.5	0.3
Beagle	--	Upflow into cell						
Filson 5 Pond	In	4.10	16.5	6.61	853	268	30.6	29.1
	Out	4.20	23.5	6.91	807	205	1.6	0.2
Filson 6 Pond	In	0.75	12.9	6.39	862	247	49.8	49.6
	Out	1.20	15.7	6.37	829	212	35.6	35.2
Morrow 1	In	0.15	13.1	6.86	689	214	8.3	8.4
	Out	6.19	21.9	7.29	640	170	0.7	0.0
McKinley 2	In	6.40	18.0	5.92	1233	30	4.7	4.7
	Out	7.60	22.5	5.90	1182	7	1.5	1.0
Schnepp 1	In	0.28	10.8	6.27	1120	143	82.5	81.0
	Out	7.00	27.9	4.76	980	1	2.2	0.6

The results of the field analysis and survey to evaluate operational parameters identified several parameters that may be useful in evaluating operating conditions of aerobic ponds/wetlands. Total or ferrous iron measured at the influent and effluent is the most useful in evaluating current performance, operational issues, and assessing required maintenance to the units. As can be seen in Figure TUE-6, iron removal is a function of the detention time.

To evaluate whether the oxidation model predicts performance, several units were examined in the Filson 5/6 passive treatment system. The field data (pH, dissolved oxygen, and temperature) collected during the field analysis was used as input in the oxidation model. Figure TUE-7 and TUE-8 show the data collected and the oxidation model results for the Filson 5 and Filson 6 aerobic ponds (Filson 5 Aerobic Pond 1 and Filson 6 Aerobic Pond 1) that follow the ALD. The two aerobic ponds are similar in size, but receive different flows and have different accumulation depths of iron oxide. The effluent iron concentrations collected compare closely to the abiotic ferrous iron oxidation model results for the conditions sampled. The results indicate the abiotic model predicts operating performance of aerobic ponds. The Filson 5 aerobic pond had an effluent iron concentration near 0 mg/L, which the model predicted would occur after 30 hours for the conditions measured in the aerobic pond. As a comparison, the Filson 6 aerobic pond only showed about 40% iron removal, which the oxidation model predicted reasonably well. This lower removal was related to the higher flow and greater iron solids accumulated in this pond that cause a lower detention time. The lower detention time and higher influent iron in the aerobic pond cause the lower pH, dissolved oxygen and temperatures. The figures also show a comparison of the field data to both expected average conditions and maximum flow conditions. This is an important consideration because the observed conditions in the two ponds are related to the summer conditions (i.e., higher temperature increases and lower flows). The abiotic oxidation modeling shows that iron removal will be lowered across each pond during average and higher flow conditions, which is related to the detention time in the ponds.

Figure TUE-7. Calculated Iron Removal in Filson 5 Pond as a function of detention time

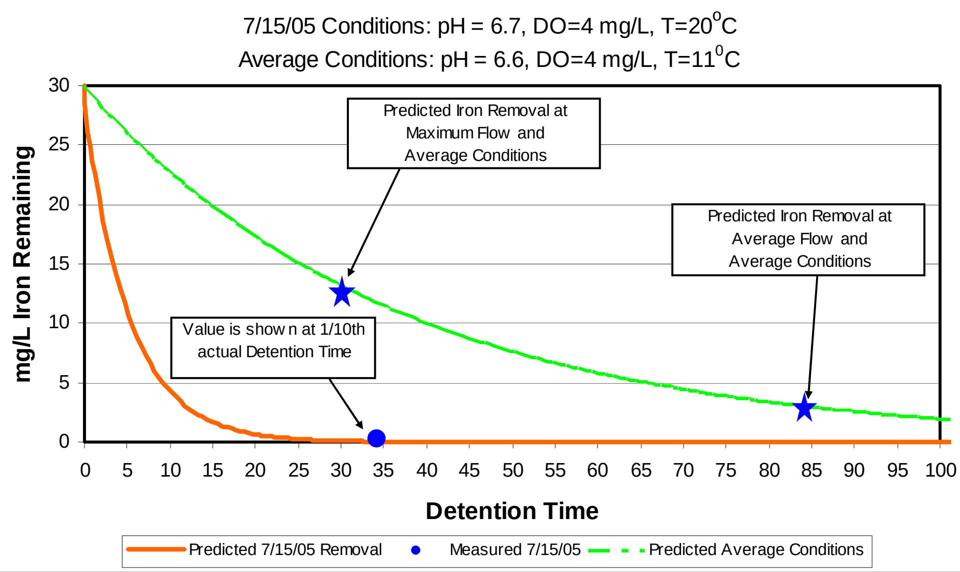
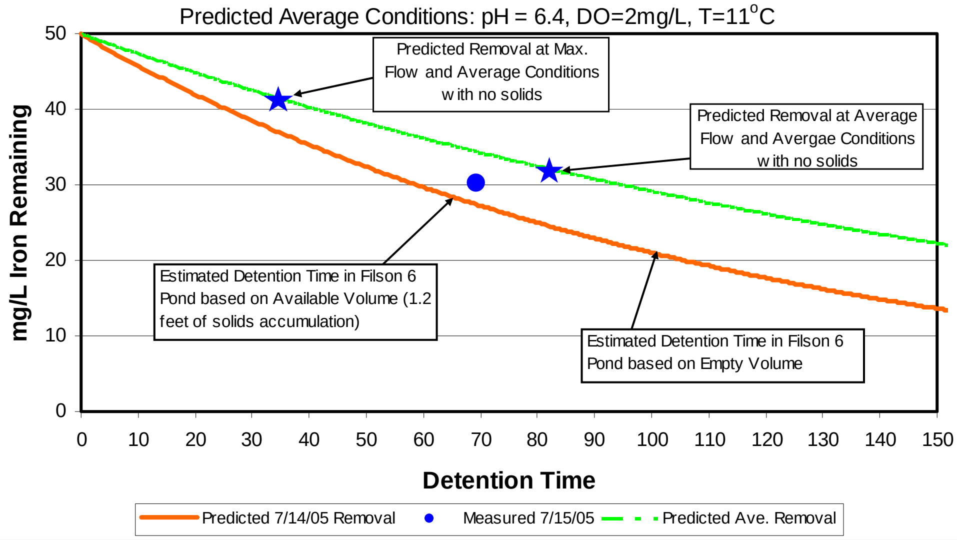


Figure TUE-8. Calculated Iron Removal in Filson 6 Pond as a function of detention time

7/15/05 Conditions: pH = 6.4, DO=2 mg/L, T=14^{o}C

Predicted Average Conditions: pH = 6.4, DO=2mg/L, T=11^{o}C



Iron removal in aerobic ponds is clearly a function of detention time with iron removal increasing as detention time increases. However, it is not linear as suggested by the conventional 10 and 20 gr/day/m^2 removal rates. Figure TUE-6 details iron removal will only slightly change over a broad range of detention times; 20% decrease in removal as detention time decreases from 150 to 50 hours. The decrease in detention time is attributed to the filling of the unit with iron oxide solids. After this initial slow change, Figure TUE-6 shows iron removal will decrease rapidly, dropping by 10% for every 5 to 10 hours change in detention time, as indicated by the steeper regions of the curves shown on Figure TUE-6. As a result, the filling of the ponds with iron oxide solids and its corresponding decrease in detention time will be reflected in performance as % iron removal of the unit.

Based on the above evaluation, the aerobic pond/wetland criteria developed for the OM&R effectiveness levels are:

- ***Satisfactory Effectiveness*** - % iron removal is greater than 90%.
- ***Moderate Effectiveness*** - % iron removal is between 80 and 90%.
- ***Reduced Effectiveness*** - % iron removal is less than 80%.

Sampling Protocol

Based on the above selection of operating conditions and operational assessment, several parameters of the passive treatment units will need to be monitored. Table TUE-4 summarizes the various parameters, locations of samples, frequency and time period for sampling that will need to be monitored at each type of treatment unit. The only additional field equipment needed to conduct the field assessment is an Eh field pen. All other parameters are currently sampled and analyzed by the MCC at the various sample locations.

Table TUE-4. Summary of required sampling and analysis for operational assessment of treatment units in MCC passive treatment systems.

Treatment Unit	Water Quality Parameter	Location	Frequency	Time Frame
ALD	Alkalinity Total Iron Total Manganese	ALD Effluent	1 per year	May
SAPS/AVFW	Eh	Underdrain Outlet	1 per year	May
Aerobic Pond	Total Iron	Influent & Effluent	1 per year	May

The limited number of parameters for operational assessment can potentially decrease the current sampling efforts by the MCC. The proposed monitoring consists of routine sampling of the influent and effluent discharges at each passive treatment system and the operational parameters listed above that can be collected in conjunction with routine sampling. This would be a substantial decrease in sampling and analysis effort by MCC; current sampling is at influent, effluent and all intermediate points in the various systems.

To further assist the MCC in the required sampling, Table TUE-5 has been developed to provide a sampling summary. This table provides the passive system name, sample identification, treatment unit and water quality parameters to be sampled at each location.

Table TUE-5: Passive Treatment System Sampling Parameters for GIS analysis.						
System	**Sample Point**	**Type**	**Alkalinity**	**Mn**	**Fe (total)**	**Eh**
Beagle	BE_S1	SAPS	---	---	☼	☼
	BE_B1	Aerobic Pond	---	---	☼	---
Bog	BO_S1	SAPS	---	---	---	☼
	BO_S2	SAPS	---	---	---	☼
Daiva	DI_A1	ALD	☼	☼	☼	---
	DI_B1	Aerobic Pond	---	---	☼	---
Filson1	F1_S1	SAPS	---	---	☼	☼
	F1_B1	Aerobic Pond	---	---	☼	---
	F1_B2	Aerobic Pond	---	---	☼	---
	F1_S2	SAPS	---	---	---	☼
	F1new_S3	SAPS	---	---	☼	☼
	F1new_B3	Aerobic Pond	---	---	☼	---
Filson2	F2_S1	SAPS	---	---	☼	☼
	F2_B1	Aerobic Pond	---	---	---	☼
Filson3	F3_S1	SAPS	---	---	---	☼
Filson4	F4_A1	ALD	☼	☼	☼	---
	F4_S1	SAPS	---	---	☼	☼
	F4_B1	Aerobic Pond	---	---	---	---
	F4_B2	Aerobic Pond	---	---	☼	---
Filson5/6	F5_A1	ALD	☼	☼	☼	---
	F5_B1	Aerobic Pond	---	---	☼	---
	F5_S1	SAPS	---	---	☼	☼
	F5_B2	Aerobic Pond	---	---	☼	---
	F6_A1	ALD	☼	☼	☼	---
	F6_B1	Aerobic Pond	---	---	☼	---
	F6_B2	Aerobic Pond	---	---	☼	---
Howe Bridge	HB_A1	ALD	☼	☼	☼	---
	HB_A2	ALD	---	---	---	---
	HB_B0	Aerobic Pond	---	---	☼	---
	HB_B1	Aerobic Pond	---	---	☼	---
	HB_S1	SAPS	---	---	---	☼
	HB_B2	Aerobic Pond	---	---	---	---
	HB_S2	SAPS	---	---	☼	☼
	HB_B3	Aerobic Pond	---	---	☼	---
McKinley1	MK1_S1	SAPS	---	---	☼	☼
	MK1_B1	Aerobic Pond	---	---	☼	---
McKinley2	MK2_S1	SAPS	---	---	☼	☼
	MK2_B1	Aerobic Pond	---	---	☼	---
Morrow	MO1_A1	ALD	☼	☼	☼	---
	MO1_B1	Aerobic Pond	---	---	☼	---
	MO1_B2	Aerobic Pond	---	---	☼	---

Table TUE-5 (cont): Passive Treatment System Sampling Parameters for GIS analysis.

System	Sample Point	Type	Alkalinity	Mn	Fe (total)	Eh
REM	REM(ALD)	ALD	☼	☼	☼	---
	REM(SB1S)	Aerobic Pond	---	---	☼	---
	REM(SAPS1S)	SAPS	---	---	☼	☼
	REM(SB2S)	Aerobic Pond	---	---	☼	---
	REM(SB1N)	Aerobic Pond	---	---	☼	---
	REM(SAPS1N)	SAPS	---	---	☼	---
	REM(SB2N)	Aerobic Pond	---	---	☼	---
	REM(SB3N)	Aerobic Pond	---	---	☼	---
	REM(SAPS2N)	SAPS	---	---	☼	☼
	REM(SB4N)	Aerobic Pond	---	---	☼	---
	REM(SAPS3N)	SAPS	---	---	☼	☼
	REM(SB5N)	Aerobic Pond	---	---	☼	---
	REM(SB6N)	Aerobic Pond	---	---	☼	---
Simpson1	SI1_A1	ALD	☼	☼	☼	---
	SI1_B1	Aerobic Pond	---	---	---	---
	SI1_B2	Aerobic Pond	---	---	☼	---
Schnepp1/2	SR_A1	ALD	☼	☼	☼	---
	SR_B1	Aerobic Pond	---	---	☼	---
	SR_B2	Aerobic Pond	---	---	---	---
	SR_B3	Aerobic Pond	---	---	---	---
	SR_B4	Aerobic Pond	---	---	---	---
	SR_S1	SAPS	---	---	---	---
	SR_S2	SAPS	---	---	---	☼

Note:
Systems listed in alphabetical order.
☼ indicates parameter to be sampled
Aerobic ponds require iron influent and iron effluent. Typically, a component effluent is the downstream component's influent. Using the Simpson1 system as an example, the aerobic pond 2 effluent iron would be sampled at the aerobic pond 2 discharge. The influent iron used for component effectiveness evaluation would be iron concentration obtained from the ALD effluent iron concentration.

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GIS APPLICATION SUMMARY

The Mill Creek Coalition OM&R Plan GIS application was developed using ERSI ArcView 8.3 and Microsoft Access. Microsoft Access stores all treatment system and sample data and performs any necessary calculations. ArcView 8.3 is utilized to geospatially arrange the data and provide a user interface to access the Microsoft Access database.

Microsoft Access

The various tables, queries, forms and reports found in the Mill Creek Coalition OM&R database are summarized below.

General Notes:

1. If the Main Switchboard does not appear when the Access file is opened, go to “Forms” and doubleclick “Switchboard”.
2. All data input, editing, report generation, should be done from the Main Switchboard or a subsequent switchboard.

Enter new water chemistry data.

1. From the Main Swithboard, click the appropriate data entry category.
2. Choose sample site from combo-box.
3. Enter sample date as mm/dd/yy.
4. Enter data in appropriate locations in correct units.
5. Click arrow button at the bottom of the page to enter next data entry (go to #2).
6. After entering the last data entry, click the “Update and Exit” button to close the form. Accept the three prompts to overwrite data if data has been entered correctly.

Enter new OM&R system component analysis data.

1. From the Main Swithboard, click the appropriate data entry category.
2. Choose sample site from combo-box
3. Enter sample date as mm/dd/yy.
4. Enter data in appropriate locations in correct units.
5. Click arrow button at the bottom of the page to enter next data entry (go to #2).
6. After entering the last data entry, click the “Update and Exit” button to close the form. Accept the three prompts to overwrite data if data has been entered correctly.

Edit water chemistry data.

1. From the Main Swithboard, click the “Edit Existing Data” entry, then chose the appropriate data edit category.
2. Scroll through the existing data to find the data to be modified.
3. Modify data in appropriate locations in correct units.
4. After editing the data entry, click the “Update and Exit” button to close the form. Accept the three prompts to overwrite data if data has been entered correctly.

Edit OM&R system component analysis data.

1. From the Main Swithboard, click the “Edit Existing Data” entry, then chose the appropriate data edit category.
2. Scroll through the existing data to find the data to be modified.
3. Modify data in appropriate locations in correct units.
4. After editing the data entry, click the “Update and Exit” button to close the form. Accept the three prompts to overwrite data if data has been entered correctly.

Generate Pre-defined Reports

1. From the Main Swithboard, click the “Reports” entry, then chose the appropriate repot category.
2. Right click within the report and print.

The following is a listing of all tables, queries, forms and reports found in the Access database with a brief description.

Access Tables:

CellAnalysis
Summary of OM&R sample point data.

CellCALCs
Summary of field data & calculations of DG recommended sampling parameters. Data entered from “CellAnalysis_data_analysis” form. Automatically generated table created when GIS_Post_system_data (Post-System Data Input Form) form button “Update & Exit” is executed. Do not delete/edit/modify; this table is directly linked to ArcMap.

CellIDs
Listing of Cell Identifiers for system components.

GDB_*
Automatically generated tables created by geodatabase. Do not delete/edit/modify.

GIS_Post_system_data
Summary of all post system water chemistry samples (CUP data). Enter data from switchboard (form “GIS_Post_system_data_entry”).

GIS_Pre_system_data
Summary of all pre system water chemistry samples (CUP data). Enter data by form switchboard (form “GIS_Pre_system_data_entry”).

GIS_Report_PDF
Summary of pdf reports for individual treatment sites.

GIS_System_Desc
Summary of system data. Designer, funding source, operation date, etc.

GIS_system_sample points
Summary of water chemistry sample points for "GIS_Pre_system_data" and "GIS_Post_system_data". Enter new sample points by form "GIS_New_sample_point_location".

GIS_UpdateTable_WaterData
Automatically generated table created when GIS_Post_system_data (Post-System Data Input Form) form button "Update & Exit" is executed. Do not delete/edit/modify; this table is directly linked to ArcMap.

MCCwatershedBndy
Automatically generated table created by ArcMap. Do not delete/edit/modify.

MCCwatershedBndy_Shape_Index
Automatically generated table created by ArcMap. Do not delete/edit/modify.

RankDescription
Summary of numeric ranking and description.

SamplePts
Automatically generated table created by ArcMap. Do not delete/edit/modify.

SamplePts_Shape_Index
Automatically generated table created by ArcMap. Do not delete/edit/modify.

SelectedObjects
Automatically generated table created by ArcMap. Do not delete/edit/modify.

Selections
Automatically generated table created by ArcMap. Do not delete/edit/modify.

StrmChemMonitoringPts
Automatically generated table created by ArcMap. Do not delete/edit/modify.

StrmChemMonitoringPts_Shape_Index
Automatically generated table created by ArcMap. Do not delete/edit/modify.

Switchboard Items
Automatically generated table created by Access. Do not delete/edit/modify.

SysStandardsTable
Numeric rank and evaluation parameter trigger values

SystemNamePolygon
Automatically generated table created by ArcMap. Do not delete/edit/modify.

SystemNamePolygon_Shape_Index
Automatically generated table created by ArcMap. Do not delete/edit/modify.

TRTcellPolygon
Automatically generated table created by ArcMap. Do not delete/edit/modify.

TRTcellPolygon_Shape_Index
Automatically generated table created by ArcMap. Do not delete/edit/modify.

Access Queries:

Cell_Analysis_Currentdata
Latest cell analysis of OM&R sample data query. Cell IDs sorted by maximum sample date.

GIS_ArcView_Latest_Water_Data_UpdateTable
Latest water chemistry of CUP sample data used as GIS data source. Converts query into table "GIS_Update_Table_WaterData". Do not delete/edit/modify.

GIS_Cell_Analysis_Latest_SampleDate
Query of Cell_Analysis of maximum system date.

GIS_POST_latest_system_sample
Query of GIS_Post_system_data of maximum system date.

GIS_Post_system_query
Query of post system sample points.

GIS_PRE_latest_system_sample
Query of GIS_Pre_system_data of maximum system date.

Query_CellCALCs
Latest OM&R data for GIS. Converts query into table "CellCALCs". Do not delete/edit/modify.

Report_Component_Rankings
Summary of site system ranking for "Report_Component_Rankings_ALL"

Access Forms:

CellAnalysis_data_analysis
Input form for "CellAnalysis" table.

GIS_New_sample_point_location
Input form for "GIS_system_sample points" table.

GIS_Post_system_data_entry
Input form for "GIS_Post_system_data" table.

GIS_Pre_system_data
Input form for "GIS_Pre_system_data" table.

Switchboard
Main form for navigation throughout Access

Access Reports:

GIS_Post_Latest_Sample_Summary
Summary report of last sample date for specific sample points.

GIS_Pre_latest_system_sample
Summary report of last sample date for specific sample points.

GIS_system_sample_pt_Inventory
Summary of all pre and post sample points.

GIS_system_sample_summary_POST
Summary of all post water chemistry samples.

GIS_system_sample_summary_PRE
Summary of all pre water chemistry samples.

Report_Component_Rankings_ALL
Summary of system component rankings utilizing latest OM&R sample date data.

ERSI ArcView

The GIS application utilizes several data sources to create a geospatial map of the Mill Creek Coalition passive treatment facilities. Various data sources include: 1)USGS maps; 2) infra-red aerial photographs; 3) road networks; 4) stream networks; and 5) customized Mill Creek Coalition treatment system data. In addition, the following Microsoft Access tables detailed above are linked to the GIS application:

- Tables: CellIDs, GIS_Post_system_data, GIS_System_desc, GIS_Report_PDF, CellAnalysis, CellCALCs, GIS_UpdateTable_WaterData,

All data assists the user to navigate throughout the GIS application. Various symbols and color/hatch schemes are utilized to present the user with visual indicators as to the treatment system conditions. Current and historic data found in the Microsoft Access database can be accessed by the GIS application. Also, visual indicators presented in the GIS output for component effectiveness are shown in Figure GIS-1.

Table GIS-1 summarizes the results of the ALD cubitainor study that are required by the GIS application.

General Notes:

1. To zoom to specific treatment sites, from the View menu chose Bookmarks and then a specific site.
2. Accessing CUP water data
    a. Current data:
        i. Select sample location point.
        ii. Open attribute table and click "Selected" button to view data records.
    b. Historic data:
        i. Follow same procedure for Current data.
        ii. Click "Options" and then chose "Related Tables" to open a new attribute table detailing the selected sampling point historic records.
3. Accessing OM&R data:
    a. Open the attribute table for the Site_ALD, Site_Basin, or Site_SAP.
4. Accessing site schematics and OM&R report.
    a. Use hyperlink button to access site schematic and OM&R report pdfs. Verify "Treatment System – General Data & Schematic" and "Treatment System – OM&R Report" layers are active.

Datasets & Layers:

The following is a listing of all datasets and layers in the ArcMap application with a brief description.

Treatment System Monitoring Points
Location of current CUP monitoring point locations. Points linked to current and historic water sample data.

Stream Chemistry Monitoring Points
Location of current CUP monitoring point locations.

Treatment System – General Data & Schematic
Attribute table summaries system information. Hyperlinks to treatment system schematic.

Treatment System – OM&R Report
Hyperlinks to specific treatment system OM&R report.

Treatment Components – Overview
Locates all treatment system components.

Site_ALD
Details treatment effectiveness based upon most current field data. Shapefile joined to Access table "CellCALCs."

Site_Basin
Details treatment effectiveness based upon most current field data. Shapefile joined to Access table "CellCALCs."

Site_SAP
Details treatment effectiveness based upon most current field data. Shapefile joined to Access table "CellCALCs."

Watershed Boundary
Details Mill Creek watershed boundary.

USGS_Corsica
USGS quadrangle coverage.

USGS_Brookville
USGS quadrangle coverage.

Jefferson_IR
2004 infrared photograph

Clarion_IR
2004 infrared photograph

Figure GIS-1: Legend of Treatment Unit Operating Condition

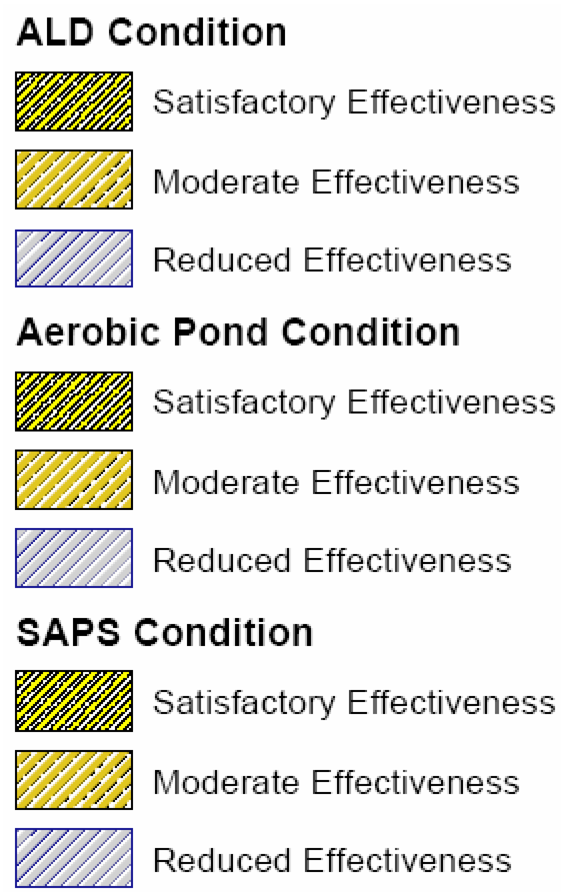


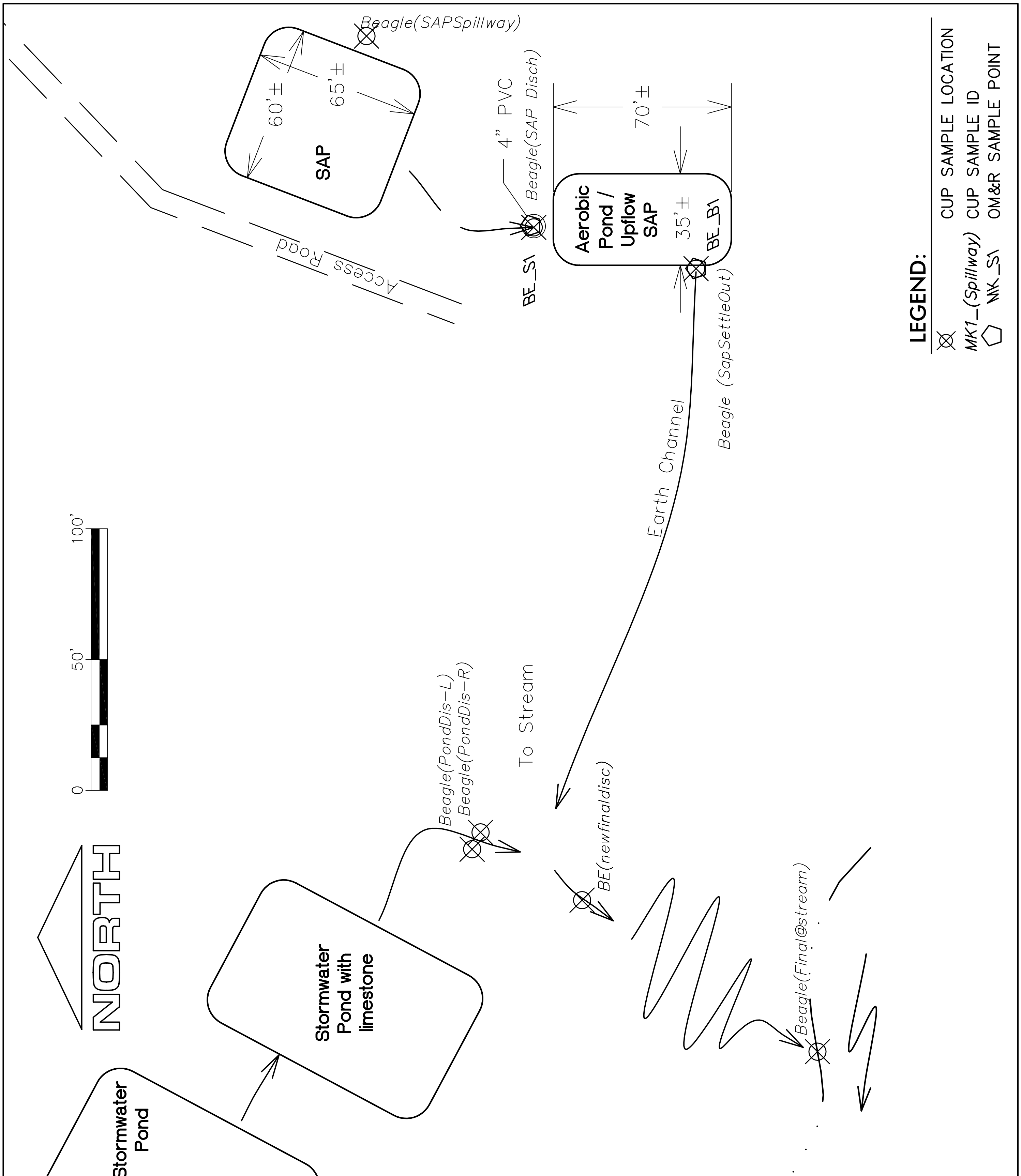
Table GIS-1: ALD Cubitainor Test Results	
System (Sample Point)	**Cubitainor Alkalinity (mg/L)**
Daivia (DI_A1)	not operational
Filson4 (F4_A1)	283
Filson5 (F5_A1)	341
Filson6 (F6_A1)	341
Howe Bridge (HB_A1)	263
Howe Bridge (HB_A2)	not operational
Morrow (MO1_A1)	205
Schnepp1/2 (SR_A1)	249
Simpson1 (SI1_A1)	297

Beagle Passive Treatment System

Cell 1 – Upflow SAPS

Cell 2 – Aerobic Pond white pipe is SAPS Outlet

Discharge Channel



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 Beagle-1 Existing Beagle Treatment System & OM&R Sample Points Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Beagle passive treatment system was reviewed and data evaluated to determine performance and recommendations for the system. The following summarizes the findings:

- There are two separate AMD sources being treated in the Beagle system:
  - a toe-of-spoil, low pH, high aluminum discharge
  - an upwelling anoxic, high iron discharge.
- The current passive treatment system is performing inadequately for a number of reasons:
  - The constructed location of the SAPS (or Aluminator) had an unexpected effect on the toe-of-spoil AMD discharge hydrology causing little or no flow to be treated or discharged, or the high aluminum chemistry and subsurface inflow caused the SAPS to fail.
  - The constructed aerobic pond intercepted deeper high iron source water and can not be treated adequately in the existing aerobic pond that also has little aeration for oxidation.
- Analysis of historical data indicates the SAPS was chemically overloaded, which may have caused premature failure of the SAPS.
- Analysis of the upwelling discharge into the aerobic pond indicates it is net acidic with high iron (~100 mg/L) with characteristics of an anoxic discharge.

Recommendations for the Beagle passive treatment system are as follows:

- Remove and replace the existing system with two separate systems.
- Install a collection channel to collect the toe-of-spoil discharge and convey it to an alternative downgradient location and treat the discharge with an AVFW.
- Collect the upwelling discharge and install an upflow limestone well to add sufficient alkalinity to raise the pH and permit iron removal.
- Construct a new shallow aerobic pond/channel downgradient of the aerobic pond.

The following provides details to support the above summary and recommendations.

System Description

The Beagle passive treatment system layout is depicted on Figure Beagle-1. The Beagle system was constructed in 1998 to treat a toe-of-spoil AMD seep, known as the "Beagle Seep". The original (upper) Beagle Seep was a highly acidic discharge with low pH (< 3.5), high aluminum (> 20 mg/L), and flows of approximately 10 gpm based upon MCC data. The original Beagle passive treatment system was designed to treat this discharge employing an Aluminator© (Damariscotta) or SAPS. The system was modified in 2001 to improve performance of the SAPS and retain iron from a lower elevation discharge encountered during the original construction. The 2001 modifications included an aerobic pond to allow mixing of the SAPS effluent with the high iron seep to promote iron removal in the aerobic pond. Table Beagle-1 details the typical pre-construction AMD characteristics of the upper and lower Beagle seeps.

Table Beagle-1: Typical pre-construction AMD characteristics

	pH	**Alkalinity mg/L**	**Acidity mg/L**	**Al mg/L**	**Fe (total) mg/L**	**Mn mg/L**	**Sulfate mg/L**	**Flow gpm**
Upper	3.3	4	236	28	19	13	685	4
Lower	5.2	15	245	8	109	7	658	11

Operational Assessment

The Beagle passive treatment system was not functioning at the time of the field visit in April 2005 nor during the system assessment on July 14, 2005. The functional issues observed included 1) little or no flow being discharged by the SAPS, and 2) an additional AMD flow containing high iron discharging from the aerobic pond. The first issue, as indicated by the Mill Creek Coalition, is related to the inability of the discharge to flow out of the SAPS due to the elevation at which it was constructed. The second issue is related to the lower elevation AMD discharge entering subsurface into the aerobic pond with inadequate aeration.

Diagnosis

Table Beagle-2 summarizes the current conditions of the Beagle passive treatment system. The SAPS is functioning at a reduced effectiveness due to insufficient AMD inflow caused by the elevation of the discharge pipe or the SAPS underdrain collection piping is plugged. The available data indicate clogging may be an issue because high aluminum concentrations were monitored in the Beagle seep prior to system construction. Clogging may have resulted from the direct contact of the AMD with the limestone. It is also uncertain whether regular flushing is an adequate preventative measure to avert this clogging issue. The aerobic pond is also operating at a reduced effectiveness due to poor iron removal of the subsurface inflow of an anoxic, net acidic, and high iron discharge.

Table Beagle-2: Summary of Beagle passive treatment system unit conditions.			
Unit	**Condition**	**Criteria**	**Effectiveness Level**
SAPS	No or minimal flow	Eh ≥ 0 mV	Reduced
Aerobic Pond	Effluent Iron = 106 mg/L	Fe Removal <80%	Reduced

Design Methodology

No design basis was available. Table Beagle-3 provides the estimated surface area and limestone volume in the SAPS treatment cell. Table Beagle-3 also provides the estimated limestone bed detention time, acidity loading and surface hydraulic loading on the SAPS.

Table Beagle-3: Summary of Beagle passive treatment system estimated size and design parameters					
SAPS	**Surface Area ft^2**	**Limestone Volume ft^3**	**Limestone Bed Detention Time hrs**	**Acidity Loading $gr/day/m^2$**	**Hydraulic Loading gpm/acre**
Cell 1	3,900	8,800	30-40	55	167

Comparing the acidity loading and hydraulic loading in Table Beagle-3 to reported design guidance for an AVFW of 25 $gr/day/m^2$ and 150 gpm/acre (Rose & Dietz 2002, Dietz et al 1996, and Dietz 1997) indicate the SAPS is only slightly overloaded with respect to both parameters when the system is receiving maximum reported historical flows. It is likely this system size would have been adequate to treat the upper Beagle AMD discharge if construction and operational problems related to the location of the SAPS in relation to the discharge elevation were mitigated. Clogging of the SAPS can not be eliminated as a cause of the operational problems since the upwelling of the high aluminum AMD would directly contact the limestone in the vicinity of the underdrain piping.

Action

As shown in Beagle-2, the treatment units in the Beagle system are currently operating at a reduced effectiveness level. No repairs or changes in operation can resolve the existing problems within the present Beagle passive treatment system. Recommendations for the Beagle AMD discharge include:

1) Upper AMD Seep - Removal of the existing SAPS and replacement with a new treatment system located at a lower elevation. The upper discharge will be collected and gravity flow to a new treatment location.
2) Lower AMD Seep - Installation of a new system to address the high iron AMD seep encountered in the aerobic pond.

The two alternatives and recommendations are provided in the following section.

Operation, Maintenance & Replacement Plan

The current Beagle passive treatment system is not functioning and/or is inadequate to address the two AMD sources at this site. Replacement of the system will be required to mitigate the discharges and minimize their impacts on Little Mill Creek. Treatment of the two discharges is important because of their upstream location in the watershed and because they are the first significant AMD sources in the watershed. The following recommendations are based on historical data for the upper Beagle AMD discharge and field observations made during the system assessments for the lower Beagle AMD discharge.

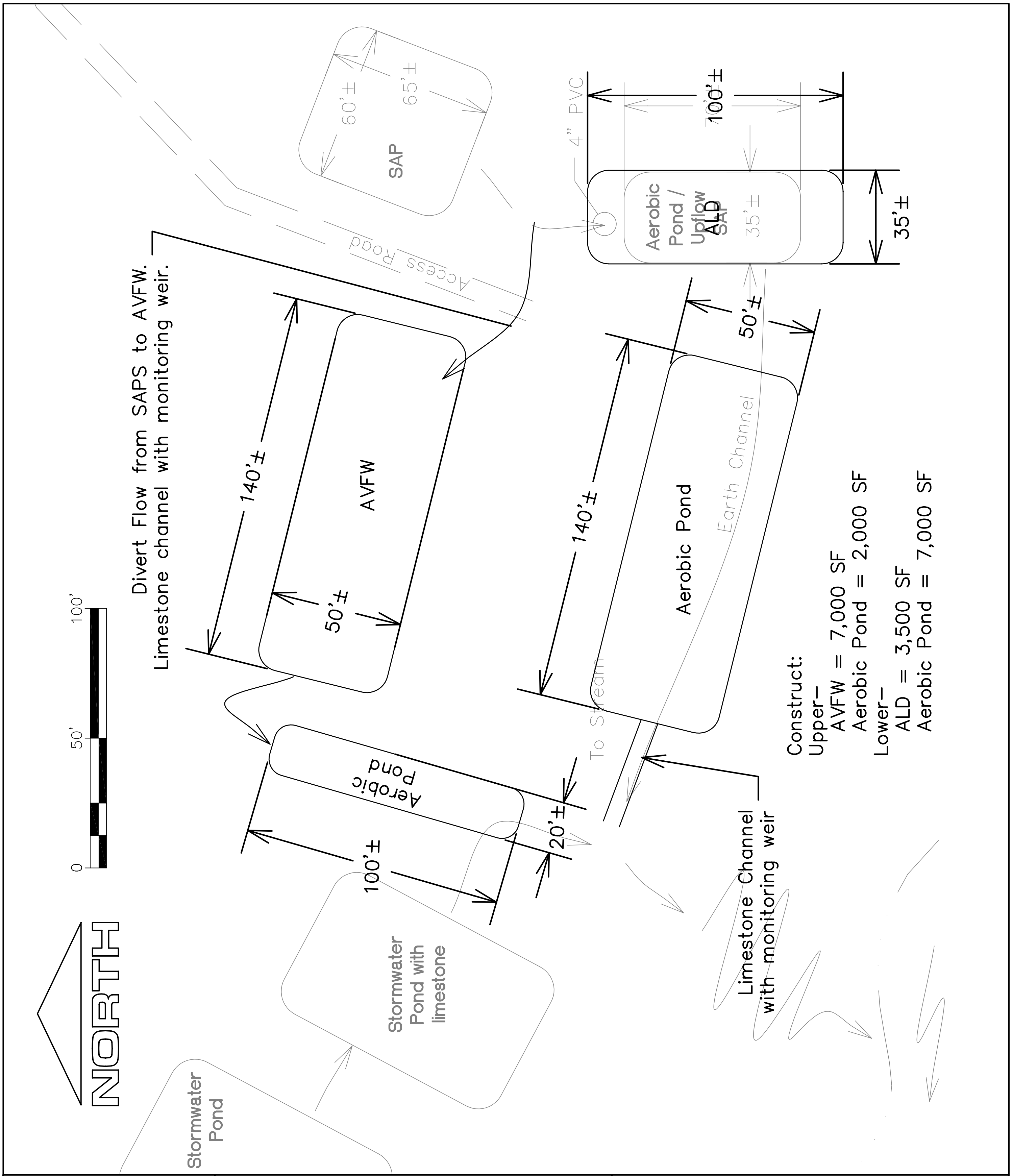
The upper Beagle AMD discharge is a high aluminum, low pH, and high acidity discharge (i.e., aerobic discharge). The discharge characteristics limit the passive treatment choice to an AVFW similar in size to the current system, but with greater organic layer depth. However, the current SAPS location has proven problematic, as well as the SAPS being slightly undersized with respect to the current design information (i.e., acidity loading). The multi-cell model was used to estimate the required size and number of cells needed to address the upper Beagle AMD discharge. Based on the modeling, a single AVFW cell with 7,000 ft^2 of surface area would be adequate to treat 15 gpm (the design basis flow) of AMD discharge with the acidity of the Beagle AMD discharge. A small 2,000 ft^2 aerobic pond would also be included in the system design to retain metals. The conceptual design is depicted in Figure Beagle-2.

Table Beagle-4: Summary of field water quality data for the Beagle AMD discharges

Source	pH	Alkalinity mg/L	Acidity mg/L	Dissolved Oxygen mg/L	Total Iron mg/L	Ferrous Iron mg/L	Aluminum mg/L
Upper	3.30	0	240	--	35	--	26
Lower	5.84	25	200	5.0	106	104	NA

The lower Beagle AMD discharge has different chemical characteristics than the upper discharge. Field observations made in July in the aerobic pond, where the lower discharge emanates, are summarized in Table Beagle-4. The data indicate the discharge has initial alkalinity and a pH greater than 5. In addition, the iron present in this discharge is nearly all as ferrous iron (the soluble reduced form). This data indicate the lower Beagle AMD discharge is an anoxic discharge and can be treated with an anoxic limestone drain or similar approach, in combination with an aerobic pond/wetland to oxidize and remove the iron.

Based on this evaluation, the MAEM-AKM was used to estimate the maximum alkalinity and the rate at which alkalinity can be produced. The model predicts a maximum alkalinity of between 225 and 250 mg/L and indicates the needed alkalinity of greater than 180 mg/L for iron removal can be achieved in approximately 8 to 10 hours of limestone detention time. Using the homogeneous oxidation model, the required detention time to achieve an average 95% removal is approximately 80 hours, which equates to an area for an aerobic pond/wetland of approximately 6,500 ft^2. A conceptual system layout is shown on Figure Beagle-2 and an estimated cost is provided in Table Beagle-5.



Project No.: MCC–OMR Drawing No.: 06–002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	**Figure Beagle-2** **Proposed Modifications** **OM&R Plan** Union Township Jefferson County, PA

Table Beagle-5

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Beagle System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	1.25	ACRE	$ 1,750.00	$ 2,187.50
3.	E&S Control	0.5	LS	$ 10,000.00	$ 5,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	600	CY	$ 5.00	$ 3,000.00
	(b) Wet	4000	CY	$ 6.00	$ 24,000.00
8.	Embankment Construction	975	CY	$ 7.00	$ 6,825.00
9.	Geotextile Liner	3120	SY	$ 15.00	$ 46,800.00
10.	Geonet	780	SY	$ 5.50	$ 4,290.00
11.	High Quality Limestone	1640	Ton	$ 28.00	$ 45,920.00
12.	Mushroom Compost Substrate	520	CY	$ 30.00	$ 15,600.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	580	LF	$ 15.00	$ 8,700.00
	(b) 4" Solid pipe	100	LF	$ 12.00	$ 1,200.00
	(c) 6" Solid pipe	380	LF	$ 12.00	$ 4,560.00
	(d) 4" Gate Valve	2	EA	$ 1,500.00	$ 3,000.00
14.	Orifice Flow Control	2	EA	$ 75.00	$ 150.00
15.	Wetland Vegetation and Planting	440	EA	$ 3.00	$ 1,320.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	350	SY	$ 22.00	$ 7,700.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	4	EA	$ 450.00	$ 1,800.00
20.	Seeding/Restoration	1	Acre	$ 2,400.00	$ 2,400.00
21.	Sludge Removal/Disposal	455	CY	$ 15.00	$ 6,825.00

TOTAL AMOUNT OF COST ESTIMATE **$ 198,777.50**

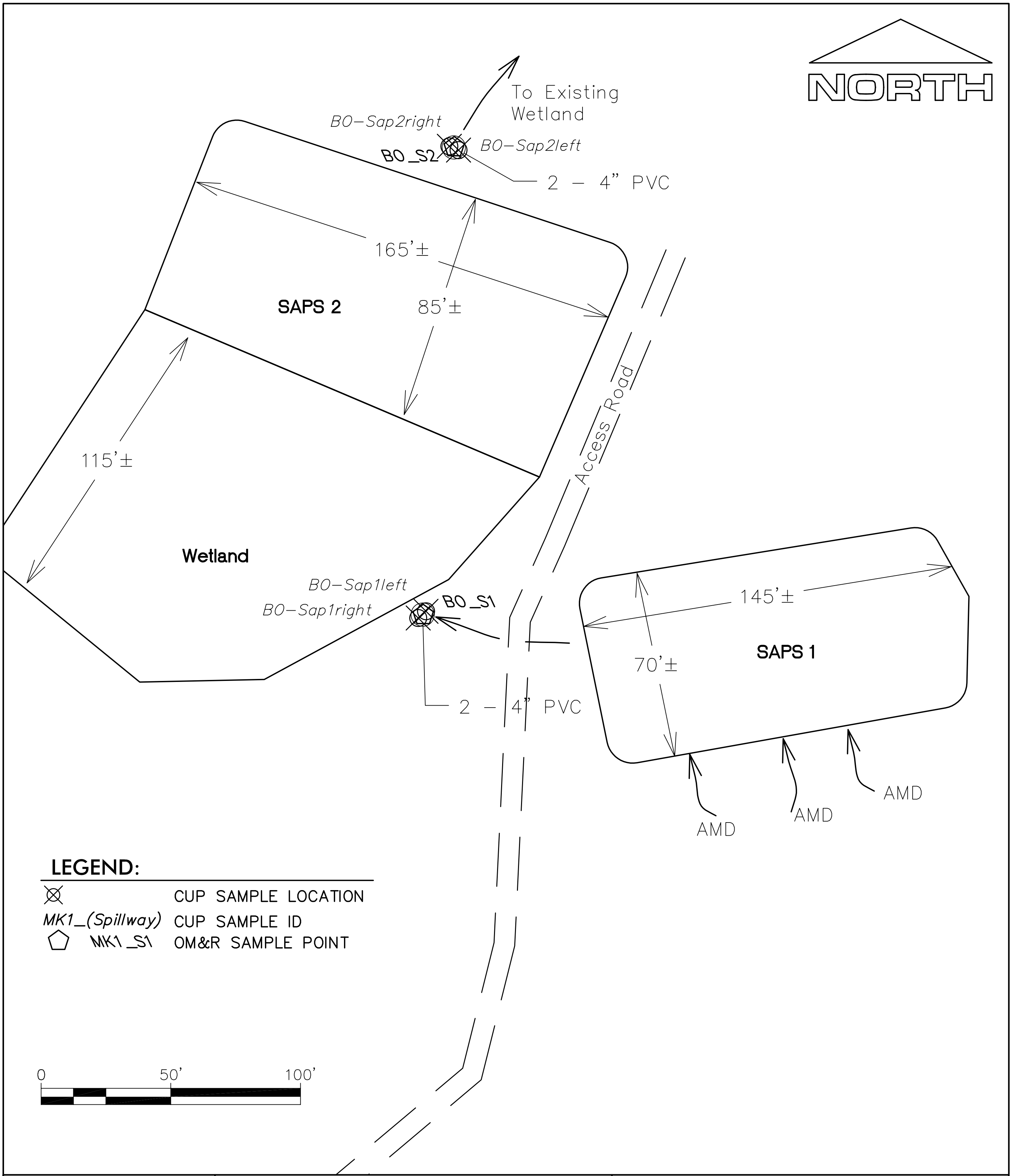
Bog Passive Treatment System

Cell 1 – SAPS

Cell 1 Underdrain Outlet (2 pipes)

Cell 2 - Aerobic Pond/SAPS Wetland

Cell 2 Underdrain Outlet



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 Bog-1 Existing Bog Treatment System & OM&R Sample Points Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Bog passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The Bog passive treatment system is a two-cell SAPS constructed in 2001.
- Current effluent water quality indicates the system is operating satisfactorily with slight deterioration in underdrain performance.
- Analysis of historical data indicates the two SAPS are occasionally hydraulically overloaded (during high flow events) causing significant deterioration in short term performance and long term overall decline of the SAPS performance.
- Effluent iron is gradually increasing from the system and is likely a result of excessive iron oxide solids loading on the second SAPS, an effect of short-circuiting through the aerobic wetland portion of the SAPS.

Recommendations for the Bog passive treatment system are as follows:

- Replace the uncontrolled stand-pipe outlets with flow regulating (orifice) stand-pipes to prevent hydraulic loading during high flow periods.
- Install an overflow spillway connecting SAPS 1 to SAPS 2.
- Install a membrane curtain(s) or earthen berm in SAPS 2 between the aerobic wetland and SAPS portions to minimize short-circuiting and accumulation of iron oxides in the SAPS.
- Monitor flushing to determine if the periods between flushing can be lengthened and/or eliminated as well as the possibility of reduced flushing duration.

The following provides details to support the above summary.

System Description

The Bog passive treatment system layout is depicted in Figure Bog-1. The Bog system was constructed in 1999 to treat toe-of-spoil AMD seeps with low pH and high metals detailed in Table Bog-1. The system started treating the discharge in October 1999 and has been treating the AMD to the present with minimal operation and maintenance effort.

Table Bog-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
3.2	0	200	4	12	44	1,000	50

The Bog passive treatment system consists of two treatment cells. The first treatment cell, SAPS 1, contains a 0.5 feet depth of compost over a 3.5 feet deep bed of limestone. Standing water in the treatment cell is approximately 2 to 3 feet. The surface area of SAPS 1 at the top of the compost is approximately 10,700 ft^2. SAPS 1 receives AMD along the entire length of the cut slope from toe-of-spoil seeps, and may also receive AMD from subsurface seeps entering into the cell. Treated AMD is discharged from SAPS 1 through two, 4-inch diameter underdrain header standpipes to regulate standing water depth in SAPS 1. The underdrains in SAPS 1 are also equipped with valves to permit periodic flushing of the solids collected in the limestone bed. The underdrain discharge from the standpipes flows down a steeply sloped channel that provides aeration to SAPS 1 effluent before entering the second SAPS. An emergency spillway is located in SAPS 1 to carry excess flows. This spillway is located on the backside of the SAPS and directs the overflow away from the remainder of the Bog passive treatment system

SAPS 2 consists of an aerobic wetland in combination with a SAPS. The aerobic wetland in SAPS 2 is approximately 3,000 ft^2 and contains 2 to 3 feet of standing water. The SAPS portion is approximately 10,000 ft^2 and has similar substrate and standing water depth as SAPS 1. SAPS 2 is also equipped with two underdrain discharge headers and flushing valves similar to SAPS 1. The underdrain discharge from SAPS 2 flows into a channel and an established natural wetland.

Operational Assessment

The Bog treatment system was functioning properly, based on all flow passing through the underdrains, at the time of the initial site visit on April 27, 2005 and during the field evaluation conducted on July 14, 2005. Historical alkalinity, pH and flow data from the SAPS underdrains are shown in Figure Bog-2 and Bog-3. Historic effluent data indicate SAPS 1 and SAPS 2 have produced excess effluent alkalinity and circumneutral pH. Closer examination of alkalinity and flow in Figure Bog-2 and Bog-3 shows that effluent alkalinity (and underdrain alkalinity) varied as a function of flow with lower alkalinity observed at higher flow. It is not a direct correlation as there appears to be a lag in alkalinity and pH decreases (and increases) as flow changes. It is also evident that the recent minimum pH and alkalinity in response to flow increases is lower than shortly after the system began treatment.

Figure Bog-2: Bog passive treatment system SAPS 1 underdrain water quality

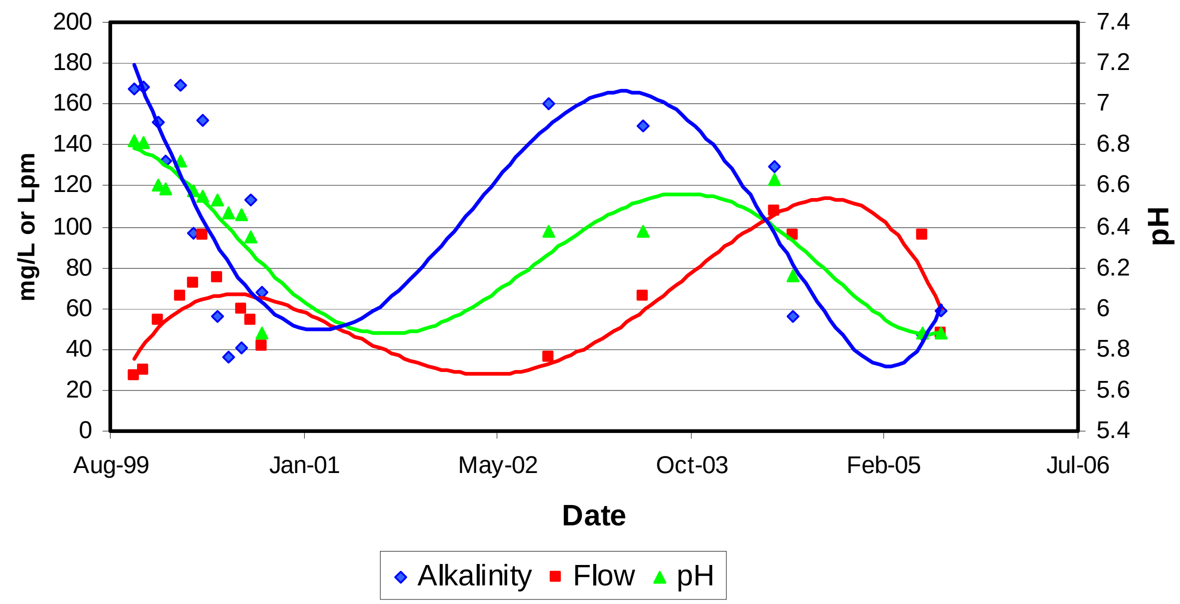


Figure Bog 3: Bog passive treatment system SAPS 2 underdrain water quality

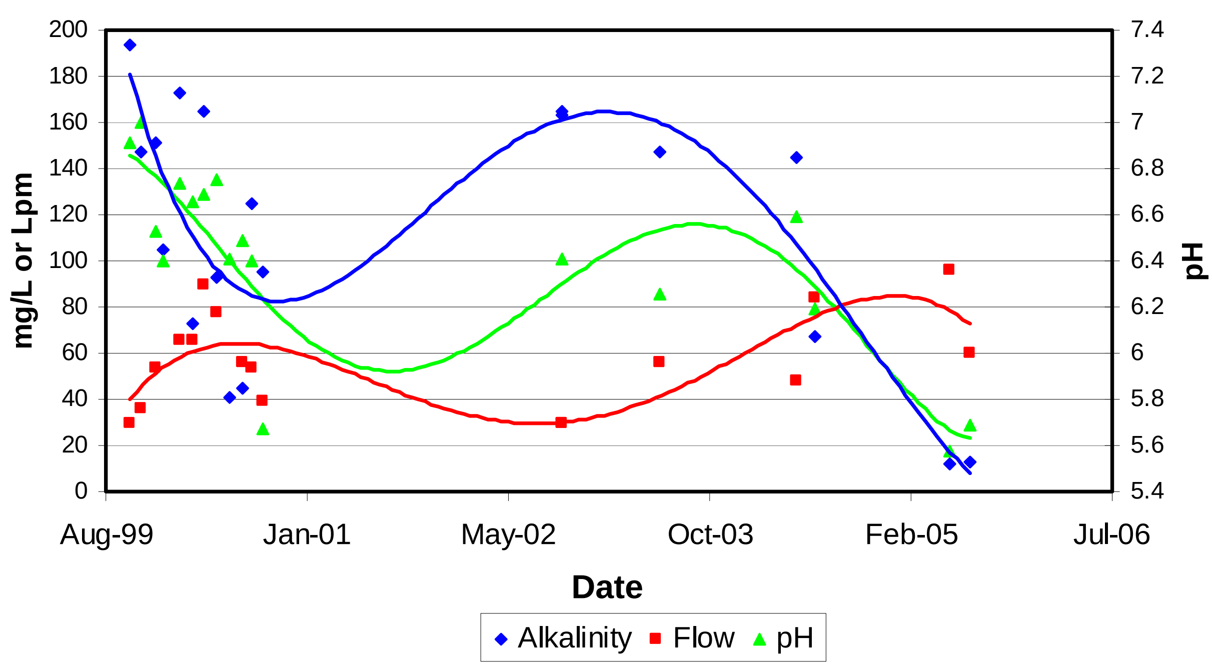


Figure Bog-4 shows total iron has gradually increased from the SAPS and system, which is likely the result of: 1) inadequate oxidation of ferrous iron in the aerobic wetland portion of SAPS 2, 2) washout of iron oxide solids from the aerobic wetland into the SAPS, and/or 3) gradual accumulation of iron oxide in SAPS 2 and its subsequent reduction to ferrous iron in the organic substrate of the SAPS.

Figure Bog-4: Bog passive treatment system trends in SAPS underdrain total iron

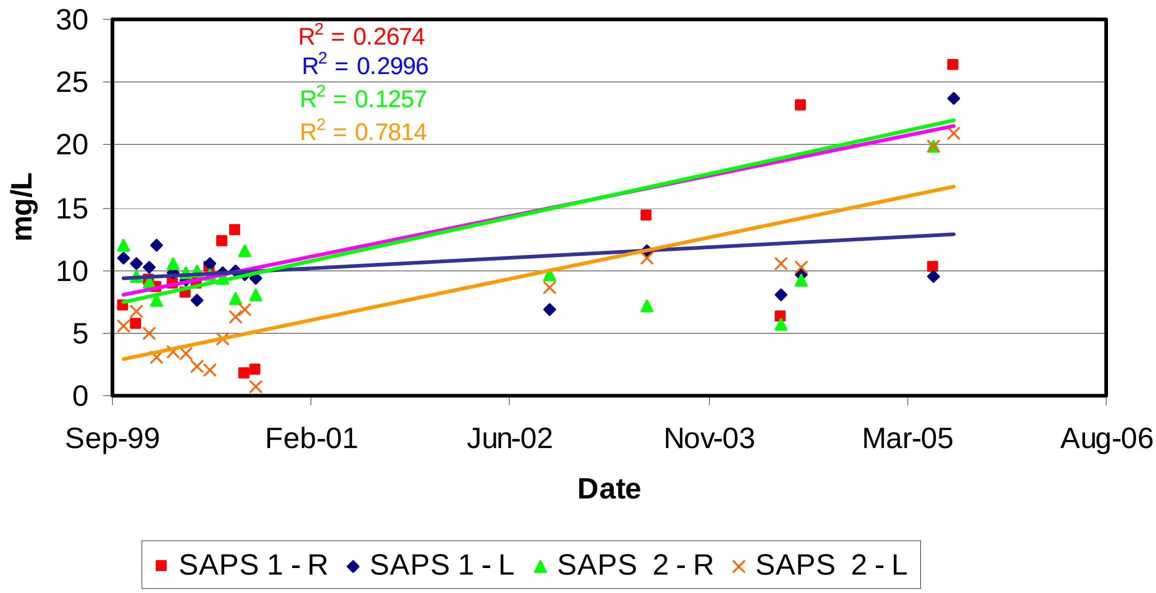


Table Bog-2 provides the results from the in-depth field assessment conducted at the SAPS underdrain outlets on July 14, 2005. This in-depth sampling shows the underdrain characteristics of the two treatment cells. The AMD inflow is a low pH and high iron discharge containing dissolved oxygen and Eh indicative of an oxic discharge.

The SAPS 1 and SAPS 2 were evaluated by examining the underdrain discharges from field measurements that provide indications as to the conditions within the SAPS substrate. The underdrain discharge from SAPS 1 was found to have elevated alkalinity greater than 100 mg/L, slightly acidic pH and Eh less than 0 mV. The conditions indicate the SAPS has reducing substrate conditions and is in reasonably good operating condition. However, Eh was not less than -50 mV and no sulfide was found in the underdrain water, indicators of sulfate reduction. Underdrain samples contained elevated iron, as ferrous iron, at levels approaching influent AMD. The absence of low Eh and sulfide and elevated ferrous iron suggests, that while reducing conditions are good within the SAPS, they are inadequate to reduce sulfate to sulfide, which is needed to 1) prevent oxidation and precipitation of ferrous iron in the compost and limestone bed, 2) form a ferrous iron sulfide precipitate within the compost substrate, and 3) produce alkalinity through biological reduction of sulfate.

Table Bog-2: Bog passive treatment system Evaluation Conducted on July 14, 2005.						
			SAPS 1 Underdrain		**SAPS 2 Underdrain**	
Parameter	**Unit**	**Inlet**	**Right**	**Left**	**Right**	**Left**
Dissolved Oxygen	mg/l	1.50	0.10	0.12	0.05	0.09
Temperature	°C	14.5	21.0	20.8	22.7	23.0
Conductance	µS	1041	1080	1125	1101	1096
pH	s.u.	4.39	6.55	6.51	6.98	6.86
Eh	mV	340	-22	-20	-69	-65
Sulfide	mg/l	-	<0.05	0.05	0.15	0.08
Ferrous Iron	mg/l	27.1	16.8	19.8	5.25	5.08
Total Iron	mg/l	27.7	16.8	20.4	5.20	5.03
Alkalinity	mg/l	0	129	125	105	-
Flow	gpm	-	11	11	9	15

The SAPS 2 underdrain discharge also contained elevated alkalinity greater than 100 mg/L, slightly acidic pH and Eh less than -50 mV. In addition, sulfide was found in the underdrain water, an indicator of sulfate reduction. These conditions indicate the SAPS is in satisfactory operating condition. Underdrain iron was also substantially lower than influent AMD suggesting 1) iron removal is occurring in the aerobic wetland portion of SAPS 2, and/or 2) sulfide produced in the SAPS is adequate to remove a portion of the ferrous iron. However, a sample from the standing water in the pond also contained approximately 5 mg/L of ferrous iron, which suggests little ferrous iron is removed as sulfide with the SAPS. Definitive conclusions are not possible because the variability in flow and underdrain chemistry prior to the sampling likely affected the sampled water quality.

Diagnosis

The Bog passive treatment system is currently functioning properly with no or minimal indication of reduced flow or deterioration of water quality in the SAPS. Table Bog-3 summarizes the two SAPS operating conditions, which are moderate and satisfactory effectiveness, respectively. Several operational issues were identified based on the evaluation of historical data collected since start-up of the system: 1) the SAPS occasionally receive high flows that cause a decrease in underdrain alkalinity and pH; and 2) ferrous iron from the SAPS has increased over time, a result of inadequate sulfate reduction and/or iron removal prior to the SAPS.

Table Bog-3: Summary of Bog system SAPS conditions.			
Unit	**Condition**	**Criteria**	**Level**
SAPS 1	Eh = -20 mV	0 mV< Eh<-50 mV	Moderate
SAPS 2	Eh = -65 mV	Eh < -50 mV	Satisfactory

The alkalinity and pH decreases suggest the Bog SAPS are subject to periodic upset in response to high flows. This is an inherent problem with the standpipe design that allows flows up to the hydraulic capacity of the system without regard to the delicate balance of the anaerobic environment in the compost layer. This potential problem can result in premature failure of a SAPS and/or the system. The issue is easily corrected by using valves and or flow control orifices to limit the SAPS underdrain flow.

Design Methodology

The Bog SAPS were sized based on a 24 hour limestone bed detention time and a 25 year longevity by NRCS. Table Bog-4 provides the estimated surface area and limestone volume in the two treatment cells and the calculated detention time. The calculated detention time does not include the volume of limestone added to provide for operational life, which has been included in several other MCC passive treatment system designs. Table Bog-4 also provides the estimated limestone bed detention time, acidity loading and surface hydraulic loading on the two cells.

Table Bog-4: Summary of Bog passive treatment system size and design parameters

SAPS	Surface Area ft^2	Limestone Volume ft^3	Limestone Bed Detention Time hrs	Acidity Loading $gr/day/m^2$	Hydraulic Loading gpm/acre
Cell 1	10,000	30,000	8-10	185	620
Cell 2	10,500	30,500	8-10	45	620

Comparing the acidity loading and hydraulic loading in Table Bog-4 to reported design guidance for SAPS of 25 $gr/day/m^2$ and 150 gpm/acre (Rose & Dietz, 2002; Dietz et al, 1996; and Dietz, 1997) indicates the SAPS 1 and SAPS 2 are overloaded with respect to both parameters when the system is receiving maximum reported historical flows. This high hydraulic loading can cause premature failure of the SAPS. The decrease in alkalinity at increasing flow through the SAPS underdrains is evidence of this effect.

Action

The Bog passive treatment system is currently operating satisfactorily. Modifications to the existing treatment system are recommended to ensure continued effective treatment and operation of the Bog passive treatment system. The recommendations include:

1) Installation of flow control orifices on the underdrain outlet stand pipes to regulate flow.
    a. Orifices on the SAPS 1 should be 1.125 inch diameter to restrict flow through the underdrain to 30 gpm (15 gpm per outlet), which is the allowable flow based on acidity loading.
    b. Orifices on the SAPS 2 should be 1.25 inch diameter to restrict flow through the underdrain to 40 gpm (20 gpm per outlet), which is the allowable flow based on hydraulic loading.
2) Move the existing emergency spillway in SAPS 1 to a new location to direct overflow (the volume of water that does not pass through the underdrain) into SAPS 2 instead of bypassing the system.

Figure Bog-5 shows the recommended modifications to the Bog passive treatment system to enable the system to continue to operate effectively until replacement of the substrate is required. Table Bog-6 provides the estimated costs for the recommended modifications.

In addition, a water sampling and underdrain water chemistry data collection program should be instituted to provide data for continual evaluation of the health of the system. In addition to sampling presently conducted, recommended annual sampling should include measurement of field Eh in the underdrain outlets. These data will be used to determine conditions of the system and planning for reconstruction.

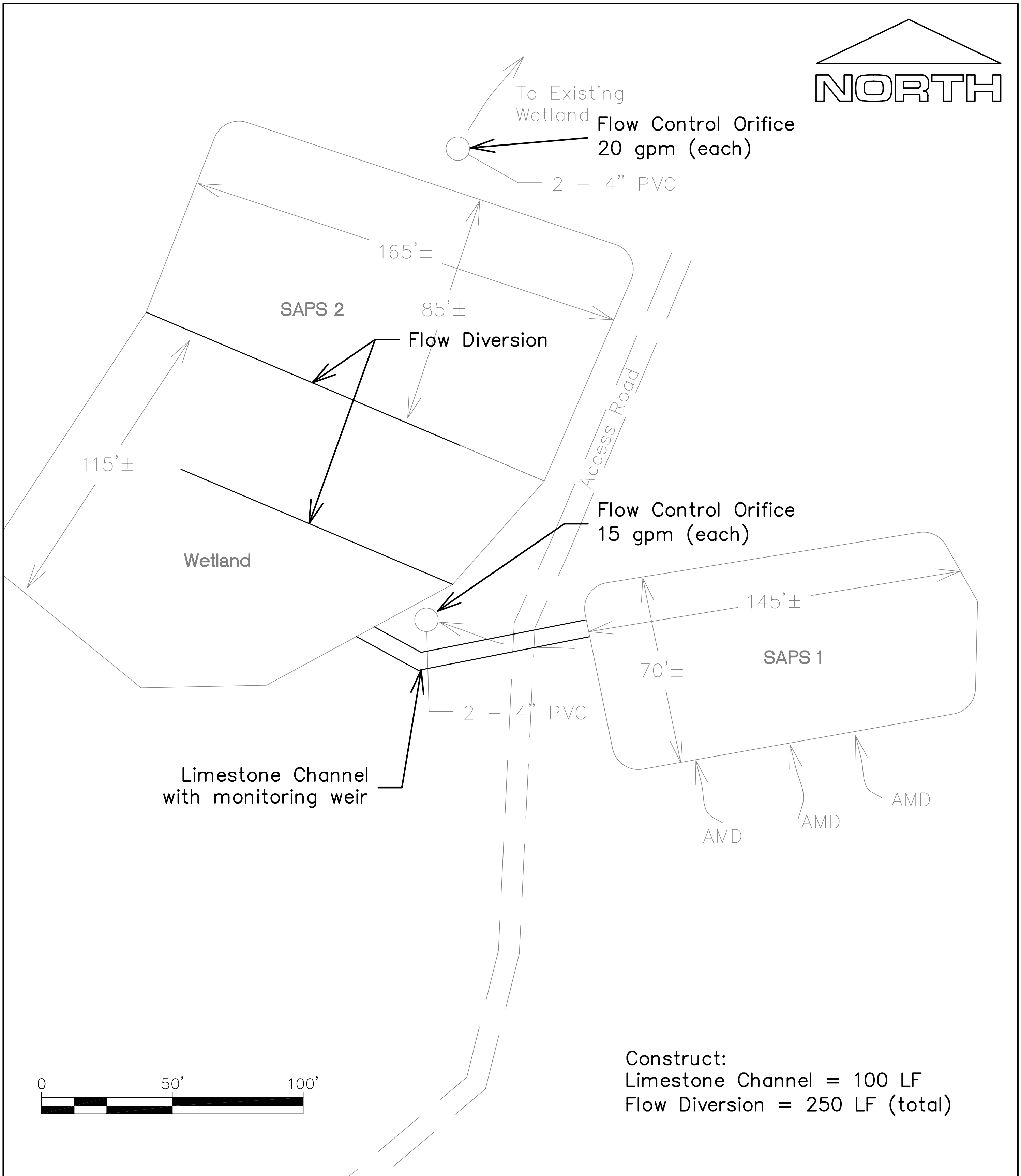
Based on analysis conducted above, future reconstruction of the system will require replacement of substrates and piping in the cells with no additional treatment required. An additional earthen berm or membrane curtain separating the aerobic wetland from the SAPS (in SAPS 2) is recommended to create a better defined settling area and inhibit iron oxide accumulation in SAPS 2.

Operation, Maintenance & Replacement Plan

The system is currently operating satisfactorily. Replacement of the existing underdrain standpipe outlets with orifice flow control outlets should lower loading to the SAPS substrates, and thereby stabilize SAPS conditions and performance. This type of control should have an operation and maintenance benefit by reducing/eliminating SAPS flushing. This is a result of the decrease in acidity and iron loading to the substrates, improving the biological process, and decreasing iron oxide formation in the limestone substrate. Current flushing cycles can be evaluated based on iron oxide solids observed during flushing. If flow controls reduce solid qualities produced during flushing, then maintenance cycles can be lengthen or eliminated.

Replacement of the Bog passive treatment system was evaluated to determine adequacy of existing treatment areas. A multi-cell acidity loading model was used to determine whether the existing or additional treatment area is needed to adequately treat the discharge. The results of the modeling are shown in Table Bog-5, which indicates the existing treatment areas are adequate to produce a net alkaline effluent for AMD flow up to 100 gpm. Since it is likely discharge chemistry will improve with time, the existing area is adequate and replacement will require removal and placement of new substrate. The replacement system should contain a deeper compost layer, 1½ to 2 feet, supplemented with limestone fines, which is consistent with converting the SAPS to an AVFW. The conversion should result in better and longer term treatment of the Bog AMD discharge.

Table Bog-5: Multi-cell modeling for the Bog passive treatment system for Acidity = 120 mg/L and Flow = 100 gpm		
	Effluent Quality	
	Cell 1	**Cell 2**
Surface area (sq. ft.)	10,000	10,500
Depth of limestone (ft)	2	2
Depth of limestone (ft)	2	1.5
Hydraulic-based flow (gpm)	34.4	36.2
Acidity loading-based flow (gpm)	35.4	100.8
Subsurface flow (gpm)	34.4	36.2
Effluent acidity (mg/L)	44	-8



Project No.: MCC–OMR
Drawing No.: 06–002
By: TSG 3/3/06
Chkd: JMD 3/14/06

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THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure Bog-5
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Table Bog-6

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Bog System Upgrade

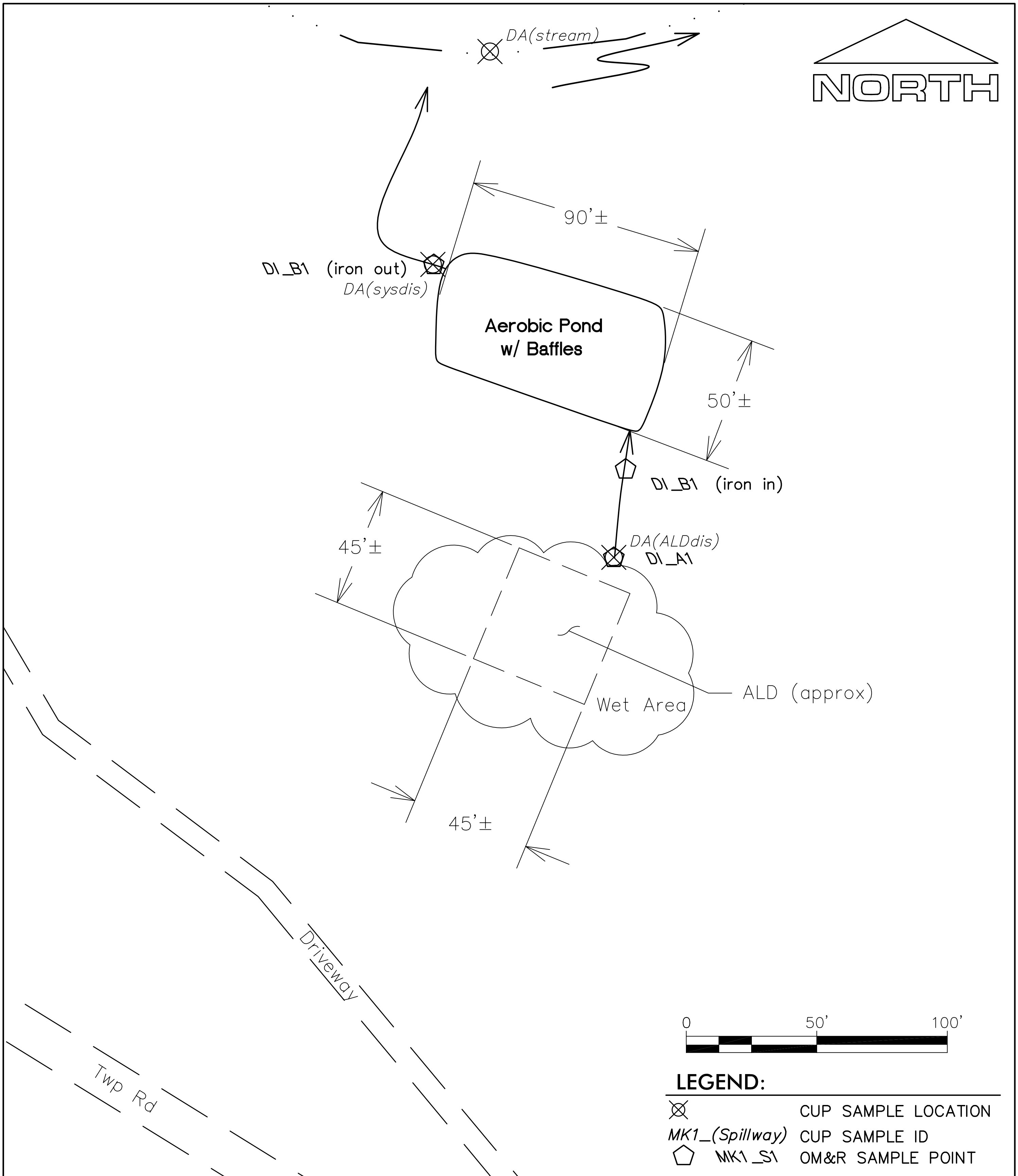
Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	0.25	LS	$ 7,500.00	$ 1,875.00
2.	Clearing and Grubbing	0	ACRE	$ 1,750.00	$ -
3.	E&S Control	0	LS	$ 10,000.00	$ -
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	25	CY	$ 15.00	$ 375.00
	(b) Wet	0	CY	$ 30.00	$ -
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	0	SY	$ 15.00	$ -
10.	Geonet	0	SY	$ 5.50	$ -
11.	High Quality Limestone	0	Ton	$ 28.00	$ -
12.	Mushroom Compost Substrate	0	CY	$ 30.00	$ -
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	0	LF	$ 15.00	$ -
	(b) 4" Solid pipe	0	LF	$ 12.00	$ -
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	0	EA	$ 1,500.00	$ -
14.	Orifice Flow Control	4	EA	$ 75.00	$ 300.00
15.	Wetland Vegetation and Planting	0	EA	$ 3.00	$ -
16.	Flow Diversion (membrane curtain)	250	LF	$ 40.00	$ 10,000.00
17.	Rock Lining / Rock Channel	70	SY	$ 22.00	$ 1,540.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	1	EA	$ 450.00	$ 450.00
20.	Seeding/Restoration	0	Acre	$ 2,400.00	$ -
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

TOTAL AMOUNT OF COST ESTIMATE **$ 14,540.00**

Daiva Passive Treatment System

Anoxic Limestone Drain (ALD) and Aerobic Pond with baffles



Project No.: 05-009
Drawing No.: 05-001
By: TSG 8/17/05
Chkd: JMD 9/14/05

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Figure Daiva-1

Existing Daiva Treatment System
& OM&R Sample Points

Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Daiva passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive system consists of an ALD and an aerobic pond constructed in 1996.
- Current information indicates the ALD is not functioning due to clogging within the ALD.
- Evaluation indicates the discharge contains adequate alkalinity to remove the iron concentration, but the high carbon dioxide concentration in the discharge results in an acidic pH.
- The existing aerobic pond has poor performance due to a combination of the acidic pH of the discharge and the inadequate size of the aerobic pond.

Recommendations for the Daiva passive treatment system are as follows:

- Remove accumulated iron oxide solids from the aerobic pond.
- Increase the size of the existing aerobic pond to account for the greater surface area needed to remove the iron for the current acidic conditions of the discharge.
- Construct an open limestone channel from the new aerobic pond to the receiving stream for manganese removal and additional alkalinity generation.

The following provides details to support the above summary.

System Description

The Daiva passive treatment system was constructed in 1996 to treat an AMD seep on the Terry Bish property. Pre-construction data indicate the Daiva discharge is an acidic discharge with an initial alkalinity (~30 mg/L), pH (>5) and low aluminum (< 0.5 mg/L) consistent with an anoxic discharge. The iron and manganese concentrations (30 and 10 mg/L, respectively) indicates the discharge is only slightly net acidic (~40 mg/L). Table Daiva-1 details the AMD characteristics.

Table Daiva-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
6	30	40	0	30	10	---	55

The Daiva passive treatment system was designed to treat this discharge employing an ALD followed by an aerobic pond to remove metals. The Daiva passive treatment system layout is depicted on Figure Daiva-1. Information was available on the ALD size and indicates it was 45 feet by 45 feet with a 4 foot depth. The ALD size was to provide 6 hours of detention time at a flow of 50 gpm. A discharge pipe from the ALD enters into the aerobic pond. The aerobic pond is 3,800 ft^2 with approximately 4 feet of water depth. Baffles were installed in the aerobic pond to minimize short-circuiting.

Communications with the MCC indicates the ALD failed shortly after installation due to clogging. Surface infiltration carrying dissolved oxygen is believed to have caused oxidation within the ALD, leading to formation of iron oxides that clogged the ALD. Due to break-outs of AMD on the slope, an open channel was constructed to convey the discharge to the aerobic pond.

Operational Assessment

The Daiva passive treatment system was partially functioning at the time of the field visit in April 2005 and during the system assessment on July 14, 2005. The ALD was not operating, but there was flow in the open channel and the aerobic pond was receiving the discharge flow. The discharge flow was approximately 25 gpm during the July evaluation.

Anoxic Limestone Drain

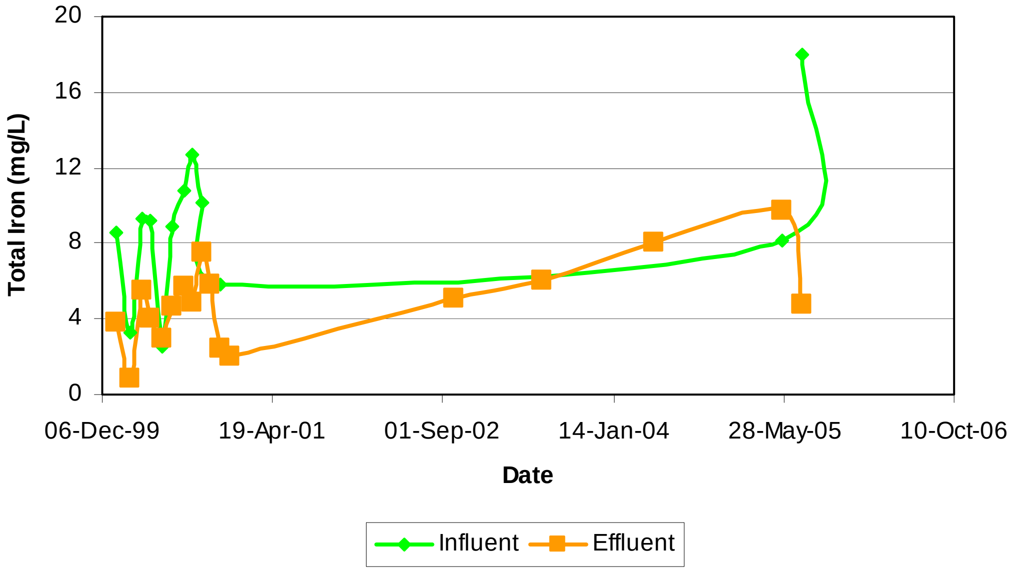
Based on no water flowing in the ALD outlet pipe, the ALD was not operational and no data was collected from the ALD. However, the alkalinity in the influent channel is greater than pre-existing AMD chemistry suggesting the buried limestone may still be generating some alkalinity (see Table Daiva-1 and Table Daiva-2).

Aerobic Pond

The aerobic pond was functioning and was evaluated by examining influent and effluent water quality. Effluent water quality measured during the evaluation is shown in Table Daiva-2. The data indicate the aerobic pond is removing only about 30% of the influent iron. Figure Daiva-2 shows the effluent data from the aerobic pond over the past 5 years and indicates the pond has had poor removal over this period. Little if any manganese is removed by the aerobic pond.

Table Daiva-2: Field sampling results from the Daiva passive treatment system assessment conducted on July 14, 2005							
Location	**DO mg/L**	**Temp ºC**	**Cond µS**	**pH**	**Fe(II) Iron mg/L**	**Total Iron mg/L**	**Alkalinity mg/L**
Influent	6.5	11.7	735	6.17	16.2	16.3	63
Effluent	6.9	15.7	748	6.22	9.6	11.8	61

Figure Daiva-2: Total iron data for Daiva aerobic pond



Diagnosis

Table Daiva-3 summarizes the operating condition of the Daiva passive treatment system. The Daiva ALD was not functioning during the field evaluation. Mill Creek Coalition communications indicate the ALD failed within the first year of operation due to clogging.

Table Daiva-3: Summary of Daiva passive treatment systems SAPS conditions.			
Unit	**Condition**	**Criteria**	**Level**
ALD	No Flow	NA	Reduced
SAPS 2	Iron removal = 30%	Iron Removal < 80%	Reduced

The aerobic pond was evaluated by examining effluent water quality, which indicates less than 30% of the iron is removed by the aerobic pond. This indicates the aerobic pond is operating at a reduced effectiveness. It should be noted the field observations indicate there is adequate alkalinity (~60 mg/L) to treat the influent iron concentration of approximately 16 mg/L. A 20 mg/L ferrous iron concentration would require 36 mg/L of alkalinity; there is approximately 25 mg/L of excess alkalinity in the inflow to the aerobic pond.

Design Methodology

Due to the failed status of the ALD, no design methodology was evaluated.

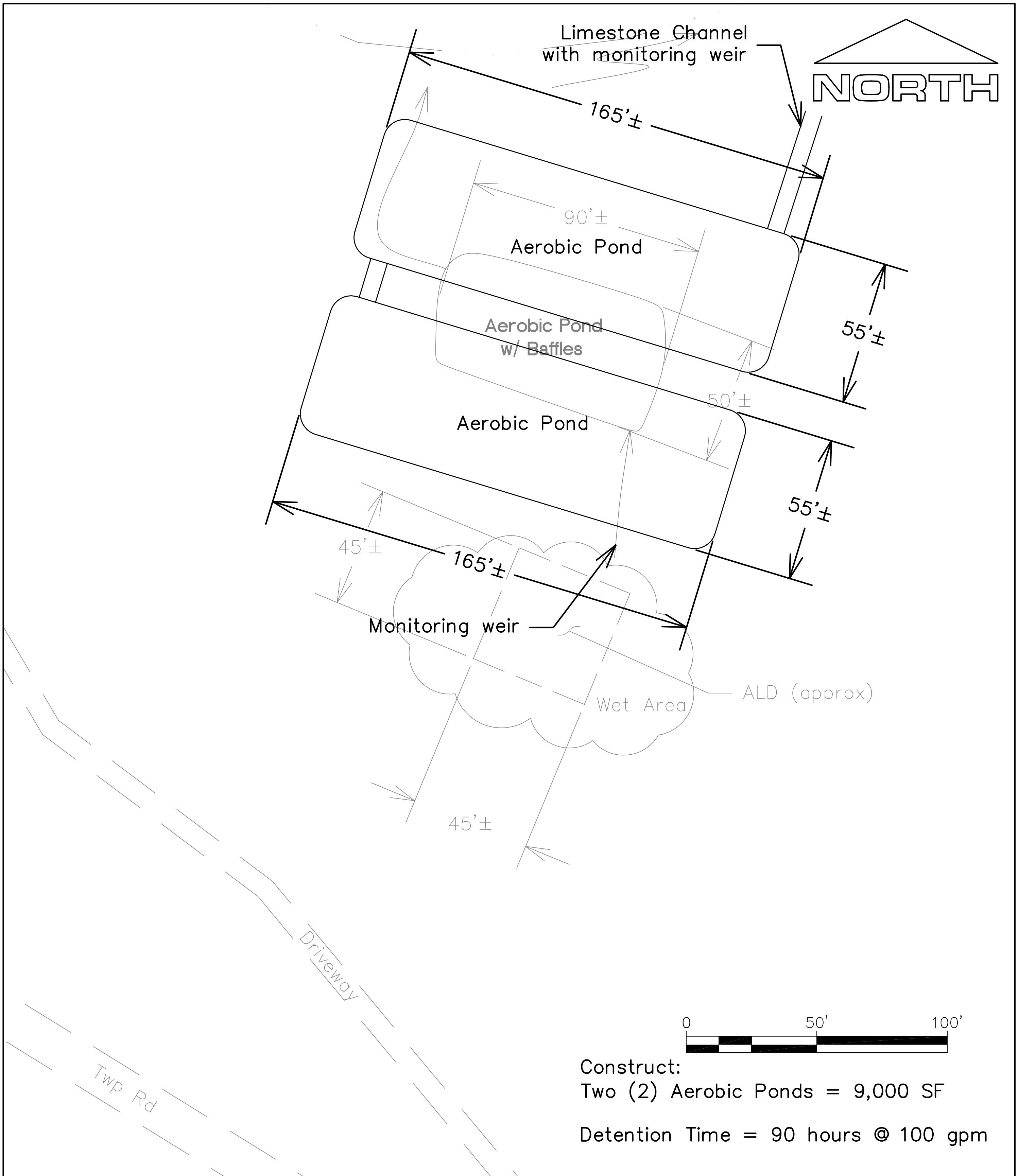
Design methodology was available for the aerobic pond and indicates the aerobic pond was sized for a 24 hour detention time at a flow rate of 50 gpm. This is an inadequate design criterion to provide adequate detention time for iron oxidation. In addition, historic data from the system indicates the average flow is closer to 60 gpm with maximum flows reaching 100 gpm. The higher flows would further exacerbate the aerobic pond size, resulting in poor operational performance.

Action

The Daiva passive treatment system is currently operating at a reduced effectiveness due to the failed ALD and poor iron removal in the aerobic pond. No repairs or changes in the system can improve operation and performance. Replacement of the system will be required.

Operation, Maintenance & Replacement Plan

The current Daiva passive treatment system is not functioning adequately to address the AMD source at this site. Replacement of the system will be required to adequately treat the Daiva discharge. The proposed changes are depicted on Figure Daiva-4, which include increasing the size of the aerobic pond(s) to 18,000 ft^2 with approximately 90 hours of detention time at the maximum flow rate (100 gpm). This larger size should achieve greater than 90% iron removal under expected operating conditions. The costs for the new Daiva passive treatment system are summarized in Table Daiva-3. Although not included in the proposed system changes, an upflow limestone well to replace the ALD may be needed if future data indicate required alkalinity is greater than the discharge alkalinity. The size of the upflow limestone well needed to generate an alkalinity of 125 mg/L is 1,600 ft^3 and contains 75 tons of limestone. This alternative may also be included to improve aerobic pond performance and/or if additional alkalinity is needed in the watershed.



Construct:
Two (2) Aerobic Ponds = 9,000 SF

Detention Time = 90 hours @ 100 gpm

Project No.: MCC-OMR Drawing No.: 06-002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	Figure Daiva-3 Proposed Modifications OM&R Plan Union Township Jefferson County, PA

Table Daiva-4

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Daiva System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.3	ACRE	$ 1,750.00	$ 525.00
3.	E&S Control	0.25	LS	$ 10,000.00	$ 2,500.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	3350	CY	$ 3.00	$ 10,050.00
	(b) Wet	840	CY	$ 10.00	$ 8,400.00
8.	Embankment Construction	1000	CY	$ 5.00	$ 5,000.00
9.	Geotextile Liner	2,300	SY	$ 15.00	$ 34,500.00
10.	Geonet	0	SY	$ 5.50	$ -
11.	High Quality Limestone	0	Ton	$ 28.00	$ -
12.	Mushroom Compost Substrate	0	CY	$ 30.00	$ -
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	0	LF	$ 15.00	$ -
	(b) 4" Solid pipe	0	LF	$ 12.00	$ -
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	0	EA	$ 1,500.00	$ -
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	0	EA	$ 3.00	$ -
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	460	SY	$ 22.00	$ 10,120.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	2	EA	$ 450.00	$ 900.00
20.	Seeding/Restoration	0.15	Acre	$ 2,400.00	$ 360.00
21.	Sludge Removal/Disposal	840	CY	$ 15.00	$ 12,600.00

TOTAL AMOUNT OF COST ESTIMATE $ 92,455.00

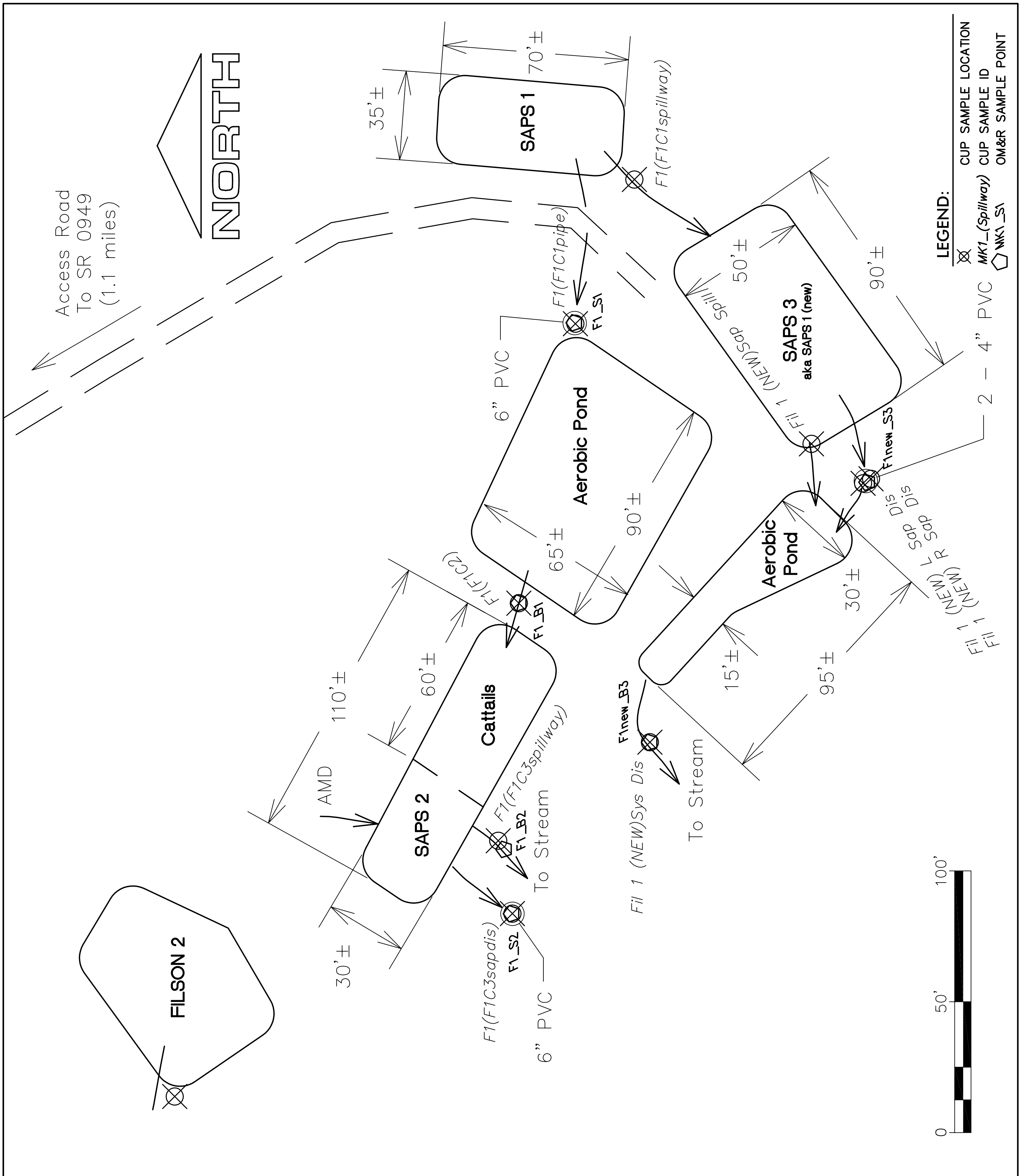
Filson 1/2/3 Passive Treatment System


Filson 1 SAPS


Filson 1 SAPS Outlet


Filson 1 New SAPS


Filson 3 SAPS Outfall Pipes



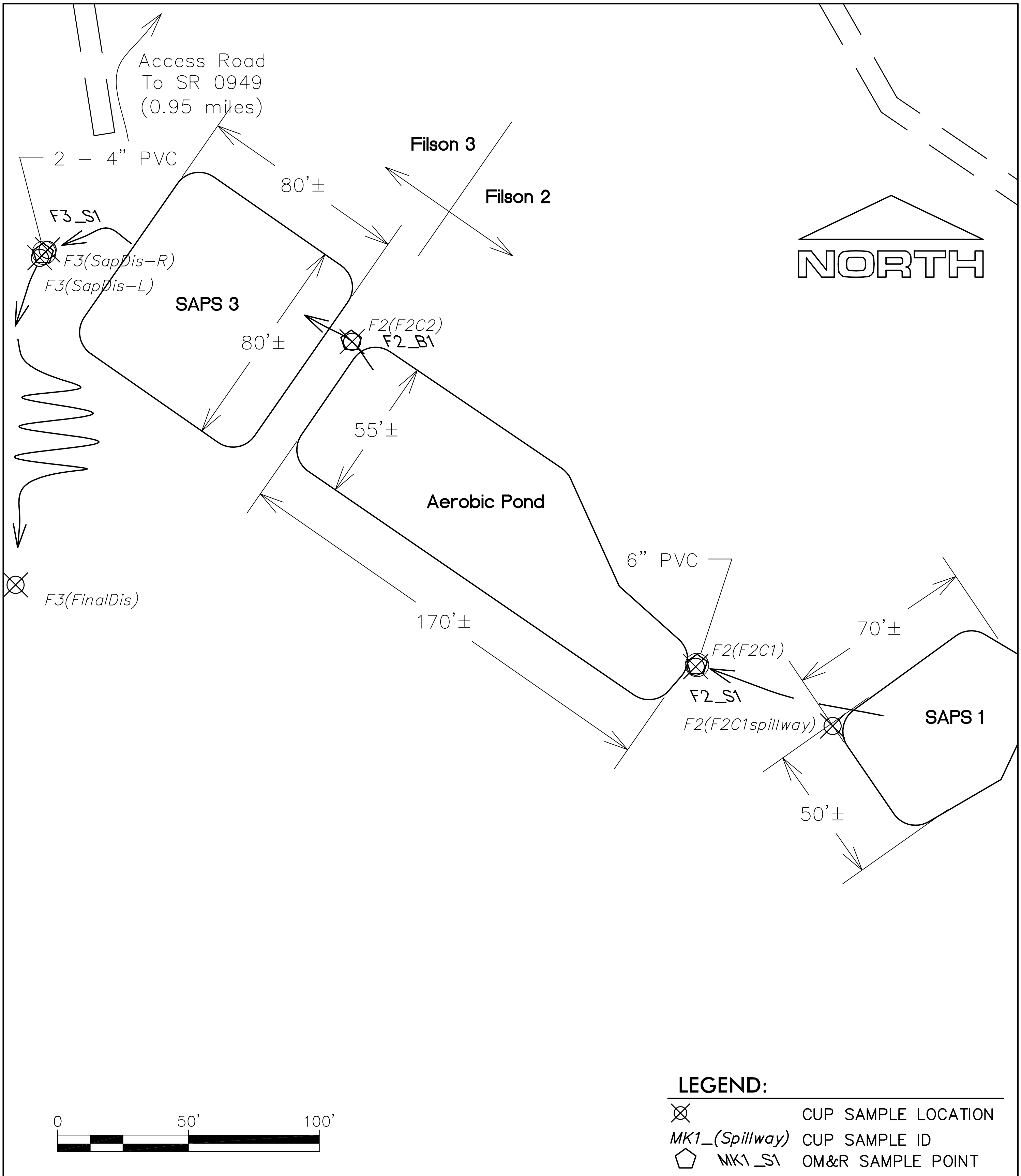
Project No.: 05-009
Drawing No.: 05-001
By: TSG 8/17/05
Chkd: JMD 9/14/05

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure Filson 1/2/3-1a

Existing Filson 1 Treatment System
& OM&R Sample Points

Union Township Jefferson County, PA



Project No.: 05–009
Drawing No.: 05–001
By: TSG 8/17/05
Chkd: JMD 9/14/05

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Figure 1/2/3-1b

Existing Filson 2 & 3 Treatment System
& OM&R Sample Points

Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Filson 1/2/3 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive treatment systems consist of a number of SAPS and aerobic ponds that were constructed at various times between 1990 and 2000 to treat various toe-of-spoil discharges from an abandoned and reclaimed surface mine.
- The original Filson 1 SAPS was one of the first SAPS constructed in Pennsylvania. The SAPS underdrain flow decreased and treatment performance declined a short time after start-up.
- Nearly all of the SAPS in the combined system have operational problems ranging from inadequate underdrain flow to inadequate treatment performance.
- Field evaluation indicated all the SAPS in the combined system contained elevated Eh (> 0 mV) with low effluent alkalinity ranging from 20 to 80 mg/L.
- Only the left underdrain of the new Filson 1 SAPS contained Eh less than 0 mV and alkalinity greater than 100 mg/L, characteristic of a SAPS in satisfactory condition.
- The underdrain conditions found during the field evaluation indicate the SAPS in the Filson 1/2/3 passive treatment systems are in various states of reduced effectiveness, which was found to be an effect of 1) periodic overloading, 2) upflow of AMD into the SAPS, and/or 3) undersized SAPS, with respect to current information on sizing and design.

Recommendations for the Filson1/2/3 passive treatment systems are as follows:

- Current conditions indicate the Filson1/2/3 passive treatment system will require replacement that includes:
  - redesign employing multi-stage AVFW and interspaced aerobic ponds.
    - increase the overall treatment size to adequately treat the various discharges for a longer operational period (may not be possible due to site limitations), or
    - design a system within available area and treat only a portion of the discharge flow, or
    - relocate the passive treatment system away from the toe-of-spoil to prevent upflow into the bottom of the treatment units.
- Alternative treatment employing a toe-of-spoil collection system and innovative active treatment system should be considered due to:
  - high acidity and the high aluminum contained in the discharges, and
  - site constraints in the vicinity and adjacent to the discharge locations that limit the available treatment area.

The following provides details to support the above summary.

System Description

The Filson1/2/3 passive treatment systems consist of a number of SAPS and aerobic ponds that were constructed at various times. Figure 1/2/3-1a & 1b detail the treatment systems. The first SAPS constructed, Filson 1, was one of the first SAPS ever constructed for passive AMD treatment. The Filson 1 SAPS began operation in 1995 to treat one of numerous AMD discharges emanating from an abandoned and unreclaimed surface mine, known as "Filson" and are toe-of-spoil seeps. Table Filson 1/2/3-1 contains water quality characteristics for several of the sampled discharges prior to construction at Filson 1, Filson 2 and Filson 3. The majority of flows at the Filson1/2/3 discharges are low pH and high acidity. The acidity is comprised of high aluminum, iron and manganese concentrations. A small, lower elevation seep, Filson 3, is characteristic of an anoxic AMD discharge (i.e., slightly acidic pH with initial alkalinity) with high ferrous iron.

Table Filson 1/2/3-1. Filson1/2/3 pre-construction AMD discharge water quality.

Location	Flow gpm	pH	Alkalinity mg/L	Acidity mg/L	Total Al mg/L	Total Fe mg/L	Total Mn mg/L	Sulfate mg/L
Filson 1	55	3.5	0	315	9.2	23.7	28.0	1141
Filson 2	28	3.3	0	350	4.0	42.6	46.8	1495
Filson 3	6	5.6	40	350	0.4	120	18.4	1200

The Filson1/2/3 passive treatment systems were designed to treat the various discharges employing SAPS followed by aerobic ponds to remove metals. The Filson1/2/3 systems are depicted on Figure Filson 1/2/3-1. Table Filson 1/2/3-2 contains the sizes of the various SAPS and aerobic ponds based on field measurements and the limited design information. Filson 3 SAPS is included as part of the Filson 2 passive treatment system since it was added to the Filson 2 system to improve effluent quality after declining performance of the initial Filson 2 SAPS. The following provides an assessment of the Filson1/2/3 passive treatment systems.

Table Filson 1/2/3-2 Summary of treatment units and sizes in the Filson1/2/3 passive treatment system

Unit	Surface Area ft^2	Total Depth Ft	Compost Depth Ft	Limestone Depth ft
Filson 1				
SAPS 1	2,400	3.5	0.5	3
Aerobic Pond 1	6,000	2-3	NA	NA
SAPS 2	~3,000	Unknown	Unknown	Unknown
SAPS 1(new)*	4,800	3	0.5	3
Aerobic Pond 2	3,000	2-4	NA	NA
Filson 2				
SAPS 1	3,500	3	0.5	3
Aerobic Pond	8,500	2-4	NA	NA
Filson 3 SAPS	5,800	3	0.5	3

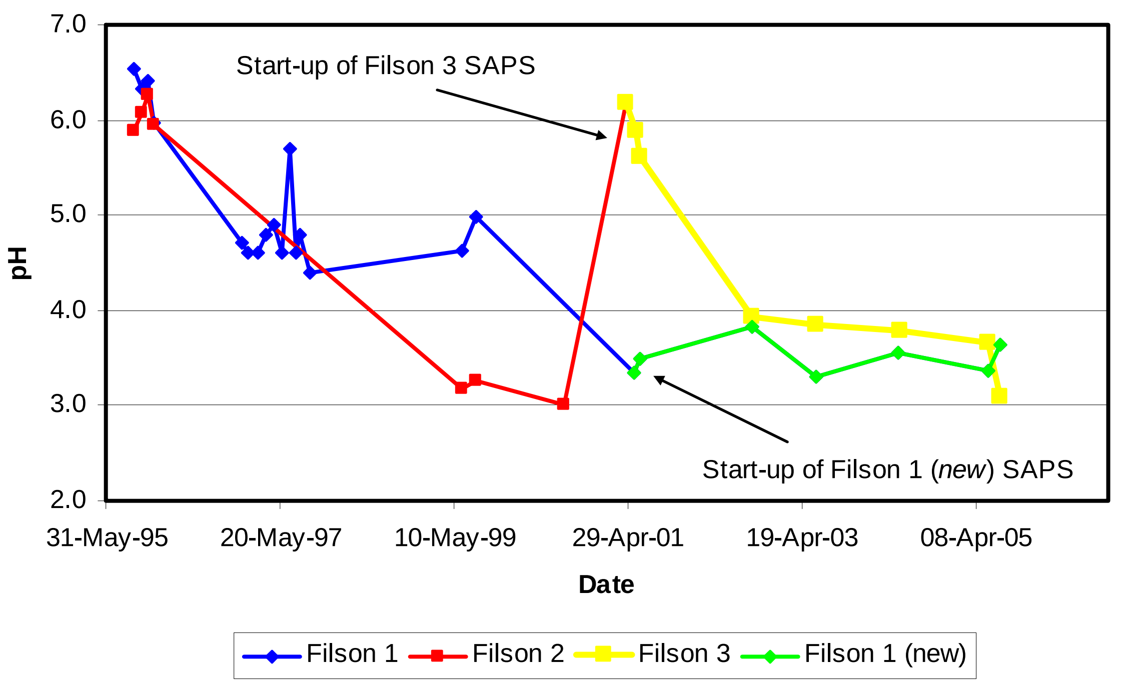
*Filson 1 SAPS (new) labeled as SAPS 3 on Figure Filson 1/2/3-1a

Operational Assessment

The Filson1/2/3 passive treatment system was functioning at the time of the field visit in April 2005 and during the system assessment on July 14, 2005. Flows over the SAPS spillway with only a portion of the flows passing through the underdrain outlets were observed at nearly all SAPS in the Filson 1/2/3 system.

Long term pH monitoring data for the Filson1/2/3 passive treatment system are provided in Figure Filson 1/2/3-2. Figure Filson 1/2/3-2 illustrates the operational decline of the various SAPS after initial start-up. The Filson 1 effluent pH data depicted show an initial effluent pH greater than 6 and gradual decline to near influent pH over a 2 to 3 year period. Installation of the Filson 1 (new) SAPS (labeled SAPS 3 on Figure Filson 1/2/3-1a) provided little improvement in effluent pH. This was most likely the result of capturing additional AMD flow through the bottom of the SAPS. Filson 2 effluent pH shows a similar pattern of high pH followed by a gradual decline. The pH increase shown is associated with the installation of Filson 3 downstream of the Filson 2 system. This installation temporarily increased the pH to original conditions, but was followed by a steady decline to levels near the influent pH. This evaluation based on pH is intended to show the declining performance of the SAPS over the monitoring period. Despite this effluent pH decline, the Filson1/2/3 passive treatment systems decreased acidity of the discharges by 30 - 50%, depending on the discharge flows.

Figure Filson 1/2/3-2: Filson 1/2/3 passive treatment system effluent pH



The results of the SAPS field evaluation are summarized in Table Filson 1/2/3-3. A comparison of flows indicates less than 30% of the discharge flow at the time of the field evaluation was flowing through the Filson 1 SAPS and Filson 2 SAPS underdrains. The reduced underdrain flows are an indication of reduced permeability of the SAPS. At the time of the initial visit, there was flow over both spillways of Filson 3 SAPS and Filson 1 (new) SAPS (labeled SAPS 3 on Figure Filson 1/2/3-1a). However, during the field assessment in July, all flow was passing through the underdrains of both SAPS. In the case of Filson 3 SAPS, all the flow was passing through the right underdrain standpipe due to elevation differences between the two stand-pipe outlets.

The operational parameters indicate all the SAPS in the Filson1/2/3 system contain elevated dissolved oxygen and/or Eh. This indicates the organic substrate layer is not functioning adequately to reduce iron and is likely that both ferric iron and aluminum have precipitated within the limestone layers. This is an operational problem that has likely resulted in the decreasing underdrain flow and performance of the SAPS.

Table Filson 1/2/3-3. Filson1/2/3 SAPS Underdrain evaluation conducted on July 14, 2005.

Parameter	Unit	Filson 1	Filson 2	Filson 1 (new)*		Filson 3	
				Right	Left	Right	Left
Dissolved Oxygen	mg/l	0.24	0.12	0.08	0.55		0.12
Temperature	ºC	17.9	17.1	17.9	19.8		18.0
Conductance	µS	1075	1085	1095	1014		1229
pH		5.72	5.80	6.45	5.62		5.92
Eh	mV	+95	+117	-17	+120		+37
Sulfide	mg/l	<0.05	<0.05	0.10	<0.05		0.15
Ferrous Iron	mg/l	--	43.6	41.6	8.56		79.5
Total Iron	mg/l	--	44.4	39.6	8.52		78.5
Alkalinity	mg/l	32	54	131	24		82
Flow	gpm	<0.5	3	1.4	4.5	No Flow	17

Underdrains right/left determined by looking upstream
*Filson 1 SAPS (new) labeled as SAPS 3 on Figure Filson 1/2/3-1a

Interesting results were observed from the Filson 1 (new) SAPS. The right underdrain contained Eh less than 0 mV, while the left underdrain had an Eh greater than +100 mV. The dissolved oxygen was also much higher in the left underdrain than the right. In addition, there are significant differences in pH, alkalinity and iron discharged by the right and left underdrains. It is likely that there is upwelling in at least a portion of the SAPS that is causing the observed differences.

Diagnosis

Operating conditions of the Filson1/2/3 SAPS are summarized in Table Filson1/2/3-4. As indicated, all of the SAPS in the Filson1/2/3 passive treatment system are operating at a reduced treatment effectiveness. The SAPS classification is based on two treatment issues: 1) the decreasing amount of flow passing through the underdrains; less than one-third of the total flow during high flow periods; and 2) operating conditions (i.e., Eh) of the SAPS indicate the reducing environment is no longer adequate to sustain the needed treatment. The SAPS substrate conditions are likely due to continuous and periodic excessive acidity loading to the SAPS.

Table Filson 1/2/3-4. Summary of Filson 1/2/3 passive treatment systems SAPS conditions.			
Unit	**Condition**	**Criteria**	**Level**
Filson 1	Eh = +95 mV	Eh > 0 mV	Reduced
Filson 2	Eh = +117 mV	Eh > 0 mV	Reduced
Filson 1 (new)*	Eh = -17, +120 mV	Eh > 0 mV	Reduced
Filson 3	Eh = +37 mV	Eh > 0 mV	Reduced

*Filson 1 SAPS (new) labeled as SAPS 3 on Figure Filson 1/2/3-1a

Design Methodology

There was no design methodology for SAPS or aerobic ponds in the Filson1/2/3 systems. The sizes were evaluated using the information provided and field measurements, along with current flow and pre-construction water quality. The Filson 3 and Filson 1 new acidity loading were based on the final discharge data from the Filson 2 and overflow from the Filson 1 SAPS, respectively. The design evaluation for the SAPS is provided in Table Filson 1/2/3-5. Limestone bed detention times varied from of 7.5 to 26 hours in the different SAPS, which fall in the range of the 8 to 16 hour detention time design basis. The detention time is consistent to historically accepted design approaches. The reduced flow currently passing through the underdrain of SAPS would dramatically increase the limestone bed detention time. The acidity loading and hydraulic loading calculated for the SAPS are well above the current sizing guidance of 25 gr/day/m^2 and 150 gpm/acre. In several SAPS, the acidity loading calculated is approaching or exceeded the design criteria by a factor of 10. This indicates the SAPS are chemically and hydraulically overloaded, with respect to current guidance, which may have contributed to their present reduced treatment effectiveness condition.

Table Filson 1/2/3-5. Summary of Filson 1/2/3 passive treatment system SAPS size and design parameters					
SAPS	**Surface Area ft^2**	**Limestone Volume ft^3**	**Limestone Bed Detention Time hrs**	**Acidity Loading gr/day/m^2**	**Hydraulic Loading gpm/acre**
Filson 1	2,300	6,000	7.5	440	1,100
Filson 2	3,500	10,000	20	165	340
Filson 3	3,500	10,500	26	80	340
Filson 1 new	4,500	11,500	15	140	530

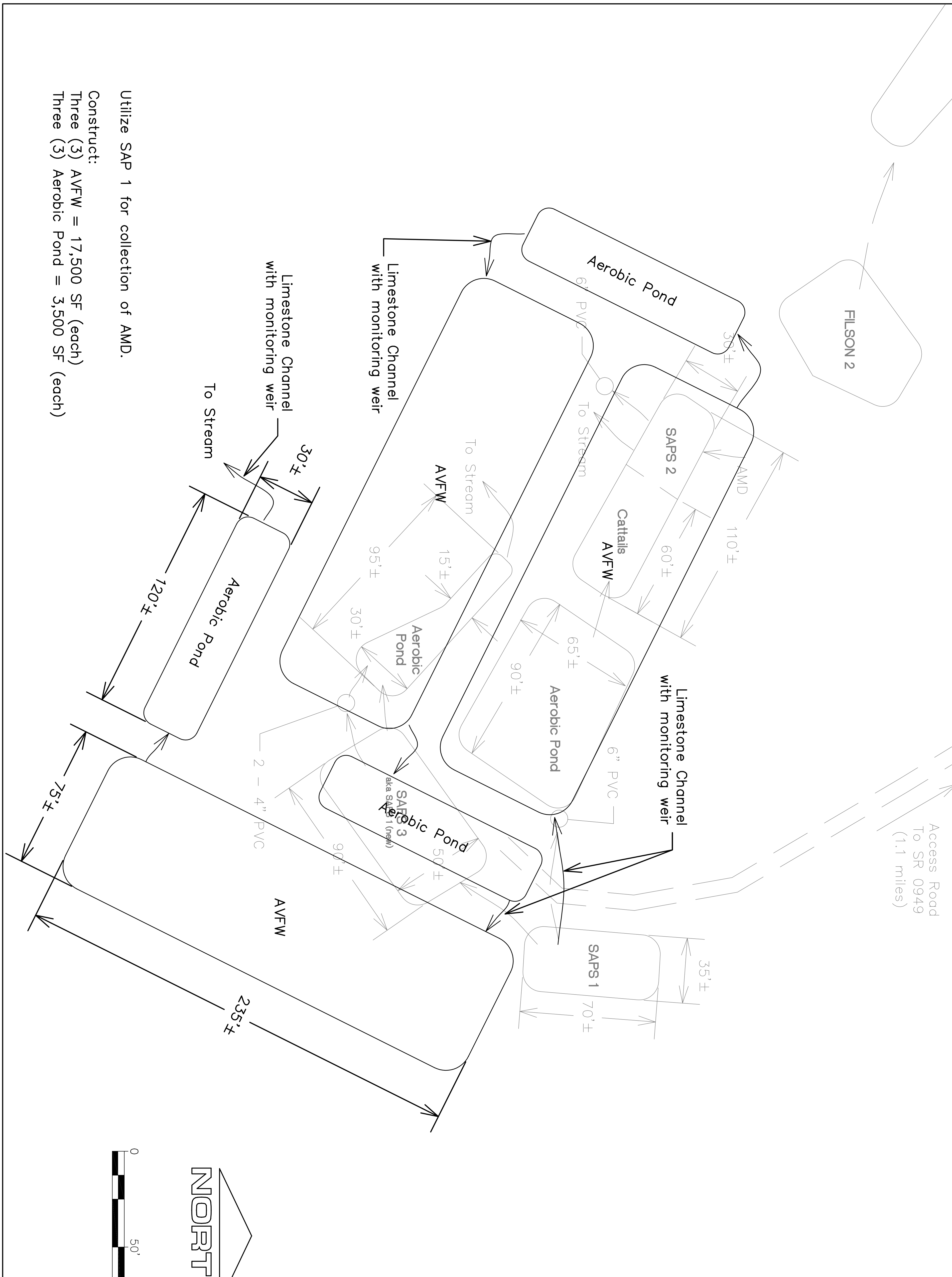
Action

The Filson1/2/3 passive treatment system consists of a number of SAPS that are currently operating at reduced effectiveness. No repairs or changes in operation can resolve the operational issues due to the current condition of the SAPS. The Filson1/2/3 passive treatment system is operating at a reduced effectiveness and should be replaced with a new multi-cell AVFW system based on acidity and hydraulic loading to improve performance and long term operation. Based on analysis conducted above, future reconstruction of the system will be required to resolve the current Filson1/2/3 passive treatment system reduced effectiveness operating condition.

Operation, Maintenance & Replacement Plan

The current Filson1/2/3 passive treatment system is functioning at reduced effectiveness. Replacement of the Filson1/2/3 system will be required to achieve the desired effluent water quality goals. A conceptual design, depicted in Figure Filson 1/2/3-3, has been developed for the Filson1/2/3 discharges that includes installation of 1) a new multi-cell AVFW with deeper compost layers, and 2) installation of aerobic ponds interspaced between the AVFW. The estimated costs for the replacement are contained in Table Filson 1/2/3-6.

The Filson1/2/3 site has a number of constraints including: 1) upwelling of AMD throughout the toe-of-spoil construction area; 2) steeply sloped topography along mined area; 3) poor quality construction materials; and 4) natural wetlands in the available flat area. The site constraints limit the area, which in turn limits the size of a passive treatment system that can be constructed to treat the Filson1/2/3 discharges. As a result, alternative approaches should be considered including: 1) collecting the various Filson discharges and conveying the AMD by pipe to an alternative site for treatment; and 2) providing passive treatment of only a portion of the AMD flows at the existing location. Whether the latter option is acceptable depends on the ability of a smaller system with only partial treatment to achieve water quality objectives in Little Mill Creek. In addition, alternative treatment involving innovative active treatment should be considered. Newer active treatment approaches hold the promise of improved effectiveness at a lower treatment cost. The new approaches include a combination of PLAR and AIS treatment. PLAR is an acronym for Pulverized Limestone Aluminum Removal, which is capable of removing aluminum and adding alkalinity to the discharge. The AIS (activated iron solids) treatment approach can rapidly oxidize ferrous iron and remove the associated acidity in a small foot print system. Based on maximum flows and metal concentrations, the PLAR and AIS system would have a tank volume of 10,000 and 25,000 gallons, respectively. The active system would require a pulverized limestone silo and feed system. Electricity would be needed to run blowers, mixers and feed system. The complete installed system has an estimated capital cost of $350,000 with an annual operating cost of $6,000 (does not include labor or sludge handling).



Project No.: MCC–OMR Drawing No.: 06–002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	Figure Filson 1/2/3-3a Filson 1 Proposed Modifications OM&R Plan Union Township Jefferson County, PA

Table Filson 1/2/3-6a

Preliminary Engineering Cost Estimate

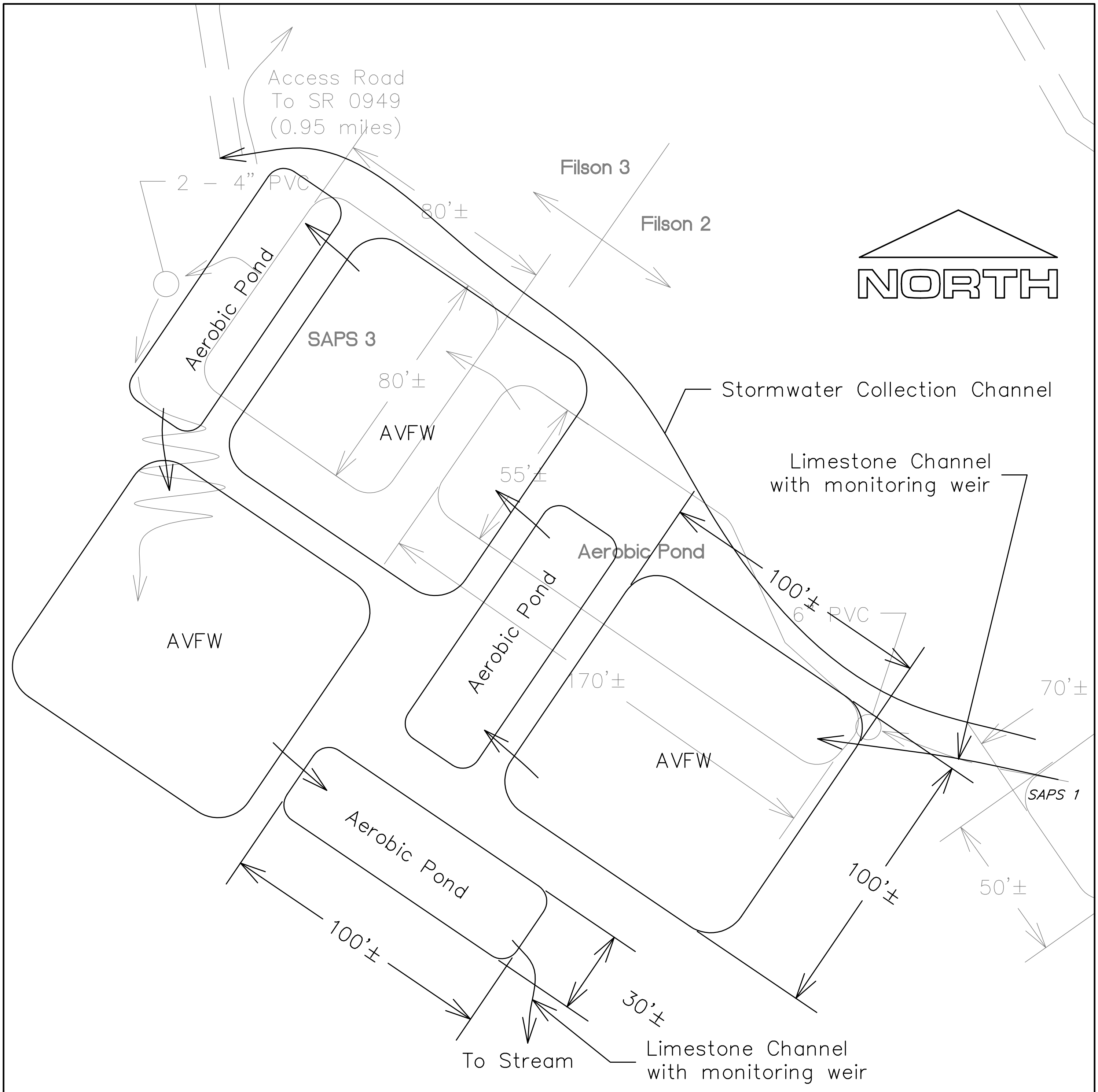
Mill Creek Coalition: OM&R System Modifications

Site: Filson 1 System Upgrade

Date: December 29, 2006

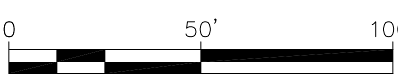
Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	1.5	ACRE	$ 1,750.00	$ 2,625.00
3.	E&S Control	1	LS	$ 10,000.00	$ 10,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	4500	CY	$ 3.00	$ 13,500.00
	(b) Wet	4500	CY	$ 6.00	$ 27,000.00
8.	Embankment Construction	3000	CY	$ 5.00	$ 15,000.00
9.	Geotextile Liner	7870	SY	$ 15.00	$ 118,050.00
10.	Geonet	4875	SY	$ 5.50	$ 26,812.50
11.	High Quality Limestone	4600	Ton	$ 28.00	$ 128,800.00
12.	Mushroom Compost Substrate	3600	CY	$ 30.00	$ 108,000.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	4290	LF	$ 15.00	$ 64,350.00
	(b) 4" Solid pipe	1530	LF	$ 12.00	$ 18,360.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	6	EA	$ 1,500.00	$ 9,000.00
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	3300	EA	$ 3.00	$ 9,900.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	1180	SY	$ 22.00	$ 25,960.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	4	EA	$ 450.00	$ 1,800.00
20.	Seeding/Restoration	0.5	Acre	$ 2,400.00	$ 1,200.00
21.	Sludge Removal/Disposal	600	CY	$ 15.00	$ 9,000.00

TOTAL AMOUNT OF COST ESTIMATE **$ 596,857.50**



Utilize SAPS 1 for collection of AMD.

Construct:
Three (3) AVFW = 10,000 SF (each)
Three (3) Aerobic Pond = 3,000 SF (each)



Project No.: MCC–OMR Drawing No.: 06–002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	**Figure Filson 1/2/3-3b** **Filson 2 & 3** **Proposed Modifications** **OM&R Plan** Union Township Jefferson County, PA

Table Filson 1/2/3-6b

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Filson 2 & 3 System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.8	ACRE	$ 1,750.00	$ 1,400.00
3.	E&S Control	1	LS	$ 10,000.00	$ 10,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	3200	CY	$ 3.00	$ 9,600.00
	(b) Wet	3200	CY	$ 6.00	$ 19,200.00
8.	Embankment Construction	2150	CY	$ 5.00	$ 10,750.00
9.	Geotextile Liner	4900	SY	$ 15.00	$ 73,500.00
10.	Geonet	1800	SY	$ 5.50	$ 9,900.00
11.	High Quality Limestone	2520	Ton	$ 28.00	$ 70,560.00
12.	Mushroom Compost Substrate	2020	CY	$ 30.00	$ 60,600.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	2400	LF	$ 15.00	$ 36,000.00
	(b) 4" Solid pipe	660	LF	$ 12.00	$ 7,920.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	6	EA	$ 1,500.00	$ 9,000.00
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	1875	EA	$ 3.00	$ 5,625.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	880	SY	$ 22.00	$ 19,360.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	2	EA	$ 450.00	$ 900.00
20.	Seeding/Restoration	0.4	Acre	$ 2,400.00	$ 960.00
21.	Sludge Removal/Disposal	880	CY	$ 15.00	$ 13,200.00

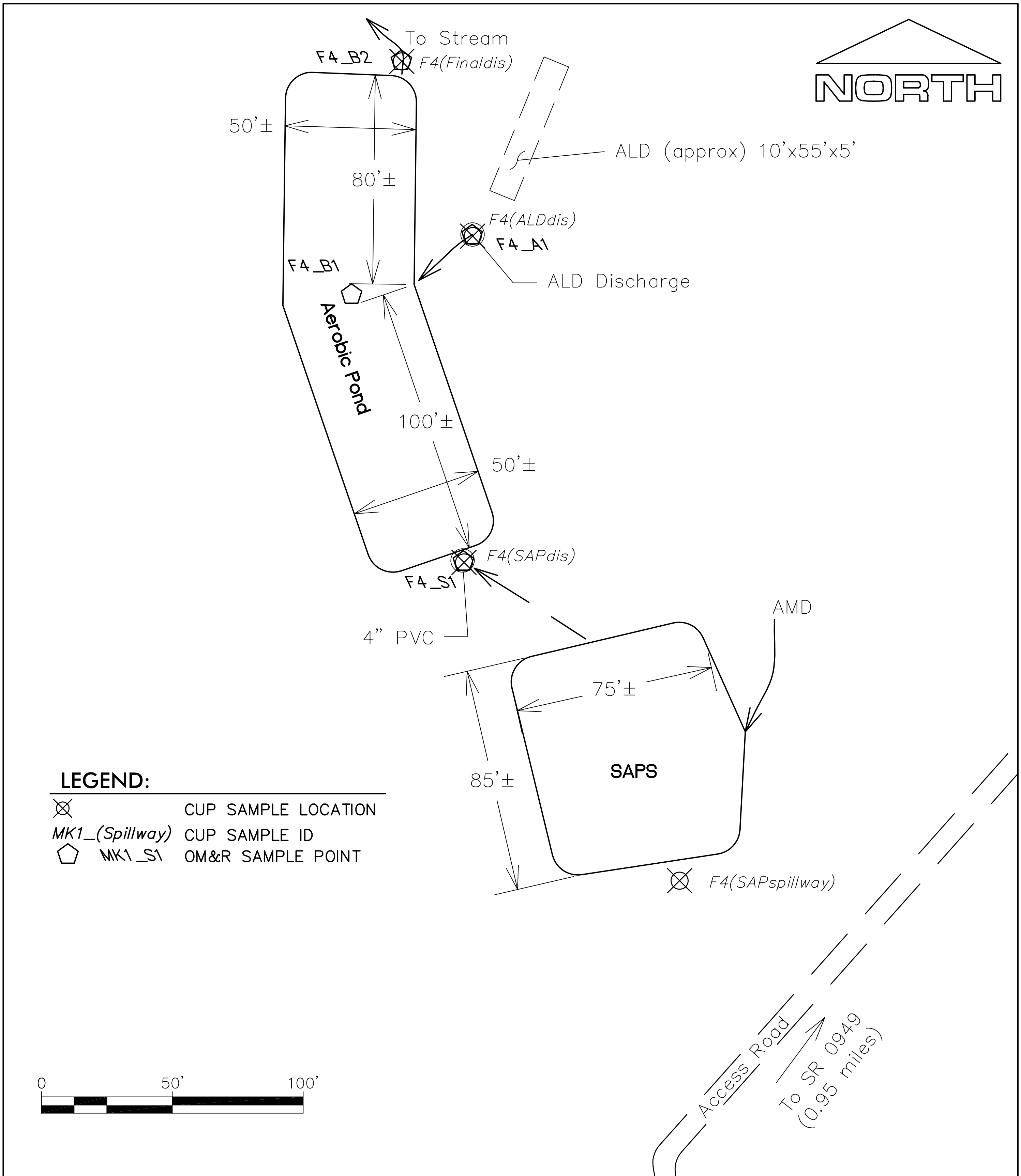
TOTAL AMOUNT OF COST ESTIMATE **$ 365,975.00**

Filson 4 Passive Treatment System

SAPS and Overflow Spillway

SAPS Stand-pipe Outlet

Aerobic Pond



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 Filson 4-1** **Existing Filson 4 Treatment System & OM&R Sample Points** Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Filson 4 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The Filson 4 passive treatment system was constructed in 2000 and consists of a SAPS, an aerobic pond, and an ALD that discharges into the last half of the aerobic pond.
- Current effluent water quality indicates the system, despite the performance and alkalinity generated by several units, may be operating at a reduced effectiveness due to the influence of AMD upwelling in the aerobic pond.
  - The effluent had a measured pH of 3.95 indicating AMD may be entering the system.
  - An in-depth investigation is needed to identify source water and source water chemistry.
- The SAPS underdrain has an elevated Eh (+25 mV) indicating the unit is operating at a reduced effectiveness and may be in the initial stages of declining performance.
  - During high flow periods, AMD is bypassing the system through the emergency spillway.
  - Current effluent alkalinity from the SAPS underdrain is greater than 100 mg/L.
  - Sizing criteria indicate the SAPS may be chemically overloaded.
- Evaluation results indicate the ALD effluent alkalinity is approximately 60% of the maximum, but exceeds the required alkalinity to remove the iron and manganese in the discharge and is therefore at a moderate effectiveness condition.

Recommendations for the Filson 4 passive treatment system are as follows:

- Conduct an in-depth flow and water quality evaluation to determine causes of the low effluent pH.
- Redirect the emergency spillway (i.e., SAPS overflow) into a new limestone channel and into the aerobic pond.
- Install an outlet orifice to control the underdrain flow to prevent chemical and hydraulic overloading of the SAPS.

The following provides details to support the above summary.

System Description

The Filson 4 passive treatment system layout is depicted on Figure Filson 4-1. The Filson 4 system was constructed in 2000 to treat an AMD seep, known as the "Filson 4" that emanates from the toe-of-spoil of the Filson surface mine. The Filson 4 Seep is a highly acidic discharge with low pH (< 3.5) and elevated iron (~ 60 mg/L), aluminum (~ 5 mg/L) and manganese (~ 40 mg/L) (Table Filson 4-1). The Filson 4 passive treatment system was designed to treat this discharge employing a SAPS followed by an aerobic pond to remove metals. In addition, a low flow seep (no pre-construction data) adjacent to the aerobic pond was encountered during construction. An ALD was installed to add alkalinity to this discharge prior to entering the aerobic pond.

Table Filson 4-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
3.3	0	400	2	60	40	---	---

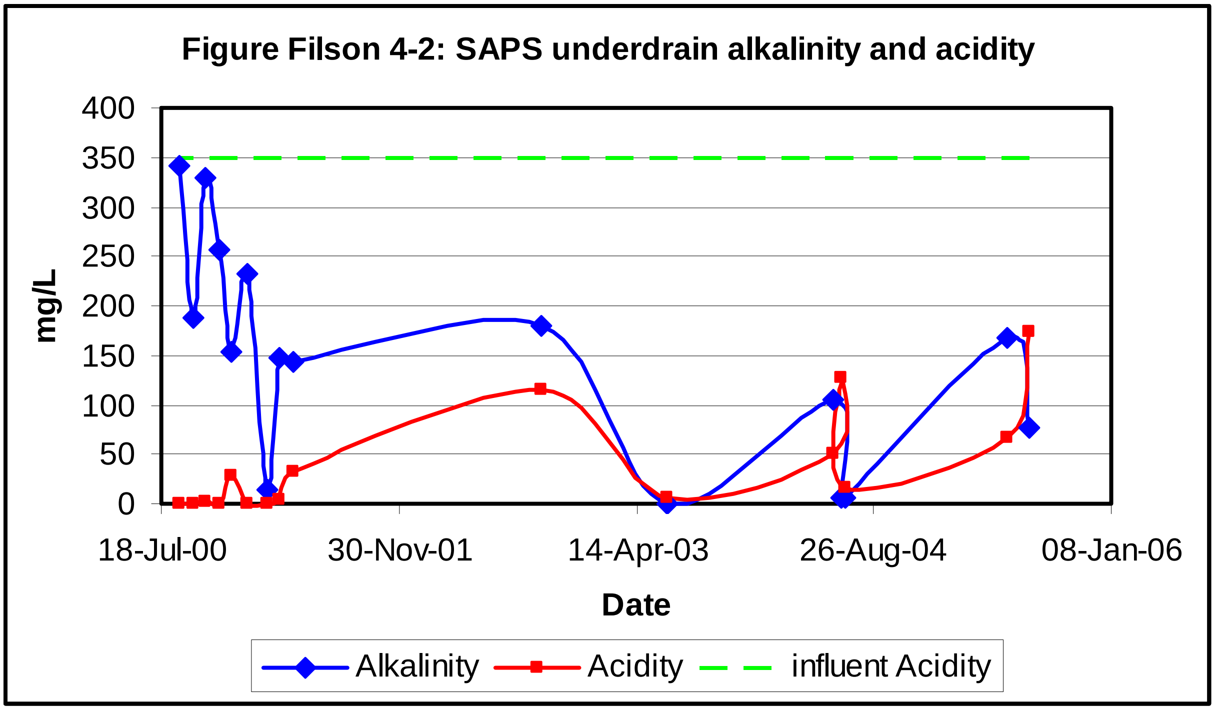
Operational Assessment

The Filson 4 passive treatment system was functioning (i.e., water passing through underdrain and ALD) at the time of the field visit in April 2005 and in July 2005. The following provides an operational assessment of the various treatment units in the Filson 4 passive treatment system.

SAPS

A large amount of flow (> 20 gpm) was passing over the emergency spillway and less than 10 gpm discharging through the underdrain of the SAPS during the April 2005 visit. The emergency spillway flows into a limestone channel that bypasses the remainder of the system. During the system assessment on July 13, 2005, the discharge flow had decreased and all the flow was passing through the underdrain outlet. The low underdrain flow during high flow periods is a functional issue that can result in inadequate treatment of the discharge.

Acidity and alkalinity data from the SAPS underdrain monitored by the Mill Creek Coalition are provided in Figure Filson 4-2. These data indicate the SAPS produced high levels of alkalinity (200 to 300 mg/L) during the first year of operation. Following this first year period, alkalinity from the SAPS has declined and is approaching 0 mg/L. Also shown on the figure is the underdrain acidity. The acidity was initially 0 mg/L during the first year of operation, but has increased following this period to current acidity levels between 50 and 100 mg/L. While the SAPS is still substantially treating the AMD (effluent acidity is less than 50% of influent acidity), the current conditions indicate the SAPS performance is deteriorating and inadequate to treat the AMD.



The Filson 4 SAPS was evaluated for a variety of performance parameters on July 13, 2005 with the results summarized in Table Filson 4-2. Several parameters measured from the underdrain of the SAPS raise concern regarding the conditions and long term performance of the SAPS. The high underdrain Eh (> 0 mV) indicates the SAPS does not support reducing conditions needed to raise the pH (through sulfate reduction) and prevent aluminum from precipitating on the limestone. The high Eh may also affect the underdrain alkalinity, which was high (>100 mg/L) at the low flow time of the field evaluation. However, historic data indicate there have been alkalinities near and below 0 mg/L during recent monitoring when flows were substantially higher (Figure Filson 4-2). The field results indicate the SAPS is in a reduced effectiveness condition and may not be able to adequately treat the Filson 4 AMD discharge.

Table Filson 4-2. Filson 4 passive treatment system field evaluation conducted on July 13, 2005.

Parameter	Unit	SAPS Underdrain	ALD Outlet
Dissolved Oxygen	mg/L	0.12	0.16
Temperature	ºC	18.6	13.8
Conductance	µS	1307	1386
pH	s.u.	5.99	6.11
Eh	mV	+25	+84
Sulfide	mg/L	<0.1	--
Ferrous Iron	mg/L	41.2	23.4
Total Iron	mg/L	40.2	23.2
Alkalinity	mg/L	113	169
Flow	gpm	3	0.3

ALD

Long term operational data from the ALD outlet monitored by the MCC for acidity and alkalinity are provided in Figure Filson 4-3. These data indicate the ALD produced high levels of alkalinity (~300 mg/L) during the first year of operation. Following this first year period, alkalinity from the ALD has steadily declined at a rate of approximately 30 mg/L per year and is currently discharging approximately 150 mg/L, about 50% of its initial alkalinity. Also shown on the figure is the ALD outlet acidity. The acidity has gradually increased as the outlet alkalinity has decreased. This indicates ALD outlet alkalinity will soon be inadequate to neutralize the discharge acidity and maintain a pH greater than 6 once metals are fully oxidized and precipitated.

Figure Filson 4-3: Filson 4 ALD outlet alaklinity and acidity

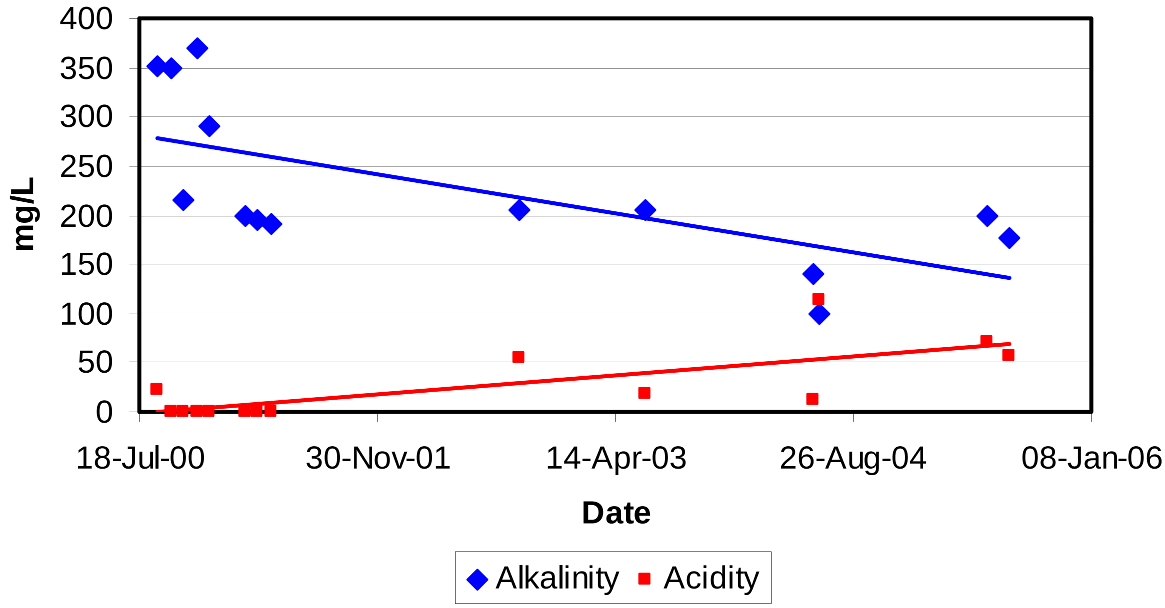


Table Filson 4-2 also contains measurements made on the outlet from the ALD. The field measured parameters do not indicate any operational problems with the ALD. The presence of low dissolved oxygen concentrations may be due to the difficulty in measuring a zero concentration or interference by hydrogen sulfide. The Eh measured was slightly elevated (> 50 mV) and may reflect the presence of oxygen and/or ferric iron. No particulate iron was detected in the outlet and all iron was in the ferrous form. Both iron and alkalinity concentrations were consistent with long term monitoring data by the Mill Creek Coalition.

Table Filson 4-3 contains the results of the cubitainor study conducted on outlet water from the ALD. The alkalinity results shown should approach the maximum alkalinity concentration that can be achieved with long contact times (> 100 hours). The 280 mg/L alkalinitiy from the cubitainor studies are similar to the start-up alkalinity from the ALD (Figure Filson 4-3), which should be expected because the 16 hour detention time plus the volume for longevity should equate to initial ALD detention times in excess of 40 hours. Current alkalinity is only about 60%

of maximum concentration and this was during a low flow period. The percent of maximum is important because it reflects the actual detention time being utilized or that is left in the ALD. In the case of the Filson 4 ALD, only between 4 and 5 hours of the ALD detention time is being utilized. However, based on duration of system operation (approximately 6 years of the 25 years longevity volume) in excess of 20 hours, detention time should be available in the ALD. This difference may be due to short-circuiting within the ALD (e.g., preferential flow paths) and/or iron accumulation/clogging/armoring of the limestone that reduces the effective surface area and contact time.

Table Filson 4-3: Summary of results from cubitainor tests conducted on the Filson 4 ALD effluent.

Bottle No.	Temp ºC	Conduct µS	pH	Alkalinity mg/L	Elapsed Time Hrs
1131	23.1	1454	6.60	284	52.7
1141	23.1	1426	6.61	282	52.8

Diagnosis

Table Filson 4-4 summarizes the current operating conditions, based on the criteria developed, of the various units in the Filson 4 passive treatment system. The SAPS in the Filson 4 system is in the reduced effectiveness classification. The ALD in the Filson 4 system has a moderate effectiveness, but is rapidly approaching the reduced effectiveness classification. The aerobic pond could not be assessed due to the low pH effluent, indicative of AMD inflow into the aerobic pond. Additional evaluation indicates the Filson 4 system does not adequately treat the AMD discharge, based on effluent net acidity and low pH.

Table Filson 4-4: Summary of Filson 4 passive system unit conditions.

Unit	Condition	Criteria	Level
SAPS	Eh = +25 mV	Eh ≥ 0 mV	Reduced
ALD	60% Maximum	60 to 85% AD < ALD Alkalinity	Moderate
Aerobic Pond	Low Effluent pH	NA	Satisfactory

The SAPS is functioning at a reduced effectiveness due to: 1) inadequate underdrain flow during high inflow periods; and/or 2) elevated Eh in the underdrain during low flow conditions. The available data indicate clogging and coating of the limestone may be the cause. This may be the result of excessive acidity (or aluminum) loading to the SAPS.

The ALD is operating at a moderate effectiveness condition due to lower alkalinity produced by the ALD. The ALD would be in a reduced effectiveness if iron (and manganese) were higher and required a greater alkalinity to neutralize their acidity. However, it appears higher alkalinity from the ALD may be important to aid in neutralizing acidity that can not be addressed by the SAPS. In addition, based on the declining trend the Filson 4 ALD will be operating at a reduced effectiveness within the next several years.

Design Methodology

Design basis was available for the Filson 4 passive treatment system. Table Filson 4-5 provides the estimated surface area and limestone volume and limestone bed detention time in the SAPS and ALD. Table Filson 4-5 also provides the estimated acidity loading and surface hydraulic loading on the SAPS.

Table Filson 4-5: Summary of Filson 4 passive treatment system size and design parameters

Cell	Surface Area ft^2	Limestone Volume ft^3	Limestone Bed Detention Time Hrs	Acidity Loading $gr/day/m^2$	Hydraulic Loading gpm/acre
SAPS 1	4,800	11,200	12-70	30-250	50-500
ALD	550	2,750	16-80	NA	NA

Comparing the acidity loading and hydraulic loading in Table Filson 4-5 to reported design guidance for AVFW of 25 $gr/day/m^2$ and 150 gpm/acre (Rose & Dietz, 2002; Dietz et al, 1996; and Dietz, 1997) indicate the SAPS is overloaded with respect to both parameters when the system is receiving maximum reported historical flows. It is likely the periodic maximum flows are causing the reduced operating performance of the SAPS. Underdrain outlet flow controls would prevent excess loading to the SAPS.

The ALD was designed for a 16 hour detention time with limestone added for longevity. However, no record of flows was available for the discharge. At higher flows, the detention time could decrease to less than the 16-hours. However, this lower detention time does not explain the gradual decline in effluent alkalinity. Based on a 25 year longevity, the ALD should still have an effluent alkalinity near the start-up and cubitainor alkalinity. This suggests there is short-circuiting or metal coating of the limestone, therefore lowering the apparent detention time and effluent alkalinity and causing the reduced effectiveness.

Action

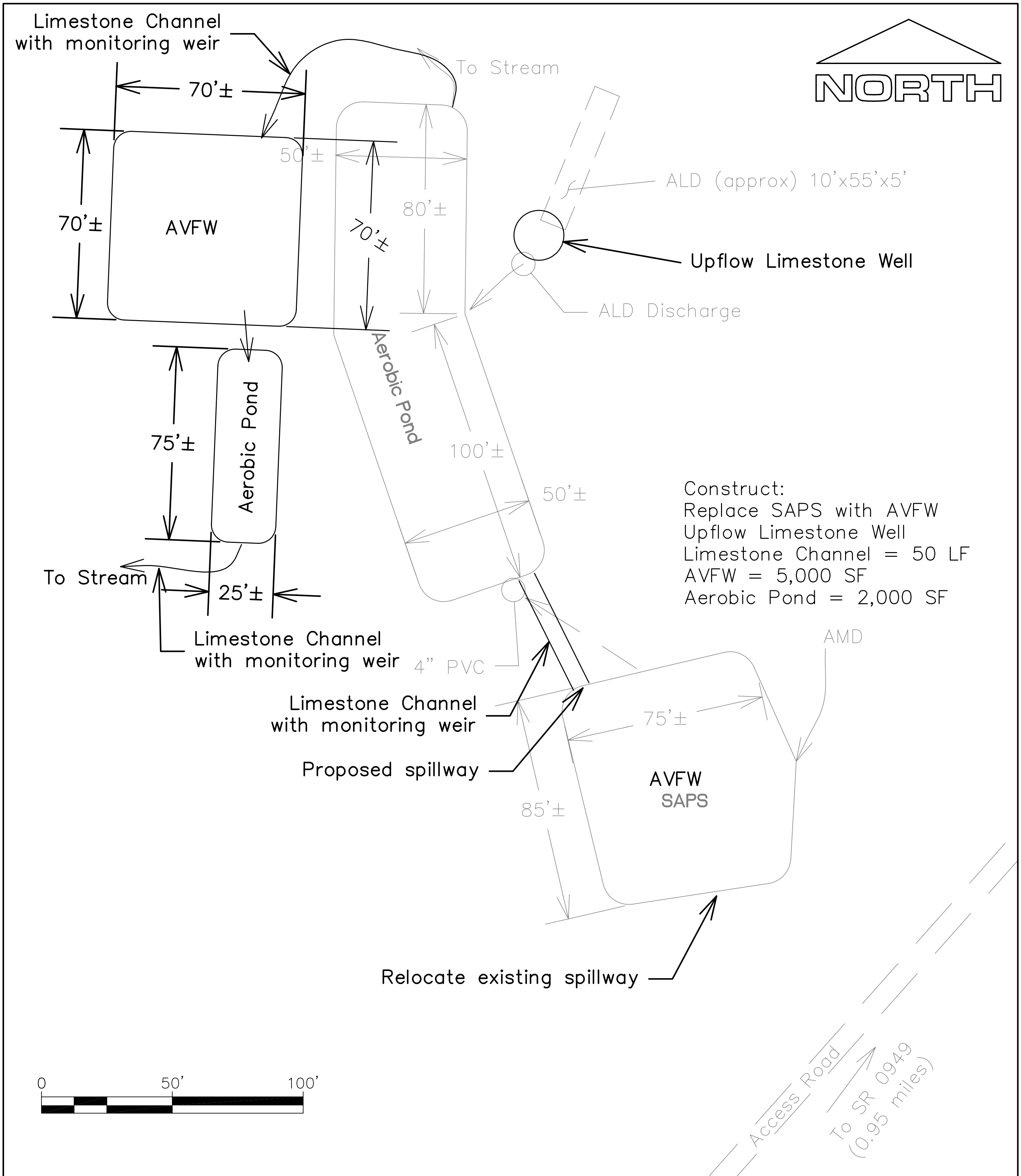
Based on the evaluation, the Filson 4 passive treatment system is currently operating at a reduced effectiveness. The SAPS longevity may be prolonged if an outlet control device is installed. However, this is unlikely to return permeability to treat existing flows. In addition, the average and higher flows result in severe acidity and hydraulic overloading based on current design guidance and likely contributed to the current reduced effectiveness condition of the SAPS. As shown in the above analysis, the ALD is also rapidly approaching a reduced effectiveness condition. Based on the current conditions, the recommendations for the Filson 4 system include:

1) Replacement of the existing SAPS with a new AVFW unit at the current location, but with greater compost depth.
2) Installation of a new ALD or an upflow limestone well to treat the ALD treated discharge.
3) Construct a second AVFW and aerobic pond to treat remaining acidity in the water and produce net alkaline water under all flow conditions.

Operation, Maintenance & Replacement Plan

The current Filson 4 passive treatment system is functioning at a reduced effectiveness condition and does not fully address the AMD at this site. Replacement of the system will be required to remediate the discharge and minimize impacts on Little Mill Creek. The following recommendations are based on historical data for the Filson 4 AMD discharge and field observations made during the system assessment.

The main Filson 4 AMD discharge is a high acidity, low pH, and elevated iron, aluminum and manganese discharge (i.e., aerobic discharge). The discharge characteristics limit the passive treatment choice to an AVFW (or SAPS) technology similar to the current system, but with greater compost depth (2 to 2½ feet) than the existing SAPS. The multi-cell model was used to estimate the required size and number of cells needed to address the Filson 4 AMD discharge. Based on the modeling, a two cell AVFW would be adequate to treat up to 20 gpm with the acidity of the Filson 4 AMD. The first AVFW would utilize the area occupied by the existing SAPS. The second AVFW would be approximately 3,500 ft^2 and be located down gradient of the existing aerobic pond. A second aerobic pond would be constructed after the second AVFW and would be approximately 2,000 ft^2. The conceptual design is depicted in Figure Filson 4-4. The estimated construction costs for the system are summarized in Table Filson 4-6.



Project No.: MCC–OMR
Drawing No.: 06–002
By: TSG 3/3/06
Chkd: JMD 3/14/06

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure Filson 4-4
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Table Filson 4-6

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Filson 4 System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.5	ACRE	$ 1,750.00	$ 875.00
3.	E&S Control	0.5	LS	$ 10,000.00	$ 5,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	1250	CY	$ 3.00	$ 3,750.00
	(b) Wet	825	CY	$ 10.00	$ 8,250.00
8.	Embankment Construction	500	CY	$ 7.00	$ 3,500.00
9.	Geotextile Liner	3100	SY	$ 15.00	$ 46,500.00
10.	Geonet	1180	SY	$ 5.50	$ 6,490.00
11.	High Quality Limestone	925	Ton	$ 28.00	$ 25,900.00
12.	Mushroom Compost Substrate	740	CY	$ 30.00	$ 22,200.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	950	LF	$ 15.00	$ 14,250.00
	(b) 4" Solid pipe	200	LF	$ 12.00	$ 2,400.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	4	EA	$ 1,500.00	$ 6,000.00
14.	Orifice Flow Control	4	EA	$ 75.00	$ 300.00
15.	Wetland Vegetation and Planting	750	EA	$ 3.00	$ 2,250.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	430	SY	$ 22.00	$ 9,460.00
18.	Upflow Limestone Well	1	EA	$ 12,500.00	$ 12,500.00
19.	Monitoring Weir	3	EA	$ 450.00	$ 1,350.00
20.	Seeding/Restoration	0.3	Acre	$ 2,400.00	$ 720.00
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

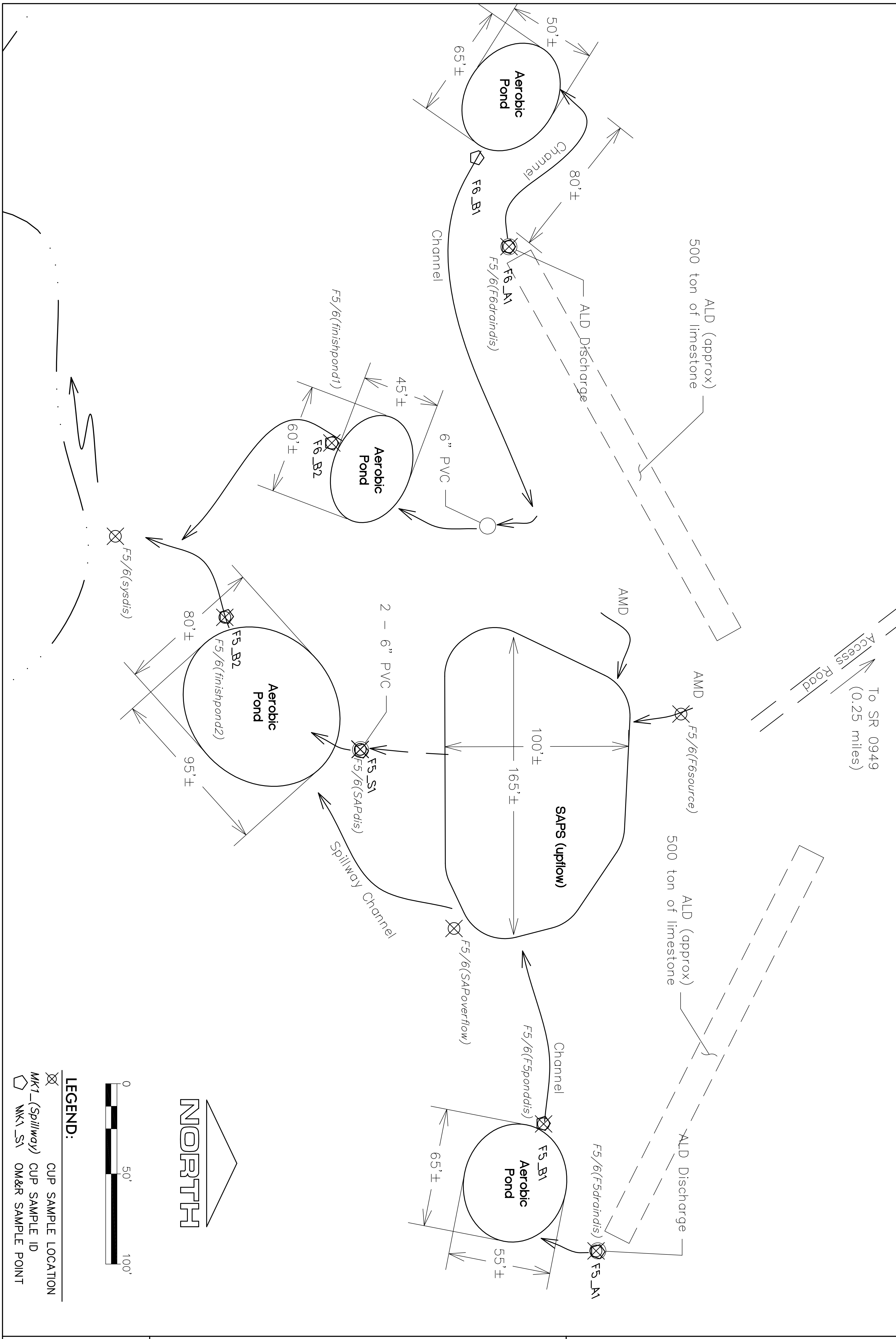
TOTAL AMOUNT OF COST ESTIMATE **$ 179,195.00**

Filson 5/6 Passive Treatment System

Filson 5 – Anoxic Limestone Drain

Filson 6 – Anoxic Limestone Drain

Filson 5/6 -SAPS



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 Filson 5/6-1 Existing Filson 5/6 Treatment System & OM&R Sample Points Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Filson 5/6 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- Three separate sources are treated passively in two separate flow path systems that include Anoxic Limestone Drains (ALDs), aerobic ponds, open channels, and a SAPS constructed in 1996.
- Current effluent water quality indicates the ALDs are operating satisfactorily, but with a steady decrease in effluent alkalinity.
- Analysis of historical data indicate the aerobic ponds are periodically overloaded during high flow events causing significant deterioration in effluent water quality (i.e., inadequate oxidation/settling time in the aerobic ponds and channels).
- Effluent iron is increasing from the system and is likely a result of increasing iron oxide accumulation within the systems
- The SAPS has very high effluent iron, but has Eh and alkalinity indicating the SAPS is operating satisfactorily.

Recommendations for the Filson 5/6 passive treatment system are as follows:

- Remove iron oxide solids from Filson 5 and Filson 6 portions of the system, including the first pond and channel.
- Install an upflow limestone well to add alkalinity to the Filson AMD entering the SAPS.
- Redirect the Filson 6 channel into the SAPS similar to the Filson 5 discharge to improve iron removal and add alkalinity to treat the other AMD sources in the Filson 5/6 system.
- Install standpipes with flow control orifices on the SAPS underdrain outlets to allow for greater water depth and improved iron removal.
- The SAPS may eventually fail due to excessive solids loading, however, the current alkalinity from the ALDs and the recommended upflow limestone well will provide adequate alkalinity and the SAPS will eventually function as an aerobic pond for iron removal.

The following provides details to support the above summary.

System Description

The Filson 5/6 passive treatment system layout is depicted in Figure Filson 5/6-1. No design information was available for the Filson 5/6 system and sizes were estimated from a field investigation of the site. The Filson 5/6 system was constructed in 1996 to treat toe-of-spoil AMD seeps with elevated pH (5 to 6) and high iron, characteristics of anoxic mine drainage (Table Filson 5/6-1). The Filson 5/6 has been treating the AMD to the present with minimal operation and maintenance effort.

Table Filson 5/6-1: Typical pre-construction AMD characteristics

	pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
Filson 5	5.6	36	191	0.02	44	13	615	20
Filson 6	5.8	63	177	0	49	11	566	30

The Filson 5/6 passive treatment system consists of a two separate flow paths. The Filson 5 system contains an ALD followed by a short 30 foot length of open channel leading to an aerobic pond with a surface area of 3,500 ft^2. The effluent from the aerobic pond flows in a second, slow moving 100 foot length of open channel into a SAPS with a surface area of approximately 16,000 ft^2. The SAPS was constructed to address additional source water found during construction of the Filson 5/6 system. The effluent from the SAPS discharges by underdrain outlets to a wet area and into a final aerobic pond with a surface area of 7,000 ft^2. The treated water is then discharged into a natural emergent/open water wetland complex along Little Mill Creek.

The Filson 6 system is similar with an ALD followed by 80 feet of open channel leading into a 3,500 ft^2 aerobic pond. The effluent from the pond flows in a 200 foot long open channel. However, instead of flowing into the SAPS, the discharge from the open channel enters into a 2,500 ft^2 aerobic pond. This aerobic pond discharges into a combined channel with the Filson 5 system before entering the natural wetland complex along Little Mill Creek.

The SAPS contains 0.5 feet deep layer of compost over above a 3 feet deep bed of limestone. Standing water in the treatment cell varies considerably from the top of the compost to the overflow spillway. AMD passing through the SAPS is discharged through two 4-inch diameter underdrain pipes with flow and water level controlled by gate valves. This water level/flow control using valves is the cause of the variable water levels in the SAPS.

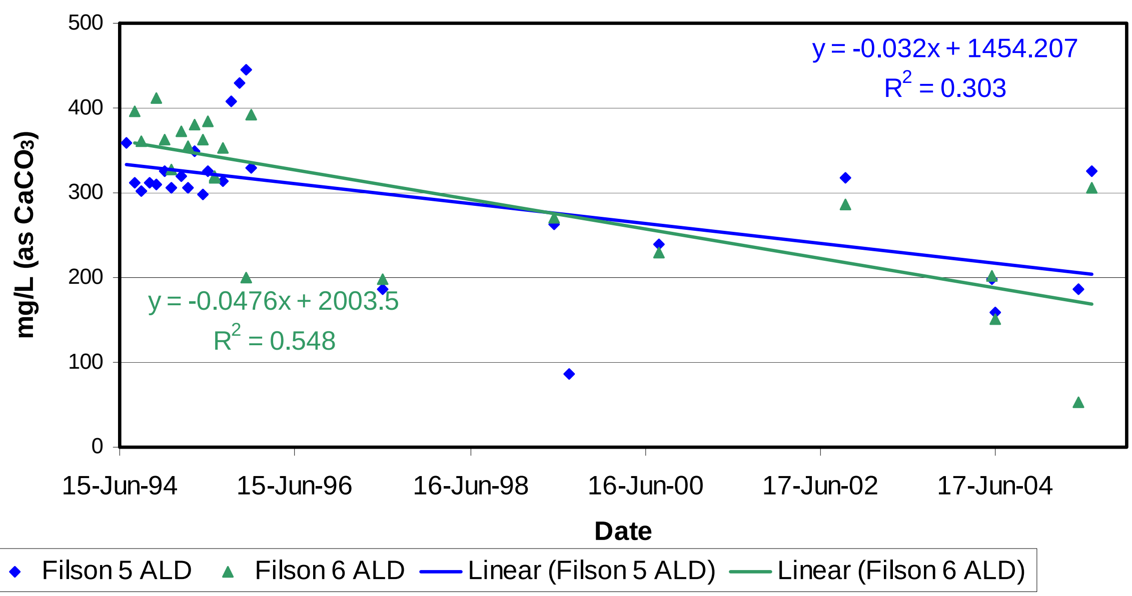
Operational Assessment

The Filson 5/6 Treatment System was functioning properly, based on all flow passing through the ALDs, aerobic ponds, and SAPS at the time of the initial site visit on April 27, 2005 and during the in-depth sampling on July 14, 2005. Water was flowing over the spillway from the SAPS during the April visit, which was due to the aforementioned gate valves which make it difficult to maintain a constant water level in the SAPS. In addition, Filson 6 open channels showed accumulation of iron solids that have caused, based on observed wet areas and iron oxide staining, overflow of the embankments along the channel and short-circuiting of the remaining units.

ALD

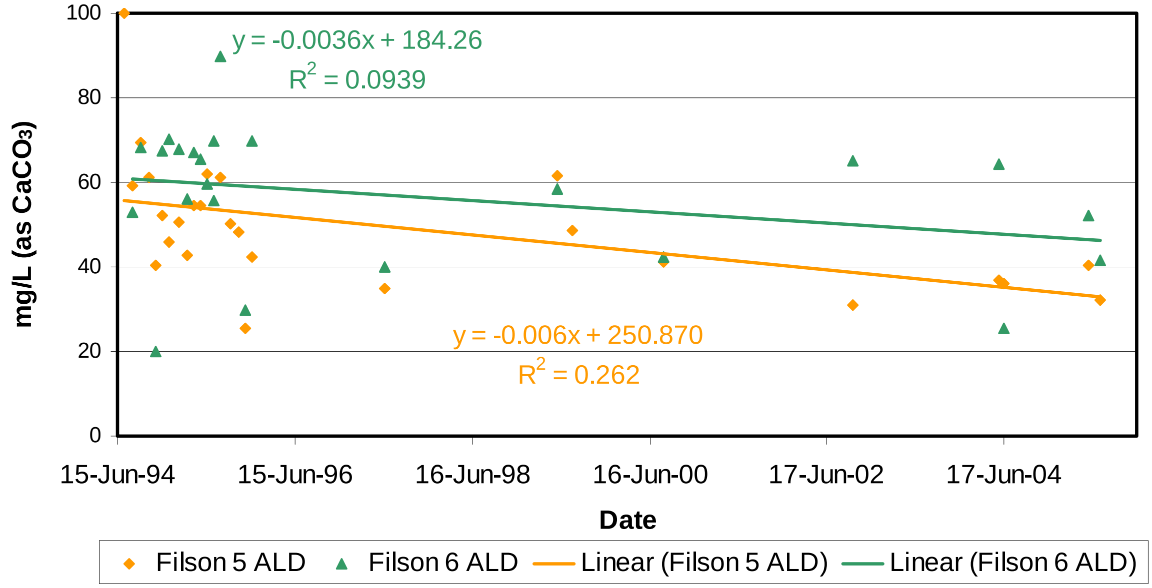
Long term ALD outlet alkalinities from the two ALDs in the Filson 5/6 passive treatment system are plotted in Figure Filson 5/6-2. The plots indicate ALD outlet alkalinity decreases gradually over time. Although the regressions shown have low R^2, the decreasing trends should be considered significant because flow varied considerably within the data set (3 to 45 gpm), which affects detention time and alkalinity within an ALD. Based on the regressions, the Filson 5/6 passive treatment system ALDs outlet alkalinity decreased over the past ten years of operation by approximately 120 and 180 mg/L, respectively.

Figure Filson 5/6-2: Anoxic Limestone Drains (ALDs) outlet alkalinity at the Filson 5/6 passive preatment system



As a comparison, Figure Filson 5/6-3 shows the change in outlet iron from the ALDs over the sampling program. The data show a gradual decrease in ALD effluent total iron in addition to the decrease in alkalinity. However, only the regression for the Filson 5 ALD was significant. Overall, the Filson 5 ALD outlet total iron has been decreasing at a rate of 2 mg/L per year. The decrease at the Filson 6 ALD is not significant, but the data suggest a decrease of about 1 mg/L per year. Due to the inability to measure raw discharge water, it can not be determined whether this observed decrease is from a gradual decline in AMD iron concentration or increasing removal of iron within the ALDs, an indicator of potential future operational problems.

Figure Filson 5/6-3: Anoxic Limestone Drains (ALD) outlet total iron at Filson 5/6 passive treatment system



During the field study, a number of measurements were made on the outlets from the two ALDs. The results are summarized in Table Filson 5/6-2. The field results do not indicate any operational problems with the ALD. The presence of low dissolved oxygen concentrations may be due to the difficulty in measuring a zero concentration or interference by hydrogen sulfide. The Eh measured was near zero and reflective of an anoxic (near zero) discharge. No particulate iron was detected in the outlet and all iron was in the ferrous form. Both iron and alkalinity concentrations were consistent with long term monitoring data by the Mill Creek Coalition.

Table Filson 5/6-2: Summary of field evaluation of the Filson 5/6 ALDs.

ALD	Flow gpm	D.O. mg/L	Temp. °C	Cond. µS	pH	Eh mV	Fe^{2+} mg/L	Total Fe	Alkal. mg/L
Filson 5	1.4	0.20	13.8	877	6.48	-6	35.8	35.8	280
Filson 6	8.5	0.17	12.2	867	6.38	+7	51.5	51.5	250

Table Filson 5/6-3 contains the results of the cubitainor studies conducted on outlet water from each ALD. The alkalinity results shown should approach the maximum alkalinity concentration that can be achieved with long contact times (> 100 hours). The alkalinities from the cubitainor studies are similar to the start-up alkalinities from the ALDs, which should be expected because the 16 hour detention time plus the volume for longevity should equate to initial ALD detention times in excess of 40 hours. The ratio of the current alkalinity to the cubitainor alkalinity is important because it reflects the actual detention time being utilized or that is left in the ALD. In the case of the Filson 5/6 ALDs only between 5 and 6 hours of the detention time is being utilized. However, based on the duration of system operation (approximately 10 years of the 25 years longevity volume) in excess of 20 hours detention time should be available in the ALD. This difference may be due to short-circuiting within the ALDs (e.g., preferential flow paths) and iron accumulation/clogging/armoring of the limestone in the ALD that reduces the effective surface area and contact time.

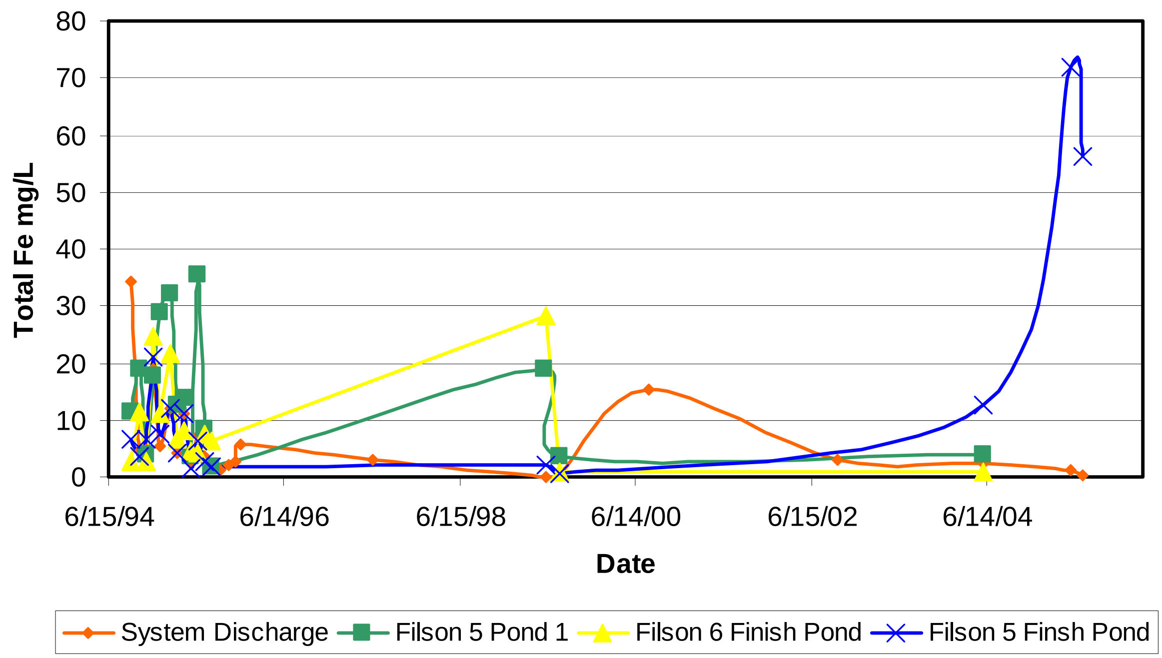
Table Filson 5/6-3: Summary of cubitainor study results on the Filson 5/6 ALDs.

ALD	Duration hrs	Temp. °C	Cond. µS	pH	Alkal. mg/L
Filson 5	47.2	22.4	946	6.67	339
	47.5	22.5	958	6.64	343
Filson 6	46.2	22.5	942	6.69	336
	46.5	22.5	942	6.66	346

Aerobic Pond

Figure Filson 5/6-4 shows the total iron at various locations within the Filson 5/6 passive treatment system including the final discharge. The initial sampling on the system was conducted shortly after start-up (1994 and 1995) was more frequent (monthly) than more recent annual sampling. The initial sampling showed considerable variability and at times less than 50% removal of iron. More recent sampling has been less frequent and typically occurs during lower flow and warmer weather conditions. No trend was apparent in the effluent iron data, which may in part due to the strong influences of flow and temperature on iron removal in the passive treatment system. Recent sampling does indicate higher effluent iron from the Filson 6 system.

Figure Filson 5/6-4: Total iron concentration at various locations in the Filson 5 and 6 passive treatment system.



Aerobic pond iron removal performance and the depth of solids in the ponds were also measured during the field evaluation. Table Filson 5/6-4 provides the results from the field analysis. As shown in Table Filson 5/6-4, the two ponds function differently with respect to conditions and effluent water quality, despite being the same size and treating similar historic flows and iron concentrations. The Filson 5 pond has a higher pH, dissolved oxygen concentrations, and temperature compared to the Filson 6 Pond. The conditions are related to the differences in flow of the two discharges, which results in less gas transfer (as indicated by dissolved oxygen) and lower temperatures (i.e., less heating). Influent iron concentration is also an important factor with its oxidation causing lower dissolved oxygen (consumed by oxidation) and precipitation causing lower pH (carbon dioxide formation).

Table Filson 5/6-4: Summary of field analysis on Filson 5/6 initial aerobic ponds (i.e., aerobic ponds following ALDs).

Location	Flow gpm	Temp. °C	pH	D.O. mg/L	Ferrous Iron mg/L	Total Iron mg/L	Alkalinity mg/L
Filson 5 -1 Inlet	2.5	16.5	6.61	4.18	29.1	30.6	268
Filson 5 -1 Outlet	--	23.5	6.91	4.20	0.2	1.6	205
Filson 6 -1 Inlet	11.7	12.9	6.39	0.8	49.6	49.8	247
Filson 6 -1 Outlet	--	15.7	6.37	1.2	30.2	35.6	212

Table Filson 5/6-5 shows the measured total depth and the depth of solids accumulation in each pond. The ponds currently contain between 25 and 30% solids. The solids accumulation decreases the total water volume in the ponds and the detention time available for iron oxidation and settling of iron solids. This could have a negative consequence on the performance of the system and effluent quality.

Table Filson 5/6-5: Summary of field solids measurements on Filson 5/6 aerobic ponds.

System	Pond Description	Total Depth ft	Solids Depth ft
Filson 5	Aerobic Pond following ALD	3	0.8
Filson 5	Finish Aerobic Pond	4	1.2
Filson 6	Aerobic Pond following ALD	3.6	1.2
Filson 6	Finish Aerobic Pond	4	1.3

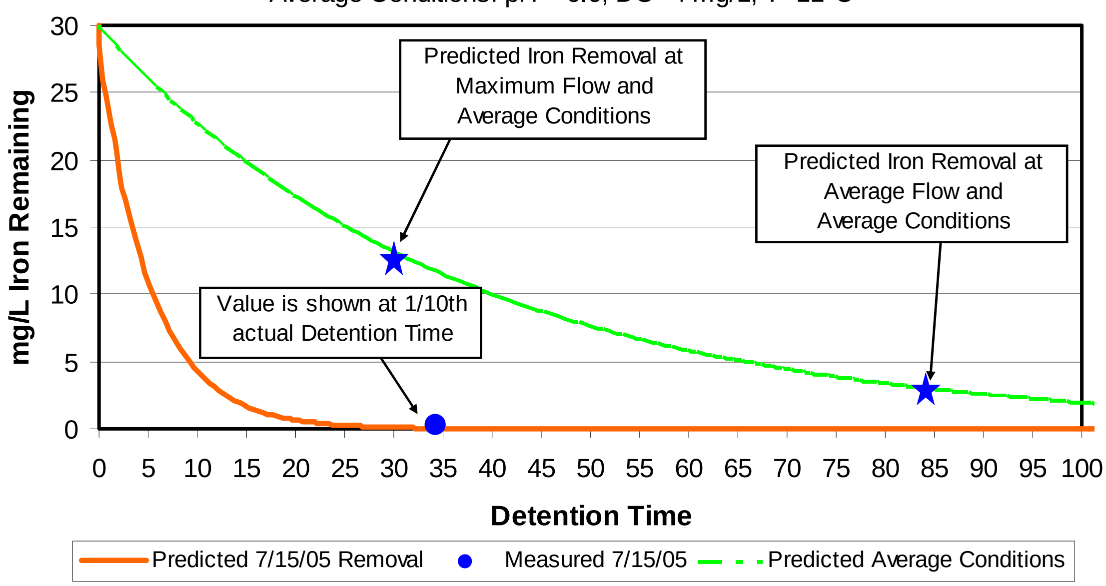
As part of our evaluation, we examined removal in the two ponds using the abiotic iron oxidation model. This was done to evaluate the ability of the model to predict observed performance of the aerobic ponds and to evaluate pond performance under conditions more representative of average flow and seasonal average temperatures since our field investigation was conducted during a warm, low flow period. Figures Filson 5/6-5 and Filson 5/6-6 show the iron removal predicted as a function of detention time in the ponds for conditions monitored on July 15, 2005 and for expected average conditions based on field monitoring data collected by the Mill Creek Coalition.

The Filson 5 pond (Figure Filson 5/6-5) shows the detention time needed is substantially less than the operating conditions for the July 15 measured flows. The measured effluent concentration is consistent with the model prediction as well as the removal rate of 20 grams per day per square meter (Hedin et al., 1996). Comparison to the predicted removals, reflective of average flow and conditions, indicates expected removal is still acceptable for this pond with an expected effluent of less than 5 mg/L. However, at high flows, removal is expected to decrease to about 50% of the influent concentration. As shown in Table Filson 5/6-5, the Filson 5 aerobic pond following the ALD contains approximately 0.8 feet of solids, which reduces the overall detention time by about 25 to 30%. Solids will continue to accumulate in the aerobic pond, decreasing pond detention time and causing additional deterioration of water quality at average and maximum flow. Removing the solids and increasing the depth of the pond would have immediate and long term benefits including: 1) improve effluent quality at average and maximum flow to less than 2 mg/L and 10 mg/L, respectively; 2) increasing depth would allow for greater solids accumulation without deterioration of effluent quality; and 3) improving effluent quality would decrease iron solids accumulation in subsequent units (e.g., SAPS).

Figure Filson 5/6-5. Calculated iron removal in Filson 5 Pond as a function of detention time

7/15/05 Conditions: pH = 6.7, DO=4 mg/L, T=20^{0}C

Average Conditions: pH = 6.6, DO=4 mg/L, T=11^{0}C



The Filson 6 pond is the same size as the Filson 5 pond. However, this pond is much less effective at iron removal (Figure Filson 5/6-6). The difference is associated with the effects of higher flow, higher iron in the Filson 6 discharge and greater solids accumulation. This results in a lower Filson 6 aerobic pond pH, dissolved oxygen and temperature than is found in the Filson 5 aerobic pond. The measured aerobic pond effluent value of 30 mg/L from the field study is very close to the 27 mg/L predicted by the iron oxidation model and indicates the model can predict pond performance. In comparison, the surface iron removal rate of 20 grams per day per square meter used to size the aerobic pond (Hedin et al 1996) predicts the effluent from the pond should be 0 mg/L at the flows measured. This indicates the conventional sizing methodology is inadequate to address variability in discharge chemistries (i.e., pH and iron concentration) as well as changes in aerobic pond performance as solids accumulate. The iron oxidation model was also used to evaluate iron removal reflective of average flow and conditions. Iron removal in the aerobic pond during these higher flows will also be inadequate (greater than 30 mg/L or less than 50% removal) due to the lower pH and dissolved oxygen.

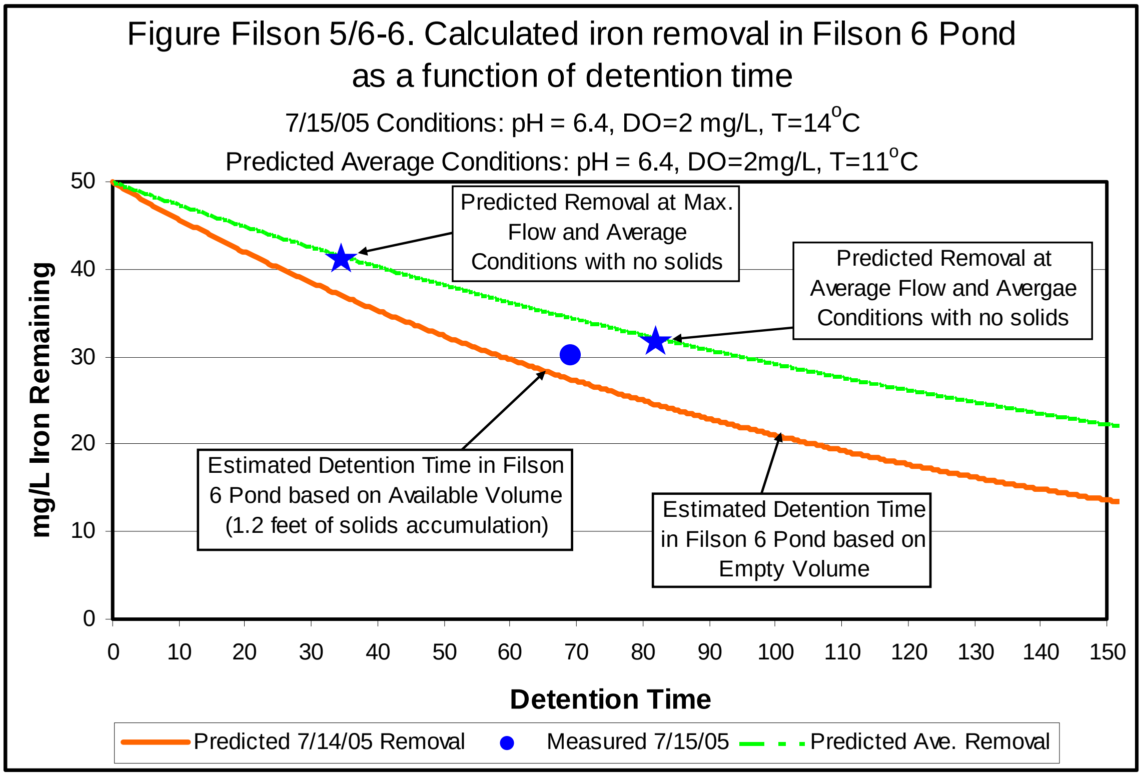


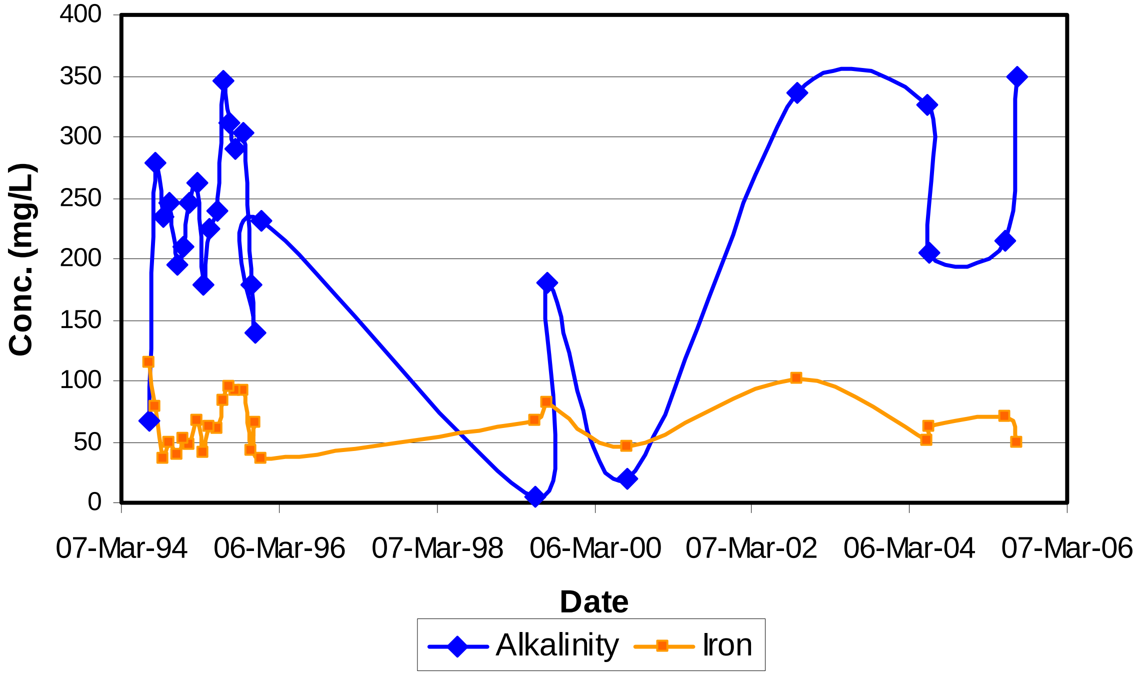
Figure Filson 5/6-6. Calculated iron removal in Filson 6 Pond as a function of detention time

In summary, the Filson 5 aerobic ponds were found to provide adequate removal for the lower flow and lower iron, which permits the pond to have higher pH, dissolved oxygen and temperature to promote more rapid iron oxidation and removal. In comparison, the Filson 6 pond (same size as the Filson 5 pond) does not provide adequate iron removal because the higher iron and flow in the discharge cause lower pH and dissolved oxygen in the aerobic pond. The Filson 5/6 systems would benefit from solids removal and the increase of aerobic pond depth to provide for longer more stable treatment without maintenance to remove solids.

SAPS

The SAPS in the Filson 5/6 system has been operating effectively since installation. The surface of the compost shows accumulation of iron oxide solids that may eventually affect the permeability. Figure Filson 5/6-7 shows the SAPS underdrain outlet alkalinity and total iron data collected by the Mill Creek Coalition. The SAPS has produced a high alkalinity with high total iron. Only two points approached zero. Although the Filson 5/6 SAPS has consistently produced a high alkalinity, it should be noted that overflow data, collected from the SAPS spillway (occurs when valves from the underdrains are not sufficiently open), also has high alkalinity ranging between 35 and 150 mg/L, with iron ranging between 3 and 30 mg/L. The performance of this system may reflect the low acidity strength of the inflow water and/or, based on discussions with the Mill Creek Coalition, an anoxic subsurface inflow similar to the two Filson 5/6 ALDs.

Figure Filson 5/6-7: Filson 5/6 SAPS underdrain outlet alkalinity and total iron



The results of the Filson 5/6 SAPS field evaluations are summarized in Table Filson 5/6-6. The measured underdrain alkalinity and iron is consistent with historical data. Nearly all of the iron was in the reduced form, ferrous iron. The SAPS also had low dissolved oxygen and Eh reflective of anaerobic conditions. The field results indicate the Filson 5/6 SAPS is in good condition with no indication of performance problems. It should be noted, however, that the Filson 5/6 SAPS is receiving low acidity, net alkaline water and/or anoxic water, which may explain the satisfactory conditions.

Table Filson 5/6-6: Filson 5/6 SAPS evaluation conducted on July 14, 2005.			
		Underdrain	
Parameter	Unit	Right	Left
Dissolved Oxygen	mg/l	0.09	0.07
Temperature	ºC	20.7	19.6
Conductance	µS	822	801
pH	s.u.	6.68	6.67
Eh	mV	-90	-70
Sulfide	mg/l	<0.1	<0.1
Ferrous Iron	mg/l	36.8	33.2
Total Iron	mg/l	35.8	34.2
Alkalinity	mg/l	194	197
Flow	gpm	5	17

Right & left pipe determined from downstream looking upstream

Diagnosis

The Filson 5/6 passive treatment system contains a number of operational treatment units including two ALDs, multiple aerobic ponds, open channels, and a SAPS. Results of the evaluation are summarized in Table Filson 5/6-7. The evaluation indicates the two ALDs are operating at a moderate effectiveness level due to decreasing effluent alkalinity. However, the ALD alkalinity is still adequate to remove the metal acidity in the discharges. The Filson 5 aerobic pond is operating satisfactorily, but the Filson 6 aerobic pond is functioning at a reduced effectiveness due to the accumulation of iron oxide solids, as well as the effect of the influent characteristics. The SAPS is currently functioning satisfactorily with no or minimal indication of reduced flow or deterioration of water quality.

Table Filson 5/6-7: Summary of Filson 5/6 passive system unit conditions.			
Unit	Condition	Criteria	Level
Filson 5 ALD	60% Maximum	60 to 85% AD < ALD Alkalinity	Moderate
Filson 6 ALD	60% Maximum	60 to 85% AD < ALD Alkalinity	Moderate
Aerobic Pond 5-1	Iron Removal = 98%	IR >90%	Satisfactory
Aerobic Pond 6-1	Iron Removal = 25%	IR<80%	Reduced
SAPS	Eh = -90, -50 mV	Eh < -50 mV	Satisfactory
Aerobic Pond 5-2	Iron Removal = 98%	IR >90%	Satisfactory
Aerobic Pond 6-2	Solids = 1 foot	NA	Moderate

Future maintenance will be required immediately to remove accumulated solids and restore detention time in the Filson 5 and Filson 6 treatment system.

Design Methodology

No design methodology was available for the Filson 5/6 passive treatment system. Based on the construction timeframe, the system was likely sized to treat average flows using: 1) ALD - 16 hour detention time plus added limestone volume for longevity (20 to 25 years); 2) aerobic ponds - 20 gr/day/m^2 iron removal rate; and 3) SAPS - 8 hour limestone bed detention time.

The SAPS receives various inputs and an evaluation of chemical loading or hydraulic loading is not possible. The SAPS underdrain flow is also controlled by valves, which must be opened and closed in response to changing flows. This also makes it difficult to assess loading on the SAPS. The SAPS may eventually fail due to excessive solids loading; however, the current alkalinity from the Filson 5/6 ALDs may be adequate to offset the iron acidity of direct AMD inflow into the SAPS.

Action

The Filson 5/6 passive treatment system is currently operating satisfactorily except for iron removal. This reduced iron removal effectiveness is a result of iron accumulation and inadequate sizing of the aerobic pond (Filson 6) for the current ALD outlet characteristics. Modifications to the existing Filson 5/6 passive treatment system are recommended to ensure continued effective treatment and operation. The recommendations include:

1) Remove iron oxide solids from the Filson 6 portion of the system, including the first pond and channel.
2) Redirect the Filson 6 channel into the SAPS similar to the Filson 5 discharge to improve iron removal and add alkalinity to treat the other AMD sources in the Filson 5/6 system.
3) Install an upflow limestone well to add alkalinity to the Filson AMD entering the SAPS.
4) Installation of standpipes and flow control orifices on the SAPS underdrain outlet to regulate flow and water level.
5) Orifices on the SAPS should be a 1.375 inch diameter to restrict flow through the underdrain to 50 gpm (25 gpm per outlet), which is the allowable flow based on hydraulic loading.

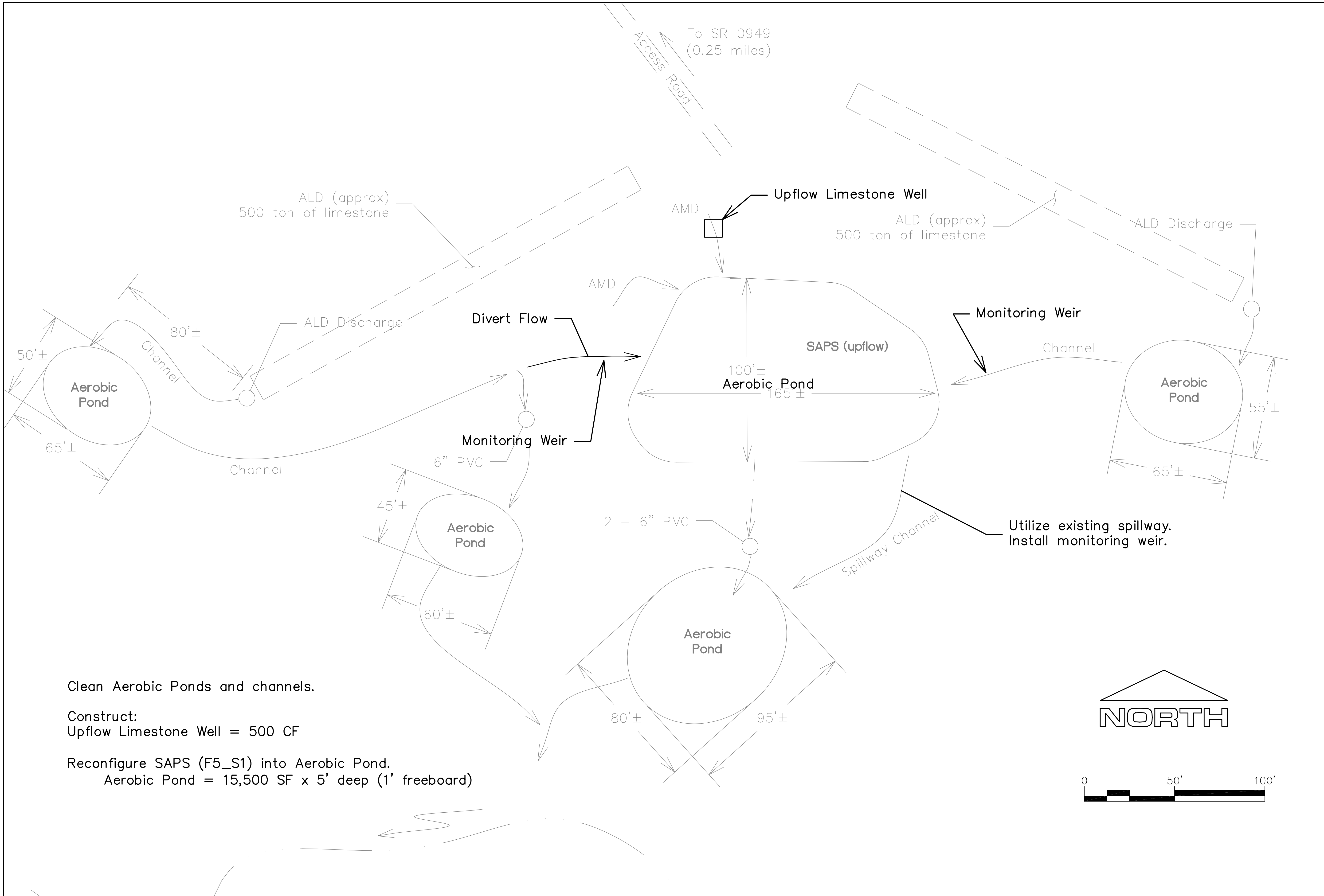
This approach involves converting the SAPS to a combination Aerobic Pond/SAPS. This may eventually lower underdrain flow due to excessive iron solids accumulation. However, the current alkalinity from the ALDs and the recommended upflow limestone well will provide adequate alkalinity for treatment of the Filson 5/6 discharges. In addition, if the SAPS is treating an upwelling of anoxic water, accumulation of solids on the surface of the SAPS will not affect treatment.

Water sampling and underdrain water chemistry data collection program should be continued to evaluate the health of the system. In addition to the sampling presently conducted, it is recommended that additional sampling include measurement of field Eh in the SAPS underdrain outlets. These data will be used to determine the conditions of the system and planning for reconstruction. Current sampling of the system can be decreased, if desired, to focus on the operational parameters important to assessing treatment unit health and the overall performance of the system.

Based on analysis conducted above, future reconstruction of the system will require replacement of the ALDs and removal of accumulated iron oxide solids with no additional treatment required.

Operation, Maintenance & Replacement Plan

The system is currently operating satisfactorily. The proposed modifications should provide improved treatment and increased longevity of the Filson 5/6 system. Current flushing cycles can be evaluated based on iron oxide solids observed during flushing, and if flow controls reduce the solids produced during flushing, then the cycles can be lengthened or eliminated. Figure Filson 5/6-8 shows the proposed modifications to the Filson 5/6 passive treatment system. The costs of the modifications are summarized in Table Filson 5/6-8.



Clean Aerobic Ponds and channels.

Construct:
Upflow Limestone Well = 500 CF

Reconfigure SAPS (F5_S1) into Aerobic Pond.
Aerobic Pond = 15,500 SF x 5' deep (1' freeboard)

Project No.: MCC–OMR
Drawing No.: 06–002
By: TSG 3/3/06
Chkd: JMD 3/14/06

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure Filson 5/6-8
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Table Filson 5/6-8

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: Filson 5 & 6 System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0	ACRE	$ 1,750.00	$ -
3.	E&S Control	0	LS	$ 10,000.00	$ -
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	35	CY	$ 15.00	$ 525.00
	(b) Wet	2200	CY	$ 6.00	$ 13,200.00
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	0	SY	$ 15.00	$ -
10.	Geonet	0	SY	$ 5.50	$ -
11.	High Quality Limestone	25	Ton	$ 28.00	$ 700.00
12.	Mushroom Compost Substrate	0	CY	$ 30.00	$ -
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	0	LF	$ 15.00	$ -
	(b) 4" Solid pipe	0	LF	$ 12.00	$ -
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	0	EA	$ 1,500.00	$ -
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	0	EA	$ 3.00	$ -
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	0	SY	$ 22.00	$ -
18.	Upflow Limestone Well	1	EA	$ 12,500.00	$ 12,500.00
19.	Monitoring Weir	3	EA	$ 450.00	$ 1,350.00
20.	Seeding/Restoration	0	Acre	$ 2,400.00	$ -
21.	Sludge Removal/Disposal	700	CY	$ 15.00	$ 10,500.00

TOTAL AMOUNT OF COST ESTIMATE **$ 46,275.00**

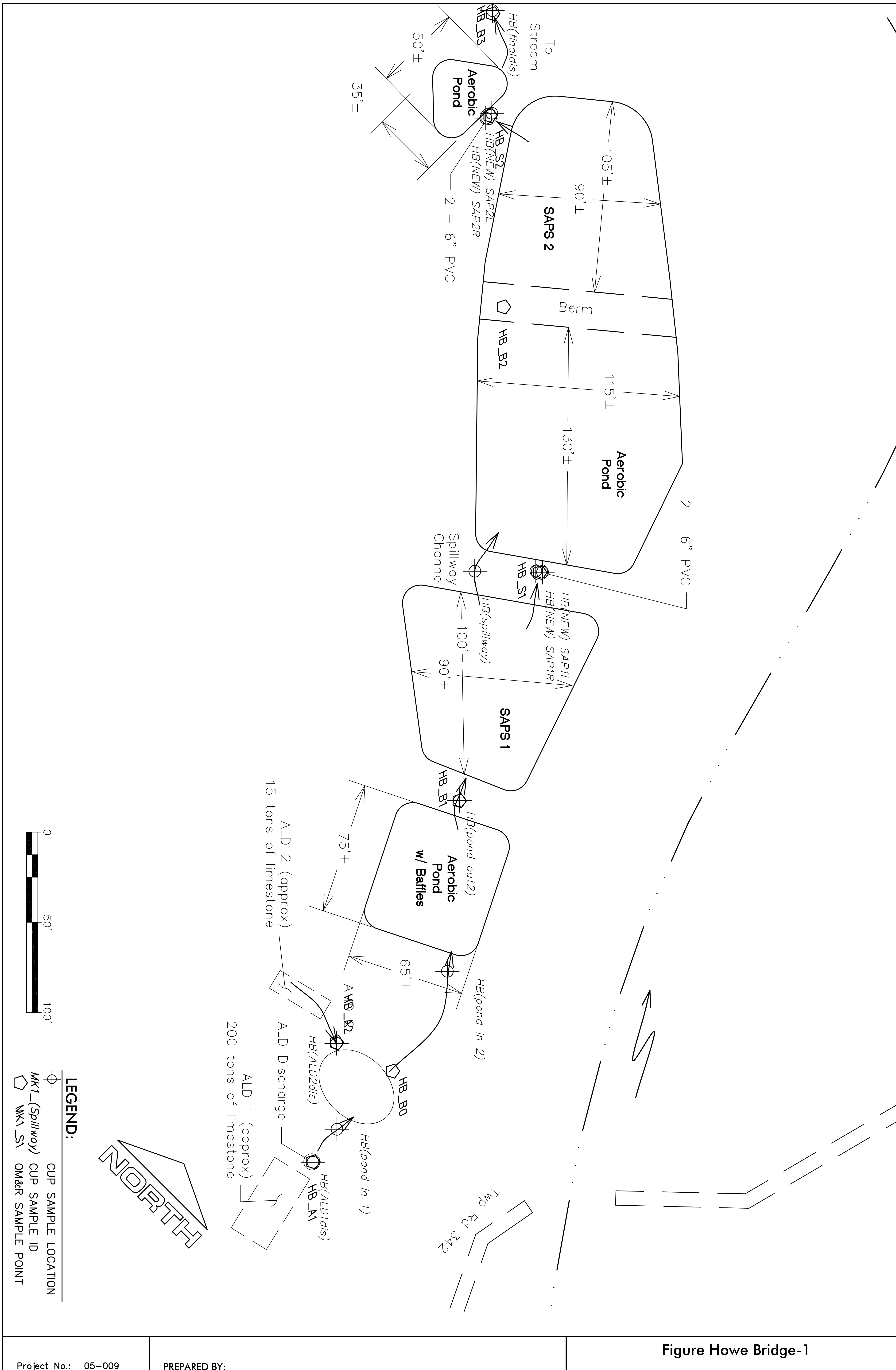
Howe Bridge Passive Treatment System

Anoxic Limestone Drain (ALD)

Aerobic Pond with Baffles

SAPS 1

SAPS 1 Stand-pipe Outlet



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 Howe Bridge-1 Existing Howe Bridge Treatment System & OM&R Sample Points Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Howe Bridge passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive system consists of an ALD, aerobic ponds, and two SAPS. The original system was constructed in 1991. The original SAPS was reconstructed in 2002 into SAPS.
- Current water quality indicates the Howe Bridge passive system has an effluent with a net acidic discharge (> 50 mg/L) containing elevated iron (> 10 mg/L) and manganese (> 20 mg/L). The system currently removes approximately 300 mg/L of acidity from the AMD.
- The ALD evaluation indicates the discharge alkalinity is less than 60% of the expected maximum alkalinity and less than the needed alkalinity to remove iron. Therefore, the unit will need to be replaced in order to provide effective iron removal prior to the SAPS.
- The first aerobic pond is removing less than 50% of the influent iron and approximately 70% of the iron the aerobic pond is capable of removing. The evaluation indicates the aerobic pond effectiveness is limited by its size and influent chemistry.
- The first SAPS unit has an unsatisfactory underdrain flow rate with satisfactory underdrain Eh and alkalinity. The high inflow particulate iron and surface iron oxide accumulation may limit the permeability of the substrate, potentially causing reduced effectiveness (thereby reducing the underdrain flow rate).
- The second SAPS has satisfactory underdrain flow, but with moderate Eh indicating the system may have inadequate reducing conditions that may cause premature decline in performance.

Recommendations for the Howe Bridge passive treatment system are as follows:

- Current conditions indicate the ALD will need to be replaced due to insufficient outlet alkalinity.
- Evaluation indicates the aerobic pond is insufficient to provide adequate iron removal and prevent excess iron loading on the first SAPS. The aerobic pond size should be increased, if possible.
- Planning should be initiated to replace the first SAPS with an AVFW due to inadequate underdrain flow from past excessive particulate iron loading.
- SAPS outlet flow control orifices should be installed on the underdrain outlets to prevent future hydraulic and chemical overloading that can cause reduced performance of the SAPS.
- Due to the high maintenance and short replacement cycle of the Howe Bridge passive treatment system, a direct effect of the influent water quality characteristics, consideration should be given to an alternative treatment approach involving an active treatment technology such as AIS treatment developed by Iron Oxide Technologies, LLC.

The following provides details to support the above summary.

System Description

The Howe Bridge passive treatment system was one of the first passive treatment systems constructed in the Mill Creek watershed and in Pennsylvania; the original construction was in 1991. The original system consisted of two ALDs, two Aerobic Ponds and one large SAPS. The system operated successfully for a number of years, but the Aerobic Ponds gradually filled with iron oxide solids and the SAPS gradually deteriorated in performance. As a result, the system was upgraded in 2002 and began treatment in 2003. The redesign included the cleanout and deepening of the second Aerobic Pond and dividing the large single SAPS into two smaller SAPS separated by an Aerobic Pond. The new system is depicted in Figure Howe Bridge-1.

The Howe Bridge passive treatment system was constructed to treat a highly acidic and high iron discharge as detailed in Table Howe Bridge-1. Historic monitoring data indicate the Howe Bridge AMD has a pH of 5.5, alkalinity of 30 mg/L, and ferrous iron of approximately 200 mg/L. The discharge is highly acidic with an acidity of greater than 500 mg/L. AMD discharge flow varies from 15 to 30 gpm.

Table Howe Bridge-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
5.5	30	~500	---	200-300	---	---	15-30

The Howe Bridge system contains multiple treatment units summarized in Table Howe Bridge-2. No documented information was available for the ALD sizes. The Aerobic Pond sizes were measured in the field and the SAPS sizes were based on information provided by the Mill Creek Coalition. Aerobic Pond 2 contains baffles to prevent short-circuiting. The SAPS contain 0.5 feet depth of compost overtop a 3 feet deep bed of limestone. Standing water in the SAPS varies considerably and is typically 3.5 feet. Both SAPS are equipped with flushing systems and are regularly flushed with the intent of removing accumulated iron oxides from the underdrains and restore permeability.

Table Howe Bridge-2: Summary of treatment units and sizes in the Howe Bridge passive treatment system.

Unit	Surface Area ft^2	Total Depth Ft	Compost Depth ft	Limestone Depth ft
ALD1	Unknown	Unknown	--	(200 tons)
ALD2	Unknown	Unknown	--	(15 tons)
Aerobic Pond 1	500	4	--	--
Aerobic Pond 2	4,500	5	--	--
SAPS 1	4,800	3	0.5	3
Aerobic Pond 3	14,000	3	0.5	3
SAPS 2	4,900	3	0.5	3

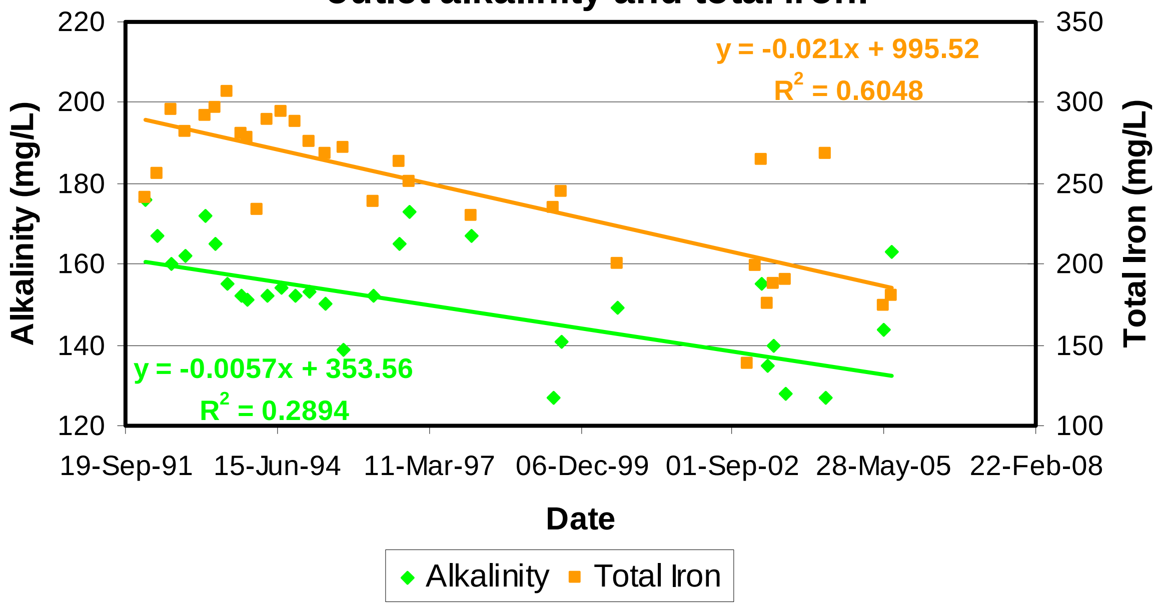
Operational Assessment

The Howe Bridge passive treatment system was operational at the time of the field visit in April 2005 and during the system assessment on July 14, 2005. The discharge flow was approximately 25 gpm during the July evaluation. The following provides assessment of the various units.

ALD(s)

Only the main ALD was discharging water during the July field assessment. Long term monitoring data are plotted in Figure Howe Bridge-2 and indicates a gradual decrease in outlet alkalinity, approximately 2 to 3 mg/L per year. This is not unexpected since the limestone in the ALD is being consumed, resulting in a decrease in detention time and a corresponding decrease in ALD effluent alkalinity. Figure Howe Bridge-2 also provides a long term plot of ALD outlet total iron, which also shows a decrease in ALD outlet total iron over time. This decrease is either the result of decreasing iron concentration in the discharge or iron is being removed within the ALD.

Figure Howe Bridge-2: Long term trend in ALD outlet alkalinity and total iron.



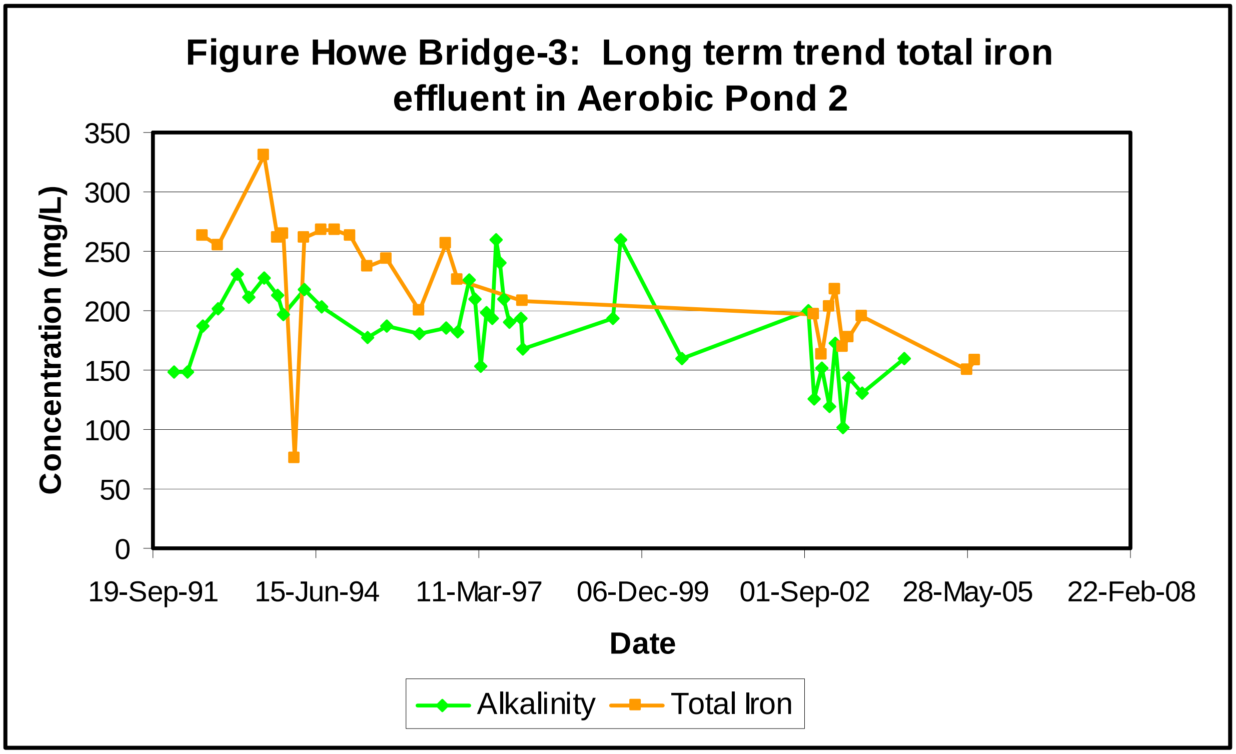
The field assessment results are provided in Table Howe Bridge-3. Dissolved oxygen was very low in the discharge from the ALD and the iron was all in the ferrous form. The pH remained in the low 6s with an alkalinity of 160 mg/L. As part of the field evaluation, effluent from the ALD was placed in cubitainors filled with high quality limestone. The results of the cubitainor testing are provided in Table Howe Bridge-4 and indicate there is a substantial increase in the alkalinity with greater contact time with limestone. The maximum alkalinity possible from the ALD is approximately 100 mg/L greater than the current ALD effluent. As noted in the above paragraph regarding iron, this difference in alkalinity production suggests there may be short-circuiting, limestone coating, or iron clogging within the ALD.

Table Howe Bridge-3: Field sampling results from the Howe Bridge passive treatment system assessment conducted on July 14, 2005								
Location	**DO mg/l**	**Eh mV**	**Temp ºC**	**Cond µS**	**pH**	**Fe(II) Iron mg/l**	**Total Iron mg/l**	**Alkalinity mg/l**
ALD 1	0.24	-16	10.1	1227	6.34	196	199	148
Aerobic Pond Outflow	2.42	105	22.0	1094	5.82	106	125	23

Table Howe Bridge-4: Summary of results from cubitainor tests conducted on the Howe Bridge ALD effluent.					
Bottle No.	**Temp ºC**	**Conduct µS**	**pH**	**Alkalinity mg/l**	**Elapsed Time hrs**
1138	22.5	1300	6.57	266	42.0
1148	22.8	1272	6.52	261	43.1

Aerobic Ponds

Aerobic Pond 1 was not evaluated due to its small size and the presence of iron oxides within 0.5 feet of the surface. Aerobic Pond 3 was also not evaluated due to its location within SAPS 2 and no clear point to sample the outlet flow. Figure Howe Bridge-3 shows the long term effluent data from Aerobic Pond 2 and indicates the pond only averages about 25% iron removal over this period. There have been periods during cooler, higher flow conditions when little iron removal has been monitored. Effluent water quality measured during the field evaluation is shown in Table Howe Bridge-3. Low dissolved oxygen (<3 mg/L) and low pH (~5.9) were found in the effluent along with an alkalinity of 23 mg/L. Iron removal during this field investigation was approximately 90 mg/L of ferrous and 70 mg/L of total iron out of the influent ferrous iron concentration of 200 mg/L. Based on the flow of 23 gpm, this equates to an surface area removal rate of 21 gr/day/m^2.

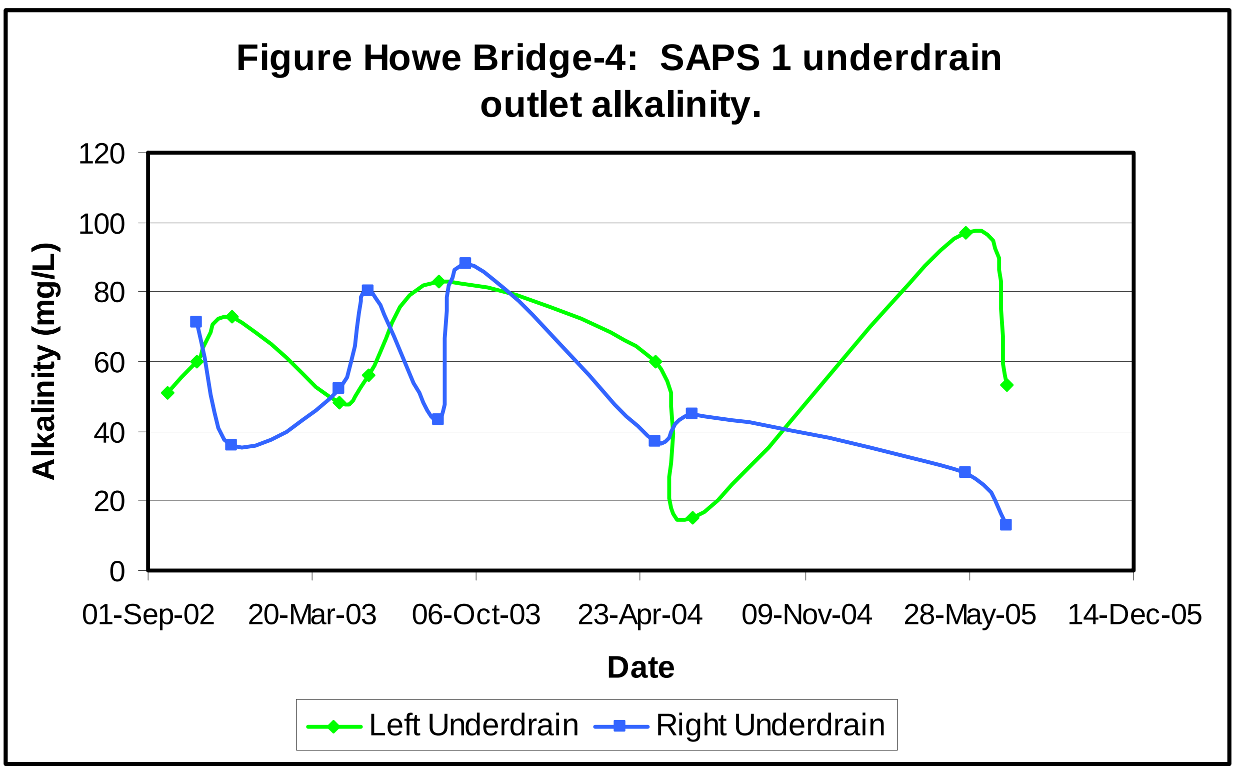


This removal rate appears to be high given the conditions in the pond (i.e., low pH and dissolved oxygen). It is consistent with the iron oxidation model prediction of an iron removal of approximately 80 mg/L; based on a detention time of 130 hours, pH of 6, dissolved oxygen of 2.5 and temperature of 19°C. Removal of iron is limited by water quality conditions in the aerobic pond as a higher dissolved oxygen and pH would yield greater iron removal; nearly all the ferrous iron would be removed at the current detention time of the pond if the pH were 6.5 and dissolved oxygen was 5 mg/L. However, greater removal is not likely given the limited alkalinity in the water. It should also be noted that water temperature increased by 12°C across the pond at the time of the field evaluation. If the aerobic pond temperature was more typical of average conditions (12°C), the expected iron removal would decrease to less than 35 mg/L across the pond, consistent with long term historical averages. Based on the cooler temperature predictions, the aerobic pond appears to be undersized for adequate iron removal. Maximum retention of iron by Aerobic Pond 2 is essential to prevent accumulation of iron oxide solids in the SAPS.

SAPS

The Howe Bridge passive treatment system contains two SAPS, SAPS 1 and SAPS 2. During the initial field visit in April 2005 and the subsequent field evaluation in July 2005, only a portion of the discharge flow was passing through the SAPS 1underdrain. All flow was passing through the SAPS 2 underdrain during both visits.

SAPS 1 evaluation examined the long term monitoring data and results from the field evaluation. Historical alkalinity from SAPS 1 underdrain outlets are plotted in Figure Howe Bridge-4. The data indicate SAPS 1 has produced an underdrain effluent with low alkalinity averaging 50 mg/L; remaining metals indicate SAPS 1 removed approximately 100 mg/L of acidity. However, the long term data also indicate alkalinity has varied with underdrain alkalinity approaching 0 mg/L during the past year and with increasing effluent acidity. It was apparent from both visits and the evaluation of the Aerobic Pond 2 (see above) that large amounts of iron oxides are precipitated within SAPS 1. Figure Howe Bridge-5 shows the total iron removed within the SAPS averages approximately 50 mg/L with much of this total iron deposited as an iron oxide on the surface of the compost, an effect of an undersized aerobic pond. The results of the field evaluation of SAPS 1 are summarized in Table Howe Bridge-5. A comparison of flows indicates that less than 30% of the discharge flow, at the time of the field evaluation, was flowing through the SAPS 1 underdrains, an indication of reduced permeability of the SAPS. The field evaluation also confirms approximately 50% of the total iron is removed across the SAPS with a large portion likely removed as iron oxide on the surface of the organic layer. Other operational parameters, such as dissolved oxygen and Eh, indicate SAPS 1 has an adequate reducing environment. The adequate reducing environment may be a result of lower permeability from iron oxide accumulation that has restricted flow through the SAPS underdrain. This restricted flow through the compost layer limits both hydraulic and chemical loading on SAP 1 improving its underdrain performance and field evaluation results, but at a reduced treatment performance (i.e., inadequate underdrain flow).



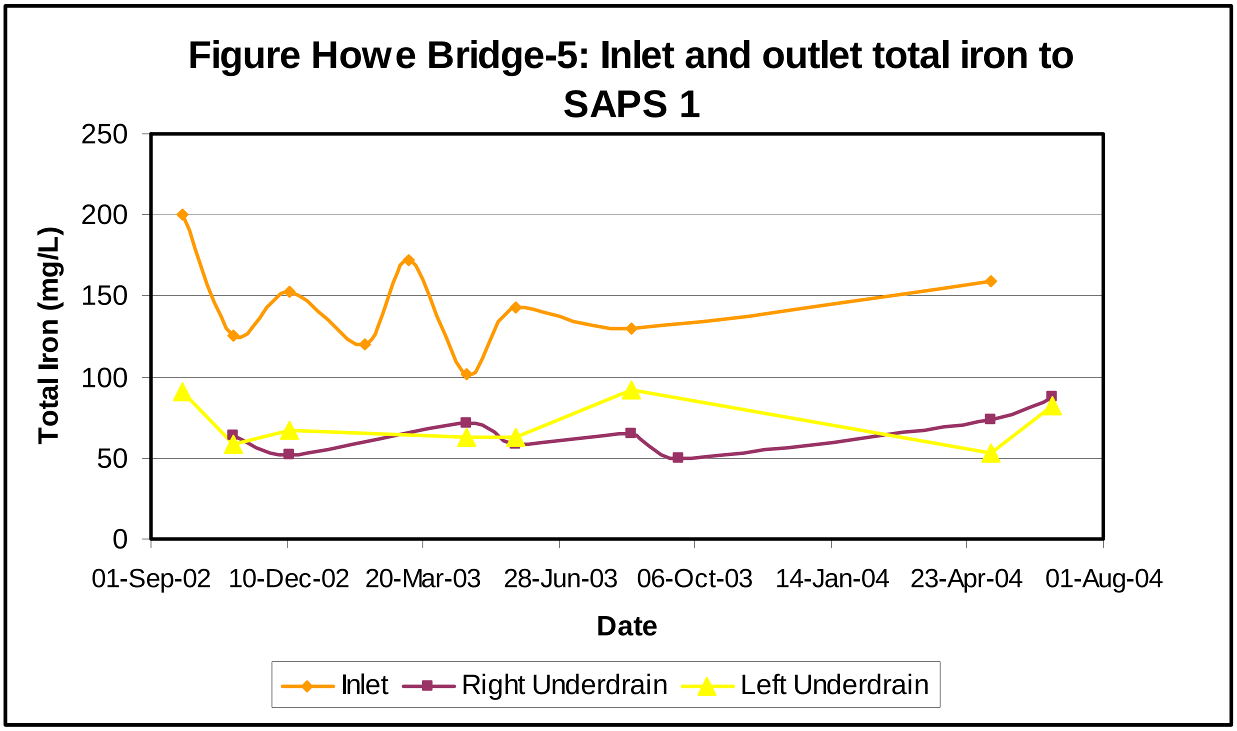


Table Howe Bridge-5:	Howe Bridge SAPS evaluation conducted on July 14, 2005.				
		SAPS 1 Underdrain		SAPS 2 Underdrain	
Parameter	**Unit**	**Right**	**Left**	**Right**	**Left**
Dissolved Oxygen	mg/l	0.07	0.20	0.25	0.36
Temperature	ºC	18.6	18.9	24.4	25.4
Conductance	µS	1100	1133	1127	1114
pH	s.u.	6.62	6.53	6.53	6.52
Eh	mV	-67	-56	-29	-11
Sulfide	mg/l	<0.05	<0.05	<0.05	<0.05
Ferrous Iron	mg/l	73.0	71.0	22.5	9.3
Total Iron	mg/l	72.0	68.0	22.0	7.8
Alkalinity	mg/l	128	116	94	80
Flow	gpm	4.6	2.2	9.2	13.8

SAPS 2 long term alkalinity data are shown in Figure Howe Bridge-6. Both left and right underdrains produce similar alkalinity averaging 55 mg/L. There may be a slight downward trend in alkalinity with recent alkalinity produced by the underdrains falling below 30 mg/L. Long term effluent iron from the underdrains is shown in Figure Howe Bridge-7. Initial elevated effluent iron decreased to less than 5 mg/L. Recent sampling indicates total iron is increasing from the underdrains. This increasing total iron results in a net acidic effluent. This may be an effect of total iron entering SAPS 2 from the decreased flow through the SAPS 1 underdrains, which causes high iron and low alkalinity water to enter into SAPS 2. The field evaluation results for SAPS 2 are summarized in Table Howe Bridge-5. SAPS 2 has a slightly higher dissolved oxygen approaching 0.5 mg/L. The Eh in the underdrain outlets were only slightly less than 0 mV, indicating anoxic conditions are present within the SAPS 2 substrate, but probably inadequate for sulfate reduction. No sulfide was detected in either underdrain confirming the lack of sulfate reduction conditions. Measured underdrain alkalinity was approximately 90 mg/L, which was close to the reported maximum from SAPS 2. Iron was slightly elevated, and at times results in a net acidic effluent from the Howe Bridge passive treatment system (likely to increase in frequency). It should be noted the flows were much lower than observed in April 2005 and conditions could be substantially different due to increase iron and acidity loading on SAPS 2 during higher flow and cooler temperature periods. The observed alkalinity and total iron variability suggest SAPS 2 may be periodically overloaded, which would be reflected in lower underdrain alkalinity and higher underdrain total iron. This periodic overloading could have substantial implications on the long term operation of SAPS 2.

Figure Howe Bridge-6: SAPS 2 underdrain outlet alkalinity.

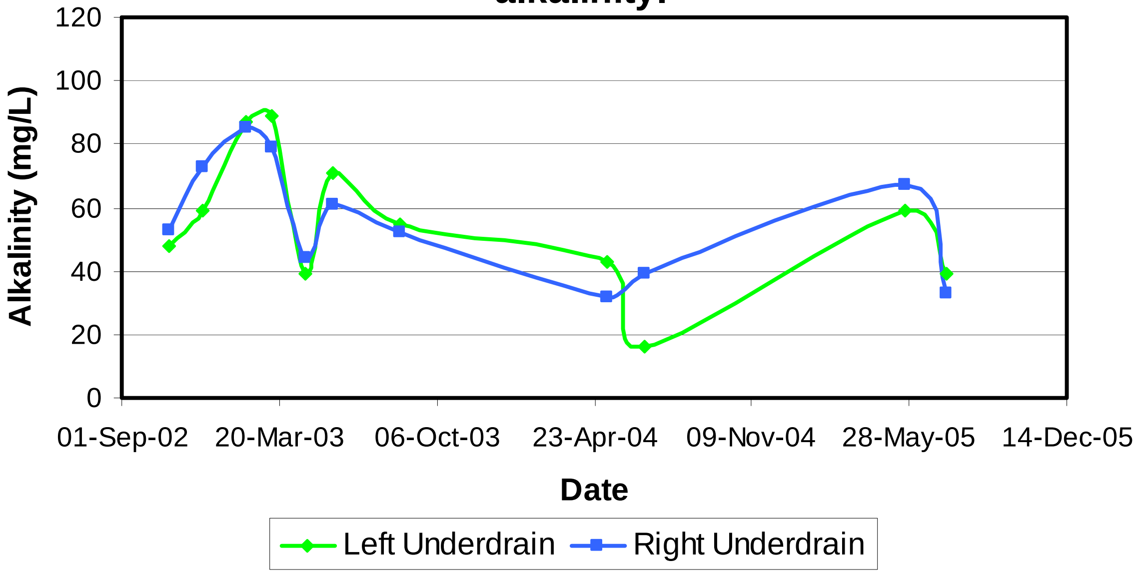
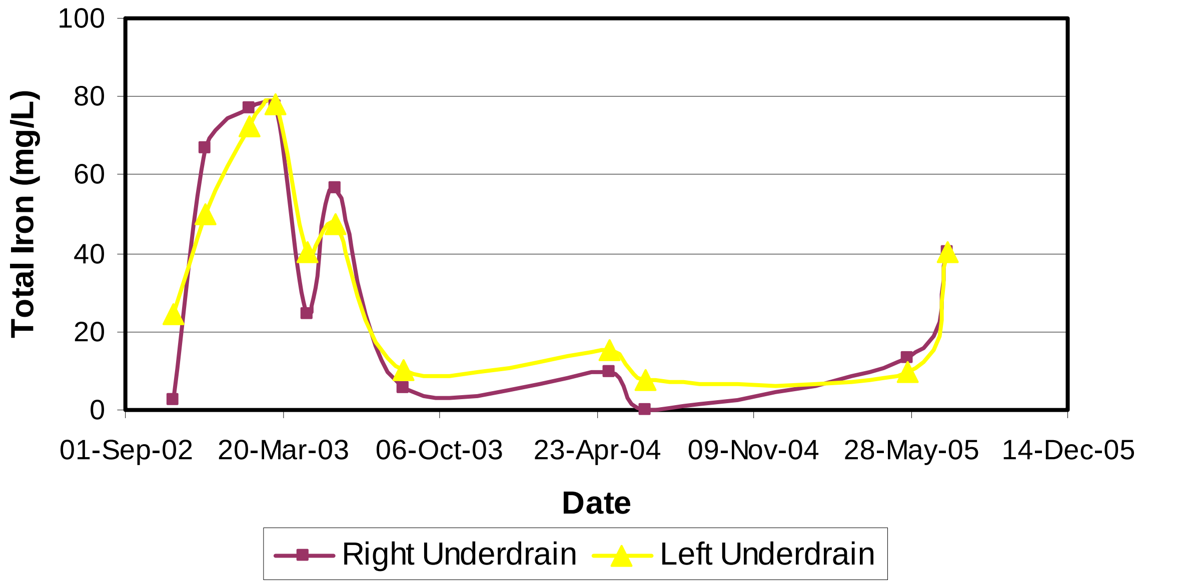


Figure Howe Bridge-7: SAPS 2 Underdrain outlet total iron



Diagnosis

Table Howe Bridge-6 summarizes the current operating conditions of the various Howe Bridge passive treatment system units. The following provides a discussion of the current conditions.

Table Howe Bridge-6. Summary of Howe Bridge passive treatment system unit conditions.

Unit	Condition	Criteria	Level
ALD	60% Maximum	60 to 85% Alkalinity Demand > ALD Alkalinity	Reduced
Aerobic Pond 1	Full of Solids	Not Assessed	Reduced
Aerobic Pond 2	Iron Removal < 25%	IR<80%	Reduced
SAPS 1	Eh = -67, -56 mV Reduced Flow	Eh < -50 mV	Reduced
Aerobic Pond-SAPS 2	Not Assessed	IR >90%	---
SAPS 2	Eh = -29, -11 mV	0mV<Eh < -50 mV	Moderate
Final Aerobic Pond	Not Assessed	IR >90%	---

The ALD was operating during the field evaluation. Long term monitoring data and cubitainor results indicate the Howe Bridge ALD is operating at less than 70% of the maximum alkalinity that can be generated in the ALD. This lower ALD alkalinity is also inadequate for the ferrous iron concentration (or corresponding alkalinity demand) contained in the AMD. As a result of the AMD iron concentration and ALD alkalinity combination, the Howe Bridge ALD is operating at a reduced effectiveness treatment level.

Aerobic Pond 2 was evaluated by examining influent and effluent water quality. Long term monitoring indicates iron removal from this aerobic pond is only 25%, which represents about half the possible iron that can be removed, based on the ALD alkalinity. In addition, monitoring data and abiotic oxidation modeling indicate this aerobic pond is inadequate in size to remove the maximum amount of iron during summer operation. During cooler and higher flow periods iron removal is reduced further. The low iron removal has substantial implications to downstream treatment units that can be affected by high iron concentrations. The decreasing underdrain flow through SAPS 1 is likely the result of iron oxide deposits on the surface of the substrate. Based on the performance and the implications of inadequate removal on downstream treatment units, Aerobic Pond 2 is operating at a reduced effectiveness.

The two SAPS in the Howe Bridge passive treatment system are operating at reduced and moderate treatment effectiveness, respectively. In SAPS 1 the reduced effectiveness is due to the decreasing amount of flow passing through the underdrains, which was less than one-third of the total flow at the time of the field evaluation. In SAPS 2, the operating condition was based on the monitored underdrain Eh during the field evaluation. This condition is likely due to periodic excessive iron and acidity loading to SAPS 2 during cooler and higher flow periods.

Design Methodology

There was no design information available for the ALD, aerobic ponds or SAPS in the Howe Bridge passive treatment system. The ALD was likely sized based on 16 hours detention time plus an additional limestone volume for longevity. The Aerobic Pond 2 was likely sized based on an iron removal of 20 gr/day/m^2 or a 24 hour detention time. However, the current average and maximum loading to the aerobic pond are 60 and 120 gr/day/m^2. Even if the alkalinity produced by the ALD were considered, approximately 50 % of the iron could be removed and the removal based loading would exceed 20 gr/day/m^2. As a comparison, the abiotic model was used to estimate the needed aerobic pond size for iron removal based on the alkalinity produced by the ALD and the expected conditions in the aerobic pond (pH=6.1, dissolved oxygen=4 mg/L, and T=12°C). The model predicts a minimum detention time of 225 hours, which equates to a surface area of 23,000 ft^2 at maximum AMD flow. The model results indicate the aerobic pond is about one-quarter the needed size.

SAPS sizes were evaluated using the information provided on the new sizes and field measurements, along with current flow. The design evaluation for the two SAPS is provided in Table Howe Bridge-7. Both SAPS have an estimated limestone bed detention time of 12 hours at maximum flow. The reduced flow currently passing through the underdrain of SAPS 1 would dramatically increase the limestone bed detention time. The acidity loading and hydraulic loading calculated for the two SAPS are well above the recommended sizing guidance of 25 gr/day/m^2 and 150 gpm/acre. This suggests the SAPS are chemically and hydraulically overloaded.

Table Howe Bridge-7. Summary of Howe Bridge passive treatment system SAPS size and design parameters					
SAPS	**Surface Area ft^2**	**Limestone Volume ft^3**	**Limestone Bed Detention Time hrs**	**Acidity Loading $gr/day/m^2$**	**Hydraulic Loading gpm/acre**
SAPS 1	4,800	10,000	12	185	480
SAPS 2	4,900	10,500	13	145	470

Action

The Howe Bridge passive treatment system is currently operating but requires immediate action to maintain adequate levels of treatment. The following actions should be initiated:

1) The Howe Bridge ALD is producing inadequate alkalinity and should be replaced to produce the maximum amount of alkalinity that is required to remove metals and reduce the impacts of the metals and acidity loading on the SAPS.
2) The Aerobic Pond 2 is inadequate in size to remove influent iron levels and should be replaced. This improvement will lower the amount of iron loading on the SAPS, which is causing the reduced underdrain flow.
3) Installation of flow control orifices should be immediately installed on the SAPS underdrain outlet stand pipes to restrict flow and prevent chemical and hydraulic overloading.
    a. Orifices on the SAPS 1 should be a 0.5 inch diameter to restrict flow through the underdrain to 7 gpm (3.5 gpm per outlet), which is the allowable flow based on acidity loading.
    b. Orifices on the SAPS 2 should be a 1.25 inch diameter to restrict flow through the underdrain to 40 gpm (20 gpm per outlet), which is the allowable flow based on hydraulic loading.

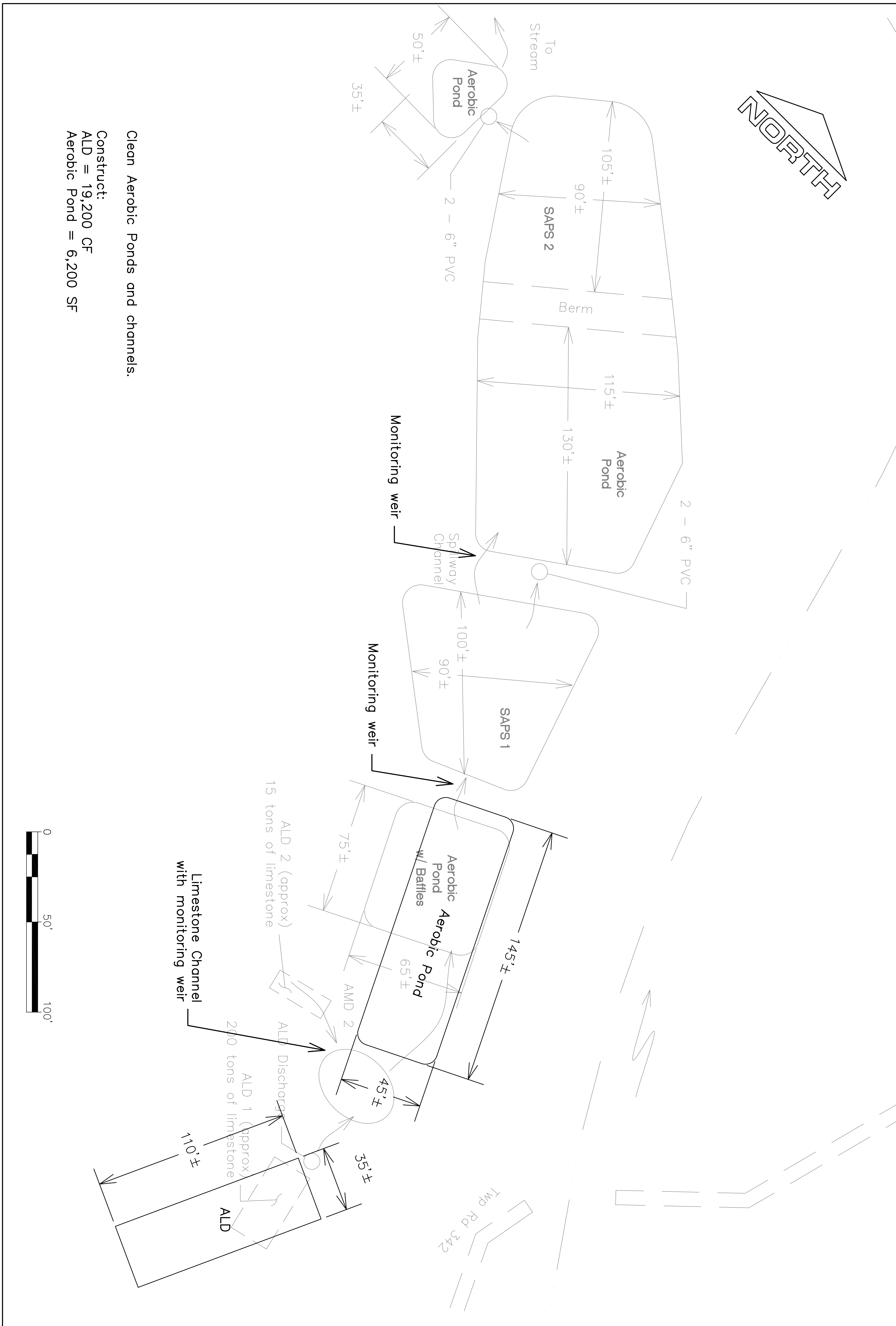
In addition to the sampling regimen presently conducted, recommended sampling includes 1) measurement of field Eh in the underdrain outlets and 2) monitoring of underdrain outlet flow and total flow through the system. These data will be used to determine the operating conditions of the system and planning for reconstruction.

Based on analysis conducted above, future reconstruction of the system will be required to provide a resolution of the Howe Bridge passive treatment system's reduced treatment effectiveness.

Operation, Maintenance & Replacement Plan

The current Howe Bridge passive treatment system is functioning at reduced effectiveness. Immediate modifications will be required to prevent further operational problems in the SAPS. The current ALD and Aerobic Pond can not be modified to resolve the operational issues based upon site constraints. Increasing the size of the Aerobic Pond is not possible due to the location of other treatment components in the Howe Bridge system. Therefore, replacement of the Howe Bridge system will be required to achieve the desired effluent water quality goals. A conceptual design, depicted in Figure Howe Bridge-8, has been developed for the Howe Bridge AMD discharge that includes 1) replacement of the ALD with an Upflow Limestone Well; 2) construction of a new and larger Aerobic Pond; and 3) installation of new AVFW with deeper compost layers. The estimated costs for the replacement are contained in Table Howe Bridge-8.

Due to the water quality characteristics of the Howe Bridge AMD, alternative active treatment methods should be considered. A new active treatment process known as AIS treatment has recently been developed. The Activated Iron Solids (AIS) treatment approach, currently being developed by Iron Oxide Technologies, LLC, can rapidly oxidize ferrous iron and remove the associated acidity in a small foot print. Based on maximum flows and iron concentration, an AIS system would have a total tank volume of 25,000 gallons. The system would require a pulverized limestone silo and feed system. Electricity would be needed to run blowers, mixers and feed system. The complete installed system has an estimated capital cost of $250,000 with an annual operating cost of $5,000 (does not include labor). The existing passive treatment system could be used for solids storage and polishing of the discharge.



Project No.: MCC–OMR
Drawing No.: 06–002
By: TSG 3/3/06
Chkd: JMD 3/14/06

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure Howe Bridge-8
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Preliminary Engineering Cost Estimate
Mill Creek Coalition: OM&R System Modifications

Site: **Howe Bridge System Upgrade**
Date: **December 29, 2006**

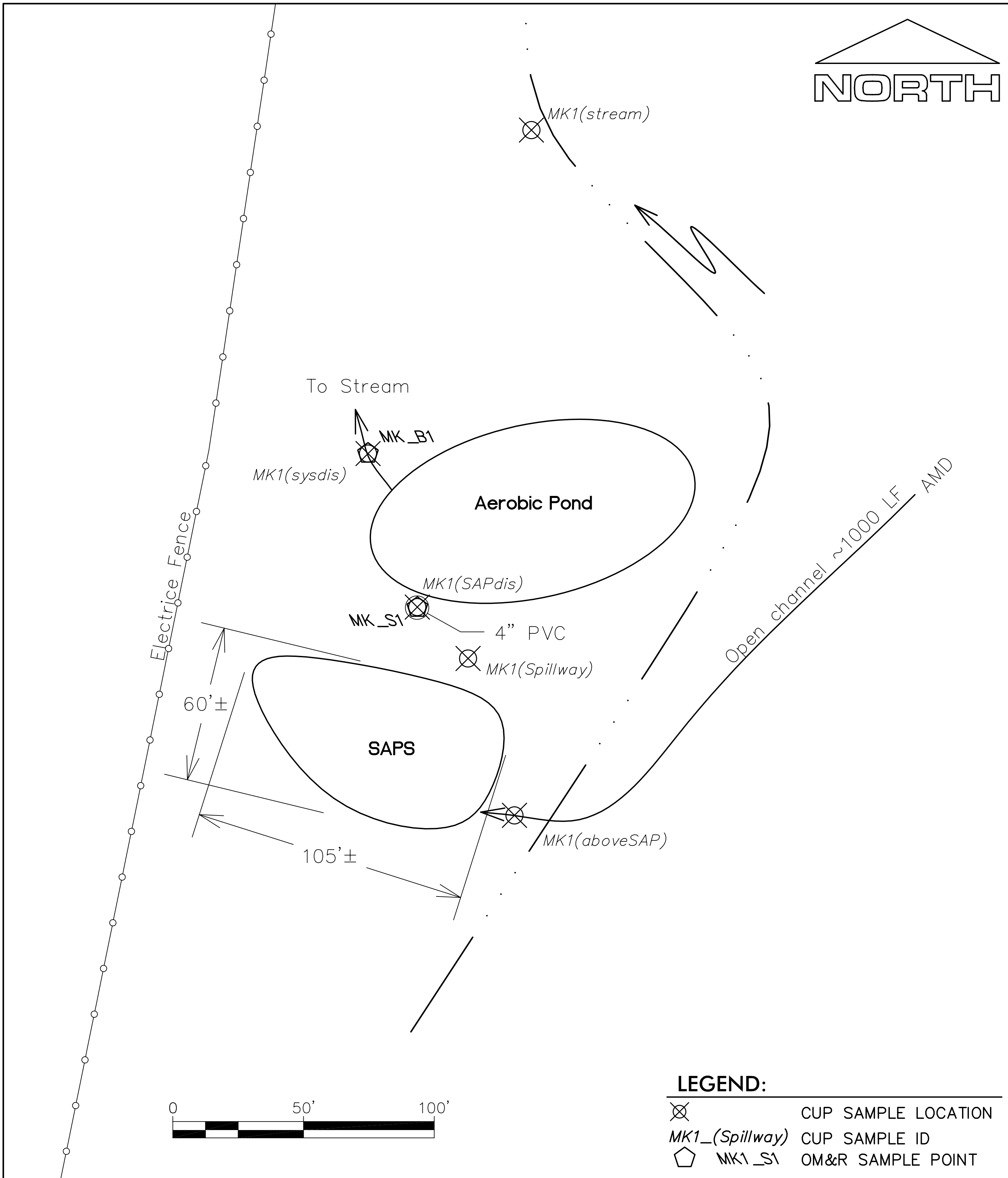
Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.2	ACRE	$ 1,750.00	$ 350.00
3.	E&S Control	0.5	LS	$ 10,000.00	$ 5,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	0	CY	$ 15.00	$ -
	(b) Wet	2450	CY	$ 6.00	$ 14,700.00
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	1860	SY	$ 15.00	$ 27,900.00
10.	Geonet	0	SY	$ 5.50	$ -
11.	High Quality Limestone	890	Ton	$ 28.00	$ 24,920.00
12.	Mushroom Compost Substrate	0	CY	$ 30.00	$ -
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	80	LF	$ 15.00	$ 1,200.00
	(b) 4" Solid pipe	20	LF	$ 12.00	$ 240.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	0	EA	$ 1,500.00	$ -
14.	Orifice Flow Control	4	EA	$ 75.00	$ 300.00
15.	Wetland Vegetation and Planting	0	EA	$ 3.00	$ -
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	180	SY	$ 22.00	$ 3,960.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	3	EA	$ 450.00	$ 1,350.00
20.	Seeding/Restoration	0.2	Acre	$ 2,400.00	$ 480.00
21.	Sludge Removal/Disposal	750	CY	$ 15.00	$ 11,250.00
	TOTAL AMOUNT OF COST ESTIMATE				**$ 99,150.00**

McKinley 1 Passive Treatment System

SAPS

SAPS Outlet

Aerobic Pond



LEGEND:

CUP SAMPLE LOCATION
MK1_(Spillway) CUP SAMPLE ID
MK1_S1 OM&R SAMPLE POINT

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

SUMMARY & RECOMMENDATIONS

The McKinley 1 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive system is a SAPS and an aerobic pond constructed in 1999.
- Current effluent water quality indicates the system is not operating satisfactorily due to inadequate flow through the underdrain.
- Analysis of historical data indicates the SAPS is slightly overloaded with respect to average acidity and flow.
- The design of the inflow open channel may have caused severe hydraulic overloading (stormflow capture) and very low inflow temperatures, both of which may have led to premature failure.

Recommendations for the McKinley 1 passive treatment system are as follows:

- Replace the SAPS with a new AVFW with material depths of 2 to 2½ feet of limestone fines amended compost and 2 to 2½ feet of limestone.
- Install stand-pipe outlets with flow regulating orifice stand-pipes to prevent occasional AVFW hydraulic loading.
- Install an underground gravity pipe system to convey the discharge to the McKinley 1 passive treatment system
- Divert surface runoff collected in the open channel away from the McKinley 1 passive treatment system.
- Lower the water elevation in the aerobic pond to provide greater operational hydraulic differential between AVFW and aerobic pond.

The following provides details to support the above summary.

System Description

The McKinley 1 passive treatment system layout is depicted in Figure McKinley-1. The McKinley 1 system was constructed in 1999 to treat toe-of-spoil AMD seep, known as the "McKinley 1 Seep". The McKinley 1 Seep is a low pH (< 3.5) with moderate acidity (Table McKinley 1-1). The McKinley 1 passive treatment system was designed to treat this discharge employing a SAPS followed by an aerobic pond to remove metals.

Table McKinley 1-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
3.6	0	100	0.8	3	22	890	---

Operational Assessment

The McKinley 1 passive treatment system was not functioning at the time of the field visit in April 2005, based on a large amount of flow (> 10 gpm) flowing over the spillways and less than ½ gpm flowing through the underdrain. During the system assessment on July 14, 2005, the discharge flow had decreased and only a small amount of flow was flowing over the spillway and the underdrain flow was similar to that observed in April. This low underdrain flow is a functional issue and results in inadequate treatment of the discharge.

The available data indicate clogging may be an issue. This may have resulted from excessive acidity (or aluminum) loading to the SAPS. However, operational issues associated with the AMD collection and transport in an open channel may also have been a contributing factor by 1) collecting and directing excessive flows from stormwater runoff, and 2) decreasing the water temperature during cold weather periods.

The open channel is approximately 1,000 feet in length and is along a slightly sloping field. The channel collects direct precipitation as well as surface runoff generated from upslope areas. This can cause periodic increases in discharge flow that would exceed the hydraulic capacity of the SAPS and force untreated water into direct contact with the limestone leading to solids accumulation and clogging of the system.

The open channel also permits heat exchange. Heat loss would occur during colder weather periods that would decrease the temperature of the discharge entering the SAPS. Treatment reactions in the SAPS are biological and chemical, both of which are affected by temperature, with lower temperatures decreasing the reaction rates. As an example, the oxidation rate for iron decreases by 50% for every 6°C drop in temperature. It is likely the biological reactions (e.g., sulfate reaction) are similarly affected. The acidity loading to the SAPS for this type of cold weather condition would likely have to be at least ½ of normal loading to achieve adequate treatment.

Diagnosis

Table McKinley 1-2 summarizes of McKinley 1 passive treatment systems operating conditions. The SAPS is not functioning due to insufficient underdrain flow. The aerobic pond could not be evaluated because of the SAPS condition.

Table McKinley 1-2: Summary of McKinley 1 passive treatment systems SAPS conditions.

Unit	Condition	Criteria	Level
SAPS	No Flow	NA	Reduced
Aerobic Pond	Not Determined	NA	Satisfactory

Design Methodology

No design basis was available. Table McKinley 1-3 provides the estimated surface area and limestone volume in the SAPS treatment cell. Table McKinley 1-3 also provides the estimated limestone bed detention time, acidity loading, and surface hydraulic loading on the cell.

Table McKinley 1-3: Summary of McKinley 1 passive treatment system size and design parameters

SAPS	Surface Area ft^2	Limestone Volume ft^3	Limestone Bed Detention Time hrs	Acidity Loading $gr/day/m^2$	Hydraulic Loading gpm/acre
Cell 1	3,900	8,800	30-40	55	167

Comparing the acidity loading and hydraulic loading in Table McKinley 1-3 to reported design guidance for AVFW of 25 $gr/day/m^2$ and 150 gpm/acre (Rose & Dietz, 2002; Dietz et al, 1996; Dietz, 1997) indicates the SAPS is only slightly overloaded with respect to both parameters when the system is receiving maximum reported historical flows. It is likely this system size would have been adequate to treat the upper McKinley 1 AMD discharge if the open channel with its associated periodic high flows and low winter temperatures did cause the operational problems.

Action

Table McKinley 1-2 summarizes the current operating conditions, based on the criteria developed, of the various units in the McKinley 1 passive treatment system. The SAPS in the McKinley 1 system does not meet the criteria as no flow is currently passing through the underdrain.

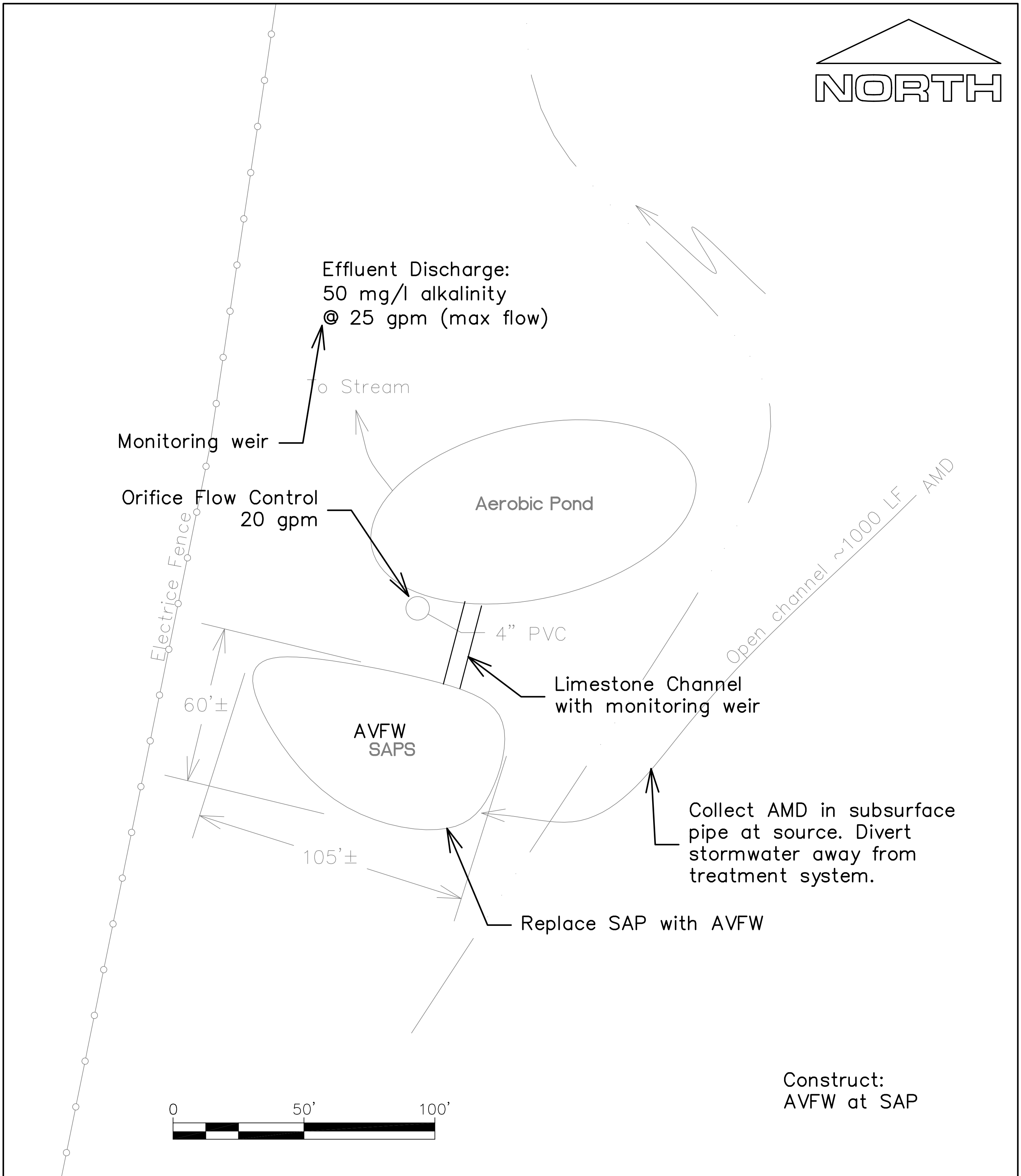
Based on the evaluation, the McKinley 1 passive treatment system is currently not operating and no repairs or changes in operation can resolve the existing problems. Recommendations for the McKinley 1 passive treatment system include:

1) Replace the existing nonfunctioning SAPS with a new AVFW treatment cell containing greater compost depth and with added limestone fines.
2) Use a flow control stand-pipe underdrain discharge system to regulate flow through the underdrain and prevent hydraulic and acidity overloading.
3) Collect and convey the AMD discharge from its source to the McKinley 1 passive treatment system by an underground gravity PVC pipe to minimize heat loss from the discharge.
4) Divert the open channel and stormwater flow away from the McKinley 1 passive treatment system.
5) Lower the pool elevation in the aerobic pond to provide greater head differential between the AVFW and the aerobic pond.

Operation, Maintenance & Replacement Plan

The current McKinley 1 passive treatment system is not functioning and/or inadequate to address the AMD source at this site. Replacement of the SAPS will be required to remediate the discharge and minimize its impacts on Little Mill Creek. The following recommendations are based on historical data for the upper McKinley 1 AMD discharge and field observations made during the system assessment.

The McKinley 1 AMD discharge is a low flow, low pH and moderate acidity (< 100 mg/L) discharge. The discharge characteristics limit the passive treatment choice to an AVFW similar to the current system, but with greater compost depth (2 to 2½ feet) than the existing SAPS. The AVFW multi-cell model was used to estimate the required size and number of cells needed to address the upper McKinley 1 AMD discharge. Based on the AVFW multi-cell modeling, the existing single AVFW cell with 3,900 ft^2 of surface area would be adequate to treat up to 20 gpm of AMD discharge with the acidity of the McKinley 1 AMD discharge. The existing aerobic pond would be adequate to retain iron and aluminum metals as well as oxidation and removal of some manganese. The conceptual design is depicted in Figure McKinley 1-2. The estimated construction costs for the system are summarized in Table McKinley 1-4.



Project No.: MCC–OMR
Drawing No.: 06–002
By: TSG 3/3/06
Chkd: JMD 3/14/06

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure McKinley 1-2
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Table McKinley 1-4

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: McKinley I System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.1	ACRE	$ 1,750.00	$ 175.00
3.	E&S Control	0.25	LS	$ 10,000.00	$ 2,500.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	45	CY	$ 15.00	$ 675.00
	(b) Wet	670	CY	$ 10.00	$ 6,700.00
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	675	SY	$ 10.00	$ 6,750.00
10.	Geonet	500	SY	$ 5.50	$ 2,750.00
11.	High Quality Limestone	525	Ton	$ 28.00	$ 14,700.00
12.	Mushroom Compost Substrate	335	CY	$ 30.00	$ 10,050.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	480	LF	$ 15.00	$ 7,200.00
	(b) 4" Solid pipe	200	LF	$ 12.00	$ 2,400.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	1	EA	$ 1,500.00	$ 1,500.00
14.	Orifice Flow Control	1	EA	$ 75.00	$ 75.00
15.	Wetland Vegetation and Planting	282	EA	$ 3.00	$ 846.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	250	SY	$ 22.00	$ 5,500.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	2	EA	$ 450.00	$ 900.00
20.	Seeding/Restoration	0.2	Acre	$ 2,400.00	$ 480.00
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

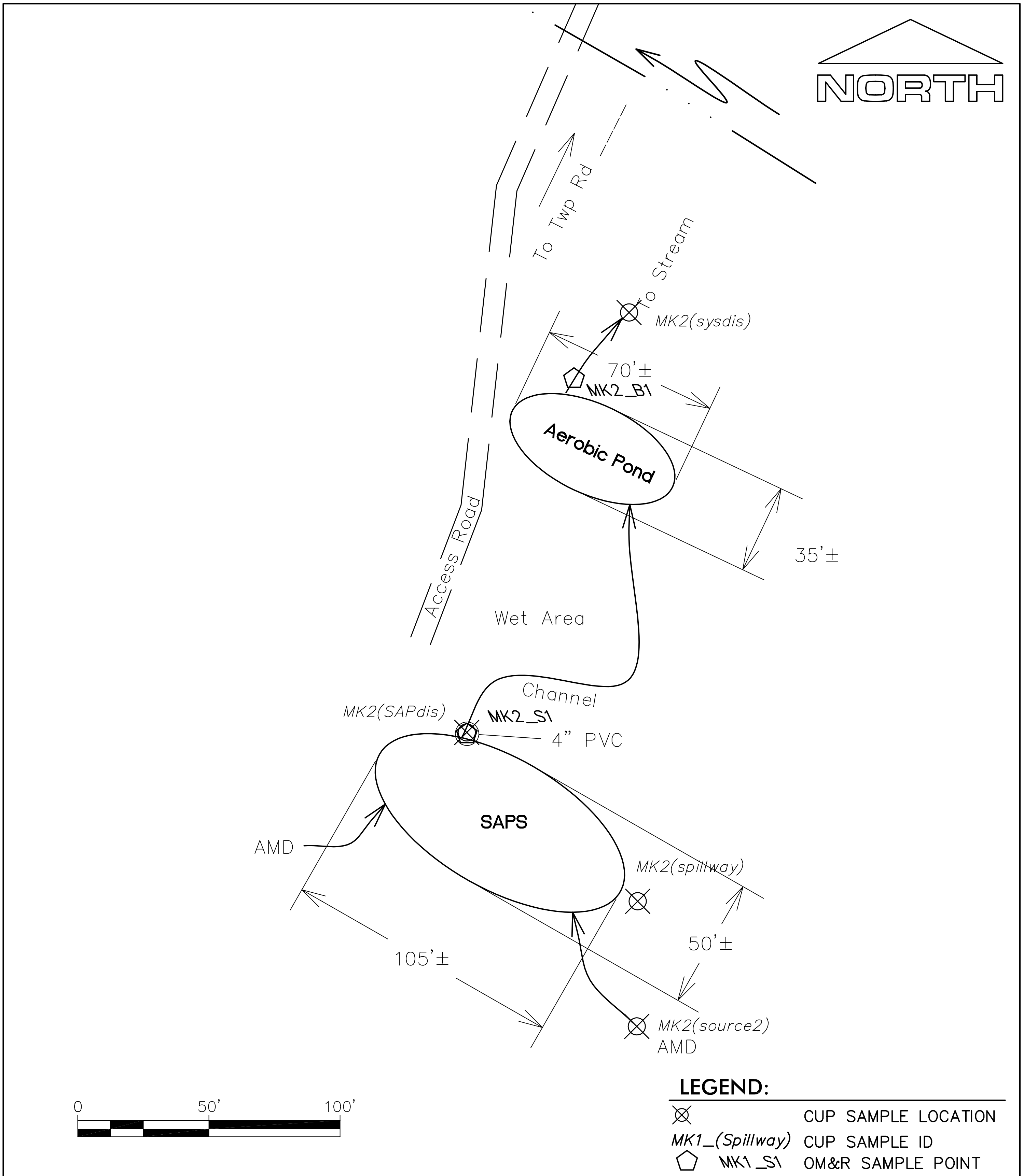
TOTAL AMOUNT OF COST ESTIMATE **$ 70,701.00**

McKinley 2 Passive Treatment System

Cell 1 – SAPS

Cell 1 SAPS Underdrain Outlet

Cell 2 - Aerobic Pond



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 2-1** **Existing McKinley 2 Treatment System & OM&R Sample Points** Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The McKinley 2 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The McKinley 2 passive treatment system contains a SAPS and aerobic pond that was constructed in 1999.
- Current effluent water quality indicates the system is not operating satisfactorily with poor effluent quality and inadequate underdrain flow during high flow periods.
- Analysis of historical data indicates the SAPS and the system has an effluent with net acidity over the past two years.
- Field analysis of the SAPS indicates it has high dissolved oxygen, elevated Eh and low discharge alkalinity reflective of reduced effectiveness.
- Analysis indicates the SAPS has been both hydraulically and chemically overloaded during average and high flow periods, which may have contributed to its current condition.

Recommendations for the McKinley 2 passive treatment system are as follows:

- Replace the existing SAPS with a new AVFW with material depths of 2 to 2½ feet of limestone fines amended compost and 2 to 2½ feet of limestone.
- Install stand-pipe outlets with flow regulating orifices to prevent occasional AVFW hydraulic overloading.
- Install an open limestone channel with small basins in the sloped area between the SAPS and aerobic pond.
- An additional option involves converting the aerobic pond to a second AVFW in order to produce a net alkaline discharge under high flow conditions to provide additional alkalinity to the watershed.

The following provides details to support the above summary.

System Description

The McKinley 2 passive treatment system layout is depicted in Figure McKinley 2-1. The McKinley 2 system was constructed in 1999 to treat an AMD seep, known as the "McKinley 2 Seep" and is shown in the adjacent picture. The McKinley 2 Seep AMD characteristics are detailed in Table McKiney 2-1. The McKinley 2 passive treatment system was designed to treat this discharge employing a SAPS followed by an aerobic pond to remove metals.

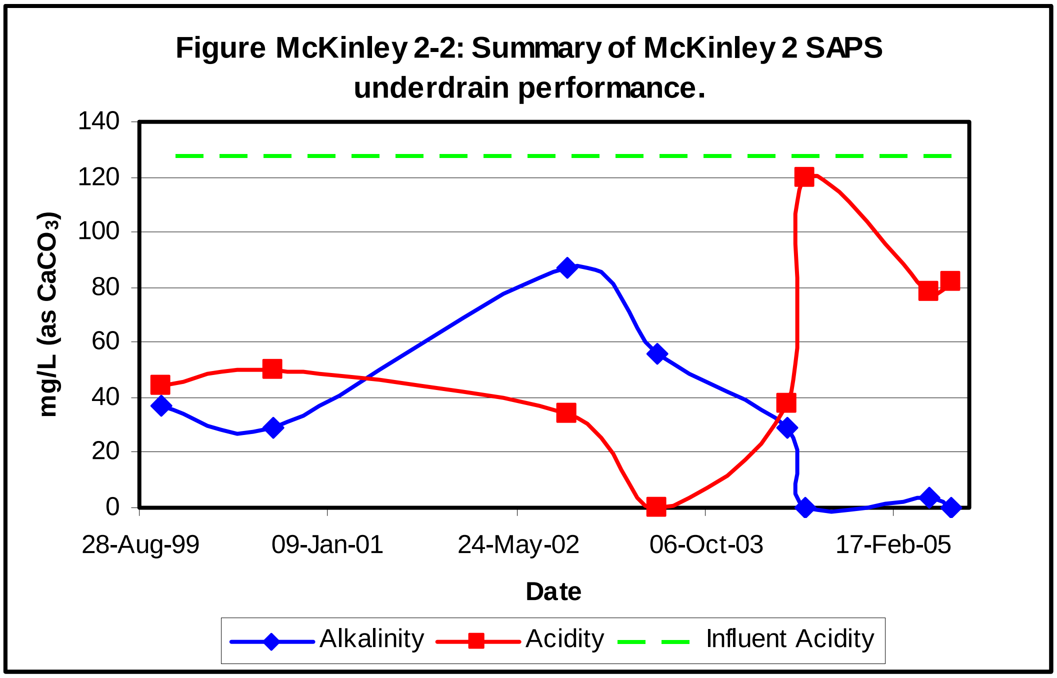
Table McKinley 2-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
3.8	0	140	3	8	42	975	12

Operational Assessment

The McKinley 2 passive treatment system was functioning (i.e., water passing through underdrain) at the time of the field visit in April 2005, but with a large amount of flow (> 20 gpm) passing over the spillway and less than 5 gpm discharging through the underdrain. During the system assessment on July 13, 2005, the discharge flow had decreased and all the flow was passing through the underdrain flow. The low underdrain flow during high flow periods is a operational issue and can result in inadequate treatment of the discharge.

Evaluation of long term SAPS undedrain acidity and alkalinity data monitored by the Mill Creek Coalition are provided in Figure McKinley 2-2. These data indicate the system produced low levels of alkalinity (30 to 90 mg/L) during the first three years of operation. The maximum alkalinities were observed during 2002 and 2003, which is the third and fourth year of the passive system operation. Following this two year period, alkalinity from the SAPS declined to near 0 mg/L, which has been the SAPS underdrain condition since 2004. Also shown on the figure is the underdrain acidity. The acidity was initially 50 mg/L and declined to a near 0 mg/L, which corresponds to the maximum alkalinity period from the SAPS. An increase in acidity followed this period to current acidity levels of between 80 and 100 mg/L. The current conditions indicate the SAPS is only removing 10 to 30% of the influent acidity.



The McKinley 2 SAPS was evaluated for a variety of performance parameters on July 13, 2005 with the results summarized in Table McKinley 2-2. Several parameters measured from the underdrain of the SAPS raise concern regarding the conditions and long term performance of the SAPS. The high underdrain dissolved oxygen (>0.5 mg/L) and the Eh (> 0 mV) indicate the SAPS does not support reducing conditions needed to raise the pH (through sulfate reduction) and prevent aluminum from precipitating on the limestone. An inadequate reducing environment can also affect the alkalinity produced by the SAPS (through low carbon dioxide production), which was 30 mg/L at the time of the field evaluation, a time of low flow and an expected maximum underdrain alkalinity.

Table McKinley 2-2: McKinley 2 SAPS evaluation conducted on July 13, 2005.

Parameter	Unit	Inlet	Underdrain
Dissolved Oxygen	mg/l	10.3	6.4
Temperature	ºC	11.9	18.0
Conductance	µS	1239	1233
pH	s.u.	4.24	5.92
Eh	mV	+480	+39
Sulfide	mg/l	-	<0.1
Ferrous Iron	mg/l	-	4.68
Total Iron	mg/l	0.42	4.68
Alkalinity	mg/l	0	30
Flow	gpm	-	12

Diagnosis

The McKinley 2 passive treatment operating condition is summarized in Table McKinley 2-3. The SAPS is operating at a reduced effectiveness due to: 1) inadequate underdrain flow during high inflow periods; 2) elevated underdrain Eh greater than 0 mV; and/or 3) inadequate alkalinity produced by the underdrain. The available data indicate accumulation of the high aluminum concentrations monitored in the McKinley 2 AMD may be causing clogging and coating of the limestone, thereby reducing its effectiveness. This may be the result of excessive acidity (or aluminum) loading to the SAPS. The aerobic pond was not assessed due to the reduced effectiveness condition of the SAPS. Minimal solids were found in the aerobic pond.

Table McKinley 2-3: Summary of McKinley 2 passive treatment systems SAPS conditions.

Unit	Condition	Criteria	Level
SAPS	Eh = +39 mV Low Flow	Eh < 0 mV	Reduced
Aerobic Pond	Not Determined	NA	Satisfactory

Design Methodology

No design basis was available. Table McKinley 2-4 provides the estimated surface area and limestone volume in the SAPS treatment cell. Table McKinley 2-4 also provides the estimated limestone bed detention time, acidity loading and surface hydraulic loading on the cell. It is likely the McKinley 2 SAPS was sized based on limestone bed detention of 16 hours. This was the accepted sizing criteria at the time of the McKinley 2 passive treatment system construction.

Table McKinley 2-4. Summary of McKinley I passive treatment system size and design parameters

AVFW	Surface Area ft^2	Limestone Volume ft^3	Limestone Bed Detention Time hrs	Acidity Loading $gr/day/m^2$	Hydraulic Loading gpm/acre
Cell 1	3,900	10,500	20-60	63	360

Comparing the acidity loading and hydraulic loading in Table McKinley 2-4 to reported design guidance for an AVFW of 25 $gr/day/m^2$ and 150 gpm/acre (Rose & Dietz, 2002; Dietz et al, 1996; Dietz ,1997) indicates the SAPS is overloaded with respect to both parameters when the system is receiving maximum reported historical flows. It is likely the periodic maximum flows caused the current operating condition of the McKinley 2 SAPS. The failure could have been prevented if the system design included underdrain outlet flow controls that would have prevented excess loading to the SAPS.

Action

The SAPS in the McKinley 2 system is operating at a reduced effectiveness. Additional evaluation indicates the SAPS, as well as the McKinley 2 system, does not adequately treat the AMD discharge, based on net acidity of the SAPS underdrain and system discharge.

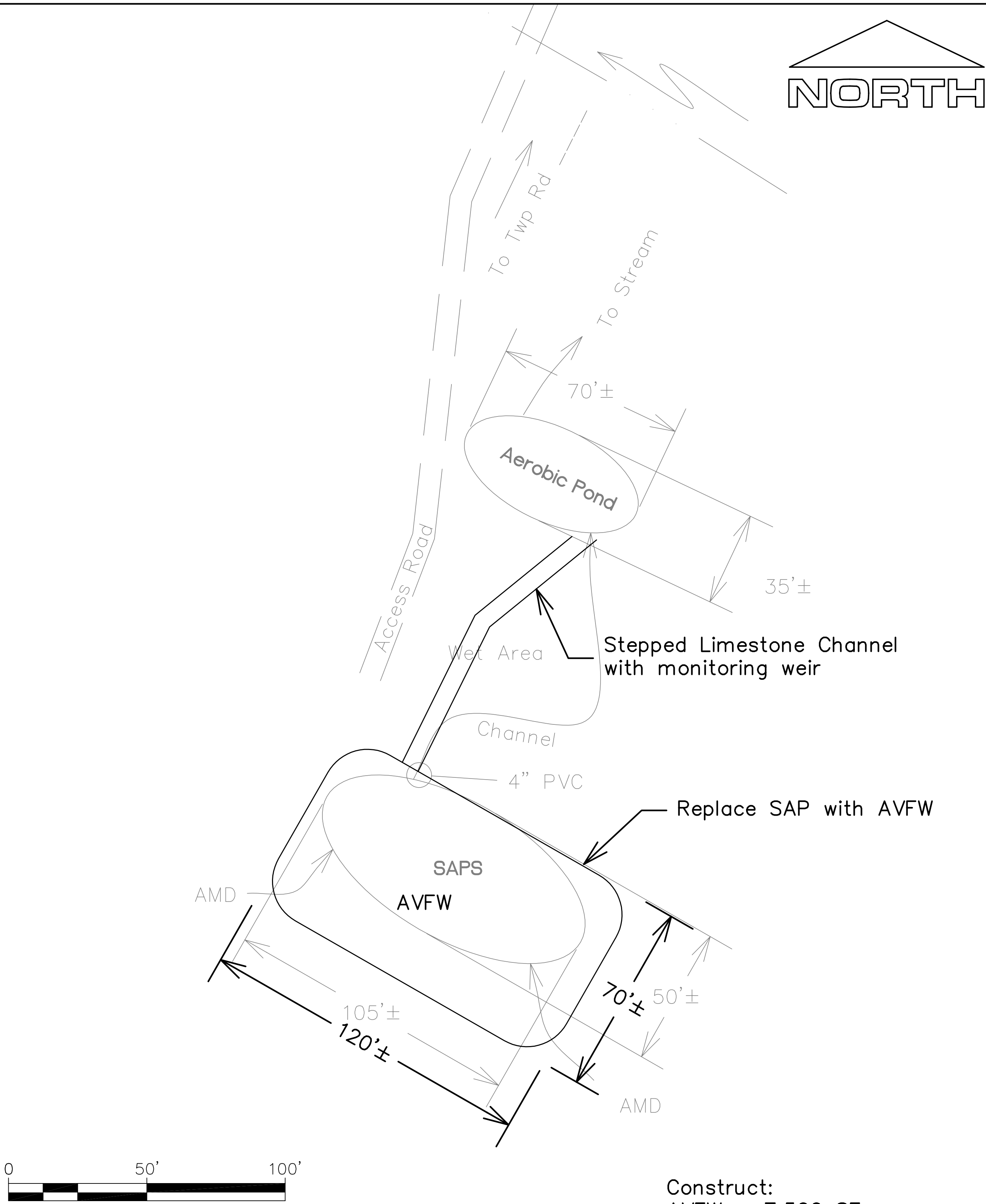
Based on the evaluation, the McKinley 2 passive treatment system is currently operating inadequately and no repair or changes in operation can resolve the existing problems. Recommendations for the McKinley 2 AMD discharge include:

1) Replacement of the existing SAPS with a new AVFW unit at the current location with greater compost depth and added limestone fines.
2) Installation of an open limestone channel to convey and remove manganese from the net alkaline AVFW treated average flow to the lower elevation aerobic pond.
3) As an additional option, convert the aerobic pond into a second AVFW to treat remaining acidity in the water and produce net alkaline water under all flow conditions (up to 32 gpm).

Operation, Maintenance & Replacement Plan

The current McKinley 2 passive treatment system is not functioning adequately to address the AMD at this site. Replacement of the SAPS is required to remediate the discharge and minimize impacts on Little Mill Creek. The following recommendations are based on historical data for the McKinley 2 AMD discharge and field observations made during the system assessment of the McKinley 2 AMD discharge.

The McKinley 2 AMD discharge is a high aluminum, high manganese, low pH, and moderate acidity discharge (i.e., aerobic discharge). The discharge characteristics limit the passive treatment choice to an AVFW (or SAPS) similar to the current system, but with greater compost depth (2 to 2½ feet) than the existing SAPS. The AVFW multi-cell model was used to estimate the required size and number of cells needed to address the McKinley 2 AMD discharge. Based on the AVFW modeling, a single 7,500 ft^2 AVFW is needed to treat up to 22 gpm (the average flow) of AMD discharge with the acidity of the McKinley 2 AMD discharge. Due to the low metals in the discharge and retention of aluminum within the SAPS, metal removal can be incorporated in the open limestone channel using small collection basins. The open limestone channel would also be effective for manganese oxidation and removal. If the aerobic pond is converted to an AVFW, the McKinley 2 passive treatment system would have the capacity to treat ~30 gpm of discharge flow, which is nearly the maximum flow historically reported during monitoring of the McKinley 2 passive treatment system. The conceptual design is depicted in Figure McKinley 2-3. The estimated construction costs for the replacement system are summarized in Table McKinley 2-5. The cost for the second AVFW is not included in Table McKinley 2-5.



Construct:
AVFW = 7,500 SF
Limestone Channel = 110 LF

Project No.: MCC-OMR
Drawing No.: 06-002
By: TSG 3/3/06
Chkd: JMD 3/14/06

PREPARED BY:
THE EADS GROUP, INC.
DIETZ-GOURLEY CONSULTING, LLC

Figure McKinley 2-3
Proposed Modifications
OM&R Plan

Union Township Jefferson County, PA

Table McKinley 2-5

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: McKinley 2 System Upgrade

Date: December 29, 2006

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.2	ACRE	$ 1,750.00	$ 350.00
3.	E&S Control	0.25	LS	$ 10,000.00	$ 2,500.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	620	CY	$ 5.00	$ 3,100.00
	(b) Wet	620	CY	$ 10.00	$ 6,200.00
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	1,050	SY	$ 15.00	$ 15,750.00
10.	Geonet	740	SY	$ 5.50	$ 4,070.00
11.	High Quality Limestone	675	Ton	$ 28.00	$ 18,900.00
12.	Mushroom Compost Substrate	525	CY	$ 30.00	$ 15,750.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	1,050	LF	$ 15.00	$ 15,750.00
	(b) 4" Solid pipe	200	LF	$ 12.00	$ 2,400.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	1	EA	$ 1,500.00	$ 1,500.00
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	470	EA	$ 3.00	$ 1,410.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	220	SY	$ 22.00	$ 4,840.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	1	EA	$ 450.00	$ 450.00
20.	Seeding/Restoration	0.25	Acre	$ 2,400.00	$ 600.00
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

TOTAL AMOUNT OF COST ESTIMATE **$ 101,070.00**

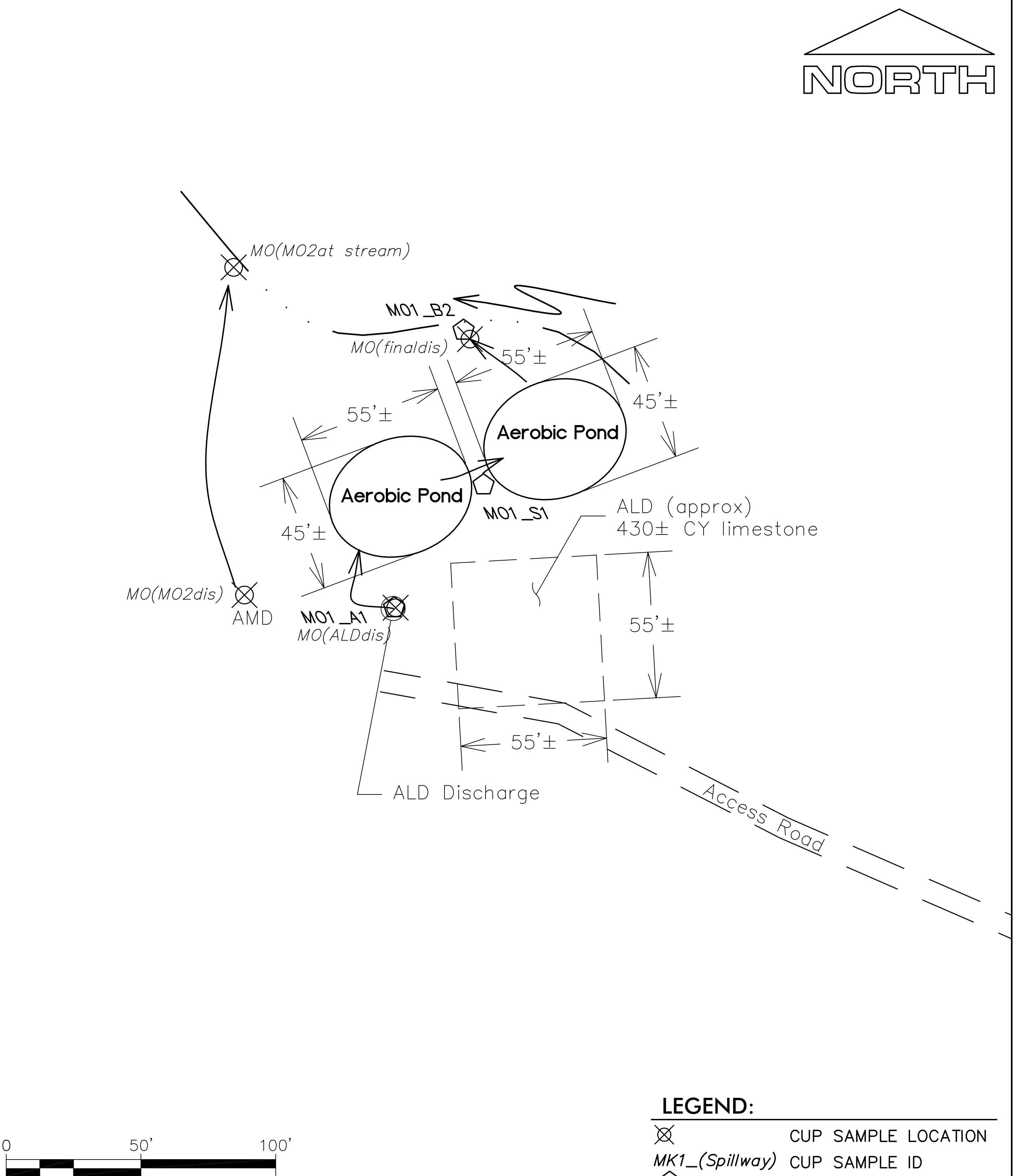
Morrow 1 Passive Treatment System

Cell 1 – Anoxic Limestone Drain (ALD)

ALD Outlet

Cell 2 – Aerobic Pond

Cell 3 – Flushing Pond



LEGEND:

⊗	CUP SAMPLE LOCATION
MK1_(Spillway)	CUP SAMPLE ID
⬠ MK1_S1	OM&R SAMPLE POINT

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 Morrow 1-1

Existing Morrow Treatment System
& OM&R Sample Points

Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Morrow 1 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive system consists of an ALD, an aerobic pond and a flushing pond that was constructed in 1998.
- Current effluent water quality indicates the system is operating satisfactorily and is currently removing manganese in the flushing pond due to low influent iron and effectiveness of the first aerobic pond.
- Excessive alkalinity produced by the ALD was found, based on alkalinity measurements, to be precipitating as calcite in the aerobic pond and flushing pond.
- Water quality results and sizing evaluation indicates the system is adequate to treat the Morrow 1 discharge.

Recommendations for the Morrow 1 passive treatment system are as follows:

- Current conditions indicate no changes to the system are required
- Direct the Morrow 2 discharge into the system, which is feasible due to:
  - Excess alkalinity produced by the ALD can be used to neutralize the acidity in the Morrow 2 discharge
  - Aerobic pond has adequate detention time to include the flow from the Morrow 2 discharge without deteriorating system performance.
- Construction of an open limestone channel to direct the Morrow 2 discharge into the first aerobic pond of the Morrow 1 passive treatment system.

The following provides details to support the above summary.

System Description

The Morrow 1 system was constructed in 1998 to treat an AMD seep, known as the "Morrow 1 Seep". The Morrow 1 Seep is a slightly acidic discharge with an initial alkalinity, pH (>5) and aluminum (< 0.5 mg/L), all consistent with an anoxic discharge. Table Morrow 1-1 details the iron and manganese concentration. In comparison to the discharge alkalinity, the discharge AMD is only slightly net acidic (< 10 mg/L).

The Morrow 1 passive treatment system was designed to treat this discharge employing an ALD followed by an aerobic pond to remove metals. The Morrow 1 passive treatment system layout is depicted on Figure Morrow 1-1. The ALD size is 13,000 ft^3 and was designed to produce additional alkalinity and raise the pH in order to remove the iron and manganese in the discharge. The aerobic pond is 5,200 ft^2 with approximately 6 feet of water depth. In addition, there is a flushing pond into which a flushing line from the ALD discharges. This was included to periodically remove iron oxides from the ALD, which have a tendency to form in the ALD due to oxygen infiltration.

Table Morrow 1-1: Typical pre-construction AMD characteristics

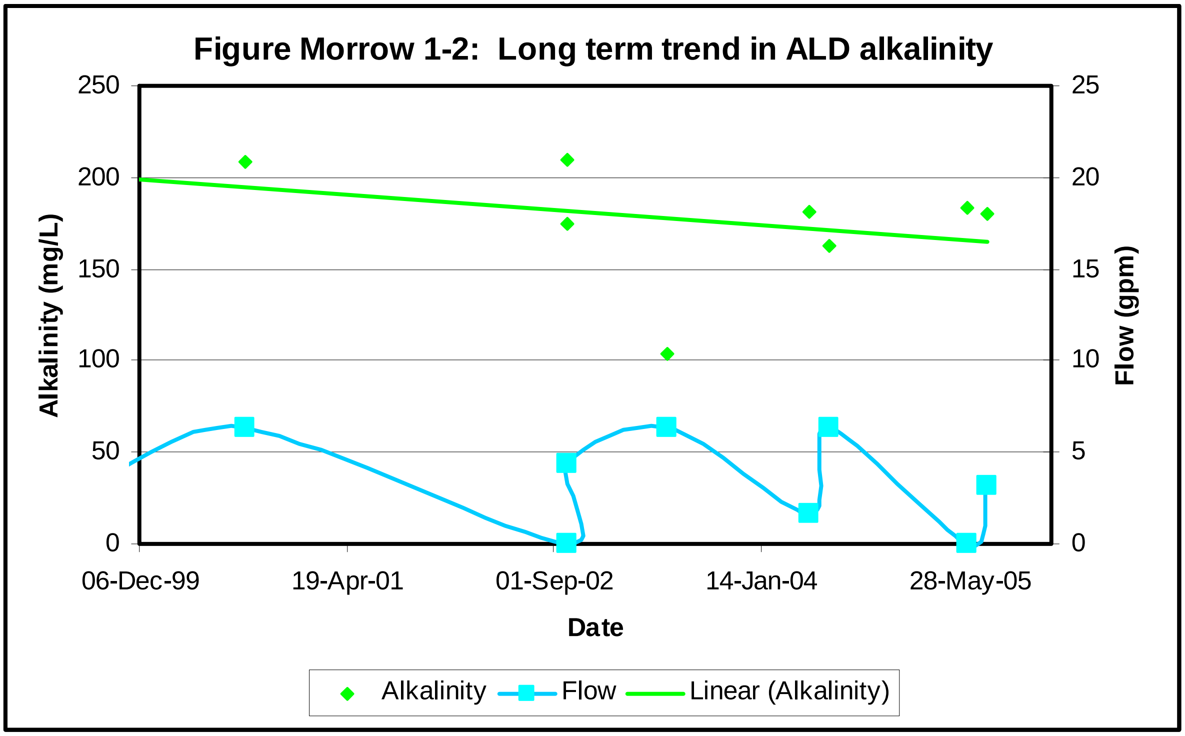
pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
5.6	37	46	0.13	9.3	10	196	22

Operational Assessment

The Morrow 1 passive treatment system was functioning at the time of the field visit in April 2005 and during the system assessment on July 14, 2005. The discharge flow was less than 2 gpm during the July evaluation. There was also a second untreated discharge, Morrow 2, flowing adjacent to the system that was monitored as part of the evaluation. The following provides an assessment of the Morrow 1 system.

ALD

Long term monitoring data provided in Figure Morrow 1-2 indicate a gradual decrease in alkalinity since the ALD was constructed. Based on the trend, the alkalinity decrease is approximately 7 to 8 mg/L per year. This gradual trend is not unexpected since the limestone in the ALD is being consumed resulting in a decrease in detention time and a corresponding decrease in ALD effluent alkalinity. The current alkalinity is substantially greater than the 16 mg/L needed to remove the ALD outlet iron concentration of 9 mg/L.



The field assessment indicated the ALD was in good operating condition. Dissolved oxygen was very low in the discharge from the ALD and the iron was all in the ferrous form. The pH was found to be approaching 7 and with an alkalinity in excess of 200 mg/L. The current pH is over a full pH unit greater than was found in the discharge (current system data is provided in Table Morrow 1-2). As part of the field evaluation, effluent from the ALD was placed in cubitainors filled with high quality limestone. The results of the cubitainor testing are provided in Table Morrow 1-3, which indicates there is no increase in the alkalinity with greater contact time with limestone. This indicates the maximum alkalinity possible is being produced by the ALD, which is not unexpected since the ALD detention time is in excess of 700 hours at the observed flow. It also indicates the ALD is functioning properly with little or no short circuiting, clogging, or loss of limestone volume.

Table Morrow 1-2. Field sampling results from the Morrow 1 passive treatment system assessment conducted on July 14, 2005

Location	DO mg/l	Temp ºC	Cond µS	pH	Fe(II) Iron mg/l	Total Iron mg/l	Total Mn mg/l	Alkalinity mg/l
ALD out	0.15	13.1	689	6.86	8.4	8.3	9.3	214
Aerobic Pond Out	6.19	21.9	640	7.29	0	0.7	2.4	170
Morrow 2 Seep	-	12.1	510	5.52	15.4	15.1	--	18

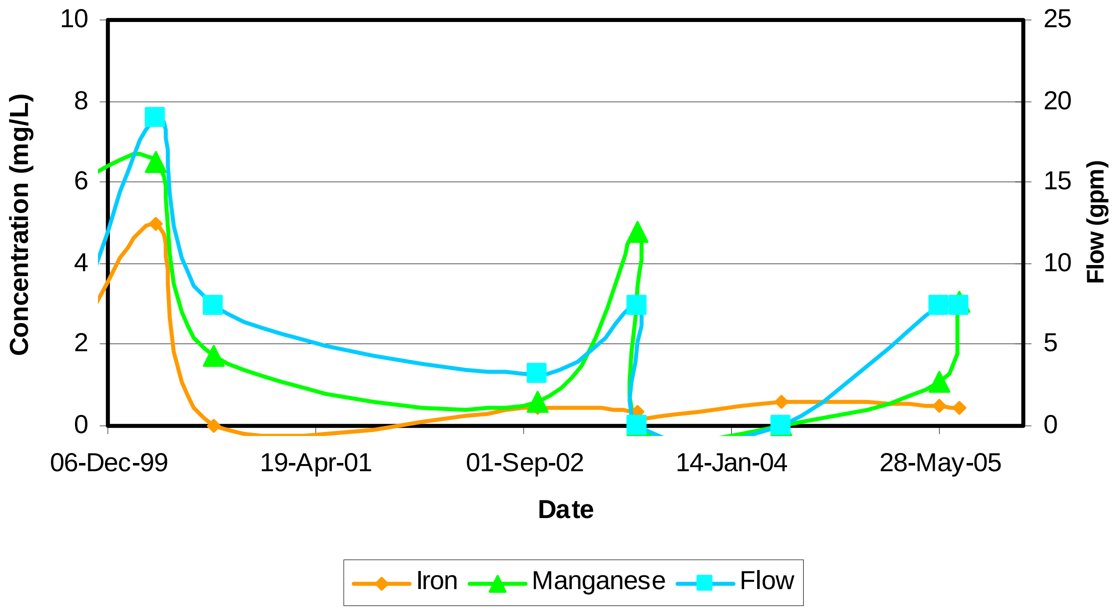
Table Morrow 1-3. Summary of results from cubitainor tests conducted on the Morrow 1 ALD effluent.					
Bottle No.	**Temp °C**	**Conduct µS**	**pH**	**Alkalinity mg/l**	**Elapsed Time Hrs**
1149	23.0	689	7.01	206	57.18
1175	22.8	694	7.04	205	57.32

Aerobic Pond

The aerobic pond was evaluated by examining effluent water quality. Effluent water quality measured during the field evaluation is shown in Table Morrow1-2. The data indicate the aerobic pond is removing nearly all the iron and 75% of the manganese at the low flow and conditions during the July assessment.

Figure Morrow 1-3 shows the long term effluent data from the aerobic pond. The aerobic pond shows some initial fluctuations in effluent total iron, but stable and low effluent total iron over the last 4 years. Removal of total manganese by the aerobic pond was initially negligible, but increased with time and the effluent currently varies between 0 and 3 mg/L, which may be related to the formation of manganic oxides that catalyze manganese removal.

Figure Morrow 1-3: Long term trend in effluent iron and manganese



An interesting observation was identified that may affect the quality of the solids removed and the longevity of the aerobic pond. The observation relates to the measured alkalinity across the system and the associated metals (and acidity) removed. The metals removed account for approximately 30 mg/L of acidity, or alkalinity consumed. Comparing this to the alkalinity decrease of greater than 40 mg/L suggests additional alkalinity is being lost across the aerobic pond. The observed increase in pH is the likely explanation, which causes a decrease in calcite solubility. It is likely as the pH increases across the aerobic pond, calcite is being precipitated, in the amount of 10 to 15 mg/L, and results in a corresponding decrease in alkalinity. This is a small amount but could lead to increased solids accumulation in the aerobic pond resulting in a decrease in longevity in comparison to calculations based solely on metals accumulation.

Diagnosis

The operational conditions of the Morrow 1 passive treatment units are summarized in Table Morrow 1-4.

Table Morrow 1-4. Summary of Morrow 1 passive treatment system unit conditions.

Unit	Condition	Criteria	Effectiveness Level
ALD	Alkalinity 99% of Maximum	Alkalinity > 85% of Maximum	Satisfactory
Aerobic Pond	Effluent Iron = 0.5 mg/L	Fe Removal > 90%	Satisfactory

The ALD was functioning at a satisfactory effectiveness based on the field evaluation of the maximum alkalinity. Long term data indicated a gradual trend with an approximate alkalinity decrease of 7 to 8 mg/L per year. Based on the iron concentration in the discharge, system replacement is likely to be greater than 10 years. The triggers developed for ALD technology should identify when substantial depletion of the limestone has occurred and replacement should be initiated.

The aerobic pond was functioning at a satisfactory effectiveness based on effluent iron in comparison to influent iron, which indicated the aerobic pond is removing greater than 95% of the ferrous iron to an effluent of less than 0.5 mg/L. The aerobic pond also is removing manganese. No maintenance is anticipated in the next 8 to 15 years. The triggers should provide adequate indications of when maintenance to remove solids will be required.

Design Methodology

The design methodology for ALD and aerobic pond in the Morrow 1 passive treatment system are as follows. The ALD was based on an accepted detention time of 16 hours with added limestone for longevity based on alkalinity produced. This design approach for ALD has proven successful. The only potential concern is high alkalinity concentrations produced and the precipitation of calcite in the aerobic pond that was discussed above. This excess alkalinity may be desirable where additional AMD inputs can not be treated in the watershed.

The design methodology for the aerobic pond was based on an iron removal of 10 gr/day/m^2, which may be inadequate compared to the abiotic model for low iron concentrations similar to the Morrow 1 AMD. However, the high pH created by the ALD as well as the increase in pH caused by release of carbon dioxide in the aerobic pond creates conditions for the rapid oxidation and precipitation of iron, as well as manganese.

Action

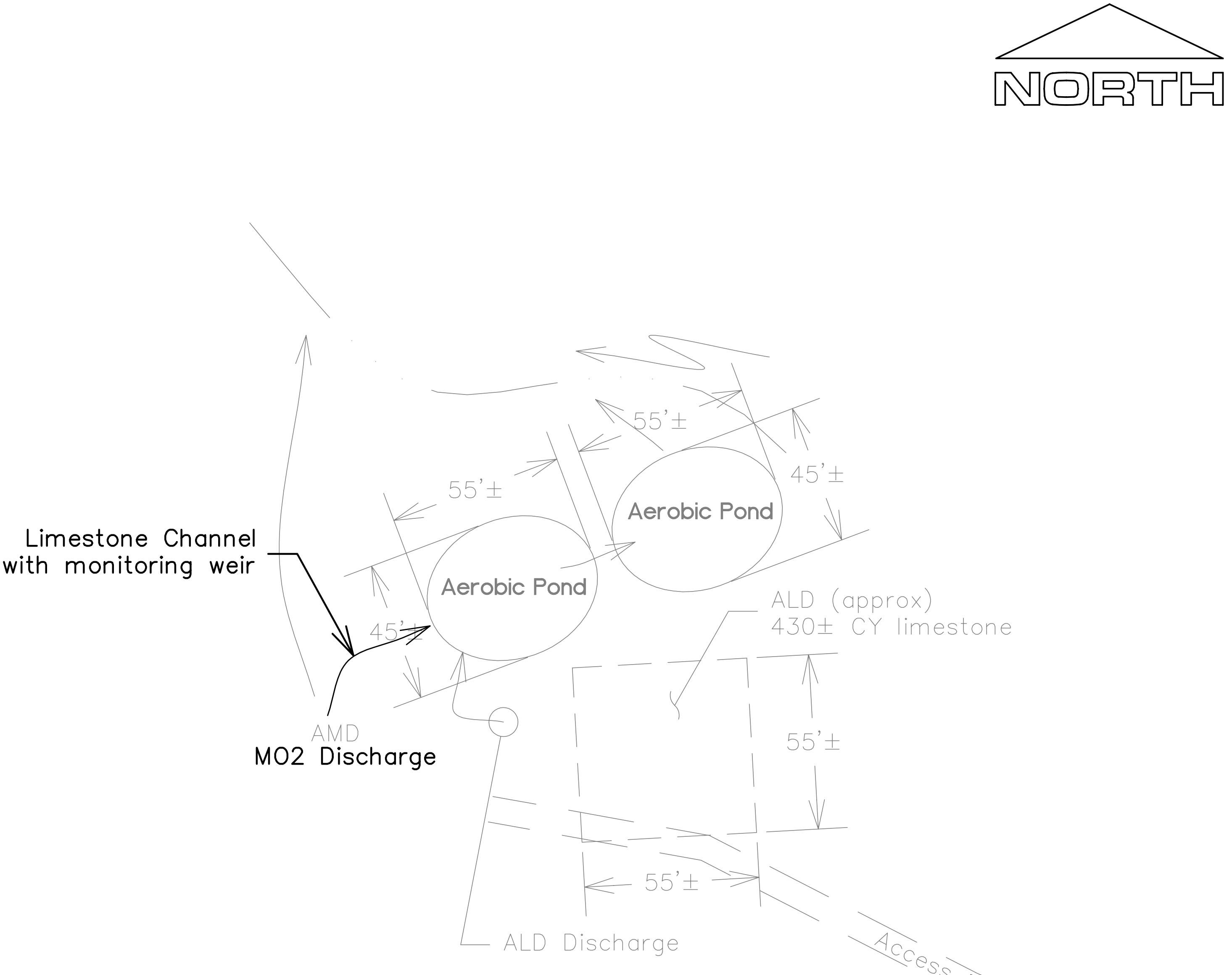
The Morrow 1 passive treatment system is currently operating satisfactorily and no repairs or changes in operation are required. Continued monitoring of the system should be conducted.

The presence of a second AMD discharge in a channel in close proximity to the Morrow 1 passive treatment system was evaluated for treatment in the existing Morrow 1 passive treatment system. The discharge (data provided in Table Morrow 1-2), has similar characteristics as the Morrow 1 AMD discharge. Preliminary analysis indicates the Morrow 2 discharge can be incorporated into the Morrow 1 passive treatment system based on alkalinity produced by the ALD and the size of the aerobic pond and flushing pond. A conceptual design option for this AMD discharge is depicted in Figure Morrow 1-4. Table Morrow 1-5 summarizes the costs associated with the modifications to treat the Morrow 2 AMD discharge. To provide a final evaluation for the Morrow 2 AMD discharge, the following are recommended:

1) Additional monitoring of flow and water quality of the discharge.
2) If the discharge is anoxic, evaluate alkalinity and determine whether additional treatment (e.g., upflow limestone well) is needed prior to discharge into the Morrow 1 system.
3) Evaluate additional data to determine if adequate detention time is available to include the Morrow 2 AMD discharge into the Morrow aerobic pond.

Operation, Maintenance & Replacement Plan

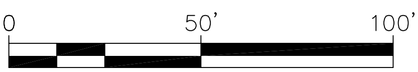
The current Morrow 1 passive treatment system is functioning adequately to address the AMD sources at this site. In addition, the system may be adequate to treat an additional AMD discharge (Morrow 2) identified during the field investigation. The system should be continued to be operated and monitored. Replacement of the system will require construction of a new ALD with the aerobic pond and flushing pond only requiring solids removal, based on the triggers developed for aerobic ponds. At the time the ALD replacement is required, other newer technologies should be evaluated that may provide lower construction and/or replacement costs, including a tank system known as an upflow limestone well.



Divert AMD (Morrow 2 seep) into existing treatment system.

Alkainity in ALD discharge is adequate to treat additional AMD.

Aerobic Ponds have adequate capacity.



Project No.: MCC–OMR Drawing No.: 06–002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	Figure Morrow 1-4 Proposed Modifications OM&R Plan Union Township Jefferson County, PA

Table Morrow 1-5

Preliminary Engineering Cost Estimate

Mill Creek Coalition: OM&R System Modifications

Site: **Morrow System Upgrade**

Date: **December 29, 2006**

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	0.1	LS	$ 7,500.00	$ 750.00
2.	Clearing and Grubbing	0	ACRE	$ 1,750.00	$ -
3.	E&S Control	0.05	LS	$ 10,000.00	$ 500.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	25	CY	$ 15.00	$ 375.00
	(b) Wet	0	CY	$ 30.00	$ -
8.	Embankment Construction	0	CY	$ 18.00	$ -
9.	Geotextile Liner	0	SY	$ 15.00	$ -
10.	Geonet	0	SY	$ 5.50	$ -
11.	High Quality Limestone	0	Ton	$ 28.00	$ -
12.	Mushroom Compost Substrate	0	CY	$ 30.00	$ -
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	0	LF	$ 15.00	$ -
	(b) 4" Solid pipe	0	LF	$ 12.00	$ -
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	0	EA	$ 1,500.00	$ -
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	0	EA	$ 3.00	$ -
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	35	SY	$ 22.00	$ 770.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	1	EA	$ 450.00	$ 450.00
20.	Seeding/Restoration	0.1	Acre	$ 2,400.00	$ 240.00
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

TOTAL AMOUNT OF COST ESTIMATE **$ 3,085.00**

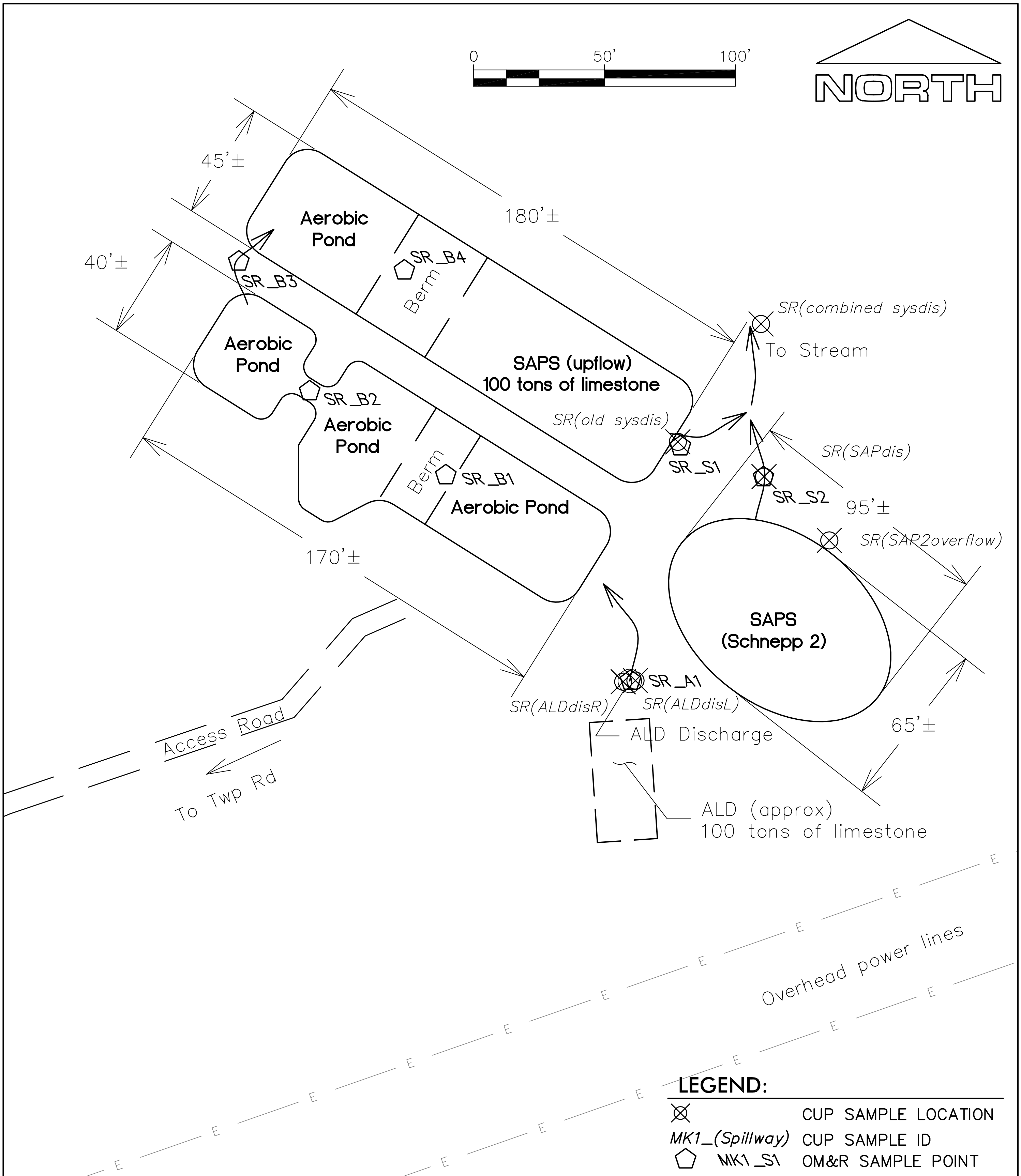
Schnepp 1/2 Passive Treatment System

Schnepp 1 Anoxic Limestone Drain

Aerobic Pond

Schnepp 2 Upflow SAPS

Schnepp 2 SAPS Stand-pipe Outlet



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 Schnepp 1/2-1

Existing Schnepp 1/2
Passive Treatment System

Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Schnepp 1/2 passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The passive system consists of two treatment systems -
  - Schnepp 1 consists of an ALD, a series of aerobic ponds, and an upflow SAPS that was constructed in 1996.
  - Schnepp 2 consists of a single SAPS constructed in 1998.
- Current effluent water quality and the field evaluation indicates the two systems are operating at reduced effectiveness.
- Schnepp 1-
  - The existing ALD is clogged with only minimal flow discharging through the outlet.
  - The first aerobic pond is filled with iron oxide solids.
  - The upflow SAPS treatment effectiveness is reduced due to inflows at various locations.
- The Schnepp 2 SAPS –
  - Underdrain flow is inadequate at times to treat the discharge flow
  - Eh (> 0 mV) indicates oxidizing conditions are present in the SAPS substrate.

Recommendations for the Schnepp 1/2 passive treatment system are as follows:

- Current conditions indicate the Schnepp 1/2 passive treatment systems need to be replaced with a new AVFW system adjacent to the existing Schnepp 1/2 system.

The following provides details to support the above summary.

System Description

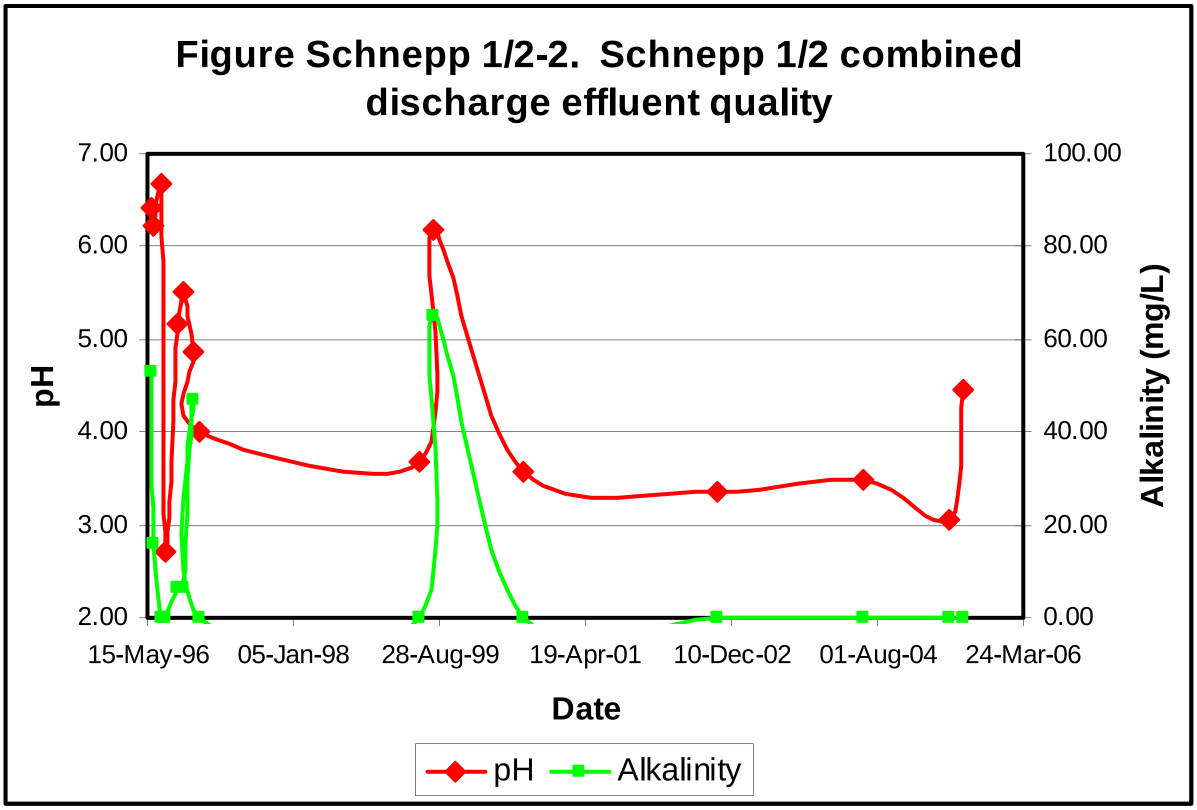
The Schnepp 1/2 passive treatment system is comprised of two separate systems, Schnepp 1 and Schnepp 2, treating multiple sources of AMD. The pre-construction monitoring for the Schnepp seeps, contained in Table Schneep 1/2-1, vary considerably in characteristics. Only pre-construction data are available for the seeps due to the ALD construction and upflow SAPS, which do not permit sampling of the discharges. Schnepp 1 represents the water entering the ALD or the Schnepp 1 system, and Schnepp 2 is the water entering the SAPS or the Schnepp 2 system.

Table Schnepp 1/2-1: Typical pre-construction AMD characteristics

	pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
Schnepp 1	3.5	0	231	3	22	11	650	12
Schnepp 2	4	0	275	0.9	50	20	---	---

The Schnepp 1 passive treatment system was originally designed to treat the discharge employing an ALD followed by an aerobic pond to remove metals. However, a number of other upflow areas were encountered during construction in 1996 and additional treatment cells were added to the system. The Schnepp 2 SAPS was constructed in 1998 to address a second AMD upwelling located downgradient of the Schnepp 1 ALD. The Schnepp 1/2 passive treatment system layout is depicted in Figure Schnepp 1/2-1. Limited design information is available for this system as it was field designed and constructed by the Pennsylvania National Guard.

Operational problems were encountered at the Schnepp 1 passive treatment system shortly after installation. A major storm event in July of 1996 produced several inches of rain in a short period of time within days of system construction completion. The impacts of the storm event may have compromised the treatment system. The outlet flow from the ALD decreased and clogging became apparent. One of the two outlets stopped flowing completely and flow from the other outlet decreased well below normal flows.



Operational Assessment

The historic effluent quality from the Schenepp 1/2 passive treatment system is shown in Figure Schnepp 1/2-2. The data show the system initially produced a high pH effluent with alkalinity. However, system performance rapidly deteriorated to a low pH discharge with substantial acidity. The following provides an assessment of the treatment units within the Schenepp 1/2 passive treatment system.

ALD

The Schnepp 1 ALD was observed at the time of the initial field visit in April 2005 and during the system assessment on July 14, 2005. The Schnepp 1 ALD had a minimal flow of approximately 2 gpm. Long term monitoring data from the ALD are shown in Figure Schnepp 1/2-3. Not only is the decreased flow an issue, but the plot shows decreasing alkalinity from the ALD over time. There is also an indication total iron varied over time, reflecting possible oxidation and precipitation within the ALD. Field assessment results are shown in Tables Schnepp 1/2-2 and Schnepp 1/2-3. Field measurements indicate low dissolved oxygen concentrations and concentrations of ferric (or particulate iron) are present. These conditions may reflect the occurrence of iron oxidation and precipitation in the ALD. Cubitainor results in Table Schnepp 1/2-3 indicate the current ALD outlet alkalinity is less than 60% of the maximum alkalinity which reflects an ALD detention of less than 5 hours. The decreased alkalinity also provides evidence the ALD may be clogged with short circuiting or reduced limestone surface area due to iron oxide coating.

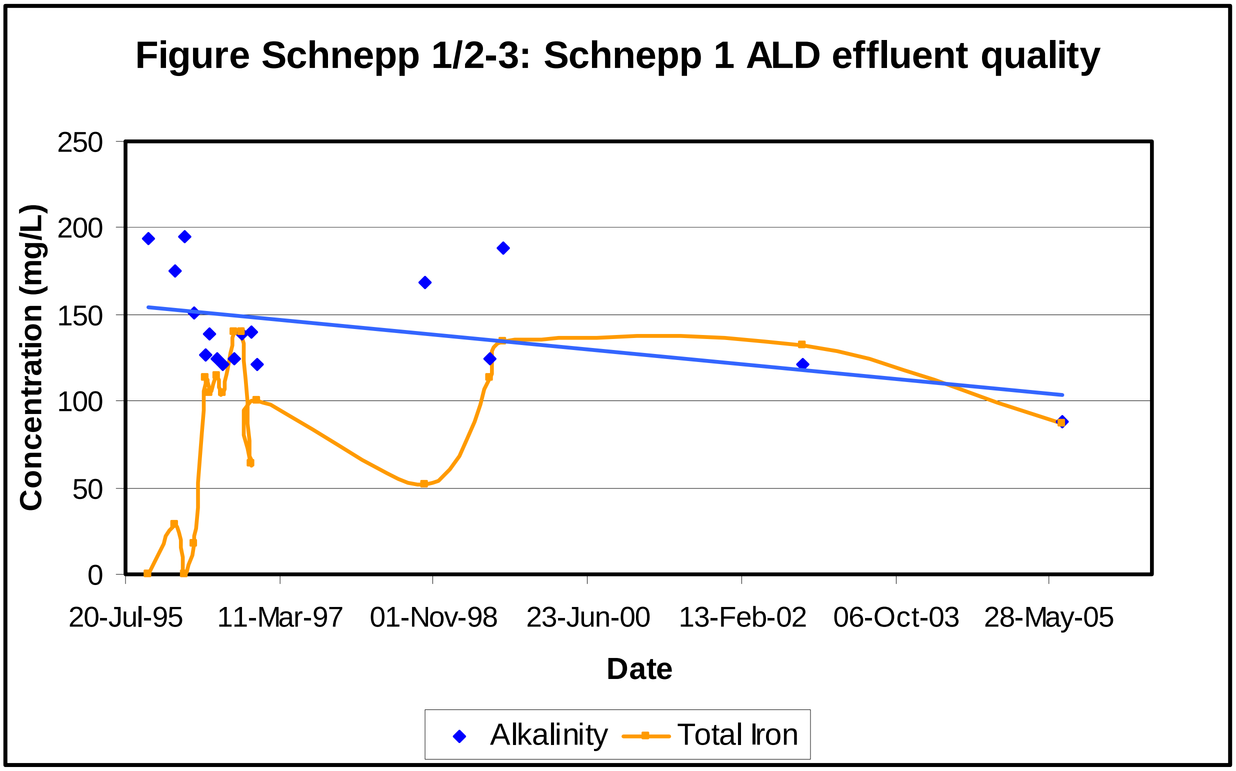


Table Schnepp 1/2-2. Field sampling results from the Schnepp 1 ALD assessment conducted on July 14, 2005								
Location	**DO mg/l**	**Temp ºC**	**Cond µS**	**pH**	**Fe(II) Iron mg/l**	**Total Iron mg/l**	**Fe(II) mg/l**	**Alkalinity mg/l**
ALD out	0.28	10.8	1120	6.27	8.4	82.5	81.0	145

Table Schnepp 1/2-3. Summary of results from cubitainor tests conducted on the Schnepp I ALD effluent.					
Bottle No.	**Temp ºC**	**Conduct µS**	**pH**	**Alkalinity mg/l**	**Elapsed Time hrs**
1032	22.9	1207	6.76	249	55.7
1048	23.0	1203	6.72	250	55.8

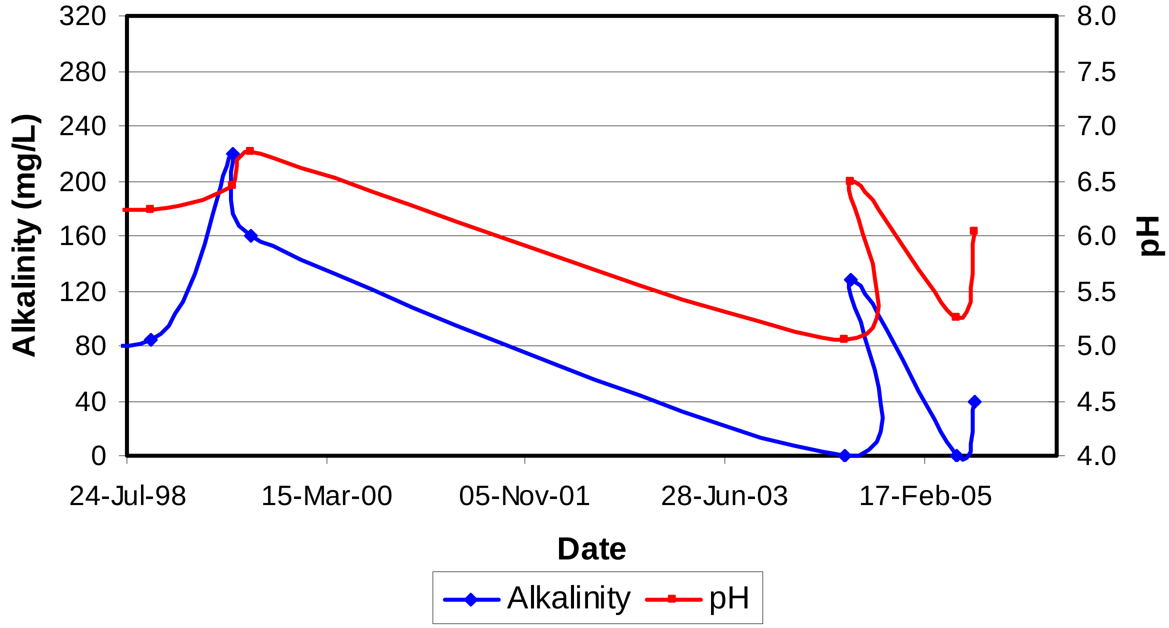
Aerobic Ponds

Several of the aerobic ponds in the Schnepp 1 passive treatment system were evaluated. Poor performance of the ALD as well as numerous inflows throughout the Schnepp 1 system prevented assessment of the aerobic ponds. Measurements of accumulated solids were evaluated. Only the first aerobic pond located downgradient of the ALD contained significant solids, which were 1 to 2 feet deep.

SAPS

The Schnepp 2 SAPS had minimal underdrain flow during both the April visit and the July field assessment. The Schnepp 2 SAPS had about 5 gpm underdrain flow and substantial (>25 gpm) spillway flow during the April 2005 view. During the July visit all the flow was passing through the underdrain at a rate of 5 gpm. The Schnepp 2 SAPS historical data are plotted in Figure Schnepp 1/2-4. The data indicate that not only has underdrain flow decreased over time, but so has performance. Effluent alkalinity decreased from an initial (i.e., first year) of 150 mg/L to less than 40 mg/L with an occasional alkalinity of 0 mg/L. A corresponding decrease in pH was also observed due to the relationship of pH and alkalinity.

Figure Schnepp 1/2-4. Schnepp 2 SAPS effluent quality



The Schnepp 2 SAPS was evaluated during the field assessment; see Table Schnepp 1/2-4. No inlet flow was apparent during the assessment and discussions with the Mill Creek Coalition indicate the discharge enters the SAPS subsurface. To evaluate inlet water, the standing water in the pond was sampled. Table Schnepp 1/2-4 indicates the discharge has a low pH and high iron concentration. Actual AMD chemistry is unknown due to the subsurface inflow to the SAPS. The SAPS was found to be producing an effluent with a low alkalinity of 60 mg/L and a pH slightly less than 6. However, the SAPS underdrain discharge remains net acidic. Several operating parameters were evaluated, including sulfide and Eh. No sulfide was detected and Eh was found to be greater than 0 mV, indicating slightly oxidizing conditions are present in the SAPS substrate. The elevated Eh indicates the SAPS does not support a reducing environment in the SAPS substrate; needed to prevent iron oxide precipitation on the limestone.

Diagnosis

The current operating conditions of the Schnepp 1/2 passive treatment system are summarized in Table Schnepp 1/2-5. The system is currently in a reduced effectiveness condition.

Based on the field evaluation and historic data, the Schnepp 1 ALD is functioning at a reduced effectiveness and is only treating a portion of the AMD flow and producing less than 60% of the desired alkalinity. This alkalinity is inadequate to remove the iron in the AMD discharge as well as the additional flows entering into the Schnepp 1 system. The evaluation of the causes is suggested by the historic data the ALD is treating (Table Schnepp 1/2-1), which indicates the presence of aluminum, greater than 1 mg/L, and a low pH indicative of soluble ferric iron and the presence of dissolved oxygen. The influent conditions would result in the precipitation of both metals in the ALD and cause the observed operational and effluent quality conditions. It should be understood that ALD water quality requirements were not thoroughly understood at the time of the Schnepp 1 ALD construction and that this installation must be viewed based on the time frame of installation.

Table Schnepp 1/2-4. Schnepp 2 SAPS evaluation conducted on July 14, 2005.

Parameter	Unit	Pond	Underdrain
Dissolved Oxygen	mg/l	6.2	0.18
Temperature	ºC	26.0	21.3
Conductance	µS	1025	1015
pH	s.u.	3.27	5.93
Eh	mV	+530	+31
Sulfide	mg/l	-	<0.1
Ferrous Iron	mg/l	-	51.4
Total Iron	mg/l	-	51.8
Alkalinity	mg/l	0	62
Flow	gpm	-	5.5

Table Schenepp 1/2-5. Summary of Schnepp 1/2 passive treatment system unit conditions.

Unit	Condition	Criteria	Level
Schnepp 1 ALD	60% Maximum, Reduced Flow	60 to 85% AD > ALD Alkalinity	Reduced
Schnepp 1 Aerobic Pond	No IR determined Avg. solids = 1.5 feet	IR<80%	Reduced
Schnepp 2 SAPS	Eh = +31 mV Reduced Flow	Eh > 0 mV	Reduced

The field evaluation and review of historical data also indicate the Schnepp 2 SAPS is operating at reduced effectiveness due to low underdrain flow and decreasing effluent alkalinity. The reduced effectiveness state is indicated by the historical data that show alkalinity approaches 0 mg/L at certain times of the year. In addition, the field Eh indicates oxidizing conditions in the SAPS substrate, which may have negative consequences on future SAPS operation. The causes may be related to inadequate sizing of the SAPS based on today's knowledge of SAPS design and limitations along with periodic overloading during high flow periods.

Design Methodology

No design basis was available. Due to the various sources of flow into Schnepp 1, it is not possible to evaluate the design of the systems. However, our current understanding of the ALD and its water quality limitations indicates an ALD is not an appropriate technology due to the presence of aluminum at greater than 1 mg/L and historic characteristics that suggest the discharge contained dissolved oxygen.

The Schneep 2 SAPS was constructed based on minimal data; one sample date with no flow. The post-construction maximum flow of 26 gpm and the pre-construction influent acidity of 275 mg/L were used to evaluate the size of the SAPS. The existing Schnepp 2 SAPS is about 5,000 ft^2. Based on the area of the system and an estimated limestone depth of four feet (communications with Mill Creek Coalition), the SAPS has a limestone bed detention time of greater than 16 hours, which is likely the design criteria used at the time of the Schnepp 2 SAPS installation. However, based upon current recommended design criteria (acidity loading rate of 25 $gr/day/m^2$), the Schnepp 2 SAPS should have been slightly larger than 15,000 ft^2. This suggests the SAPS has been overloaded, resulting in its reduced effectiveness. It should be understood the current sizing guidance were not available at the time of the Schnepp 2 installation.

Action

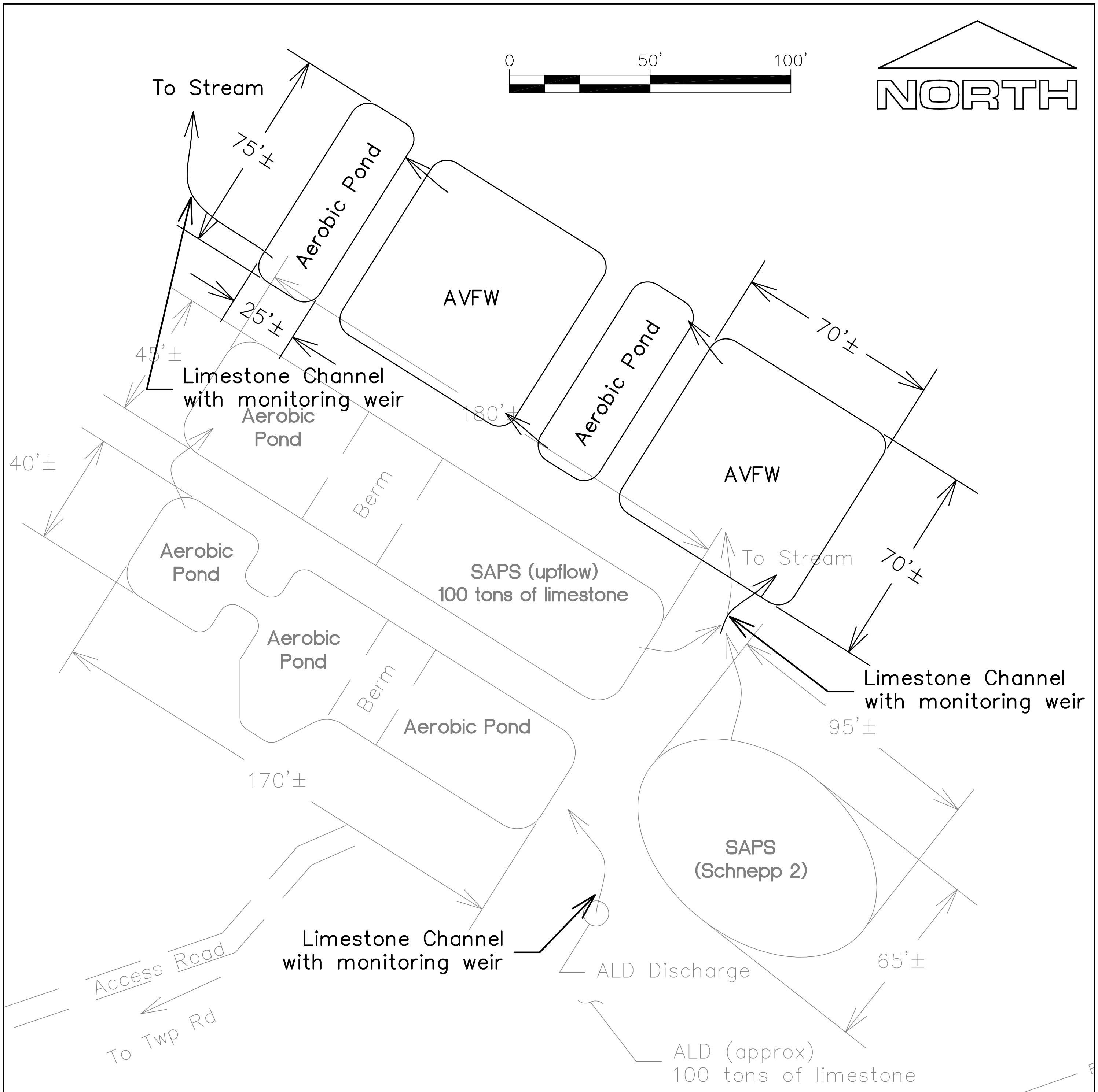
The Schnepp 1/2 passive treatment systems are currently operating at reduced effectiveness condition. No modifications or repairs of the current Scheneep 1/2 passive treatment system will resolve the reduced effectiveness conditions. As a result, planning should be initiated to replace the systems in order to adequately treat the Schnepp discharges under expected AMD flows and water quality. Recommendations for the Schnepp AMD discharges involve replacement of the existing ALD and SAPS with a new AVFW unit downstream of the current location due to AMD upwelling in the existing system.

Operation, Maintenance & Replacement Plan

The current Schnepp 1/2 passive treatment systems are functioning at reduced effectiveness and replacement of the systems are required to adequately treat the AMD discharges. The following recommendations are based on historical data for the Schnepp AMD discharges and field observations made during the system assessment.

The Schnepp AMD discharges contain elevated aluminum, high iron, low pH, and is a high acidity discharge. The discharge characteristics limit the passive treatment choice to an AVFW with a greater compost depth (2 to 2½ feet) than the existing SAPS. The multi-cell model was used to estimate the required size and number of cells needed to address the Schnepp AMD discharges. Based on the modeling, a two cell AVFW system with 5,000 ft^2 of surface area in each cell would be needed to adequately treat up to 50 gpm (reported maximum system discharge flow) of Schnepp AMD discharges (using a calculated acidity of 150 mg/L). Due to the high metals (i.e., iron) in the discharges, aerobic ponds are also needed after each AVFW cell.

The conceptual design is depicted in Figure Schnepp 1/2-5. This system is located downstream of the existing systems. This location was selected to avoid the existing AMD upwellings into the existing systems. The proposed treatment system will utilize the existing Schnepp systems as a collection system due to the AMD upwellings in the existing system. The estimated construction costs for the system are summarized in Table Schnepp 1/2-6.



Utilize existing system for collection of AMD.

Construct:
Two (2) AVFW = 5,000 SF (each)
Two (2) Aerobic Pond = 2,000 SF (each)

Project No.: MCC–OMR Drawing No.: 06–002 By: TSG 3/3/06 Chkd: JMD 3/14/06	PREPARED BY: THE EADS GROUP, INC. DIETZ-GOURLEY CONSULTING, LLC	Figure Schnepp 1/2-5 Proposed Modifications OM&R Plan Union Township Jefferson County, PA

Table Schnepp 1/2-6

Preliminary Engineering Cost Estimate
Mill Creek Coalition: OM&R System Modifications

Site: **Schnepp Road System Upgrade**
Date: **December 29, 2006**

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1.	Mobilization and Demobilization	1	LS	$ 7,500.00	$ 7,500.00
2.	Clearing and Grubbing	0.6	ACRE	$ 1,750.00	$ 1,050.00
3.	E&S Control	1	LS	$ 10,000.00	$ 10,000.00
4.	Access Road	0	SY	$ 10.00	$ -
5.	Access Gate	0	LS	$ 1,500.00	$ -
6.	Stream Crossing	0	LS	$ 8,000.00	$ -
7.	Excavation				
	(a) Dry	50	CY	$ 15.00	$ 750.00
	(b) Wet	2130	CY	$ 6.00	$ 12,780.00
8.	Embankment Construction	900	CY	$ 7.00	$ 6,300.00
9.	Geotextile Liner	1785	SY	$ 15.00	$ 26,775.00
10.	Geonet	800	SY	$ 5.50	$ 4,400.00
11.	High Quality Limestone	770	Ton	$ 28.00	$ 21,560.00
12.	Mushroom Compost Substrate	630	CY	$ 30.00	$ 18,900.00
13.	Piping (SCH 40 PVC) installed				
	(a) Underdrain - 4" slotted	700	LF	$ 15.00	$ 10,500.00
	(b) 4" Solid pipe	160	LF	$ 12.00	$ 1,920.00
	(c) 6" Solid pipe	0	LF	$ 12.00	$ -
	(d) 4" Gate Valve	2	EA	$ 1,500.00	$ 3,000.00
14.	Orifice Flow Control	0	EA	$ 75.00	$ -
15.	Wetland Vegetation and Planting	630	EA	$ 3.00	$ 1,890.00
16.	Flow Diversion (membrane curtain)	0	LF	$ 40.00	$ -
17.	Rock Lining / Rock Channel	450	SY	$ 22.00	$ 9,900.00
18.	Upflow Limestone Well	0	EA	$ 12,500.00	$ -
19.	Monitoring Weir	3	EA	$ 450.00	$ 1,350.00
20.	Seeding/Restoration	0.4	Acre	$ 2,400.00	$ 960.00
21.	Sludge Removal/Disposal	0	CY	$ 15.00	$ -

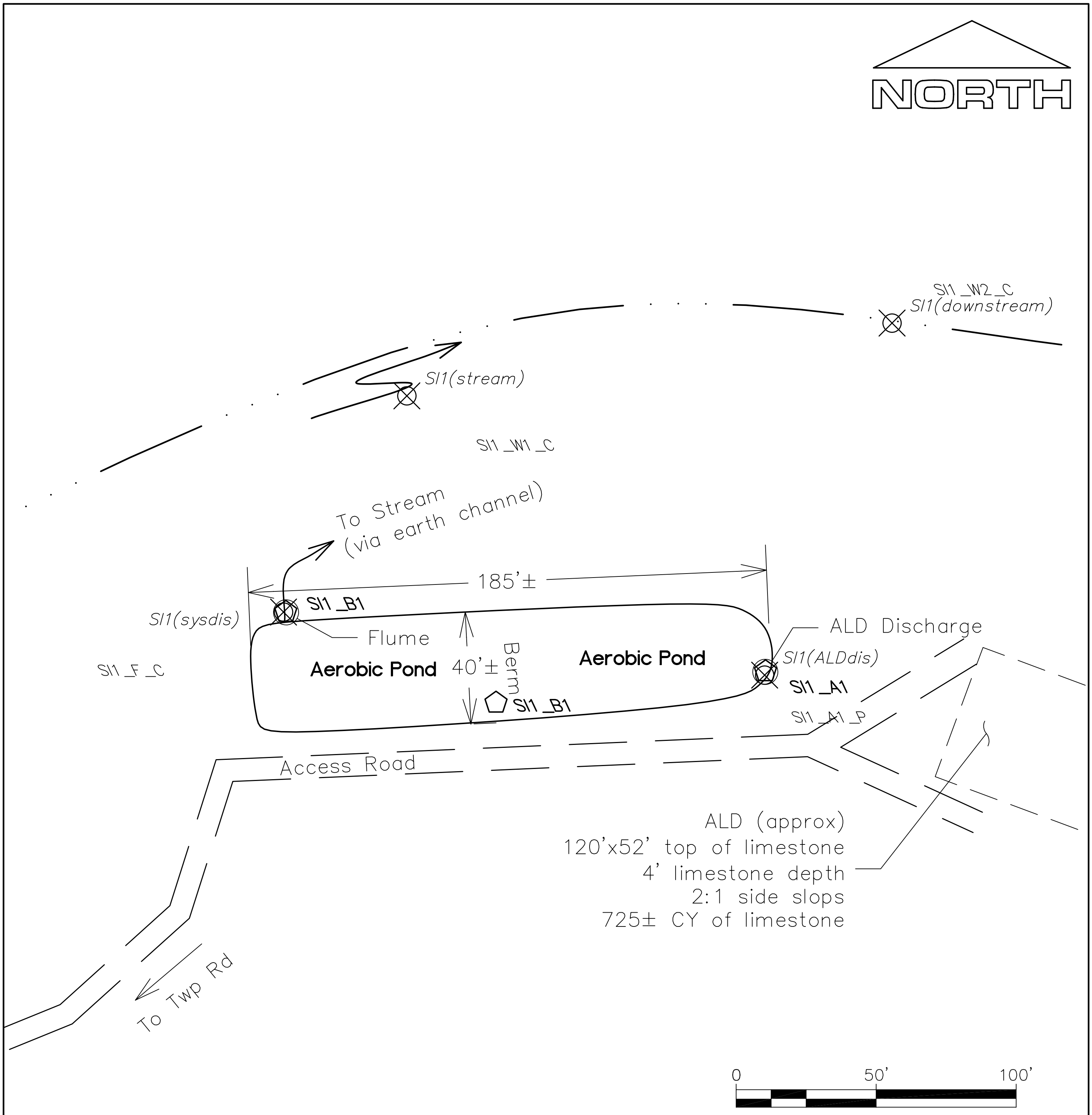
TOTAL AMOUNT OF COST ESTIMATE **$ 139,535.00**

Simpson Passive Treatment System

Cell 1 – Anoxic Limestone Drain (ALD)

ALD Outlet

Cell 2 – Aerobic Pond



LEGEND:

⊗	CUP SAMPLE LOCATION
MK1_(Spillway)	CUP SAMPLE ID
⬠ MK1_S1	OM&R SAMPLE POINT

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 Simpson-1

Existing Simpson Treatment System
& OM&R Sample Points

Union Township Jefferson County, PA

SUMMARY & RECOMMENDATIONS

The Simpson passive treatment system was reviewed and data evaluated to determine system performance and recommendations for the system. The following summarizes the findings:

- The Simpson passive system consists of an ALD and an aerobic pond that was constructed in 1999.
- Current effluent water quality indicates the system is operating satisfactorily.
- Excessive alkalinity produced by the ALD was found, based on alkalinity measurements, to be precipitating in the aerobic pond as calcite.
- Water quality results and sizing evaluation indicate the system has been adequately sized.

Recommendations for the Simpson passive treatment system are as follows:

- Current conditions indicate no changes to the system are required.
- Iron oxide solids will need to be removed from the inlet portion of the pond in the next 3 to 5 years to maintain system performance.

The following provides details to support the above summary.

System Description

The Simpson system was constructed in 1999 to treat an AMD seep. Pre-construction data for the Simpson seep indicate it is a slightly acidic discharge with an initial alkalinity (~50 mg/L), pH of 5.5, and aluminum of 1 mg/L consistent with an anoxic discharge (Table Simpson-1). The iron and manganese concentration in comparison to the measured alkalinity indicates the discharge is slightly net acidic (~60 mg/L).

Table Simpson-1: Typical pre-construction AMD characteristics

pH	Alkalinity mg/L	Acidity mg/L	Al mg/L	Fe (total) mg/L	Mn mg/L	Sulfate mg/L	Flow gpm
5.5	50	60	1	40	15	---	10

The Simpson passive treatment system was designed to treat the discharge employing an ALD followed by an aerobic pond to remove metals. The Simpson passive treatment system layout is depicted in Figure Simpson-1. The ALD size is approximately 100 feet in length by 50 feet in width and contains approximately 1,200 tons of limestone. The ALD is equipped with a water level control outlet and a valved flushing pipe to remove precipitated metals from the ALD. The aerobic pond is 8,000 ft^2 with approximately 5 feet of water depth. There is a shallow underwater berm that separates the aerobic pond into two separate areas. The water level in the aerobic pond can be adjusted exposing the berm to isolate each of the areas using a plastic flume with removable plates that is located at the pond outlet.

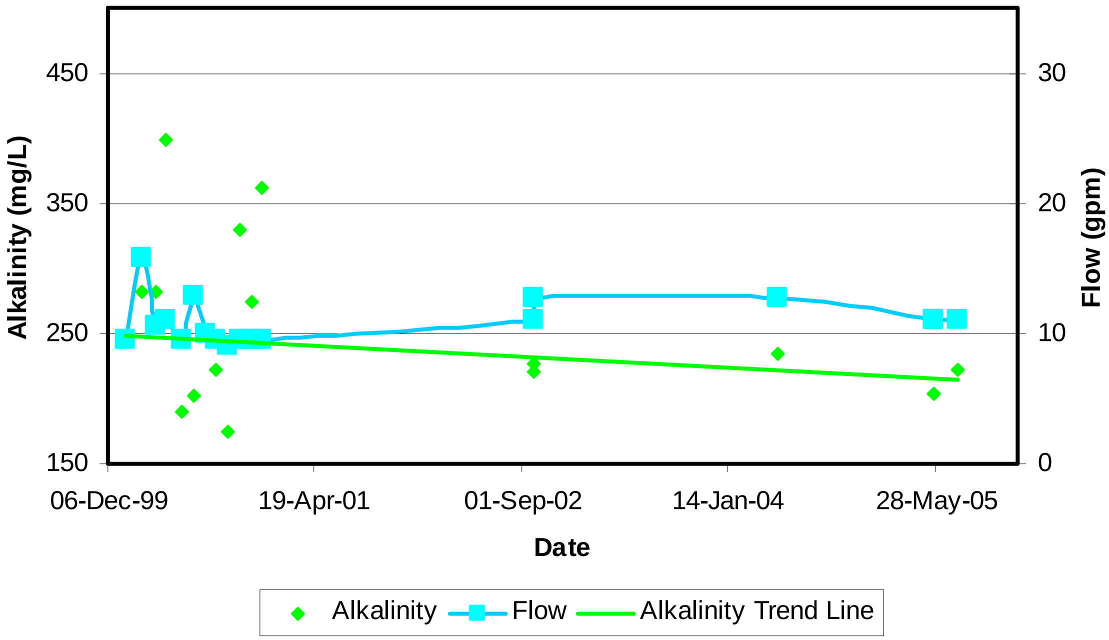
Operational Assessment

The Simpson passive treatment system was functioning at the time of the field visit in April 2005 and during the system assessment on July 14, 2005. The discharge flow was 9 gpm during the July evaluation. Evaluation of the ALD and aerobic pond is discussed below.

Anoxic Limestone Drain

The ALD was functioning adequately during the field evaluation. Long term monitoring provided in Figure Simpson-2 shows a relatively consistent alkalinity since construction and a relatively consistent discharge flow. Trend analysis indicates a gradual decrease in alkalinity since construction (consistent with other Mill Creek Coalition ALDs) with an approximate alkalinity decrease of 50 mg/L since start-up. This is not unexpected since the limestone in the ALD is being consumed resulting in a decrease in detention time and a corresponding decrease in ALD effluent alkalinity. There may also be short-circuiting, limestone coating, and clogging in the ALD, thus decreasing the ALD effectiveness.

Figure Simpson-2: Long term trend in ALD alkalinity



The field assessment data, contained in Table Simpson-2, indicated the system was in good operating condition. Dissolved oxygen was low in the discharge from the ALD and the iron was nearly all in the ferrous form. The pH was 6.4 with an alkalinity in excess of 200 mg/L. The pH is over a full pH unit greater than was found in the untreated discharge, based on pre-construction monitoring data. As part of the field evaluation, effluent from the ALD was placed in cubitainors filled with high quality limestone. The results of the cubitainor testing is provided in Table Simpson-3, and shows there is an increase in the alkalinity with greater limestone contact time. The ALD is producing about 77% of the maximum alkalinity, which equates to an apparent ALD detention time of approximately10 hours at the observed flow. This suggests there may be short circuiting, coating, clogging, or loss of limestone volume that is reducing the apparent detention time.

Table Simpson-2: Field sampling results from the Simpson passive treatment system assessment conducted on July 14, 2005

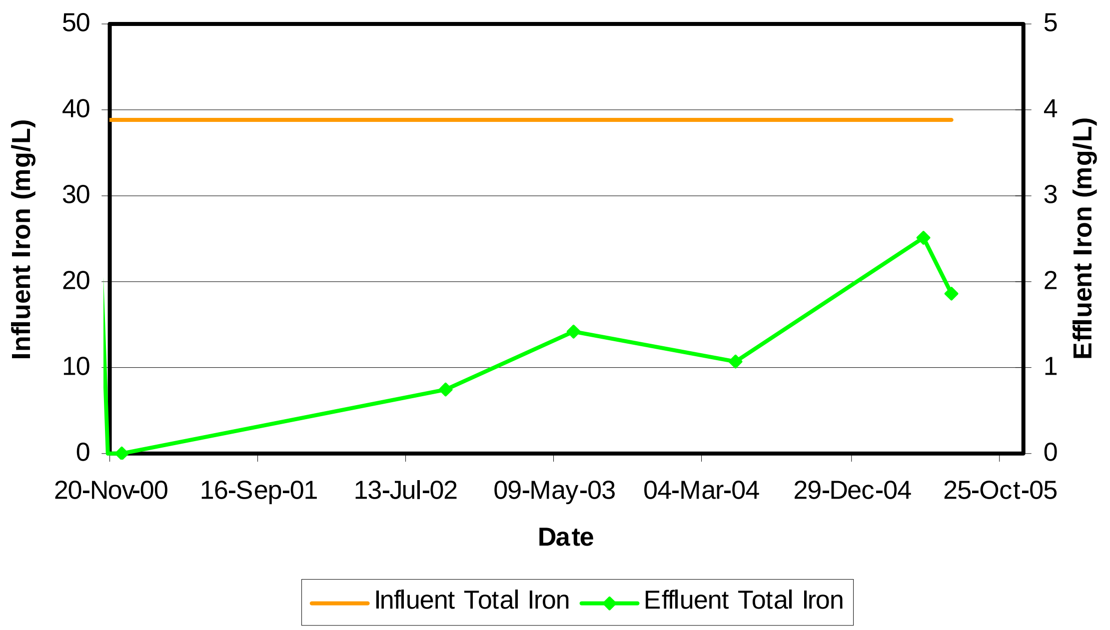
Location	DO mg/L	Temp °C	Cond. µS	pH	Fe(II) Iron mg/L	Total Iron mg/L	Alkalinity mg/L
ALD out	0.28	13.5	980	6.42	47.4	50.0	228
Pond Effluent	7.04	25.8	891	6.86	0.26	1.45	135

Table Simpson-3: Summary of results from cubitainor tests conducted on the Simpson ALD effluent.					
Bottle No.	**Temp °C**	**Conduct µS**	**pH**	**Alkalinity mg/L**	**Elapsed Time Hrs**
1165	22.7	1032	6.79	305	72.2
1180	22.9	1045	6.68	289	72.3

Aerobic Pond

The aerobic pond was evaluated by examining effluent water quality. Effluent water quality measured during the field evaluation is shown in Table Simpson-2. The data indicate the aerobic pond is removing nearly all the iron at the low flow and warm weather conditions during the July assessment. Figure Simpson-3 shows the long term effluent data from the aerobic pond over the past 5 years and indicates the pond has had greater than 95% removal over this period. A gradual increase in effluent iron is apparent in the Mill Creek Coalition monitoring data and likely reflects a gradual decrease in pond detention time from the filling of the pond with iron oxides. The aerobic pond also removes between 30 - 50% of manganese from the influent concentration of approximately 12 mg/L.

Figure Simpson-3: Long term effluent iron data from the aerobic pond



Similar to other ALD/aerobic pond systems (i.e., Morrow 1) there is a discrepancy of about 20 mg/L between measured alkalinity loss across the system and the associated metals (and acidity) removed. This may be due to calcite precipitation as the pH increases across the aerobic pond (see ALD out versus aerobic pond effluent in Table Simpson-2). The calcite precipitation could lead to increased solids accumulation in the aerobic pond and decrease operational longevity in comparison to calculations based solely on metals accumulation.

Diagnosis

The operational conditions of the Simpson passive treatment units are summarized in Table Simpson-4.

Table Simpson-4: Summary of Simpson passive treatment system unit conditions.

Unit	Condition	Criteria	Effectiveness Level
ALD	Alkalinity 77% of Maximum & > Req'd Alkalinity	Alkalinity 60 to 85% of Maximum; Alkalinity > Req'd Alkalinity	Moderate
Aerobic Pond	Effluent Iron = 3 mg/L	Fe Removal > 90%	Satisfactory

The ALD was functioning at a moderate effectiveness level based on the field evaluation and long term monitoring data. Long term data indicates a gradual trend with an approximate alkalinity decrease of 7 to 8 mg/L per year. The ALD was currently operating at 77% of the maximum alkalinity, based on the cubitainor tests. While this is lower than the expected alkalinity from an ALD, it is sufficient to oxidize and precipitate the ferrous iron contained in the discharge. Possible causes of the reduced alkalinity include: 1) short-circuiting through the ALD; 2) gradual coating of the limestone in the ALD with iron oxides; and/or 3) filling of void space in the ALD with iron oxide or other precipitates. The observed decrease in alkalinity is consistent with other ALDs in the Mill Creek watershed. The triggers developed for ALD technology should identify when substantial depletion of the limestone has occurred and replacement should be initiated. Based on the acidity of the discharge, replacement is likely to be required between the next 5 to 10 years.

The aerobic pond was functioning at a satisfactory effectiveness based on a comparison of influent and effluent iron concentrations. The aerobic pond is removing greater than 95% of the ferrous iron to an effluent of less than 3 mg/L. The aerobic pond shows some gradual increases in effluent total iron, which is likely due to a decrease in detention time caused by 6 years of metal oxide (and calcite) accumulation. Future maintenance will be required to remove accumulated solids and restore the original detention time. The effluent performance triggers should be adequate to determine when solids removal will be required. Based on the effluent quality and an 80% removal rate criterion, the system should require maintenance in the next 4 to 6 years.

Design Methodology

The design methodology for the ALD and aerobic pond in the Simpson passive treatment system is as follows. The ALD was based on an accepted detention time of 16 hours and limestone consumption rate, based on alkalinity produced. This design approach for the Simpson AMD discharge has proven successful, except for the calcite precipitation associated with the high

ALD effluent alkalinity, discussed above for the aerobic pond. This excess alkalinity may be desirable where additional AMD inputs that can not be treated occur in the watershed.

The design methodology for the aerobic pond was based on an iron removal rate of 10 gr/day/m^2. This is lower than the standard 20 gr/day/m^2 removal rate, but as shown in the Simpson system performance, it provides a more reliable long term performance. In addition, this lower removal rate is consistent with the newer sizing that would be estimated using abiotic oxidation models.

Action

The Simpson passive treatment system is currently operating and no repairs or changes in operation are required. Continued monitoring of the system should be conducted.

Operation, Maintenance & Replacement Plan

The current Simpson passive treatment system is functioning adequately to address the AMD sources at this site. The system should be continued to be operated and monitored. Replacement of the system will require construction of a new ALD with the aerobic ponds requiring solids removal only. At the time the ALD replacement is required, other newer technologies should be evaluated that may provide lower construction and/or replacement costs, including a tank system known as an upflow limestone well.