Appendix

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ACID MINE DRAINAGE ABATEMENT AND TREATMENT PLAN FOR THE MOXAHALA CREEK WATERSHED

Prepared by:

The Institute for Local Government Administration and Rural Development

ACID MINE DRAINAGE ABATEMENT AND TREATMENT PLAN FOR THE MOXAHALA CREEK WATERSHED

Andrew Creek

Underground mine seep in Bear Creek

Highwall in McLuney Creek

Iron flocculate deposits in McLuney Creek

Prepared by

The Institute for Local Government Administration and Rural Development (ILGARD)

At Ohio University

Athens, Ohio

April 2005

This publication was financed in part by a grant
From the Ohio EPA and U.S. EPA under the provisions of
Section 319 (h) of the Clean Water Act

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Acknowledgements

The Moxahala Creek Watershed AMDAT/TMDL plan would not have been possible without financial and technical support from the Ohio Department of Natural Resource, Division of Mineral Resources Management, Ohio Environmental Protection Agency, and The Moxahala Creek Watershed Restoration Project. In addition to these organizations, other people and partners have been instrumental in the research, collecting data, and writing of this document including:

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Moxahala Watershed Restoration Project
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Ohio Department of Natural Resources, Division of Mineral Resources Management
Bill Jonard, Mary Ann Borch, and Nancy Seger

Ohio Environmental Protection Agency
Keith Orr and Dan Imhoff

Office of Surface Mining
Max Luehrs

Mid-west Biodiversity Institute (MBI) and Center for Applied Bioassessment and Biocriteria (CABB)
Chris Yoder and Ed Rankin

I would like to especially thank J.T. Kneen, Bill Jonard, Chad Kinney, Ben McCament and other volunteers for their help and assistance with conducting the field work needed to complete this AMDAT report.

SECTION I

INTRODUCTION

The major source of impairment in the Moxahala Watershed is acid mine drainage (AMD). AMD is so prevalent it overwhelmingly masks other potential causes of impairment. Therefore, the goal of the Moxahala Creek AMDAT/TMDL plan is to create a strategy to systematically restore acid mine drainage impacted segments of Moxahala Creek and its tributaries to meet their potential "aquatic life designated use" as established by the Ohio EPA. The purpose of this AMDAT/TMDL plan is to identify all of the major existing sources of acid mine drainage (AMD) in the Moxahala Creek Watershed, and to prioritize areas for treatment based on their chemical load and relative effects on the aquatic health of the watershed. The objective of the plan is to improve surface water quality that has been adversely affected by coal mining practices that occurred prior to the passages of the Surface Mining Control and Reclamation Act (SMCRA) in 1977. To accomplish this goal, a thorough watershed investigation, including field and laboratory data, was collected from October 2003 to November 2004. The data from this investigation, along with biological data collected summer of 2004, Kocsis Study 2000 data, and data collected by Eberhart and Olujic in 1997 and 1998, were used to prioritize potential sites for acid mine drainage abatement and treatment in the Moxahala Creek Watershed (excluding Jonathan Creek). Treatment alternatives are discussed in the Restoration Strategy sections of this plan.

For purposes of the TMDL study, only load allocations from acid mine drainage are discussed. Wasteload allocations are not discussed because the cause of impairment in Moxahala Creek is acidity and the existing NPDES permits in the Moxahala Creek Watershed do not discharge acidic water so are irrelevant and are not included in this report.

IDENTIFICATION OF THE HYDROLOGIC UNIT

Name: Moxahala Creek Watershed (excluding Jonathan Creek)
11-digit Hydrologic Unit Code (HUC): 05040004050
Tributary To: Muskingum River: Ohio River Basin
Drainage Area: 69,352 acres
Length: 25 miles
Location: Perry, Muskingum, and Morgan Counties
Quadrangles: New Lexington, Deavertown, Fultonham, and Crooksville.

Watershed Description

The 106-square mile Moxahala Creek watershed is located in southern Ohio, in parts of Perry, Muskingum, and Morgan Counties (Map 1). Moxahala Creek originates in southern Perry County near Moxahala, Ohio, and flows northeast for 25 miles before reaching its confluence with Jonathan Creek (Eberhart, 1998). Moxahala Creek then flows another three miles before discharging into the Muskingum River, which ultimately flows into the Ohio River. Perry, Muskingum, and Morgan counties lie in the western section of the Western Alleghany Plateau ecoregions. The Moxahala Creek watershed is also located on the western edge of the Appalachian coal basin that stretches from western Kentucky, through Ohio, into western Pennsylvania. The northwestern third of Perry County has been glaciated and is characterized by gently rolling topography. The unglaciated portions of Perry County, all of Morgan County, and the southernmost portions of Muskingum County are characterized by narrow ridges, steep slopes, and a high degree of stream dissection (Spahr, 1997). Average relief in this area is 200-250 feet, with a maximum relief of 500 feet.

There are four major tributaries to the Moxahala Creek: Jonathan Creek (length 26.1 miles excluded from this study), Black Fork (length 7.7 miles), McLuney Creek (length 5.6 miles), and an unnamed tributary (referred to as Andrew Creek length 4.4 miles). Three minor sub-watersheds of note are Elk Run (length 3.6 miles), Bear Creek (length 3.5 miles), and Burley Run (length 3.2 miles). The entire reach of Moxahala Creek is 29.2 miles long. The AMDAT/TMDL plan focuses on the priority sub-watersheds identified as the major contributors of AMD from ODNR's 1998 watershed characterization investigation; McLuney Creek, Andrew Creek, Bear Creek, Black Fork, and Burley Run (Eberhart, 1998). In addition to the above identified sub-watersheds two additional sub-watersheds were added to this study; Elk Run and Snake Run (length 1.25 miles).

Geology

The strata exposed in the Moxahala Creek watershed belong to the Pennsylvanian System, which is divided in ascending stratigraphic order (oldest to youngest) into the Pottsville, Allegheny, Conemaugh, and Monongahela Groups. In Ohio, these four groups encompass roughly 50 million years of geologic time, and contain many different coal seams, all of which have been mined in the state to some degree. Within the Moxahala Creek Watershed, strata are derived from the middle and uppermost Pottsville Group, the Allegheny Group, and the Conemaugh Group. In Ohio, sedimentary deposits divisions between the major Pennsylvanian groups were originally made on the basis of the amount of mineable coal, and constitute a practical, rather than a lithological, framework for differentiating formations. However, general trends and patterns of lithological change can be recognized both within and among groups. From the base of the Pottsville Group to the top of the Monongahela Group, the overall percentage of sandstone decreases while the percentages of shale and limestone increase. In Perry, southern Muskingum, and Morgan counties, shale, coal, and fine-grained sandstones dominate the bedrock geology, with discontinuous exposures of medium- and coarse-grained sandstones and brackish-to-marine limestones. Coal beds mined within the Moxahala Creek watershed include the Lower Kittanning (No. 5), Middle Kittanning (No. 6), Lower Freeport (No. 6a), Upper Freeport (No. 7), and the Pittsburgh (No. 8). Of these, the thickest, most persistent, and the most economically important is the Middle Kittanning coal.

Mining History

Coal was used primarily by various industries in the 1920's. Other uses of coal at the turn of the century included private homes and railroads. By the 1940's about half of the coal used in the United States was used by electric utilities, with most of the remaining coal being used by industry. In the 1990's electric utilities used over three-quarters of the coal produced, with industry using almost all of the remaining coal (National Energy Foundation, 1995). Coal production has increased over the past 100 years from about 210,000 tons in 1897 to about 1,025,000 tons in 1997 (Office of Surface Mining Reclamation and Enforcement, 1999). Recent estimates suggest that at this rate the United States coal reserves will last at least 500 years.

Five different types of mining techniques have been used in the Moxahala watershed. S*trip mining* is used when the coal seam is near to the ground's surface. The soil and rock overburden is removed and the coal is taken out before the overburden is replaced. In *drift mining*, a tunnel is driven into the side of a hill at a coal outcrop. The coal is mined out by following the contour of the bed. *Slope mining* uses tunnels on a low enough incline to permit mine cars to enter. More than half of all coal mined in the watershed was taken from drift or slope mines (Ahmad, 1979). A vertical opening is driven into the coal in *shaft mining*. This technique proceeds along the coal seam with excessive depth increasing entry, exit and ventilation hazards. *Auger Mining* is usually associated with contour strip mining. The coal is removed by drilling auger holes from the last contour cut and extracting the coal in the same manner that shavings are produced by a carpenter's drill bit. Auger mining allows additional coal to be removed at a limited depth from behind the highwall after contour strip mining is complete.

Shaft and deep mines were originally used until the 1940s, before strip mines became more common. From the 1940's to the present, strip mining has replaced underground mining as the dominant method. According to calculations based on digitized layers of surface and underground mines on U.S. Geological Survey 1:24,000, 7.5 minute quadrangles, approximately 8,484 acres of underground mines and 8,307 acres of surface mines were established in the Moxahala Creek watershed. In addition to coal and limestone, clay, sand and iron ore are found in the basin, though the high-grade iron ore was essentially depleted in the early 1900's.

Perry County, where the Moxahala Creek watershed is mainly located, started producing coal in 1816 and is the fourth highest coal-producing county historically in Ohio (Crowell, 1995). Coal mining in the Moxahala Creek watershed has taken place since the 1840s and continues today. Coal mining in Ohio began around 1800. Mining took place almost completely underground, and consisted almost entirely of manual labor, until the 1910's. Large earth moving equipment and techniques were introduced to the mining industry around 1940, providing the capacity to move large amounts of earth very quickly. Increased efficiency led to more surface mining, which today accounts for about half of the coal removal in Ohio: fifty-two companies mined 152 sites to produce 30.6 million tons of coal in Ohio in 1997 (Office of Surface Mining Reclamation and Enforcement, 1999). Surface mine operators were not required to restore disturbed mine lands before the enactment of federal legislation they simply left the overburden rock behind (Ctcnet Inc., 1998). Ohio ranked 11th nationally in production of coal in 1995, in part due to Ohio's location on the northern tip of the Appalachian Coal Basin (Ohio Division of Mines and Reclamation, 1999). One of the largest coalfields in the United States, the Appalachian Coal Basin, covers 72,000 square miles in several states, including Ohio, Pennsylvania, West Virginia, and Kentucky (National Energy Foundation, 1995).

WATER QUALITY

Acid Mine Drainage Formation

Coal mining disturbs large amounts of geologic material and exposes them to the environment. When this material is exposed to air and water, iron sulfide (pyrite) from the coal deposits is oxidized, resulting in acid mine drainage (AMD). These conditions lower pH, increase acidity, increase dissolved metals, and lead to an overall degradation of water quality. AMD is a low pH, high sulfate water with high acidity usually due to oxidation of iron, aluminum, and manganese and also due to hydrogen ions.

The following discussion is adapted from the Pennsylvania DEP web page (PA-DEP website, 2004). The formation of AMD is primarily a function of the geology, hydrology and mining technology employed at the mine site. AMD is formed by a series of complex geo-chemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH rises to a level where precipitation occurs.

There are four commonly accepted chemical reactions that represent the chemistry of pyrite weathering to form AMD. An overall summary reaction is as follows:

$$4\ FeS_2 + 15\ O_2 + 14\ H_2O \rightarrow 4\ Fe(OH)_3 \downarrow + 8\ H_2SO_4$$

Pyrite + Oxygen + Water → "Yellowboy" + Sulfuric Acid

The first reaction in the weathering of pyrite includes the oxidation of pyrite by oxygen. Sulfur is oxidized to sulfate and ferrous iron is released. This reaction generates two moles of acidity for each mole of pyrite oxidized.

$$2\ FeS_2 + 7\ O_2 + 2\ H_2O \rightarrow 2\ Fe^{2+} + 4\ SO_4^{2-} + 4\ H^+ \qquad \textbf{(1)}$$

Pyrite + Oxygen + Water → Ferrous Iron + Sulfate + Acidity

The second reaction involves the conversion of ferrous iron to ferric iron. The conversion of ferrous iron to ferric iron consumes one mole of acidity. Certain bacteria increase the rate of oxidation from ferrous to ferric iron. This reaction rate is pH dependant with the reaction proceeding slowly under acidic conditions (pH 2-3) with no bacteria present and several orders of magnitude faster at pH values near 5. This reaction is referred to as the "rate determining step" in the overall acid-generating sequence.

$$4\ Fe^{2+} + O_2 + 4\ H^+ \rightarrow 4\ Fe^{3+} + 2\ H_2O \qquad \textbf{(2)}$$

Ferrous Iron + Oxygen + Acidity → Ferric Iron + Water

The third reaction that may occur is the hydrolysis of iron. Hydrolysis is a reaction that splits the water molecule. Three moles of acidity are generated as a byproduct. Many metals are capable of undergoing hydrolysis. The formation of ferric hydroxide precipitate (solid) is pH dependant. Solids form if the pH is above about 3.5 but below pH 3.5 little or no solids will precipitate.

$$4\,Fe^{3+} + 12\,H_2O \rightarrow 4\,Fe(OH)_3 + 12\,H^+ \qquad \textbf{(3)}$$

Ferric Iron + Water → Ferric Hydroxide (yellowboy) + acidity

The fourth reaction is the oxidation of additional pyrite by ferric iron. The ferric iron is generated in reaction steps 1 and 2. This is the cyclic and self-propagating part of the overall reaction and takes place very rapidly, and continues until either ferric iron or pyrite is depleted. In this reaction, iron is the oxidizing agent, not oxygen.

$$FeS_2 + 14\,Fe^{3+} + 8\,H_20 \rightarrow 15\,Fe_2+ + 2\,SO_4^{2-} + 16\,H^+ \ \textbf{(4)}$$

Pyrite + Ferric Iron + Water → Ferrous Iron + Sulfate + Acidity

Approximately 12,500 miles of streams and rivers in the United States are impacted by AMD, and about 85 to 90% of these streams receive AMD from old, abandoned surface and deep mines (Skousen, 1995). Due to the high costs involved for reclaiming abandoned mine lands, AMD continues to contaminate numerous surface and groundwater supplies (Eberhart, 1998).

Ohio Water Quality Standards

Water chemistry values determined by the USEPA suggest AMD impacts to waters. The parameters include: pH, total dissolved solids (TDS), sulfate, iron, manganese, aluminum, and zinc. The only two standards created by the USEPA are for pH (6.5 to 9) and TDS (1,500 mg/l). Although there are no standards for the other AMD parameters, criteria limits suggest impacts from AMD and are summarized below (Table 1).

Table 1. Water quality values that suggest AMD impacts (FWPCA, 1968)

Parameter	Criteria Limit
Iron	> 0.5 mg/l
Manganese	> 0.5 mg/l
Aluminum	> 0.3 mg/l
Conductivity	> 800 uS/cm
Sulfate	> 74 mg/l
Alkalinity	< 20 mg/l
pH	< 6

Besides values that show the presence of AMD, certain other known threshold values exist for the effects of heavy metals associated with AMD on aquatic life. These thresholds (Table 2) are based on literary research and suggest that once parameters reach the limit, aquatic life will be affected. Aquatic species are affected by contaminates in various ways, so these thresholds do not suggest that all aquatic life will be affected, but that some species will be negatively affected.

Table 2. Ohio, USEPA, and literature values used as guidelines for analysis of mine drainage systems (Ohio EPA, 1979)

Parameter	Limit
Iron- total (mg/l)	1.0
Aluminum (mg/l)	0.5
Manganese (mg/l)	0.1

Categories of stream attainability also exist in the form of potential Ohio EPA's "Designated Aquatic Life Uses". These categories are not chemical parameter specific, but instead use the biological integrity of the stream to classify the health of a stream segment. The contaminates that are affecting the biological health of the stream are then identified and targeted for restoration so the stream can achieve the highest "designated use" attainment possible. The five designated uses consist of:

- Exceptional Warmwater Habitat (EWH) is the most biologically productive environment. These waters support "unusual and exceptional" assemblages of aquatic organisms, which are characterized by a high diversity of species, particularly those that are highly intolerant and/or rare, threatened, endangered, or special status. This use designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.

- Warmwater Habitat (WWH) defines the "typical" warm water assemblage of aquatic organisms of Ohio streams. It is the principal restoration target for the majority of water resource management efforts in Ohio.

- Modified Warmwater Habitat (MWH) applies to streams with extensive and irretrievable physical habitat modifications, for which the biological criteria for warm water habitat are not attainable. The activities contributing to the modified warm water habitat designation have been sanctioned and permitted by state or federal law. The representative assemblages are generally composed of species that are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor habitat quality. **The category applies to dammed or channelized rivers, and can also be applied to streams affected by AMD**.

- Limited Resource Water (LRW) applies to small streams (usually <3 square mile drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis, or other irretrievably altered waterways.

- Coldwater Habitat (CWH) - this use designation is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall. No specific biological criteria have been developed for the CWH use although the WWH biocriteria are viewed as attainable for CWH designated streams.

In determining aquatic life uses, the Ohio EPA surveys fish and macro-invertebrate populations along with chemical and physical water quality parameters throughout a given watershed. The results from the bio-survey at each sampling station are used to calculate a metric score for both fish (IBI and MIwb) and macro-invertebrate (ICI) populations that indicates the biological integrity of that given stretch of a stream.

The Index of Biologic Integrity (IBI) metric is a measure of fish species diversity and species populations. This index gives a score which indicates how much a stream habitat is affected by pollutants, and which types of fish are present. Depending on the pollution tolerance of specific species, the IBI indicates which species are likely to be found and the level of fish diversity in the stream. The MIwb is a metric that incorporates four measures of fish communities: numbers of individuals, biomass, and the Shannon diversity index based on numbers and weight.

The Invertebrate Community Index (ICI) metric is based on measurements of macro-invertebrate communities living in a stream. Macro-invertebrate studies are important to assess because many insect taxa are known to be either pollution tolerant or intolerant. The presence of certain species indicates the general water quality of an area. This index gives indications about the amount of pollution stressing the stream environment (Table 3).

Table 3. IBI and ICI scores that suggest Designated Aquatic Life Uses

	LRW	MWH	WWH	EWH
IBI	12-24	25-43	44-49	50+
ICI	<30	31-35	36-45	>45

A Qualitative Habitat Evaluation Index (QHEI), developed by the Ohio EPA, is also used to characterize physical habitat of the stream at each sampling station. Physical features that affect or are critical for fish and invertebrate communities are evaluated. Some of the features evaluated include; type of substrate, amount and type of riparian cover, channel width, sinuosity, and erosion. QHEI scores over 60 are considered conducive to meeting WWH criteria although they are not used to determine the aquatic life designated use (Ohio EPA, 2001).

AMD Impacts on Stream Health

Acid mine drainage has the potential to effect many different aspects of a stream's biological integrity. The chemical and physical changes to the stream from the AMD result in the impacts on the biological and ecological functions listed in Table 4. AMD is a complex contaminate effecting streams in many different ways. The full scope of these impacts should be considered in any watershed AMD remediation strategy.

Table 4. Major effects of acid mine drainage on stream systems (Modified from Gray, 1997)

Chemical	Physical	Biological	Ecological
Increased acidity	Substrate modification	Behavioral	Habitat modification
Reduction of pH and buffering capacity	Turbidity	Respiratory	Niche loss
Increase in metal concentrations	Sedimentation	Reproduction	Bio-accumulation in food chain
	Absorption of metal into sediment	Acute and chronic toxicity	Loss of food source
	Decrease in light penetration	Acid-base balance in organisms	Elimination of sensitive species
		Migration or avoidance	Reduction in primary productivity
			Food chain modifications

Moxahala Creek Watershed Restoration Targets

The goal for this plan is to restore AMD impacted waters throughout the Moxahala Creek watershed to meet WWH criteria wherever possible. To accomplish this goal, water quality targets were established. Table 5 shows a summary of all targets for the Moxahala Watershed. However since pH values can not be modeled as a loading, alkalinity and acidity are used as a surrogate for all AMD parameters.

Table 5. Summary of Moxahala Creek Targets

Parameter	Criteria Available Units	Sources		Target	Source Used	Comments
		OEPA	USEPA			
pH	S.U.	yes	yes	6.5-9.0	OEPA	6.5-9.0 & 6.0-9.0 USEPAs nearly maximum level of protection and high level of protection
Net Alkalinity	mg/l	N/A	N/A	67	Sunday Creek TMDL	10th percentile of sites meeting WWH
Iron	ug/l	no	yes	1000 ccc[A], no cmc[B]	USEPA	National Recommended Criteria
Aluminum	ug/l	no	yes	87 ccc, 750 cmc	USEPA	National Recommended Criteria
Manganese	ug/l	drinking water only	drinking water only	2000[F]	USEPA (see comment)	40 CFR Ch. 1 (7-1-92 edition) Subpart 434.32[C]
TDS	ug/l	yes	no	1500000 omza[D], no omzm[E]	OEPA	

[A] Criterion continuous concentration, USEPA's criterion which is equivalent to OEPA's avg. aquatic life criterion.
[B] Criteria maximum concentration, USEPA's criterion which is equivalent to OEPA's max. aquatic life criterion
[C] National BPT effluent limitations for acid and ferruginous mine drainage
[D] omza = outside mixing zone average
[E] omzm = outside mixing zone maximum
[F] average of 30 consecutive days

Target Identification

The establishment of in-stream numeric targets is a significant component of the AMDAT/TMDL process. The numeric targets serve as a measure of comparison between observed in-stream conditions and conditions that are expected to restore the stream to its designated uses. The AMDAT/TMDL identifies the load reductions and other actions that are necessary to meet the target, thus resulting in the attainment of applicable water quality standards.

Due to the overwhelming prevalence of Acid Mine Drainage (AMD) in the Moxahala Watershed, capturing and treating all the affected water would be very difficult and cost prohibitive. As a result the mouths of subwatersheds were selected as the points where targets will be met. However, it should be noted that in order to meet targets at the segment ends, many of the upstream sites must meet the target.

In choosing an alkalinity target that would be meaningful for the Moxahala Creek Watershed, water chemistry data that was collected in Moxahala Creek at two reference sites were compared to other reference sites throughout Ohio’s Western Alleghany Plateau (WAP) eco-region, and other targets that were established for watersheds in the vicinity; Sunday Creek, Monday Creek, and Raccoon Creek. From these selected watersheds, the range of alkalinity values in which a site still meets WWH varies widely, 204 to 30 mg/l. Ideally, water quality sites within the Moxahala Watershed whose biological data meet the WWH use designation should be used to set a target alkalinity value, however there are only two sites that meet WWH. Two sites are not a large enough data-set to establish target values. OEPA WAP eco-region values from reference sites have alkalinity values that range from 134 -203 mg/l depending on size of stream and IBI range. However, these values are much higher than other target values used in similar reports; Monday Creek TAMDL 30 mg/l alkalinity, Raccoon TMDL 20 mg/l alkalinity, Sunday Creek TMDL 67 mg/l alkalinity, and Sunday Creek AMDAT 90 mg/l alkalinity.

Therefore a target net alkalinity value of 67mg/l was chosen as the target for this AMDAT/TMDL report. This is the same target used in the Sunday Creek TMDL. Sunday Creek Watershed is adjacent to Moxahala and has similar causes of impairment and water quality. The alkalinity target of 67 mg/l is the 10th percentile of the data points that meet WWH in the Sunday Creek Watershed. A low end target was chosen instead of a higher end target because the high cost of AMD remediation. The net alkalinity target had to be at a minimum so as to not unnecessarily burden the existing and future remediation resources.

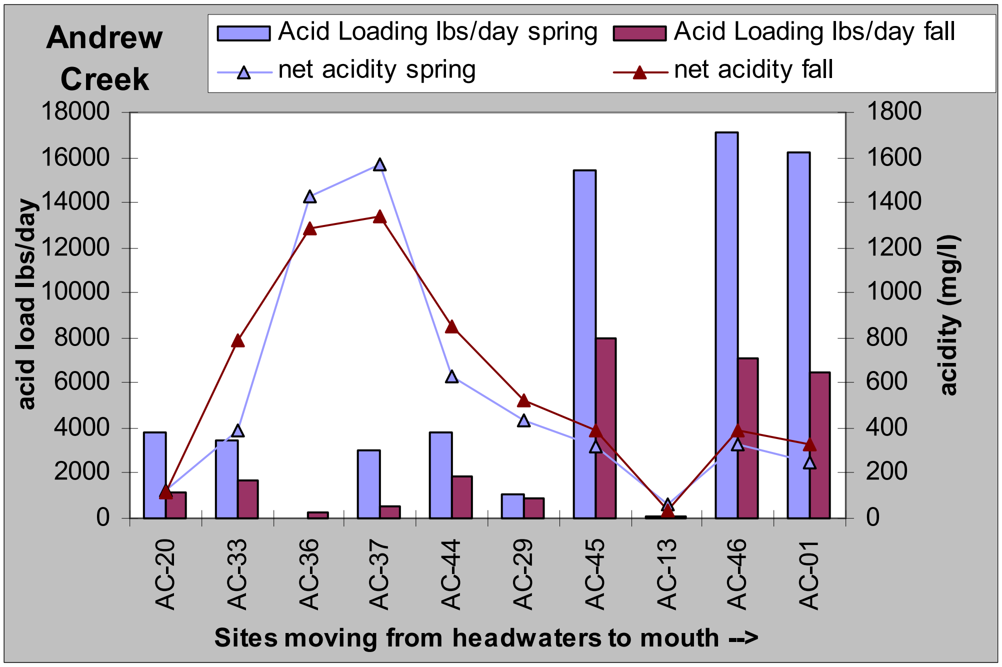
Margin of Safety

The alkalinity target of 67 mg/l is the 10th percentile of the data points that meet WWH in the Sunday Creek Watershed. Therefore there is a 10% margin of safety or the equivalent 18 mg/l of alkalinity. The site with the lowest amount of alkalinity that still met WWH was on Johnson run with 49 mg/l of alkalinity, thus 67-49 = 18 mg/l of alkalinity. AMD Treat, the program used to generate the costs of the AMD treatment systems, usually only treats to zero mg/l alkalinity. However for this AMDAT/TMDL study, costs were generated for each treatment system to achieve its target alkalinity value of 67mg/l. Therefore, costs were calculated to be higher to account for the additional 67mg/l of alkalinity needed to be generated from each AMD treatment system.

Critical Conditions

During high flow regimes the acid loading to the Moxahala Creek are typically higher than during the low flow. Figure 1 shows an example of where the high flow condition in the spring produces higher acid load than the low flow regime in the fall. Therefore high flow conditions are considered the critical condition for this study. Flow data measured during high flow conditions were used to determine costs from the AMD Treat program, target alkalinity loads, and the needed acid load reduction. Using the high flow as the design flow in AMD Treat and to calculate the target alkalinity loads ensures the worst case scenario is represented. However, it should be known that this will over estimate the cost of treatment since high flow conditions are not the typical base flow seen through the year.

Figure 1. High versus low flow acid loading in Andrew Creek Subwatershed



Historical Water Quality

A 1983 study declared the Moxahala Creek watershed the fourth most chemically polluted watershed, and the second most affected by sedimentation, in Ohio (USDA, 1985). This study sampled thirty watersheds and evaluated their respective pH, iron, manganese, sulfate, and specific conductivity. The data indicated that Moxahala Creek and its tributaries were chemically polluted along 100 miles, or over 60%, of the 166 combined miles in length. The study also found that these water bodies had excess sedimentation along 82 miles, or almost 50%, of their 166 miles. The authors attributed both forms of pollution to mining activities in the watershed. Historically, coal was mined in approximately one quarter of the total watershed area. Authors of the study estimated that strip mining took place in approximately 8,307 acres (slightly less than 13 square miles), ranking Moxahala Creek second in total strip-mined area among Ohio watersheds. Deep mining took place beneath 8,484 acres (about 13.25 square miles), ranking the watershed fourth in total deep-mined area among Ohio watersheds (USDA, 1985).

Eberhart Study

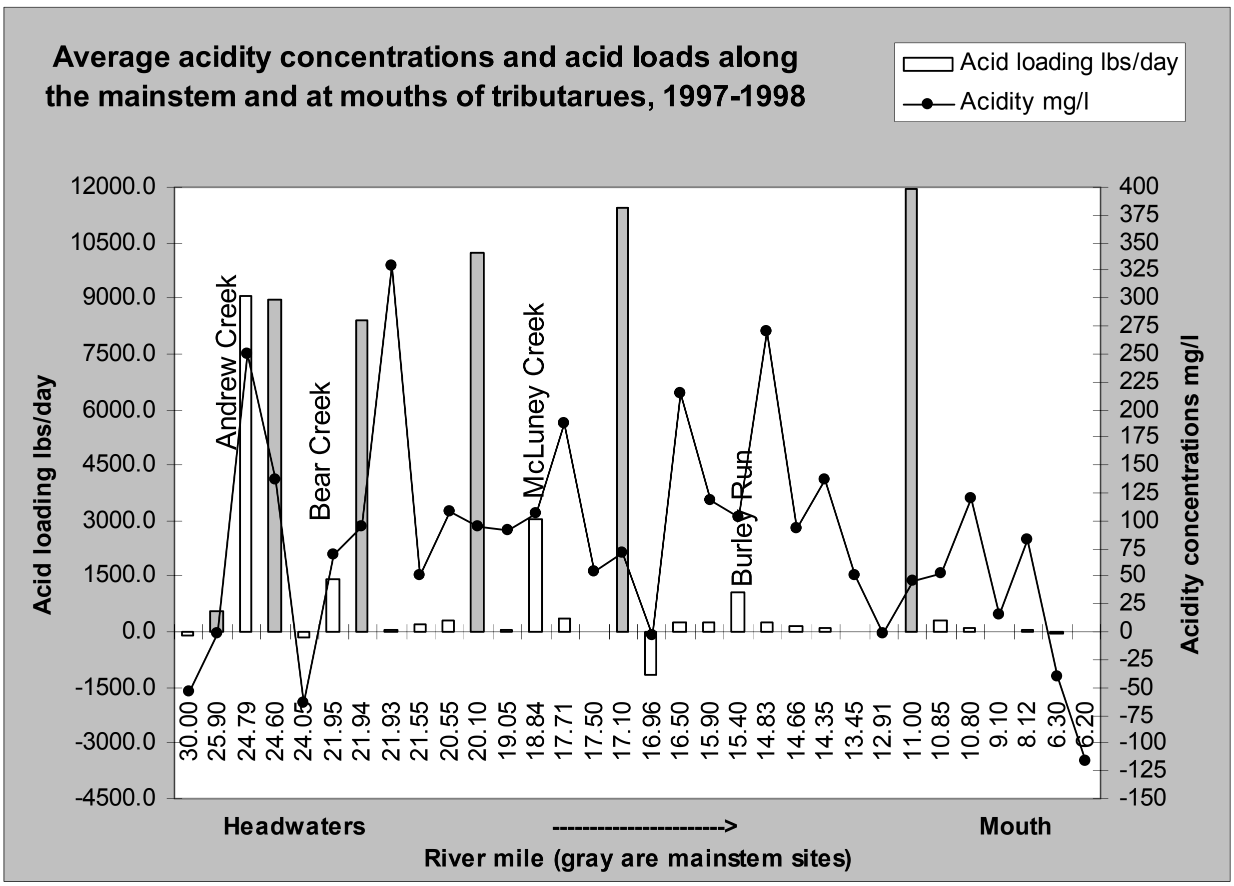
Moxahala Creek Watershed has been severely impacted chemically and physically from the significant amount of mine drainage that has resulted from past surface and underground mining activities within the watershed (Eberhart, 1998). As part of the Eberhart study, initial field reconnaissance was conducted at fifty sites. Conductivity, pH, and an estimated flowrate at these fifty sites were analyzed for pH values less than 6.0, conductivity values greater than 1000 µS/cm, and high flowrates (Appendix A – Phase I 1997-1998). The result of this analysis narrowed the initial fifty sites down to twenty-four tributary sites. In addition to the twenty-four tributary sites, eight mainstem sites were selected to document change in water quality along its twenty-five mile length (Map 2 Eberhart Study sites, Table 6).

Table 6. List of 32 sampling locations from the Eberhart study 1997-1998

Site	Directions and Location Description	RM (confluence with the mainstem)
1	Route 93 North, Right on Lambert Road just south of Avondale,OH	
2	Route 93 North, Right on Lambert Road just south of Avondale, OH (Moxahala Creek)	6.10
9	Route 93 North, Right on Ceramic Road into Roseville, Left on Marietta Road, Bridge near oil well	10.80
10	Route 93 North, Right on Road into Roseville, Near RR Bridge	10.85
11	Route 93 North, Right on Road into Roseville, Near RR Bridge (Moxahala Creek)	11.00
12	Route 93 North, Right on Lambert Road for about 2.5 miles, Bridge near yard with firewood	9.10
14	Route 93 North, Right on Lambert Road for about 2 miles, Bridge at Baughman Rd. Intersection	8.12
18	Route 93 North, Left on Ceramic Road, First Bridge	12.91
19	Route 93 North, Right on Ceramic Rd., culvert under Ceramic Rd. in yard of first house on the left	13.45
20	Route 93 North, Right on Ceramic Road for about 1 mile, Near 2 gray buildings	14.83
21	Route 93 North, Right on Ceramic Road for about 1.5 miles, Near Certified Gas (Burley Run)	15.40
22	Route 93 North, Right on Main St. in Crooksville, Left on N. State St., Bridge at Harrison TR.	14.66
23	Route 93 North, Right on Main St. in Crooksville, Left on N. State St., 0.25 mile past #22, Near Auto Garage	14.35
24	Route 93 North, Right on Rd. across from Crooksville H.S., first left, 0.5 miles at Bridge (Black Fk)	16.96
25	Route 93 North about 0.5 mile past Crooksville High School, on right side of road (Moxahala Ck.)	17.10
26	Route 93 North, Right on Main St. in Crooksville, Right at first Light, 0.25 miles on the left	15.90
27	Route 93 North about 1 mile past Crooksville H.S., Cinder Parking Area on Right, Bridge over 93	16.50
28	Route 93 North, Large culvert underneath 93 near #25	17.50
29	Route 93 North 0.1 mile past Crooksville High School, Large submerged culvert underneath 93	17.71
30	Route 93 North about 1 mile south of Crooksville H.S., Bridge over 93 (McCluney Creek)	18.84
33	Route 93 North about 0.25 mile south of #30, Daffy Duck	19.05
35	Route 93 North, Right on Bearfield Township Rd., Bridge (Moxahala Creek)	20.10
36	Route 93 North, 0.75 mile past 13,93 intersection, Near Midway Race Track and Driving Range	20.55
37	Route 93 North, 0.5 mile past 13,93 intersection, Bridge near open grassy field on left	21.55
38	Route 13 North, Right at 13,93 intersection, Small culvert near abandoned parking lot on the right	21.93
39	Route 13 North, Right at 13,93 intersection, Bridge over Moxahala Creek (Moxahala Creek)	21.94
40	Route 13 North, Bridge over 13 just about 0.1 mile south of 13,93 intersection (Bear Creek)	21.95
49	Route 13 North for 2 miles past Moxahala RR tracks, Right on gravel road about 0.2 mile, Culvert	24.05
55	Route 13 North after the RR tracks, walk through open field, sinking culvert (Moxahala Creek)	24.60
56	Route 13 North about 0.1 mile south of Moxahala RR tracks, Bridge (Andrew Creek)	24.79
57	Route 13 North, Left on Marietta Rd. in Moxahala, 0.5 miles near softball field (Moxahala Creek)	25.90
60	Route 13 North, Left on Marietta Rd. in Moxahala 5 miles, headwaters of Mox. Ck. (Moxahala Ck)	30.00

Water quality samples and discharge measurements were collected at these thirty-two sites monthly for eleven months, from April 1997 to February 1998. Average values were calculated from the eleven sampling events for pH, conductivity, acidity, sulfate, acid loads, sulfate loads, and metal loads as well as analyzing peak degradation periods based on loading and flow regimes. Figure 2, shows the average acid load and average acidity concentrations from the headwaters to the mouth measured on Moxahala mainstem and at mouth of tributaries. River miles indicate the confluence of each site with the mainstem of Moxahala in Figure 2.

Figure 2. Average acid load and acidity along Moxahala Creek 1997-1998

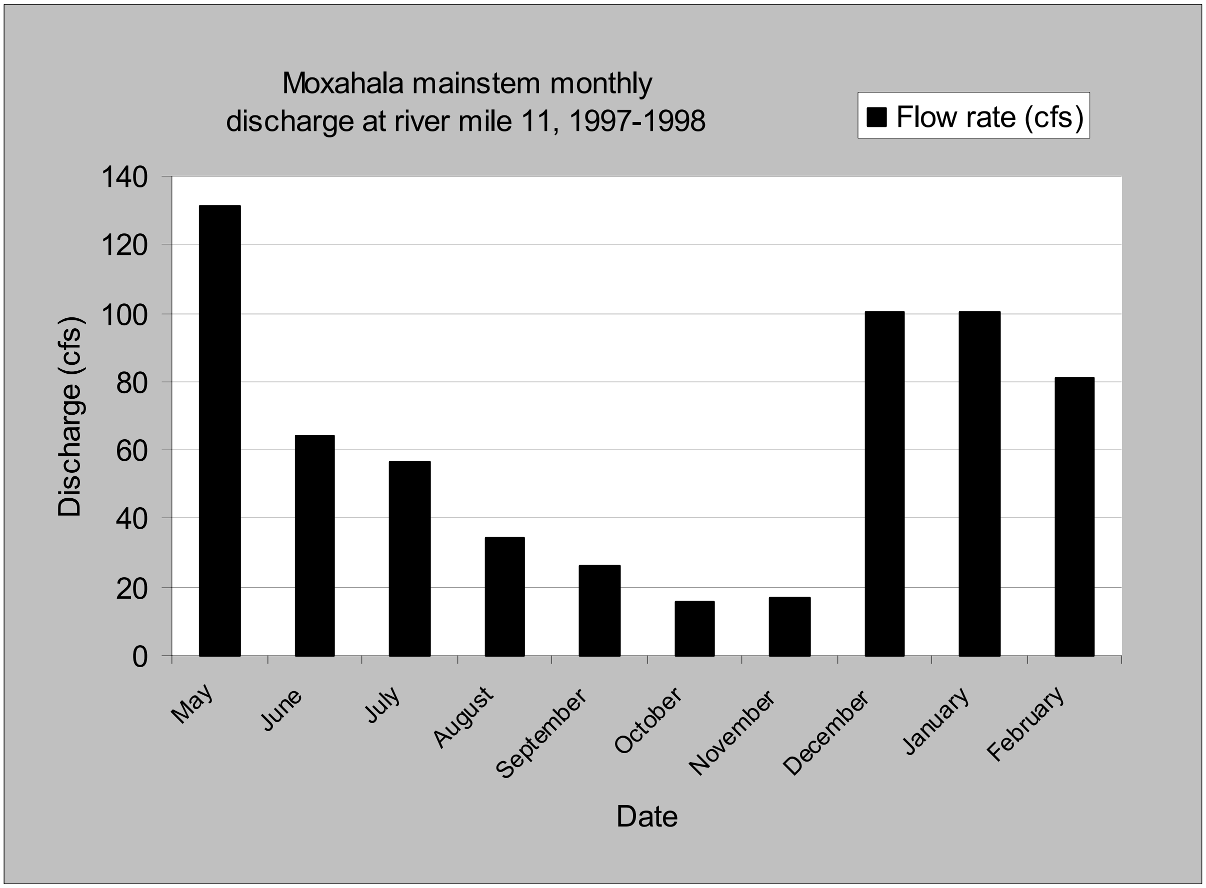


The average tributary and mainstem acid loading and acidity concentration of Moxahala is clearly dominated by Andrew Creek. On average the loading at the mouth of Andrew Creek produces 9,072 lbs/day of acid and acidity concentration of 250 mg/l. The contribution from this sub-basin is nearly 75% of the total load in the mainstem at the furthest downstream location at RM 11.0, 11,973 lbs/day. Mcluney Creek (3,030 lbs/day), Bear Creek (1,440 lbs/day), and Burley Run (1,078 lbs/day) all produce significant loads but they are minor in comparison to Andrew Creek. The mainstem site locations, colored gray in Figure 2, show the acid loading increases moving downstream. However, looking at the acidity concentration measured along the mainstem, acidity decreases along the mainstem. River mile 24.6, just downstream of Andrew Creek on average is 136 mg/l, at RM 11.0 upstream Riders Run is 45 mg/l on average. Therefore the acid loading is increasing moving downstream because of the increase in flow volume not the increase in acidity concentration.

The Eberhart study allows for analysis of tributary loading over a range of flow regimes. The three-month period of June, July and August of 1997 provides a slightly higher range of flows in the basin. Flows measured at River mile 11.0 during this period range from 34 to 64 cfs. Tributary loading increased on average for the period compared to the three-month average of the lowest flow period. This is an expected outcome with higher flow rates and runoff in a basin that has had substantial surface mining occur. Relative contributions however remained much the same. Andrew Creek (RM 24.79) produced an average discharge of over 10,000 lbs/day followed by Mcluney Creek (RM 18.84, 2,644 lbs/day), Bear Creek (RM 21.95, 1,281 lbs/day), and Burley Run (RM 15.4, 1024 lbs/day). December 1997, January and February 1998 provide an even higher flow regime ranging from 84 to 100 cfs. Again overall loadings increase with the increased runoff and flow rates and again the main contribution was coming from Andrew Creek. At this elevated level the average contribution does drop off for Andrew Creek but still contributes over 9,000 lbs/day of acidity. May 1997, provided the highest recorded flow during the 1997-1998 study period, 131 cfs, and the tributary loading signature mimicked the data reported for nearly all flow regimes. The Andrew Creek sub-basin provides the greatest load, followed by Mcluney Creek, Bear Creek and Burley Run.

The measured discharge rate at RM 11.0 (site #11) was used to determine the lowest flow period for 1997 - 1998. This site is located just upstream of Riders Run and was the furthest downstream site measured for water quality and discharge once a month from May of 1997 through February 1998. During the study the lowest recorded flow at RM 11.0, 15.6 cfs, occurred during October. The lowest three-month period occurred from September through October of 1997 (Figure 3).

Figure 3. Moxahala mainstem monthly discharge at RM 11.0, 1997-1998



During the three-month low flow period from September through October 1997, average acidity load for each tributary was calculated and again was dominated by Andrew Creek, followed by McLuney Creek, then Bear Creek and Burley Run.

The highest loading occurred during January when the discharge was high but not at its peak discharge. However, the highest acidity concentration conditions occurred in the mainstem during the low flow periods in October and November. Figure 4, below shows acidity concentrations and flow rate while Figure 5, shows acid loading and acidity concentrations.

Figure 4. Acidity concentrations and flow rate at Moxahala mainstem site RM 11.0

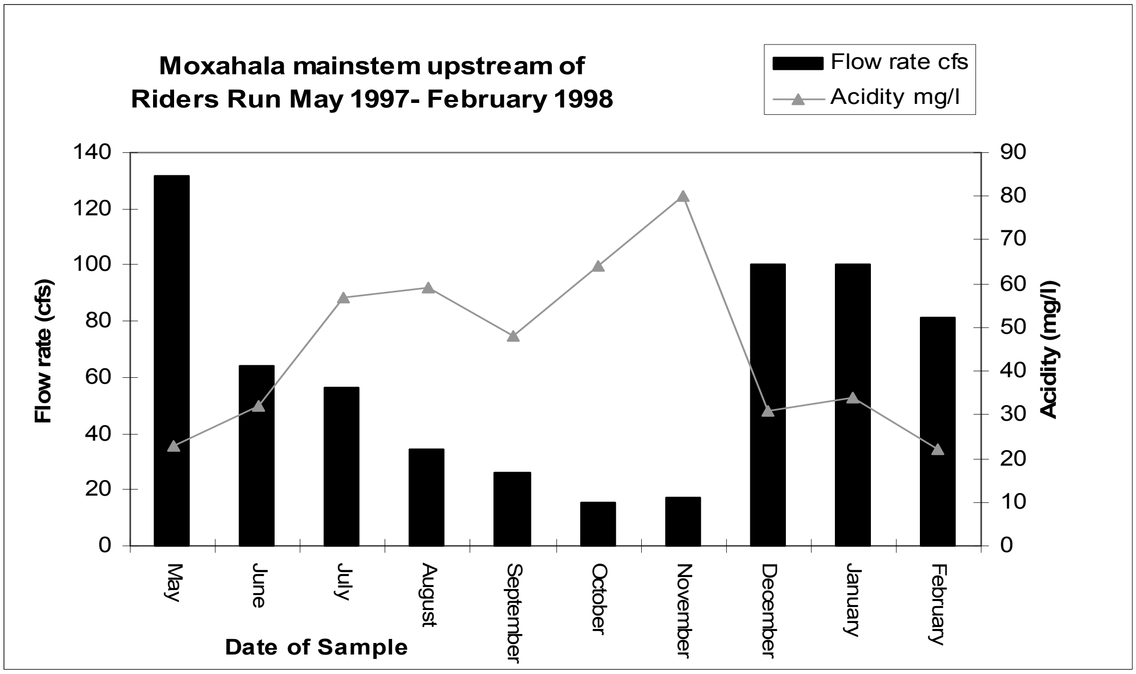
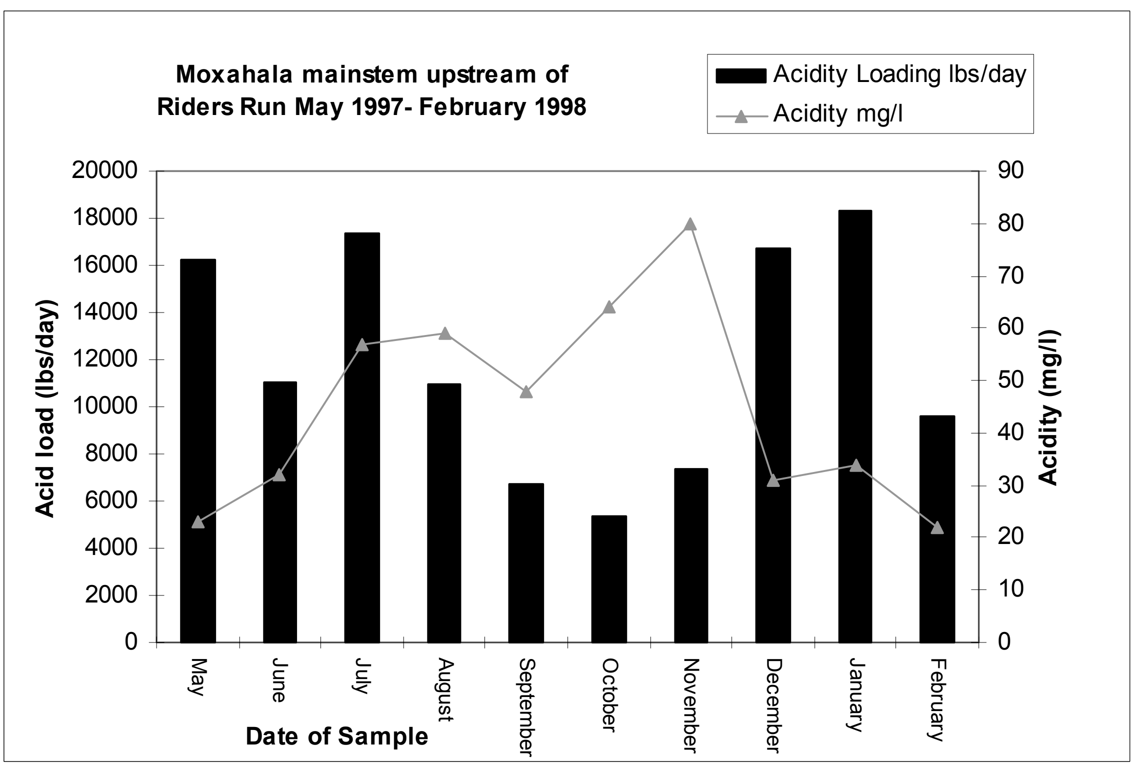


Figure 5. Acid loading and acidity concentrations at Moxahala mainstem site RM 11.0



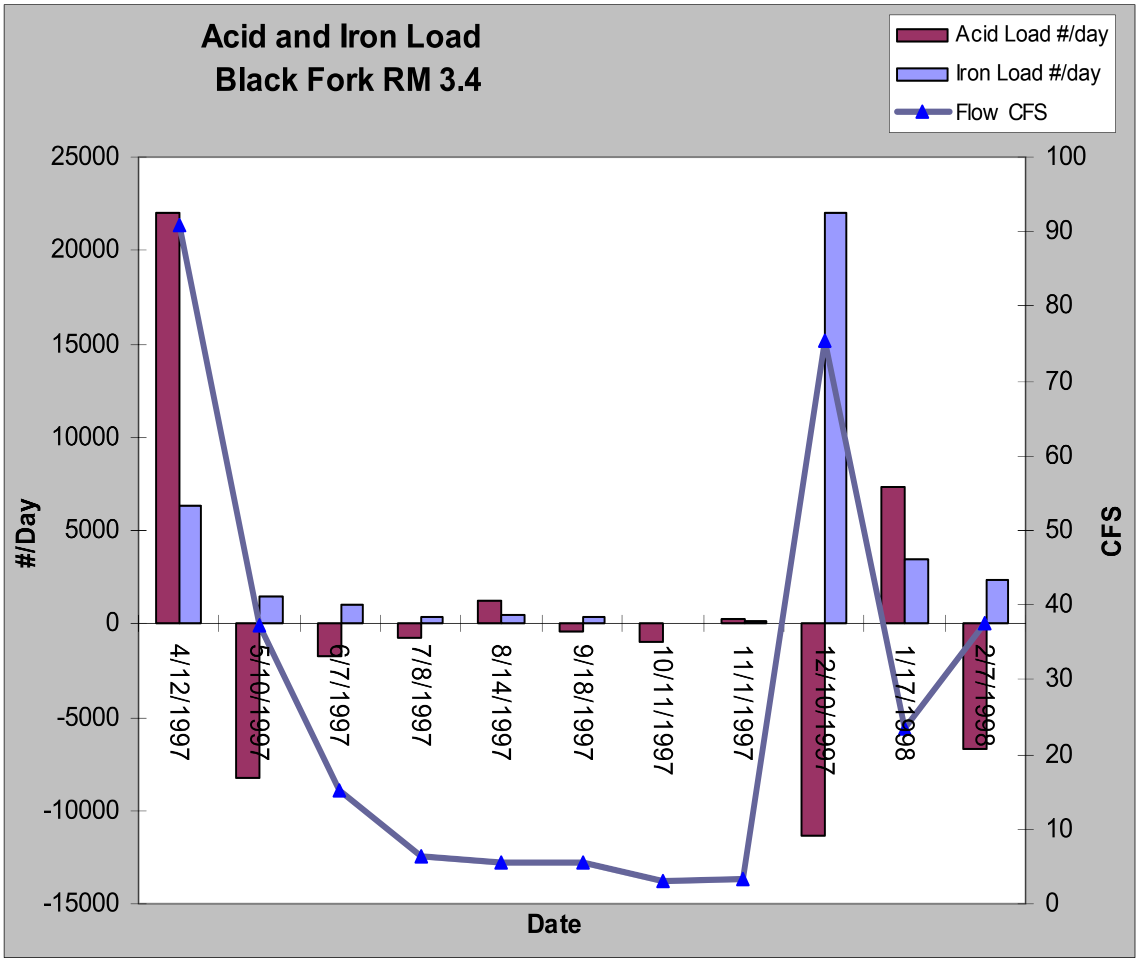
"All of the analyses performed point to Andrew Creek (#56), Bear Creek (#40), McLuney Creek (#30), and Black Fork (#24) as the main sources of acidity, sulfate, iron, aluminum, and manganese (Eberhart, 1998)." The Black Fork Subwatershed is described below.

A site near the mouth of Black Fork was among the 33 sites included in the Eberhart thesis. Water quality data from this Black Fork site (RM 3.4) indicates that Black Fork did not contribute significant acid loads to Moxahala Creek during the study interval. Nevertheless, certain measured parameters reflect water quality conditions in Black Fork that can degrade aquatic habitats. During the study period, pH ranged from 4.70-6.41, with an average pH of 5.74, and with the lowest values seen during low flow (July-November, 1997). Conductivity values during low flow ranged from 930-1229 uS/cm, and acidity loads and metal concentrations also increased significantly during this period. Table 7, summarizes the data collected over the eleven month period of the Eberhart study. The water quality data conveys a highly variable condition with the stream oscillating between net alkaline and net acidic conditions without regard to flow rate or time of year. The condition of the water was extreme in each direction showing a net acidic load of over 20,000 pounds per day in April of 1997 and net alkaline load above 10,000 pounds per day (represented by a negative value in figure 6 in December of 1997.

Table 7. Water quality data at RM 3.4 in Black Fork

Date	Flow (cfs)	Lab pH	Lab conductivity (uS/cm)	Total acidity (mg/L)	Total alkalinity (mg/L)	SO_4 (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)
4/12/1997	90.75	5.29	790.00	45.00	0.00	282	13.00	2.83	1.38
5/10/1997	37.36	6.38	414.00	-33.00	41.00	137	7.50	1.67	0.53
6/7/1997	15.26	6.20	586.00	-17.00	21.00	255	12.40	1.14	1.10
7/8/1997	6.42	6.41	933.00	-16.00	22.00	415	9.20	0.50	1.67
8/14/1997	5.42	5.59	1185.00	44.00	0.00	601	16.60	1.50	3.34
9/18/1997	5.39	6.34	1006.00	-14.00	15.00	448	10.70	0.61	1.94
10/11/1997	3.17	6.40	1060.00	-39.00	54.00	466	1.79	0.30	1.89
11/1/1997	3.22	5.62	1198.00	14.00	0.00	552	11.10	1.40	2.54
12/10/1997	75.49	5.98	404.00	-19.00	28.00	240	54.00	28.00	0.47
1/17/1998	23.51	4.70	585.00	58.00	0.00	293	27.50	3.50	0.80
2/7/1998	37.66	6.41	392.00	-16.00	33.00	153	11.50	3.50	0.54

Figure 6. Acid and iron loading at RM 3.4 in Black Fork from April 1997 through February 1998



Current Water Quality Assessment

Phase I

In October 2003, field parameters were re-analyzed at both the Moxahala Creek mainstem and identified tributaries from the Eberhart study, data was collected at 8 mainstem sites and 23 tributaries (Appendix B Phase I 2003 data). Phase I inventory identified very low, impacted pH values in the headwaters with an increasing trend in pH moving downstream along the mainstem to the confluence with Jonathan Creek. The mainstem shows improvement as it nears Jonathan Creek. Ten tributaries were identified as likely AMD contributors based on pH values that were less than 6.0, these include; Rider Run, Opossum Run, Burley Run, Snake Run, McLuney Creek, Pussy Hollow, Unnamed Tributary along Twp. Rd. 1194, Race Track tributary, Bear Creek and Andrew Creek. Table 8, indicates the priority tributaries identified as likely sources of AMD to the mainstem with pH of less than 6.0.

Table 8. Phase I priority tributaries identified

Tributary	pH	Tributaries with a pH < 6.0 identified during October 2003 Phase I inventory
Morrison	6.8	
Baughman Run	6.57	
Claypit Hollow	7.38	
UT @ Payne Rd	6.76	
UNAMED TRIB	7.38	
Porter Run	7.35	
Rider Run	5.37	Yes
UT 2 (above Roseville)	6.5	
Possum Hollow	4.4	Yes
Burley Run	3.88	Yes
Snake Run	3.26	Yes
Black Fork	6.36	
McLuney Ck	3.4	Yes
Pussy Hollow	4.68	Yes
Milligan Twp Rd 1194	3.58	Yes
RD 169	7.01	
Race Track	3.38	Yes
Jehovah's Kingdom Hall trib.	6.44	
Herb Powers trib.	6.79	
Bear Creek	3.75	Yes
UT up stream of Bear Ck.	6.3	
Fowlers Cemetery Creek	6.37	
Andrew Creek	2.99	Yes

The pH data from the October 2003 Phase I was compared to the data provided by the Eberhart thesis along the mainstem. Eberhart collected water quality samples at eight mainstem sites monthly for 11 months. This information was used to identify the peak pH degradation period as July to November. The average pH values for each site during the 11 monthly sampling events are shown in Figure 6. Figure 7, shows the pH values recorded along Moxahala Creek mainstem on October 10th, 2003. Sites sampled during the October 2003 event are not at the same location as the 1997-1998 data but the trend mimics the conditions that occurred during 1997-1998 data. The headwaters and majority of the mainstem sustain low pH values only after the confluence of Jonathan Creek does the pH value rise to near neutral. PH values are slightly elevated in 2003 when compared to the October 1997-1998 data.

Figure 7. Average pH values along Moxahala Creek mainstem 1997-1998

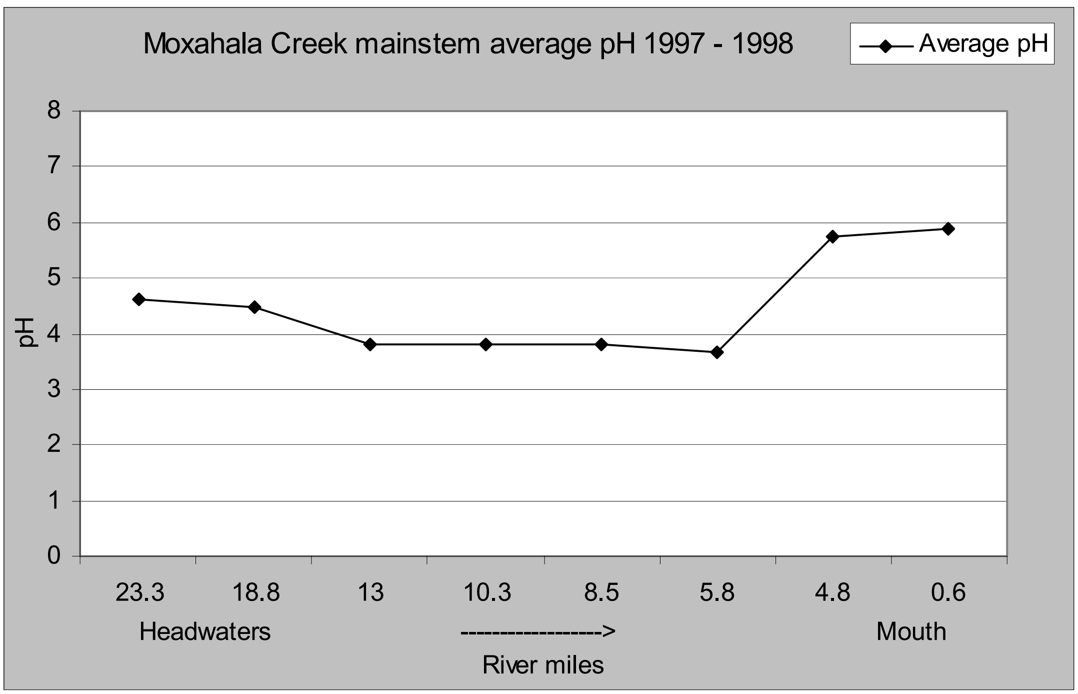
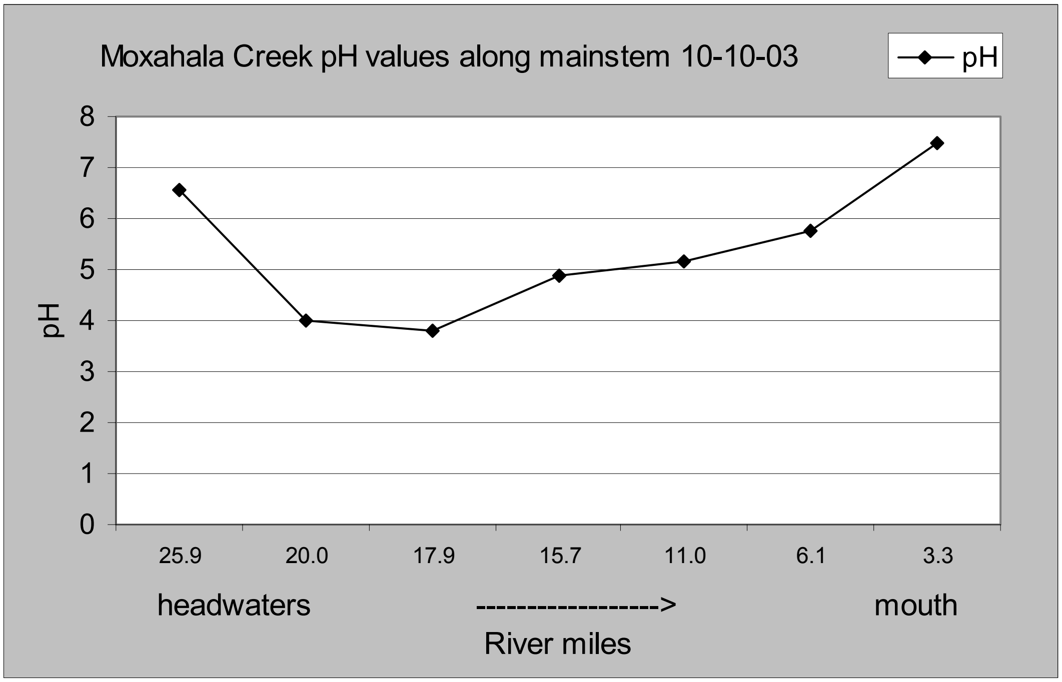
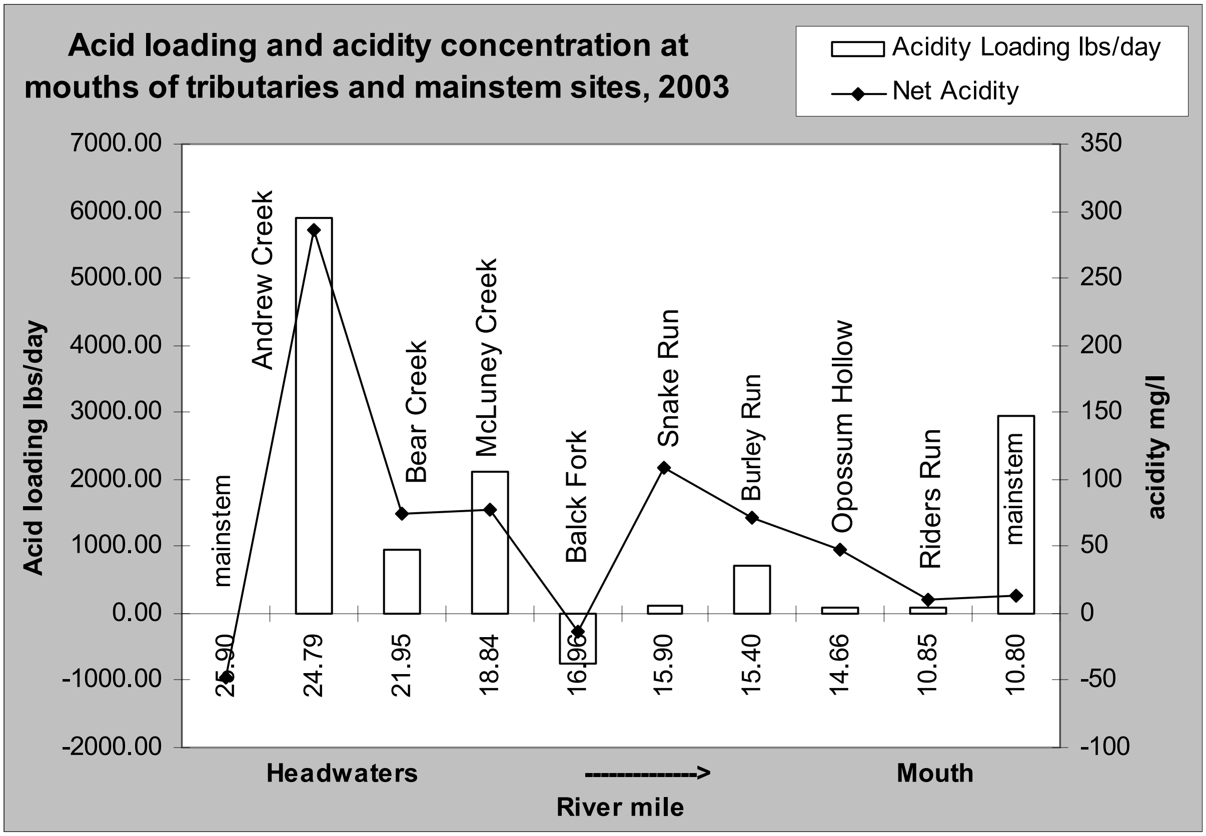


Figure 8. pH values along mainstem Moxahala Creek, 10-10-03



Ten water quality samples were collected on November 10, 2003 (Appendix 2). Samples were collected to compare with the Eberhart study 1997-1998 water quality data. Two mainstem sites were selected one downstream of Riders Run and one upstream of Andrew Creek, and eight tributaries were sampled along the reach. The tributaries were selected based on pH priority, estimated contribution of overall flow, and with reference to the Eberhart thesis conclusions. The list was comprised of seven of the ten priority tributaries (Riders Run, Opossum Run, Burley Run, Snake Run, Black Fork, Mcluney Creek, Bear Creek and Andrew Creek). Figure 8, shows the acid loads and acidity concentrations at these selected sites sampled November 2003.

Figure 9. Acid loads and acidity concentrations at selected sites sampled November 2003.



From the Phase I field reconnaissance, water quality samples, and the data from the Eberhart study the following priority tributaries were identified for further Phase I field work within each of the sub-watersheds: Andrew Creek, Bear Creek, McLuney Creek, Burley Run, Snake Run, and Riders Run. Black Fork was eliminated due to the previous study conducted in 2000 (Kocsis, 2000). Black Fork is discussed in detail in Section II of this plan.

Phase I Field Reconnaissance within Priority Tributaries

During January to March 2004, Phase I reconnaissance was conducted within the priority tributary subwatersheds, Andrew Creek, Bear Creek, McLuney Creek, Snake Run, Burley Run, and Riders Run. Field pH, conductivity, acidity, temperature and estimated flow were recorded along the mainstem of the selected priority subwatersheds and at mouths of tributaries draining into the mainstem of the priority subwatersheds (Appendix C – Reconnaissance data). The field data was analyzed and priority sites were selected for further field investigation based on an estimated acid load. Phase II sampling plan included further reconnaissance at selected sites to track down the source of the acid mine drainage and to collect high and low flow water quality samples. In Andrew Creek Subwatershed nine sites were selected for Phase II investigation (AC- 33, 13, 29, 36, 37, 24, 30, 31, 32). These sites contributed an estimated 85% of the acid load in Andrew Creek Subwatershed. Nine sites were also chosen in Bear Creek for Phase II sampling (BR- 15, 16, 17, 18, 22, 25, 26, 29, 30), they contributed an estimated 89% of the acid load in Bear Creek. In McLuney Creek six sites were selected for Phase II sampling (ML – 6, 14, 16, 20, 38, 49), these sites contributed an estimated 77% of the total acid load in McLuney. Site ML-38 was included the Phase II water quality sampling but excluded from source tracking field work. Nine sites in Burley Run contributed an estimated 80% of the acid load and were selected for further field work (BR- 9, 10, 11, 13, 14, 15, 21, 22, 24). During spring 2004, Riders Run was excluded from Phase II sampling and investigation because Phase I sampling conducted in October 2003 and March 2004 indicated low acid loading and near neutral pH values (84 lbs/day and pH 6.5). However, sampling conducted in July 2004 revealed lower pH values and iron staining near the mouth. Riders Run Subwatershed was then investigated for Phase II. Phase II sampling in Riders Run was only conducted during low flow, fall of 2004. Phase I and Phase II data are available in Appendix B, C, and D. Sites are located on their respective subwatershed map and photos of sites are shown in Appendix E.

Phase II Sampling

High and low flow sampling were completed during May and June 2004 for higher flow regime and August, September, and November for low flow regime. Discussions regarding high and low flow acid loading, acidity concentration, and metal loading at each sample point are displayed in Section II under each of the priority subwatershed sections. Phase II, high and low flow water quality data are listed under Appendix D. Black Fork data was collected as part of the Kocsis study in 2000. Phase I and II data are listed under Appendix F and G. Site locations are shown on Map 9 – Black Fork Subwatershed sampling sites.

Biological Health

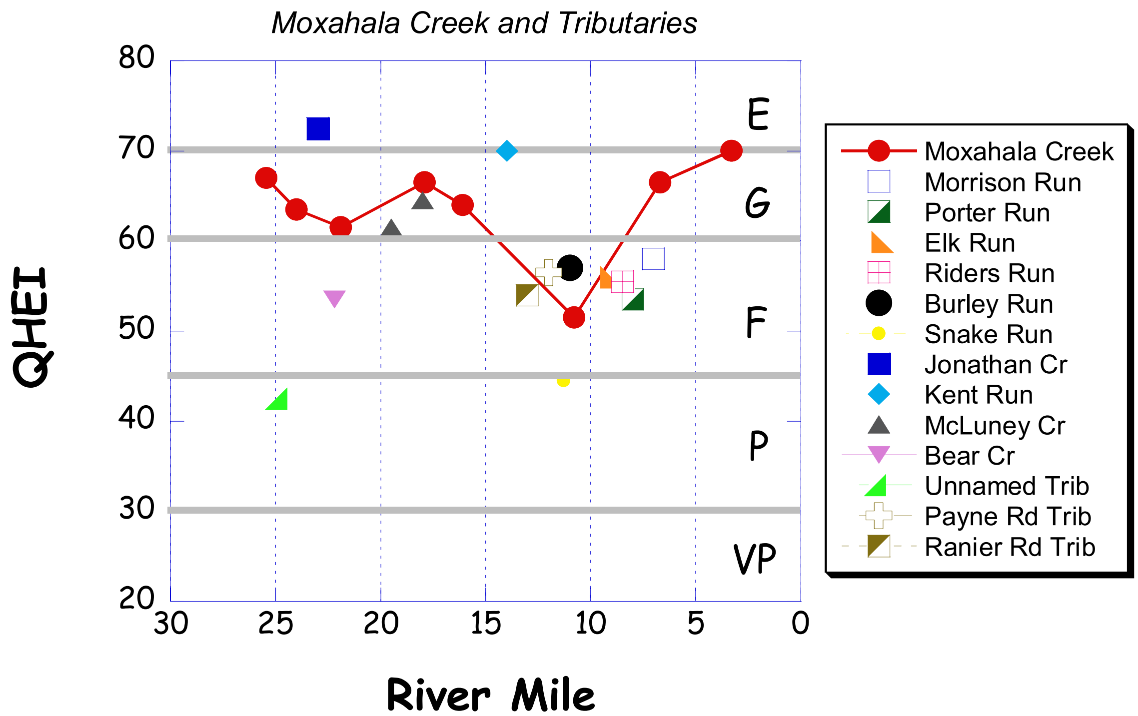
The following section is an executive summary of the fish, macroinvertebrate, and habitat survey of the Moxahala Creek Watershed. It was conducted and written by Mid-west Biodiversity Institute (MBI) and Center for Applied Bioassessment and Biocriteria (CABB), in 2004. Water quality data collected at biological stations are listed in Appendix H. Sampling locations are shown on Map 1

This write-up summarizes the impacts on fish and macroinvertebrate communities observed in Moxahala Creek watershed during 2004. The Moxahala Creek watershed has been extensively mined over the past century. The data we collected during 2004 confirmed the perception that this watershed is extensively impaired by acid mine drainage (AMD). We sampled 21 sites in the Moxahala Creek watershed in 2004 (a subwatershed, the Black Fork of Moxahala Creek, was monitored in 2003 and is not included in this summary) and two reference sites in the adjacent Jonathan Creek watershed to gauge biological potential for streams in the area.

All 21 sites in the Moxahala Creek watershed are impaired and do not attain Ohio's biocriteria (Table 1) even the for the LRW which is designed to protect against acute toxicity (i.e., all of these sites are in effect acutely toxic to aquatic life) . The biological assemblages respond to a wide range of anthropogenic stressors and integrate the typical range of water quality stressors common to Ohio watersheds. Ten of the stations were totally devoid of fish and 14 had the lowest possible IBI score, which is 12. The macroinvertebrate communities were similarly impaired with most sites having very poor assemblages and extreme low taxa richness. For both fish and macroinvertebrates the most downstream site on Moxahala Creek had the highest numbers of fish species and macroinvertebrate taxa which reflected some recovery and dilution. Porter Run, Elk Run, and the Ranier Road tributaries had more fish species and macroinvertebrate taxa than the other tributaries in the Moxahala Creek watershed, but all were still impaired. Such impairment can be exacerbated by the biological isolation that occurs related to the severe nearby and mainstem AMD impacts making recolonization from previous mining or natural stresses (e.g., flooding, drought) more difficult.

Habitat conditions in the Moxahala Creek watershed largely ranged from fair to good. None of the habitat problems by themselves would be considered limitations to eventual attainment of a warmwater habitat use. Many of the identified habitat impacts at stations were related to increased fine sediments from mining activities that would likely be reduced as part of any mine remediation efforts. This habitat does not limit the aquatic community and in fact the relatively good habitat conditions should speed any recovery if water chemistry problems can be abated.

In contrast to Moxahala Creek the sites in nearby Jonathan Creek had excellent fish communities and good to excellent macroinvertebrate assemblages. Given the similar natural settings and the inherent physical potential of the Moxahala Creek watershed, if mining effects could be remediated, would be high. Jonathan Creek and tributaries like Kent Run would be long-term sources of fish and macroinvertebrate species which could recolonize the Moxahala system. Similarly, the Black Fork of Moxahala Creek still harbors populations of some sensitive species which could reinvade restored areas of Moxahala Creek.



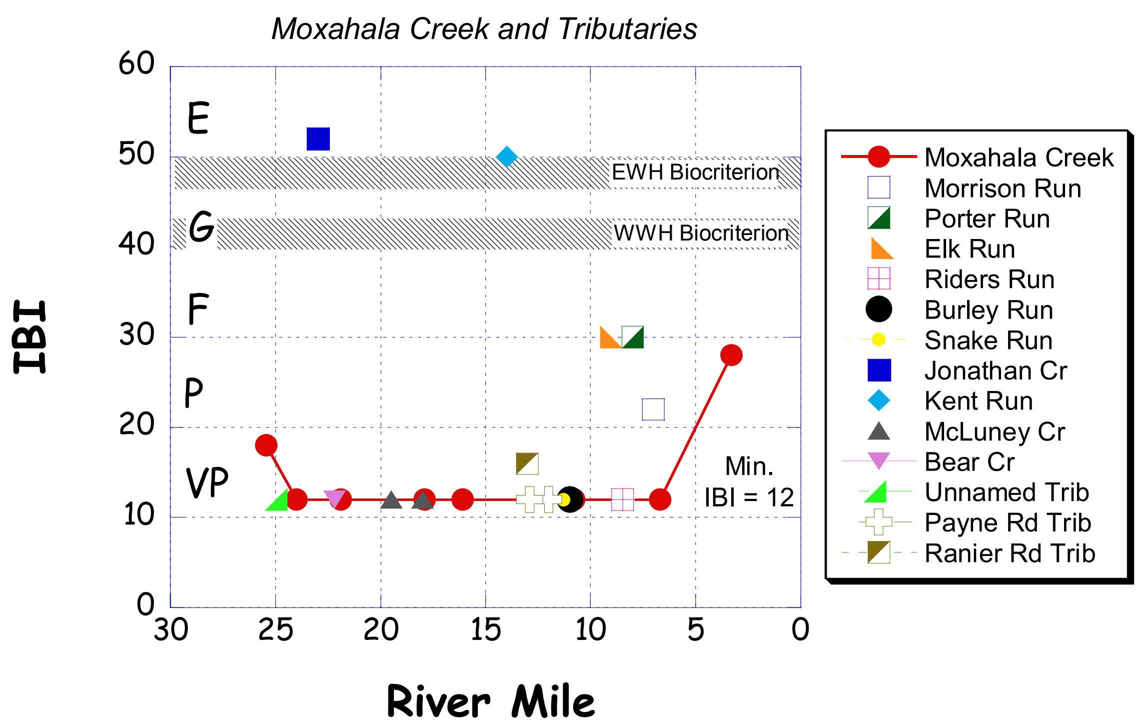


Figure 10. Longitudinal profiles of QHEI (top) and IBI (bottom) scores versus RM for station monitored during 2004 in the Moxahala Creek watershed. Tributary RMs were estimated distance from the mouth of Moxahala Creek to place them in their relative watershed position. QHEI gradient scores estimated. River miles start at the mouth of Moxahala (*i.e.,* upstream is on the left).

Table 1. Aquatic life use attainment status for stations sampled in the Moxahala Creek watershed based on data collected by MBI in 2004. The Index of Biotic Integrity (IBI) and narrative estimates of macroinvertebrate condition relative to the Invertebrate Community Index (ICI) are measures of biotic community condition and the Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community. The Qual ICI on this table is a draft tool designed to help in the derivation of narrative ratings.							
Station	Fish RM	Macro. RM	IBI/MIwb	Macro. Narrative Rating[a] Qual ICI	QHEI	Existing Aq Life Use/Rec. Use	Attainment Status[b]
Moxahala Creek - 17300							
S17300 3.302004	3.3	3.3	28/6.6	P* - 12	70.0	LRW	NON
S17300 6.702004	6.7	6.7	12*	VP* - 0	66.5	LRW	NON
S17300 10.802004	10.8	**10.8**	12*	VP* - 0	51.5	LRW	NON
S17300 16.102004	16.1	**16.1**	12*	VP* - 0	64.0	LRW	NON
S17300 17.902004	17.9	**17.9**	12*	VP* - 0	66.5	LRW	NON
S17300 21.902004	21.9	**21.9**	12*	VP* - 0	61.5	LRW	NON
S17300 24.002004	24.0	**24.0**	12*	VP* - 0	63.5	LRW	NON
V S17300 25.402004	25.4	**25.4**	22	VP* - 0	67.0	LRW	NON
Morrison Run - (17-302)							
S17302 0.852004	0.85	0.85	14*	VP* - 0	62.5	LRW	NON
Porter Run - (17-303)							
S17303 0.802004	0.80	0.70	30	P* - 2	53.5	LRW	NON
Elk Run - (17-304)							
S17304 0.302004	0.30	0.10	30	VP* - 2	56.0	LRW	NON
Riders Run - (17-305)							
S17305 1.302004	1.30	1.30	12*	VP* - 2	55.5	LRW	NON
Burley Run - (17-306)							
S17306 0.702004	0.70	0.80	12*	VP* - 0	57.0	LRW	NON
Snake Run - (17-307)							
S17307 0.102004	0.10	0.10	12*	VP* - 0	46.5	LRW	NON
McLuney Creek - (17-323)							
S17323	1.30	1.64	12*	VP* - 0	61.5	LRW	NON

1.302004							
S17323 0.102004	0.10	0.60	12*	VP* - 0	64.5	LRW	NON
Bear Creek - (17-324)							
S17324 0.102004	0.10	0.1	12*	VP* - 0	53.5	LRW	NON
Trib. to Moxahala Creek (RM 24.79) - (17-326)							
S17326 0.302004	0.30	0.3	12*	VP* - 0	44.5	None/LRW	NON
Payne Rd Trib - (17-3X)							
S173X 0.102004	0.10	0.20	12*	VP* - 0	58.5	None/LRW	NON
Claypit Run - (17-3Y)							
S173Y 0.902004	0.90	0.80	12*	VP* - 0	57.5	None/LRW	NON
Ranier Rd Trib - (17-3Z)							
S173Z 0.202004	0.20	0.50	20	P* - 6	54.0	None/LRW	NON
Jonathan Creek - (17310)							
S17310 20.102004	20.10	21.10	52/9.6	E - 22	72.5	EWH	Full
Kent Run - (17313)							
S17313 0.602004	0.60	0.90	50/9.5	VG - 22	70.0	WWH	Full
Ecoregion Biocriteria: Western Allegheny Plateau (WAP)							
	Index Site Type	WWH	EWH	MWH	LRW-AMD		
	IBI – Wading & Headwater	44	50	24/24	18		
	Mod. Iwb - Wading	8.4	9.4	6.2/5.5	4.0		
	ICI/Narrative	36/G	46/E	22/30	8/MF		

Footnotes:

a - A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition, EPT taxa richness, and QCTV scores were used when quantitative data were not available (E-exceptional, G-good, MG-marginally good, F-fair, P-poor, VP-very poor); for Moxahala Creek a draft Qualitative ICI index was also used.

b - Attainment status is given for existing use designations, except where a use designation change is recommended, in which case, the attainment status for the recommended use is given.

c - Limited Resource Water - acid mine drainage (LRW-AMD) benchmarks based on best professional judgment driven by the need to protect against acutely toxic stream conditions. Macroinvertebrate qualitative only data were evaluated based on densities of EPT taxa on the natural substrates (see Methods Section), a narrative VP* or P* indicates departure from the benchmark.

N/A - Miwb not applicable at headwater sites (< 20 mi). 2

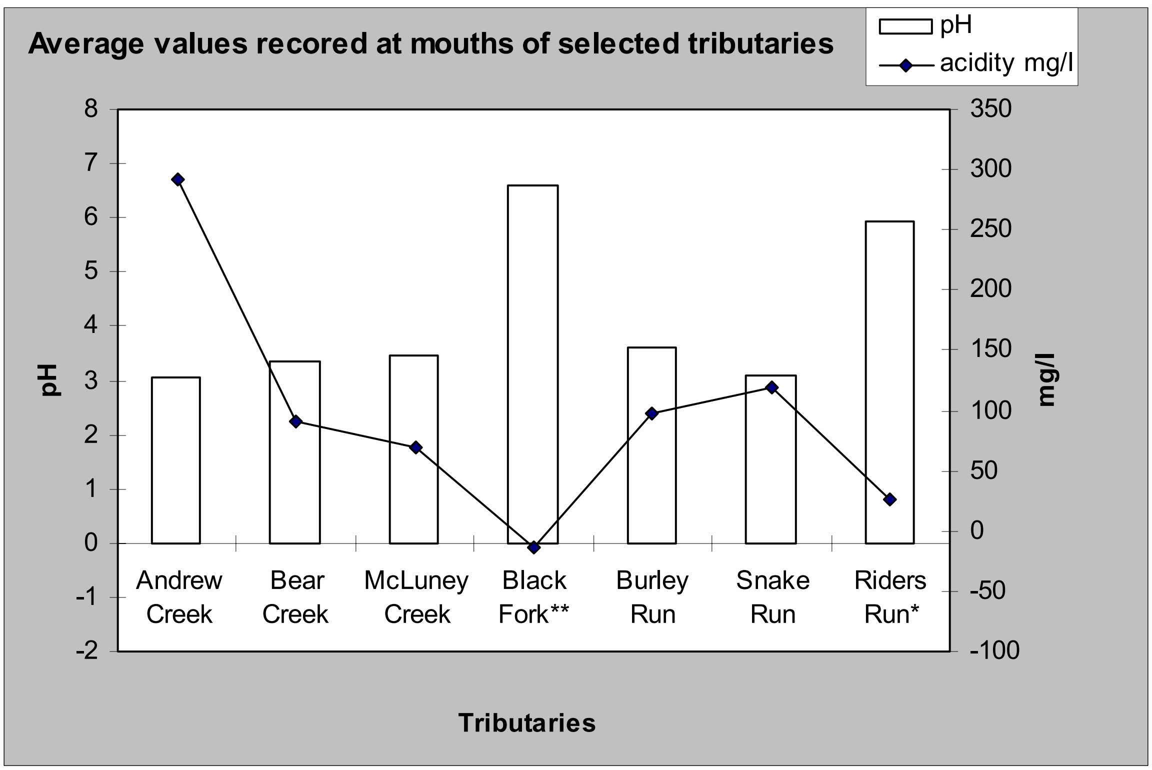
ns - Nonsignificant departure from biocriteria (<4 IBI or ICI units, or <0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIw uits). Underlined scores are in the Poor or Very Poor range.

AMD Impacts in Watershed

Comparing the average pH and acidity values and acid loading contributions from the mouths of priority subwatersheds shows the ranking of acid producers in Moxahala Creek Watershed, Figure 11 and Figure 12. Figure 11, shows the average of the high and low flow Phase II data collected in 2004 at mouths of priority tributaries for pH and acidity. The highest contributor of acidity and lowest pH values measured at the mouth was Andrew Creek, followed by Snake Run. Looking at just the acidity concentrations the highest acidity contributions comes from Andrew Creek followed by Snake Run, Burley Run, Bear Creek, McLuney Creek, Riders Run, and Black Fork, which was net alkaline during low flow sample collected in November 2003.

Figure 11. Average pH and acidity values at the mouth of priority subwatersheds

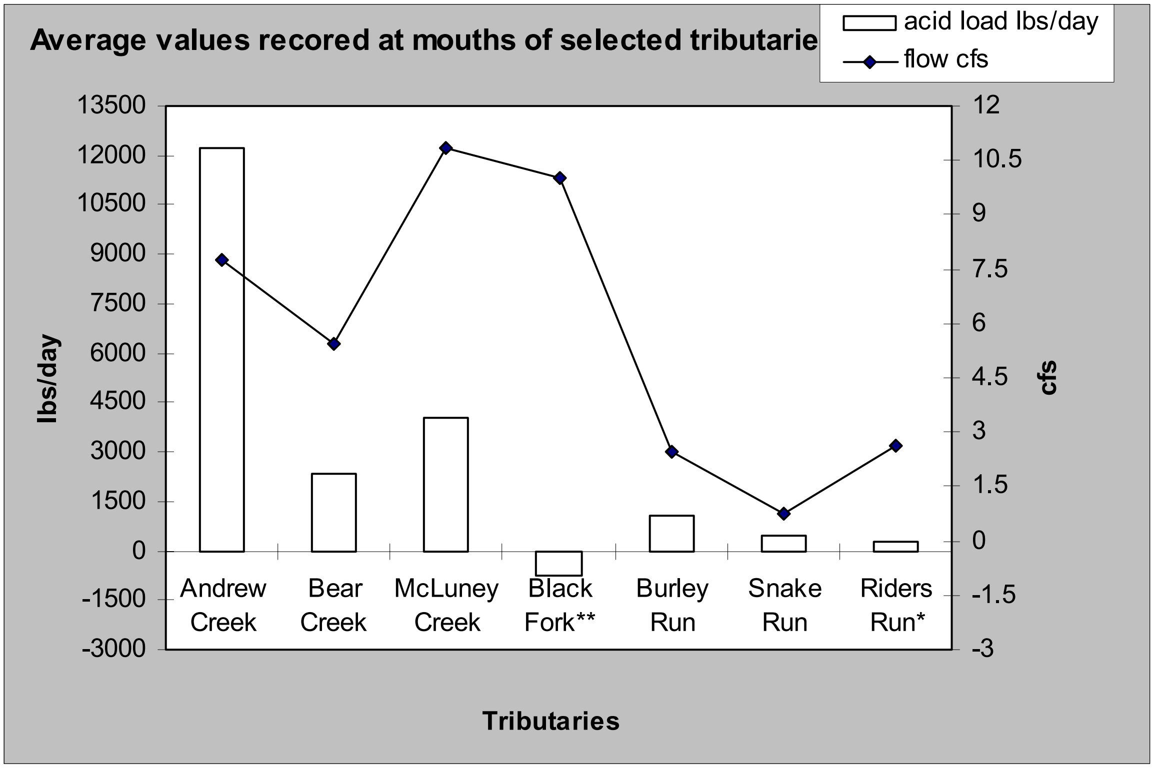


*Riders Run – low flow only Nov. 2004

**Black Fork – low flow only Nov. 2003

Similarly, Figure 12 shows the largest acid loading from Andrew Creek followed by McLuney Creek, Bear Creek, Burley Run, Snake Run, Riders Run, and Black Fork (net alkaline loading).

Figure 12. Average acid loading and flow at mouth of priority subwatersheds.



*Riders Run – low flow only Nov. 2004

**Black Fork – low flow only Nov. 2003

SECTION II

RESTORATION STRATEGY

Section II is organized into sections by each priority subwatershed. Within each subwatershed section the following sub-sections are found. First a basin description is given for each subwatershed. Second, there is a discussion about the mining impact and water quality impact to the mainstem of Moxahala Creek. Third, the current water quality investigation is explained. Fourth, a list of projects is found followed by a description of each project site including acid and metal loading during high and low flow. Fifth, tables of various treatment costs are displayed. Sixth, needed acid load reductions, costs, and cost versus benefit analysis are displayed in a table. Finally, phases of recommended treatment plan are suggested and future monitoring.

Andrew Creek

Basin Assessment

Andrew Creek is an unnamed tributary that was unofficially named Andrew Creek as part of the Eberhart thesis in 1998. Andrew Creek is located in Perry County on the New Lexington quadrangle and has a drainage area of 5.69 square miles. It is located near the headwaters of Moxahala Creek. The confluence of Andrew Creek with Moxahala Creek is located just north of the town of Moxahala at RM 24.79. Much of the land located in the Andrew Creek Subwatershed is privately owned and has been previously subject to surface and deep mine operations. Surface mines were in operation in the 1950's-1970's disturbing 1,182 acres of land, leaving unreclaimed spoil piles, strip pit impoundments, barren soils, highwalls, slurry ponds, and acid mine drainage (Appendix – Surface mine information). While the surface mining impacts can be seen on the surface, Andrew Creek Subwatershed was also extensively underground mined, totaling 1,265 acres. Table 9, shows the known and mapped underground deep mines in Andrew Creek, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Andrew Creek Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines.

Table 9. Andrew Creek underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-91	Brownfield	1948	
PY- 251	Red Run	1923	
PY-238	J.M.	1927	
PY-34	Clay Bank	1895	
PY-314	Webster	1922	
PY-159	Sunny Hill No.1	1966	
PY-338	Sunny Hill No.7	1967	886
PY-241	Loyal	1921	
PY-339	Sunny Hill No.4	1982	879
PY-332	Sunny Hill No.2	1969	956
PY-334	Sunny Hill No.3	1971	940
PY-010	Chestnut Hill	1926	
PY-315	White Elm	1935	864
PY-80	Smith	1921	

Impacts of Andrew Creek on the Mainstem of Moxahala Creek

The impact from Andrew Creek to the mainstem of Moxahala Creek is profound (Table 10). Andrew Creek on average lowers the pH of the mainstem by 3.5 pH points, increase the conductivity 650 μS/cm, and increases acidity by 176 mg/l.

Table 10. Impacts of Andrew Creek on the mainstem of Moxahala Creek

Site	pH	Conductivity μs/cm	Acidity mg/l
Upstream (RM 27.9)	6.50	919	7
Andrew Creek (RM 24.8, RM 0.1)	2.97	2080	337
Downstream (RM 24.0)	3.00	1570	183

Summer 2004 data

From the Eberhart study in 1998, monthly data shows the same trend as the 2004, the impact from Andrew Creek on the mainstem of Moxahala is shown by decreasing the pH (Table 11), increasing conductivity (Table 12), and on average supplies more than half of the water to the mainstem (Table 13).

Table 11. Effect of Andrew Creek on Moxahala Creek's pH

	Upstream	Mouth of Andrew Creek	Downstream
April	6.34	3.38	4.24
May	5.16	2.7	3.14
June	5.87	3.11	3.54
July	6.21	2.8	3.4
August	5.18	3.11	3.4
September	6.3	3.7	3.8
October	5.39	2.94	3.14
November	6.48	4.27	4.08
December	4.9	3.3	3.8
January	5.5	3.53	4.23
February	5.96	3.75	4.1

Table 12. Effect of Andrew Creek on Moxahala Creek's Specific Conductivity

	Specific Conductivity (uS/cm)		
	upstream	**Mouth of Andrew Creek**	**Downstream**
April	804	1968	1170
May	1045	2300	1564
June	600	2000	1432
July	942	2240	1840
August	726	1405	1378
September	890	2170	1930
October	976	2480	2260
November	1125	2370	1952
December	1170	2040	1312
January	508	1860	1210
February	754	1989	1404

Table 13. Water budget for the Confluence of Andrew Creek and Moxahala Creek

	Flow rate (lpm)		
	upstream	**Mouth of Andrew Creek**	**Downstream**
May	24,100	12,100	39,100
June	10,000	14,000	23,600
July	3440	7000	16,200
October	1520	5400	7370
November	3020	7000	10,100
December	29,100	8720	44,170
January	19,100	15,400	34,100
February	16,300	12,700	32,400

Water Quality Investigation

Andrew Creek Subwatershed produces on average 12,200 lbs/day of acid loading (292 mg/l of acidity concentration) and 3,675 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 13 and 14). The sites sampled in Andrew Creek were located at the mouths of tributaries and at acid mine drainage sources. Comparing the average acid loading measured at each tributary site to the average acid loading measured at the mouth (AC-01), gives a percentage of acid load each site contributes in Andrew Creek. Table 14, shows the percent acid load each site contributes in Andrew Creek.

Table 14. Andrew Creek percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
AC-20	2480	20
AC-33	3236	27
AC-36	325	3
AC-37	1694	14
AC-44	3024	25
AC-29	994	8
AC-13	121	1

Table 14 shows the largest producers of acid in Andrew Creek are site AC-33 and AC-44. The sites listed account for an average 97% of the acid load produced in Andrew Creek Subwatershed.

Figure 13. Andrew Creek acid loading and acidity concentration

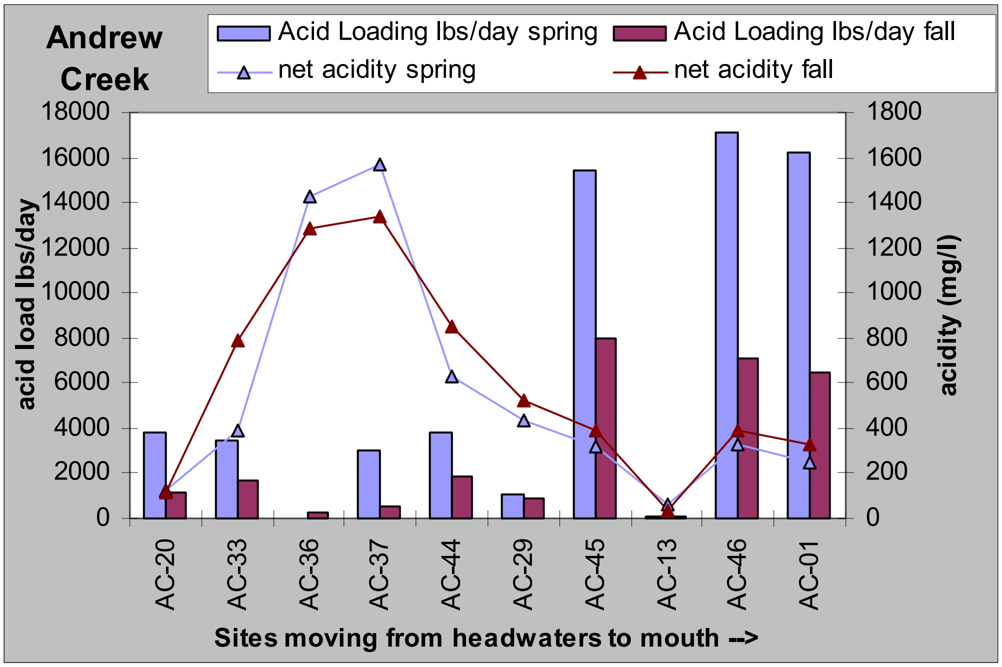
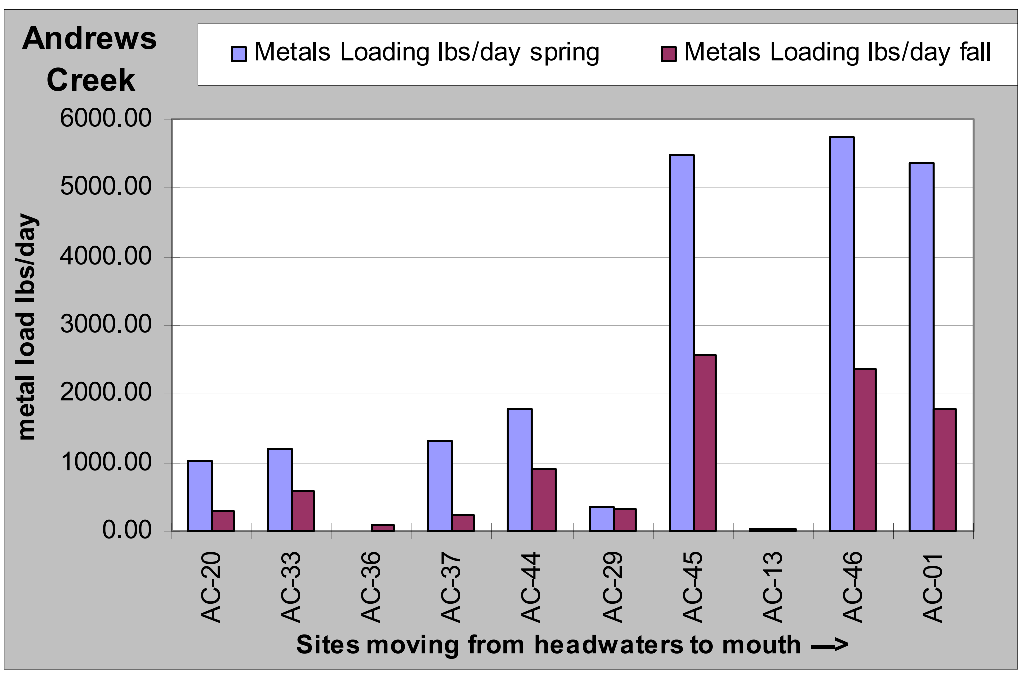


Figure 14. Andrew Creek metal loading



Sample site locations can be found on Map 3 for Andrew Creek Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 15.

Table 15. List of project sites in Andrew Creek Subwatershed

Sub-watershed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Town-ship	County	Project name	Mines
Andrew Creek	#20	HWL, 39, 38, 41, 42,40	Owen	New Lexington	Pike	Perry	Howard William Lake	PY-332, PY-334, PY-339
Andrew Creek	#33	34,35,43,47, 48,57,58,59	Owen	New Lexington	Pike	Perry	Suny Hill #1 Underground	PY-159, PY-332, PY-034, SM*
Andrew Creek	#44	24,30,31,32	Owen	New Lexington	Pike	Perry	Gob Pile B Discharge	PY 238, PY-251, SM*
Andrew Creek	#29	53,54,55,56	Owen	New Lexington	Pleasant	Perry	Suny Hill East	PY 338, SM*
Andrew Creek	#36	49,50,51	Owen	New Lexington	Pike	Perry	Murph's Gob	PY 238, SM*
Andrew Creek	#37	52- deep mine source	Owen	New Lexington	Pike	Perry	West Hopper Boil	PY 238, SM*
Andrew Creek	#13	11	Owen	New Lexington	Pleasant	Perry	Andrew South pits	PY 314, SM*

*SM surface mines see Appendix I - Surface mine information

1) AC-20 - Howard William Lake project

Location/Access

This site, #20, called Howard William Lake project is located on private property east of Township Road 218 on the south side of the railroad tracks in the mainstem of Andrew Creek at RM 3.21 and drains a 2.4 square mile area. The site is accessible by foot and is located on the mainstem of Andrew Creek in Section 22, Pike Township, Perry County.

Site Description

The site is located downstream of the outlet from Howard William Lake and tributary sites 40, 42, 41, and 38. Site AC-40 and AC-42 drain acidic tributaries on the north side of Andrew Creek and on the west side of TR 218, pH values 3.02 and 2.98 respectively. Site AC-41 is drainage from a failed Anoxic Limestone Drain (ALD) previously installed by ODNR-DMRM, pH 3.15. Site AC-38 drains a small non-acidic tributary on the south side of Andrew, pH 6.48. AC-20 flow rate during spring 2004 was 5.78 cfs and during the fall 2004 it was 1.89 cfs. AC-20 is the third largest contributor of acid and fourth largest contributor of AMD metals in Andrew Creek Subwatershed, contributing approximately 21% of the acid and 14% of the metals among all sites in Andrew Creek. This site contributes 905,200 lbs of acid and 233,600 lbs of metals annually to Andrew Creek (Table 16).

Table 16. AC-20 Net acid and metal loadings

AC-20	High Flow	Low Flow	Average
Acid load (lbs/day)	3831	1193	2480
% Acid load contribution	23	18	21
Metal load (lbs/day)	1023	296	640
% Metal load contribution	17	12	14

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

2) AC-33 - Sunny Hill #1 underground

Location/Access

Sunny Hill #1 underground project area is located on private property east of Township Road 218 on the north side of the railroad tracks. It is a tributary that enters the mainstem of Andrew Creek at RM 2.85 and drains a 0.54 square mile area. Site AC-33 is located at the mouth of the tributary at RM 0.1 in Sections 15, 22, and 23, Pike Township, Perry County. The site is accessible by private property owner's dirt access road.

Site Description

Sunny Hill #1 underground project includes the following sites: 34, 35, 43, 47, 48, 57, 58, and 59. AC-34 is the mouth of drainage from west side of AC-33, pH 2.88. Site AC-35 is located in a ditch on the southeast side of AC-33 that drains through spoil in the floodplain. Site AC-43 is a small strip pit on the east side of AC-33, pH 2.64. Site AC-47 and AC-48 are located on the east side of AC-33. AC-48 consists of a large shallow pond surrounded by spoil and planted pine trees. Site AC-47 is a series of small, swampy, pools draining through spoil. Site AC-57 is located in a strip pit impoundment with noticeable upwelling, pH 2.98. Site AC-58 and AC-59 are located on the west side of AC-33 in a series of strip pit impoundments, pH 2.58 and 2.64 respectively. AC-33 flow rate during spring 2004 was 1.65 cfs and during the fall 2004 it was 0.39 cfs. AC-33 is the largest contributor of acid on average and second largest contributor of AMD metals in Andrew Creek Subwatershed, contributing approximately 28% of the acid and 24% of the metals among all sites in Andrew Creek. This site contributes 1,180,775 lbs of acid and 413,545 lbs of metals annually to Andrew Creek (Table 17).

Table 17. AC-33 Net acid and metal loadings

AC-33	High Flow	Low Flow	Average
Acid load (lbs/day)	3436	1663	3236
% Acid load contribution	20	25	28
Metal load (lbs/day)	1206	582	1136
% Metal load contribution	20	23	24

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

3) AC-36 - Murph's Gob pile

Location/access/description

Murph's Gob pile, site AC-36, project area is located on private property east of Township Road 218 on the north side of the railroad tracks. It is a tributary that enters the mainstem of Andrew Creek at RM 2.61 and drains a 0.03 square mile area. Site AC-36 is located at the mouth of the tributary at RM 0.1 in Sections 23, Pike Township, Perry County. The site is accessible by private property owner's dirt access road.

Site Description

Murph's Gob pile project includes the following sites: 49, 50, and 51. Site AC-49 enters into AC-36 from the west. It consists of porous diffuse flow through spoil, pH 2.93. AC-50 and 51 are small flows both entering into AC-36 from the east, pH 2.70 and 2.69 respectively. AC-36 flow rate during spring 2004 was estimated to be 100 gpm and during the fall 2004 it was 20 gpm. AC-36 is on eof the smaller contributors of acid and AMD metals in Andrew Creek Subwatershed, contributing approximately 8% of the acid and 6% of the metals among all sites in Andrew Creek. This site contributes 355,875 lbs of acid and 98,915 lbs of metals annually to Andrew Creek (Table 18).

Table 18. AC-36 Net acid and metal loadings

AC-36	High Flow*	Low Flow	Average
Acid load (lbs/day)	1712	308	975
% Acid load contribution	10	5	8
Metal load (lbs/day)	460	89	271
% Metal load contribution	8	4	6

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)
*High flow discharge measurement was estimated visually at 100 gpm

4) AC-37 - West Hopper Boil

Location/Access

West Hopper Boil, site AC-37, project area is located on private property east of Township Road 218 on the north side of the railroad tracks. It is a deep mine discharge that enters the mainstem of Andrew Creek at RM 2.51. Site AC-37 is located in a ditch to the north of the dirt access road in Section 23, Pike Township, Perry County. The site is accessible by private property owner's dirt access road.

Site Description

West Hopper Boil project consists of one deep mine discharge site that emerges from the ground in the ditch next to the road site AC-52. The discharge from this site is dependent on seasonal flow variations. In the fall sampling event the site discharged at a low 32 gpm and increased to 162 gpm in the spring sampling event. The discharge is likely connected to the J.M. mine, PY-238, abandoned in 1927. AC-37 flow rate during spring 2004 was 161 gpm and during the fall 2004 it was 32 gpm. On average AC-37 is the fourth largest contributor of acid and third largest contributor of AMD metals in Andrew Creek Subwatershed, contributing approximately 14% of the acid and 16% of the metals among all sites in Andrew Creek. This site contributes 617,945 lbs of acid and 276,670 lbs of metals annually to Andrew Creek (Table 19).

Table 19. AC-37 Net acid and metal loadings

AC-37	High Flow	Low Flow	Average
Acid load (lbs/day)	3047	517	1693
% Acid load contribution	18	8	14
Metal load (lbs/day)	1313	242	758
% Metal load contribution	21	10	16

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

5) AC-44 - Gob Pile B Discharge

Location/access/description

Gob Pile B Discharge, site # AC-44 project area is located on private property east of Township Road 218 on the north side of the railroad tracks. It is a tributary that enters the mainstem of Andrew Creek at RM 2.10 and drains a 4.1 square mile area. Site AC-44 is located at the mouth of the ditch tributary at RM 0.1 in Section 23, Pike Township, Perry County. The site is accessible by private property owner's dirt access road.

Site Description

Gob Pile B Discharge project includes the following sites: 24, 30, 31, and 32. Site AC-24 sampled drainage through a spoil bank that is possibly be fed by deep mine Red Run, PY-251, abandoned in 1923 and/or impounded surface mine water located in a strip pit northeast of the site. Site AC-30 sampled water emitting from the ground likely draining from deep mine Red Run, PY-251, and possibly deep mine Sunny Hill #7, PY-338, abandoned in 1967. Site AC-31 is located at the mouth of a discharge from a 4,800 foot long slurry pond. Site AC-32 is a deep mine source that emerges from the ground at the base of a highwall. The discharge is likely connected to deep mine J.M. mine, PY-238, abandoned in 1927. AC-44 flow rate during spring 2004 was 501 gpm and during the fall 2004 it was 180 gpm. On average AC-44 is the second largest contributor of acid and the largest contributor of AMD metals in Andrew Creek Subwatershed, contributing approximately 24% of the acid and 32% of the metals among all sites in Andrew Creek. This site contributes 1,103,760 lbs of acid and 534,725 lbs of metals annually to Andrew Creek (Table 20).

Table 20. AC-44 Net acid and metal loadings

AC-44	High Flow	Low Flow	Average
Acid load (lbs/day)	3798	1832	3024
% Acid load contribution	22	28	24
Metal load (lbs/day)	1776	911	1465
% Metal load contribution	29	36	32

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

6) AC-29 - Sunny Hill East

Location/access/description

Sunny Hill East, site AC-29, project area is located on private property east of Township Road 218 on the north side of the railroad tracks. It is a tributary that enters the mainstem of Andrew Creek at RM 1.58 and drains a 0.15 square mile area. Site AC-29 is located at the mouth of the tributary at RM 0.1 in Sections 24, Pleasant Township, Perry County. The site is accessible by private property owner's dirt access road.

Site Description

Sunny Hill East project includes the following sites: 53, 54, 55, and 56. Moving upstream from the mouth at site AC-29, the first drainage in to the stream enters from the east side, site AC-53, and consists of water that drains through a limestone channel from a previous reclamation project, pH 6.30. Just north of AC-53 is site AC-54 with an artesian discharge, pH 3.49. Moving north the surface of the ground is covered with crusted iron precipitate in an alluvial fan shape, AC-55 located in the shallow channel forming the northern part of the alluvial fan, pH 4.13. Site AC-56 located south of the dirt access road into Merkle Lake, is another artesian discharge. However this discharge is colored white with aluminum precipitate and supplies some of the water at site AC-55, pH 4.58. Sunny Hill East project has been surfaced mined and deep mined. Possible source water to artesian discharge sites AC-54 and 56 is deep mine Sunny Hill No.7, PY-338, abandoned in 1967. AC-29 flow rate during spring 2004 was 205 gpm and during the fall 2004 it was 142 gpm. On average AC-29 is one of the smaller contributors of acid and AMD metals in Andrew Creek Subwatershed, contributing approximately 8% of the acid and 7% of the metals among all sites in Andrew Creek. This site contributes 362,810 lbs of acid and 125,925 lbs of metals annually to Andrew Creek (Table 21).

Table 21. AC-29 Net acid and metal loadings

AC-29	High Flow	Low Flow	Average
Acid load (lbs/day)	1067	889	994
% Acid load contribution	6	14	8
Metal load (lbs/day)	336	333	345
% Metal load contribution	5	13	7

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

7) AC-13 - Andrew South Pits

Location/access/description

Andrew South pits, site AC-13, project area is located on private property east of Township Road 218 on the south side of the railroad tracks. It is drainage from the south side of Andrew Creek that converges under the railroad tracks and drains into the mainstem of Andrew Creek at RM 1.3 and drains a 0.05 square mile area. Site AC-13 is located at the culvert under the railroad tracks at RM 0.05 in Sections 25, Pleasant Township, Perry County. The site is accessible by private property owner's dirt access road. Andrew South pits project includes one strip pit located at site 11 and possibly drainage from the underground Webster mine, PY-314, abandoned in 1922. AC-13 flow rate during spring 2004 was 136 gpm and during the fall 2004 it was 296 gpm. On average AC-13 is the smallest contributor of acid and AMD metals in Andrew Creek Subwatershed, contributing approximately 1% of the acid and 1% of the metals among all sites in Andrew Creek. This site contributes 44,165 lbs of acid and 10,585 lbs of metals annually to Andrew Creek (Table 22).

Table 22. AC-13 Net acid and metal loadings

AC-13	High Flow	Low Flow	Average
Acid load (lbs/day)	97	120	121
% Acid load contribution	1	2	1
Metal load (lbs/day)	19	38	29
% Metal load contribution	0	2	1

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Andrew Creek Subwatershed. In addition to AMD Treat, costs for standard reclamation of strip pit impoundments were estimated from the area and length of the ponds, 1% grade channels, 2:1 slope - c rock transition channels from reclaimed channel to receiving stream, re-vegetation area, lime material, treating the impoundment during dewatering, and mobilization (Appendix J – Basic Reclamation Data and Maps). Table 23, summarizes the cost estimates from various treatment alternatives from the AMD Treat program. Table 24, summarizes the cost estimated for basic strip pit reclamation (BSPR).

Table 23. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Manganese Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual chemical) ($)	Primary Retention Pond ($)	Secondary Pond ($)	Sludge removal ($)
ac-01	7,004,384	3,252,055	20,364,202	11,908,179	2,391,092	120,419	180,843	299,560	176,545	163,164
ac-13	241,409	57,472	278,945	175,335	132,168	57,919	3,563	10,785	9,816	1,278
ac-46	5,690,096	3,128,664	20,727,581	12,119,635	1,946,809	120,419	180,710	283,245	143,768	185,032
ac-29	333,997	189,649	1,447,711	869,337	91,536	48,513	12,943	18,339	6,810	15,266
ac-45	5,220,381	2,412,591	19,115,467	11,181,453	1,788,295	120,419	146,671	269,261	132,073	181,979
ac-44	1,163,710	687,433	4,513,632	2,668,260	223,704	120,419	39,748	65,420	16,584	64,776
ac-37	635,169	417,145	2,556,380	1,521,436	71,889	111,013	21,387	30,722	5,355	33,598
ac-36	79,534	48,911	228,451	144,819	8,930	94,739	4,119	5,000	5,000	3,999
ac-33	1,467,368	824,929	4,559,300	2,694,981	330,868	120,419	43,553	62,260	24,503	50,033
ac-20	2,447,338	824,776	6,740,524	3,969,866	1,158,708	120,419	46,649	106,681	85,618	27,927

Table 24. Summary of basic strip pit reclamation (BSPR)

Site	area of pond	length	Trans. Channel	re-veg area	re-veg	lime material	2:1 slope trans. rock channel	C rock	est. quicklime dewatering	sub-total	mobili-zation	final cost	Project total
	acres	ft	ft	acres	$750/ac	$440/ac	1.66tons/ linear ft.	$28/ton	(WVU) ($)	($)	10% final cost	($)	($)
AC-33			3068				5,093	142,601		142,601	14,260	156,861	
59	1.4	806		4.2	3,150	1,848			128	20,108	2,011	22,119	
58	2.1	1721		7.7	5,775	3,388			191	48,877	4,888	53,764	
47	0.4	361		1.2	900	528			16	4,145	415	4,560	
48	1.1	307		2.3	1,725	1,012			45	9,683	968	10,651	
57	0.5	483		1.9	1,425	836			101	6,280	628	6,908	
43	0.3	290		0.7	525	308			61	2,731	273	3,004	**257,866**
AC-44			2239				3,717	104,069		104,069	10,407	114,476	
30	13.2	2372		18.9	14,175	8,316			2,674	349,844	34,984	384,828	
31a	14.3	4883		26.2	19,650	11,528			2,897	704,428	70,443	774,871	
31b	1.3	632		2.9	2,175	1,276			263	15,618	1,562	17,180	
31c	5.6	1188		8.7	6,525	3,828			1,134	90,396	9,040	99,435	
24	9.4	2530		17.7	13,275	7,788			1,904	267,356	26,736	294,092	**1,684,882**
HWL			1897				3,149	88,173		88,173	8,817	96,990	
a	7.7	3152		19.5	14,625	8,580			234	266,128	26,613	292,741	
b	7.2	3566		23.9	17,925	10,516			219	282,040	28,204	310,244	
c	7.4	2732		16.1	12,075	7,084			225	225,039	22,504	247,543	
d	6.5	3068		14.7	11,025	6,468			198	217,714	21,771	239,485	
e	4.6	1673		8.6	6,450	3,784			140	94,988	9,499	104,487	
f	5.9	1774		12.7	9,525	5,588			179	129,107	12,911	142,017	
g	3.8	1675		6.5	4,875	2,860			115	77,816	7,782	85,598	**1,519,105**

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow conditions (critical conditions) were used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order to meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. BSPR is a more permanent treatment and can expect to achieve results for infinity. Although for comparison analysis between BSPR and other treatments a lifetime of fifty years is used, which is approximately the break even point when compared to the over passive and active treatment alternatives. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 25, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 25. Andrew Creek cost versus benefit analysis and acid load reduction

Site	Existing acid load (lbs/ day) A (net acidity x design Q)	Target acidity load ** (lbs/day) B (-67 mg/l x design Q)	Needed load reduction to meet target (lbs/day) C= (A+/B/)	Type of treatment	Expected acid load reduce -tion D	Remaining needed load reduction (lbs/day) E= (C x ((100-D)/100)))	Cost for lifetime of system (cost per day) F	Tons / 10-yr G= (C-E)/ 2000 x 365 x lifetime of 10 yr)	Benefit ratio (cost/ ton lifetime) H= (F/G)	Life-time (yrs)	Stream miles to next dst. input of AMD
AC-33	5228	-596	5,824	Active Doser	100%	0	555,949	10,629	$52	10	0.21
	5228	-596	5,824	BSPR	71%*	1689	257,866	7546	$34	10	0.21
	5228	-596	5,824	Passive VFP	100%	0	1,467,368	10,629	$138	10	0.21
	5228	-596	5,824	SAPS (WVU)	99%	58	73,853 {258,486}	10,523	$25	2.8 {10}	0.21
AC-44	4,449	-403	4,852	Active Doser	100%	0	517,899	8855	$58	10	0.42
	4,449	-403	4,852	BSPR	71%*	1407	1,684,882 {336,976}	6287	$54	50 {10}	0.42
	4,449	-403	4,852	Passive VFP	100%	0	1,163,710	8855	$131	10	0.42
	4,449	-403	4,852	SAPS (WVU)	99%	49	49,933 {214,712}	8765	$24	2.3 {10}	0.42
	4,449	-403	4,852	OLC (WVU)	98%	97	71,297 {237,657}	8678	$27	3.0 {10}	0.42
AC-29	1169	-165	1,334	Active Doser	100%	0	177,943	2435	$73	10	0.14
	1169	-165	1,334	Passive VFP	100%	0	333,997	2435	$137	10	0.14
	1169	-165	1,334	SAPS (WVU)	99%	13	20,432 {60,094}	2411	$25	3.4 {10}	0.14
AC-36	325	-16	341	Active Doser	100%	0	135,929	622	$219	10	0.14
	325	-16	341	Passive VFP	100%	0	79,534	622	$127	10	0.14
	325	-16	341	SAPS (WVU)	99%	3	1,993 {15,331}	617	$25	1.3 {10}	0.14

Table 25 continued. Andrew Creek cost versus benefit analysis and acid load reduction

AC-37	2811	-129	2940	Active Doser	100%	0	324,883	5366	$61	10	0.49
	2811	-129	2940	Passive VFP	100%	0	635,169	5366	$118	10	0.49
	2811	-129	2940	SAPS (WVU)	99%	29	16,046 {133,717}	5313	$25	1.2	0.49
	2811	-129	2940	OLC (WVU)	100%	0	31,688 {158,440}	5366	$30	2.0 {10}	0.49
AC-13	163	-238	401	Active Doser	100%	0	324,829	732	$444	10	1.05
	163	-238	401	Passive VFP	100%	0	241,409	732	$330	10	1.05
	163	-238	401	SAPS (WVU)	99%	4	29501 {18,210}	725	$25	16.2 {10}	1.05
AC-20	3737	-2086	5,823	Active Doser	100%	0	586,909	10,627	$55	10	0.30
	3737	-2086	5,823	BSPR	71%*	1689	257,866	7,545	$34	10	0.30
	3737	-2086	5,823	Passive VFP	100%	0	2,447,338	10,627	$230	10	0.30
	3737	-2086	5,823	SAPS (WVU)	99%	58	258,636 {263,914}	10,521	$25	9.8 {10}	0.30
AC-01	18,700	-4305	23,005	Active Doser	100%	0	1,928,849	41984	$46	10	3.06
AC-45	13,841	-3220	17,061	Active Doser	100%	0	1,587,129	31,136	$51	10	0.14
AC-46	18626	-3505	22,131	Active Doser	100%	0	1,927,519	40,389	$48	10	1.40

*71% is the known reduction in acidity at the SR 124 reclamation site in Raccoon Creek from 1997-2004.

**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Andrew Creek Subwatershed

After reviewing the water quality data and estimated costs of treating sites in Andrew Creek with members of the Technical Advisory Committee for the Moxahala Watershed Restoration Project, the following phased approached was decided. Since individual passive treatments systems (VFP) installed at each of the project sites mentioned in Table 25 totals $6,368,525, with an expected lifetime of 10 years, a different approach is considered. Installing two active doser systems would provide immediate buffering to Andrew Creek and the mainstem of Moxahala although active treatment systems are not a permanent solution. A more permanent solution is considered in phase II and III of this treatment strategy. Phase II and III provides a permanent solution by reclaiming hundreds of acres of abandoned strip mine land and installing steel slag beds as a way to add alkalinity to Andrew Creek in a passive system rather than an active doser.

Phase I -Install an two active pebble quick lime doser one at sites AC-20 downstream of Howard William Lake and the other at site AC-46 on the mainstem of Andrew Creek. This will require a conservation easement from private property owner before installation of treatment system. The total cost of phase I is $5,648,358 based on a 10 year lifetime (including annual chemical costs and maintenance). Phase I will consist of two 75 ton silo pebble quick active dosers and access pads. Access roads already exist for both sites. A settling pond will be needed below each doser to collect metals. Sludge removal costs are included annually for ten years. Appendix L shows the AMD Treat project cost for these two sites. AC-20 capital cost $259,848, annual cost $97,236. AC-20 total cost over a ten year lifetime $1,232,208. AC-46 capital cost $466,410, annual cost $394,974. AC-46 total cost over a ten year lifetime $4,416,150.

Phase II - Install steel slag beds near mouth of Andrew Creek in the identified alkaline streams (#6, 26, 8, 9, 25). Re-evaluation of the acidity in the mainstem after phase I is needed to calculate the amount alkalinity needed from slag pits.

Phase III - Complete the basic strip pit reclamation at sites AC-33, AC-44 (including a clay cap over slurry pond), and AC-20 (Howard William Lake) and control infiltration through spoil. Total cost of basic strip pit reclamation is $3,461,853 lifetime 50 years (ten year period $692,371) (Cost doesn't include cost of clay cap).

The total restoration cost in Andrew Creek over a ten year period equals $6,340,729. This cost is nearly equal to that of installing passive VFP at every site. However, the phased approach would provide a long-term solution to a very severely degraded watershed and possibly add extra buffering capacity to the mainstem of Moxahala for miles downstream of Andrew Creek. After the completion of phase II and III, the active doser installed at AC-20 would no longer be needed and could be moved to a different location in Moxahala Creek. The AC-20 doser wouldn't be needed because the acid load reduction expected from Phase II equals 50% of the acid produced from sites AC-33, 44, and 20.

Given this recommended treatment strategy the limiting factor in this plan for AMD remediation will be funding. Funding for this scale of a project will be difficult to secure.

Future Monitoring

Andrew Creek site AC-20 and AC-46 water quality will need to be monitored monthly for at least one year prior to installation of an active treatment doser as part of phase I restoration. This data will allow the determination of the highest flow condition to accurately determine its design flow and the needed chemical to effectively buffer the acid load produced during all flow regimes.

As part of phase II future monitoring, sites AC- 6, 8, 9, 25, and 26 will need be investigated and water quality monitored quarterly for one year to determine the flow rates and available space to size the steel slag beds.

Phase III monitoring needed prior to basic strip pit reclamation includes high and low sampling at the outlet of all discharging strip pits, strip pit impoundments, and receiving streams after water from strip pits run through the spoil. This will provide the needed pre-reclamation water quality data to determine effectiveness of the restoration and provide acidity concentrations of the impounded water to treat effectively during de-watering.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

Bear Creek

Basin Assessment

Bear Creek is located in Perry County on the Deavertown and New Lexington USGS topographic quadrangles and has a drainage area of 3.88 square miles. Bear Creek drains into the Moxahala Creek at RM 21.95, just south of Moore's Junction. The land within Bear Creek Subwatershed is privately owned and was primarily surfaced mined. Surfaced mines have left unreclaimed spoil piles, strip pit impoundments, barren soils, highwalls, slurry ponds, and acid mine drainage covering 763 acres (Appendix I – Surface mine information). While the surface mining impacts can be seen on the surface, Bear Creek Subwatershed also contains underground mines totaling 339 acres and auger mines. Table 26, shows the known and mapped underground deep mines in Bear Creek, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Bear Creek Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines.

Table 26. Bear Creek underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-215	Grey Eagle	1940	800
PY-182	King	1932	820
PY-299	Storts	1942	824
PY-193	Service	1922	
PY-338	Sunny Hill No.7	1967	886
PY-167	Bear Run #6	1942	816
PY-179	Buchanan	1937	818
PY-265	Parker	1937	
PY-270	Fred Price	1944	804
PY-214	Bear Run No.1	1924	
PY-181	Calhoon	1932	822

Impacts of Bear Creek on the Mainstem of Moxahala Creek

The impact from Bear Creek to the mainstem of Moxahala Creek is masked due to the highly degraded water discharging from Andrew Creek at RM 24.79 (Table 27) and other unmeasured sources of water between mainstem sites. To isolate the impact from Bear Creek a mainstem site would be needed directly upstream and downstream of Bear Creek (RM 21.95).

Table 27. Impacts of Bear Creek on the mainstem of Moxahala Creek

Site	pH	Conductivity µs/cm	Acidity mg/l
Upstream (RM 24.0)	3.0	1570	183
Bear Creek (RM 0.1/21.95)	3.19	1800	103
Downstream (RM 20.0)	3.12	1490	135

Summer 2004 data

Water Quality Investigation

Bear Creek Subwatershed produces on average 2,329 lbs/day of acid loading (90 mg/l of acidity concentration) and 714 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 15 and 16). The sites sampled in Bear Creek were located at the mouths of tributaries and at acid mine drainage sources. Comparing the average acid loading measured at each tributary site to the average acid loading measured at the mouth (BR-01), gives a percentage of acid load each site contributes in Bear Creek. This shows which sites are the largest producers of acidity. Table 28, shows the percent acid load each site contributes in Bear Creek.

Table 28. Bear Creek percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
BR-34	-18	-1
BR-18	34	2
BR-30	148	6
BR-29	205	9
BR-22	83	4
BR-26	115	5
BR-25	53	2
BR-37	13	1
BR-17	6	0.3
BR-15	80	4
BR-16	-3.4	-0.1
BR-13*	375	30

* BR-13 was measured separately from the rest of the sites and was compared to BR-01 in fall 2004 (1264lbs/day).

Table 28, shows the largest producer of acid in Bear Creek is site BR-13. The sites listed account for 63% of the average acid load produced in Bear Creek Subwatershed with 30% coming from BR-13.

Figure 15. Bear Run acid loading and acidity concentrations

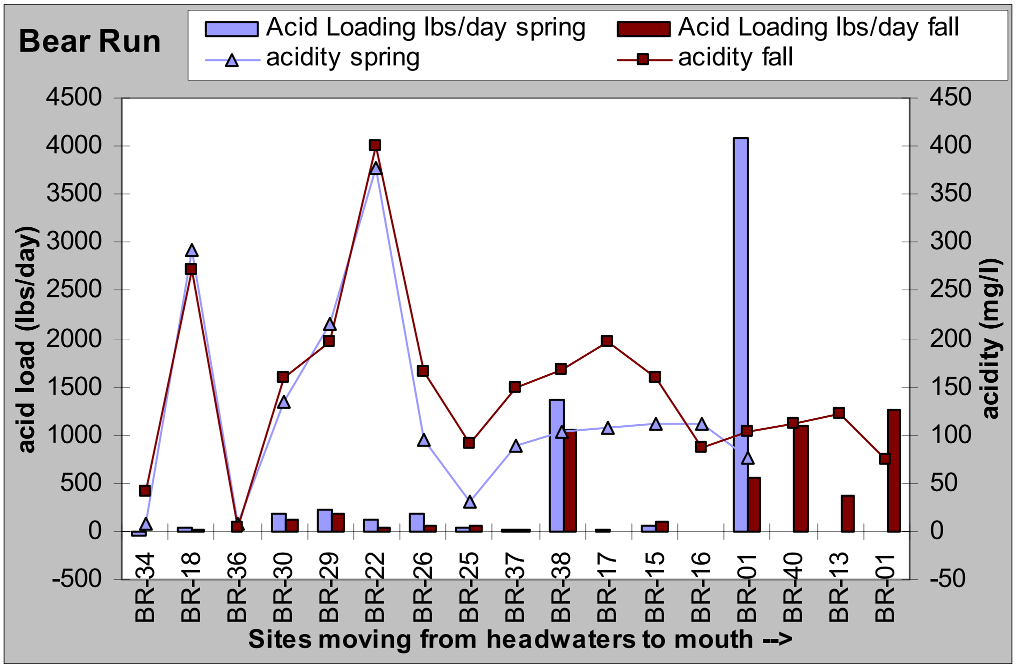
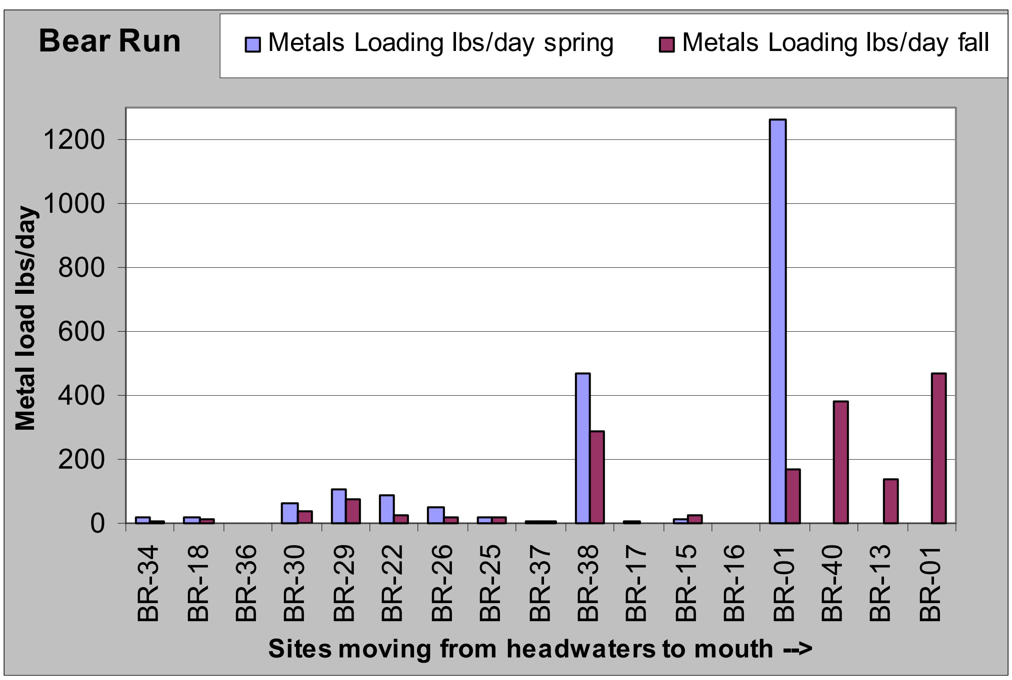


Figure 16. Bear Run metal loadings



Sample site locations can be found on Map 4 for Bear Creek Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 29.

Table 29. List of projects in Bear Creek Subwatershed

Sub-watershed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Township	County	Project name	Mines
Bear Creek	#18	Slurry pond	Lindamood	New Lexington	Pike	Perry	Lindamood South	SM
Bear Creek	#30	36,39,52	Dorsey & Garcia	New Lexington	Pike	Perry	Garcia/ Dorsey North	PY-193, SM*
Bear Creek	#29	29,28	Dorsey	New Lexington	Pike	Perry	Dorsey strip pit	SM*
Bear Creek	#22	22	Lindamood	New Lexington	Pike	Perry	Lindamood seep	PY-338
Bear Creek	#26	27,41,42,43,44	Gene Sumner	New Lexington	Pike	Perry	Gene Sumner North	SM*
Bear Creek	#25	17,37,45,46,47	Eli Sumner & Stort	New Lexington	Pike	Perry	Stort's Mine North	PY-229, SM*
Bear Creek	#15	48,49,50,51	Bruce	New Lexington	Pike & Bearsfield	Perry	Gildee North	PY-229
Bear Creek	#13	53,54,55,56, 57,58,59,60, 61,62	Dennis & Chestnut Ridgeland Co.	New Lexington	Pike & Bearsfield	Perry	Dennis/Chestnut	PY-214, PY-182, SM*

1) BR -18 – Lindamood South

Location/Access

Site BR-18, Lindamood South project, is located on private property east of Jamestown Rd (CR 56) on the south side of SR 93/13/37 and Bear Creek. BR-18 is an AMD source discharge that drains into a ditch along CR 56 then flows north into Bear Creek near its headwaters at RM 3.05. The site is accessible by road and is located in Section 14 of Pike Township, Perry County.

Site Description

BR-18 is an upwelling of AMD that originates from a covered slurry pond, pH 3.9. The area east of BR-18 had been previously surfaced mined and contained the waste material from the mining operation creating a slurry pond. The slurry pond was reclaimed in 1990. BR-18 is the residual AMD that still percolates through the buried slurry pond. BR-18 flow rate during spring 2004 was 13 gpm and during the fall 2004 it was 8 gpm. BR-18 is one of the smaller contributors of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 2% of the acid and 4% of the metals among all sites in Bear Creek. This site contributes 12,410 lbs of acid and 5,840 lbs of metals annually to Bear Creek (Table 30).

Table 30. BR-18 Net acid and metal loadings

BR-18	High Flow	Low Flow	Average
Acid load (lbs/day)	44	25	34
% Acid load contribution	5	3	2
Metal load (lbs/day)	21	11	16
% Metal load contribution	5	3	4

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*)

2) BR -30 Garcia and Dorsey North Project

Location/Access

Site BR-30, Garcia and Dorsey North project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 2.90 and drains a 0.024 square mile area. Site BR-30 is located at the mouth of the tributary at RM 0.05. The site is accessible by road in Sections 14, Pike Township, Perry County.

Site Description

Garcia and Dorsey North project includes the following sites: BR-36, 39, and 52. Site BR-36 is a discharging strip pit impoundment that contains fish and near neutral pH values (6.58). However there is a small deep mine complex (PY-193) in the northern part of the strip pit that could possibly be supplying water to the pit impoundment. The water exiting this strip pit impoundment poorly drains across spoil and creates a marshy area, site BR-39 (pH 5.60). Site BR-52 is also seepage through spoil, pH value 2.93. BR-30 flow rate during spring 2004 was 110 gpm and during the fall 2004 it was 61 gpm. On average BR-30 is the third largest contributor of acid and fourth largest contributor of AMD metals in Bear Creek Subwatershed, contributing approximately 10% of the acid and 12% of the metals among all sites in Bear Creek. This site contributes 54,020 lbs of acid and 18,615 lbs of metals annually to Bear Creek (Table 31).

Table 31. BR-30 Net acid and metal loadings

BR-30	High Flow	Low Flow	Average
Acid load (lbs/day)	179	117	148
% Acid load contribution	20	12	10
Metal load (lbs/day)	62	40	51
% Metal load contribution	15	11	12

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

3) BR -29 Dorsey Strip pit

Location/Access

Site BR-29, Dorsey Strip pit project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 2.80 and drains a 0.017 square mile area. Site BR-29 is located at the mouth of the tributary at RM 0.05. The site is accessible by road in Sections 14, Pike Township, Perry County.

Site Description

Dorsey Strip pit project includes the following sites: BR-29 and 28. Site BR-29 is a discharging strip pit impoundment that drains water through spoil, pH 2.93. Site BR-28 is also seepage through spoil, pH value 3.00. BR-29 flow rate during spring 2004 was 89 gpm and during the fall 2004 it was 76 gpm. On average BR-29 is the second largest contributor of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 14% of the acid and 20% of the metals among all sites in Bear Creek. This site contributes 74,825 lbs of acid and 32,485 lbs of metals annually to Bear Creek (Table 32).

Table 32. BR-29 Net acid and metal loadings

BR-29	High Flow	Low Flow	Average
Acid load (lbs/day)	230	179	205
% Acid load contribution	26	18	14
Metal load (lbs/day)	105	73	89
% Metal load contribution	26	20	20

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

4) BR -22– Lindamood Seep

Location/Access

Site BR-22, Lindamood Seep project, is located on private property south of SR 93/13/37 and Bear Creek. It is an acidic discharge that enters the mainstem of Bear Creek at RM 2.50. Site BR-22 is located 60 feet south of Bear Creek. The site is accessible by foot in Sections 13, Pike Township, Perry County.

Site Description

Lindamood Seep project consists of an AMD discharging seep that is likely connected to Sunny Hill No.7 mine, PY 338, abandoned in 1967, pH value 5.26. BR-22 flow rate during spring 2004 was 30 gpm and during the fall 2004 it was 8 gpm. On average BR-22 is the fifth largest contributor of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 6% of the acid and 12% of the metals among all sites in Bear Creek. This site contributes 30,295 lbs of acid and 19,710 lbs of metals annually to Bear Creek (Table 33).

Table 33. BR-22 Net acid and metal loadings

BR-22	High Flow	Low Flow	Average
Acid load (lbs/day)	132	35	83
% Acid load contribution	15	4	6
Metal load (lbs/day)	84	24	54
% Metal load contribution	21	7	12

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

5) BR -26 – Gene Sumner North

Location/Access

Site BR-26, Gene Sumner North project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 2.35 and drains a 0.22 square mile area. Site BR-26 is located at the mouth of the tributary at RM 0.05. The site is accessible by road in Sections 14, Pike Township, Perry County.

Site Description

Gene Sumner North project includes the following sites: BR-27, 41, 43, and 44. Site BR-41 is a discharging strip pit impoundment (pH 3.55), the water discharges across spoil creating a marshy braided steam that flows east where it joins with flow from site BR-43 and then flows through strip pit site BR-44. BR-43 is located downstream of a surface mine area with a highwall but no impoundment exists. The drainage from the area flows south in a wide, braided, marshy pattern at the base of the highwall, pH 3.83. BR-44 is a surface mining impoundment that collects drainage from BR-43 and BR-41, pH 3.39. BR-27 is a collection of water that seeps through spoil from the surface mining operations north of the site, pH values (3.08). BR-26 flow rate during spring 2004 was 155 gpm and during the fall 2004 it was 28 gpm. On average BR-26 is the fourth largest contributor of acid and fifth largest contributor of AMD metals in Bear Creek Subwatershed, contributing approximately 8% of the acid and 8% of the metals among all sites in Bear Creek. This site contributes 41,975 lbs of acid and 12,410 lbs of metals annually to Bear Creek (Table 34).

Table 34. BR-26Net acid and metal loadings

BR-26	High Flow	Low Flow	Average
Acid load (lbs/day)	175	56	115
% Acid load contribution	20	6	8
Metal load (lbs/day)	51	16	34
% Metal load contribution	13	4	8

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

6) BR -25 – Stort's Mine North

Location/Access

Site BR-25, Stort's Mine North project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 2.15 and drains a 0.20 square mile area. Site BR-25 is located at the mouth of the tributary at RM 0.1. The site is accessible by road in Sections 12 and 13, Pike Township, Perry County.

Site Description

Stort's Mine North project includes the following sites: BR-17, 37, 45, 46, and 47. Site BR-17 is a discharging drain pipe from the Stort's Mine, PY-229, abandoned in 1942 (pH 3.04), the water drains out of the pipe and crosses under SR 93/13/37 and discharges directly into Bear Creek mainstem (All the other sites in the Stort's Mine Project discharge into the tributary site BR-25). BR-37 is a direct discharge from Stort's Mine, PY-229, however this site discharges through a vertical riser pipe installed by the landowner to aid in controlling the elevation of the water in the mine to reduce oxygen. Dissolved oxygen of the discharging water is less than 0.5 mg/l and a pH of 4.55. BR- 46 is a wet, marshy pond area near the northern extent of the Stort's Mine, pH 3.76. BR-45 is a strip pit impoundment near the headwaters of the tributary, pH 5.70 and site BR-47 is in the mainstem of the headwaters that flows through a series of beaver ponds and spoil, pH 5.79. BR-25 flow rate during spring 2004 was 134 gpm and during the fall 2004 it was 53 gpm. On average BR-25 is one of the smaller contributors of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 4% of the acid and 4% of the metals among all sites in Bear Creek. This site contributes 19,710 lbs of acid and 6,205 lbs of metals annually to Bear Creek (Table 35).

Table 35. BR-25 Net acid and metal loadings

BR-25	High Flow	Low Flow	Average
Acid load (lbs/day)	49	58	53
% Acid load contribution	4	4	4
Metal load (lbs/day)	17	16	17
% Metal load contribution	5	6	4

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

7) BR -15 – Gildee North

Location/Access

Site BR-15, Gildee North Project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 1.71 and drains a 0.08 square mile area. Site BR-15 is located at the mouth of the tributary at RM 0.05. The site is accessible by road in Sections 12, Pike Township, Perry County.

Site Description

Gildee North Project includes the following sites: BR-48, 49, 50, and 51. These sites are all located within the tributary BR-15. This tributary had poor water quality at the mouth (pH 3.46) and relatively good water quality in the headwaters (pH 6.21) and a distinct orange color change half-way up the tributary. Groundwater enters the stream bottom near sites BR-49 and BR-50. The likely source of this water is from the Stort's Mine, PY-229. The eastern edge of the mine aligns with the mainstem of the tributary BR-15. BR-15 flow rate during spring 2004 was 44 gpm and during the fall 2004 it was 54 gpm. On average BR-15 is one of the smaller contributors of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 6% of the acid and 4% of the metals among all sites in Bear Creek. This site contributes 29,200 lbs of acid and 6,935 lbs of metals annually to Bear Creek (Table 36).

Table 36. BR-15 Net acid and metal loadings

BR-15	High Flow	Low Flow	Average
Acid load (lbs/day)	59	102	80
% Acid load contribution	7	11	6
Metal load (lbs/day)	15	24	19
% Metal load contribution	4	6	4

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

8) BR -13 – Dennis/Chestnut Project

Location/Access

Site BR-13, Dennis/Chestnut Project, is located on private property north of SR 93/13/37 and Bear Creek. It is a tributary that enters the mainstem of Bear Creek at RM 1.50 and drains a 0.86 square mile area. Site BR-13 is located at the mouth of the tributary at RM 0.05. The site is accessible by road in Section 7, Bearsfield Township and Section 12, Pike Township, Perry County.

Site Description

Dennis/Chestnut Project includes the following sites: BR-53, 54, 55, 56, 57, 58, 59, 60, 61, and 62. Site BR-53 (pH 3.66), 55 (pH 4.57), and 56 (pH 5.83) all drain through BR-54 (pH 3.89) from the surface mine pit impoundments on the east side of the BR-13 tributary. The west side strip pit impoundments drain at point BR-61 (pH 2.95) and includes site BR-59 (pH 2.97). Site BR-60 measures water that drains through spoil before discharging into the mainstem (pH 3.00). Site BR-62 is an upwelling of mine water through spoil near the mouth, pH 6.09. Site BR-57 and 58 are sites upstream of surface mining collected in the natural drainage channel pH 6.45 and 6.40, respectively. BR-13 flow rate was only measured once during fall 2004 during low to medium flow regime (257 gpm). BR-13 is the largest contributor of acid and AMD metals in Bear Creek Subwatershed, contributing approximately 49% of the acid and 31% of the metals among all sites in Bear Creek. This site contributes 137,240 lbs of acid and 171,550 lbs of metals annually to Bear Creek (Table 37).

Table 37. BR-13 Net acid and metal loadings

BR-13	High Flow	Low –Medium Flow	Average
Acid load (lbs/day)	NA	376	NA
% Acid load contribution	NA	38	49
Metal load (lbs/day)	NA	138	NA
% Metal load contribution	NA	38	31

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Bear Creek Subwatershed. In addition to AMD Treat, costs for standard reclamation of strip pit impoundments were estimated from the area and length of the ponds, 1% grade channels, 2:1 slope - c rock transition channels from reclaimed channel to receiving stream, re-vegetation area, lime material, treating the impoundment during dewatering, and mobilization. Table 38, summarizes the cost estimates from various treatment alternatives from the AMD Treat program. Table 39, summarizes the cost estimated for basic strip pit reclamation (BSPR).

Table 38. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Manganese Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual chemical) ($)	Primary Retention Pond ($)	Secondary Pond ($)	Sludge removal ($)
br-01	$3,855,196	$1,176,566	$15,306,167	$8,963,762	$1,970,027	$120,419	$55,359	$171,730	$145,481	$34,815
br-13	$253,083	$82,930	$816,306	$496,066	$114,308	$120,419	$7,009	$11,273	$8,495	$3,675
br-40	$1,102,276	$266,045	$6,780,330	$3,993,112	$627,801	$120,419	$22,609	$71,689	$46,431	$33,493
br-16	$37,096	$10,474	$133,152	$86,758	$16,075	$32,239	$745	$5,000	$5,000	$703
br-15	$57,942	$18,603	$44,712	$31,643	$23,665	$48,513	$1,405	$5,000	$5,000	$817
br-17	$12,662	$3,678	$5,639	$5,564	$4,198	$32,239	$152	$5,000	$5,000	$91
br-38	$1,084,638	$379,887	$4,480,328	$2,648,774	$490,721	$120,419	$23,791	$49,580	$36,309	$17,594
br-37	$12,002	$3,153	$11,581	$9,825	$4,198	$32,239	$251	$5,000	$5,000	$292
br-25	$115,753	$29,424	$202,154	$128,868	$59,387	$48,513	$1,724	$5,106	$5,000	$895
br-26	$156,812	$51,904	$763,077	$464,478	$68,764	$48,513	$2,584	$6,481	$5,123	$1,795
br-22	$51,913	$23,700	$303,088	$189,885	$13,395	$32,239	$1,189	$5,000	$5,000	$2,409
br-29	$108,576	$41,855	$447,271	$276,388	$39,740	$111,013	$3,243	$5,903	$5,000	$3,876
br-30	$185,707	$91,763	$435,941	$269,610	$49,116	$111,013	$5,997	$5,402	$5,000	$2,291
br-18	$20,109	$7,669	$58,363	$40,314	$5,582	$32,239	$504	$5,000	$5,000	$689

Table 39. Summary of basic strip pit reclamation (BSPR)

Site	area of pond	length	Trans. Channel	re-veg area	re-veg	lime material	2:1 slope trans. rock channel	C rock	est. quicklime dewatering	sub-total	mobili-zation	final cost	Project total
	acres	ft	ft	acres	$750/ac	$440/ac	1.66tons/ linear ft.	$28/ton	(WVU) ($)	($)	10% final cost	($)	($)
BR-30			770				1,278	35,790		35,790	3,579	39,369	
29	7	2867		15	11,250	6,600			51	220,825	22,083	242,908	**282,276**
BR-26			1951				3,239	90,682		90,682	9,068	99,751	
41	2.7	1483		6.7	5,025	2,948			115	53,201	5,320	58,521	
44	0.9	560		2.1	1,575	924			54	10,220	1,022	11,242	
43*	1.2	2538		1.2	900	528				32,712	3,271	35,983	**205,496**
BR-25			312				518	14,502		14,502	1,450	15,952	
45**	1.2	712		2.8	2,100	1,232			10	15,173	1,517	16,690	**32,642**
BR-13			1528				2,536	71,021		71,021	7,102	78,124	
54**	9.4	7268		15.8	11,850	6,952			457	658,385	65,838	724,223	
61**	6.8	5560		13.7	10,275	6,028			661	375,921	37,592	413,514	**1,215,860**

*43 Strip pit bottom marshy with braided channel no ponds are present, channel length multiplied by 20ft wide to calculate area to determine costs

**45, 54, 61 estimated strip pit maximum depth of 8ft

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow conditions (critical conditions) were used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. BSPR is a more permanent treatment and can expect to achieve results for infinity. Although for comparison analysis between BSPR and other treatments a lifetime of fifty years is used, which is approximately the break even point when compared to the over passive and active treatment alternatives. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 40, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 40. Bear Creek cost versus benefit analysis and acid load reduction

Site	**Existing acid load (lbs/ day)** A (net acidity * design Q)	**Target acidity load ** (lbs/day)** B (-67 mg/l* design Q)	**Needed load reduction to meet target (lbs/day)** C= (A+/B/)	**Type of treatment**	**Expected acid load reduce -tion** D	**Remaining needed load reduction (lbs/day)** E= (C*((100-D)/100)))	**Cost for lifetime of system (cost per day)** F	**Tons / 10-yr** G= (C-E)/ 2000* 365* lifetime of 10 yr)	**Benefit ratio (cost/ ton lifetime)** H= (F/G)	**Life-time (yrs)**	**Stream miles to next dst. input of AMD**
BR-18	42	-10	52	Active Doser	100%	0	$37,279	95	$392	10	0.15
	42	-10	52	Passive VFP	100%	0	$20,109	95	$212	10	0.15
	42	-10	52	ALD	100%	0	$7,669	95	$81	10	0.15
BR-30	554	-88	643	Active Doser	100%	0	$170,983	1173	$146	10	0.47
	554	-88	643	Passive VFP	100%	0	$185,707	1173	$158	10	0.47

Table 40 continued. Bear Creek cost versus benefit analysis and acid load reduction

BR-29	220	-72	292	Active Doser	100%	0	$143,443	533	$269	10	0.47
	220	-72	292	Passive VFP	100%	0	$108,576	533	$204	10	0.47
	220	-72	292	BSPR	71%	85	$282,276 {56,455}	378	$149	50 {10}	0.47
BR-22	140	-24	164	Active Doser	100%	0	$44,129	299	$148	10	0.12
	140	-24	164	Passive VFP	100%	0	$51,913	299	$174	10	0.12
	140	-24	164	ALD	100%	0	$23,700	299	$79	10	0.12
BR-26	238	-124	362	Active Doser	100%	0	$74,353	661	$115	10	0.23
	238	-124	362	Passive VFP	100%	0	$156,812	661	$237	10	0.23
	238	-124	362	BSPR	71%	105	$205,496 {41,099}	469	$87	50 {10}	0.23
BR-25	97	-107	204	Active Doser	100%	0	$65,753	372	$177	10	0.25
	97	-107	204	Passive VFP	100%	0	$115,753	372	$311	10	0.25
37	13	-8	21	ALD	100%	0	$3,153	38	$83	10	0.25
BR-15	86	-43	129	Active Doser	100%	0	$62,563	235	$266	10	1.6
	86	-43	129	Passive VFP	100%	0	$57,942	235	$247	10	1.6
	86	-43	129	Passive aerobic wetland	100%	0	$31,643	235	$135	10	1.6
BR-13	375	-206	581	Active Doser	100%	0	$190,509	1060	$180	10	1.32
	375	-206	581	Passive VFP	100%	0	$253,083	1060	$239	10	1.32
	375	-206	581	BSPR	71%	169	$1,215,860 {243,172}	752	$323	50 {10}	1.32
BR-38	1794	-884	2677	Active Doser	100%	0	$250,329	4886	$51	10	1.85
	1794	-884	2677	OLC (WVU)	76%	643	$191,222 {51,962}	3712	$14	36.8 {10}	1.0
BR-40	742	-1130	1873	Active Doser	100%	0	$346,509	3418	$101	10	1.5
BR-01	4765	-3547	8312	Active Doser	100%	0	$674,009	15,169	$44	10	3.04
	4765	-3547	8312	OLC (WVU)	16.2	6982	$71,708 {22,132}	2,427	$9	32.4 {10}	3.04

*71% is the known reduction in acidity at the SR 124 site in Raccoon Creek from 1997-2004.
**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Bear Creek Subwatershed

After reviewing the water quality data and estimated costs of treating sites in Bear Creek with members of the Technical Advisory Committee for the Moxahala Watershed Restoration Project, the following phased approached was decided. Individual passive treatments systems (VFP) installed at each of the project sites mentioned in Table 40 totals $949,895 with an expected lifetime of 10 years.

Although this is cheaper than installing a doser and completing BSPR, a different approach is considered because the logistics of constructing eight VFP in one sub-basin would be more difficult than installing one doser and have immediate results. Installing one active doser systems would provide immediate buffering to Bear Creek and the mainstem of Moxahala although active treatment systems are not a permanent solution. A more permanent solution is considered in phase II and III of this treatment strategy. Phase II and III provides a permanent solution by reclaiming hundreds of acres of abandoned strip mine land and installing ALDs and VFP at a limited number of sites.

Phase I -Install one active pebble quick lime doser upstream of site BR-01 to treat all AMD discharging from Bear Creek until more permanent reclamation activities are established. This will require a conservation easement from private property owner before installation of treatment system. Phase I will consist of one 75 ton silo pebble quick active doser and access pad. A settling pond will be needed below the doser to collect metals. Sludge removal costs are included annually for ten years (Appendix L - AMD Treat cost). BR-01 capital cost $292,899, annual cost $114,791. The total cost of phase I is $1,440,809 based on a 10 year lifetime (including annual chemical costs and maintenance).

Phase II complete the basic strip pit reclamation needed in Bear Creek Subwatershed. Start with BR-13, Dennis Chestnut Project, followed by site BR-29, Dorsey strip pit, and then BR-26, Gene Sumner North Project. Total cost of basic strip pit reclamation is $1,703,632.

Phase III after completion of Phase I and II, re-evaluate the acid loading in Bear Creek. Final reclamation in Bear Creek if needed after re-evaluation is to install an ALD at site BR-37 and passive vertical flow ponds at site BR-18 and BR-22. Costs of these sites are: BR-37 capital $8,968, annual $3,472, BR-18 capital $28,010, annual $3,472, and BR-22 capital $64,208, annual $3,472. Total costs over a 10-yr lifetime $205,346.

Total cost of reclamation in Bear Creek is $3,349,787 over a time period of ten years.

Future Monitoring

Bear Creek site BR-01 and BR-40 water quality will need to be monitored monthly for at least one year prior to installation of an active treatment doser as part of phase I restoration. This data will allow the determination of the highest flow condition to accurately determine its design flow and the needed chemical to effectively buffer the acid load produced during all flow regimes.

Phase II monitoring needed prior to basic strip pit reclamation includes high and low sampling at the outlet of all discharging strip pits, strip pit impoundments, and receiving streams after water from strip pits run through spoil. This will provide the needed pre-reclamation water quality data to determine effectiveness of the restoration and provide acidity concentrations of the impounded water to treat effectively during de-watering.

Phase III monitoring plan after re-evaluation of results from Phase I and II, begin water quality sampling quarterly for one year to sufficient data to design for an ALD at site BR-37 and passive vertical flow ponds at site BR-18 and BR-22.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

McLuney Creek

Basin Assessment

McLuney Creek is the largest of the priority tributaries, with a drainage area of 8.09 square miles. McLuney Creek is located Perry County within three USGS topographic quadrangles; Deavertown, Crooksville, and Fultonham. McLuney Creek is located on the west side of Moxahala Creek near the town of McLuney at RM 18.4. McLuney Creek watershed is marked by surface mines and deep mines. Previously surface mines were in operation during the 1960's and 1970's mimng 2,043 acres of land, leaving unreclaimed spoil piles, strip pit impoundments, barren soils, highwalls, slurry ponds, and acid mine drainage (Appendix I – Surface mine information). While the surface mining impacts can be seen on the surface, McLuney Creek Subwatershed was also underground mined (895 acres). Table 41, shows the known and mapped underground deep mines in McLuney Creek, date the mine was abandoned, name of the mine, and in some cases the mine elevation. Underground mines in McLuney Creek Subwatershed mined the Middle Kittanning No. 6 and Lower Kittanning No 5. coal seam and were above drainage mines. On the south side of McLuney Creek, Oxford Mining has a permit to surface mine the south side of McLuney Creek in the upper part of the watershed.

Table 41. McLuney Creek underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-003	Beech Grove	1908	
**PY-224	Hill No. 1	1920	
PY-005	Block	1906	
PY-002	Green Valley-Lyonsdale	1908	
*PY-304	Taylor	1938	
PY-131	Redfield No. 3	1924	
*PY-101	Redfield No. 1	1924	924
*PY-083	Redfield No. 1-A	1921	
*PY-141	Keystone No. 6	1929	916
**PY-276	Keystone No. 10	1938	
*PY-115	Keystone No. 4	1938	
*PY-273	Keystone No. 1	1940	893
*PY-250	Midway	1939	889
PY-342	Keystone No. 3	1937	
*PY-242	Keystone No. 6	1937	879
*PY-130	Keystone No. 11	1939	891
PY-219	Keystone	1935	925
**PY-163	Alwine	1931	
PY-073	Mc Luney No. 2 & 3	1923	861
PY-086	Elk Mine No. 2	1920	
PY-355	Keystone No. 1	1917	848
PY-142	Keystone No. 1	1920	915

*Denotes underground mines in the Lower Kittanning No. 5 formation
**Denotes underground mines in unidentified formations

Impacts of McLuney Creek on Mainstem of Moxahala Creek

The impact from McLuney Creek to the mainstem of Moxahala Creek is masked due to the highly degraded water discharging from Andrew Creek and Bear Creek upstream at RM 24.79 and 21.95 Table 42). The impact from McLuney Creek shows a small increase in pH, decrease acidity and conductivity. This could be due to unmeasured sources of water between mainstem sites.

Table 42. Impacts of McLuney Creek on the mainstem of Moxahala Creek

Site	pH	Conductivity µs/cm	Acidity mg/l
Upstream (RM 20.0)	3.12	1490	135
McLuney Creek (RM 18.4, RM 0.1)	3.28	1520	96
Downstream (RM 17.9)	3.51	1320	79

Summer 2004 data

Water Quality Investigation

McLuney Creek Subwatershed produces on average 4,062 lbs/day of acid loading, 70 mg/l of acidity, and 913 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 17 and 18). The sites sampled in McLuney Creek were located at the mouths of tributaries and at acid mine drainage sources. Comparing the average acid loading measured at each tributary site to the average acid loading measured at the mouth (ML-01), gives a percentage of acid load each site contributes in McLuney Creek. This shows which sites are the largest producers of acidity. Table 43, shows the percent acid load each site contributes in McLuney Creek.

Table 43. McLuney Creek percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
ML-21	-273	-7
ML-20 (ML-20 includes Rort seep and	746 (257, 450)	18 (6, 11)
ML-16*	730	18
Ml-14*	535	13
ML-49	357	9
ML-06	890	22
ML-38	578	14

*ML-16 and ML-14 drain the same subwatershed but flows diverged near mouth of tributary.

Table 43 shows the largest producers of acid in McLuney Creek are sites ML-16 & ML-14 followed by site ML-06. The sites listed account for in average 87% of the acid load produced in McLuney Creek Subwatershed with 31% coming from ML -16 & ML-14.

Figure 17. McLuney Creek acid loading and acidity concentrations

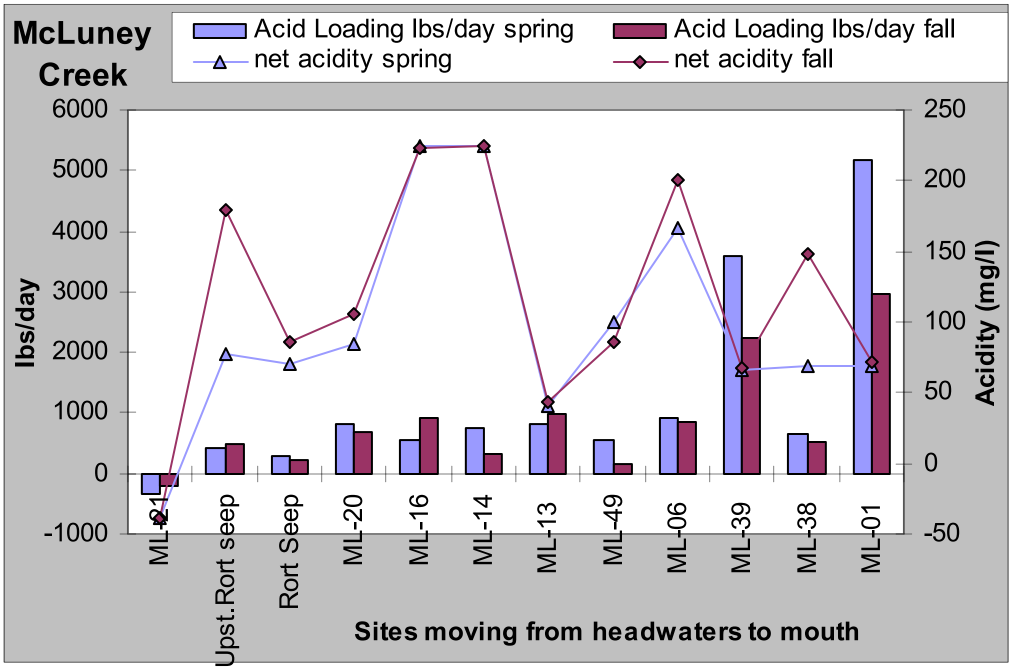
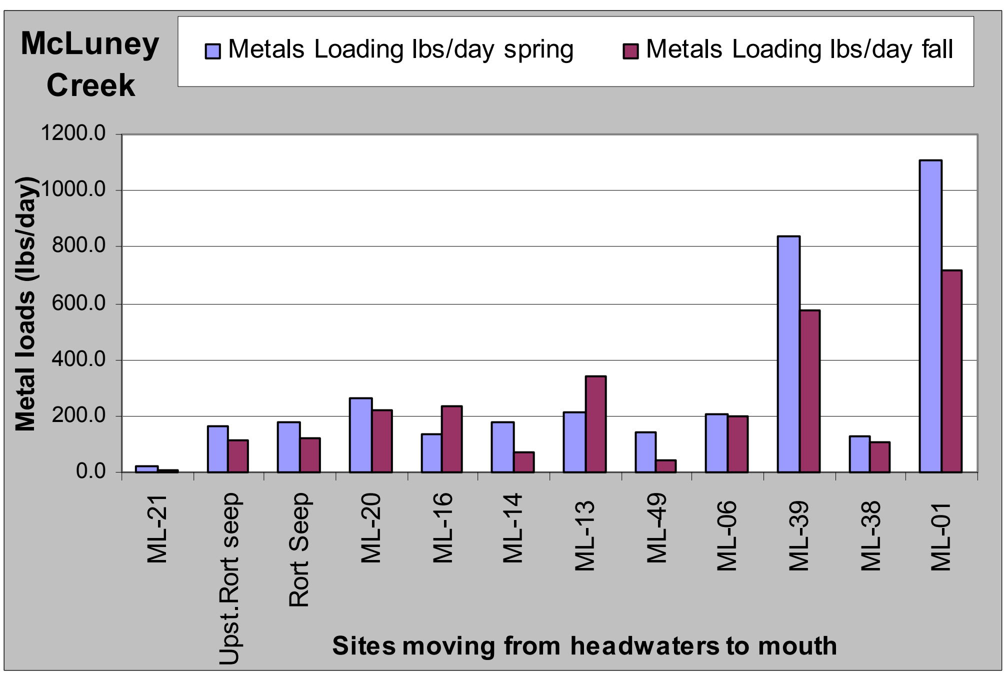


Figure 18. McLuney Creek metal loadings



Sample site locations can be found on Map 5 for McLuney Creek Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 44.

Table 44. List of Projects within the McLuney Creek Subwatershed

Sub-water-shed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Town-ship	County	Project name	Mines
McLuney	#20	75, 76	Rort	Deavertown, Fultonham, New Lexington	Harrison & Clayton	Perry	Rort	PY 83, PY101, SM*
McLuney	#14, #16	57,58,59,60, 61,62,63,64, 65,66	Oxford, Newton, Wince	Deavertown, Fultonham, New Lexington	Harrison & Clayton	Perry	Newlon	PY 250, PY130, PY 141, PY 342, PY242, PY276, PY 273, SM*
McLuney	#49		Foraker & Oxford	Deavertown, Fultonham, New Lexington	Harrison & Clayton	Perry	McLuney South	PY 202, SM*
McLuney	#6	67,68,69,70, 71,72,73,74	Treadway & McConnell	Deavertown, Fultonham, New Lexington	Harrison & Clayton	Perry	Treadway	PY 73, PY 163, PY 355, PY 142, SM*
McLuney	#38	Tunnel Hill sites	Oxford & Rambo	Deavertown, Fultonham, New Lexington	Harrison & Clayton	Perry	Tunnel Hill	PY 005, PY 86, PY 202, SM*

1) ML–20 – Rort Project

Location/Access

Site ML-20 the Rort project, is located on privately owned land north of the intersection of County Road 48 and Clayton Twp. Rd. 162A. It is the tributary that enters into the mainstem of McLuney Creek at RM 4.53 and drains an area of 0.64 square miles. ML-20 is located at the mouth of the tributary at river-mile 0.05. It is accessible by road in Section 26, Clayton Township, Perry County.

Site Description

The Rort Project includes sites ML-75 and 76. Site ML-75 is a deep mine discharge (pH 4.56) located near the mouth of ML-20 tributary at RM 0.15. Site ML-76 is upstream of ML-75 and consists of a series of beaver dams and pit impoundments that drain through spoil along the valley with no deep mine discharges (pH 3.16). ML-20 had a flow rate of 535 gpm in the fall of 2004 and 806 gpm in the spring of

2004. On average ML-20 is the third largest contributor of acid and the second largest contributor of AMD metals in the McLuney Creek Sub-watershed, contributing 19% of the acid and 24% of the metals among all sites in McLuney Creek. This site contributes 272,290 lbs of acid and 87,965 lbs of metals annually to McLuney Creek (Table 45).

Table 45. ML-20 Net acid and metal loadings

ML-20	High Flow	Low Flow	Average
Acid load (lbs/day)	811	681	746
% Acid load contribution	19	20	19
Metal load (lbs/day)	262	221	241
% Metal load contribution	25	25	24

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

2) ML-14 & 16 Newlon Project

Access/Location

Site ML-14 & 16, the Newlon Project, is located on privately owned land north of County Road 48. It is a wetland area with a diverging flow, therefore two sites were established to accurately measure the water discharging from the tributary. ML-14 enters McLuney Creek at RM 3.62 and ML-16 enters at RM 3.70. Combined ML-14 & 16 drain a 0.472 square mile area. Both are located at the mouth of the tributary. This site can be accessed by road in Section 25, Harrison Township, Perry County.

Site Description

The Newlon Project includes sites, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66. At the mouth of the tributary is a wetland with diverging flow paths the western channel is site ML-16 (pH 2.94) and ML-14 (pH 2.89) is on the eastern side of the wetland. There is a dirt access road near ML-14 that heads north. Site ML-57 (pH 3.14) is a collection of diffuse water running out of the hillside just north of site ML-14 on the right side of the access road draining into site ML-14. The source of this water is likely connected to deep mine Keystone #11, PY-130, abandoned in 1939. Mine elevation and surface elevation intersect at 891 ft creating a seepage point. Traveling northwest on the access road a culvert made of a hollowed out tree drains two shallow ponds ML-60 (pH 2.94) and ML-58 (pH 2.94) and drainage of water flowing through severely eroded spoil, ML-59 (pH 3.32). Two deep mines exist in this area Keystone No.6, PY-242, and Keystone No.3, PY-342, both abandoned in 1937. Crossing over the hollow tree culvert and heading northwest there is another strip pit impoundment and spoil, ML-61 (pH 2.96). The main drainage pattern north of this point is a series of impoundments, spoil, exposed “fire clay”, and seepage of water through spoil, ML-62 (pH 3.11), ML-63 (pH 2.60), ML-64 (pH 3.21), ML-65 (pH 2.91), and ML-66 (pH 4.86) (Map 5 McLuney Creek Subwatershed). One large deep mine in this area is Keystone No.6, PY 141, abandoned in 1929. There are smaller deep mines also located within this project area: PY-276, PY-115, PY-250, and PY-273. ML-14 and ML-16 combined had a flow rate of 479 gpm in the spring of 2004 and 462 gpm in the fall of 2004. On average ML-14 & 16 are the largest contributor of acid and AMD metals in the McLuney Creek Sub-Watershed, contributing 33% of the acid and 32% of the metals among all sites in McLuney Creek. ML-14 & 16 contributes 461,725 lbs of acid and 112,055 lbs of metals annually to McLuney Creek (Table 46).

Table 46. ML 14&16- Net acid and metal loadings

ML-14&16	High Flow	Low Flow	Average
Acid load (lbs/day)	1290	1240	1265
% Acid load contribution	31	35	33
Metal load (lbs/day)	308	397	307
% Metal load contribution	29	34	32

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

3) ML-49 McLuney South Project

Access/Location

Site ML-49, McLuney South, is located on land owned by Oxford Mining Company south of County Road 48. It is a tributary entering McLuney Creek at RM 2.85 and it drains an area of 0.39 square miles. ML-49 is located at the mouth of the tributary at RM 0.08. It is accessible by foot along a dirt path in Section 25, Harrison Township, Perry County.

Site Description

The McLuney South Project consists of a series of strip pit impoundments and spoil. Site ML-49 (pH 3.7) is located at the mouth of the tributary that drains a series of strip pits from the south into McLuney Creek. There is one deep mine Green Valley-Lyonsdale, PY 002, abandoned in 1908 in this area. ML-49 had a flow rate of 464 gpm in the spring of 2004 and 157 gpm in the fall of 2004. On average ML-49 is the smallest contributor of acid and AMD metals in the McLuney Creek Subwatershed, contributing 9% of the acid and 10% of the metals among all sites in McLuney Creek. This site contributes 130,305 lbs of acid and 33,945 lbs of metals annually to McLuney Creek (Table 47).

Table 47. ML-49 Net acid and metal loadings

ML-49	High Flow	Low Flow	Average
Acid load (lbs/day)	553	162	357
% Acid load contribution	13	5	9
Metal load (lbs/day)	143	44	93
% Metal load contribution	13	5	10

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

4) ML-6 Treadway Project

Access/Location

Site ML-6, Treadway Project, is located on private property north of County Road 48. It is a tributary entering McLuney Creek at RM 2.18 and it drains an area of 1.16 square miles. ML-6 is located at the mouth of the tributary. It is accessible by road in Section 24, 25, and 30, Harrison Township, Perry County.

Site Description

The Treadway Project includes sites: ML-67, ML-68, ML-69, ML-70, ML-71, ML-72, ML-73, and ML-74. Traveling north from the mouth site ML-67 is the first tributary on the east side of Treadway Hollow and is diffuse drainage through spoil (pH 3.93). ML-68 (pH 2.99) is the second tributary on the east side of Treadway Hollow just north of the power-line. Water seeps through spoil from a collection of pit impoundments including sites, ML-69 (pH 2.97), ML-70 (pH 2.7), and ML-71 (pH 2.66). All this water drains into site ML-68. At the head of the first tributary on the west side of Treadway Hollow, above the first beaver dam, is a series of pits created by spoil damming the natural ravine. ML-74 (pH 2.57) is one of the pit impoundments that is providing diffuse flow through the spoil to the tributary. North of the first tributary on the west is a series of three beaver dammed ponds extending to the headwaters of the hollow. At the northwest corner of the first pond ML-73 (pH 3.04) is a small tributary arising through the spoil. Water flows into the pond and creates a marshy iron alluvial fan. To the north of the third beaver pond is ML-72, a freshwater pond containing fish. ML-6 flow rate is 464 gpm in the spring of 2004 and 357 gpm in the fall of 2004. On average ML-6 is the second largest contributor of acid and the third largest contributor of AMD metals in the McLuney Creek Sub-watershed, contributing 24% of the acid and 21% of the metals among all sites in McLuney Creek. This site contributes 325,215 lbs of acid and 74,095 lbs of metals annually to McLuney Creek (Table 48).

Table 48. ML-6 Net acid and metal loadings

ML-6	High Flow	Low Flow	Average
Acid load (lbs/day)	925	857	891
% Acid load contribution	22	25	24
Metal load (lbs/day)	207	199	203
% Metal load contribution	19	23	21

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

5) ML-38 Tunnel Hill Project

Access/Location

Site ML-38, Tunnel Hill Project, is located on private property including Oxford Mining Company property. Tunnel Hill Project stretches along County Road 6, south of County Road 48. It is a tributary entering McLuney Creek at RM 1.42 and it drains an area of 0.95 square miles. ML-38 is located at the mouth of the tributary. It is accessible by road in Section 31, Harrison Township, Perry County.

Site Description

The Tunnel Hill Project includes sites: ML-23 through ML-37. The sites within the Tunnel Hill Project were not investigated upstream to each of their sources. However, mouths of tributaries were measured for field parameters. Values of pH ranged from 6.8 – 2.48, with most sites in the pH 3 range. Visible spoil exists in the floodplain and two deep mines appear to have opening leading to the Tunnel Hill area these include: Green Valley-Lyonsdale, PY-002, abandoned in 1908, Block Mine, PY-005, abandoned in 1906, and Elk Mine No.2, PY-86, abandoned in 1920. ML-38 had a flow rate of 778 gpm in the spring of 2004 and 291 gpm in the spring of 2004. On average ML-38 is the fourth largest contributor of acid and AMD metals in the McLuney Creek Sub-watershed, contributing 15% of the acid and 12% of the metals among all sites in McLuney Creek. This site contributes 210,970 lbs of acid and 41,975 lbs of metals annually to McLuney Creek (Table 49).

Table 49. ML-38 Net acid and metal loadings

ML-38	High Flow	Low Flow	Average
Acid load (lbs/day)	640	516	578
% Acid load contribution	15	15	15
Metal load (lbs/day)	126	105	115
% Metal load contribution	12	12	12

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in McLuney Creek Subwatershed. In addition to AMD Treat, costs for standard reclamation of strip pit impoundments were estimated from the area and length of the ponds, 1% grade channels, 2:1 slope - c rock transition channels from reclaimed channel to receiving stream, re-vegetation area, lime material, treating the impoundment during dewatering, and mobilization. Table 50, summarizes the cost estimates from various treatment alternatives from the AMD Treat program. Table 51, summarizes the cost estimated for basic strip pit reclamation (BSPR).

Table 50. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Manganese Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual chemical) ($)	Primary Retention Pond ($)	Second-ary Pond ($)	Sludge removal ($)
ml-01	$5,216,254	$1,464,601	$8,290,861	$4,874,877	$2,811,262	$120,419	$96,475	$238,879	$207,540	$41,459
ml-38	$732,401	$231,910	$366,018	$227,713	$346,943	$120,419	$13,538	$30,292	$25,690	$6,076
ml-39	$3,717,701	$1,026,972	$7,090,653	$4,174,321	$2,014,232	$120,419	$70,233	$172,291	$148,743	$31,165
ml-06	$512,989	$197,962	$1,216,691	$733,004	$207,183	$120,419	$14,849	$22,269	$15,363	$9,113
ml-49	$418,992	$125,887	$1,282,655	$771,955	$206,737	$120,419	$7,140	$18,362	$15,330	$4,006
ml-13	$1,454,377	$345,279	$2,223,736	$1,326,062	$838,110	$120,419	$27,833	$71,147	$61,956	$12,174
ml-14+16	$571,639	$237,216	$1,518,116	$910,844	$213,435	$120,419	$19,771	$26,198	$15,825	$13,716
ml-20	$724,320	$221,085	$1,063,460	$642,442	$359,445	$120,419	$15,627	$34,924	$26,614	$11,008
ml-rort seep	$303,174	$86,807	$515,974	$317,435	$151,816	$120,419	$6,044	$16,282	$11,269	$6,645

Table 51. Summary of basic strip pit reclamation (BSPR)

Site	Area of pond	length	Trans. Channel	re-veg area	re-veg	lime material	2:1 slope trans. rock channel	C rock	est. quicklime dewatering *	Earthwork	sub-total	mobili-zation	final cost	Project total
	acres	ft	ft	acres	$750/ ac	$440/ac	1.66tons/ linear ft.	$28/ton	(WVU) ($)	$1.10 /yd3	($)	10% final cost	($)	($)
ML 20			3,862				6,411	179,506			179,506	17,951	197,456	
a	4.7	3067		15.3	11,475	6,732			333	144,590	163,130	16,313	179,443	
b	6.3	3538		19.8	14,850	8,712			447	220,142	244,151	24,415	268,566	
c	4.1	1867		12.5	9,375	5,500			291	82,475	97,641	9,764	107,405	
d	5.9	2371		15.5	11,625	6,820			418	145,069	163,932	16,393	180,325	
e	3	1227		7.6	5,700	3,344			213	43,311	52,568	5,257	57,825	
f	11.2	5098		30.2	22,650	13,288			794	546,399	583,131	58,313	641,444	**1,632,464**
ML 14/16			4282				7,108	199,027			199,027	19,903	218,930	
62	7.4	2402		17.8	13,350	7,832			1,199	183,987	206,368	20,637	227,005	
61	3.1	574		6.2	4,650	2,728			597	26,792	34,767	3,477	38,244	
59	2.2	844		5.9	4,425	2,596			178	24,285	31,484	3,148	34,632	
58	2.2	623		5.4	4,050	2,376			490	19,970	26,886	2,689	29,575	
60	2.1	513		4.4	3,300	1,936			425	17,013	22,674	2,267	24,941	**573,327**
ML 6			6155				10,217	286,084			286,084	28,608	314,693	
70	2.4	1608		6.6	4,950	2,904			486	42,762	51,102	5,110	56,213	
69	1.4	398		2.7	2,025	1,188			170	9,913	13,296	1,330	14,626	
71	3.1	905		4.9	3,675	2,156			628	35,897	42,356	4,236	46,592	
a	2.9	762		5	3,750	2,200			588	29,901	36,439	3,644	40,083	
74	1.2	580		3	2,250	1,320			243	10,435	14,248	1,425	15,673	
73	1.2	550		3	2,250	1,320			243	10,116	13,929	1,393	15,321	
b	3.7	1825		9.7	7,275	4,268			750	73,050	85,343	8,534	93,877	
c	2.6	1932		8.8	6,600	3,872			527	53,801	64,800	6,480	71,280	
d	2.9	1875		9.5	7,125	4,180			588	58,542	70,435	7,043	77,478	**745,836**
ML 49			3444				5,717	160,077			160,077	16,008	176,085	
a	6.5	3154		17.5	13,125	7,700			988	204,983	226,796	22,680	249,475	
b	3.2	1639		9.7	7,275	4,268			486	57,897	69,926	6,993	76,918	
c	4.4	973		14.9	11,175	6,556			669	53,606	72,006	7,201	79,206	
d	2.3	1108		6.7	5,025	2,948			350	30,776	39,099	3,910	43,009	
e	11	6537		48.4	36,300	21,296			1,671	677,097	736,364	73,636	810,001	**1,434,695**

*estimated strip pit maximum depth of 5ft

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow conditions (critical conditions) were used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. BSPR is a more permanent treatment and can expect to achieve results for infinity. Although for comparison analysis between BSPR and other treatments a lifetime of fifty years is used, which is approximately the break even point when compared to the over passive and active treatment alternatives. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 52, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 52. McLuney Creek cost versus benefit analysis and acid load reduction

Site	**Existing acid load (lbs/ day)** A (net acidity * design Q)	**Target acidity load ** (lbs/day)** B (-67 mg/l* design Q)	**Needed load reduction to meet target (lbs/day)** C= (A+/B/)	**Type of treatment**	**Expected acid load reduce -tion** D	**Remaining needed load reduction (lbs/day)** E= (C*((100-D)/100)))	**Cost for lifetime of system (cost per day)** F	**Tons / 10-yr** G= (C-E)/ 2000* 365* lifetime of 10 yr)	**Benefit ratio (cost/ ton lifetime)** H= (F/G)	**Life-time (yrs)**	**Stream miles to next dst. input of AMD**
ML-20	908	-647	1555	Active Doser	100%	0	$276,689	2838	$98	10	0.79
	908	-647	1555	Passive VFP	100%	0	$724,320	2838	$255	10	0.79
	908	-647	1555	BSPR	71%	451	$1,632,464 {326,493}	2015	$162	50 {10}	0.79
	908	-647	1555	OLC (1000 ft) (WVU)	12%	1368	14,341 {8,148}	341	$24	17.6 {10}	0.79
ML-rort	335	-273	608	ALD	100%	0	$86,807	1,110	$78	10	0.94
ML-14&16	1,285	-384	1669	Active Doser	100%	0	$318,129	3,046	$104	10	0.76
	1,285	-384	1669	Passive VFP	100%	0	$571,639	3,046	$187	10	0.76
	1,285	-384	1669	BSPR	71%	484	$573,327 {114,665}	2163	$53	50 {10}	0.76
ML-49	511	-372	883	Active Doser	100%	0	$191,819	1611	$119	10	0.63
	511	-372	883	Passive VFP	100%	0	$418,992	1611	$260	10	0.63
	511	-372	883	BSPR	71%	256	$1,434,695 {286,939}	1144	$251	50 {10}	0.63

Table 52 continued. McLuney Creek cost versus benefit analysis and acid load reduction

ML-6	1019	-373	1392	Active Doser	100%	0	$268,909	2540	$106	10	0.67
	1019	-373	1392	Passive VFP	100%	0	$512,989	2540	$202	10	0.67
	1019	-373	1392	BSPR	71%	404	$773,965 {154,793}	1803	$86	50 {10}	0.67
ML-38	1007	-628	1631	Active Doser	100%	0	$255,799	2977	$86	10	1.26
	1007	-628	1631	Passive VFP	100%	0	$723,401	2977	$243	10	1.26
ML-13	923	-1509	2433	Active Doser	100%	0	$398,749	4440	$90	10	0.55
	923	-1509	2433	OLC (3000 ft) (WVU)	13.5%	2105	43,025 {16,297}	599	$27	26.4 {10}	0.55
ML-39	3627	-3627	7254	Active Doser	100%	0	$822,749	13,239	$62	10	1.26
ML-01	5,289	-5062	10351	Active Doser	100%	0	$1,085,169	18,891	$57	10	3.39

*71% is the known reduction in acidity at the SR 124 site in Raccoon Creek from 1997-2004.
**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for McLuney Creek Subwatershed

After reviewing the water quality data and estimated costs of treating sites in McLuney Creek with members of the Technical Advisory Committee for the Moxahala Watershed Restoration Project, the following phased approached was decided. Since individual passive treatments systems (VFP) installed at each of the project sites mentioned in Table 52 totals $2,951,341, with an expected lifetime of 10 years, a different approach is considered. Enhancing the wetland would provide storage of metals and conducting the BSPR needed all provide log-term solutions.

Since Oxford Mining Company has a permit to surface mine on the south side of McLuney Creek, it is recommended to postpone any treatment for ML-49 and Tunnel Hill area. It is also recommended to discuss with Oxford Mining the extent of the proposed mining operations to determine if ML-49 and Tunnel Hill area could be reclaimed with re-mining.

Phase I - Conduct aerobic wetland enhancement in the mainstem of McLuney Creek from site ML-20 to ML-39. The aerobic wetland enhance would provide higher residence time to allow metals to settle, provide addition buffering capacity by installing J-trenches of limestone, and allow cattails to populate the wetland to aid in iron removal. Total cost of the project is estimated to be between $50,000 and $700,000. The wide variation in cost is dependant on the length of the wetland enhancement and amount of limestone utilized. The high-end estimate is based on the amount of limestone needed to buffer 100% of the acid loading at site ML-13 (mainstem) is 24,030 tons of limestone. This is an extremely large amount of limestone (equivalent to about 1500 double axle truck loads) and is not practical for this site. Also due to the low gradient in the wetland and limited amount of aeration a different source of alkalinity would be needed to add upstream of the wetland. Steel slag beds could be an alternative to investigate within site ML-21. A cost will be determined after a detailed design is complete to determine the length of the wetland enhancement project and source of alkalinity.

Phase II complete the basic strip pit reclamation needed in McLuney Creek Subwatershed. Start with Ml-14 & 16, Newlon Project ($570,149), followed by site ML-6, Treadway Hollow but only complete BSPR at sites 69, 70, and 71 within Treadway Hollow ($160,000), and then ML-20, Rort Project ($1,629,719). Total cost of basic strip pit reclamation is $2,359,868.

Phase III after completion of Phase I and II, re-evaluate the acid loading in McLuney Creek. Final reclamation in McLuney Creek is to install an ALD at site ML-20, capital cost $119,858, annual $5115. Total costs over a 10-yr lifetime $171,008.

Total cost of restoration just considering phase II and III is $2,530,876.

Future monitoring

Future reconnaissance needed in McLuney Creek Subwatershed include investigating Tunnel Hill area if Oxford Mining is not going to be re-mining. Reconnaissance is also needed in ML-3, tributary to McLuney downstream of Tunnel Hill and ML-74 within Treadway Hollow.

Phase I collect water quality samples on McLuney Creek mainstem sites, ML-20, ML-13, and ML-39 quarterly for one year prior to installation of the wetland J-trenches. Also collect flow and conduct a water budget for the already present marshy/wetland in the mainstem of McLuney Creek to determine residence time. Investigate ML-21 for possible steel slag bed additions.

Phase II monitoring needed prior to basic strip pit reclamation includes high and low sampling at the outlet of all discharging strip pits, strip pit impoundments, and receiving streams after water from strip pits run through spoil. This will provide the needed pre-reclamation water quality data to determine effectiveness of the restoration and provide acidity concentrations of the impounded water to treat effectively during de-watering.

Phase III monitoring plan after re-evaluation of results from Phase I and II, begin water quality sampling quarterly for one year to obtain sufficient data to design an ALD at site Ml-20.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

Snake Run

Basin Assessment

Snake Run is the smallest of the priority tributaries, with a drainage area of 0.47 square miles. Snake Run is located within Perry County on the Crooksville USGS topographic quadrangle. Snake Run is located just south of Crooksville at RM 15.9 and is primarily privately owned. There was minimal surface mining in Snake Run (6 acres) and extensive deep mining on the south side of Snake Run (92 acres). Table 53, shows the known and mapped underground deep mines in Snake Run, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Snake Run Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines.

Table 53. Snake Run underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-319	Badger	1920	863
PY-320	Snake Hollow	1932	
PY-355	Keystone No. 1	1917	848

Impacts of Snake Run on Mainstem of Moxahala Creek

The impact from Snake Run to the mainstem of Moxahala Creek is difficult to discern due to the highly degraded water upstream and the limited amount of sampling directly upstream and downstream of Snake Run (Table 54). The following table shows the impacts to the mainstem of Moxahala Creek from RM 16.1 to RM 10.8. Overall the pH is increasing, conductivity decreases, and acidity slightly increases moving downstream.

Table 54. Impacts of Snake, Burley, and Riders Run on the mainstem of Moxahala Creek

Site	pH	Conductivity µs/cm	Acidity mg/l
Upstream (RM 16.1)	3.77	1230	64.0
Snake Run (RM 15.9, RM 0.1)	3.17	1270	133.0
Burley (RM 15.4, RM 0.1)	3.42	1380	121.0
Elk Run [Riders Run] (RM 10.85, RM 1.3)	3.97	849	53.6
Downstream (RM 10.8)	4.15	1130	67.5

Summer 2004 data

Water Quality Investigation

Snake Hollow Subwatershed produces on average 429 lbs/day of acid loading, 120 mg/l of acidity, and 88 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 19 and 20). The sites sampled in Snake Hollow were located at the mouth and at one major acid mine drainage source in the headwaters. Comparing the average acid loading measured at the AMD source to the average acid loading measured at the mouth (SN-1), gives a percentage of acid load each site contributes in Snake Hollow. This shows the percent acid load the AMD source in Snake Hollow. Table 55 shows the percent acid loading in Snake Hollow.

Table 55. Snake Hollow percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
SN-11	-0.2	-0.04
SN-8	244	57

Table 55, shows the major AMD source in Snake Hollow accounts for on average 57% of the acid produced in Snake Hollow.

Figure 19. Snake Hollow acid loading and acidity concentrations

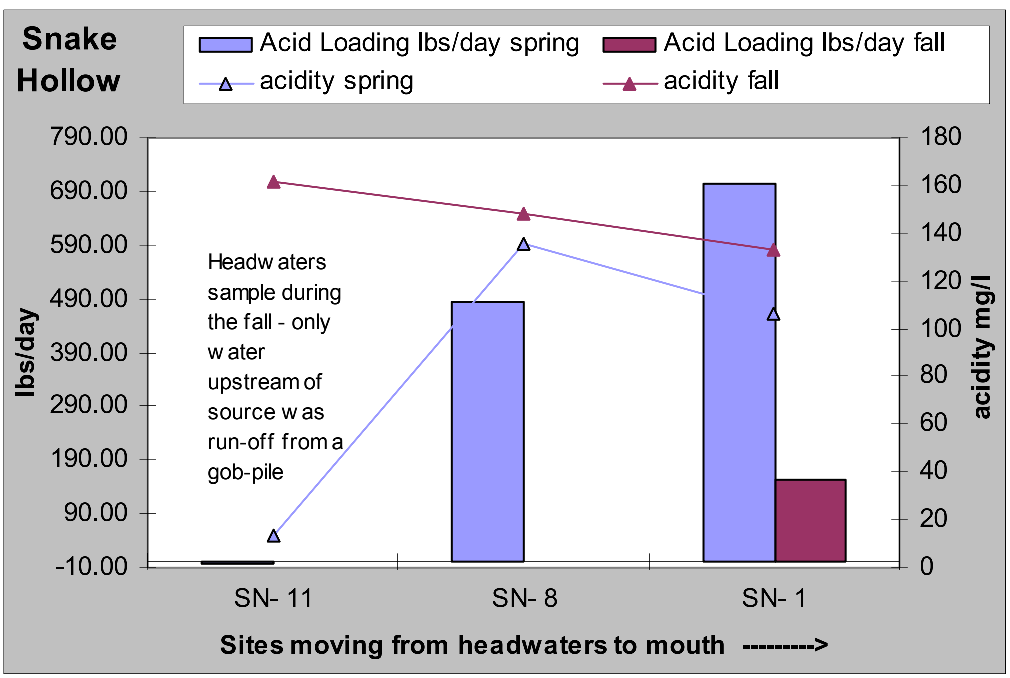
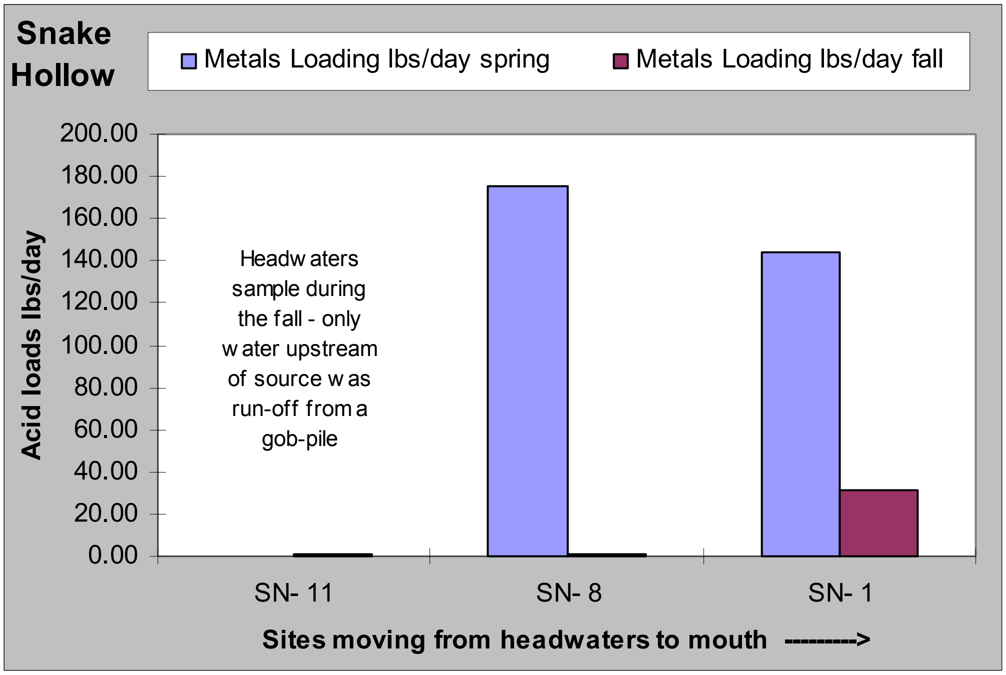


Figure 20. Snake Hollow metal loadings



Sample site locations can be found on Map 8 for Snake Run Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 56.

Table 56. List of Projects in the Snake Run Subwatershed

Sub-watershed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Town-ship	County	Project name	Mines
Snake Run	#1	#8- deep mine source	Moore	Crooksville	Harrison	Perry	Snake Run Source	PY 355, PY 320, PY 319, SM*
Snake Run	#1 - mouth							See table

1) SN-1 Snake Run Source Project

Access/Location

SN-1 mouth is located on privately owned land to the north side of Township Road 445 and the west side of State Route 97. It is a tributary that enters Moxahala Creek at RM 15.9 and drains an area of 0.47 square miles. SN-1 is located at RM 0.2 of the tributary and can be accessed by road in Section 20 of Harrison Township, Perry County. Site SN-8, AMD source is located on the north side of Township Road 445 upstream of SN-1 mouth. It is a deep mine discharge that arises to the south of the mainstem and flows into Snake Run at River-Mile 1.16. It is accessible by foot in Section 20 of Harrison Township.

Site Description

The Snake Run Source Project focuses on one large source of AMD in Snake Run, SN-8 (pH 3.36). SN-8 is a deep mine source arising near the headwaters on the south side of the stream from Keystone No.1 deep mine, PY-355, abandoned in 1917. The mouth of Snake Run, SN-1, had a flow rate of 554 gpm in the spring of 2004 and 96 gpm in the fall of 2004 (Table 57). SN-8 had a flow rate of 486 gpm in the spring of 2004 and 2 gpm in the fall of 2004. SN-8 is the major contributor of acid and AMD metals in the Snake Run Sub-watershed. This site contributes 89,060 lbs of acid and 32,120 lbs of metals annually to Snake Run (Table 58).

Table 57. SN-1 Net acid and metal loadings

SN-1	High Flow	Low Flow	Average
Acid load (lbs/day)	705	153	429
% Acid load contribution	NA	NA	NA
Metal load (lbs/day)	144	32	88
% Metal load contribution	NA	NA	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Table 58. SN-8 Net acid and metal loadings

SN-8	High Flow	Low Flow	Average
Acid load (lbs/day)	486	2.22	244
% Acid load contribution	NA	NA	NA
Metal load (lbs/day)	175	0.9	88
% Metal load contribution	NA	NA	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Snake Run Subwatershed. Table 59 summarizes the cost estimates from various treatment alternatives from the AMD Treat program.

Table 59. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow Pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Mn Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual) ($)	Primary Reten-tion Pond ($)	Secon-dary Pond ($)	Sludge removal cost ($)
sn-1	$531,887	$175,620	$471,408	$290,819	$264,924	$120,419	$8,730	$21,559	$18,300	$4,307
sn-8	$306,083	$106,596	$435,878	$269,573	$133,062	$120,419	$4,511	$13,186	$9,882	$4,373

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow condition (critical condition) was used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 60, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 60. Snake Run cost versus benefit analysis and acid load reduction

Site	Existing acid load (lbs/ day) A (net acidity * design Q)	Target acidity load ** (lbs/day) B (-67 mg/l* design Q)	Needed load reduction to meet target (lbs/day) C= (A+/B/)	Type of treatment	Expected acid load reduce -tion D	Remaining needed load reduction (lbs/day) E= (C*((100-D)/100)))	Cost for lifetime of system (cost per day) F	Tons / 10-yr G= (C-E)/ 2000* 365* lifetime of 10 yr)	Benefit ratio (cost/ ton lifetime) H= (F/G)	Life-time (yrs)	Stream miles to next dst. input of AMD
SN-8	508	-239	747	Active Doser	100%	0	$165,529	1363	$121	10	1.66
	508	-239	747	Passive VFP	100%	0	$306,083	1363	$225	10	1.66
	508	-239	747	ALD	100%	0	$106,596	1363	$78	10	1.66
	508	-239	747	OLC (5000 ft) (WVU)	76%	179	$15,844 {$26,407}	1037	$25	6 {10}	1.66
SN-1	790	-445	1234	Active Doser	100%	0	$207,719	2252	$92	10	0.5

**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Snake Run Subwatershed

After reviewing the water quality data and estimated costs of treating sites in Snake Run with members of the Technical Advisory Committee for the Moxahala Watershed Restoration Project, the following phased approached was decided.

Phase I – Investigate Keystone Mine No.1, PY- 355 for possible mine sealing at SN-8. The SN-8 discharge appears to be an up-dip discharge that is wet during the spring and dry during the fall located on the north side of the mine. Sealing an up-dip discharging mine may not cause a rupture else where in the mine complex because the hydrologic head created in sealing an up-dip mine opening will be low during part of the year during low flow regimes. The mine seal would only create hydrologic pressure during high flow regime and possibly avoid a "blow-out" else where in the mine. The overburden to mine elevation ratio needs investigated to determine the likelihood of a mine blow-out and its potential location. Costs for phase I are unknown until further investigations are complete.

Phase II – After exploring the mine sealing concept in Phase I, if an alternative treatment for SN-8 source is still needed. Install an anoxic limestone drain (capital $137,214, annual $3,472) and/or an open limestone channel from the SN-8 to the mouth of Snake Run ($26,407). Total cost of these two projects over a ten year lifetime is $198,341.

Future Monitoring

Future reconnaissance field work in Snake includes investigating other possible sources of AMD that contribute to Snake Run in the summer/fall low flow period. There is still AMD measured at the mouth of Snake during low flow when the major source of AMD in Snake, SN-8, is dry.

Phase I mine sealing project will involve an investigation of mine complex PY-355. Reconnaissance is needed to check all mapped mine openings into PY-355 for any discharging sources. Monitor flow rate and water quality from all discharging sources emitting from PY-355. Construct an overburden to mine elevation ratio map utilizing GIS to create a color coded surface showing the areas of low overburden to mine elevation. These areas could be possible blow-out locations in the event of a mine sealing project at SN-8. A risk analysis of potential mine blowouts will need to be conducted prior to sealing the mine.

Phase I and Phase II monitor the flow rate and water quality at sites SN-1 and SN-8 monthly for one year prior to restoration. This data is be used in designing an ALD, OLC, and is important pre-construction data to have if a mine seal is installed.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

Burley Run

Basin Assessment

Burley Run is located in Perry County within the USGS topographic quadrangles Fultonham and Crooksville. Burley Run has a drainage area of 3.33 square miles and drains into Moxahala Creek at RM 15.4. Most of the land area is privately owned. Surface mines were in operation during the 1960's to 1990's and cover 508 acres of land, leaving unreclaimed spoil piles, strip pit impoundments, barren soils, highwalls, slurry ponds, and acid mine drainage (Appendix I – Surface mine information). While the surface mining impacts can be seen on the surface, Burley Run Subwatershed was also underground mined (344 acres). Table 61, shows the known and mapped underground deep mines in Burley Run, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Burley Run Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines.

Table 61. Burley Run underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-184	No. 4	1923	874
PY-176	Brown	1937	981
PY-142	Keystone No. 1	1920	915
PY-355	Keystone No. 1	1917	848
PY-059	Keystone No. 5	1922	915
PY-127	Keystone No. 7	1924	928
PY-108	Axline Clay	1932	
PY-253	Fern Hill	1921	881
PY-123	Saltillo	1921	
PY-356	Saltillo	1917	
PY-185	Stoneburner No. 5 Clay	1932	
PY-092	Bradshaw	1932	
PY-260	No. 3 Mine	1927	890

Impacts of Burley Run on Mainstem of Moxahala Creek

The impact from Burley Run to the mainstem of Moxahala Creek is difficult to discern due to the highly degraded water upstream and the limited amount of sampling directly upstream and downstream of Burley Run (Table 62). The following table shows the impacts to the mainstem of Moxahala Creek from RM 16.1 to RM 10.8. Overall the pH is increasing, conductivity decreases, and acidity slightly increases moving downstream.

Table 62. Impacts of Snake, Burley, and Riders Run on the mainstem of Moxahala Creek

Site	pH	Conductivity µs/cm	Acidity mg/l
Upstream (RM 16.1)	3.77	1230	64.0
Snake Run (RM 15.9, RM 0.1)	3.17	1270	133.0
Burley (RM 15.4, RM 0.1)	3.42	1380	121.0
Elk Run [Riders Run] (RM 10.85, RM 1.3)	3.97	849	53.6
Downstream (RM 10.8)	4.15	1130	67.5

Summer 2004 data

Water Quality Investigation

Burley Run Subwatershed produces on average 1092 lbs/day of acid loading, 98 mg/l of acidity, and 265 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 21 and 22). The sites sampled in Burley Run were located at the mouths of tributaries and at the head of hollows representing drainage from strip pits in the headwaters. Comparing the average acid loading measured at each tributary site to the average acid loading measured at the mouth (BU-01), gives a percentage of acid load each site contributes in Burley Run. This shows which sites are the largest producers of acidity. Table 63, shows the percent acid load each site contributes in Burley Run.

Table 63. Burley Run percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
BU-25*	603	55
BU-19**	-1	-1
BU-24	135	12
BU-26	886	81

*BU-25 sampled only at spring high flow

**BU-19 sampled only at fall low flow

Table 63 shows the largest producers of acid in Burley is site BU-26, headwaters of Lewis Hollow. The sites listed account for, in average, over 100% of the acid load produced in Burley Run Subwatershed with 81% coming from BU-26. The average percent of acid load totaling more than 100% indicates there is alkaline buffering occurring in the mainstem and the water quality is not in equilibrium. However, knowing the average percent acid load, points to the major acid producers within the subwatershed.

Figure 21. Burley Run acid loading and acidity concentrations

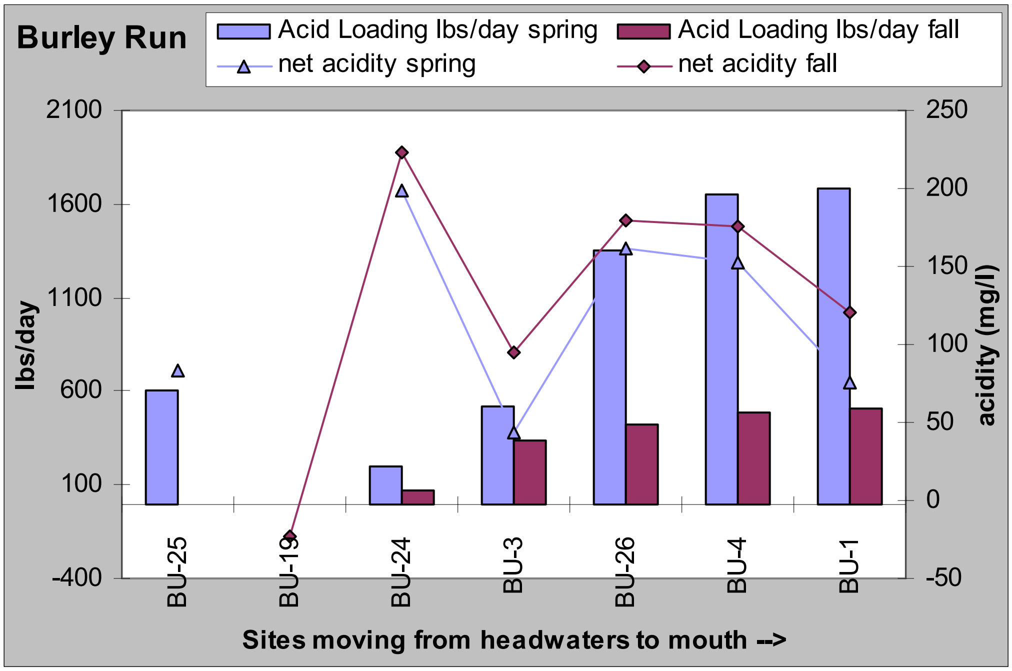
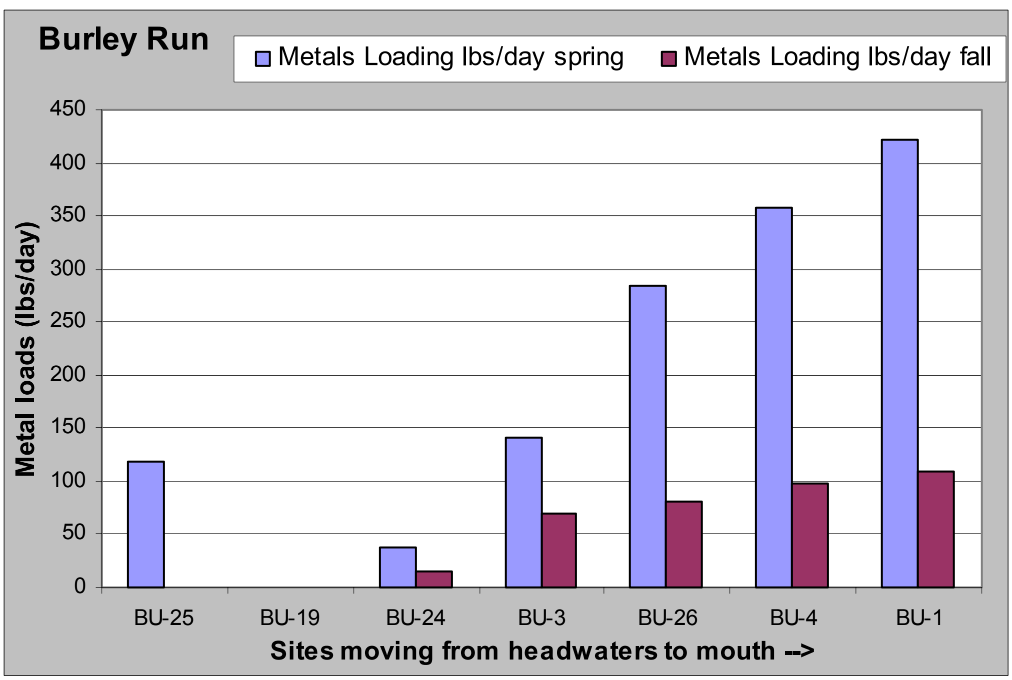


Figure 22. Burley Run metal loadings



Sample site locations can be found on Map 6 for Burley Run Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 64.

Table 64. List of Projects in the Burley Run Subwatershed

Sub-watershed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Town-ship	County	Project name	Mines
Burley Run	#20	36,37,38	Petit, McCarter, Jenkins	Fultonham, Crooksville	Harrison	Perry	Burley Run North	PY 356, PY368, PY 123, SM*
Burley Run	#21, #22	39,40,42,43, 44,45	Jenkins	Fultonham, Crooksville	Harrison	Perry	Jenkins Hollow	PY 69, PY127, PY 18, SM*
Burley Run	#3	20,21,22,36, 37,38,39,40, 41,42,43,44, 45	Jenkins Petit, McCarter	Fultonham, Crooksville	Harrison	Perry	Jenkins Hollow Burley Run South	PY 108,PY 123, PY127, PY 59, PY356 SM*
Burley Run - Lewis hollow	#26	#9,10,11,131 4,15 27,28,29,30, 31,32,33,34	Goebel & Glass	Fultonham, Crooksville	Harrison	Perry	Lewis Hollow	PY 355, PY 59, PY 176, PY 253, PY142, PY184 SM*
Burley Run	#24	46,47,48,49	Noce and Swinglees	Fultonham, Crooksville	Harrison	Perry	Burley Run railroad south	PY-184, PY-253,

1) BU-3 Burley Mainstem Project (includes Burley Run North and Jenkins Hollow)

Access/Location

BU-3 is located at the Township Road 161 bridge. It is a mainstem site in Burley Run at RM 0.89 and drains an area of 1.8 square miles. It is accessible by road in Section 17 of Harrison Township, Perry County. BU-3 contains two main projects Burley Run North and Jenkins Hollow. Burley Run North and Jenkins Hollow are accessible at the dead end side of Township Road 442 off of State Route 669 in Section 18 and 13 of Harrison Township, Perry County.

Site Description

The Burley Mainstem Project includes sites: BU-20, 21, 22, 36, 37, 38, 39, 40, 42, 43, 44, and 45, but excludes 24 (see next section for a description of BU-24). BU-20, Burley Run North project, (pH 3.36) is the tributary from the north flowing into Burley Run at the dead end of Township road 442.

Following this tributary north across a pipeline right of way leads to site BU-37 (pH 2.43) a diffuse discharge with a high volume of water. BU-37 is likely connected to deep mine Saltillo, PY 123, abandoned in 1921. To the west of BU-37 leads to site BU 38 (pH 5.51) a small diffuse discharge just west of Mt. Horeb Cemetery. The west side of tributary BU-20 leads to site 36 (pH 2.62) diffuse water arising from the hillside. Deep mines in this area are PY 356 abandoned in 1917.

Jenkins Hollow Project, BU-22 (pH 3.18), is a tributary from the south flowing into Burley Run upstream of BU-20. This tributary to the south has two main branches. Following the east branch leads to site BU-45 (pH 2.65), water flowing through spoil at the base of a pit impoundment and the branch to the west leads to site BU-44 (pH 2.77), which is another diffuse water discharge through spoil. BU-21 (pH 3.98) is the mainstem headwaters of Burley Run that is upstream of BU-22 and 20. Following the mainstem west towards its headwaters the first small diffuse drainage to the south side of the stream is site BU-43 (pH 2.86). Traveling west, upstream of BU-43 water flows from the south side. Following this water south under the old railroad bed leads to a strip pit impoundment, site BU-39 (pH 2.8). Continuing upstream in the mainstem there is a large culvert draining under the old railroad bed site BU-42 (pH 6.21) is at the culvert. The pit that the culvert drains is located to the south of the rail bed and is site BU-40 (pH 3.63) a series of pits with large highwalls feed this main pit from the south. A small pond in a field behind some houses to the east of site BU-40 is site BU-41 (pH 6.26).

BU-3 had a flow rate of 1000 gpm in the spring of 2004 and 297 gpm in the fall of 2004. On average BU-3 is the second largest contributor of acid and AMD metals in the Burley Run Sub-watershed, contributing 29% of the acid and 34% of the metals among all sites in Burley Run. This site contributes 156,220 lbs of acid and 38,325 lbs of metals annually to Burley Run (Table 65).

Table 65. BU-3 Net acid and metal loadings

BU-3	High Flow	Low Flow	Average
Acid load (lbs/day)	516	339	428
% Acid load contribution	25%	41%	29%
Metal load (lbs/day)	141	70	105
% Metal load contribution	31%	42%	34%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

2) BU-24 Burley Run Railroad South

Access/Location

BU-24 is located south of State Route 669 across from the intersection of SR 669 and Township Road 167. It is a tributary to the south of Burley Run and enters into Burley Run at RM 1.6 and drains an area of 0.07 square miles. BU-24 is located in the tributary at river-mile 0.05 and can be accessed by foot in Section 18 of Harrison Township, Perry County.

Site Description

The Burley Run South Railroad Project is a tributary site flowing into Burley Run from the south under the railroad tracks through a culvert and includes sites 46, 47, 48, and 49. On the south side of the railroad tracks is an old bench road that leads to BU-46 (pH 3.4). BU-46 consists of a shallow strip pit (less than four feet deep) with a highwall on the south side (100 feet tall). Runoff drains from the west, into this pit. One deep mine Mine No. 4 (Cannon & Thompson), PY-184, abandoned 1923, may be linked to this area. It has an entry at 874 ft. elevation and is situated east of this area. Traveling west, another strip pit is visible that runs north and south BU-47 (pH 3.45). The pit is very shallow, mostly dry, with a 50 foot highwall on the west side. Possible deep mine connection is PY-253, Fern Hill Mine (Mullen & Brown), abandoned 1921, entry elevation 881. Heading further south in this pit, eventually there is drainage flowing south, towards Lewis Hollow, in the strip pits. Heading back north, through the very shallow pit leads to site BU-48. BU-48 is a strip pit impoundment (pH 3.10), located near two deep mine entries in PY-253. Heading north is another shallow strip pit site BU-48 with a 50 foot highwall (pH 2.90). The water from BU-48 drains into the hollow below the oil well access road and eventually into Burley Run through the culvert under the railroad tracks.

BU-24 had a flow rate of 85 gpm in the spring of 2004 and 26 gpm in the fall of 2004. On average, BU-24 contributes the least amount of acid and AMD metals in the Burley Run Sub-watershed, contributing 9% of the acid and 8% of the metals among all sites in Burley Run. This site contributes 49,275 lbs of acid and 9,490 lbs of metals annually to Burley Run (Table 66).

Table 66. BU-24 Net acid and metal loadings

BU-24	High Flow	Low Flow	Average
Acid load (lbs/day)	202	68	135
% Acid load contribution	10%	8%	9%
Metal load (lbs/day)	38	15	26
% Metal load contribution	8%	9%	8%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

3) BU-26 Lewis Hollow

Access/Location

BU-26 is located southeast of Township Road 161. It is located in the mainstem of Lewis Hollow a tributary that enters Burley run at RM 0.85 and drains an area of 0.81 square miles. BU-26 is at RM 0.9

on the mainstem of Lewis Hollow. This site is accessible by road in Section 19 of Harrison Township, Perry County.

Site Description

The Lewis Hollow Project includes sites BU-9, 10, 11, 13, 14, 15, 27, 28, 29, 30, 31, 32, 33, and 34. Sites BU-9, 10, 11, 13, 14, and 15 are located at the mouths of tributaries all in the headwaters of Lewis Hollow. These tributaries drain water that runs through spoil from surface mining and possibly strip pits that are being fed by deep mines. Sites BU-27, 28, 29, 30, 31, 32, 33, and 34 are all sites that were measured upstream of their respective mouths at strip pit impoundments and channels discharging water from the strip pits. Values of pH for all these sites (excluding BU-27) are listed in the Table 67.

Table 67. pH values for sites within Lewis Hollow, Burley Run Subwatershed

Site	pH	Site	pH
9	3.14	29	3.60
10	3.03	30	4.13
11	3.52	31	3.33
13	3.18	32	4.58
14	3.36	33	3.21
15	3.51	34	3.13
28	3.36		

Deep mines that are located in this area consist of PY-176, PY-355, PY-142, PY-59, PY-253, and PY-184 (Table 61). The deep mines and surface mining extent overlap near elevation of 940-960 feet consistently throughout Lewis Hollow. Some of the overlap areas also strip pit present. These ponds could possibly be fed mine water below the surface of the water. BU-26 had a flow rate of 699 gpm in the spring of 2004 and 197 gpm in the fall of 2004. On average BU-26 is the largest contributor of acid and AMD metals in the Burley Run Subwatershed contributing 62% of the acid and 58% of the metals among all sites in Burley Run. This site contributes 323,755 lbs of acid and 66,430 lbs of metals annually to Burley Run (Table 68).

Table 68. BU-26 Net acid and metal loadings

BU-26	High Flow	Low Flow	Average
Acid load (lbs/day)	1351	423	887
% Acid load contribution	65%	51%	62%
Metal load (lbs/day)	284	81	182
% Metal load contribution	61%	49%	58%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Burley Run Subwatershed. In addition to AMD Treat, costs for standard reclamation of strip pit impoundments were estimated from the area and length of the ponds, 1% grade channels, 2:1 slope - c rock transition channels from reclaimed channel to receiving stream, re-vegetation area, lime material, treating the impoundment during dewatering, and mobilization. Table 69, summarizes the cost estimates from various treatment alternatives from the AMD Treat program. Table 70, summarizes the cost estimated for basic strip pit reclamation (BSPR).

Table 69. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow Pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Mn Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual) ($)	Primary Reten-tion Pond ($)	Secon-dary Pond ($)	Sludge removal cost ($)
bu-01	$1,657,577	$517,943	$3,384,702	$2,007,248	$823,821	$120,419	$2,221	$70,905	$60,901	$13,212
bu-04	$952,003	$356,044	$2,310,249	$1,376,892	$404,096	$120,419	$18,941	$37,574	$29,912	$10,112
bu-26	$746,881	$282,349	$1,875,532	$1,121,318	$312,114	$120,419	$15,381	$29,255	$23,117	$8,099
bu-03	$841,942	$231,721	$1,335,006	$802,854	$446,069	$120,419	$12,767	$37,083	$33,012	$5,375
bu-24	$104,559	$40,715	$185,510	$118,749	$37,954	$48,513	$2,215	$5,000	$5,000	$1,228
bu-25	$532,179	$154,776	$790,383	$480,686	$269,696	$120,419	$13,125	$23,923	$19,983	$5,203

Table 70. Summary of basic strip pit reclamation (BSPR)

Site	Area of pond	length	Trans. Channel	re-veg area	re-veg	lime material	2:1 slope trans. rock channel	C rock	est. quicklime dewatering *	Earthwork	sub-total	mobili-zation	final cost	Project total
	acres	ft	ft	acres	$750/ ac	$440/ac	1.66tons/ linear ft.	$28/ton	(WVU) ($)	$1.10 /yd3	($)	10% final cost	($)	($)
BU-26			7,366				12,228	342,372			342,372	34,237	376,609	
11a	2	1,046		4.4	3,300	1,936			373	25,662	31,271	3,127	34,398	
11b	2.2	1,367		5.8	4,350	2,552			616	34,494	42,012	4,201	46,213	
11c	1.3	999		3.5	2,625	1,540			36	16,138	20,339	2,034	22,373	
15a	6.2	2,337		20.3	15,225	8,932			39	150,575	174,771	17,477	192,248	
15b	9.9	3,568		29.8	22,350	13,112			12	348,573	384,047	38,405	422,452	
15c	4.5	1,237		9.9	7,425	4,356			188	65,365	77,334	7,733	85,068	
15d	3.3	1,966		12.6	9,450	5,544			301	69,281	84,576	8,458	93,034	
13	5.5	2,034		13.1	9,825	5,764			137	118,787	134,513	13,451	147,965	
10	5.1	2,178		16.5	12,375	7,260			100	116,665	136,400	13,640	150,040	
9a	4.6	1,849		14	10,500	6,160			445	91,798	108,903	10,890	119,794	
7	7.6	3,107		17.3	12,975	7,612			413	236,503	257,503	25,750	283,253	**1,973,445**
BU-22			1,119				1,858	52,011			52,011	5,201	57,212	
44a	4.9	1,341		12.8	9,600	5,632			447	75,698	91,377	9,138	100,514	
44	1.2	530		3.8	2,850	1,672			109	9,903	14,534	1,453	15,987	
45	5	2,541		13.7	10,275	6,028			456	130,482	147,241	14,724	161,966	**335,679**
BU-21			710				1,179	33,001			33,001	3,300	36,301	
40a	5.8	3,381		20.3	15,225	8,932			529	194,590	219,276	21,928	241,204	
40b	7.4	3,846		22.4	16,800	9,856			675	278,804	306,135	30,613	336,748	**614,253**

*15, 13, 10, 9, 44, 45, 40 estimated max depth 5ft

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow conditions (critical conditions) were used for the design flow and net acidity was used as reported from ODNR, Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime are based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. BSPR is a more permanent treatment and can expect to achieve results for infinity. Although, for comparison analysis between BSPR and other treatments a lifetime of fifty years is used, which is approximately the break even point when compared to the over passive and active treatment alternatives. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 71, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 71. Burley Run cost versus benefit analysis and acid load reduction

Site	**Existing acid load (lbs/ day)** A (net acidity * design Q)	**Target acidity load ** (lbs/day)** B (-67 mg/l* design Q)	**Needed load reduction to meet target (lbs/day)** C= (A+/B/)	**Type of treatment**	**Expected acid load reduce -tion** D	**Remaining needed load reduction (lbs/day)** E= (C*((100-D)/100)))	**Cost for lifetime of system (cost per day)** F	**Tons / 10-yr** G= (C-E)/ 2000* 365* lifetime of 10 yr)	**Benefit ratio (cost/ ton lifetime)** H= (F/G)	**Life-time (yrs)**	**Stream miles to next dst. input of AMD**
BU-25	602	-486	1087	Active Doser	100%	0	$251,669	1984	$127	10	0.77
	602	-486	1087	Passive VFP	100%	0	$532,179	1984	$268	10	0.77
	602	-486	1087	BSPR	71%	315	$949,932 {189,986}	1409	$93	50 {10}	0.77
BU-24	215	-68	284	Active Doser	100%	0	$70,663	518	$136	10	0.70
	215	-68	284	Passive VFP	100%	0	$104,559	518	$202	10	0.70
	215	-68	284	Aerobic wetland	100%	0	$118,749	518	$229	10	0.70
BU-26	1426	-562	1988	Active Doser	100%	0	$274,229	3628	$76	10	0.83
	1426	-562	1988	Passive VFP	100%	0	$746,881	3628	$206	10	0.83
	1426	-562	1988	BSPR	71%	577	$1,973,445 {394,689}	2575	$153	50 {10}	0.83
BU-3	827	-803	1630	Active Doser	100%	0	$248,089	2975	$83	10	0.85
BU-4	1781	-728	2509	Active Doser	100%	0	$309,829	4579	$68	10	0.85
BU-1	2170	-1483	3653	Active Doser	100%	0	$382,629	6667	$57	10	4.55

*71% is the known reduction in acidity at the SR 124 site in Raccoon Creek from 1997-2004.
**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Burley Run Subwatershed

After reviewing the water quality data and estimated costs of treating sites in Burley Run with members of the Technical Advisory Committee for the Moxahala Watershed Restoration Project, the following phased approached was decided. Installing passive treatments systems (VFP) at BU-24, 25, and 26 would costs $1,383,619 over a ten year lifetime. However, sources of AMD pollution in Burley Run are primarily from abandoned strip pit impoundments and could be remediated long-term if the strip pits could be treated. The possibility of batch treating the strip pits needs to be investigated further. Other considerations in Burley Run are many of the land owners have expressed concern for their land and wouldn't want to lose the strip pits or wooded ground that would be disturbed in reclaiming.

Phase I: explore the possibility of batch treating the strip pit impoundments in Lewis Hollow. Future monitoring will be needed to conduct acid-base accounting of the spoil and temperature readings at various depths in the pits during the summer to detect if water from the underground mines is entering the pits under the surface of the water.

Phase II: complete the basic strip pit reclamation needed in Burley Run Subwatershed. Start with Lewis Hollow ($1,973,445), followed by the headwaters in Burley Run, Jenkins Hollow Project ($949,932). Total cost of basic strip pit reclamation is $2,923,377.

Future Monitoring

In order to batch treat the strip pits in Lewis Hollow for Phase I with a one time addition of alkaline material additional field investigations are needed. The water quality in a limited number of strip pits that were tested as part of this AMDAT showed low pH values, however the acidity values were also low (40-60 mg/l). Therefore a one time batch treatment of alkalinity to the pits may be enough to buffer the acid present in the pits and create a useful ecosystem for aquatic biology. Additional field work needed includes recording temperature readings during the summer at various depths in the pits to determine if the pits are being fed with ground water (deep mine water). If the pits are being fed from the bottom a one time batch treatment would not be a good option due to the continuing addition of acid water to the pits. Another test needed is to conduct acid-base accounting of the spoil. The spoil in all of Moxahala Creek Watershed seemed to be very acidic and is assumed to be the source of much of the AMD. The acid-base accounting of the spoil would verify this assumption and aid in restoration decision making.

Phase II: monitoring needed prior to basic strip pit reclamation includes high and low sampling at the outlet of all discharging strip pits, strip pit impoundments, and receiving streams after water from strip pits run through spoil. This will provide the needed pre-reclamation water quality data to determine effectiveness of the restoration and provide acidity concentrations of the impounded water to treat effectively during de-watering.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

Riders Run

Basin Assessment

Riders Run is located East of Roseville in Muskingum County within the Crooksville USGS topographic quadrangle. Riders Run according to OEPA river mile maps is actually a tributary to Elk Run, but for this study the basin is referred to as Riders Run with Elk Run being a tributary to Riders Run meeting that confluence of ER 6 and RR 2 near H.O.O.F.S. Farms on County Road 87. Riders Run has a drainage area of 5.15 square miles and drains into Moxahala Creek at RM 10.85. The land is primarily privately owned. Surface mines were in operation during the 1970's to 1980's and cover 154 acres of land, leaving unreclaimed spoil piles, strip pit impoundments, barren soils, highwalls, and acid mine drainage (Appendix I – Surface mines information). While the surface mining impacts can be seen on the surface, Riders Run Subwatershed was also underground deep mined (586 acres). Table 72, shows the known and mapped underground deep mines in Riders Run, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Riders Run Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines.

Table 72. Riders Run underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
MM-191	Golden Oak No.1	1956	773
MM-278	Tedrow	1962	797
MM-097	Thompson	1953	
MM-170	Marion Cannon	1941	
MM-305			
MM-062	Penn	1935	841
MM-111	Rose Point	1954	818
MM-110	Milligan	1954	814
MM-281	Thermal No. 2	1961	
MM-009	Brooklyn	1898	
MM-185	Fundaberg & Cookson	1920	826
Elk Run			
MM-049	Midway	1927	
MM-217	Luman	1932	
MM-231	Black Arrow No. 2	1941	

Impacts of Riders Run on Mainstem of Moxahala Creek

The impact from Riders Run to the mainstem of Moxahala Creek is difficult to discern due to the highly degraded water upstream and the limited amount of sampling directly upstream and downstream of

Riders Run (Table 73). The following table shows the impacts to the mainstem of Moxahala Creek from RM 16.1 to RM 10.8. Overall the pH is increasing, conductivity decreases, and acidity slightly increases moving downstream.

Table 73. Impacts of Snake, Burley, and Riders Run on the mainstem of Moxahala Creek

Site	pH	Conductivity μs/cm	Acidity mg/l
Upstream (RM 16.1)	3.77	1230	64.0
Snake Run (RM 15.9, RM 0.1)	3.17	1270	133.0
Burley (RM 15.4, RM 0.1)	3.42	1380	121.0
Elk Run [Riders Run] (RM 10.85, RM 1.3)	3.97	849	53.6
Downstream (RM 10.8)	4.15	1130	67.5

Summer 2004 data

Water Quality Investigation

Riders Run Subwatershed produces at lower flow 273 lbs/day of acid loading, 19 mg/l of acidity, and 141 lbs/day of metal loading (includes iron, aluminum, and manganese) (Figure 23 and 24). The sites sampled in Riders Run were located at the mouths of tributaries and at AMD sources. Comparing the average acid loading measured at each tributary site to the average acid loading measured at the mouth (RR-13), gives a percentage of acid load each site contributes in Riders Run. This shows which sites are the largest producers of acidity. Table 74, shows the percent acid load each site contributes in Riders Run.

Table 74. Riders Run percent acid load from tributary sites

Site	Average acid load lbs/day	Percent acid load
RR-4	70	25
RR-5	33	12
RR-15	22	8
RR-16	28	10

Table 74 shows the largest producer of acid in Riders Run is site RR-4. The sites listed account for 57% of the acid load produced in Riders Run Subwatershed at a lower flow regime with 25% coming from RR-4.

Figure 23. Riders Run acid loading and acidity concentrations

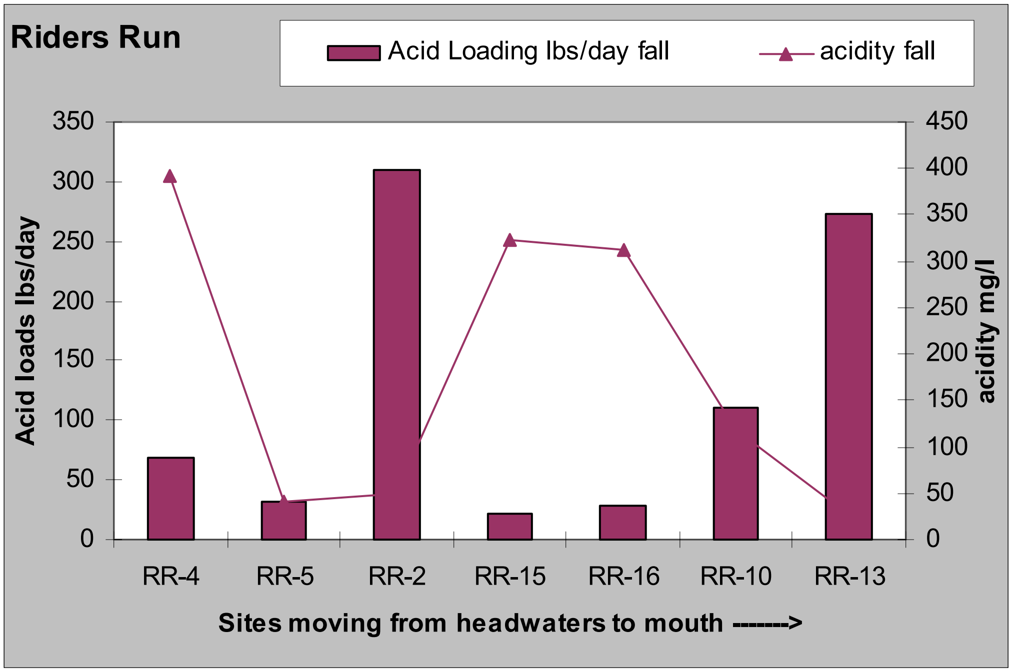
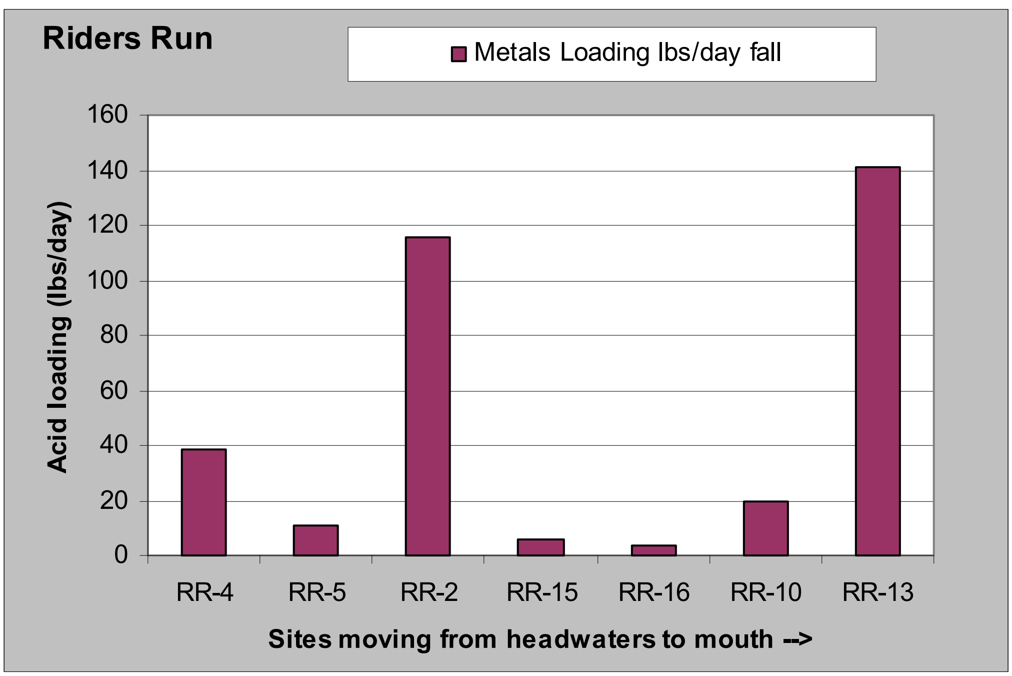


Figure 24. Riders Run metal loadings



Sample site locations can be found on Map 7 for Riders Run Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 75.

Table 75. List of Projects within the Riders Run Subwatershed

Sub-watershed	Site number at mouth	Includes these site numbers	Major land owner	Quad	Town -ship	County	Project name	Mines
Riders Run	#2	4,5	Toth/ Brown	Crooksville	Clay	Muskingum	Toth	MM-191, MM-097, MM-178, MM-305
Riders Run	#10	15, 16	Oxford Oil Co.	Crooksville	Clay	Muskingum	Oxford	MM-062, MM-185, MM-009, MM-111, MM-110, MM-281
Riders Run	#13	mouth		Crooksville	Clay	Muskingum		(see table)

1) RR-2 Toth Project (includes sites RR- 4 and RR-5)

a) RR-4

Access/Location

Site RR-4 is on privately owned land west of County Road 87. It is a site that is slightly off to the west of the main tributary that enters Riders run at RM 0.42 and drains an area of 0.70 square miles. RR-4 is located at RM 0.22 in this tributary and can be accessed by road in Section 10 of Clay Township, Muskingum County.

Site Description

RR-4 is likely linked to drainage from deep mine Marion Cannon, MM-178, abandoned in 1941 and Tedrow Mine, MM-191, abandoned in 1962. RR-4 had a flow rate of 14.81 gpm in the fall of 2004. During low flow RR-4 contributes 70 lbs of acid and 38 lbs of AMD metals per day. It contributes 47% of the acid and 65% of the metals among all sites in Riders Run (Table 76).

Table 76. RR-4 Net acid and metal loadings

RR-4	High Flow	Low Flow	Average
Acid load (lbs/day)	NA	70	NA
% Acid load contribution	NA	47%	NA
Metal load (lbs/day)	NA	38	NA
% Metal load contribution	NA	65%	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

b) RR-5

Access/Location

Site RR-5 is on privately owned land at the culvert on County Road 87. It is a site that is in the main tributary that enters Riders Run at RM 0.42 and drains an area of 0.70 square miles. RR-5 is located at RM 0.21 in this tributary and can be accessed by road in section 10 of Clay Township, Muskingum County.

Site Description

Site RR-5 drains an area that has been surfaced mined and deep mined. Marion Cannon deep mine MM-191 has mapped drift entries in this area. RR-5 had a flow rate of 70.02 gpm in the fall of 2004. During low flow RR-5 contributes 33 lbs of acid and 11 lbs of AMD metals per day. It contributes 21% of the acid and 19% of the metals among all sites in Riders Run (Table 77).

Table 77. RR-5 Net acid and metal loadings

RR-5	High Flow	Low Flow	Average
Acid load (lbs/day)	NA	33	NA
% Acid load contribution	NA	21%	NA
Metal load (lbs/day)	NA	11	NA
% Metal load contribution	NA	19%	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

2) RR-10 Oxford Project (includes sites RR-15 and RR-16)

a) RR-15
Access/Location

RR-15 is located on privately owned land on the south side of County Road 7 downstream of RR-16. RR-15 is located at the mouth of a tributary that is drainage from a deep mine discharge that enters Riders Run. RR-15 is located at RM 0.5 in the tributary and can be accessed by road in Section 3 of Clay Township, Muskingum County.

Site Description

Site RR-15 is a small AMD discharge that is likely connected to deep mine Milligan, MM-110, abandoned in 1954. RR-15 had a flow rate of 5.6 gpm in the fall of 2004. During low flow it contributes 22 lbs of acid and 6 lbs of AMD metals per day. It contributes 14% of the acid and 10% of the metals among all sites in Riders Run (Table 78).

Table 78. RR-15 Net acid and metal loadings

RR-15	High Flow	Low Flow	Average
Acid load (lbs/day)	NA	22	NA
% Acid load contribution	NA	14%	NA
Metal load (lbs/day)	NA	6	NA
% Metal load contribution	NA	10%	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

b) RR-16
Access/Location

RR-16 is located on privately owned land on the south side of County Road 7 upstream of RR-15 and downstream of the intersection of County Road 7 and Gils Hollow Rd. RR-15 is located at the mouth of a tributary that is drainage from a deep mine discharge that enters Riders Run. RR-16 is located at RM 0.6 in the tributary and can be accessed by road in Section 3 of Clay Township, Muskingum County.

Site Description

Site RR-16 is a small AMD discharge that is likely connected to Rose Point deep mine, PY-111, abandoned in 1954. RR-16 had a flow rate of 7.5 gpm in the fall of 2004. During low flow it contributes 28 lbs of acid and 3 lbs of AMD metals per day. It contributes 18% of the acid and 6% of the metals among all sites in Riders Run (Table 79).

Table 79. RR-16 Net acid and metal loadings

RR-16	High Flow	Low Flow	Average
Acid load (lbs/day)	NA	28	NA
% Acid load contribution	NA	18%	NA
Metal load (lbs/day)	NA	3	NA
% Metal load contribution	NA	6%	NA

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed)*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Riders Run Subwatershed. Table 80 summarizes the cost estimates from various treatment alternatives from the AMD Treat program.

Table 80. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow Pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Mn Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual) ($)	Primary Reten-tion Pond ($)	Secon-dary Pond ($)	Sludge removal cost ($)
rr-04	$26,927	$11,856	$61,564	$42,333	$6,609	$32,239	$982	$5,000	$5,000	$1,692
rr-05	$59,877	$13,080	$34,195	$24,879	$31,256	$48,513	$1,085	$5,000	$5,000	$484
rr-02	$438,305	$107,798	$359,986	$224,093	$242,458	$120,419	$9,125	$21,809	$17,970	$5,082
rr-15	$10,536	$3,903	$5,613	$5,545	$2,500	$32,239	$316	$5,000	$5,000	$272
rr-16	$13,422	$5,058	$2,073	$2,763	$3,349	$32,239	$412	$5,000	$5,000	$154
rr-10	$79,446	$24,874	$48,074	$33,788	$34,672	$111,013	$2,081	$5,000	$5,000	$884
rr-13	$883,103	$187,953	$613,528	$375,579	$528,674	$120,419	$15,951	$43,796	$39,112	$6,208

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on low to base flow concentrations because Riders Run was only measured during low to base flow conditions. Low to base flow conditions were used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 81, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 81. Riders Run cost versus benefit analysis and acid load reduction

Site	**Existing acid load (lbs/ day)** A (net acidity * design Q)	**Target acidity load ** (lbs/day)** B (-67 mg/l* design Q)	**Needed load reduction to meet target (lbs/day)** C= (A+/B/)	**Type of treatment**	**Expected acid load reduce -tion*** D	**Remaining needed load reduction (lbs/day)** E= (C*((100-D)/100)))	**Cost for lifetime of system (cost per day)** F	**Tons / 10-yr** G= (C-E)/ 2000* 365* lifetime of 10 yr)	**Benefit ratio (cost/ ton lifetime)** H= (F/G)	**Life-time (yrs)**	**Stream miles to next dst. input of AMD**
RR-4	69	-12	81	Active Doser	100%	0	$42,059	148	$284	10	1.5
	69	-12	81	Passive VFP	100%	0	$26,927	148	$182	10	1.5
	69	-12	81	OLC (657 ft) (WVU)	98%	2	$2,082 {3,470}	144	$24	6 {10}	1.5
RR-5	34	-56	90	Active Doser	100%	0	$59,363	164	$362	10	1.5
	34	-56	90	Passive VFP	100%	0	$59,877	164	$365	10	1.5
	34	-56	90	OLC (1000 ft) (WVU)	50%	45	$3,169 {2881}	82	$35	11 {10}	1.5
RR-15	22	-5	26	Active Doser	100%	0	$35,399	47	$753	10	0.5
	22	-5	26	Passive VFP	100%	0	$10,536	47	$224	10	0.5
	22	-5	26	OLC (200ft) (WVU)	87%	3	$423 {1058}	42	$25	4 {10}	0.5
RR-16	28	-6	34	Active Doser	100%	0	$36,359	62	$586	10	0.5
	28	-6	34	Passive VFP	100%	0	$13,422	62	$216	10	0.5
	28	-6	34	OLC (200 ft) (WVU)	78%	8	$423 {1410}	47	$30	3 {10}	0.5
RR-2	319	-437	756	Active Doser	100%	0	$211,669	1380	$153	10	1.37
RR-10	110	-62	172	Active Doser	100%	0	$131,823	314	$420	10	0.5
RR-13	369	-952	1321	Active Doser	100%	0	$279,929	2411	$116	10	~5.0

*71% is the known reduction in acidity at the SR 124 site in Raccoon Creek from 1997-2004.
**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Riders Run Subwatershed

Phase I – Install oxic limestone drains (OLC) at site RR 4, 5, 15, 16. Total length of channel (3 sq. ft.) needed at site RR 4 is 657 ft. to reduce 98% of the acid and at RR-5 1000 ft. of channel is needed to reduce 50% of the acid, at a cost of $6,351 over a ten year lifetime. Total length of channel (3 sq. ft.) needed at sites RR- 15 and 16 is 400 ft. to reduce approximately 80% of the acid at a cost of $2,468 over a ten year lifetime.

Future Monitoring

Phase I monitoring includes collected water quality and flow rates at sites RR-4, 5, 15, and 16 quarterly, for one year prior to installation of limestone channels. The additional water quality data will provide the needed information to accurately size and cost the limestone channels.

Post-construction water quality monitoring should be conducted at least twice to four times a year and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

Black Fork

Basin Assessment

The Black Fork sub-watershed encompasses approximately one third of the total Moxahala Creek watershed area, draining approximately 30 square miles of northeastern Perry County and southwestern Morgan County in southeastern Ohio (Stuart *et al*., 1998). Black Fork is located on the Crooksville and Deavertown USGS topographic quadrangles. Its main tributaries are Dry Run, Ogg Creek, and Bennett Run (a tributary of Ogg Creek). Black Fork flows northward into Moxahala Creek just south of Crooksville, Ohio. Several underground mines and large strip mines are found in the subwatershed.

Surface mines were in operation from 1960's to 1980's and cover 186 acres of land, leaving unreclaimed spoil piles, strip pit impoundments, highwalls, gob piles, and acid mine drainage (Appendix I – Surface mine information). While the surface mining impacts can be seen on the surface, Black Fork Subwatershed was also extensively underground deep mined (9313 acres). Table 82, shows the known and mapped underground deep mines in Black Fork, date the mine was abandoned, name of the mine, and in some cases the mine elevation. All the underground mines in Black Fork Subwatershed mined the Middle Kittanning No. 6 coal seam and were above drainage mines unless otherwise noted.

Table 82. Black Fork underground mine information

Mine number	Mine Name	Date Abandoned	Mine elevation
PY-298	No. 1 & 2	1923	831
MN-008	Thomas No. 2	1948	808
MN-026	Rutter	1955	
MN-011	Thomas No. 3	1959	803
MN-005	No. 52	1949	777
PY-147	Misco	1955	763
MN-001	Tropic	1923	785
**PY-026	Sunday Creek No. 321	1909	
PY-026A	Briar Hill No. 322	1905	
PY-308	Briar Hill	1938	793
PY-357	Sunnyhill No. 9 North	1985	802
MN-010	Misco No. 2	1957	656

** Denotes underground mines in unidentified formations

Impacts of Black Fork on Mainstem of Moxahala Creek

From the Eberhart Study 1998, water quality data from Black Fork (RM 3.4) indicates that Black Fork did not contribute significant acid loads to Moxahala Creek during the study interval. Nevertheless, certain measured parameters reflect water quality conditions in Black Fork that can degrade aquatic habitats. During the study period, pH ranged from 4.70-6.41, with an average pH of 5.74, and with the lowest values seen during low flow (July-November, 1997).

Water Quality Investigation

From the evaluation of the Kocsis Study in 2000, eighteen sites were selected for monthly sampling. Ten sites located in the tributaries to Black Fork and eight on the mainstem including AMD sources draining directly to the mainstem. In order to obtain a data set that reflected seasonal variations in flow conditions, the sampling was performed over a period of one year. Sampling began on March 6, 1999 and was completed on March 11, 2000 and was performed at regular intervals during both base and high flow conditions. The full set of monthly data can be found in Appendix F and G.

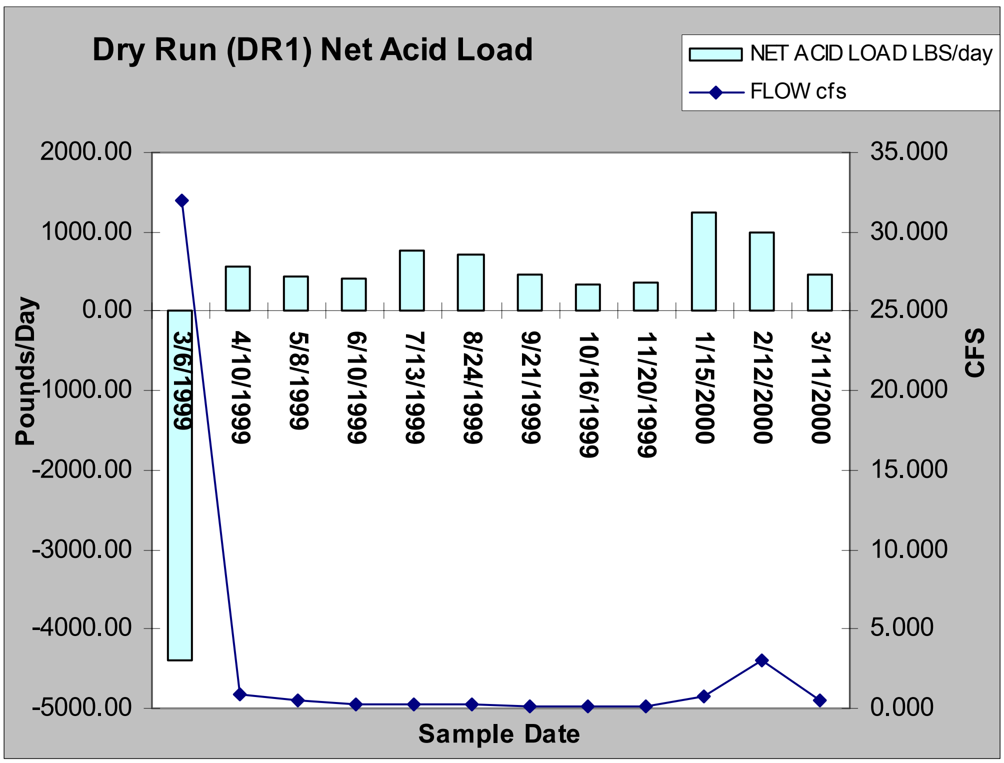
Ten tributary sites were monitored monthly in the Black Fork Subwatershed from March 1999 – March 2000. Table 83 describes the location of Phase II sampling sites located on tributaries to Black Fork subwatershed.

Table 83. Location of Tributary Monthly Sampling Sites in the Black Fork Subwatershed

Location	Description
DR 1	Dry Run before entering Black Fork
DR 2	Discharge from Seep #2
DR 3	Discharge from Seep #3
DR 7	Dry Run upstream of seeps
OC 1	Ogg Creek before entering Black Fork
OC 4	Ogg Creek upstream of AMD source
BR 1	Bennett Run before entering Ogg Creek
BR 3	Discharge from gob pile
BR 9	Bennett Run upstream of gob pile
BR 14	Bennett Run headwaters

Dry Run was sampled at its mouth (DR1), just upstream the driveway seeps (DR7) and within the two previously constructed channels that collect AMD seeps from the hillside (DR2, DR3). Flow at DR7 is near zero, with the exception of flow measured after two rain events in March, 1999 and February, 2000. Each of the hillside seeps DR2 and DR3 flowed steadily throughout the year, which is typical of seeps supplied by groundwater. The net acidic condition at the mouth of Dry Run is shown in Figure 25. On only one occasion did the stream produce a net alkaline condition (seen in the graph as a negative value) which occurred during an extremely high flow in comparison to the flows measured during the remainder of the study period. The average pH of DR1 during the study period was 3.17 and the average acidity concentration 341 mg/l. The mainstem sample location, DR7, upstream of the identified AMD sources (DR2 and DR3) is not absent of AMD but because of a consistent low flow and average net alkaline condition the data suggests it is not a factor in the load production affecting Black Fork.

Figure 25. Dry Run, DR1, Net Acid Loading



The condition of the suspected main contributors of acidity to Dry Run, sites DR2 and DR3, are shown in Figure 26 and 27. At no time do the samples show alkalinity from either DR2 or DR3. The average pH of DR2 during the study period was 2.93 and the average acidity concentration 1183 mg/l. The average pH of DR3 during the study period was 2.74 and the average acidity concentration 582 mg/l. The combined average load of sites DR2 (177 lbs/day) and DR3 (454 lbs/day) produced more acidity than the average load produced at the mouth of Dry Run (DR1, 199 lbs/day). Sites DR2 and DR3 have been identified as restoration priorities.

The scales of the graphs make the relative flows hard to compare. DR3 has a higher average flow of 0.59 CFS during the study period versus a much lower average flow of 0.03 CFS at DR2. The two highest flow events were measured after storm events.

Figure 26. Dry Run, DR2, Net Acid Loading

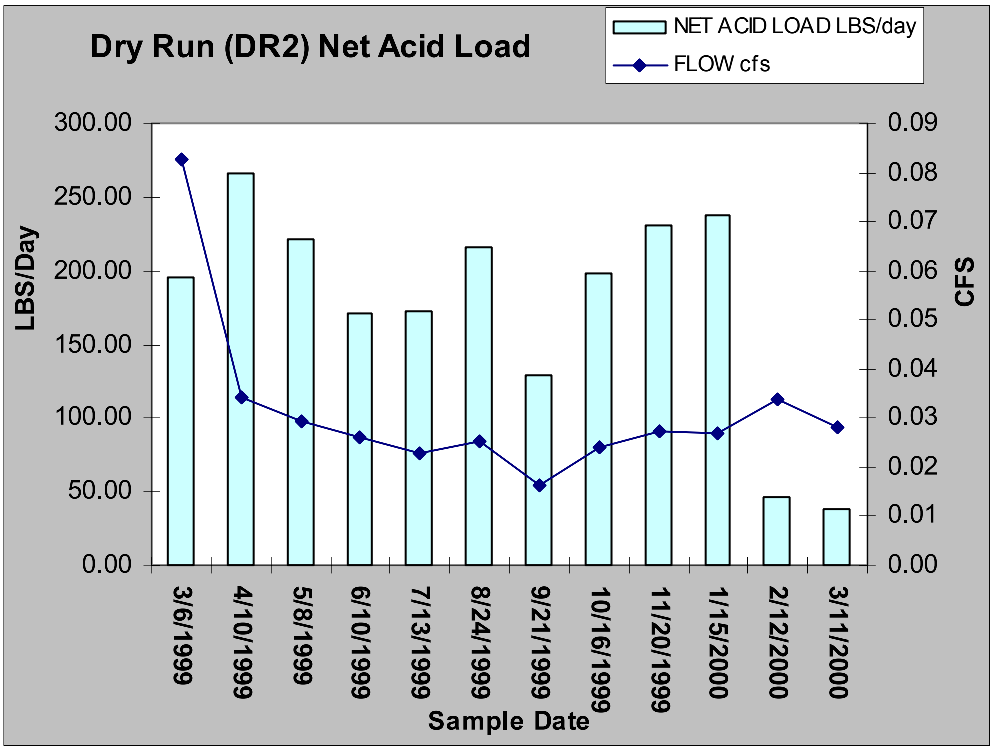
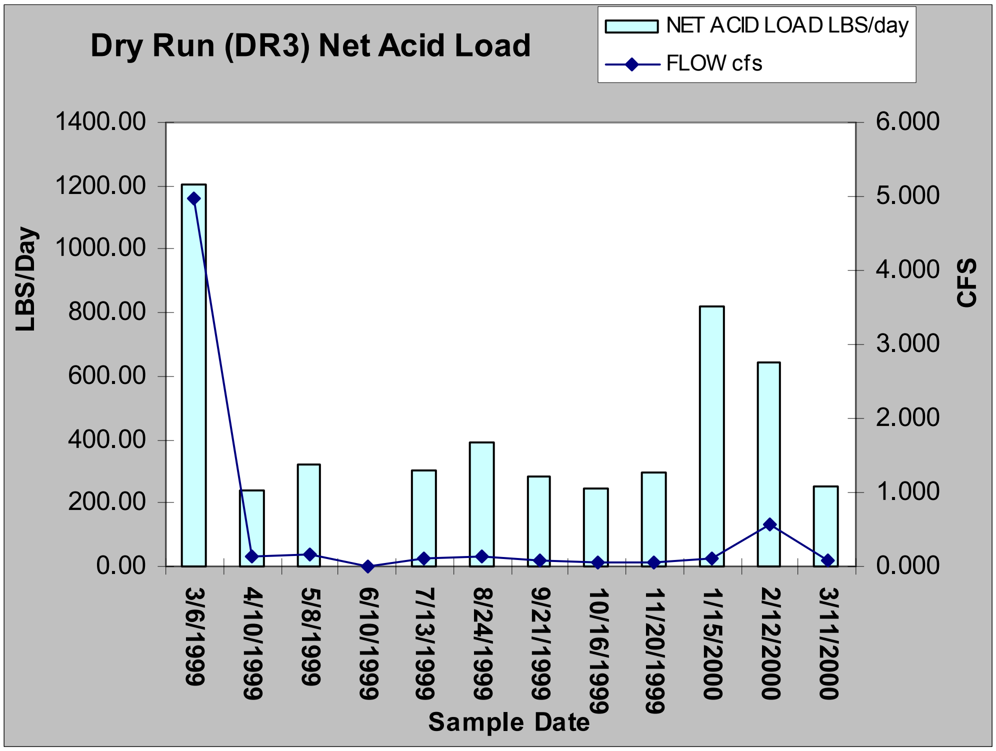


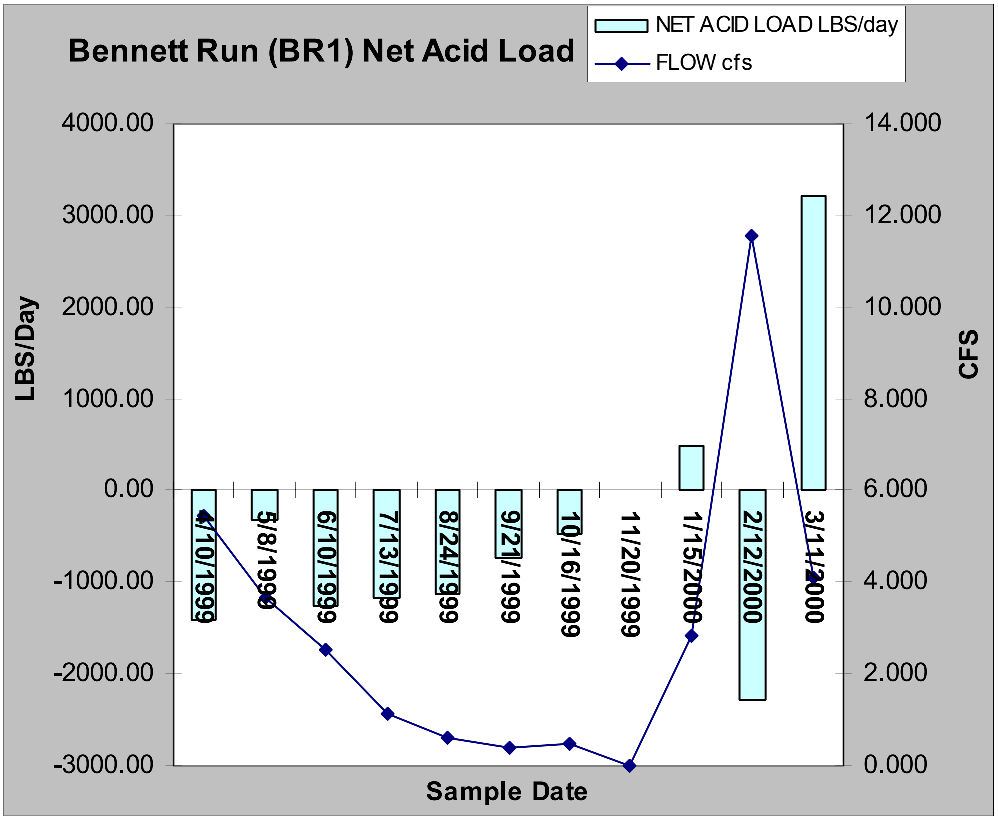
Figure 27. Dry Run, DR3, Net Acid Loading



In Bennett Run, the gob piles identified during preliminary sampling as AMD sources were located on each side of the stream. Site BR14 samples Bennett Run upstream of the gob piles in the basin's headwaters, BR9 was taken in Bennett Run just upstream of the gob pile's discharge, BR3 samples the gob pile's discharge into Bennett Run, and BR1 was taken at the mouth of Bennett Run just before its confluence with Ogg Creek.

The mainstem confluence sample location, BR1, shows the stream as a consistent alkaline load contributor (Figure 28). Even with the enormity of the Misco Gob piles in the sub-basin the stream maintained an average pH of 6.29 and a net alkaline concentration of 93 mg/l. Bennett Run only produced net acidic conditions on two occasions.

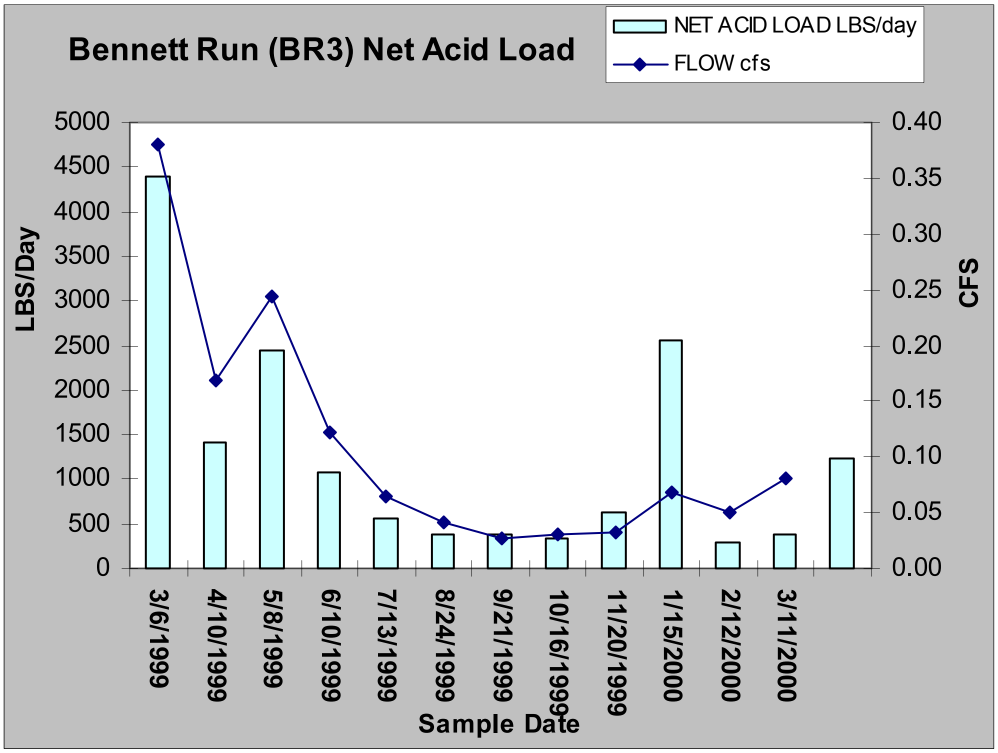
Figure 28. Bennett Run, BR1, Net Acid Loading



Site BR9, sampled just upstream of the Misco site, shows some variability. Water sampled at BR9 represented runoff from the reclaimed gob pile (the eastern side of the Misco Gob pile) in addition to base flow in the mainstem of Bennett Run. As flows decrease during summer months the stream has reverted from a net alkaline condition to net acidic conditions though it is near neutral. This is most likely the affect of the sampling location being in close proximity to the Misco Gob piles. During the high flow periods the site shows strong alkaline conditions. Even though the gob pile on the eastern side of the stream has been reclaimed, during the low flow period the base flow that is supplying much of the flow in the stream is likely coming from or in the least being affected by the buried eastern side and still exposed western side.

The sample site BR3 represents water that runs through and over the western Misco Gob pile and had a steady flow year-round. The source of water was identified as the lake perched behind the gob pile. This site was well known as a significant and the main AMD contributor in the Bennett Run sub-basin. On average the acid load at BR3 is 1235 lbs/day and as the graph shows in Figure 29 is closely related to the flow rate as the loading often increases with increased flow. The Misco Gob pile (BR3) has been identified as a priority for restoration

Figure 29. Misco Gob Pile, BR3, Net Acid Loading



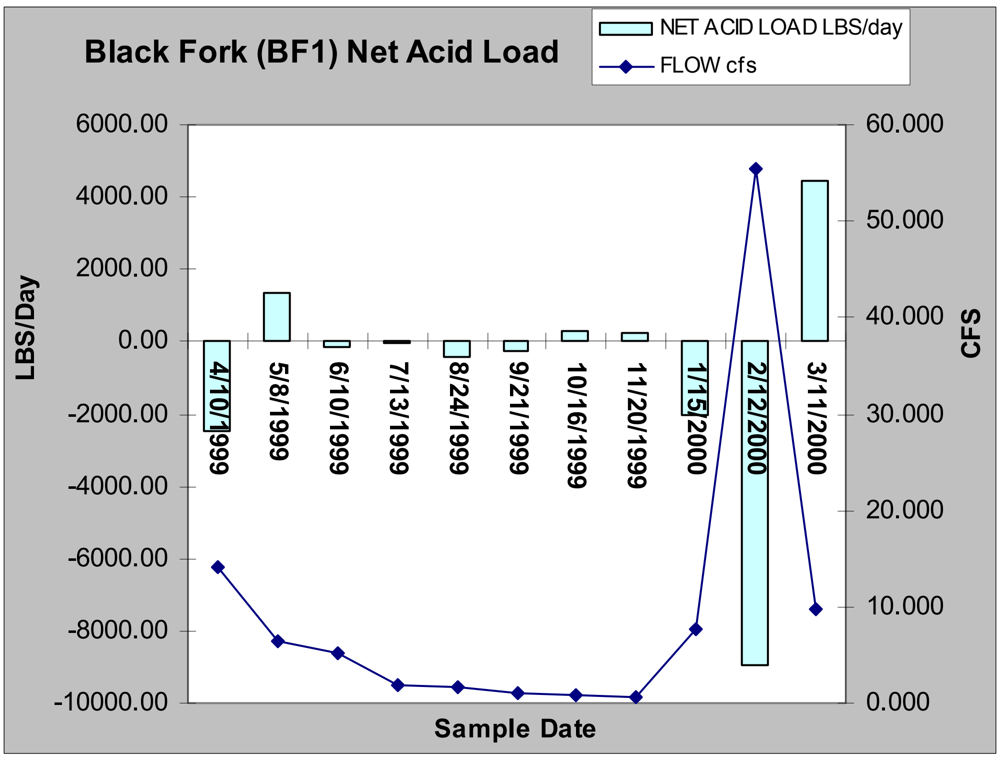
Ten sites on or discharging directly to the mainstem were selected for monthly sampling. Sampling began March 6, 1999 and was completed on March 11, 2000. The monthly data can be found in Appendix F and G. Table 84 describes the location of monthly sampling sites.

Table 84. Location of Mainstem Monthly Sampling Sites in Black Fork

Location	Description
BF 1	Mouth of Black Fork
BF 10	Whitehouse seep before entering Black Fork
BF 13	Black Fork upstream of AMD impacts
TW 0	Tropic wetland well above ALD
TW 1	Tropic wetland standpipe above ALD
TW 2	Tropic wetland below sedimentation pond
TW 3	Tropic wetland discharge pipe #1
TW 4	Topic wetland discharge pipe #2

The water quality at the mouth of Black Fork exhibited a varying condition similar to data that resulted from the Eberhart thesis. Out of 11 sampling events four exhibited net acidic conditions the rest showing a net alkaline condition. Water quality samples show spikes in each direction when looking at net alkaline/acidity concentrations ranging from 46 mg/l of alkalinity to 85 mg/l of acidity. Figure 85 shows the range and varying condition of the net acid load at the mouth of Black Fork. The headwaters sample location (upstream of known AMD sites) on the mainstem of Black Fork (BF13) has not shown any degradation averaging 77.5 mg/l of alkalinity and a pH of near 7.0.

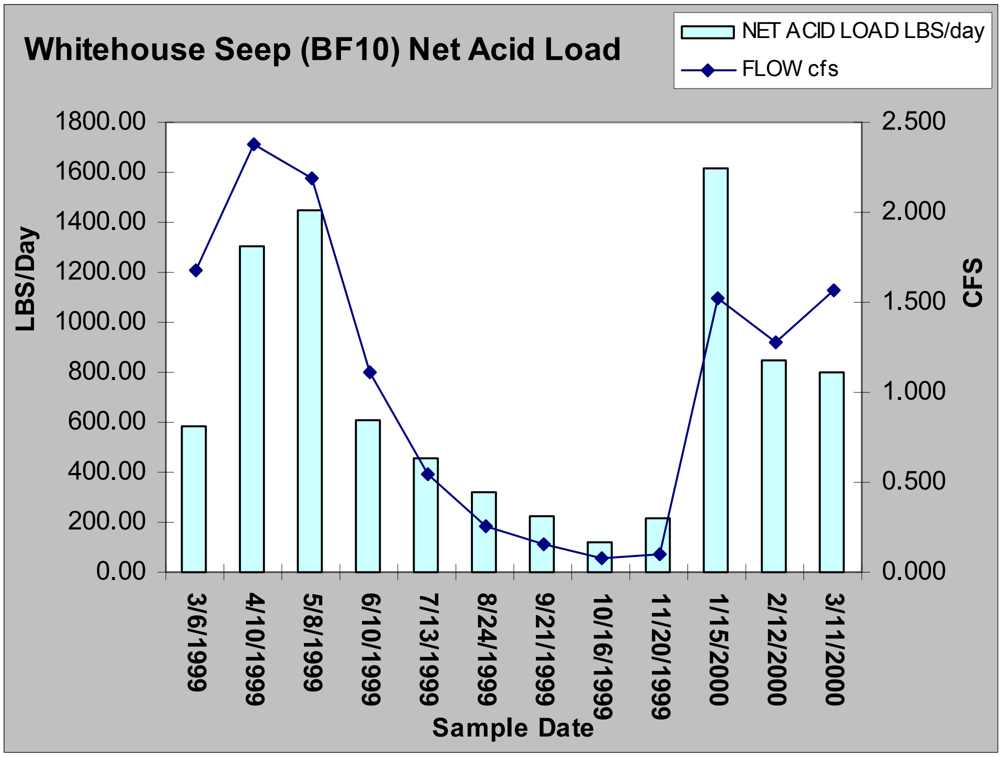
Table 85. Black Fork, (BF1) Net Acid Loading



The Whitehouse seep sample was taken about 390 feet from where the seep first surfaced, at a point approximately 20 feet before its discharge into Black Fork. This was done to allow sufficient time for the AMD oxidation reaction to occur such that samples would best represent the contaminant loads to Black Fork. Observed flow rate fluctuations at the Whitehouse seep corresponded to the variations in precipitation for the Black Fork basin. Most seeps have a steady flow regardless of seasonal variations; however, the collection channel for this seep drains a significant area, which affects the measured flow. The chemical loads also follow the precipitation trend. As Figure 30 depicts, the White House Seep

(BF10) proved to be a consistent high acid load producer throughout the study period averaging 710 lbs/day. The Whitehouse Seep has been identified as a priority site for restoration.

Figure 30. Whitehouse Seep, (BF10) Net Acid Loading



Tropic wetland was sampled at a well that measured pre-treatment discharge from the seep (TW0), at a standpipe entering the sedimentation pond (TW1) located above the previously constructed Anoxic Limestone Drain (ALD), at one of the sedimentation effluents into wetland cell (TW2), at the major discharge of the wetland into the Black Fork mainstem (TW3), and at the minor discharge to Black Fork (TW4). Figures 31 and 32 relate the acidic condition of the two discharges from the Tropic Wetland (TW3 and TW4). In combination they produce 341 pounds per day of acid. The Tropic Wetland has been identified as a priority for restoration

Figure 31. Tropic Wetland, TW3, Net Acid Loading

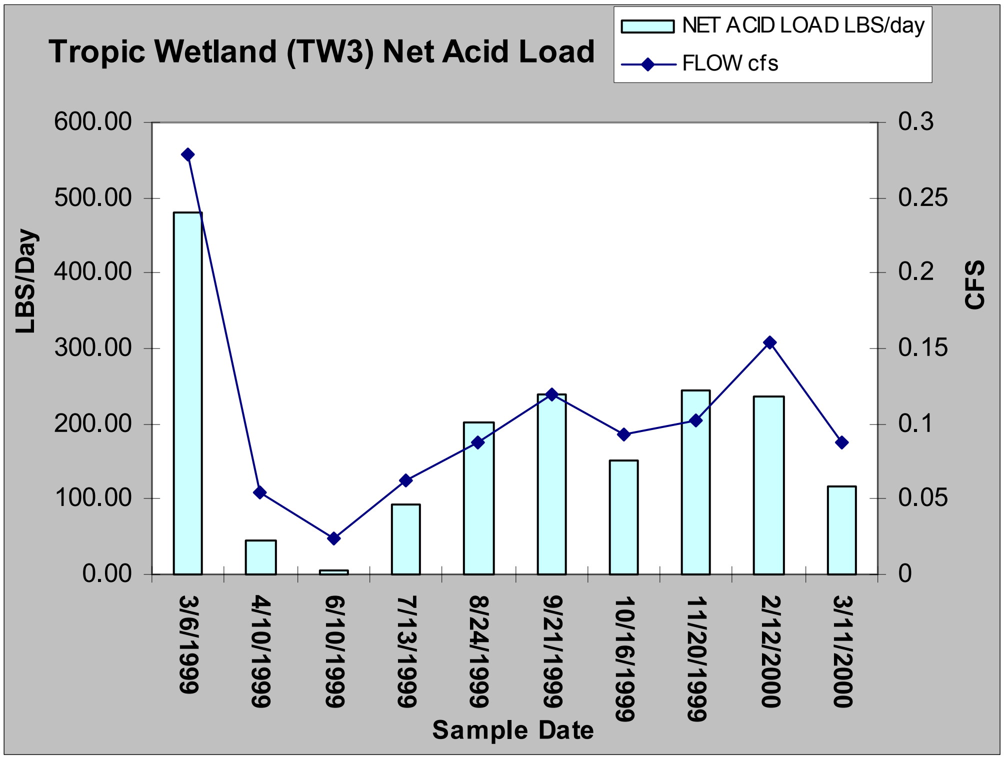
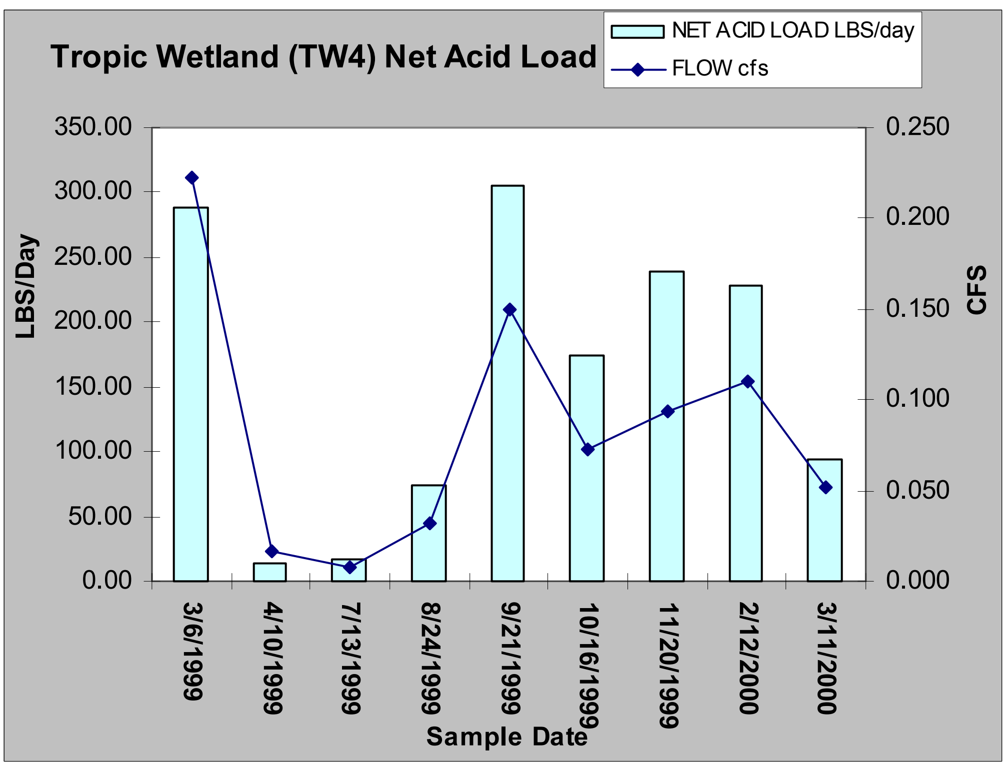


Figure 32. Tropic Wetland, TW4, Net Acid Loading



Sample site locations can be found on Map 9 for Black Fork Subwatershed and a list of project sites, major landowners, location information and underground mines found within the project area are shown in Table 86.

Table 86. List of Projects within the Black Fork Subwatershed

Sub-watershed	Site number	Includes these site numbers	Major land owner	Quad	Town-ship	County	Project name	Mines
Black Fork	BF-10	13	Crippen and Truax	Deavertown	York	Morgan	White-house seep	MN-5, MN-1, PY-26A, PY-26, PY-308,
Dry Run	DR -2 and DR- 3	1,2,3,7	Smithson and Bright	Deavertown and Crooksville	York	Morgan	Dry run seeps	PY-298, PY-290, MN-8, MN-26, MN-011, MN-5, SM*
Tropic Wetland	TW-3 and TW-4	0,1,2,3,4	Dalrymple, Allen, Marlow	Deavertown	York	Morgan	Tropic wetland enhance-ment	MN-5, MN-1
Bennett Run	BR-3	1,3,9,14	Heigley, Thomas, and Franklin Real Estate	Deavertown	Bearfield	Perry	Misco gob pile	PY-147, MN-10, SM*

*SM – Surface mines (See Appendix I – Surface mine information)

1) DR-2 and DR-3 Dry Run Seeps Project

Access/Location

DR 1 is located at the point where the stream flows underneath County Road 75, north of the abandoned railroad tracks. DR 3 is accessible from County Road 75, just past TR 256. DR 2 is located on TR 256, 0.25 miles north of County Road 75. DR 7 is located in Dry Run approximately two miles upstream of the discharge of DR 3, and is accessible by foot. Sites are located in Sections 23, 26, and 27 Range 14W, York Township, Morgan County.

Site Description

DR-2 and DR-3, Dry Run Seeps, are both deep mine discharges. Values of pH at DR-2 is 2.93 and at DR-3 is 2.74. Dry Run sub-basin has been both surface- and deep-mined; reclamation projects undertaken in the late 1970s have little to no effect on current water quality conditions. The main acid-producing sites, DR-2 and DR-3, are likely connected to deep mine No. 52, MN-5, abandoned in 1949 and Thomas No. 3 deep mine, MN-11, abandoned in 1959. DR-1 is in the mainstem of Dry Run near the mouth, it had an average pH of 3.17. The mainstem sample location, DR7, upstream of the identified AMD sources (DR2 and DR3) is not absent of AMD but because of a consistent low flow and average net alkaline condition the data suggests it is not a factor in the load production affecting Black Fork.

DR-2 and DR-3 combined produced a flow rate of 274 gpm during high flow (2/12/1999) and 38 gpm during low flow (10/16/1999). DR-2 and DR-3 rank third out of the four project areas in Black Fork contributing on average 21% of acid and 12% of metal loadings to the mainstem of Black Fork. The Dry Run seeps contribute 189,435 lbs of acid and 59,495 lbs of metals annually to Black Fork (Table 87).

Table 87. DR-2 and DR-3 Net acid and metal loadings

DR-2 and DR-3	High Flow	Low Flow	Average
Acid load (lbs/day)	692	446	519
% Acid load contribution	14%	43%	21%
Metal load (lbs/day)	328	150	163
% Metal load contribution	13%	37%	12%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*

2) BF-10 Black Fork Whitehouse Seep

Access/Location

BF-10, Black Fork Whitehouse Seep Project, is located on private property within the Deavertown USGS Topographic quadrangle. BF-10 can be accessed via an unnamed private road located on SR 669, 0.10 miles east of the intersection of SR 669 and Tatman Road. BF 1 located at the mouth of Black Fork is accessible from a bridge on SR 669, approximately 1 mile south US 93 in the village of Crooksville. BF 13 can be accessed at a bridge where the stream crosses under Tatman Road, approximately 2.5 miles south of the Rose Farm School and Tropic Wetland access road site. The bridge is located at the intersection of Tatman Road and Bearfield Township Road 209. BF-10 is located in Range 14W, Section 34, York Township, Perry County.

Site Description

BF-10 is a deep mine discharge known as the Whitehouse Seep, is the major source of AMD in the mainstem of Black Fork. BF-10 (pH 5.6) is likely connected to deep mine MN-5. BF-13 the headwaters sample location (upstream of known AMD sites) on the mainstem of Black Fork has not shown any degradation averaging 77.5 mg/l of alkalinity and a pH of near 7.0.

BF-10 produced a flow rate of 1066 gpm during high flow (4/10/1999) and 35 gpm during low flow (10/16/1999). On average, BF-10 is the second largest contributor of AMD and largest contributor of AMD metals, contributing on average 29% of acid and 52% of metal loadings to the mainstem of Black Fork. The Whitehouse seep contributes 263,530 lbs of acid and 248,565 lbs of metals annually to Black Fork (Table 88).

Table 88. BF-10 Net acid and metal loadings

BF-10	High Flow	Low Flow	Average
Acid load (lbs/day)	1306	119	722
% Acid load contribution	26%	12%	29%
Metal load (lbs/day)	119	79	681
% Metal load contribution	57%	22%	52%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*

3) TW-3 and TW-4 Tropic Wetland Enhancement Project

Access/Location

All Tropic wetland sites are accessible from Tatman Road. The access path to the wetland sites is located on the east side of the road, across the street of the abandoned Rose Farm School building. The sites are located approximately 0.25 miles from Tatman Road and are accessible on foot. Tropic Wetland is located on the Deavertown USGS topographic quadrangle in Range 14W, Section 34, York Township, Perry County.

Site Description

The Tropic Wetland, a passive treatment system, was designed and constructed by ODNR-DMR as a treatment wetland in 1994. The cells originally had a base of organic peat mixed with lime, which was intended to provide a desirable habitat for bacterial growth and add alkalinity to the water. Corrugated fiberglass sheets placed between the cells discouraged short-circuiting through individual cells. Discharge from each cell flows into a collection channel and then into one of two main outlets to Black Fork. Several of the cells have already been filled by sediment and are no longer submerged.

Some of the baffles have also been destroyed during winter freeze/thaw cycles. The wetland is not performing as originally designed.

Tropic wetland was sampled at a well that measured pre-treatment discharge from the seep (TW0), at a standpipe entering the sedimentation pond (TW1) located above the previously constructed Anoxic Limestone Drain (ALD), at one of the sedimentation effluents into wetland cell (TW2), at the major discharge of the wetland into the Black Fork mainstem (TW3), and at the minor discharge to Black Fork (TW4). TW-3 and TW-4 combined produced a flow rate of 120 gpm during high flow (9/21/1999) and 32 gpm during low flow (7/13/1999). On average, TW-3 and TW-4 are the smallest contributor of AMD and metals, contributing on average 12% of acid and 8% of metal loadings to the mainstem of Black Fork. The Tropic Wetland contributes 106,215 lbs of acid and 37,960 lbs of metals annually to Black Fork (Table 89).

Table 89. TW-3 and TW-4 Net acid and metal loadings

TW-3 and TW-4	High Flow	Low Flow	Average
Acid load (lbs/day)	545	109	291
% Acid load contribution	11%	11%	12%
Metal load (lbs/day)	166	20	104
% Metal load contribution	7%	5%	8%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*

4) BR-3 Bennett Run Misco gob pile

Access/Location

All of the Bennett Run sites, including the Misco gob pile, are accessed from the same area. The access point is located on the south side of York Township Road 259, 0.7 miles from the intersection of TR 259 and SR 555. The stream is located approximately 0.25 miles from the parking/access point, and can be reached on a footpath. Misco Gob Pile is located in Section 2, Bearfield Township, Perry County.

Site Description

The Muskingum Mining Company mined approximately four square miles of the Middle Kittanning (No. 6) coal from the Misco Mine (northeastern Perry County) before 1956. Mining activities discarded mining refuse in two piles, now known as the Misco gob piles, located on both banks of Bennett Run. Since these piles were known contributors of AMD to the Black Fork sub-watershed, they were partially reclaimed in 1990. Reclamation included the excavation and quenching of 22,000 cubic yards of burning gob and subsequent capping of the pile. Vegetation is now establishing on the topsoil placed on the gob. The second 63-foot deep, 12,000 cubic yard pile was left unreclaimed due to insufficient funds for remediation (Stuart, et al., 1998). An impounded lake perched behind this gob pile constantly feeds water through the pile before discharging directly into Bennett Run. The Misco gob pile is a major source of metals and acidity loads for the Black Fork watershed.

In Bennett Run, the gob piles identified during preliminary sampling as AMD sources were located on each side of the stream. Site BR14 samples Bennett Run upstream of the gob piles in the basin's headwaters, BR9 was taken in Bennett Run just upstream of the gob pile's discharge, BR3 samples the gob pile's discharge into Bennett Run, and BR1 was taken at the mouth of Bennett Run just before its confluence with Ogg Creek. The sample site BR3 represents water that runs through and over the western Misco Gob pile and had a steady flow year-round. The source of water was identified as the lake perched behind the gob pile. This site was well known as a significant and the main AMD contributor in the Bennett Run sub-basin. The Misco Gob pile (BR3) has been identified as a priority for restoration.

BR-3 produced a flow rate of 109 gpm during high flow (5/8/1999) and 14 gpm during low flow (10/16/1999). On average, BR-3 is the largest contributor of acid and the second largest producer of AMD metals, contributing on average 38% of acid and 28% of metal loadings to Black Fork. The Misco Gob Pile contributes 346,385 lbs of acid and 136,875 lbs of metals annually to Black Fork (Table 90).

Table 90. BR-3 Net acid and metal loadings

BR-3	High Flow	Low Flow	Average
Acid load (lbs/day)	2436	345	949
% Acid load contribution	49%	34%	38%
Metal load (lbs/day)	589	115	375
% Metal load contribution	23%	32%	28%

(*percent contribution based on % from site relative to all other sites at mouths of tributaries in subwatershed*

Treatment Alternatives, Acid Load Reductions, and Cost versus Benefit Analysis

AMD Treat was used to estimate costs for various passive treatment alternatives, pebble lime active treatment systems, sludge removal, and chemical costs for all sites in Black Fork Subwatershed. Table 91 summarizes the cost estimates from various treatment alternatives from the AMD Treat program.

Table 91. Summary of cost estimates for various treatment systems (AMD Treat)

Site	Vertical flow Pond ($)	Anoxic Limestone Drain ($)	Anaerobic Wetlands ($)	Aerobic Wetlands ($)	Mn Removal Bed ($)	Pebble Quick Lime (capital) ($)	Total Pebble Lime (annual) ($)	Primary Reten-tion Pond ($)	Secon-dary Pond ($)	Sludge removal cost ($)
BF-10	$1,015,891	$460,809	$3,658,229	$2,167,502	$475,986	$120,419	$16,779	$61,528	$35,221	$34,915
DR-2	$49,887	$29,590	$140,138	$91,043	$5,805	$94,739	$2,289	$5,000	$5,000	$3,707
DR-3	$546,365	$308,029	$750,877	$457,236	$115,648	$57,919	$6,674	$12,179	$8,594	$4,738

Cost estimates for the treatment alternatives developed using AMD Treat were calculated based on average concentrations. High flow conditions (critical conditions) were used for the design flow and net acidity was used as reported from ODNR Cambridge Laboratory. However, 67 mg/l of acidity was added to the average net acidity value in order meet the acidity target of -67 mg/l. AMD Treat calculates its cost estimates to zero mg/l of acidity, however for this study -67 mg/l of acidity is the target. AMD Treat calculations for passive vertical flow ponds (VFP) lifetime is based on limestone needed to neutralize acidity and a 16 hour retention time for 20 years. However due to the high volume of metals expected lifetime is only 10 years. Costs for active treatment systems include capital and annual chemical cost. Maintenance costs for all treatments are not included in this cost versus benefit analysis.

Table 92, shows the existing acid load, target alkalinity loads, needed acid load reduction to meet the target, various types of treatments for each site, the remaining needed load reduction for selected treatments, cost for the lifetime of the system, the tons of acid during a ten year period needed to be reduced, the benefit ratio in terms of cost per tons/10-yr, and stream miles to next downstream input of AMD.

Table 92. Black Fork cost versus benefit analysis and acid load reduction

Site	Existing acid load (lbs/ day) A (net acidity * design Q)	Target acidity load ** (lbs/day) B (-67 mg/l* design Q)	Needed load reduction to meet target (lbs/day) C= (A+/B/)	Type of treatment	Expected acid load reduce -tion D	Remaining needed load reduction (lbs/day) E= (C*((100-D)/100)))	Cost for lifetime of system (cost per day) F	Tons / 10-yr G= (C-E)/ 2000* 365* lifetime of 10 yr)	Benefit ratio (cost/ ton lifetime) H= (F/G)	Life-time (yrs)	Stream miles to next dst. input of AMD
BF-10	1535	-857	3249	Active Doser	100%	0	$288,209	5929	$49	10	0.75
	1535	-857	3249	Passive VFP	100%	0	$1,015,891	5929	$171	10	0.75
	1535	-857	3249	ALD	100%	0	$460,809	5929	$78	10	0.75
DR-2	195	-10	205	Active Doser	100%	0	$117,629	374	$315	10	1.0
	195	-10	205	Passive VFP	100%	0	$49,887	374	$133	10	1.0
	195	-10	205	ALD	100%	0	$29,590	374	$79	10	1.0
	195	-10	205	OLC (211 ft) (WVU)	99%	2	$2,229 {11,145}	370	$30	2 {10}	1.0
DR-3	1961	-208	2169	Active Doser	100%	0	$124,659	3958	$32	10	1.0
	1961	-208	2169	Passive VFP	100%	0	$546,365	3958	$138	10	1.0
	1961	-208	2169	ALD	100%	0	$308,029	3958	$79	10	1.0
	1961	-208	2169	OLC (2,785 ft) (WVU)	96%	87	$30,887 {102,957}	3800	$27	3 {10}	1.0

**Acid target load based on -67 mg/l multiplied by high flow (design flow) for the project area.

Recommended Treatment Strategy for Black Fork Subwatershed

The most significant producer of AMD in Black Fork is the Misco gob pile. Remediation activities are currently under construction. Restoration started in 2004 and is expected to be complete in 2006 (see Kocsis Study summary below for a description of remediation activities).

Treatment alternatives discussed in this section were determined from ODNR-DMRM, Moxahala Watershed Restoration Project, and Kocsis Study 2000.

Phase I – Install aerobic wetland and anoxic limestone drain at Whitehouse Seep (BF 10). Further investigation will be needed to determine the ALD’s efficiency due to high concentrations of aluminum. If the proper elevation could be created a Vertical Flow Pond could be another treatment alternative as discussed in the Kocsis Study below. Total cost of the ALD and two aerobic settling ponds is $1,077,124 over a ten year lifetime (capital $613,314, annual $43,381).

Phase II – Install open limestone channels at the Dry Run Seeps. Total cost for both DR-2 and DR-3 is $114,102 over a ten year lifetime with approximately 97% reduction in acid.

Phase III – Re-evaluate the effectiveness of the ALD at the Tropic Wetland site. Install limestone berms within the wetland to increase retention time and add buffering capacity. Estimated costs of limestone berms is $75,000, outlet channel, $2,666, re-vegetation $2,250, engineering, $10,000, and mobilization $15,000. Total project cost is $104,916.

Phase IV – Investigate Misco Gob Pile on the east side after current restoration activities are complete to determine if additional remediation activities are needed.

Recommended Treatment Strategy for Black Fork from the Kocsis Study, 2000

Detailed recommended remediation strategies were determined for the Black Fork sites as part of the Kocsis Study, 2000. Chapter 5 discussing the conclusions and recommendations from Kocsis Study 2000 can be found below:

1) Sequestration of Misco Burning Gob Pile

Because of the high pollution loads being discharged from the burning gob pile, this AMD source is important to address in order to reduce the AMD impact on the overall subwatershed. Prevention of AMD formation at the gob pile can be achieved. Since prevention is the ideal abatement strategy, this is the technique recommended for this AMD source. The burning of the gob should also be ceased by quenching. The general concept of the prevention strategy recommended is to sequester the gob material, quenching the material as the process is performed. To achieve the sequestration, placement of the material in a pit similar to that done in a landfill is recommended.

It was previously estimated that 12,000 cubic yards (324,000 cubic feet) of gob are in the burning pile (Stuart, et al., 1998). However, on site investigation has led to the conclusion that there is substantially more material in the pile. Therefore, the design that follows is for 24,000 cubic yards (648,000 cubic feet), which allows for 100% error in estimation. There is a possibility that the design is too large, therefore the pit should be excavated in stages so that only the amount of earthwork that is needed is performed. There also could be more material in the pile than is anticipated. Therefore, room for expansion should be allowed. It is recommended that the pit is excavated and soil placed at one end of the pit as shown in Figure 5.1. This would allow room at the other end of the pit for expansion if needed. As the process advances, cover should be placed on the gob in order to reduce water infiltration from precipitation events.

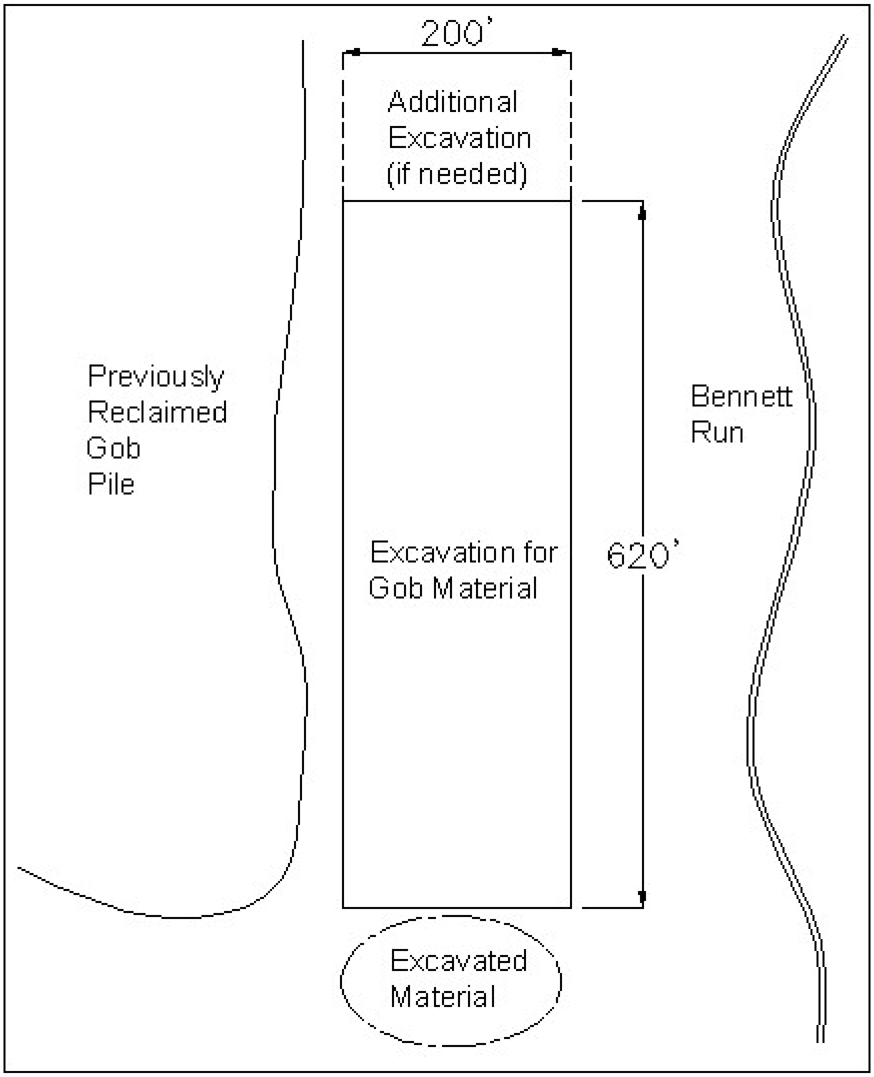


Figure 5.1 – Gob Excavation Plan

The designed pit is a trapezoidal cross section area with the top being 200 feet and the bottom 150 feet with a 6 foot depth. The pit should be 620 feet long. These dimensions provide 651,000 cubic feet of space for the gob and more than a 4H:1V slope on the sides, which will be discussed further below. The site conditions provide ample room for this design and additional excavation if needed.

The material being excavated can be used as a topsoil if the quality is acceptable. The USDA soil survey classification of this area is mine dumps (Ds). This material is not classified or characterized by USDA. Field testing will be required to determine the depth of the deteriorated soil and the extent of the contamination. Unacceptable soil in the area may need to be buried with the gob material. There is ample room at the site to broaden the size of the excavation to meet this need. Another option is to increase the depth of material in the pit, thus elevating the surface of the formation. This would not be unreasonable since it is next to the large reclaimed gob pile and a continuous slope could be graded. If the quality of the soil at the site is acceptable, surplus soil excavated can be used to revamp the previously reclaimed gob pile in areas where erosion is evident. It should also be graded over the area where the burning gob had resided.

The placement of the excavation should be in the area adjacent to the previously reclaimed gob pile, as shown in Figure 5.2. There is sufficient area at this location for the pit and it is in close proximity to the burning gob. While most of the gob material should be placed beneath the surface of the current groundlevel, the cap and topsoil may mound at an elevated height. The surface should be contoured to match the topography of the area. Since the reclaimed gob is next to this excavation site, the hillside could simply be continued at a lesser slope as opposed to the more dramatic decrease in elevation that currently exists at the site. Also, the elevated height would discourage ponding of runoff water from rain events. Ponding could encourage infiltration into the sequestered gob.

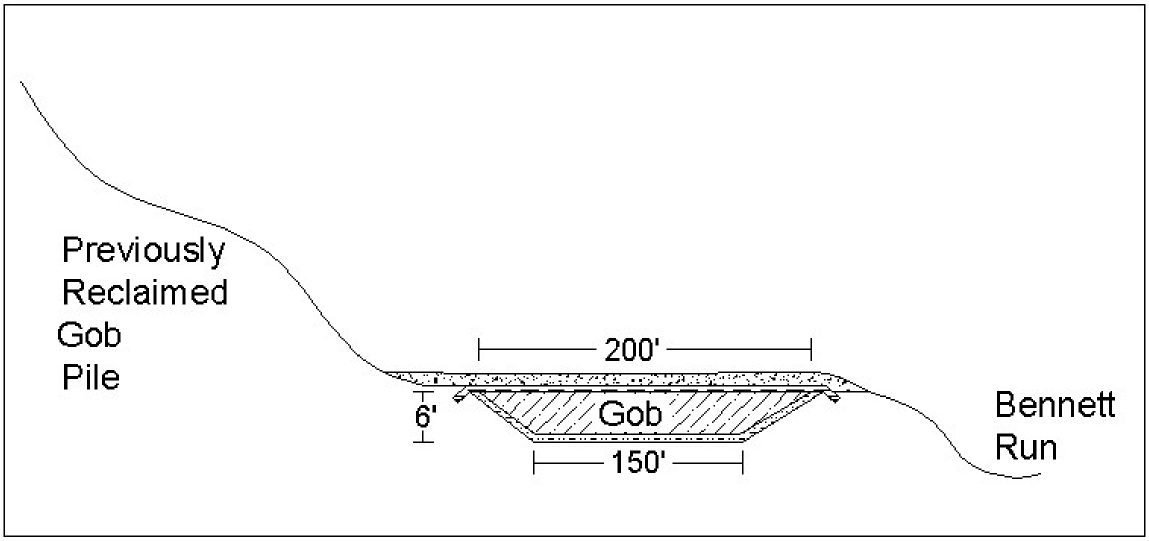


Figure 5.2 – Profile of Burning Gob Sequestration

The cross section of the pit is shown below in Figure 5.3. The recommendation for the pit is that flue gas desulfurization sludge (FGD) be used to line the excavation. Once the quenched gob is placed in the pit, it should be capped with a nearly impermeable layer such as compacted clay or a geotextile. Finally, a topsoil layer should be placed on top and vegetation should be established. This would inhibit erosion and provide wildlife habitat.

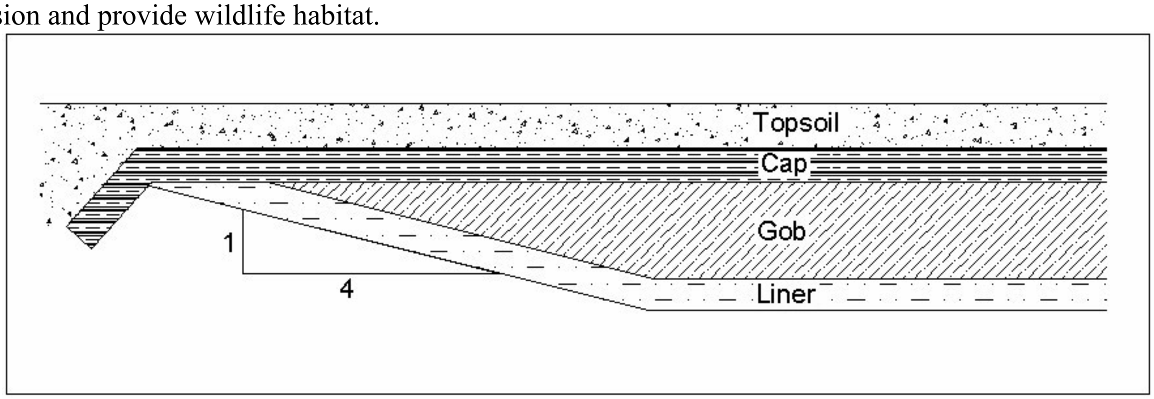


Figure 5.3 – Cross Section of Gob Sequestration

One consideration in the design was drainage of the pit. Should water infiltrate into the material, a route to escape would prevent the water pressure from forcing the cap and liner to fail. A drainage system similar to that used in municipal landfills was considered. However, another option is to discourage infiltration into the pit through the cap layer and to allow some leaching through the liner. This plan sustains the ideology of preventing water's contact with the material, but has a contingency plan should water infiltrate. Instead of allowing water pressure to build, the water would seep through the liner material. This seepage would be minimal and would not produce the AMD at nearly the magnitude that it currently exists.

It is assumed that the pit is well above the groundwater table so water would not infiltrate the sequestered gob from below. Wells should be drilled prior to construction in order to determine the groundwater level. If the level is too high for this excavation depth, the pit may be raised. Raising the pit would decrease the amount of excavation needed, thus reducing the amount of soil available for topsoil and cover for the previously reclaimed gob pile and the site of the current burning gob pile. However, the raised pit would reduce cost required for excavation.

FGD is recommended for the liner layer of the excavation because of its low permeability and ability to add alkalinity to water that leaches through it. FGD typically yields a pH between 10 and 12, and a permeability of 2.5×10^{-6} to 4.5×10^{-8} cm/sec (Rudisell, 1999). This range is dependant on the ratio of fly ash to filter cake, the percentage of quick lime, and the allowed curing time (Faulconer et al., 1997). FGD becomes slippery and difficult to work with in the field when wet. It is recommended that FGD material is used on side slopes of 4H:1V or flatter to decrease difficulty in compacting (Rudisell, 1999). The permeability is such that water would be discouraged to seep through the layer, however, should water pressure build, the flow would likely travel through the FGD as opposed to rupturing the cap. As the water would leach through the FGD, some treatment would be obtained before being discharged into the atmosphere. One concern about using FGD is that it can leach Boron, which is toxic to plants. However, this design does not call for FGD to be near vegetation, thus there should be no harm to the environment. FGD is a waste that would otherwise be landfilled and can be obtained for only the cost of transportation. The FGD should be placed into the pit at a similar rate of the gob being placed in the excavation. Exposure of the FGD to the elements could increase its permeability and weaken its strength properties.

The liner on top of the pile should be either compacted clay or a synthetic material such as a geomembrane. The advantage of compacted soil is the lower cost, however, geomembranes are a thinner material with a lower permeability. The depth of a compacted soil as a cap would need to be approximately two feet, whereas the thickness of a geomembrane is less than one inch. Although the USDA soil survey did not provide information on the soil at the exact site, surrounding areas were described. Soils adjacent to this area are Guernsey-Westmoreland silt loam with 25 to 40% slopes (GwE), Newark silt loam, frequently flooded (Ne), Westmore silt loam, 8 to 15% slopes (WkC), and Zanesville silt loam, 1 to 8% slopes (ZnB). These on site soils have a permeability on the order of 10^{-4} cm/sec whereas geomembranes have permeabilities of the 10^{-12} cm/sec magnitude.

This recommendation would significantly improve the water quality of the Black Fork subwatershed. First, moving the material would disallow the water from the impounded perched lake from flowing through the pile, thus creating AMD. While some infiltration into the sequestered gob could occur, the result would be minimal compared to the current conditions. Also, in addition to using low permeability materials to prevent AMD formation FGD is recommended, which can assist in attenuation of any AMD that is formed.

While capping was performed to remediate the adjacent gob pile on Bennett Run, sequestration is a better alternative for this particular case. The primary reason is that successful capping would difficult to achieve with the lake that borders the pile. The water in this lake would have a tendency to undercut any capping attempt of the pile, thus flowing through the material and continuing to create AMD. Because the gob is burning, quenching is needed for any alternative chosen. Since quenching requires dislocation of the material, it is relatively easy to move the material to an adjacent area into the pit.

2) Treatment of Whitehouse Seep

Whitehouse seep is the largest flow contributor of the four AMD sources to Black Fork. It also contributes significant pollutant loads to the receiving stream. Prevention of AMD formation was first considered for this source, however, that option is not practical. The flow is surfacing from an underground manmade mine shaft. If the shaft would be closed, the water would find another way to escape due to its high flowrate. The best option at this source is to initiate a passive treatment system.

The existing configuration of the Whitehouse seep is sketched in Figure 5.4. The seep source is the mine shaft from which the water flows. The solid line represents a general flow pattern of that water, which flows approximately 400 feet before passing under a bridge on Whitehouse Road and discharging into Black Fork. There is sediment accumulation at the discharge point from the high metal content of the seep. The dotted line represents a general boundary denoting sparse vegetation. Within that area, there are few to no trees and other vegetation present. In fact, the area is covered with a deep layer of loosely packed sediment and no soil is visible. A higher density of trees and vegetation surrounds that area.

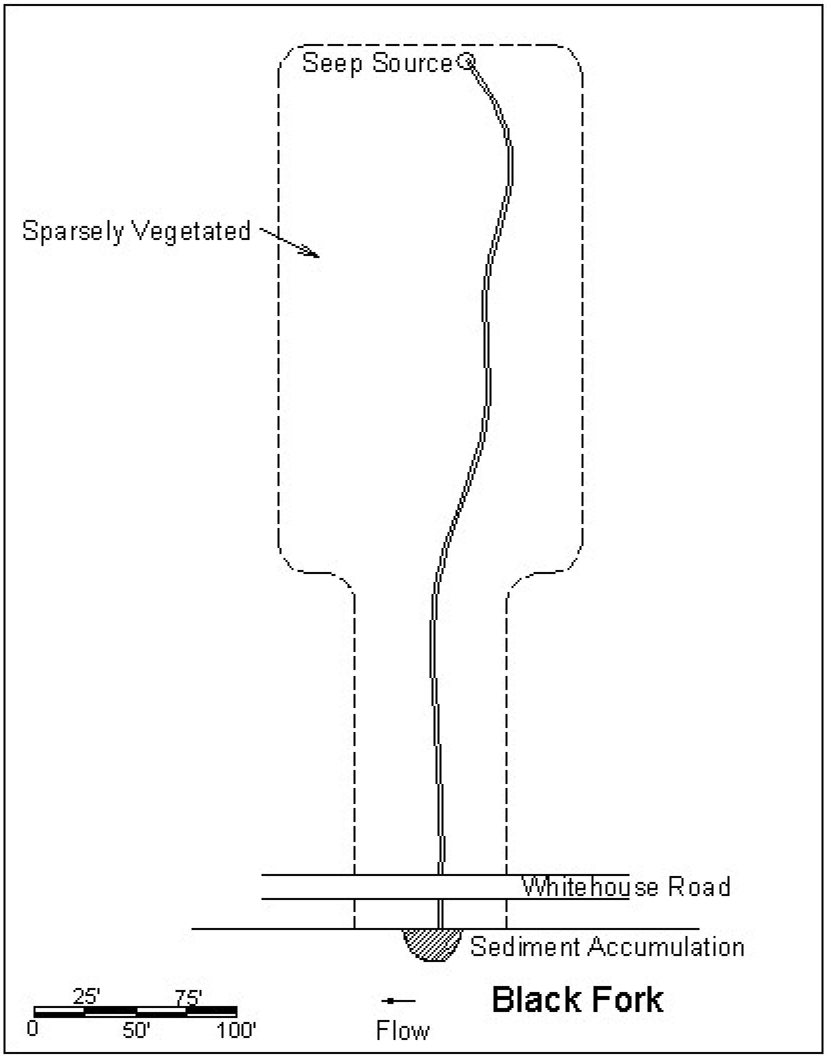


Figure 5.4 – Existing Whitehouse Seep Configuration

Because of the land area available (about 50,500 ft^2 or 1.2 acres) the treatment method chosen was a successive alkalinity producing system (SAPS). The land available was considered to be the sparsely vegetated area, although some wooded area surrounding the site could be used for treatment purposes. Primarily using the land that is already barren reduces the amount of tree clearing for the project. The design flow and contaminant load used was the high flow average data presented in Chapter 4. This provides a conservative design, as a lower flow and contaminant load would yield a longer retention time, implying higher treatment efficiency. The recommended design for the SAPS is shown in Figure 5.5.

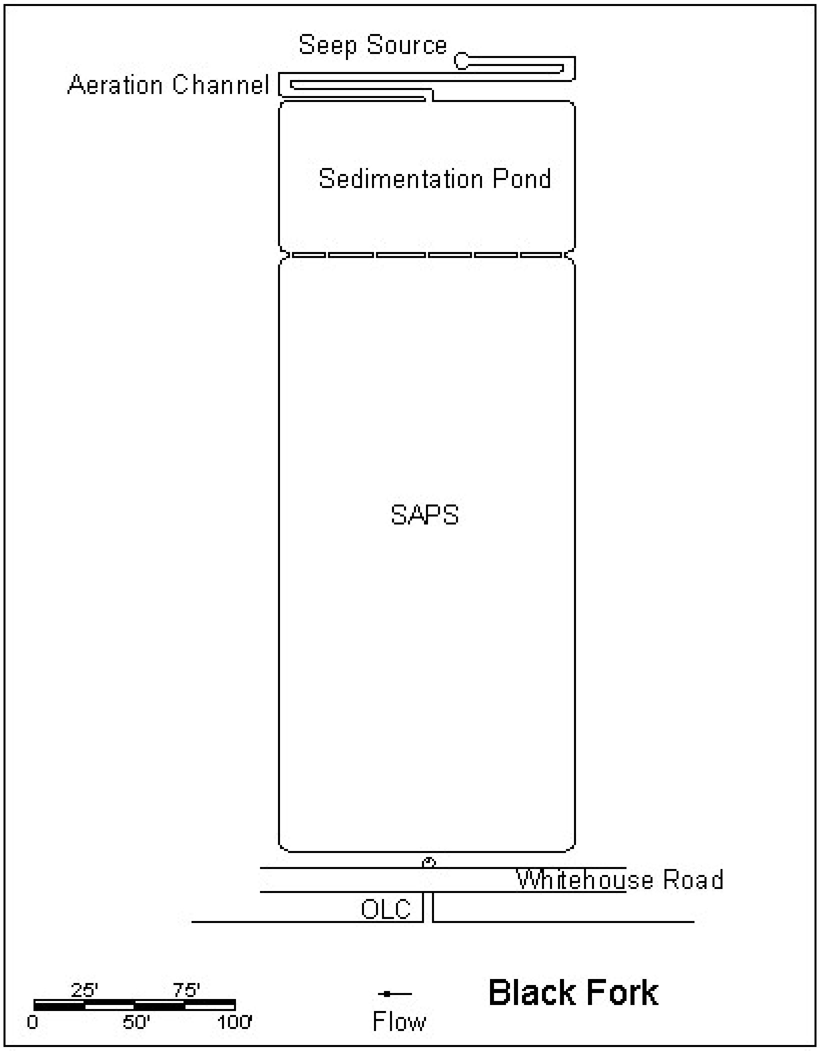


Figure 5.5 – Whitehouse SAPS Plan View

The first stage in this treatment system would aerate the water flowing from the seep. Oxidizing the water would complete the AMD reaction and begin the process of precipitating metals. The flow would then be routed into a sedimentation pond. The desired retention time is at least one day. This sedimentation pond would remove some of the metals, specifically iron, so that fouling of the following SAPS system would be minimized. A lower influent metal concentration to the SAPS would give a higher treatment efficiency and a longer life expectancy. The SAPS would discharge into an open limestone channel (OLC) before being discharged into Black Fork. The sediment in Black Fork that has accumulated over time would be removed.

As stated previously, the first stage is aeration. If the water flowing from the seep would enter a sedimentation pond without first being oxidized, the AMD reactions would not have had a chance to take place, therefore there would be minimal metal removal. The preliminary assessment showed that the ORP of the water increased from 30 mV to 190 mV between the source of the seep to Whitehouse Road, which is a distance of about 400 feet. When peroxide was added at each sampling locations the ORP increased to about 490 mV. This 490 mV detected in the preliminary assessment was consistent with the monthly data gathered (high flow average = 487 mV, standard deviation = 25 mV; low flow average = 488 mV, standard deviation = 41 mV). This implies that when this seep is fully oxidized, the ORP is about 490 mV. Assuming the relationship between distance and ORP is linear, the seep needs 1,150 feet of channel at the current depth to fully oxidize. To reduce the length of channel, the surface area of the flow must be increased, thereby increasing the amount of contact between the water and atmosphere. With twice the surface area, only 575 feet of stream length is needed for the water to be fully oxidized. Because of restricted area available for treatment, a shorter stream length was used than the 575 feet desired. The seep would be routed through a four-foot wide serpentine channel for a length of about 300 feet. This would yield an expected ORP of 256 mV using the linear relationship. While this is not the desired output of the aeration channel, it is oxidized moderately for better metal removal in the sedimentation pond. The slope of the channel should be approximately 1/4-inch vertical change per one foot horizontal change. The expected resulting velocity was found using the Manning formula, shown in Equation 5.1.

$$v = \frac{1.49}{n} R^{2/3} S^{1/2} \qquad \text{Equation 5.1}$$

Where v is the velocity in ft/s, 1.49 is the conversion factor for USC units, n is the Manning roughness factor, R is the hydraulic radius, and S is the slope of the bottom of the channel. The hydraulic radius is equal to the cross-sectional area of the channel divided by the wetted perimeter. The roughness factor used was 0.025, which is the value for earth. With a channel width of four-feet and water depth of 0.5 feet (aeration provided from the atmosphere generally penetrates up to six-inches of stream depth) the velocity would be 4.66 feet per second.

The sedimentation pond's desired retention time is a minimum of one day. However, due to area restraints this could not be achieved. The depth of the sedimentation pond should not be too great in order to avoid groundwater infiltration. The length was restricted by the amount of area needed by the SAPS and the width was restricted by the land available. The dimensions of the sedimentation were designed with a length of 80 feet, a width of 150 feet, and a depth of 9 feet. The sides should be sloped at a 2V:1H ratio for safety reasons. If someone would fall into the sedimentation pond, this would allow an easier retreat from the water. This yielded a retention time of about 0.73 days for the design flow of 1.67 cfs. The average low flow was 0.23 cfs, which yields a retention time of almost 5.3 days. The cross-section of the sedimentation pond is shown in Figure 5.6.

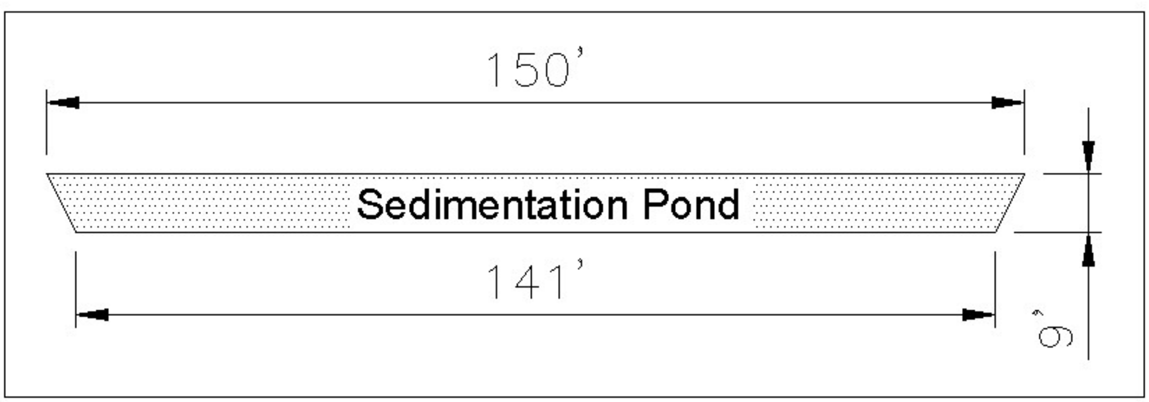


Figure 5.6 – Cross-Section of Whitehouse Sedimentation Pond

The difference in elevation between the inlet and outlet of the sedimentation pond need only be a few inches. This elevation change can be set using box culverts similar to those currently being used in the Tropic wetland and shown in Figure 5.7. While the water entering the sedimentation pond will only flow through one point, the effluent should flow through several evenly spaced culverts to distribute the flow into the SAPS. The box culverts are approximately two-feet wide, and the sketch shown in Figure 5.5 shows seven discharges into the SAPS.


Figure 5.7 – Box Culvert

The cross section of the SAPS is shown below in Figure 5.8. There should be approximately 1.5 feet of freeboard to prevent overflow. The surrounding land should be contoured such that runoff from precipitation events runs away from the SAPS as opposed to draining into the SAPS. The potential runoff into the system from storm events would reduce detention times, thus lowering removal efficiency. The high velocity through the system could also displace some of the material, particularly the organic substrate.

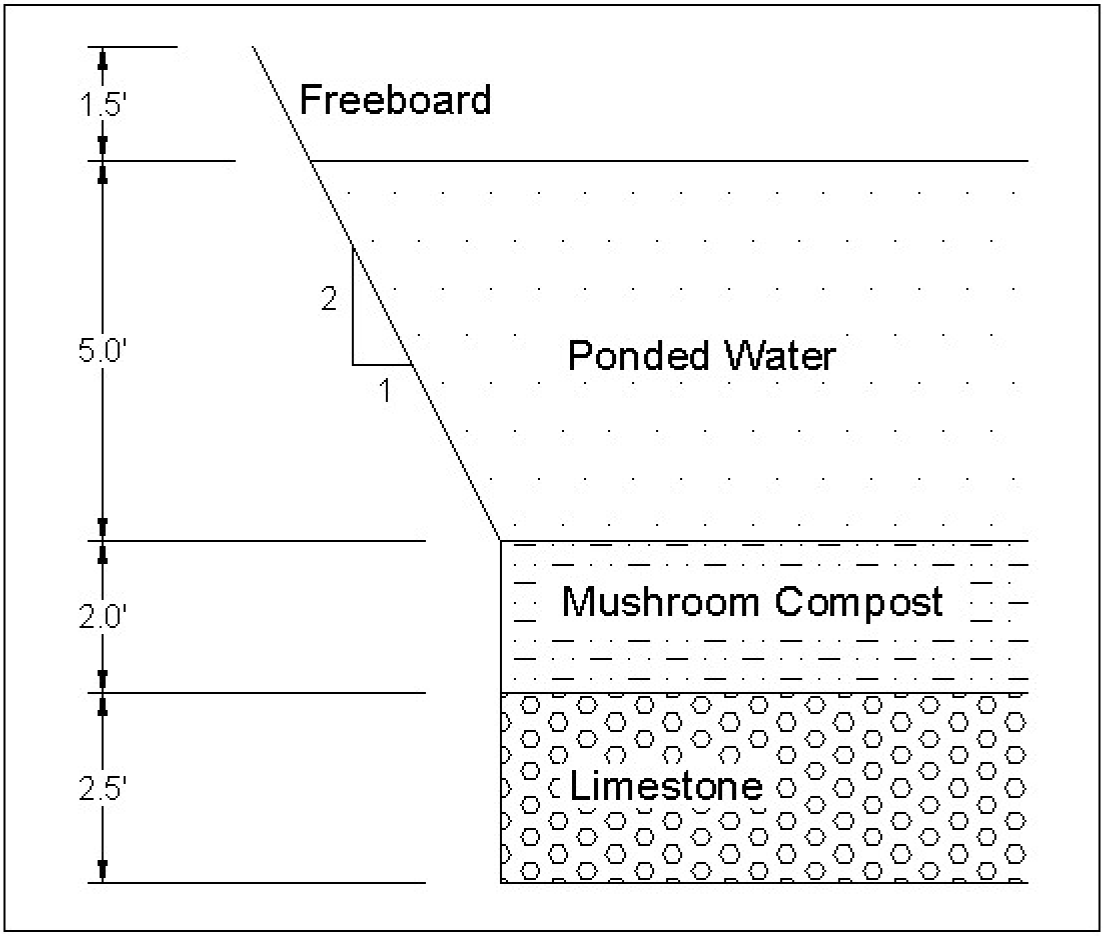


Figure 5.8 – Whitehouse SAPS Cross-Section

The size of the SAPS was designed based on an overall detention time of 50 hours (12 hours in the limestone layer). The life expectancy of the system is 20 years based on the limestone. With time, the $CaCO_3$ being used from the limestone to provide alkalinity will deteriorate the limestone layer, leaving smaller porous space in the layer, thus enabling clogging.

The ponded water has a depth of five feet so that the environment is fairly anoxic toward the mushroom compost. It is reasonable to assume that the water will be anoxic at the organic substrate layer even though aeration is being performed prior to the water's discharge into the SAPS. First, the expected ORP at the effluent of the aeration channel is 256 mV. This is lower than the saturated ORP of 490 mV. Oxygen is being provided in order to assist with the AMD formation reaction, not for retention of oxygen in the water. The oxygen being added to the water should be consumed by the reaction and should not be present in the water as it travels downward in the SAPS. Also, documented SAPS show that influent oxygen content does not imply high effluent oxygen content. One such example is that of Howe Bridge in Jefferson County, Pennsylvania. This SAPS system had a water depth of about 6 feet, and a compost and limestone layer of about 1.5 feet each. The influent dissolved oxygen (DO) concentration was between 5 and 10 mg/L and the effluent DO concentration was consistently less than 0.2 mg/L. A healthy stream exhibits DO concentrations in the range of 8 to 10 mg/L. Therefore, by introducing fully oxidized water, the depth of water provided in the SAPS system was enough to provide an anoxic environment for a working system, not producing sediment that would clog the system and hinder treatment (Kepler, et al., 1994).

The water is desired to be oxygen deficient at the bottom in order to provide better sulfate removal and to avoid coating the limestone layer. Removal by sedimentation in the SAPS is not desired because it would cause fouling of the system and reduce removal effectiveness and life span. The ponded water and freeboard sides are sloped for safety reasons.

The mushroom compost is a commonly used organic substrate. It is very high in organic content and provides a good environment for bacteria. The anoxic environment provides a good habitat for sulfate reducing bacteria (SRB). SRB reduce sulfate concentrations in the following manner. The bacteria need a source of oxygen, however, as stated above there is a low oxygen content at this depth. Therefore, the oxygen from sulfate, SO_4^{2-} is used as a source for respiration. The sulfur that is left from the reduction bonds with the hydrogen ions in the water and the compound escapes as hydrogen sulfide gas (H_2S). This removes the sulfur and hydrogen ions (which contribute to acidity), however, there is an unpleasant odor to hydrogen sulfide gas. The amount of mushroom compost needed for this design is 657 tons. The mushroom compost should not be compacted when it is installed.

Mushroom compost is recommended because of its high organic content, which allows bacteria to thrive because it provides a good food source. However, due to the high cost of the material, another enriched organic substrate could be used.

The water would then flow through the limestone layer. Again, the anoxic environment is beneficial to the system because oxygen present would enable the AMD reactions to occur, thereby producing an iron precipitate that would armor the limestone. Coated limestone provides lower alkalinity addition. Also, sediment produced from the reaction would clog the pores between the limestone rock. This would reduce residence time, thereby reducing efficiency and shortening the life expectancy. The limestone layer adds alkalinity, thereby reducing net acidity. Typical estimates for alkalinity addition are stated below. Conservatively, 30 mg/L alkalinity as $CaCO_3$ is added, realistically 50 mg/L alkalinity as $CaCO_3$ is added, and optimistically 80 mg/L alkalinity as $CaCO_3$ is added. These values are based on the performance of a SAPS system only and do not take into account pre-aeration or sedimentation. The system being recommended provides oxidation and sedimentation, which will remove some mineral acidity prior to the water's entrance into the SAPS. Therefore, these estimates are conservative and better treatment is expected. The results are shown below in Table 5.1.

Table 5.1 – Alkalinity Addition of Whitehouse SAPS

Flow Conditions	Flow (cfs)	Alkalinity added (mg/L as $CaCO_3$)	Alkalinity load added (kg/day as $CaCO_3$)	Acidity present (kg/day as $CaCO_3$)	Resulting Net Acidity (kg/day as $CaCO_3$)
Low	0.23	80	45	130	85
Average	0.95	50	116	355	239
High	1.67	30	101	580	479

The low and high flow conditions are the same as used in Chapter 4. The average flow conditions are the average of the low and high flow conditions. The low flow conditions provide 35% reduction, average flow provides 29% reduction, and high flow provides 17% reduction in acidity as $CaCO_3$.

The limestone used should be one to two-inch diameter limestone rock with at least eighty percent $CaCO_3$ content. Eighty percent $CaCO_3$ content is recommended since it is available in this area. The top three inches of the limestone layer should be three-eighths inch limestone. This is done in order to place a geotextile on top of the layer. The addition of this smaller material will provide a smoother surface for the geotextile, which will reduce the likelihood of fabric failure. The three-eighths inch material is large enough to not slip between the pores of the larger limestone being used. This design calls for 6,607 tons of limestone having 80% $CaCO_3$ content.

A geotextile should be placed between the layers of the system and along the slope in the ponded water. Along the slopes of the system, the geotextile stabilizes the banks and maintains the soil in its place if soil is being used as a liner. If a geomembrane is being used as a liner, a geotextile is not needed along the slopes of the water layer. Geotextile should be placed on top of the organic layer primarily for maintenance. As the unavoidable sedimentation of metals occurs and as vegetation such as leaves and other material falls into the system, it will collect at the bottom, potentially clogging the system. The geotextile could be cleaned by lifting it from the water or raking it in order to move such debris. The layer between the mushroom compost and limestone would allow the layers to be kept separate. Organic material passing through the lower system could inhibit flow through the pores of the limestone rock or clog collection drains. The openings in the geotextile should not be too small in order to avoid inhibiting the flow through the layers.

Once the water flows downward through each layer, it should be collected in one of three six-inch perforated pipes. There should be a pipe running along the centerline of the SAPS with another pipe 50 feet on each side of it. This leaves almost 25 feet between the end pipes and the walls of the system. It is desired to have increased spacing in the center of the SAPS to discourage channeled flow along the shortest path. The pipes do not need to be installed at any slope, as the head pressure from the system will feed the water through. The velocity of the water through each of the six-inch pipes was calculated to be 2.84 ft/s. Since this velocity is greater than 2 ft/s, sufficient velocity is provided to transport sediments. The three pipes should join together underground in the center of the SAPS. The pipe would then be run vertically to surface as a standpipe similar to that in Tropic wetland.

A clean-out pipe should be included in the design as shown in Figure 5.9. This pipe would discharge at a lower elevation than the standpipe, thereby increasing the velocity of the water through the pipes when its valve is opened due to the decreased head pressure. This would allow fairly easy and inexpensive maintenance of the system should it need cleaning. The clean-out pipe should be installed at a slight angle from the standpipe (not perpendicular to Black Fork, as the OLC will run). This will allow the clean-out pipe to surface from the bank of Black Fork at a different location from the normal discharge of the system, which would allow researchers to more easily sample the location. The clean-out pipe does not have to be at an elevation nine feet below groundlevel, as the other pipes are. The elevation can be increased depending on ease of construction and field conditions. As long as the clean-out pipe has a lower elevation than the standpipe, the velocity will be increased, therefore eliminating clogging in the pipes.

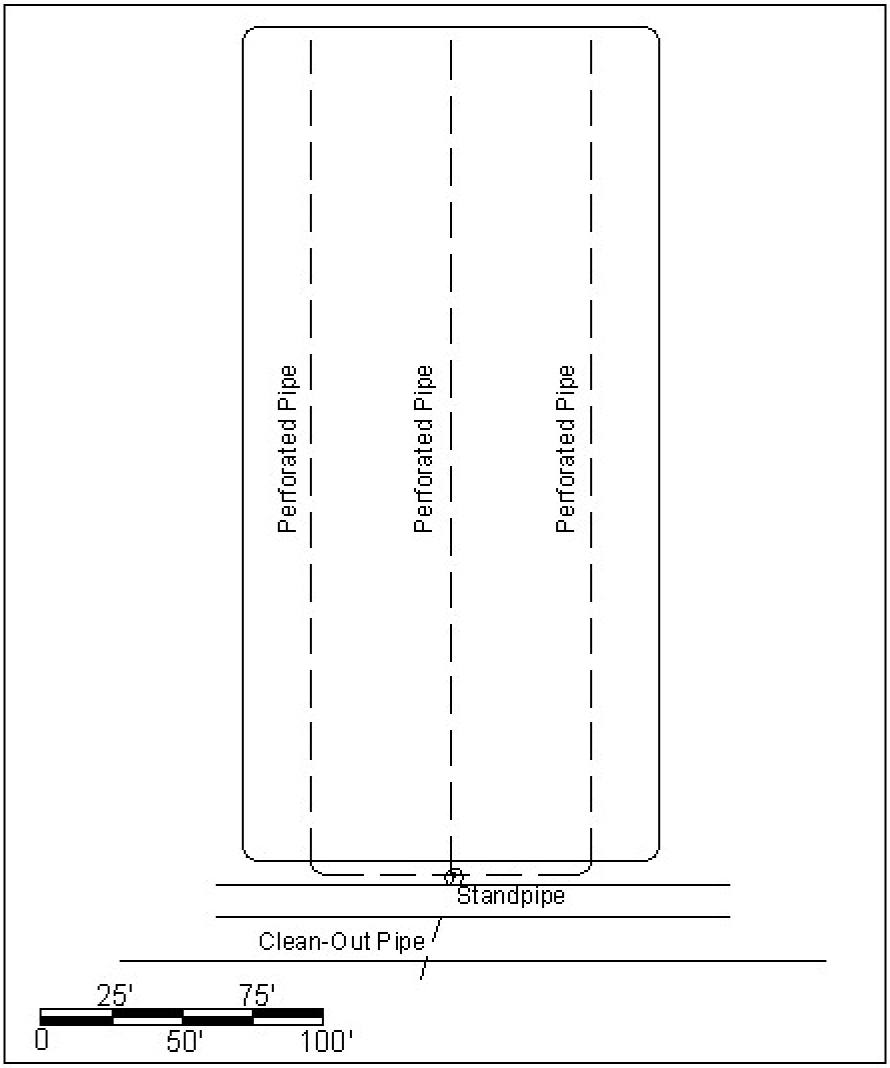


Figure 5.9 – Pipe Configuration for Whitehouse SAPS

The SAPS should be lined with some kind of impermeable material. If the depth of the water table is a concern, a geotextile should be used. Geomembranes are generally 60 mil thick with a permeability on the order of 10^{-12} cm/sec, however, they are costly. Another option is to use soil in the field compacted to a depth of two feet on all sides and bottom of the SAPS.

The soil in the area of the Whithouse seep is predominantly Euclid silt loam, rarely flooded (EuA). The surface layer (0 to 10 inches) is dark grayish brown brittle silt loam. The subsoil (10 to 43 inches) is multicolored, brittle silty clay loam and silt loam. The substratum (43 to 80 inches) is multicolored brittle loam. The permeability is moderately slow. There is a low shrink-swell potential and a permeability of 0.2 to 0.6 in/hr in the top layer and 0.06 to 0.2 in/hr in the subsequent layers. The soil consists of 2 to 3 percent organic matter (USDA, 1998).

The area approximately between the bridge and Black Fork consists of Nolin silt loam, occasionally flooded (No). The surface layer (0 to 10 inches) is brown brittle silt loam with a permeability of 0.6 to 2.0 in/hr. The subsoil (10 to 52 inches) is dark yellowish brown brittle silt loam with a permeability of 0.6 to 2.0 in/hr. The substratum (52 to 82 inches) is also dark yellowish brown brittle silt loam but with a permeability of 0.6 to 6.0 in/hr. The soil has a low shrink-swell potential and consists of 2 to 4 percent organic matter (USDA, 1998).

The channel leading from the SAPS, under the Whitehouse bridge into Black Fork should be lined with limestone. This 20-foot stretch of OLC will provide further addition of alkalinity. Variable sized limestone rock should be used in this channel to avoid undercutting of the channel and to provide more surface area with less clogging.

3) Remediation of Dry Run

The Dry Run area does not have one specific source contributing AMD to the stream. As presented in Chapter 4, the AMD of this region enters the system through either one of two collection channels, or the headwaters of Dry Run. The headwaters of Dry Run do not have a specific point at which they become contaminated. It was concluded that AMD seeps upward through the streambed into the channel from the ground. There is one obvious seep area contributing to the collection channel that drains to DR3. In addition, the hillside that the collection channels flow through is seeping with AMD in small quantities. Because the entire hillside is a contributor, prevention of formation would be a major undertaking that could displace homes in the area because of their proximity. The challenge and cost of the project would not be worth the effects to the watershed. Instead, treatment strategies can be implemented. Again for this section, the months used for high and low flow discussion in Chapter 4 are used.

The headwaters of Dry Run (DR7) are not a significant AMD contributor because of the minimal flow. Many times throughout the sampling period this sampling point was simply standing water from which data was collected. While there is some contamination, a greater affect is from the two collection channels. The chemical loadings found at DR2 and DR3 are summarized in Table 5.2.

Table 5.2 – Chemical Loadings from DR2 and DR3

	Flowrate	Acid	Sulfate	Iron
	(cfs)	(kg/day)	(kg/day)	(kg/day)
DR2				
high flow	0.030	74	183	37
std. deviation	*0.003*	*45*	*32*	*8*
low flow	0.023	86	143	30
std. deviation	*0.004*	*18*	*28*	*7*
DR3				
high flow	0.176	176	309	27
std. deviation	*0.202*	*130*	*202*	*22*
low flow	0.084	138	267	22
std. deviation	*0.028*	*24*	*53*	*2*

The source of AMD for DR2 is exclusively from the seepage of the hillside. The channel flowing into DR3 is fed not only by the hillside seepage, but also from the visible seep alongside a private driveway as discussed in Chapter 4. Therefore, DR3 contributes the higher flowrate and pollutant loads of the two channels. The current conditions allow the water from this driveway seep to flow freely from the observed mineshaft toward the roadway and along two separate channels before rejoining into the collection channel that becomes DR3.

Both collection channels have a length of about 300 feet between Morgan County Road 75 and a forested area uphill. There is ample clearing on either side of both channels; however, it is unknown who currently owns this property. This must be determined prior to implementing a treatment option. The channel widths are currently each about 10 to 15 feet.

The primary recommendation for Dry Run is a SAPS for each collection channel. The advantage of treating each channel separate is that the flow will be lower and the loads will not be as high as if treatment was performed once the water discharged into Dry Run. Because of the lower flowrates and loads, better treatment can be achieved. SAPS are suggested over wetlands because they have been shown to provide more removal using less area (Kepler, et. al. 1994).

The basic strategy recommended for the DR3 channel is an anoxic limestone drain (ALD), aeration channel, sedimentation pond, and SAPS, as shown in Figure 5.10. The first step would be to remove the sediment along the driveway. The ALD should be constructed over the seep opening so that the water does not come in contact with the oxygen present in the atmosphere. This will disallow the AMD forming reaction to take place and alkalinity can be added without armoring of the limestone.

The design for the ALD was based on the design used at Tropic wetland, which yields a retention time of about 2.8 days based on an average flow of 0.15 cfs. The volume was scaled up for the flow at DR3 of 0.176 cfs, which is the average high flow conditions thus resulting in a conservative design.

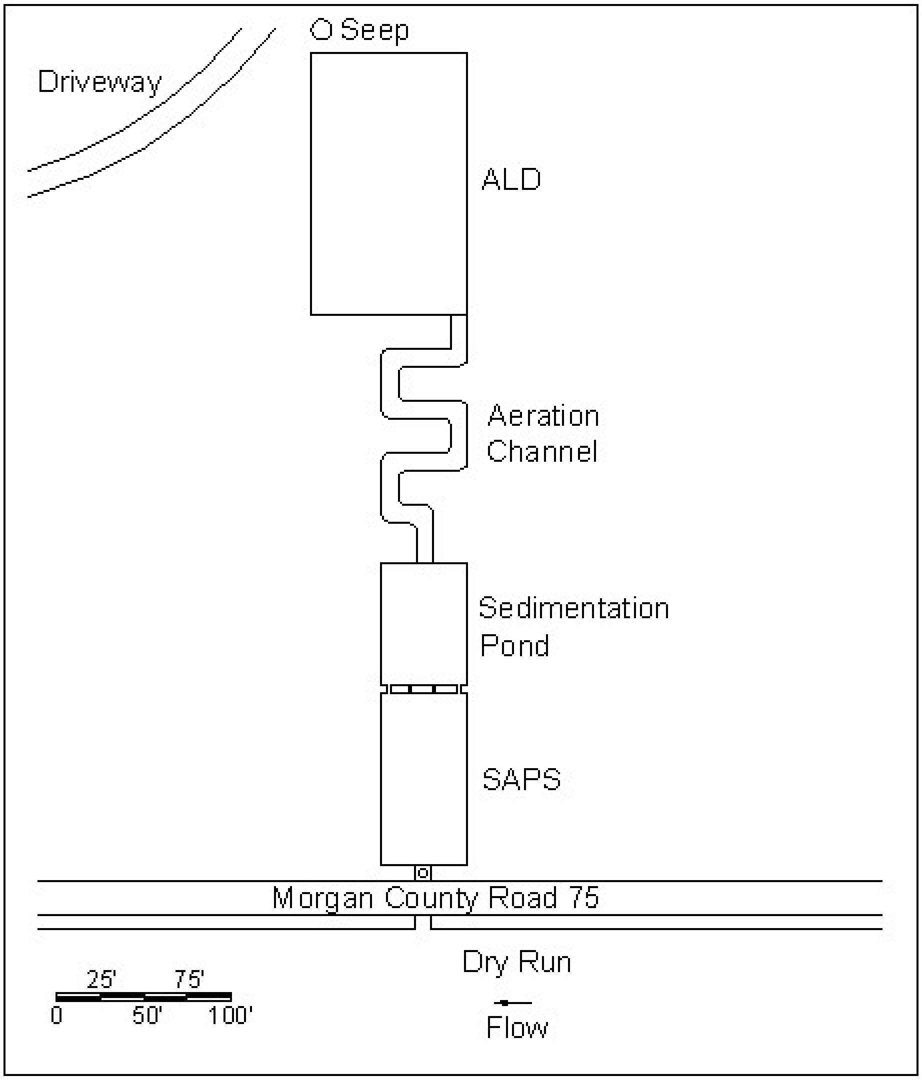


Figure 5.10 – DR3 Remediation Plan

The volume of limestone needed to scale the design to this flow was 43,243 ft^3. Keeping the depth of limestone at 3.5 feet and assuming a channel length of 150 feet, the width of the ALD was found to be 76.3 feet. To facilitate construction, the width was increased to 78 feet on the bottom, and 90 feet on top as shown in Figure 5.11. The resulting limestone volume was 44,100 ft^3, which gives a retention time of 2.9 days.

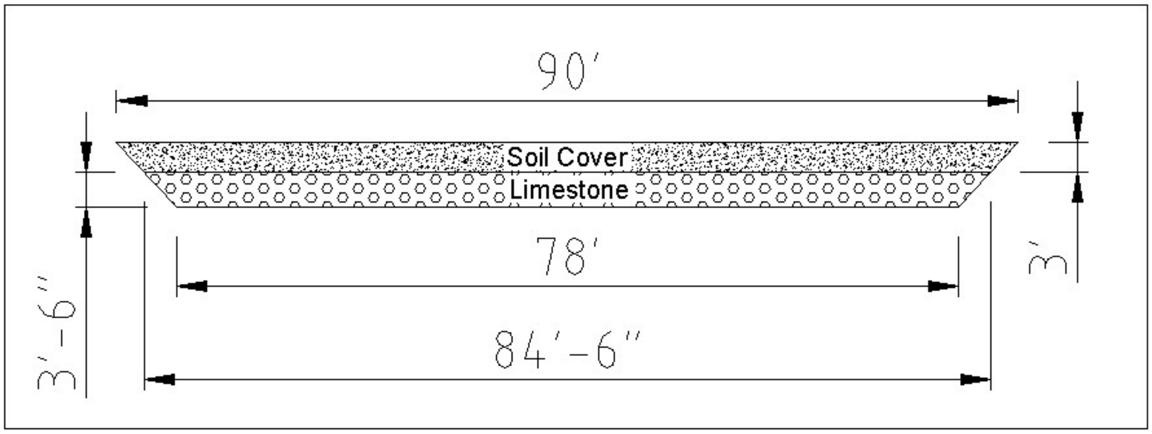


Figure 5.11 – DR3 ALD Cross Section (Width)

The seep will be routed through the ALD by surrounding the seep with compacted field soil on all sides except toward the ALD configuration. At that point, the opening to the ALD will have a 10-foot long drain of gravel as shown in Figure 5.12. The flow will travel through number 57 limestone (3/4-inch diameter) on a downward slope of 0.005 ft/ft, as used in the Tropic wetland design. The water will then drain through a 3-foot wide collection ditch of numbers 1 and 2 limestone (3 and 2-inch diameter, respectively) before discharging through a pipe. This pipe effluent will allow for the collection of samples.

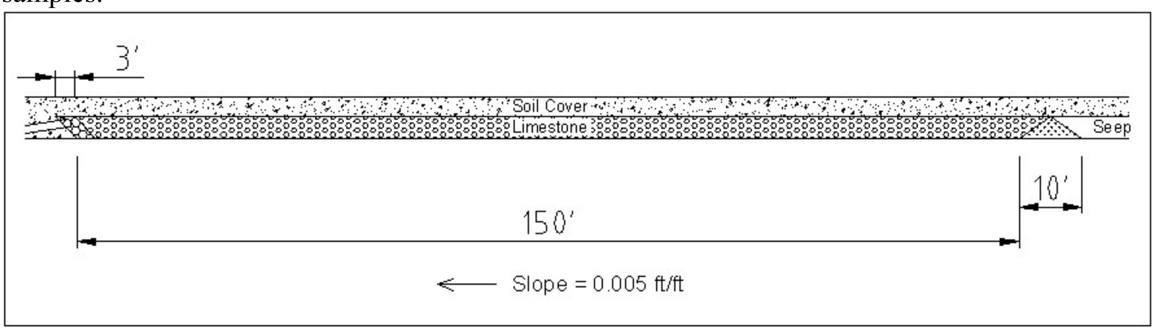


Figure 5.12 – DR3 ALD Cross Section (Length)

The Tropic ALD provides an average of 334 mg/L net alkalinity as $CaCO_3$. Since this design uses the same retention time and materials, it is reasonable to predict similar treatment efficiency. A geomembrane should be placed over the limestone layer in the ALD to prevent infiltration of precipitation.

Once the anoxic water exits the ALD, it will flow through a serpentine aeration channel. This channel will be 10-feet wide, similar to the existing conditions. The positioning of the channel is shown above in Figure 5.10. The total channel length is 280 feet, which is similar to existing conditions, which provides full oxidation of the seep (the current ORP at DR3 averages over 500 mV).

The sedimentation basin was designed for a retention time of 2 days. The depth used was 9 feet and the width used was 50 feet. These values were chosen in order to retain consistency with the design of the SAPS. The resulting length of the sedimentation pond was found to be 70 feet.

The SAPS was designed based on an overall retention time of 50 hours, with 12 hours detention in the limestone. This required 31,680 ft^3 of space. Using a relationship of the length being twice as long as the width, the resulting dimensions were 50-feet by 100-feet with a 9.5-foot depth. This yielded a void space of 34,375 ft^3. The same cross section was used as with the Whitehouse seep design, which can be seen in Figure 5.8. The amount of limestone and organic substrate needed was found to be 8,125 ft^3 and 5,000 ft^3, respectively.

One 6-inch pipe collecting the water from this channel would yield a velocity of 0.89 ft/s. Although this is the preferred pipe size used in this area, this flow could be too low to carry solids and prevent clogging. Instead, a 4-inch pipe should be used, which would produce a velocity of 2 ft/s. The effluent should be equipped with a clean-out pipe as described for the Whitehouse design. The standpipe should exit near ground level, and discharge into the current channel, which passes under a bridge of Morgan County Road 75 before discharging into Dry Run.

The seep at DR2 has a very low flow and high acidity, iron, and sulfate concentrations. A SAPS system would not effectively treat this seep. Two options will be presented as recommendations for this seep. While passive approaches are preferred, this seep may need active treatment since passive systems would provide less than 50% treatment.

The active treatment option is chemical addition followed by a sedimentation pond and vegetated polishing pond. There are many chemicals that can be effectively used to neutralize AMD. Table 5.3 presents common chemicals used with the amount that would be needed for this seep, which produces about 35 tons of acid each year. The costs are based on 1996 prices not using bulk discounts (table adapted from Skousen, Hilton, Faulkner's "Overview of Acid Mine Drainage Treatment with Chemicals").

Table 5.3 – Chemical Treatment Options for Neutralization at DR2

Common Name	***Chemical Name***	**Formula**	**ton/yr needed**	**cost per year**
Limestone	Calcium carbonate	$CaCO_3$	115	$1,730
Hydrated Lime	Calcium hydroxide	$Ca(OH)_2$	28	$2,885
Pebble Quicklime	Calcium oxide	CaO	22	$5,167
Soda Ash	Sodium carbonate	Na_2CO_3	61	$19,561
Ammonia	Anhydrous ammonia	NH_3	12	$8,000
Caustic Soda (solid)	Sodium hydroxide	NaOH	28	$24,358
			gal/yr needed	
20% Liquid Caustic	Sodium hydroxide	NaOH	27,126	$16,276
50% Liquid Caustic	Sodium hydroxide	NaOH	8,858	$11,072

The best alternatives are to use a diversion well with limestone or to implement a liquid caustic system diluted with potassium hydroxide, which would help avoid freezing. These were identified as the best alternatives based on effectiveness and cost.

The neutralized water would discharge from the chemical treatment system still high in metal concentration. A serpentine aeration channel could again be utilized to oxidize the water and assist the AMD reaction. Currently, the water travels about 300 feet between the seep emergence from the hillside and the sampling location DR2. The ORP is almost 400 mV at DR2, indicating that the water is oxidized. The total length of the aeration channel should therefore be about 300 feet for sufficient contact with the atmosphere.

The water should then enter a sedimentation pond. The pond was designed to have a retention time of 7 days. A depth of 9 feet was used to be consistent with the DR3 design. A narrow width is desired in order to avoid using local residents' land, therefore a 20-foot width was used for this design. Using these parameters with a 0.03 cfs flow yielded a required length of 100 feet for a 7 day retention time. Again, slopes of 2V:1H should be implemented, which will increase the pond size slightly, thereby increasing detention time. These slopes are implemented for safety reasons. Since it is a residential area, people could fall into the pond and would need a fairly easy way to exit.

Once sedimentation is complete, a final polishing pond should be utilized. The remaining 100 to 150 feet in length before reaching Morgan County Road 75 should be used for this purpose. With a width of 20 feet and depth of about 3 feet, the retention time would be 2.3 to 3.5 days. This pond should be vegetated with plants such as cattails, which provide further treatment before being discharged into Dry Run using the existing culvert. Vegetation should be established one season before being exposed to AMD water.

The other option for treatment at DR2 is passive treatment. An ALD would first be used, followed by aeration, sedimentation, and a SAPS. The ALD would be constructed similar to the one designed for DR3. The dimensions needed for this seep would be 3.5 feet deep with a bottom width of 18 feet and top width of 30 feet, leaving more than a 2:1 slope on the sides. The length would be 100 feet, giving a total volume of 8,400 cubic feet and a retention time of about 3.25 days. The same materials and construction techniques should be followed as with the ALD at DR3. The effluent could be either a one or two inch pipe, yielding a velocity of about or 5.5 ft/s or 1.4 ft/s, respectively. Because of the high sulfate concentration at DR2, a problem that could occur within the ALD is the precipitation of gypsum ($CaSO_4$). High sulfate concentrations are considered to be over 1,500 mg/L while this seep has an average sulfate concentration of 2500 mg/L (standard deviation = 215 mg/L).

The seep should flow through an aeration channel like that described for the active treatment option above. The aeration channel should be discharged into a sedimentation pond. The sedimentation pond should have a length of 100 feet, width of 20 feet, and depth of 9 feet. This yields a retention time of almost 7 days. The sides should again be sloped for safety reasons.

Finally, a series of two SAPS should be used before the seep is discharged into Dry Run. Each SAPS should be constructed identically. The cross section should be like that one used for the Whitehouse seep as shown in Figure 5.8. The width should be 20 feet and the length 40 feet. This yields a retention time of over 12 hours in the limestone layer and more than 50 hours total. This design calls for about 121 tons of limestone (80% $CaCO_3$ content) and 12 tons of organic substrate for each SAPS. The collection and effluent pipe should be 1 or 2 inch diameter, resulting in velocities of 5.5 ft/s or 1.4 ft/s. If two collection lines are desired, one-inch diameter pipes should be used, which would result in a velocity of about 2.25 ft/s per pipe.

Another option to enhance treatment is to use steel slag instead of limestone in these passive systems. Steel slag is a byproduct of the production of steel and has a high calcium content. It is a glass-like material, which has a high permeability (about 9.5×10^{-2} cm/s) even after water passes through the material. Unlike limestone the material doesn't absorb carbon dioxide, therefore its life expectancy is longer. It has been shown to provide several hundred times more alkalinity than limestone in preliminary studies. It has, however, been shown to have decreased performance in acid conditions. Therefore it is recommended to use this treatment in streams prior to contamination by AMD in order to provide buffering once AMD impacts the stream (Ziemkiewicz, in review).

4) Improvements to Tropic Wetland

Tropic wetland removes 65% of the acid load, 85% of the iron load, and up to 15% of the sulfate load, and lowers the pH by 1.5 to 2.0 units. While this treatment is fairly good, fouling of the cells can be observed. This yields an expected reduction in residence time, thus lower contaminant removal efficiency. Also, some of the fiberglass cell dividers were observed to be destroyed, apparently due to freeze-thaw cycles. This allows the water to disperse into other cells and create non-uniform flow patterns. Some modifications should be made to prolong the life expectancy of the treatment system and to increase removal efficiencies. The recommendations that follow utilize the current structure as much as possible, thereby reducing needed earthwork and providing increased efficiency at a lower cost than redesigning the system. The current configuration of Tropic wetland is shown in Figure 5.13.

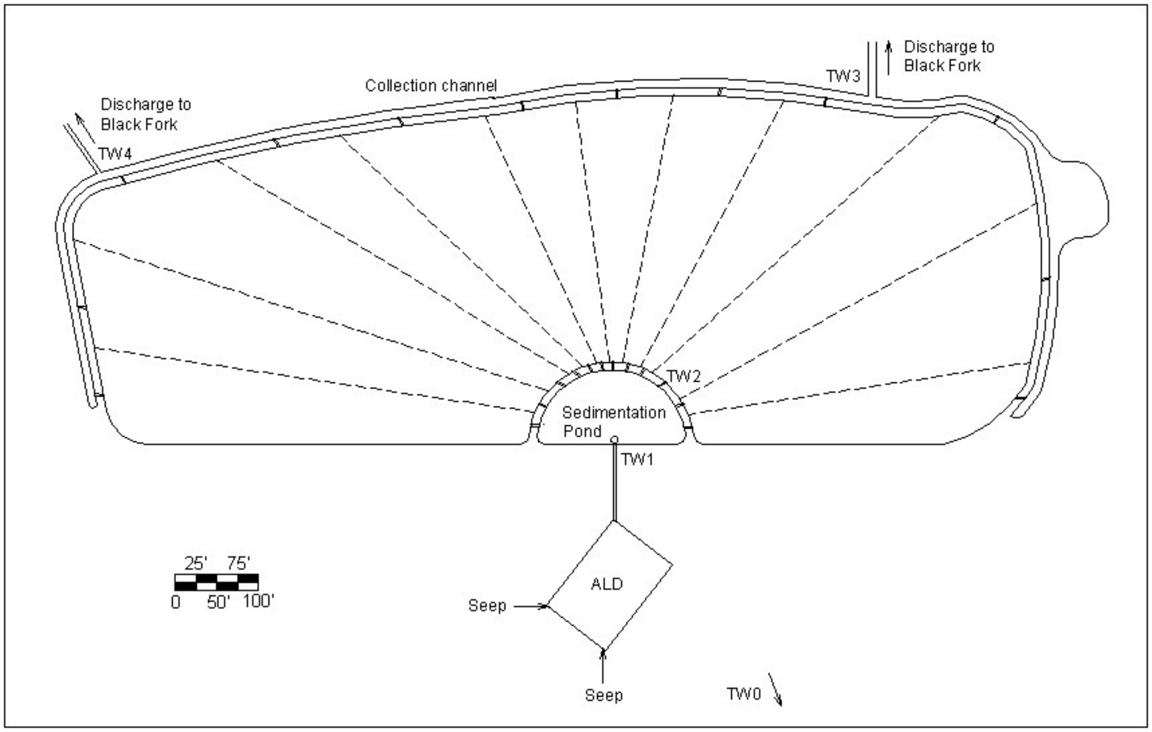


Figure 5.13 – Current Tropic Wetland Configuration

The ALD in place is adding approximately 300 mg/L of net alkalinity as $CaCO_3$. Little fouling is expected due to the lack of oxygen in the channel. Because it has shown a high buffering capacity and no obvious threat to its life span, there are no recommendations for improving the ALD.

At the effluent of the ALD (into the sedimentation pond), which was sampling point TW1, the ORP averaged 40 mV. The ORP at the effluent of the sedimentation pond (TW2) was typically 90 mV, and the average ORP of the wetland discharges (TW3 and TW4) was around 400 mV. This shows that the water entering the sedimentation pond is in a reduced state. Little oxygenation is achieved through the pond. However, the water reaches an oxidized state at the point of discharge into Black Fork. Because the water entering the sedimentation pond is not oxidized, the AMD reaction does not proceed to completion, thus sufficient precipitation of metals does not occur. As water contacts the oxygen in the atmosphere in the pond it is oxidized, however, the potential treatment for the size of the pond is not being reached because of the oxygen deficiency at the influent. As a result of the lower metal removal than expected in the sedimentation pond, as the water oxidizes in the wetland cells there is accumulation of sediment. Some of the cells are filled to the point such that no water is observed to flow through them. Water typically only discharges through 3 to 5 box culverts from the sedimentation pond into the wetland cells.

To increase the effectiveness of the sedimentation pond, the seep should be aerated prior to the reaching the pond. First, the underground pipe from the ALD should be rerouted to the southeast of the ALD as shown in Figure 5.14. The standpipe should surface about 10 to 20 feet from the ALD boundary in order to ensure that the ALD is not disturbed during the construction process. The standpipe should be fitted with a 90-degree elbow to provide ease of future sampling. This flow should then enter an aeration channel. The cross section of the channel should be 3 feet wide by 6 inches deep in order to provide ample surface area exposure to the atmosphere. This channel should be at a slope of 4 inches per 100 feet. The channel should run parallel to the wetland boundary for about 300 feet before turning downhill, toward the wetland, and returning back to the sedimentation pond as shown in Figure 5.14. This channel distance of almost 600 feet will provide sufficient aeration to assist metal precipitation in the sedimentation pond.

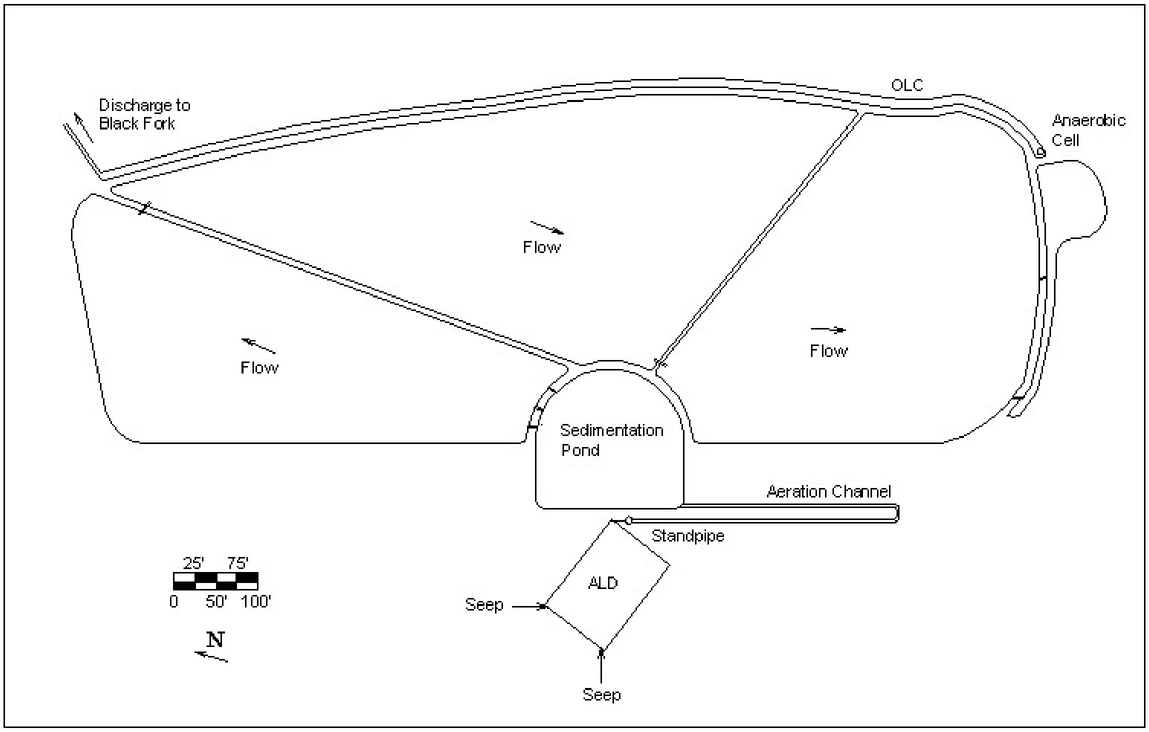


Figure 5.14 – Tropic Wetland Recommendations

The size of the sedimentation pond should be increased to prolong its life expectancy and to provide more retention time, thus increasing removal efficiency. This will also decrease the amount of sedimentation taking place in the wetland cells, thus allowing substrate to be exposed in the cells, which is conducive to plant growth. The reduction of sediments in the cells will also improve flow uniformity, increase detention time, and enhance removal efficiency. To utilize the earthen dam that is already in place at the outlet of the sedimentation pond, the size may be increased in the southwest direction toward the ALD. There is 90 feet available for expansion, however care should be taken as to not disturb the ALD. Therefore, the sedimentation pond should be increased by 80 feet over the width of the pond. Keeping the current depth and side slopes of 4 feet and 2H:1V, respectively, this would give a retention time of about 7 days.

The aerobic wetland cells that follow should be changed to a series configuration from the current parallel arrangement. This will reduce the potential for flow short-circuiting, allow for additional residence time in the system, and increase treatment efficiency. The box culverts from the sedimentation pond should be removed and/or filled with earth to route flow into the northern cell. Three culverts should be left to disperse the flow in a more sheet-like pattern into the first cell.

The overall size of the wetland should remain the same in order to use the existing conditions, however, the fiberglass cell dividers should be removed. They are somewhat ineffective because of their poor durability. Instead, earthen dams should be used to separate the three cells similar to that used between the sedimentation pond and cells. The material for these walls can be obtained from the excavation of the extended sedimentation pond or from the refuse disposal areas adjacent to the site. The box culverts between the cells and collection channel should also be removed or filled, with the exception of those on the southern cell, which will be discussed subsequently. At the end of the first cell, a box culvert should be installed to allow flow to pass to the second cell. The same method should be used for the following cell. In the third cell, which is at the southern end, the flow should discharge in one of two box culverts into the existing collection channel.

The size of the earthen dams between cells should be between 8 and 10 feet at the top with a 2V:1H slope on the sides. This should allow ample room for construction equipment, without removing a significant amount of area for treatment. This dam should also restrict short circuiting of the water more effectively than the current material and it is a fairly economic alternative.

When the construction in the wetland system is being performed, it is important that the area is first drained. The water from the ALD can be routed directly to the collection channel while the aeration channel, sedimentation pond, and wetland cells are under construction. Once the wetland is empty, the sedimentation pond and wetland cells should be dredged so that the subgrade is at the designed depth. This dredging will also re-expose the original substrate in the wetland cells, which is a combination of organic and limestone material. This substrate allows a good habitat for microorganisms and vegetation in addition to providing alkalinity.

Wetland plants native to Ohio include *Typha latifolia* (cattail), *Juncus effusus* (soft rush), *Lysimachia numularia* (moneywort), *Scirpus atrovirens* (green bulrush), *Scirpus cyperinus* (woolrush), *Eleocharis obtusa* (blunt spikerush), *Ludwigia palustris* (water purslane), *Polygonum spp*. (smartweeds), and *Epilobium coloratum*. Cattails are commonly used and have shown good treatment efficiency for AMD while being tolerant to the toxic conditions. Preliminary constructed wetlands typically used *Sphagnum*, however, it was later found that iron concentrations greater than 10 mg/L were toxic to the species. Planting is generally done just after spring. The vegetation should be established prior to the introduction of the AMD to assist in plant survival.

Once the water exits the wetland cells it should have a low acidity and iron concentration. However, the sulfate will likely remain at a high concentration since it is not removed through sedimentation. As previously discussed, aerobic processes are not effective in sulfate removal. In fact, literature suggests that anaerobic treatment should follow aerobic treatment if the two are being used in series (US Bureau of Mines, 1991).

The existing pond in the collection channel should be converted to an anaerobic treatment cell for sulfate removal. Clogging by sediment should not be a problem since most of the contaminants will have been removed at by this stage. An organic substrate such as mushroom compost should be used in this vertical flow cell, which is shown in Figure 5.15. The water level of 5 feet over the organic layer will allow anaerobic conditions toward the bottom. The water will flow downward through the 3 feet of organic material into the perforated collection pipes embedded into a 4-inch gravel or limestone drainage layer (not shown). There should be two 2-inch pipes collecting the flow, resulting in a velocity of 3.4 ft/s in each. These pipes should join and exit in a standpipe in the existing collection channel.

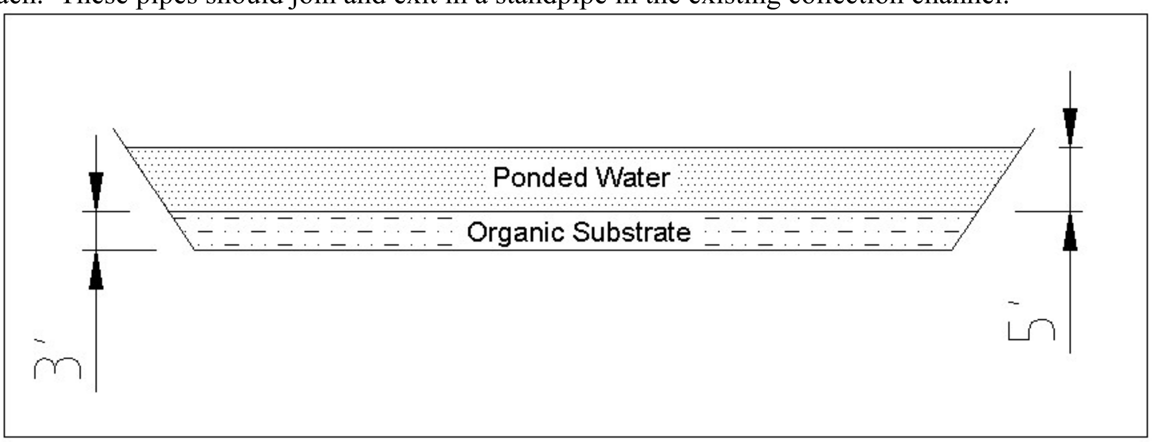


Figure 5.15 – Anaerobic Cell Recommended for Tropic Wetland

To provide a retention time of about 12 hours in the organic substrate the surface area should be about 6500 ft^2. The resulting dimensions could be anywhere between 80ft by 80ft and 60ft by 120ft depending on actual size of the existing pond. The total retention time in this anaerobic cell will be about 3 days.

The standpipe from the anaerobic cell should empty into the existing collection channel. This channel should be lined with limestone to form an open limestone channel (OLC). The maximum length of existing channel should be utilized, so discharge into Black Fork from TW3 should be disallowed. Instead, the water should flow the length of the wetland in the channel (over 1,000 feet). There should be little armoring of the limestone since most of the iron will have been removed in previous stages of the system. The flow should discharge into Black Fork at the current TW4 location. At this point, there should be near 100% iron and acidity removal. The water should have a neutral pH and a net alkalinity, thus assisting with buffering the receiving stream. This is advantageous since the discharge of the Whitehouse seep is approximately 500 feet upstream from the TW4 discharge. If full treatment is not reached in the Whitehouse SAPS, as expected, the net alkaline water from Tropic wetland can assist with further treatment.

With each of the abatement measures discussed, it should be noted that some maintenance is still required. Dredging of the sedimentation ponds and wetland cells should be performed at some time interval. This will remove some of the sediment that has precipitated and maintain the designed residence time of the system. In the wetland cells, the organic and limestone substrate will be re-exposed, increasing treatment capacity. Periodic maintenance will maintain predicted treatment ability and prolong the life expectancy of the treatment systems.

Future monitoring

Phase I monitoring includes collecting two to four samples at site BF-10 during high and low flow to compare with the monthly sampling already collected there as part of the Kocsis Study. The additional water quality data should be compared to the Kocsis Study data and if there are no significant differences the Kocsis data can be used to determine the size of the ALD or SAPS and aerobic wetland at the Whitehouse Seep. If there are significant differences collect monthly sampling for one year prior to design and construction.

Phase II monitor the Dry Run Seeps for flow and water quality two to four times during high and low flow conditions in order to size the limestone drains correctly and to compare with the monthly data already collected at these sites.

Phase III monitoring is needed at the Tropic wetland to re-evaluate the effectiveness of the ALD. Water quality and flow samples are needed at TW0 – TW4 to evaluate the ALD and wetland effectiveness quarterly for one year. A quick dye tracer test should be inserted at the inlet of the wetland and visually watched as is travels through the wetland to see the flow paths and residence time. This information will be useful in designing the limestone berms to maximize residence time.

Phase IV water quality samples are needed on the East side of the Misco Gob Pile to determine remaining AMD generated from the pile after the current restoration activities are complete.

Post-construction water quality monitoring should be conducted at least twice a year to four times and biological monitoring once a year upstream and downstream the restoration project. Multiple sites downstream should be established to provide water quality and biological improvements made over a given distance from the treatment site. Post-construction monitoring should begin within 6 months of completion and continue for at least 10 years or until otherwise determined.

METHODOLOGY

Watershed Assessment

The assessment of the watershed was based upon data collected during water quality monitoring of selected locations along the main stem of Moxahala Creek as well as an individual assessment of all sub-watersheds using a three-phase approach. A three phased approach has become the standard method of watershed characterization for acid mine drainage abatement plans over the past five years. Phase I involves collecting field parameters (including pH, specific conductance, acidity and alkalinity) to provide investigators with a quick snapshot of water quality conditions and to be used as an initial screening. Phase II requires the collection of water quality grab samples analyzed for ODNR Group 1 parameters and discharge measurements at the confluence of all AMD impacted tributaries identified in Phase I, some net alkaline tributaries, and selected sites along the mainstem, always including the furthest downstream location of the study area. Phase III involves the evaluation of potential project sites within the sub-watershed or project area. Additionally, data collected will serve as part of a Total Maximum Daily Load (TMDL) study for the OEPA to assess water quality and aquatic health of Moxahala Creek and its sub-watersheds.

Study Area and Site Identification

The study area for the Moxahala AMDAT stretches from upstream of the confluence of Moxahala Creek and Jonathan Creek to the headwaters of the Moxahala mainstem and includes all tributaries. Site locations were identified on USGS topographic quadrangle sheets, GPS coordinates, and OEPA RMs maps. River miles begin at the confluence of the Ohio River with the Muskingum River (RM0 809.19), followed by the RM at the confluence of Moxahala Creek and the Muskingum River (RM1 73.49). The remaining RMs (RM2, RM3, RM4, and RM5) are used to direct the user to the actual site location within the Moxahala Creek Watershed. For example site BR-34 is located at; RM0 809.19, RM1 73.49, RM2 21.95, RM3 3.24. This series of RMs points the user first to the confluence of the Muskingum River and the Ohio, then to the Moxahala and Muskingum River, followed by the confluence of Bear Creek and the mainstem of Moxahala Creek, and finally ending at the actual sample location at 3.24 miles upstream of the mouth of Bear Creek. Drainage areas for water quality sampling sites were calculated using GIS ArcView BASINS tool and Xtools extension.

Phase I- Reconnaissance

In 1997 the Ohio Department of Natural Resources provided funding to Ohio University to complete a characterization along with restoration strategies for a small, unnamed tributary (referred to as Andrew Creek) in the Moxahala Watershed. Before the report was complete the scope of work was expanded to characterize the entire Moxahala Watershed. Fieldwork for this project was conducted from April 1997 through February 1998 resulting in 11 months of water quality sample and stream discharge data collection at eight Moxahala mainstem sites and along 24 tributaries. The 24 tributaries included in the sampling plan were identified from a list of 100 streams having the greatest impact on water quality in Moxahala Creek. An additional Phase I event covering the entire Moxahala Creek watershed was conducted in October 2003 and compared to the earlier data. This information was presented to and reviewed by ODNR Division of Mineral Resources, Ohio EPA, and the Coordinator for the Moxahala Watershed Restoration project where consensus was reached that the 1997- 1998 data would serve as the Phase I stages of sampling for AMDAT preparation. From this Phase I reconnaissance data, sites were organized by pH values less than 6.0 and priority subwatersheds were chosen for further reconnaissance; Andrew Creek, Bear Creek, McLuney Creek, Snake Run, Burley Run, and Riders Run. Further Phase I reconnaisance work was conducted in April and May of 2004 in these selected sub-watersheds to track the AMD impacted streams upstream to the origin of AMD (spoil pile, gob pile, deep mine entry, surface mining impoundment, or groundwater seepage).

Field parameters were tested at the mouth of the sub-watershed and at each input to the main stem and marked on a field map. Field parameters collected included pH, specific conductivity, acidity, and temperature. Specific conductivity and pH field parameters were taken using a Hanna combination pH-specific conductivity meter. Acidity was tested using a HACH titration kit, by adding phenolphthalein indicator and titrating a small water sample with 0.035 M Na(OH). A GPS Trimble meter was used to record coordinates of each site.

In addition to screening the area for AMD sources, phase I screening also involved the screening of the area for points of water loss (e.g. subsidence, sinkhole, etc). However, no subsidence features were found during this study period.

All Phase I data for each sub-watershed was recorded in the field, entered into an EXCEL spreadsheet, and data points were entered into ArcView GIS. Phase I data was then evaluated in order to determine areas of AMD impact where further assessment was necessary.

Phase II- Sub-watershed Evaluations

Areas designated as requiring further assessment during the phase I screening then underwent a phase II study, where AMD impacted areas were sampled for water quality and flow data in a manner to create a mass balance in small sub-watersheds. AMD impacted sites were sampled in order to quantify the amount of acid and metal loading the sub-watershed is contributing to Moxahala Creek. A qualitative description was recorded for each site and water quality samples and discharge measurements were collected. Phase II data were collected during both fall and spring flow stages in 2004. All Phase II data were entered into an EXCEL spreadsheet and sample sites recorded on maps. Phase II data were used to determine potential reclamation sites that will require further analysis.

Biological Assessments

As part of the OEPA's Total Maximum Daily Load (TMDL) study, in addition to water chemistry data, an assessment of the biological condition of the watershed was conducted. From June 15th to September 30, 2004, aquatic macroinvertebrates and fish were collected by Midwest Biodiversity Institute (MBI) for the calculation of two multi-metric indexes, the Index of Biotic Integrity (IBI) and the Invertebrate Community Index (ICI) that rate the overall health of the watershed.

Priority Selection Process

An adaptive phased approach is recommended within each subwatershed's remediation strategy section. Phase I activities are priority projects followed by phase II and III. Between each phase of restoration, water quality should be re-evaluated to determine success of the previous restoration activity. This process of constructing remediation projects and re-evaluating the water quality is considered an adaptive management approach. It allows the plan to be flexible and is a sensible approach to maximize the cost versus benefit from each project.

Field Sampling Procedures

Field parameters were conducted during Phase I as a first initial screening and during Phase II for investigations of the water quality of sub-watersheds. Field sampling consisted of measuring in-stream pH values, specific conductivity, and acidity. Specific conductivity and pH values were determined using a Hanna combination pH-specific conductivity probe. When using it for pH and specific conductivity, the probe was inserted into the stream in an area of moving water to a minimum depth marked on the probe.

The value was then displayed on the screen of the probe. The value was not recorded until the value displayed on the probe remained constant. Water temperature was also recorded at each site also with the Hanna meter. The meter was calibrated for pH, using a two-point calibration method (pH 4 and pH 7), and one-point calibrated for conductivity (1413 $\mu S/cm$) each day it was in use.

Acidity values were determined using a in-field high range HACH titration kit. Seven and one-half milliliter samples were collected in a clean test tube and placed in a 25 ml beaker for titration. One drop of phenolphthalein indicator was added to the sample, which was then titrated using 0.035M Na(OH) that was added to the sample-indicator solution one drop at a time. The solution was mixed after each drop. When the solution turned pink following the addition of a drop of Na(OH) and remained pink after mixing for 30 seconds, the number of drops added to the sample was recorded. The total number of drops of Na(OH) added to the solution was then multiplied by 20 to determine the concentration of acid in milligrams per liter.

Collection of Water Samples for Laboratory Analysis

Water for each sample was collected in either a bucket or directly from the stream in appropriate locations and split into two bottles. Samples were placed in either a 250 ml bottle or 1000 ml cubitainer. At each sample site a non-acidified and an acidified sample are taken. The 250 ml bottle was acidified with 5 ml of 20% Nitric Acid (HNO_3) solution. Samples were not filtered. Samples were analyzed at ODNR's Cambridge laboratory. Parameters analyzed were the ODNR Group I suite (pH, total acidity as $CaCO_3$, total alkalinity, specific conductance, total suspended solids, sulfate, total iron, total manganese, total aluminum, hardness and total dissolved solids). Group I is sufficient to prioritize sources based on acidity and metal loads. The non-acidified sample was collected in a collapsible cube that was completely filled so that the sample was preserved in an oxygen-free environment. This non-acidified sample was evaluated for total acidity, total alkalinity, pH, specific conductivity, total suspended solids, total dissolved solids and sulfates.

Water samples collected in the field for laboratory evaluation were preserved at 4 degrees Celsius until they reached the Department of Mineral Resources Management laboratory in Cambridge, Ohio where they were analyzed.

All data from collected samples were recorded on ODNR laboratory data sheets that were returned to ILGARD and entered into an Excel spreadsheet.

Flow Data Collection

Flow was measured at each water quality sampling site in order to calculate loading (concentration multiplied by discharge). At a majority of sample sites, flow was determined using a Swoffer electric flow meter or pygmy digital meter. A spin test was conducted daily on the pygmy and Swoffer flow meter. The stream was divided into intervals of known areas (width and depth) along its cross section. Velocity measurements were collected for each interval and multiplied by the area of that interval to calculate a discharge measurement. The discharge rate for each site was defined as the sum of the discharge rates at each interval. In moderate discharges a collapsible cutthroat Baski flume was used. Flume throat size (8”) was selected in order to keep the stage in the flume between 0.2 and 0.5 feet. For small discharges, the flow was dammed and piped into a length of PVC to capture with a bucket; a stopwatch was then used to measure filling time.

Loading is calculated as the product of discharge with acidity, alkalinity or metal concentration and is expressed in lb/day for treatment considerations. In this report, metal loading is the sum of the individual loads of the three Group I metals, iron, manganese and aluminum.

Equipment

Table 93. Equipment List

Equipment	Manufacturer	Catalog No.	Calibration
Hanna combo pH-EC probe	Hanna Instruments	4JE-89307	Two-point calibration: Acid Calibration using standard 4.01 and 7.01 solution. A 1413µS/cm calibration solution was used for specific conductivity
HACH Acidity Test Kit	HACH	4JE-100820	
Trimble GeoExplorer CE GPS unit	Ellderbusch Company Inc.	Part# 46475-10	
Electric current velocity flow meter	Swoffer Instruments Inc.		See Calibration and Care of the Model 2100 Current Velocity Meter pp.1-3
Pygmy Model 1205 price type “mini” current meter	Scientific Instruments Inc.		30-60 second spin test
Digimeter CMD 9000	Scientific Instruments Inc		
Collapsible Cutthroat Flume	Baski Inc.		
YSI model 55 Dissolved Oxygen Meter	YSI Inc.	4JE-221302	push-button air calibration with built-in calibration chamber

PUBLIC INVOLVEMENT

Moxahala Watershed Public Participation Section written by J.T. Kneen, Coordinator of the Moxhala Watershed Restoration Commission.

The Moxahala Watershed Restoration Commission was initially started in the Village of Crooksville to look into water quality and quantity (flooding) issues that had been affecting the local area. Any program that seeks to significantly affect the water quality in an area needs to have the local stakeholder participation and support to effectively maintain a project. Generally, local efforts recognize a need, and by cooperating with Local, State and Federal Government and Agencies, the effort can payoff in long-term action that can lead to changes in lifestyle and local decision making.

In the fall of 2002, the Moxahala Watershed Restoration Commission, a stakeholder group that desired to see effective changes in water quality in the Moxahala Creek watershed, working with the Village of Crooksville as the sponsor, signed the Ohio EPA 319 Grant to begin a two year implementation grant. Part of that grant funding provided for the hiring of a watershed coordinator, someone who could effectively develop local participation and coordinate that with government expertise to create a Comprehensive Watershed Management Plan for the eastern portion of the Moxahala Creek watershed. As the planning developed, the Advisory Committee of Village officials from Crooksville and Roseville, Ohio Extension, Buckeye Hills RC&D, the Office of Surface Mining, Ohio EPA, Ohio Division of Mineral Resource Management, Perry County Soil and Water District, Perry County NRCS, assisted in steering the development of an Acid Mine Drainage Total Maximum Daily Loading plan, along with the Acid Mine Drainage Abatement and Treatment plan. Acid Mine Drainage has been noted as the greatest impairment in the eastern Moxahala Creek watershed through local stakeholder survey and OEPA and DMRM studies, so the focus was developed.

Through cooperative grants from Ohio EPA 319 Program and the Ohio Division of Mineral Resource Management, a research team from ILGARD was hired to guide the process of data collection and write-up of the AMDAT, in support of the creation of an AMD TMDL that would scientifically prove and support the creation of limits on the Moxahala Creek watershed to restore warm water habitat to the creek. The grants were proposed in late spring of 2003, with approvals occurring by October 2003.

A new Advisory Committee of ILGARD, Ohio EPA and Ohio DMRM personnel worked on the development of the research plan and reviewed the data and steps to collect the necessary data for an effective study that would support conclusions and planning for the restoration and long term control of AMD in the Moxahala Creek. Public participation included actual assistance of the research team in collecting samples, talking to landowners that would require their permission for access, and then reviewing the data and recommendations from the research team, Advisory Committee, and other experts involved.

Going back to look at public participation and the open meeting formats, where the public was encouraged to participate in Advisory Committee meetings and other aspects of the decision to develop an AMD TMDL for the eastern Moxahala Creek Watershed, we submit the following.

Table 94. Moxahala Creek Restoration Commission and Other Public Participation

Date	Time	Description of Activity
10/08/2002	7 PM	Public watershed meeting introducing the OEPA Comprehensive Watershed Action Planning grant and the idea of research to determine, scientifically, the water quality of the watershed. Also, we introduced the idea to participate in the developing Clay Valley Foundation, an umbrella organization that supports or community action and Can act as a future sponsor.
10/2002 7 PM		Meet with the Morgan County Soil and Water Supervisory Board and staff to discuss the Moxahala Creek watershed planning grant. Through this meeting, the Morgan County Commissioners were introduced to the project, and have been updated.
11/2002 ?		Meet with personnel from the Muskingum Soil and Water District, and receive the opportunity to publish an article about the planning grant and watershed group in the Muskingum County SWCD newsletter. A full page was dedicated to the article.
11/12/2002	7 PM	Public meeting to discuss the development of a mailing list of the stakeholders in the watershed to include residents, landowners, businesses, and commercial and industrial operations.
12/10/2002	7 PM	Public meeting to discuss comprehensive planning that would include septic and sewage treatment as a concern for our planning grant, as well as discuss the meeting with DMRM to begin planning to chemically sample the creek water. Through the support and assistance of Kathy Davis, Wolf Creek watershed, a proposal to develop and distribute a watershed survey to gauge the interest and understanding of the watershed and the planning process. Local stakeholders have begun contacting our offices for assistance in water quality issues on their property. The first PowerPoint presentation that explains what the Moxahala Watershed Restoration Project is about and how to participate was presented.
01/13/2003	AM	Advisory meeting of ILGARD, DMRM and MWRP personnel to discuss the design of a sampling program to best utilize the DMRM match of sample analyses in their lab.
01/14/2003	7 PM	Special guest speaker, Kathy Davis came over from the Wolf Creek Watershed to share her planning experience, and surprise her with the poor water quality that was evident in the Moxahala Creek (the iron precipitate covered the icy surface of the creek that day). The first draft of the survey and the information sheet was presented for review before printing and distributing.
02/13/2003	2 PM	Meeting with Village of South Zanesville Administration to present a letter of introduction for the watershed project and coordinator and discuss the objectives of building stakeholder support from South Zanesville, inventorying
03/11/2003	7 PM	Discussions on monitoring planning; the survey mailing; opportunities to go to workshops and tours that showcase water quality skills and activities; and planning for

		a stream clean up day in May.
04/01/2003	5 PM	Moxahala watershed leadership planning session, by special invitation. A brainstorming session on how to organize and work on management planning.
05/06/2003	7 PM	Surveys were hand delivered in populous areas of Crooksville, with some responses coming back with comments and interest. More planning for Saturday, May 17 stream clean up day.
05/17/2003	9 AM	Clean up portions of the Moxahala Creek corridor from SR 37 in the south, to Roseville Ohio.
06/10/2003	7 PM	Public meeting to discuss watershed planning and the proposal from ILGARD to work on the research and chemical sampling to create an AMDAT and TMDL for the eastern portion of the Moxahala Creek watershed. DMRM will hire the biological research team in a separate contract. The survey has been delivered throughout Crooksville, half of Roseville, and Dry Run, and this has been great to talk to stakeholders.
06/11/2003		Receive first version of the Moxahala Creek Watershed map for use in planning and research of our management planning area. The map was prepared by Brett Allphin, Buckeye Hills and Hocking Valley RDD.
07/07/2003		Proposal and letter of support for Perry County Board of Health grant proposal to the Ohio Environmental Education Fund to work on home septic system maintenance education and stream sampling by local students.
07/08/2003	7 PM	Discussion of grant proposals submitted to OEPA and DMRM for the AMDAT and TMDL. Present a PowerPoint presentation on how to investigate a stream reach in the Moxahala watershed as part of our watershed inventory.
08/07/2003	6 PM	Planning and practicing goal setting for the management plan.
09/06/2003	9 AM	Ultimate Recycling Day at the Crooksville Recreation Center as follows: 51 appliances; 94 tires; 70 gal. of used motor oil; 26 car batteries; 1 1/2 tons misc. scrap metal; 53 cars came through; and 9 volunteers helped.
09/09/2003	7 PM	Public meeting to discuss the management planning and the grants for the AMDAT and TMDL.
09/27/2003	day	Booth at Roseville festival to promote the watershed planning and distribute the surveys and explain AMDAT and TMDL proposals to the general public.
10/11/2003	day	Booth at the Crooksville festival to promote the watershed planning and distribute the surveys and explain AMDAT and TMDL proposals to the general public.
10/14/2003	7 PM	Liza Flemming, ILGARD researcher comes back to speak about the AMDAT and TMDL research that can begin, now that the grant papers are signed. Review of the Ohio Mineland Partnership Fall Tour of Monday and Sunday Creek Watersheds.
11/11/2003	7 PM	Public meeting that continues discussion, planning, and reporting on activities including the inclusion of two new stakeholders, a business owner and a farmer. The ILGARD team has begun research for documents and field work on the AMDAT and TMDL.
12/09/2003	5:30	Pot luck dinner and a guest speaker, JP Leiser, Watershed Management Agent, Ohio State University Extension. JP spoke about the importance of water; why we need to Monitor; and shared his experience in biologically monitoring streams.
01/13/2004	7PM	Chip Rice, ILGARD researcher, presents an update on the AMDAT and TMDL data collected so far and how that will be used in developing the plans. We continue to make contacts with property owners and assist when possible in the data collection.
02/14/2004	7 PM	Public meeting to discuss AMDAT and TMDL research; group participation in inventorying the watershed; and planning for the annual spring clean up.
03/10/2004	7 PM	Public meeting to discuss the AMDAT and TMDL research that has been ongoing with Ben McCament, Bill Jonard, JT Kneen, and other volunteers in Andrew Creek, Bear Creek, and McLuney Creek. The West Misco Burning Gob Reclamation project, directed By DMRM, has gone out to bid. Our group requested a grant from OSM, through the Clay Valley Foundation, to support the project, and improve water quality in Black Fork.
04/02/2004	9 AM	Technical Advisory Committee meeting on AMDAT and AMD TMDL planning and review of field research for a high flow sampling plan in the AMD sub watersheds chosen for our study.
04/06/2004	AM	MWRC hosts the West Misco Burning Gob Reclamation Project pre-bid meeting for the contractors. Bids are to be opened on April 27, 2004, with start up scheduled to begin

		on July 1, 2004.
05/11/2004	7 PM	Public meeting to review the results of the AMDAT and TMDL field research; planning for the upcoming May 15 stream clean up day; a review of the OMP spring tour (May 5) to the Carbondale Doser on Raccoon Creek. Share photos from the field research team of Ben McCament, Bill Jonard, Jen Bowman, and JT Kneen. Because of the field work on the data collection for the AMDAT and TMDL, more landowners have been personally contacted or written to, exposing them to our plan for the watershed.
O5/15/2004	9 AM	A very rainy and wet day to try and clean up the creek corridor. A local Weblos Den from Pack 200 was the only truly working group this year. They worked the corridor in the Black Fork area.
06/08/2004	7 PM	Public meeting to discuss progress on the AMDAT and TMDL included the field work in McLuney Creek, Snake Run, Burley un, and Bear Creek. Although water samples have been collected from Andrew Creek, the results are not available yet. Shared a PowerPoint presentation of field work, including views of the AMD sources. Reviewed the River Network's River Rally 2004 conference in Wintergreen, VA. A very insightful weekend, with lots of education on watershed planning.
6/14/2004	9 AM	Tour the West Misco Gob Reclamation Project video taping the present conditions, in preparation for continuous taping as reclamation progresses. Scott Frame the videographer, Bob Frame, Max Luehrs, Bill Jonard, Tony Scales, Stuart Miller, and JT Kneen present, and in the video.
6/17/2004		Perry County Board of Health is once again applying for an Ohio Environmental Education Fund grant to prepare a home septic treatment system maintenance training program. We are in support of this, as there are obviously failed HSTS in our watershed.
07/13/2004	6 PM	A cook out before the public meeting to share food and fellowship. Share Jen Bowman, ILGARD researcher's draft listing of areas of investigation, sampling sites, and possible project areas. Also, some of the laboratory analyses are available from the research. Review the Perry County Board of Health grant proposal to OEEF for home septic treatment system education.
07/28/2004	9 AM	Technical Advisory Committee meets on the high flow sampling results and any need to change sampling plans or other recommendations to achieve AMDAT and TMDL plans for the Moxahala watershed.
07/29/2004	8 AM	Fish shocking in reference areas with Jim Grow and associates of MBI as part of the data collection for the AMDAT and TMDL. Through landowner contacts, develop more interest in the watershed plan and activities.
08/10/2004	7 PM	Public meeting to present new research data and photos from AMDAT and TMDL field work. Review progress of the West Misco Gob Reclamation Project. Planning for Saturday, September 11, 2004, Ultimate Recycling Day.
09/11/2004	9 AM	Ultimate Recycling Day another success although Crooksville suffered severe flooding from rainfall on Tuesday and Wednesday, September 7 & 8. This offered a great drop off point for recycling appliances destroyed in the flood!
09/14/2004	6 PM	Potluck dinner before the public meeting where special guest, Jen Bowman, will share her experiences in watershed work and her research in the Moxahala Creek watershed for the AMDAT and TMDL. Update on the biological sampling research going on under a grant from DMRM as part of the data needed for the AMDAT and TMDL. The macro invertebrate sampling has been completed, but there are a couple more fish sites to complete. Share the results of the watershed survey that has been mailed out and delivered to over 3000 residents. Only 94 surveys have been returned so far, and that represents a 3% return rate, but we had the opportunity to contact over 3000 stakeholders, exposing them to the watershed planning and the AMDAT and TMDL planning.
10/07/2004	8 AM	Complete biological fish shocking on the Moxahala Creek with Jim Grow and Ed Rankin, MBI, and JT Kneen. Actually found 10 species of fish downstream, below the Jonathan Creek inflow to the Moxahala Creek.
10/12/2004	7 PM	Public meeting at Crooksville Firehouse, due to flood damage at Heritage Hall. Present updates on research, show photos of the fish shocking, and play the MSHA DVD on "Stay Out, Stay Alive" a video on safety at old mine sites.
10/27/2004	AM	US Department of Interior, Deputy Director Steve Griles visits the Moxahala Watershed

		and specifically views the West Misco Gob Reclamation Project to view what the Abandoned Mineland Fees can do in an AMD watershed! Chief Mike Sponsler, ODMRM, some staff, Max Luehrs and George Geiger, OSM, Larry Householder, and other visitors recorded the visit and reported it in the Perry County Tribune newspaper.
11/09/2004	7 PM	Public meeting at Heritage Hall, renovated since the flooding of September, and discussion of the grant extensions; Steve Griles visit to Moxahala; progress on the West Misco Gob Reclamation Project; reporting on the completion of the water quality sampling for the AMDAT and TMDL.
11/22/2004	9 AM	Technical Advisory Committee meets to review the data and suggest strategies for developing the AMDAT and TMDL.
12/01/2004	9 AM	Meet with Keith Orr, OEPA TMDL writer with Jen Bowman, Bill Jonard, and JT Kneen to go over progress and direction of the Moxahala Watershed AMD TMDL.
12/14/2004	7 PM	Public meeting to discuss progress on the AMDAT and TMDL plans; Misco Gob Reclamation Project; extension of the grants to write the management plan, AMDAT, and TMDL; and discuss the AML fee extension that could support future watershed work here!
12/15/2004	9 AM	Meet with Brett Allphin, BHHVRDD specialist, on watershed maps for management plan.
01/11/2005	7 PM	Public meeting to discuss sustaining membership and create local funding; view photos of the West Misco Gob Reclamation Project and how the contractor is handling the burning gob; review the AMDAT and TMDL planning as well as management planning.
01/30/2005	AM	Mayor Douglas Cannon passed after a long battle with cancer. Doug was influential in the start up and continuance of the Moxahala Watershed Restoration Commission. Doug believed that a cleaner and vibrant creek would help the local area to renew.
02/08/2205	6 PM	A potluck dinner prior to the business meeting should help bring out a crowd. At the meeting, the problems of the watershed were discussed, along with proposals for dealing with the problems.
02/11/2005	9 AM	Special review of the collected data for AMDAT planning by Jen Bowman, Bill Jonard, and JT Kneen. Nancy Seger could not attend at this time, but would review the plans and add her input to the AMDAT. Jen has been in contact with Keith Orr on TMDL issues.
03/15/2005	7 PM	Public meeting to go over progress in the plan s; work on an events calendar that includes Earth Day activities; a community clean up in Crooksville in April; highway litter clean up can stat any time now; planning for the May stream clean up date.

It is the intent of the Moxahala Watershed Restoration Commission to continue the process by implementing as much of the plan as possible, through cooperation with local landowners, businesses, and agencies that support the TMDL.

FUNDING OPPORTUNTIES

There are various existing funding sources, which are dedicated to AMD remediation and others that can be adapted to assist in restoration of the watershed (ILGARD, 2001).

Ohio Department of Natural Resources, Division of Mineral Resources Management

1) Federally Funded Abandoned Mine Land Program: Federal excise taxes on coal are returned to the State of Ohio for reclamation of abandoned mine land sites that adversely affect the public's health and safety.
2) Acid Mine Drainage Set-Aside Program: Up to ten percent of Ohio's federal excise tax monies are set aside for acid mine drainage abatement. Priority is given to leveraging these funds with watershed restoration groups and other governmental agencies.
3) State Abandoned Mine Land Program: State excise taxes on coal and industrial minerals are dedicated to reclamation projects that improve water quality in impacted streams. Priority is given to leveraging these funds with partners.

Office of Surface Mining (OSM), Reclamation and Enforcement

1) Appalachian Clean Streams Initiative: The mission of ACSI is to facilitate and coordinate citizens groups, university researchers, the coal industry, corporations, the environmental community, and local, state, and federal government agencies that are involved in cleaning up streams polluted by acid mine drainage. OSM provides funds for ACSI projects on an annual basis.
2) Direct grants to Watershed Groups: A grant process for directly funding citizen watershed group efforts to restore acid mine drainage impacted streams on a project basis.

Environmental Protection Agency

1) EPA Section 319 Non-point Source Grant Program: Funding is available for planning, education and remediation of watershed pollution problems including acid mine drainage.
2) Office of Water – Watershed Protection and Flood Prevention/PL566 Program: This program provides technical and financial assistance to address resources and related economic problems on a watershed basis that address watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation. Technical assistance and cost sharing with varied amount are available for implementation of NRCS-authorized watershed plans.

United States Army Corps of Engineers

1) Section 905b – Water Resource Development Act (86): Recent additions to the Army Corps conventional mission include a habitat restoration grant program for the completion of feasibility studies and project construction where a Federal interest can be verified. A principle non-federal sponsor must be identified for this cost-share program.
2) Flood Hazard Mitigation and Ecosystem Restoration Program/Challenge 21: This watershed based program assists in groups involved in mitigating flood hazards and restoration of riparian ecosystems. Assistance is provided nonstructural solutions in flood-prone areas, while retaining traditional measures where appropriate. Cost-share between federal and local governments Federal share is 50 percent for studies and 65 percent for project implementation, up to a maximum federal allocation of $30 million.
3) Section 206 Aquatic Ecosystems Restoration Project under the Water Resources Development Act of 1996. Annual appropriation of $25 million. The maximum Federal cost-share is $5

million. 100% federal for study costs, 35% of the study costs are recovered from the non-federal sponsor during the first year. Both programs have a 65/35 cost-share ratio during contruction.

United States Fish and Wildlife Service

1) Partners for Fish and Wildlife Program: This program assists private landowners by providing technical and financial assistance to establish self-sustaining native habitats.
2) Clean Water Action Plan Fund: The purpose of this fund is to restore streams, riparian areas and wetlands resulting in direct and measurable water quality improvements.
3) Five Star Challenge Restoration Grants: The purpose of this program is to provide modest financial assistance to support community-based wetland and riparian restoration projects that build diverse partnerships and foster local natural resource stewardship.

Ohio Division of Wildlife

1) Wildlife Diversity Fund: This fund financially assists with research, surveys (biological or sociological), management, preservation, law enforcement, education, and land acquisition.

Lindbergh Foundation

1) Lindbergh Grants: This program financially assists organizations that are making significant contributions toward the balance between technology and nature through the conservation of natural resources. The Lindbergh Grants provides a maximum grant of $10,580. The program is considered a provider of seed money and credibility for pilot projects that subsequently receive larger sums from other sources.

The Acorn Foundation

1) The Acorn Foundation supports projects dedicated to building a sustainable future for the planet and to restoring a healthy global environment. The Acorn Foundation funds community-based projects which; preserve and restore habitats supporting biological diversity and wildlife; advocate for environmental justice, particularly in low-income and indigenous communities; and prevent or remedy toxic pollution.

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Appendix A: Phase I 1997-1998 data

Appendix A: Phase I 2003 Data

Site Identification	Date	pH	Spec. Cond.	Site Identification	Date	pH	Spec. Cond.
Andrew Ck	10/16/2003	3.05	1687	Possum Hollow	10/16/2003	4.84	565
Andrew Ck	10/23/2003	2.99	1942	Possum Hollow	10/23/2003	4.19	680
Bear Creek	10/16/2003	4.07	1297	Burley Run	10/10/2003	3.88	1130
Bear Creek	10/23/2003	3.75	1500	Burley Run	10/16/2003	4.35	974
Black Fork	10/10/2003	6.36	770	Burley Run	10/23/2003	4.01	1134
Black Fork	10/16/2003	6.53	552	Snake Run	10/10/2003	3.26	1155
Black Fork	10/23/2003	6.6	720	Snake Run	10/16/2003	3.33	976
Mcluney Ck	10/10/2003	3.4	1350	Snake Run	10/23/2003	3.4	1111
Mcluney Ck	10/16/2003	3.5	1120	Moxa MS dst of Jonathen Cr.	10/10/2003	7.5	830
Mcluney Ck	10/23/2003	3.37	1330	Moxa MS upst of Jonathen Cr.	10/10/2003	5.75	1014
UT upst of Bear	10/16/2003	6.3	797	Moxa MS dst of Rider Run	10/10/2003	5.15	1033
UT upst of Bear	10/23/2003	6.79	931	Moxa MS dst of Rider Run	10/16/2003	6.05	814
Fowlers Cemetery Ck	10/16/2003	6.37	524	Moxa MS dst of Rider Run	10/23/2003	5.77	1066
Fowlers Cemetery Ck	10/23/2003	6.83	595	Moxa MS @Watershed Office	10/10/2003	4.89	1030
Pussy Hollow	10/16/2003	4.68	558	Moxa MS dst of McLuney	10/10/2003	3.8	1280
Pussy Hollow	10/23/2003	4.4	675	Moxa MS upst of McLuney Ck	10/10/2003	4.02	1200
milligan Twp Rd 1194	10/16/2003	3.58	630	Moxa MS upst of McLuney Ck	10/16/2003	5.05	1046
milligan Twp Rd 1194	10/23/2003	3.45	776	Moxa MS upst of McLuney Ck	10/23/2003	4.5	1265
RD 169	10/16/2003	7.01	1300	Moxa MS Bridge in Moxahala	10/16/2003	6.6	635
RD 169	10/23/2003	6.9	1440	Moxa MS Bridge in Moxahala	10/23/2003	6.55	757
Race Track	10/16/2003	3.49	1335	Baughman Run	10/10/2003	6.57	777
Race Track	10/23/2003	3.38	1530	Claypit Hollow	10/10/2003	7.38	780
Jehovah's Kingdom	10/16/2003	6.13	1224	UT @ Payne Rd	10/10/2003	6.76	714
Jehovah's Kingdom	10/23/2003	6.44	1390	UNAMED TRIB	10/10/2003	7.38	675
Herb Powers trib	10/16/2003	6.3	1230	Porter Run	10/10/2003	7.35	690
Herb Powers trib	10/23/2003	6.79	1366	Rider Run	10/10/2003	5.37	785
UT 2 (above Roseville)	10/10/2003	6.5	1122	Rider Run	10/16/2003	6.4	642
UT 2 (above Roseville)	10/23/2003	6.7	1100	Rider Run	10/23/2003	5.85	780
Possum Hollow	10/10/2003	4.4	669	Morrison	10/10/2003	6.8	620

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
1	Morrison Run	5/10/1997	6.9	1219	-25	38	-31.9	620	0.11	0.22	0.98	1.67	6	120	84	9.8	2.96	0.24	106.20	402	11	6.9	1302
1	Morrison Run	6/7/1997	6.9	837	-36	47	-58.4	340	0.16	0.23	0.93	2.14	6	95	48.6	8.4	6	0.30	135.26	512	17.2	6.1	850
1	Morrison Run	7/9/1997	6.41	1422	-26	37	-2.1	580	0.27	0.1	1.04	0.12	4.9	154	77	11.4	3.1	0.02	6.82	25.8	24.1	6.2	1420
1	Morrison Run	8/12/1997	7.37	1374	-35	54	-4.3	795	0.08	5.38	0.3	0.70	6	146	118	10.7	4.51	0.02	10.14	38.4	24.6	5.58	1330
1	Morrison Run	9/16/1997	7.44	1356	-63	75	-36.5	728	0.27	0.1	0.41	0.45	8.1	145	110	12.5	3.82	0.11	48.34	183	22	7.5	1370
1	Morrison Run	10/11/1997	6.95	1595	-54	62	-39.9	921	0.02	0.1	0.17	0.21	7	186	138	14.5	4.5	0.14	61.55	233	13.2	6.2	1464
1	Morrison Run	11/1/1997	6.98	1538	-61	83	-6.8	875	0.09	0.25	0.58	0.10	11	157	118	14.3	4.88	0.02	9.30	35.2	7.5	7.4	1137
1	Morrison Run	12/10/1997	6.78	859	-34	44	-388.0	448	0.99	1.1	1.13	36.75	11	97	59	12.1	5.1	2.12	951.02	3600	5.5	6.4	950
1	Morrison Run	1/15/1998	7.08	781	-34	50	-89.4	341	0.2	0.2	1.23	4.28	9	80	57	8.6	3.34	0.49	219.00	829	4	5.9	730
1	Morrison Run	2/6/1998	7.05	954	-33	50	-30.0	454	0.2	0.3	1.57	1.88	20	98	73	18.4	2.73	0.17	75.82	287	2.4	6.3	940
2	Moxahala Creek	5/10/1997	4.91	775	22	0	0.0	325	5.2	2.84	3.8	0.00	13	84	31.2	18.2	3.07	0.00	0.00	0	9.7	5.6	800
2	Moxahala Creek	6/7/1997	4.6	854	18	0	0.0	408	3.58	2.19	4.64	0.00	17	82	39.4	23.9	3.64	0.00	0.00	0	17.4	4.6	880
2	Moxahala Creek	7/9/1997	3.82	1239	59	0	0.0	500	0.85	1.9	7.1	0.00	19	117	41	39.3	4	0.00	0.00	0	21.6	3.7	1230
2	Moxahala Creek	8/12/1997	3.77	1357	74	0	0.0	783	1.01	16.8	8.2	0.00	24	114	66	42.9	5.4	0.00	0.00	0	25	3.45	1380
2	Moxahala Creek	9/16/1997	4.19	1226	47	0	0.0	655	1.12	4.28	7.9	0.00	21.6	110	56	39.1	5.1	0.00	0.00	0	20.3	4.1	1280
2	Moxahala Creek	10/11/1997	3.64	1373	60	0	5251.5	680	0.55	4.1	8.6	1159.71	23	141	80	61	6.7	16.28	7293.79	27,610	14	3.9	678
2	Moxahala Creek	11/1/1997	3.46	1402	92	0	0.0	733	1.44	4.55	8.8	0.00	31	122	72	44.8	5.7	0.00	0.00	0	9.8	3.8	1402
2	Moxahala Creek	12/10/1997	4.31	944	16	0	0.0	553	8.3	3.7	5	0.00	21	101	50	37.1	4	0.00	0.00	0	5.2	5.3	1090
2	Moxahala Creek	1/15/1998	4.36	712	24	0	0.0	357	11.3	2.9	3.27	0.00	17	70	35	20.5	4.31	0.00	0.00	0	4	5.7	675
2	Moxahala Creek	2/6/1998	4.7	849	35	0	0.0	450	12.5	4	3.92	0.00	33	80	48	39.2	3.56	0.00	0.00	0	2.1	6	810
3	Unnamed trib to MxC	5/10/1997	7.7	478	-120	130	-15.2	98	0.42	1.53	3.8	0.73	13	58	15.2	15.1	2.78	0.02	10.57	40	10	7.4	510
3	Unnamed trib to MxC	6/7/1997	7.4	389	-114	118	-12.8	93	0.46	1.91	0.02	0.27	6	60	12.4	11.1	3.19	0.02	9.35	35.4	13.7	7	410
9	Unnamed trib to MxC	5/10/1997	3.7	1007	87	0	303.4	480	5.6	16.1	3	86.13	12	93	41	13.3	3.38	0.65	290.59	1100	10	4.5	1040
9	Unnamed trib to MxC	6/7/1997	3.7	989	92	0	125.1	449	0.52	13.4	3.02	23.04	12	90	44.8	13.5	3.63	0.25	113.33	429	15.2	4.3	1010
9	Unnamed trib to MxC	7/9/1997	3.29	1371	160	0	9.9	550	6.8	5	3.9	0.97	10	115	64	14	3.6	0.01	5.15	19.5	20.4	3.1	1350
9	Unnamed trib to MxC	8/12/1997	3.33	1406	150	0	65.1	805	9.5	14	4.35	12.10	11	107	57	43	4.4	0.08	36.19	137	22.8	3.09	1359
9	Unnamed trib to MxC	9/16/1997	3.35	1380	143	0	54.9	764	11.6	15.9	4.24	12.17	13	115	51	19	4.33	0.07	31.96	121	20.7	3.5	1330
9	Unnamed trib to MxC	10/8/1997	2.93	1474	186	0	0.0	784	14.1	17	4.2	0.00	11	122	75	17.9	5.1	0.00	0.00		17.1	3	1460
9	Unnamed trib to MxC	10/30/1997	2.98	1408	238	0	77.7	781	14.5	17.6	4.51	11.95	12	106	61	16	4.8	0.06	27.21	103	9.6	3.3	1334
9	Unnamed trib to MxC	12/9/1997	3.48	948	90	0	66.5	641	9.6	16	3	21.12	17	111	53	19.6	3.9	0.14	61.55	233	4.2	3.8	990
9	Unnamed trib to MxC	1/14/1998	4.56	798	38	0	45.7	424	8.1	6.9	2.3	20.79	15	84	39	13.5	4.75	0.22	100.12	379	0.9	4.8	679
9	Unnamed trib to MxC	2/6/1998	5.16	895	17	0	42.1	366	3.3	7.7	1.86	31.88	86	78	35	68	4.2	0.46	206.58	782	3.1	5.4	840
10	Rider Run	5/10/1997	5.78	561	19	0	424.0	225	10.5	3.75	1.44	350.16	10	53	18.6	15.8	2.4	4.15	1859.77	7040	8.8	6.1	590
10	Rider Run	6/7/1997	3.4	782	43	0	500.3	385	15	3.06	2.18	235.47	11	97	30.7	23.4	2.93	2.16	969.51	3670	15.3	4.5	790
10	Rider Run	7/8/1997	3.32	1094	79	0	395.7	362	4.8	2.1	3.1	50.09	14	83	25	36	3.4	0.93	417.39	1580	19.5	3.84	1091
10	Rider Run	8/14/1997	3.5	1118	62	0	106.5	545	2.39	4.41	3.54	17.77	13	88	44.8	15.1	5.1	0.32	143.18	542	21.5	3.25	1077
10	Rider Run	9/18/1997	3.43	1220	70	0	248.5	613	4.76	5.63	4.13	51.55	13.7	107	52	40.4	4.89	0.66	295.87	1120	19.3	3.6	1290
10	Rider Run	10/9/1997	3.15	1300	72	0	59.3	658	4.4	7.4	4.57	13.49	15	121	61	60	5.9	0.15	68.68	260	18.9	3.3	1399
10	Rider Run	10/30/1997	3.11	1257	114	0	393.9	646	7.1	5.76	4.28	59.23	14	99	53	42.4	5.2	0.64	287.95	1090	10.6	3.4	1243
10	Rider Run	12/9/1997	4.64	824	42	0	410.1	488	23	3.8	2.37	284.81	15	83	39	36.8	3.4	1.82	813.65	3080	3.2	5.4	782
10	Rider Run	1/15/1998	5.87	578	18	0	608.8	295	9.9	2.4	1.81	477.27	12	81	25	16.9	3.7	6.29	2818.72	10,670	4.2	6	565
10	Rider Run	2/8/1998	6.25	535	4	12	120.5	258	8.3	2.1	1.44	356.57	16	55	23	22.1	2.35	5.60	2509.63	9500	2.5	6.24	504
11	Moxahala Creek	5/10/1997	4.65	783	23	0	16259.3	310	6.5	3.5	4.28	10094.88	14	68	29.6	19.2	3.28	131.46	58910.38	223,000	9.6	5.5	750
11	Moxahala Creek	6/7/1997	4.2	923	32	0	11057.2	390	3.69	4.15	5.3	4540.36	17	98	41.6	26.5	3.87	64.26	28794.76	109,000	17.4	4.4	970
11	Moxahala Creek	7/8/1997	3.7	1298	57	0	17328.5	638	1.35	2.1	7.3	3268.10	22	122	71	42.6	3.1	56.53	25334.10	95,900	18.7	3.96	1320
11	Moxahala Creek	8/14/1997	3.64	1337	59	0	10960.2	656	2.03	5.22	7.9	2814.35	18	111	59	41.8	5.5	34.55	15480.49	58,600	26.2	3.43	1295
11	Moxahala Creek	9/18/1997	3.8	1305	48	0	6756.0	764	1.29	4.92	8.4	2056.37	20.7	120	72	42.1	5.4	26.17	11729.24	44,400	21.4	3.7	1360
11	Moxahala Creek	10/11/1997	3.41	1457	64	0	5396.7	789	1.41	6.7	8.9	1434.35	23	143	73	65	6.7	15.68	7026.98	26,600	18.6	3.88	1540
11	Moxahala Creek	11/1/1997	3.21	1489	80	0	7339.3	889	3.68	4.8	10.4	1732.08	23	128	77	43.7	6.2	17.06	7645.14	28,940	10.5	3.6	1457
11	Moxahala Creek	12/10/1997	4.33	1009	31	0	16686.6	573	17.5	3.8	5.2	14264.34	24	99	56	41.6	3.9	100.10	44856.42	169,800	5.5	5.4	1150
11	Moxahala Creek	1/17/1998	3.93	812	34	0	18323.0	353	13.7	3	4.1	11209.35	18	75	39	20.7	4.29	100.22	44909.26	170,000	4	5.33	849
11	Moxahala Creek	2/7/1998	5.57	688	22	0	9624.3	353	10.6	4	3.15	7765.07	20	67	43	29.9	3.05	81.35	36455.75	138,000	2	3.09	608
12	Unnamed trib to MxC	5/10/1997	4.9	520	20	0	28.5	193	0.17	1.84	2.14	5.92	4.9	43.7	19.9	5.9	2.13	0.27	118.88	450	10	5.9	520
12	Unnamed trib to MxC	6/7/1997	5.6	417	18	0	17.3	200	0.2	1.17	1.69	2.94	<5	59	20.2	6.3	1.5	0.18	80.04	303	15.5	6.1	450
12	Unnamed trib to MxC	7/9/1997	6.22	525	10	0	2.3	224	0.1	0.3	2.43	0.64	4.9	50	26	8.7	4.6	0.04	18.94	71.7	25	5.4	540
12	Unnamed trib to MxC	8/12/1997	6.61	525	-3	11	-0.3	234	0.23	0.1	2.73	0.27	4.9	52	26.2	7.5	3.28	0.02	7.32	27.7	29.5	5.57	557

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
12	Unnamed trib to MxC	9/16/1997	6.29	519	10	10	21.9	226	0.29	0.28	2.8	7.37	4.9	44.9	28.4	7.3	3.12	0.41	182.28	690	23	5.4	550
12	Unnamed trib to MxC	10/11/1997	6.38	540	-23	29	-6.3	243	0.68	0.4	4.2	1.45	4.9	59	31	10.2	5.3	0.05	22.93	86.8	15.6	4.7	555
12	Unnamed trib to MxC	11/1/1997	5.99	582	102	0	11.4	329	1.18	0.76	3.14	0.57	4.9	55	29.8	8.1	4.13	0.02	9.30	35.2	9.4	6	573
12	Unnamed trib to MxC	12/9/1997	5.83	520	-4	4	-1.1	242	0.25	1.1	1.96	0.91	4.9	61	28.3	9.6	2.53	0.05	22.93	86.8	3.9	5.4	509
12	Unnamed trib to MxC	1/17/1998	5.65	386	12	0	14.4	175	0.24	1	1.37	3.14	4.9	40	17.9	5.7	2.38	0.22	100.12	379	4.6	5.5	433
12	Unnamed trib to MxC	2/7/1998	6.12	416	14	0	29.6	201	0.37	1.6	1.33	6.99	4.9	42	28	8	1.98	0.39	176.47	668	3.6	5.6	478
14	Unnamed trib to MxC	5/10/1997	3.4	964	118	0	203.9	410	5.1	16.8	3.58	44.02	11	62.7	36.8	12.9	2.11	0.32	143.97	545	10	4.2	1010
14	Unnamed trib to MxC	6/7/1997	4.1	766	60	0	83.7	355	1.57	8.73	3.63	19.43	10	92	29.9	12.8	2.3	0.26	116.24	440	14	4.9	780
14	Unnamed trib to MxC	7/9/1997	4.59	975	36	0	5.2	479	0.91	1.8	3.8	0.95	14	118	53	19.6	3.2	0.03	12.13	45.9	21.7	4.4	960
14	Unnamed trib to MxC	8/12/1997	5.24	1094	10	0	0.5	604	1.13	1.26	3.59	0.32	14	138	52	19.4	4.86	0.01	4.41	16.7	24.5	5.51	1096
14	Unnamed trib to MxC	9/16/1997	4.73	1125	32	0	4.1	591	1.44	4.73	4.45	1.37	13.1	128	56	18.5	5.2	0.02	10.73	40.6	20.5	4.8	1160
14	Unnamed trib to MxC	10/11/1997	5.15	1145	6	0	2.3	595	0.23	0.8	9.1	3.89	15	161	63	26.5	8.2	0.07	31.96	121	14.9	4.6	1212
14	Unnamed trib to MxC	11/1/1997	3.96	1474	114	0	16.6	956	1.43	19.3	7	4.03	12	155	82	20.8	4.98	0.03	12.13	45.9	7.5	5	1339
14	Unnamed trib to MxC	12/9/1997	3.74	1295	187	0	61.1	896	3.4	33	4.9	13.49	13	115	72	25	2.56	0.06	27.21	103	3.7	3.9	1353
14	Unnamed trib to MxC	1/17/1998	3.97	880	106	0	106.2	475	5.5	10	3.43	18.96	11	84	45	13.5	2.61	0.19	83.48	316	4.2	4.5	1043
14	Unnamed trib to MxC	2/7/1998	3.57	1092	158	0	206.9	578	10.6	20	3.5	44.64	23	80	63	27.5	1.7	0.24	109.10	413	2.6	4.1	1137
18	Unnamed trib to MxC	5/8/1997	6.85	1091	6	0	209.2	560	1.35	2.47	1.83	197.02	11	108	70	10.7	3.3	6.48	2905.89	11,000	13	6.4	1080
18	Unnamed trib to MxC	6/5/1997	6.1	948	12	0	287.2	465	0.51	0.67	2.35	84.49	8	109	72	10.5	2.91	4.45	1994.50	7550	18.5	6.9	1040
18	Unnamed trib to MxC	7/7/1997	6.1	1306	15	0	69.9	664	0.53	0.2	2.34	14.31	15	136	93	15.4	2.68	0.87	388.33	1470	23.6	5.8	1280
18	Unnamed trib to MxC	8/14/1997	6.81	1261	-17	19	-88.4	737	0.47	0.57	2.11	16.38	14	127	86	15.2	4.31	0.97	433.24	1640	22.6	6.9	1260
18	Unnamed trib to MxC	9/17/1997	6.49	1274	-2	15	-32.3	761	0.38	0.1	1.81	36.95	15.9	135	94	14.7	4.13	3.00	1344.64	5090	19.2	5.8	1300
18	Unnamed trib to MxC	10/9/1997	6.18	1139	-12	16	-24.5	680	0.23	0.1	2.46	5.70	15	149	111	19.2	4.8	0.38	170.39	645	18.7	5.9	1384
18	Unnamed trib to MxC	10/29/1997	6.06	1285	-17	17	-58.7	737	0.64	0.32	2.42	11.68	12	123	93	13.4	4.92	0.64	287.95	1090	10.2	7	1189
18	Unnamed trib to MxC	12/9/1997	6.06	1003	-4	10	-18.4	666	1.07	0.5	2.26	17.60	16	132	96	18.8	3.7	0.85	383.05	1450	2.9	5.6	1069
18	Unnamed trib to MxC	1/15/1998	6.11	899	-16	16	-401.7	483	0.63	0.6	1.75	74.82	10	93	62	10.6	3.43	4.67	2092.24	7920	3.2	6.1	790
18	Unnamed trib to MxC	2/7/1998	6.14	945	14	0	265.8	545	0.86	1	1.79	69.31	12	103	74	15.4	2.26	3.53	1582.39	5990	1.2	5.77	800
19	Unnamed trib to MxC	5/10/1997	4.08	688	65	0	42.2	300	0.99	7.64	3.28	7.74	13	59	22.7	11.6	2.49	0.12	54.16	205	10	4.9	700
19	Unnamed trib to MxC	6/7/1997	4	697	48	0	18.3	310	0.94	7.55	3.97	4.74	13	59	26.3	11.6	2.56	0.07	31.70	120	17.4	4.3	725
19	Unnamed trib to MxC	7/9/1997	3.7	873	83	0	11.8	422	1.52	5.2	0.46	1.02	15	75	37	15.2	2.2	0.03	11.86	44.9	22.7		870
19	Unnamed trib to MxC	8/14/1997	3.87	854	58	0	4.8	396	2.43	6.62	4.65	1.14	18	65	37.2	15.1	2.91	0.02	6.95	26.3	22.8	4.3	880
19	Unnamed trib to MxC	9/17/1997	3.82	920	53	0	7.1	443	2.43	6.79	5.3	1.96	14	82	45.6	14.7	3.03	0.03	11.23	42.5	20.1	4	910
19	Unnamed trib to MxC	10/8/1997	3.29	1013	79	0	8.3	461	2.86	12	6.2	2.20	15	93	51	18.6	3.3	0.02	8.72	33	17.4	3.5	1050
19	Unnamed trib to MxC	10/30/1997	3.54	946	75	0	12.2	505	2.56	8.02	5.3	2.59	15	73	45.4	14.4	4.49	0.03	13.58	51.4	8.7	4.3	947
19	Unnamed trib to MxC	12/11/1997	5.86	611	-4	12	-2.9	249	1.58	1.5	2.31	3.84	27	66	28	19.4	2.49	0.13	59.44	225	3.4	6.2	660
19	Unnamed trib to MxC	1/14/1998	4.88	612	24	0	15.6	279	1.97	3.1	2.91	5.19	17	58	30	13	3.28	0.12	54.16	205	0.5	5	582
19	Unnamed trib to MxC	2/6/1998	5.37	842	22	0	17.7	269	1.4	3.6	2.11	5.72	124	66	24	76	2.29	0.15	67.10	254	2	5.5	820
20	Unnamed trib to MxC	5/8/1997	2.99	1365	204	0	711.4	550	20.4	24.5	3.07	167.27	35	68	33.4	20.1	3.54	0.65	290.59	1100	13.3	3.4	1230
20	Unnamed trib to MxC	6/5/1997	3	1349	226	0	181.3	596	14.7	22.7	3.18	32.55	39	102	40.4	25.5	2.87	0.15	66.84	253	18.6	3.3	1330
20	Unnamed trib to MxC	7/9/1997	2.9	1709	333	0	170.0	574	15.1	12	4	15.87	38	89	57	28.9	2.7	0.09	42.53	161	23	2.6	1680
20	Unnamed trib to MxC	8/12/1997	3.03	1682	319	0	65.6	711	14.8	30.4	4.17	10.16	36	74	56	27.8	4.52	0.04	17.14	64.9	25	2.71	1636
20	Unnamed trib to MxC	9/16/1997	3.02	1771	333	0	233.3	860	19.2	34.5	4.56	40.82	38.6	95	57	25.2	3.89	0.13	58.38	221	21.9	3	1800
20	Unnamed trib to MxC	10/8/1997	2.61	1880	395	0	0.0	886	21.7	48	5	0.00	36	101	66	33.9	4.1	0.00	0.00			2.5	
20	Unnamed trib to MxC	10/29/1997	2.7	1711	346	0	154.7	880	25.4	35.4	4.95	29.39	40	85	60	27.5	4.95	0.08	37.25	141	10	3	1741
20	Unnamed trib to MxC	12/9/1997	2.89	1453	229	0	187.3	793	20.7	33	3.89	47.10	45	89	56	28.2	3.8	0.15	68.16	258	4	2.8	1338
20	Unnamed trib to MxC	1/14/1998	3.21	1075	178	0	317.1	489	14.2	12	2.74	51.56	38	69	38	10.6	3.57	0.33	148.46	562	0.7	3.2	1007
20	Unnamed trib to MxC	2/6/1998	3.65	1148	130	0	341.6	476	13.3	14	2.17	77.45	100	82	35	78	2.72	0.49	219.00	829	3.3	3.2	1140
21	Burley Run	5/8/1997	3.3	1233	95	0	1782.8	700	3.69	11.8	8.9	457.72	11	106	72	14.1	3.72	3.49	1563.90	5920	13.6	4.3	1110
21	Burley Run	6/5/1997	3.5	1048	84	0	1749.5	517	2.98	9.53	7.7	420.92	12	103	54	12.8	3.67	3.87	1735.61	6570	19.5	3.9	1060
21	Burley Run	7/7/1997	3.48	1371	129	0	822.0	533	2.51	4	9.5	102.01	14	110	77	20	3.4	1.18	530.99	2010	24.2	3.2	1340
21	Burley Run	8/14/1997	3.55	1378	115	0	499.4	729	3.36	12.9	10.9	117.96	13	101	74	16.9	5.2	0.81	361.92	1370	23.6	3.7	1410
21	Burley Run	9/17/1997	3.51	1415	110	0	753.2	769	4.12	13.5	12.1	203.50	11.8	114	84	15.9	4.85	1.27	570.61	2160	19.8	3.6	1450
21	Burley Run	10/9/1997	3.1	1490	136	0	513.0	820	4	21	14.2	147.88	12	143	100	22.7	5.7	0.70	314.36	1190	19.7	3.1	1586
21	Burley Run	11/1/1997	3.12	1473	132	0	786.7	875	5.2	14.6	13.2	196.67	11	113	81	16.1	5.3	1.11	496.64	1880	11.3	3.4	1497
21	Burley Run	12/9/1997	3.37	1227	99	0	897.6	708	4.3	11	11.1	239.35	15	116	75	15.9	4	1.69	755.53	2860	4.1	3.4	1190
21	Burley Run	1/15/1998	3.75	944	68	0	1610.3	489	4.5	5.3	7.1	400.20	10	85	49	13	3.93	4.40	1973.37	7470	4.5	4.1	885
21	Burley Run	2/7/1998	4.45	953	70	0	1364.7	508	4.3	8.3	7.1	384.07	19	92	48	22.8	2.71	3.63	1624.66	6150		4.4	900

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
22	Possum Hollow	5/10/1997	3.99	475	36	0	264.8	223	6.2	6.13	1.04	98.33	7	40	14.4	8.9	1.79	1.37	612.88	2320	10	5.4	470
22	Possum Hollow	6/7/1997	3.4	700	88	0	227.6	280	4.28	9.92	1.65	41.00	9	53	27.8	10.2	2.56	0.48	215.56	816	16.2	3.8	708
22	Possum Hollow	7/9/1997	3.4	928	112	0	97.3	286	2.64	5	2.19	8.54	15	71	29	16.5	2.9	0.16	72.38	274	20.5	3.2	900
22	Possum Hollow	8/12/1997	3.53	1070	138	0	66.1	534	2.3	17.5	3.03	10.93	15	69	44.5	16.1	3.72	0.09	39.89	151	23.6	3.15	1053
22	Possum Hollow	9/16/1997	3.62	952	122	0	70.8	492	2.07	14.2	2.66	10.98	13.7	69	39	13.6	3.55	0.11	48.34	183	21.6	3.5	990
22	Possum Hollow	10/8/1997	3.19	1072	154	0	59.1	550	2.07	27	3.2	12.38	17	91	49	22.2	4.1	0.07	31.96	121		3.2	
22	Possum Hollow	10/29/1997	3.12	1063	174	0	158.3	525	4.49	20.8	3.09	25.82	13	67	41.9	14.6	4.3	0.17	75.82	287	11.1	3.5	1095
22	Possum Hollow	12/11/1997	5.09	380	16	0	143.9	192	4.6	3.5	0.9	80.94	7	41	16.3	8.2	2.11	1.67	749.46	2837	3.5	6.1	410
22	Possum Hollow	1/14/1998	4.46	453	46	0	309.1	213	5.2	2.5	1.11	59.21	9	44	16.3	8	2.51	1.25	560.04	2120	1.4	4	478
22	Possum Hollow	2/6/1998	4.58	477	39	0	239.8	245	6.7	5.3	1.23	81.36	9	29.5	22	9.4	2.5	1.14	512.49	1940	4.7	4.5	470
23	Unnamed trib to MxC	5/10/1997	3	868	123	0	413.3	340	4.68	12.2	2.69	65.76	4.9	44	32	7.6	3.15	0.62	280.02	1060	11	3.9	920
23	Unnamed trib to MxC	6/7/1997	3.3	858	125	0	87.6	300	4.94	11.7	2.61	13.49	<5	26.7	24.1	7.5	3.56	0.13	58.38	221	16	3.4	925
23	Unnamed trib to MxC	7/9/1997	3	1000	139	0	15.5	271	6.8	5	2.7	1.62	6	46	24	9.2	3.6	0.02	9.30	35.2	21.3	2.8	980
23	Unnamed trib to MxC	8/12/1997	3.14	1010	142	0	6.7	367	8.3	9.76	2.98	0.99	4.9	38	28.6	9.3	4.79	0.01	3.91	14.8	24.2	2.8	997
23	Unnamed trib to MxC	9/16/1997	3.14	998	140	0	198.8	411	8.9	9.55	2.98	30.43	4.9	61	29.3	9.2	4.74	0.26	118.35	448	21.5	3.1	1020
23	Unnamed trib to MxC	10/8/1997	2.78	1032	153	0	0.0	332	8.9	14	3.2	0.00	4.9	52	31	10.3	5.1	0.00	0.00			2.7	1800
23	Unnamed trib to MxC	10/29/1997	2.8	1009	159	0	51.9	396	9.9	10.5	3.28	7.73	4.9	48	31	11.2	4.83	0.06	27.21	103	12	3	1069
23	Unnamed trib to MxC	12/11/1997	2.95	919	128	0	74.3	430	7.2	11	2.98	12.29	4.9	54	33	8.2	3.7	0.11	48.34	183	4.2	2.9	1030
23	Unnamed trib to MxC	1/14/1998	3.27	743	104	0	39.9	309	4.9	6.1	2.38	5.13	5	43	25.1	6.4	3.8	0.07	31.96	121	2.2	3.1	793
23	Unnamed trib to MxC	2/6/1998	3.37	896	149	0	66.1	410	6.3	19	2.91	12.52	4.9	48	30	9	3.33	0.08	36.98	140	4.2	2.7	900
24	Black Fork	5/10/1997	6.38	414	-33	41	-6632.4	137	7.5	1.67	0.53	1949.53	11	32.5	10.6	21.7	2.55	37.37	16748.51	63,400	11.9	6.6	460
24	Black Fork	6/7/1997	6.2	586	-17	21	-1395.8	255	12.4	1.14	1.1	1202.01	15	55	24.2	40	3.55	15.27	6842.06	25,900	17	5.8	660
24	Black Fork	7/8/1997	6.41	933	-16	22	-552.9	415	9.2	0.5	1.67	392.88	16	81	20	84	4.4	6.43	2879.48	10,900	19.6	5.66	931
24	Black Fork	8/14/1997	5.59	1185	44	0	1281.8	601	16.6	1.5	3.34	624.61	19	100	34.3	91	6.4	5.42	2427.74	9190	25.8	4.83	1069
24	Black Fork	9/18/1997	6.34	1006	-14	15	-422.1	448	10.7	0.61	1.94	399.45	15.6	84	28.3	91	5.2	5.61	2512.28	9510	19.4	5.6	1070
24	Black Fork	10/11/1997	6.4	1060	-39	54	-665.1	466	1.79	0.3	1.89	67.88	16	93	28	121	6.4	3.17	1421.25	5380	15.8	5.64	1106
24	Black Fork	11/1/1997	5.62	1198	14	0	242.8	552	11.1	1.4	2.54	260.80	15	92	32.3	125	6.4	3.22	1445.02	5470	10.8	4.9	1229
24	Black Fork	12/10/1997	5.98	404	-19	28	-7715.6	240	54	28	0.47	33489.86	19	35	12.7	19.1	3.5	75.52	33840.45	128,100	6.1	6	460
24	Black Fork	1/17/1998	4.7	585	58	0	7336.2	293	27.5	3.5	0.8	4022.24	14	44	13.6	31.3	4.45	23.52	10540.47	39,900	4	5.28	615
24	Black Fork	2/7/1998	6.41	392	-16	33	-3241.1	153	11.5	3.5	0.54	3147.89	14	23.7	15.2	24.1	2.96	37.67	16880.60	63,900	5.3	6.18	259
25	Moxahala Creek	5/10/1997	3.4	1098	56	0	16332.2	583	10.2	5.63	7.1	6687.44	25	121	52	19.3	3.68	54.23	24303.83	92,000	10.4	4.1	1090
25	Moxahala Creek	6/7/1997	3.3	1186	68	0	10799.8	634	8.6	5.75	7.9	3533.75	14	108	55	22.1	4.1	29.53	13235.02	50,100	17.4	3.4	1200
25	Moxahala Creek	7/8/1997	3.21	1608	114	0	15648.1	770	7	8.7	11.5	3733.58	16	140	73	27.3	4.4	25.53	11438.65	43,300	20.2	3.34	1592
25	Moxahala Creek	8/14/1997	3.42	1510	85	0	11074.6	709	42.2	6.11	10.5	7662.34	17	119	80	28.3	5.6	24.23	10857.47	41,100	24	3.17	1390
25	Moxahala Creek	9/18/1997	3.42	1558	76	0	7830.1	828	4.86	6.25	11.8	2360.35	14.7	132	81	28.6	5.3	19.16	8585.59	32,500	19.2	3.5	1600
25	Moxahala Creek	10/11/1997	2.96	1758	109	0	5943.2	954	6.3	9	14.8	1641.21	15	174	119	45	7.2	10.14	4543.76	17,200	14.6	3.52	1847
25	Moxahala Creek	11/1/1997	3.05	1695	66	0	5747.4	889	8.4	7.08	12.9	2471.38	15	140	84	35.3	5.9	16.19	7256.81	27,470	10.2	3.3	1627
25	Moxahala Creek	12/10/1997	3.43	1014	46	0	17933.3	548	24.3	4	7.1	13800.85	16	95	53	21.8	4.9	72.50	32487.88	122,980	6	4.2	1090
25	Moxahala Creek	1/17/1998	3.67	1021	54	0	13677.6	515	13.8	2.8	6.2	5774.97	19	97	76	27	3.8	47.10	21107.35	79,900	3.7	4.98	1016
25	Moxahala Creek	2/7/1998	4.21	1031	44	0	9624.3	515	13	4.5	4.9	4899.65	20	46	68	21.4	3.73	40.68	18227.87	69,000		4.2	950
26	Snake Run	5/10/1997	2.98	1033	93	0	386.2	517	12.2	7.58	2.45	92.32	8	76	40	17	3.43	0.77	346.07	1310	12	4.1	970
26	Snake Run	6/5/1997	3.1	1072	104	0	455.0	420	9.3	8.77	2.74	91.04	9	71	34.7	17.3	3.7	0.81	364.56	1380	19.3	3.5	1060
26	Snake Run	7/9/1997	3.04	1366	140	0	175.7	643	12.1	5	3.7	26.11	8	106	44	22.4	3.9	0.23	104.61	396	21.5	2.8	1280
26	Snake Run	8/12/1997	3.22	1343	152	0	152.3	621	10.2	7.89	3.91	22.04	7	94	49.1	22.5	5.2	0.19	83.48	316	25	3.03	1312
26	Snake Run	9/16/1997	3.18	1355	141	0	128.3	634	12.8	8.87	3.81	23.18	5.8	99	53	21.6	4.8	0.17	75.82	287	21.5	3.1	1380
26	Snake Run	10/8/1997	2.78	1443	156	0	141.9	667	8.5	12	4.2	22.47	6	113	59	26.6	5.5	0.17	75.82	287		2.8	1170
26	Snake Run	10/29/1997	2.84	1307	137	0	164.6	646	17.3	7.75	4.04	34.95	6	93	49.7	21.1	5.2	0.22	100.12	379	11.5	3.2	1310
26	Snake Run	12/11/1997	3.47	723	50	0	190.2	388	8.6	1.6	1.97	46.30	11	71	29	15.4	3.2	0.71	317.01	1200	4.2	3.9	770
26	Snake Run	1/14/1998	3.12	1053	122	0	466.0	461	17.7	8.3	2.43	108.60	10	83	54	21	2.9	0.71	318.33	1205	1.5	3.2	929
26	Snake Run	2/6/1998	3.57	1033	82	0	228.2	411	9.1	6.9	2.32	50.99	60	86	37	59	3.3	0.52	231.94	878	3.9	3.6	950
27	Unnamed trib to MxC	5/10/1997	2.99	1114	157	0	537.5	490	6	13.8	4.07	81.72	4.9	55	36.1	17.1	3.3	0.64	285.31	1080	11	3.9	980
27	Unnamed trib to MxC	6/5/1997	3	1132	147	0	198.0	413	6.6	13.9	3.84	32.79	<5	53	32.9	17.6	3.34	0.25	112.27	425	18.7	3.3	1170
27	Unnamed trib to MxC	7/9/1997	2.72	1690	280	0	254.7	626	13.4	12	8	30.39	4.9	65	43	41.4	4	0.17	75.82	287	21.2	2.65	1563
27	Unnamed trib to MxC	8/12/1997	2.89	1775	320	0	210.0	743	16.1	23.7	4.36	28.98	6	55	57	39	4.72	0.12	54.68	207	24	2.74	1732
27	Unnamed trib to MxC	9/16/1997	3.08	1387	173	0	39.3	628	5.8	15.8	4.72	5.98	4.9	71	51	26.8	4.26	0.04	18.94	71.7	20.6	3	1400
27	Unnamed trib to MxC	10/8/1997	2.71	1415	194	0	99.0	683	5.6	18	5.1	14.65	4.9	83	62	36	5	0.09	42.53	161		2.7	1700

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
27	Unnamed trib to MxC	10/29/1997	2.8	1321	187	0	42.4	606	7.6	18.4	4.89	7.01	5	66	48.1	27.3	5.3	0.04	18.91	71.6	10.5	3	1403
27	Unnamed trib to MxC	12/11/1997	2.87	1124	147	0	176.6	506	17	11	4.1	38.57	4.9	60	39	16.6	3.5	0.22	100.12	379	4.2	2.9	1060
27	Unnamed trib to MxC	1/14/1998	2.94	1179	184	0	282.3	529	20	13	4.28	57.20	4.9	77	64	21	3.2	0.29	127.86	484	2.8	2.8	1157
27	Unnamed trib to MxC	2/6/1998	3.05	1449	351	0	498.5	755	38.7	33	6	110.35	4.9	33.4	58	15.3	3.24	0.26	118.35	448	3	2.5	300
28	Unnamed trib to MxC	5/10/1997	3.6	884	49	0	50.5	400	1.57	6.35	6.4	14.75	4.9	66	39.9	7.8	2.57	0.19	85.86	325	10.2	4.1	890
28	Unnamed trib to MxC	6/7/1997	3.5	937	96	0	40.2	430	0.84	6.29	7.6	6.16	<5	73	53	9.1	2.87	0.08	34.87	132	18.3	3.5	970
28	Unnamed trib to MxC	7/8/1997	3.6	1083	79	0	15.7	479	1.08	4	8.7	2.74	4.9	94	51	11.6	2.7	0.04	16.56	62.7	19	3.86	1017
28	Unnamed trib to MxC	8/14/1997	3.81	966	45	0	1.1	479	0.46	4.44	7.4	0.30	5	74	51	12.5	3.83	0.00	2.01	7.62	23.1	3.58	978
28	Unnamed trib to MxC	9/17/1997	3.88	926	44	0	0.7	466	0.2	3.86	7.9	0.19	6	78	51	13	3.63	0.00	1.31	4.97	20.5	3.8	960
28	Unnamed trib to MxC	10/30/1997	3.87	968	44	0	2.3	545	0.32	4.1	8.2	0.65	5	83	52	13	4.35	0.01	4.28	16.2	11.4	4.2	921
28	Unnamed trib to MxC	12/9/1997	3.71	957	44	0	10.0	494	0.58	4.1	8.4	2.96	5	96	46	8	3.3	0.04	18.86	71.4	4.3	3.7	918
28	Unnamed trib to MxC	1/15/1998	3.9	899	50	0	43.1	442	1.51	4.3	8.1	11.99	4.9	85	49	11	2.5	0.16	71.85	272	4.3	3.9	866
28	Unnamed trib to MxC	2/6/1998	4.42	777	43	0	51.5	409	2.32	7	6.9	19.44	5	33	47	9.2	2.07	0.22	99.86	378	3.6	4	740
29	Unnamed trib to MxC	5/10/1997	3	997	134	0	164.8	360	11.8	11.5	2.04	31.17	11	84	24.7	15.6	2.45	0.23	102.50	388	12.2	3.4	1100
29	Unnamed trib to MxC	6/5/1997	3.1	1115	167	0	741.2	410	12.6	13.8	2.4	127.82	6	33	29.7	19.1	2.75	0.83	369.84	1400	18.7	3.2	1170
29	Unnamed trib to MxC	7/9/1997	2.91	1418	185	0	71.0	579	5.8	4	4.7	5.56	4.9	74	51	26.8	3.1	0.07	31.96	121	19.4	2.99	1321
29	Unnamed trib to MxC	8/12/1997	3.07	1417	171	0	38.9	574	4.77	13.7	4.74	5.28	4.9	58	48.9	29.6	4.46	0.04	18.94	71.7	23	2.8	1386
29	Unnamed trib to MxC	9/17/1997	2.96	1663	250	0	204.5	709	13.8	22.5	4.13	33.07	6.4	67	52	35.1	4.32	0.15	68.16	258	19.5	2.9	1780
29	Unnamed trib to MxC	10/8/1997	2.58	1762	312	0	159.2	764	13.7	30	4.9	24.80	5	80	60	46	5	0.09	42.53	161		2.5	
29	Unnamed trib to MxC	10/29/1997	2.62	1632	315	0	315.5	775	19	26.8	4.61	50.50	4.9	68	48	43	5.4	0.19	83.48	316	10.5	2.8	1738
29	Unnamed trib to MxC	12/11/1997	2.96	830	97	0	793.3	337	9.7	7.7	1.77	156.79	7	43	22.1	15.5	3.63	1.52	681.56	2580	4.6	2.9	740
29	Unnamed trib to MxC	1/15/1998	3.07	910	116	0	464.8	357	9.5	8.8	2.63	83.87	6	52	39	20.2	2.3	0.75	333.91	1264	3.9	2.8	905
29	Unnamed trib to MxC	2/6/1998	3.31	928	124	0	735.1	409	10.8	14	2.58	162.31	10	32.1	30	20.5	2.64	1.10	494.00	1870	3.6	2.8	860
30	Mcluney Creek	5/10/1997	3.2	1277	93	0	5277.2	583	4.97	8.58	6.1	1115.02	9	97	62	10.8	3.4	10.55	4728.68	17,900	10.9	3.6	1270
30	Mcluney Creek	6/7/1997	3.2	1371	107	0	3629.4	573	5.6	7.57	7	684.16	<5	102	62	11.1	3.57	6.31	2826.64	10,700	17.2	3	1390
30	Mcluney Creek	7/7/1997	3.12	1600	119	0	2667.1	781	5.3	5.3	8.4	425.83	8	133	96	13.1	3.3	4.17	1867.70	7070	24.3	2.9	1560
30	Mcluney Creek	8/14/1997	3.27	1563	119	0	1637.2	724	5.7	7.76	8.3	299.38	10	124	84	13.7	5.3	2.56	1146.51	4340	23.8	3.5	1610
30	Mcluney Creek	9/18/1997	3.3	1587	110	0	2479.3	912	5.8	9	9.6	549.96	7.5	137	89	14	4.87	4.19	1878.26	7110	18.6	3.2	1650
30	Mcluney Creek	10/10/1997	2.88	1670	141	0	1618.1	836	6.6	11	10.4	321.32	8	155	112	16.5	5.6	2.13	956.30	3620	19.7	3.61	1980
30	Mcluney Creek	11/1/1997	2.96	1502	122	0	1373.0	781	7.6	8.31	9.5	285.96	10	118	79	14.4	5.6	2.09	937.81	3550	9.2	3.1	1530
30	Mcluney Creek	12/9/1997	3.07	1426	97	0	1943.4	838	8.1	9.6	8.9	532.93	9	132	76	15.4	4.1	3.73	1669.57	6320	3.1	2.9	1327
30	Mcluney Creek	1/15/1998	3.3	1151	82	0	5516.0	550	5.7	7.3	5.8	1264.65	7	99	65	10.1	3.84	12.51	5605.73	21,220	3.3	3.1	1086
30	Mcluney Creek	2/7/1998	3.53	1178	82	0	4159.1	643	5.7	7.4	7.1	1024.57	10	51	82	12.8	3.35	9.43	4226.75	16,000		3.2	1110
33	Pussy Hollow	5/10/1997	3.22	604	54	0	77.0	200	4.14	4.02	0.99	13.05	4.9	21.9	24.7	10.8	1.89	0.27	118.88	450	10	4.2	600
33	Pussy Hollow	6/7/1997	3.2	760	87	0	68.4	262	4.45	5.46	1.54	9.00	<5	26.9	21.4	15	2.2	0.15	65.51	248	14.7	3.4	790
33	Pussy Hollow	7/9/1997	3.09	993	121	0	66.0	330	2.8	7.1	2.33	6.67	4.9	51	36	22.1	2	0.10	45.44	172	17.6	2.9	1010
33	Pussy Hollow	8/12/1997	3.33	999	110	0	10.0	433	2.43	10.8	3.08	1.48	4.9	51	36.1	25.6	3.49	0.02	7.56	28.6	21.6	3.13	1017
33	Pussy Hollow	9/17/1997	3.37	959	118	0	68.5	429	1.77	12.9	3.19	10.36	4.9	58	35.5	25	3.28	0.11	48.34	183	18.5	3.2	1060
33	Pussy Hollow	10/8/1997	2.93	1100	148	0	0.0	460	1.78	18	3.8	0.00	4.9	63	46	32	3.7	0.00	0.00			2.9	1520
33	Pussy Hollow	10/30/1997	3.13	1022	144	0	16.1	501	1.67	17.8	3.87	2.60	4.9	57	40.7	27.6	4.7	0.02	9.30	35.2	11.5	3.3	1037
33	Pussy Hollow	12/11/1997	3.46	428	36	0	59.7	179	0.86	3.4	0.89	8.54	4.9	29	12.9	10.7	1.9	0.31	138.16	523	4.3	3.6	480
33	Pussy Hollow	1/14/1998	3.61	474	44	0	40.0	178	1.1	4.2	1.19	5.90	4.9	24.2	15.4	10	2.05	0.17	75.82	287	3.9	3.3	504
33	Pussy Hollow	2/6/1998	3.57	585	59	0	53.7	253	4.3	3.8	1.31	8.56	4.9	37	28	15.4	2.17	0.17	75.82	287	4	3	580
35	Moxahala Creek	5/10/1997	3.4	1165	56	0	13616.1	540	13.1	5.06	7.8	6312.02	14	90	53	20.4	3.7	45.22	20262.00	76,700	10.8	3.96	1285
35	Moxahala Creek	6/7/1997	3.4	1236	113	0	13469.0	555	13.3	4.92	0.86	2274.23	15	122	73	24.1	4.14	22.17	9932.87	37,600	18.8	3.4	1210
35	Moxahala Creek	7/8/1997	3.1	1740	125	0	10817.8	774	11.4	3.8	13.7	2501.09	18	145	109	31.3	4.1	16.09	7211.90	27,300	21	3.41	1724
35	Moxahala Creek	8/13/1997	3.33	1460	100	0	14297.0	653	11.7	6.87	10	4084.65	17	103	75	29.6	5.3	26.59	11914.16	45,100	24.3	3.18	1450
35	Moxahala Creek	9/19/1997	3.31	1694	116	0	7906.1	971	10.7	6.01	14.3	2113.53	16.2	143	90	31.8	5.5	12.67	5679.70	21,500	20.9	4	1720
35	Moxahala Creek	10/11/1997	2.88	1925	154	0	4979.5	1020	12.5	10	16.5	1261.05	16.4	172	115	43	6.7	6.01	2694.56	10,200	17.7	3.42	1989
35	Moxahala Creek	11/1/1997	2.89	1839	132	0	6820.7	990	15	6.93	15.3	1923.75	17	148	99	39.5	5.8	9.61	4306.01	16,300	10.6	3.2	1760
35	Moxahala Creek	12/10/1997	3.27	1145	52	0	12923.7	661	43	4.9	8.2	13942.71	19	108	48	29	4.2	46.22	20711.09	78,400	2.57	4.1	1220
35	Moxahala Creek	1/17/1998	3.94	1028	46	0	9259.8	485	17.4	3.8	6.6	5596.12	25	91	52	24.3	4.38	37.43	16774.93	63,500	3.8	5.31	1016
35	Moxahala Creek	2/7/1998	4.43	1069	46	0	8326.5	547	17.2	3.7	7.7	5176.91	23	93	66	28.1	3.73	33.66	15084.23	57,100		4.9	970
36	Unnamed trib to MxC	5/10/1997	3.2	1546	78	0	291.8	785	11	6.35	17.9	131.86	19	118	109	11.8	3.86	0.70	311.72	1180	12.6	3.8	1490
36	Unnamed trib to MxC	6/5/1997	3.2	1566	91	0	519.3	770	8.8	5.64	18.7	189.10	9	106	95	11.3	3.84	1.06	475.51	1800	22.9	3.6	1550
36	Unnamed trib to MxC	7/7/1997	3.19	1945	136	0	370.8	966	8.5	6.9	23.5	106.05	4.9	156	153	13.7	5	0.51	227.19	860	26	2.9	1920

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANES E mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
36	Unnamed trib to MxC	8/14/1997	3.38	1803	92	0	202.7	1121	8.3	4.19	24.5	81.50	4.9	136	125	10.1	5.2	0.41	183.60	695	26.1	3.6	1880
36	Unnamed trib to MxC	9/17/1997	3.4	1893	124	0	235.9	1044	9.2	4.88	26.8	77.76	4.9	152	138	10.5	4.91	0.35	158.50	600	20.6	3.3	2020
36	Unnamed trib to MxC	10/9/1997	2.99	1973	132	0	202.5	1167	7.5	5.5	28.8	64.13	4.9	174	169	12.2	5.3	0.29	127.86	484	20.3	3.63	
36	Unnamed trib to MxC	10/30/1997	3.03	1941	187	0	224.7	1212	8.8	5.19	28.3	50.81	4.9	155	139	11.3	5.4	0.22	100.12	379	13	3.3	1819
36	Unnamed trib to MxC	12/9/1997	3.13	1936	107	0	177.4	1257	13.5	6.3	28.6	80.24	4.9	217	131	13.3	4.5	0.31	138.16	523	3.9	3.1	1735
36	Unnamed trib to MxC	1/14/1998	3.43	1359	60	0	370.9	726	10.1	5.5	17	201.52	17	114	98	15.5	4.35	1.15	515.14	1950	3.1	3.7	1224
36	Unnamed trib to MxC	2/7/1998	3.67	1516	78	0	351.1	870	13	5.6	20.3	175.11	21	135	120	18.4	3.89	0.84	375.12	1420	2.6	4.53	1290
37	Unnamed trib to MxC	5/10/1997	4.79	1239	37	0	421.1	700	5.9	0.81	12.5	218.62	4.9	105	94	12.7	4.18	2.12	948.38	3590	13.6	5.9	1280
37	Unnamed trib to MxC	6/5/1997	4	1149	32	0	253.6	573	6	0.63	11.7	145.27	<5	87	95	11.5	4.06	1.47	660.43	2500	21.4	5.7	1190
37	Unnamed trib to MxC	7/7/1997	3.92	1663	48	0	108.0	931	5.9	1.2	18.6	57.84	4.9	146	171	20.5	4.3	0.42	187.56	710	25	4.1	1630
37	Unnamed trib to MxC	8/14/1997	3.81	1778	67	0	189.0	1044	5.8	1.13	23.6	86.14	4.9	145	142	18.3	6.4	0.52	235.11	890	23.6	4.3	1830
37	Unnamed trib to MxC	9/17/1997	4.21	1547	47	0	123.5	1063	5.4	0.73	18.9	65.78	4.9	136	121	15.3	5.4	0.49	219.00	829	21.5	4.8	1710
37	Unnamed trib to MxC	10/9/1997	3.4	1802	59	0	112.8	1055	6.1	1.3	24.2	60.40	4.9	175	170	19.1	6.9	0.36	159.30	603	20.3	4.32	1802
37	Unnamed trib to MxC	10/30/1997	3.18	1933	97	0	172.8	1172	11.6	1.59	26.6	70.89	4.9	164	149	18.6	6.6	0.33	148.46	562	12.1	3.6	1763
37	Unnamed trib to MxC	12/9/1997	3.51	1912	80	0	175.0	1307	11.9	1.7	26.5	87.71	4.9	200	146	19.3	6.2	0.41	182.28	690	5.5	3.8	1677
37	Unnamed trib to MxC	1/14/1998	5.64	865	10	0	150.9	481	7.3	1.5	8.2	256.52	4.9	73	58	10.3	4.36	2.81	1257.46	4760	4.6	5.4	782
37	Unnamed trib to MxC	2/7/1998	5.67	1255	37	0	199.4	774	11.4	1	14.9	147.12	4.9	114	125	14.6	4.22	1.00	449.09	1700	4.4	5.81	1113
38	Unnamed trib to MxC	5/10/1997	4.2	600	89	0	88.9	287	47.5	5.22	1.16	53.80	20	27.6	16.4	18	2.24	0.19	83.21	315	9.3	5.04	639
38	Unnamed trib to MxC	6/7/1997	2.9	1287	216	0	70.5	440	96	9.37	2.33	35.17	21	38.8	24.2	22.2	3.24	0.06	27.21	103	15.4	4.3	960
38	Unnamed trib to MxC	7/8/1997	2.85	1790	458	0	48.8	915	161	20	4	19.71	19	71	46	35	2.5	0.02	8.88	33.6	18.6	3.42	1651
38	Unnamed trib to MxC	8/13/1997	3.02	1768	424	0	36.4	833	153	17.1	4.28	14.98	21	67	44.2	29.7	5.1	0.02	7.16	27.1		3.3	964
38	Unnamed trib to MxC	9/17/1997	2.79	1850	526	0	30.8	1064	174	21.6	5.8	11.81	18.1	75	53	27	6	0.01	4.89	18.5	18.6	3	2060
38	Unnamed trib to MxC	10/11/1997	2.55	2350	731	0	26.4	1228	243	31	7.2	10.16	17	102	76	31.5	7.4	0.01	3.01	11.4	10.5	3.17	2080
38	Unnamed trib to MxC	10/30/1997	2.56	1982	653	0	26.9	1040	145	24	5.5	7.19	8	79	49	26.2	5.7	0.01	3.43	13	11.8	2.7	1876
38	Unnamed trib to MxC	12/11/1997	4.34	600	59	0	34.6	272	31.3	3.8	0.91	21.12	20	49	14.4	18.2	2.2	0.11	48.87	185	3.6	5.5	590
38	Unnamed trib to MxC	1/14/1998	4.49	592	60	0	24.9	234	29.6	3.7	1.03	14.26	21	30.8	15.2	18.4	2.82	0.08	34.61	131	3.3	4.9	494
38	Unnamed trib to MxC	2/6/1998	5.29	777	83	0	40.8	252	37.9	3.4	0.54	20.56	99	52	25.3	47.4	2.31	0.09	40.95	155	3.6	4.6	770
39	Moxahala Creek	5/10/1997	3.38	1167	85	0	17869.2	460	16.6	4.62	7.5	6037.69	14	88	58	21.6	3.74	39.09	17518.84	66,316	10.3	4.49	1253
39	Moxahala Creek	6/7/1997	3.3	1268	80	0	9814.5	618	17.7	4.8	8.4	3790.86	14	98	59	24.4	3.93	22.81	10223.46	38,700	18	3.4	1230
39	Moxahala Creek	7/8/1997	3.08	1787	147	0	10811.2	856	17.5	9.7	13.2	2971.24	16	174	90	41	5.3	13.68	6128.79	23,200	21.5	3.41	1734
39	Moxahala Creek	8/13/1997	3.38	1421	84	0	8654.3	668	13.3	5.3	9.3	2874.46	16	106	68	32.9	5.3	19.16	8585.59	32,500		3.35	1114
39	Moxahala Creek	9/19/1997	3.1	1710	114	0	6468.8	877	16.6	6.87	12.9	2063.79	17.2	136	89	32.7	5.3	10.55	4728.68	17,900	19.9	3.1	1700
39	Moxahala Creek	10/11/1997	2.87	1950	164	0	4081.1	1014	16.7	11	15.7	1080.01	18	179	122	50	7	4.63	2073.75	7850	13.1	3.37	1999
39	Moxahala Creek	11/1/1997	2.91	1855	149	0	5186.3	970	20.4	6.92	14.5	1455.64	22	149	88	42	5.9	6.47	2900.61	10,980	9.4	3.2	1844
39	Moxahala Creek	12/10/1997	3.62	942	32	0	8125.5	503	15	2.7	6	6017.96	19	95	42	27.9	3.6	47.22	21160.19	80,100		4.8	1020
39	Moxahala Creek	1/17/1998	3.88	1044	30	0	4802.6	503	19.5	4.1	6.2	4770.63	18	85	54	25	4.16	29.77	13340.69	50,500	3.8	5.15	993
39	Moxahala Creek	2/7/1998	4.48	1074	53	0	8299.9	543	18.9	4.2	7.2	4745.02	23	94	61	28.9	3.57	29.12	13050.10	49,400		5	960
40	Bear Creek	5/10/1997	4.12	1166	49	0	4706.6	700	9.3	4.91	11.4	2459.92	16	111	62	14.3	5.9	17.86	8004.41	30,300	13.9	5	1170
40	Bear Creek	6/5/1997	3.5	1335	49	0	1345.2	560	6.7	3.76	13.1	646.79	16	118	82	16.9	4.36	5.11	2287.73	8660	21.8	3.9	1350
40	Bear Creek	7/8/1997	3.21	1964	110	0	1534.3	1048	8.8	5.5	21	492.37	21	177	126	26.8	5.6	2.59	1162.36	4400	20.9	3.48	1900
40	Bear Creek	8/14/1997	3.38	1886	80	0	966.2	1042	7.8	3.94	20.6	390.60	24	157	124	23.1	6.2	2.25	1006.50	3810	22.5	3.2	1721
40	Bear Creek	9/19/1997	3.28	1966	94	0	855.2	1149	10	4.05	23.2	338.90	20	174	133	22.5	6.2	1.69	758.17	2870	20.1	4	2030
40	Bear Creek	10/11/1997	3.03	2070	112	0	532.6	1205	9.1	5	25.2	186.88	20	202	160	25.6	6.8	0.88	396.26	1500	12	3.64	2260
40	Bear Creek	11/1/1997	3.11	1934	74	0	672.3	1111	14.1	3.94	22.2	365.60	20	170	129	22.3	6.2	1.69	757.12	2866	8.6	3.7	1990
40	Bear Creek	12/9/1997	3.23	1796	86	0	1128.7	1088	18.8	4	19.5	555.15	22	188	114	25	5.3	2.44	1093.67	4140	4.4	3.6	1656
40	Bear Creek	1/15/1998	3.66	1136	34	0	1217.9	554	11.5	2.2	10.2	856.14	19	105	67	17.8	4.32	6.66	2985.14	11,300	4.8	5	980
40	Bear Creek	2/7/1998	3.97	1246	983	0	21782.1	649	14.1	2.9	12.6	655.90	31	115	82	26.9	3.96	4.12	1846.56	6990		5.2	1160
49	Unnamed trib to MxC	5/10/1997	7.2	719	-62	68	-888.4	270	0.26	0.18	0.79	17.62	15	71	40.2	11.9	2.34	2.66	1194.06	4520	8.6	5.5	569
49	Unnamed trib to MxC	6/7/1997	7	447	-50	65	-53.9	123	0.46	0.38	1.77	2.81	<5	45.4	19.6	10.7	1.69	0.20	89.82	340	17.3	6.05	529
49	Unnamed trib to MxC	7/9/1997	6.31	1145	-95	96	-9.2	420	0.03	0.2	4.8	0.48	20	129	63	22.8	3	0.02	8.03	30.4	21.1	5.65	1056
49	Unnamed trib to MxC	8/12/1997	7.32	1451	-96	103	-9.3	630	2.01	0.23	2.38	0.45	30	159	101	18.6	4.56	0.02	8.06	30.5	24.7	5.91	1466
49	Unnamed trib to MxC	9/19/1997	6.93	1425	-84	105	-0.8	769	0.22	0.1	1.52	0.02	18	164	86	20.3	3.96	0.00	0.76	2.87	20.3	6.8	1460
49	Unnamed trib to MxC	10/11/1997	6.78	1822	-61	99	-1.1	990	3.8	0.1	27.7	0.57	25	225	149	46	5.6	0.00	1.50	5.68	12	5.92	1849
49	Unnamed trib to MxC	10/30/1997	6.19	1654	-57	82	-2.9	902	4.59	0.16	23.5	1.41	16	177	114	28.7	3.58	0.01	4.17	15.8	10	6.7	1385
49	Unnamed trib to MxC	12/11/1997	6.78	258	-53	51	-450.3	70	0.26	0.3	0.33	7.56	5	31	9.3	10.6	1.86	1.58	707.98	2680	3.6	8.1	290
49	Unnamed trib to MxC	1/15/1998	6.75	312	-42	50	-86.0	115	0.29	0.5	0.39	2.42	6	45	19	10	1.86	0.38	170.66	646	3.8	6	415

Appendix A: Phase I 1997-1998 Data

Source Data ID	basin	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Cl mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Flowrate CFS	GPM	LPM	Temp. C	Field pH	Field Cond. uS/cm
49	Unnamed trib to MxC	2/6/1998	6.86	352	-35	50	-49.7	109	0.35	0.1	1.2	2.34	9	36	16.6	11.8	1.62	0.26	118.35	448	2.2	6.1	330
55	Moxahala Creek	5/10/1997	2.98	1481	120	0	14873.9	617	32.4	7.9	9.2	6135.50	17	106	68	28.4	4.23	23.05	10329.13	39,100	10.6	3.14	1564
55	Moxahala Creek	6/7/1997	3.1	1501	121	0	9059.3	638	35.1	7.81	9.2	3901.51	19	107	76	29.8	4.3	13.92	6239.22	23,618	22.8	3.54	1432
55	Moxahala Creek	7/8/1997	2.92	1953	209	0	10733.2	907	49	11	14.3	3815.68	22	156	98	54	5.7	9.55	4279.59	16,200	23.1	3.4	1840
55	Moxahala Creek	8/13/1997	3.31	1502	107	0	10175.9	745	23.1	6.21	9	3643.36	17	159	63	41.3	5.7	17.69	7925.16	30,000	25	3.4	1378
55	Moxahala Creek	9/19/1997	2.98	1962	205	0	6953.5	1129	38.8	13.7	14	2255.66	20	239	84	46.7	6.7	6.31	2826.64	10,700	22.1	3.8	1930
55	Moxahala Creek	10/10/1997	2.73	2260	263	0	6144.6	1174	40	14.1	15.8	1633.10	21	188	116	61	7.6	4.34	1946.95	7370	20.6	3.14	2220
55	Moxahala Creek	10/30/1997	2.87	1952	74	0	2369.3	984	46.5	10.5	14.9	2302.07	18	154	97	52	6.5	5.95	2668.14	10,100	11.6	4.08	1990
55	Moxahala Creek	12/11/1997	3.52	1312	50	0	7001.1	759	19.8	5.1	8.7	4704.73	20	134	76	29.7	4.9	26.04	11668.48	44,170	3.7	3.8	1478
55	Moxahala Creek	1/16/1998	3.29	1210	97	0	10485.6	573	30.8	5.4	6	4561.79	21	86	41	26.3	4.28	20.10	9008.27	34,100	3.8	4.23	1240
55	Moxahala Creek	2/8/1998	3.66	1404	116	0	11914.4	703	36	6.7	8.8	5289.57	24	98	62	33.4	3.94	19.10	8559.18	32,400	2.8	4.1	1047
56	Andrew Creek	5/10/1997	2.71	2310	280	0	10740.2	1140	74	14.2	16.4	4012.22	21	157	102	47.7	5.8	7.13	3196.48	12,100			
56	Andrew Creek	6/7/1997	2.9	2180	259	0	11534.1	1100	67	15.4	15.7	4368.69	21	148	84	40.6	5.9	8.28	3711.09	14,048	20	3.23	2000
56	Andrew Creek	7/7/1997	2.8	2380	313	0	6945.6	1167	52	10	18.1	1777.46	24	180	101	66	6.3	4.13	1849.20	7,000	27.6	2.8	2240
56	Andrew Creek	8/15/1997	3.26	1611	170	0	14173.4	722	29	7.74	8.8	3796.79	19	105	57	64	6	15.50	6947.73	26,300	26.6	3.11	1405
56	Andrew Creek	9/19/1997	2.94	2160	272	0	10519.5	1242	47.8	15	16.2	3055.31	23	163	94	49.9	6.7	7.19	3222.90	12,200	21	3.7	2170
56	Andrew Creek	10/10/1997	2.7	2480	316	0	5409.4	1270	56	17	18.8	1571.46	23	208	134	75	8.5	3.18	1426.53	5400	22.9	2.94	2420
56	Andrew Creek	10/30/1997	2.76	2370	195	0	4327.1	1304	68	15.5	18.8	2270.08	21	171	104	59	7.3	4.13	1849.20	7000	12.3	4.27	2240
56	Andrew Creek	12/11/1997	2.94	2040	206	0	5694.5	1012	65	12	14.5	2529.33	21	180	91	68	6.6	5.14	2303.58	8720	4.6	3.3	1962
56	Andrew Creek	1/16/1998	2.9	1860	225	0	10984.3	928	68	12	12.8	4530.40	25	140	80	38.1	5.2	9.08	4068.25	15,400	4.9	3.53	1747
56	Andrew Creek	2/8/1998	3.26	1989	258	0	10387.0	950	73	15	15	4146.76	22	150	102	55	6.3	7.49	3354.99	12,700	2.5	3.75	1559
57	Moxahala Creek	5/10/1997	5.19	900	23	0	1757.2	385	1.19	3.3	5.3	747.94	15	85	50	15.6	2.94	14.21	6366.55	24,100	11.4	5.16	1045
57	Moxahala Creek	6/7/1997	6.9	708	-14	29	-445.5	297	0.79	0.65	2.14	113.93	10	76	38.6	18.2	2.83	5.92	2652.02	10,039	19.4	5.68	734
57	Moxahala Creek	7/7/1997	6.25	1005	-9	12	-98.1	465	1.07	0.3	5.7	77.10	15	100	59	22.4	3.5	2.03	908.75	3440	25.4	6.21	942
57	Moxahala Creek	8/15/1997	5.66	737	18	0	4239.6	406	11.8	20.3	5	8738.38	12	62	46.3	11.7	6.3	43.80	19627.99	74,300	23.3	5.18	726
57	Moxahala Creek	9/19/1997	6.38	868	-5	22	-59.4	429	0.41	0.63	3.93	59.08	10	85	54	15.1	3.71	2.21	990.65	3750	19.9	6.3	890
57	Moxahala Creek	10/10/1997	6.42	976	-22	33	-106.0	475	0.23	0.1	4	20.86	11	111	73	24.9	4.7	0.90	401.54	1520	17.9	5.39	1028
57	Moxahala Creek	10/30/1997	5.79	1125	-23	18	-220.2	616	1.14	0.1	6	69.31	11	107	72	21	4.61	1.78	797.80	3020	10.7	6.48	1175
57	Moxahala Creek	12/11/1997	5.11	1170	10	9.9	922.5	713	1.56	2.7	7.6	1094.07	19	133	104	27.7	4.8	17.15	7687.41	29,100	3.4	4.9	1258
57	Moxahala Creek	1/16/1998	6.32	508	-14	22	-847.7	195	2.28	0.4	1.84	273.68	13	52	27.3	12.2	3.34	11.26	5045.69	19,100	3.7	5.5	549
57	Moxahala Creek	2/8/1998	5.84	754	14	0	723.4	371	3.9	2.2	4.8	563.23	24	71	45	18.5	3.22	9.61	4306.01	16,300	3.5	5.96	598
59	dst. Howards William Lake	5/10/1997	2.9	1604	146	0	8377.2	705	27.6	8.25	12.9	2797.19	17	115	70	23.5	5.5	10.67	4781.52	18,100			
59	dst. Howards William Lake	6/7/1997	3	1845	160	0	3479.5	925	27.1	9.34	17.3	1168.66	25	148	102	25.7	5.3	4.04	1812.22	6860	19	3.27	1840
59	dst. Howards William Lake	7/7/1997	2.95	1989	194	0	3216.4	1024	15.2	8.9	18.3	702.97	28	163	97	35.2	5.6	3.08	1381.62	5,230	28.4	2.75	1935
59	dst. Howards William Lake	8/15/1997	3.12	1820	154	0	3534.5	879	13.6	8.77	15.9	878.35	24	139	91	27.3	5.5	4.27	1912.61	7240	27	2.89	1718
59	dst. Howards William Lake	9/19/1997	3	1903	174	0	0.0	939	17	9.44	17.8	0.00	25	144	100	25.5	5.4	0.00	0.00		21.1	3.7	1960
59	dst. Howards William Lake	10/10/1997	2.8	2040	218	0	1451.3	1040	24.4	9	20.4	358.15	11	168	123	33	6.6	1.24	554.76	2100	20	2.98	2190
59	dst. Howards William Lake	10/30/1997	2.84	2080	154	0	737.2	1111	35.2	10.4	21.5	321.19	24	153	112	27.2	6.4	0.89	398.90	1510	13.9	4.05	2020
59	dst. Howards William Lake	12/11/1997	2.96	1799	157	0	1657.3	928	33.6	7.3	16.2	602.77	22	157	96	23.3	5.4	1.96	879.69	3330	3.3	3	1769
59	dst. Howards William Lake	1/16/1998	3.08	1580	133	0	3659.7	804	25	7	14.8	1287.76	23	137	92	21.8	4.3	5.12	2293.01	8680	2.5	3.48	1600
59	dst. Howards William Lake	2/8/1998	3.37	1678	141	0	1881.8	762	27.7	8	16.2	692.66	23	135	92	25.3	5.1	2.48	1112.16	4210	6	3.52	1272
60	Moxahala Creek	5/10/1997	6.81	458	-48	63	-133.0	110	3.48	0.31	0.39	11.58	36	57	11.2	20.3	2.55	0.52	230.89	874	8.7	5.08	502
60	Moxahala Creek	6/7/1997	6.8	570	-69	64	-82.0	152	5.7	0.41	0.77	8.18	32	58	13.1	24.3	3.29	0.22	99.06	375	19	5.87	600
60	Moxahala Creek	7/7/1997	6.58	791	-35	49	-20.5	299	7.6	0.4	1.32	5.47	29	94	22.6	50	4.6	0.11	48.87	185	22.6	5.62	785
60	Moxahala Creek	8/15/1997	7.15	423	-75	74	-237.8	76	2.68	1.82	0.37	15.44	36	47	10.6	22	4.3	0.59	264.17	1000	24	5.99	424
60	Moxahala Creek	9/19/1997	6.69	887	-65	71	0.0	370	44.6	3.62	1.32	0.00	41	104	26.2	39.7	5.1	0.00	0.00		15.5	6.2	990
60	Moxahala Creek	10/30/1997	5.99	928	-58	45	-22.1	425	10	0.91	1.46	4.71	37	106	27.8	43.4	5.5	0.07	31.70	120	10	6.57	1013
60	Moxahala Creek	12/11/1997	6.68	463	-51	59	-49.5	93	2.19	0.2	0.31	2.62	55	59	12.7	24.8	3.9	0.18	80.84	306	3.8	5.7	507
60	Moxahala Creek	1/16/1998	6.71	471	-50	60	-106.5	100	2.71	0.5	0.46	7.82	49	57	12.3	21	3.79	0.40	177.52	672	3.5	5.73	513
60	Moxahala Creek	2/8/1998	6.81	453	-41	62	-128.7	91	1.98	0.2	0.24	7.59	68	47	14.9	28.7	2.89	0.58	261.53	990	6	6.22	359

Appendix B: Phase I 2003 data

Appendix B: Phase I Data - 2003 lab data

Site Number	Source Data ID	Sample Number	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	Net Acidity	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Total Dissolved Solids	Total Suspended Solids	Flowrate CFS	GPM	Site Number	Source Data
MXMS0020	11	mrmmx001	11/10/2003	6.06	1010	21	7.07	13.93	2952.48	452	6.94	2.24	4.21	2838.02	699	16	39.35	17662.59	MXMS0020	ODNR-cambridge
RR0010	10	mrmmx002	11/10/2003	6.38	715	25.9	15.9	10	84.10	305	11.20	2.00	1.67	125.06	490	11	1.56	700.87	RR0010	ODNR-cambridge
MXBF0020	22	mrmmx003	11/10/2003	4.57	594	47.3	0	47.3	78.62	281	3.07	5.91	1.34	17.15	440	5	0.31	138.51	MXBF0020	ODNR-cambridge
MXBF0030	21	mrmmx004	11/10/2003	4.12	1040	72	0	72	717.12	552	2.76	8.63	7.53	188.44	804	9	1.85	829.99	MXBF0030	ODNR-cambridge
MXBF0040	26	mrmmx005	11/10/2003	3.39	1010	108	0	108	108.59	475	13.5	7.56	2.62	23.81	715	4	0.19	83.79	MXBF0040	ODNR-cambridge
BF0010	24	mrmmx006	11/10/2003	6.59	678	24.4	38	-13.6	(735.14)	242	15.2	0.823	0.958	917.90	451	18	10.04	4504.54	BF0010	ODNR-cambridge
MC0010	30	mrmmx006	11/10/2003	3.57	1170	77	0	77	2098.31	634	5.26	6.12	6.15	477.71	968	4	5.06	2270.90	MC0010	ODNR-cambridge
BC0010	40	mrmmx008	11/10/2003	3.91	1540	73.9	0	73.9	965.05	840	5.97	3.52	13.3	297.61	1250	8	2.42	1088.23	BC0010	ODNR-cambridge
AC0010	56	mrmmx009	11/10/2003	3.13	1890	**286**	0	286	5888.65	1029	70.6	13.9	12.5	1997.20	1470	19	3.82	1715.81	AC0010	ODNR-cambridge
MXMS0060	57	mrmmx010	11/10/2003	7.12	799	6.87	54.5	-47.63	#VALUE!	267	0.566	0.278	1.46	NA	550	6	NA	NA	MXMS0060	ODNR-cambridge

Appendix C: Field reconnaissance data

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	2/13/2004	3.34	1367	2.0	220	NA	NA	Andrews Creek @ SR 13 bridge
2	2/13/2004	5.38	1080	8.1	NA	3	NA	a & b, similar water quality, drains through pasture S. of Andrews
3	2/13/2004	5.49	673	4.0	NA	50	NA	pond discharge into wetland, cattle field
4	2/13/2004	NA	NA	NA	NA	NA	NA	gps check point
5	2/13/2004	6.28	204	1.8	NA	50	NA	ditch S. side RR bridge abuttment, from wetland due west
6	2/13/2004	6.75	1556	3.6	NA	30	NA	Hollow E. of treatment wetlands, drains from N. side of AC
7	2/13/2004	7.00	990	7.0	NA	60	NA	Permitted wetland discharge (TC-8), N. side of AC
8	2/13/2004	6.98	190	1.9	NA	10	NA	S. side of AC, E. of long poil banks
9	2/13/2004	6.85	710	4.3	NA	5	NA	culvert under RR tracks, two discharges from hillside
10	2/13/2004	3.43	1480	3.1	330	NA	NA	Andrews Creek W. of wetland treatment cell #4, N. side of tracks
11	2/13/2004	5.14	448	2.3	NA	NA	NA	Strip pit w/ beaver dam, 48" submerged culvert
12	2/13/2004	3.56	957	2.3	120	30	43.2	ditch before culvert to west, before it mixes w/ water from south
13	2/13/2004	3.44	1520	3.7	400	50	240	100' west of culvert draining #11 and 12
14	2/18/2004	3.36	657	4.1	NA	3	NA	Flow into #11 strip pit
15	2/18/2004	3.17	917	7.3	0	4	0	small discharge from hillside (spoil) @ dump
16	2/18/2004	3.30	821	3.2	160	30	57.6	discharge from western pit lake through spoil bank
17	2/18/2004	3.26	669	6.1	0	NA	NA	seep from S. highwall into strip pit that was breeched
18	2/18/2004	3.33	757	4.5	140	100	168	discharge point (breech) from #17 strip pit
19	2/18/2004	3.60	601	1.2	NA	NA	NA	flow into #17 strip pit from west
20	2/18/2004	3.63	966	4.0	0	NA	NA	Andrews Creek from culvert @ TR 118
21	2/18/2004	3.04	2290	2.0	400	10	48	wash out seepage on S. side of tracks, dst. #20, culvert under RR
22	2/18/2004	3.23	853	1.2	140	100	168	flow from strip pit (#17) S. of building in permitted area, W. of culvert
23	2/18/2004	3.62	1820	2.0	400	3	14.4	same as #22 except E. of culvert (culvert catches # 22 & 23)
24	2/18/2004	3.21	2344	11.8	400	30	144	seep on hillside in permitted area, drains into large ditch
25	2/18/2004	7.07	126	7.0	0	7	0	1st drainage W. side of SR13, culvert under access road but enters near RR bridge on W. of SR 13
26	2/20/2004	7.54	540	5.5	0	7	0	culvert under acces road to N. from wetland area, source is lake on highwall bench
27	2/20/2004	7.45	1628	10.4	60	40	28.8	culvert between wetland treatment cells #4 and 5
28	2/20/2004	6.92	1516	8.7	40	15	7.2	culvert W. of 1st wetland treatment cell, white precipitate in channel
29	2/20/2004	3.35	2467	9.2	400	60	288	Large steel culvert under access road, wetland on N. side upst. # 28
30	2/20/2004	3.70	2120	11.6	400	30	144	Large culvert under access road, drains valley to N., side ditch to large ditch in permit area
31	2/20/2004	3.40	2250	10.5	400	30	144	Large ditch draining slurry ponds to N., sample at culvert, turbid black water
32	2/20/2004	3.73	2082	11.9	400	15	72	side ditch to W. of large ditch, drainage from base of highwall
33	2/24/2004	2.88	2331	6.9	400	500	4800	1st culvert under access road to N., E. of TR 118, drains large hollow to N, large SS rocks at culvert
34	2/24/2004	3.21	1567	2.1	180	30	64.8	ditch from W. that enters #33 flow before entering culvert under RR spur and into AC
35	2/24/2004	2.60	3009	4.3	400	5	24	ditch flow SE of #33 into AC, source is spoil in floodplain
36	2/24/2004	2.52	3618	6.4	400	60	288	concrete culvert under access road, directly S. of oil well, edge of reclaimed area
37	2/24/2004	2.91	3355	10.0	400	50	240	flow under access road, W. of 1st reclaimed valley, S. of highwall, green algae in channel
38	2/24/2004	6.48	723	5.6	40	30	14.4	1st culvert under gated access road to W. of TR 118 to howard williams lake
39	2/24/2004	5.24	537	5.3	60	NA	NA	Spillway discharge from Howard Williams Lake
40	2/24/2004	3.02	1429	5.0	240	NA	NA	Trib to N. and W. of TR 118, along RR tracks, dst. of RR bridge
41	2/24/2004	3.15	3210	8.0	400	15	72	2nd culvert under access road, N. side of spillway, source is from ALD from reclaim N. of lake
42	2/24/2004	2.98	3900	6.4	400	30	144	small trib/flow through barren area N. of # 41
43	4/15/2004	2.64	3313		400	NA	NA	
44	4/7/2004	0.00	0	0.0	0	0	0	Combination of sites (24,30,31, and 32) flowing in large ditch in permitted area, behind building
45	4/7/2004	0.00	0	0.0	0	0	0	mainstem upst. #29
46	4/7/2004	0.00	0	0.0	0	0	0	mainstem upst. 13
47	4/15/2004	3.70	128	0	80	0	0	top of ridge in spoil
48	4/15/2004	3.00	612	0	0	0	0	top of ridge in spoil

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
49	4/21/2004	2.93	2942	17	400	0	0	through spoil
50	4/21/2004	2.70	3995	21	400	0	0	stream into Ac-36
51	4/21/2004	2.69	3348	20	400	0	0	stream into AC-36
52	4/21/2004	2.93	0	0	0	0	0	90% of flow into AC-37
53	4/21/2004	6.30	140	20	20	0	0	runoff from limst. ditch
54	4/21/2004	3.49	1952	18	400	0	0	Artisian discharge
55	4/21/2004	4.13	1980	17	400	0	0	aluvial iron fan
56	4/21/2004	4.58	2023	0	400	0	0	Artisian discharge of aluminum
57	4/15/2004	2.98	3692	0	0	0	0	porous diffuse flow near oil w
58	4/15/2004	2.64	1945	0	0	0	0	strip pond
59	4/15/2004	2.58	3875	0	0	0	0	Bright orange with highwall

Appendix C: Snake Run Recon

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	3/11/2004	3.2	925	6.4	140	100	168	Mouth of Snake Run @ driveway upst. SR 97
2	3/11/2004	2.82	1363	3.8	300	5	18	trib. to N., of TR 445, next to cream house, 3' concrete culvert all the way to creek under yard
3	3/11/2004	2.77	1301	3.6	240	5	14.4	trib. on N. side of TR 445, next to mailbox 11454
4	3/11/2004	3.05	977	4.2	100	10	12	trib. entering S-SW in SW qtr of Sec. 20, access to address 11621
5	3/11/2004	3.45	716	4.8	60	5	3.6	trib running along S. side TR 445 as it starts up over hill
6	3/11/2004	3.1	993	5.8	120	50	NA	mainstem Snake Run, N. side of TR 445, upst. of #5
7	3/11/2004	4.53	604	4.7	100	5	6	trib entering from SW; NW qtr of SW qtr Sec. 20
8	3/11/2004	3.15	1010	7.1	120	30	43.2	mainstem of Snake Run, upst. #7, water is from large seepage on S. hillside upst. of sampling site
8	5/5/2004	3.64	949	13	220	280	739.2	Main AMD source, flow was measured upstream and downstream in channel
9	3/11/2004	2.94	1073	4.4	140	5	8.4	trib entering from N. into Snake, dst. #8 mainstem site
10	5/5/2004					298		Downstream of main discharge (#8)
11	5/5/2004					16.99		Headwaters, upstream of main discharge (#8)

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	3/17/2004	4.04	920	5.8	120	NA	NA	Mouth of Burley in Crooksville, N. Buckeye St. bridge
2	3/17/2004	3.96	795	4.2	80	7	6.72	Trib from N. @ 1st culvert after turning on TR 161 (dead end road), flow from under RR
3	3/17/2004	4.31	845	3.5	60	NA	NA	mainstem Burley at TR 161 bridge, upst. trib from W-SW
4	3/17/2004	3.39	1130	3.7	220	NA	NA	Trib from W-SW (unnamed) along TR 161; flow is about 2/3 of Burley Run
5	3/17/2004	3.27	518	3.4	120	5	7.2	Trib from S. at Bates access road, 10963 TR 161, beneath power lines
6	3/17/2004	2.7	1833	4.1	400	2	9.6	roadside drainage from small trib at inlet to 12" CMP on N. side, upst. #5
7	3/17/2004	2.98	1629	4.5	240	5	14.4	S. of TR 161 at 10990 address.
8	3/17/2004	3.21	862	6	120	10	14.4	trib from S., E. of workshop building (wood-sided), across field and fence; Brown landowner
9	3/17/2004	3.14	1734	3.8	240	15	43.2	trib next to Brown's house (from N.), culvert under TR 161
10	3/17/2004	3.03	1900	3.3	280	10	33.6	Trib from NW, across from 10249 TR 161, Telephone box # 1596P 500-15
11	3/17/2004	3.52	1537	4.8	120	30	43.2	Trib from S., next to bilevel house at 10610 TR 161
12	3/17/2004	3.33	1370	3.9	160	NA	NA	mainstem of Burley, upst. # 11 at Bi-level house
13	3/17/2004	3.18	1749	3.7	220	20	52.8	trib from N., next to Glass residence, next to gray block building; <3 gpm also entering in ditch
14	3/17/2004	3.36	1168	4.6	100	NA	NA	mainstem of Burley next to white trailer @ end of road (no trespassing sign at driveway)
15	3/17/2004	3.51	1420	4.6	100	15	18	trib from S., near white trailer also
16	3/17/2004	3.47	613	6.9	100	20	24	Trib from N., along SR 669, large concrete culvert, pond in hollow upst. also
17	3/17/2004	2.82	1845	5.2	400	5	24	ditch along SR 669, limestone faced in front of residence - 11150, white 2-story house w/ fountain in yard
18	3/17/2004	5.48	832	5.6	NA	25	NA	trib next to TR 165 from N., large plastic culvert with limestone, lot's of sewage in stream
19	3/17/2004	6.06	855	6.1	20	20	4.8	trib from N. where SR 669 & TR 442 intersect, E. of yellow house
20	3/17/2004	3.36	830	5	80	20	19.2	trib from N., just pass white house @ dead end of TR 442
21	3/17/2004	3.98	1191	5.2	100	60	72	mainstem of Burley Run, upst. #22, @ trailor back driveway under construction
22	3/17/2004	3.18	1285	5.6	140	20	33.6	Trib to S., dst. #21, flow under RR tracks
23	3/19/2004	3.69	1251	6	140	10	16.8	S. side of Burley Run, dst. of Twp rd. 442 (cow pasture)
24	3/19/2004	3.08	1312	6.9	220	20	52.8	S. side of Burley Run, dst. #23, across from intersection (S.) with TR 167 and TR 442
25	5/26/2004	0.00	0.00	0.00	0.00	NA	NA	Burley run dst. 20, 21, 22
26	5/26/2004	0	0	0	0	NA	NA	Lewis hollow dst. 10, 11, 12,
27	5/3/2004	0.00	0.00	0.00	0.00	NA	NA	upwelling of water -Jen check notes
28	5/3/2004	3.36	1135.00	13.90	140.00	NA	NA	west tip of horseshoe strip pit
29	5/3/2004	3.60	0.00	0.00	0.00	NA	NA	drainage through spoil from pits, jen check notes for parameters
30	5/3/2004	4.13	612.00	11.50	60.00	NA	NA	backwater from horseshoe strip pit
31	5/3/2004	3.33	1028.00	16.90	80.00	NA	NA	Strip pit drains to main drainage over beaver dam
32	5/3/2004	4.58	738.00	16.10	80.00	NA	NA	strip pit water
33	5/4/2004	3.21	1769.00	17.30	300.00	NA	NA	barren spoil, lots of erosion
34	5/4/2004	3.13	1141.00	19.10	160.00	NA	NA	drainage from strip pit , highwall visible
35	5/4/2004	3.26	1491.00	16.80	220.00	NA	NA	mainstem Lewsi Hollow trib dst. #13
36	5/11/2004	2.62	928.00	19.20	160.00	NA	NA	Diffuse water through spoil
37	5/11/2004	2.43	1488.00	20.60	300.00	NA	NA	discharge lots of bad water
38	5/11/2004	5.51	1166.00	17.50	200.00	NA	NA	near Mt. Horeb cem.
39	5/11/2004	2.80	1069.00	19.60	240.00	NA	NA	Strip pit, exposed gob
40	5/11/2004	3.63	1859.00	23.40	0.00	NA	NA	series of strip pits, highwalls, ots of water
41	5/11/2004	6.26	1348.00	26.40	0.00	NA	NA	pond near open field
42	5/11/2004	6.21	1395.00	16.30	40.00	NA	NA	culvert under ridge/old railroad bed
43	5/11/2004	2.86	968.00	16.00	0.00	NA	NA	small diffuse flow through spoil
44	5/11/2004	2.77	1240.00	19.70	180.00	NA	NA	Strip pit, diffuse water
45	5/11/2004	2.65	2141.00	19.40	0.00	NA	NA	strip pit, through Ginseng Hollow
46	3/11/2005	3.40	1470.00	3.40	NA	NA	NA	shallow strip pit, highwall on south side
47	3/11/2005	3.45	936.00	5.00	NA	NA	NA	very shallow strip pit, highwall on west side
48	3/11/2005	3.10	1280.00	5.80	NA	NA	NA	deep strip pit ~ 5 ft.
49	3/11/2005	2.90	1452.00	6.10	NA	NA	NA	shallow strip pit, near oil access road

Appendix C: Riders Run

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	3/19/2004	6.7	5.8	388	20	NA		upst. mouth, Cannonville Rd. (CR 7) bridge crossing, @ Hall st.
2	3/19/2004	6.48	5.4	406	NA	20		at mouth near old RR bridge, off of Graybill Rd., near old prison
3	3/19/2004	6.5	5.9	253	20	NA		Elk Run upst. confluence with Rider Run
4	3/19/2004	6.5	6.2	437	40	NA		Riders Run upst. confluence with Elk Run
ER1	10/11/2004	6.3	380	11.3	20	trickle		Sw corner of sec 14 Headwaters Elk Run dst culvert 4', fish present
ER2	10/11/2004	6.01	241	11.3	20	5	1.2	mainstem Elk Run -across from house with chickens and dogs
ER3	10/11/2004	6.13	345	12.4		flow btwn pools		mainstem of Elk RunAllard's Timber landing, fish in pools
ER4	10/11/2004					dry		Trib from West
ER5	10/11/2004	6.18	561	13.4	20	NA		Mainstem Elk Run - at driveway culvert of new house, orange water
ER6	10/11/2004	2.84	2050	11.1	400	5	24	Small tributary drains from the East through a 24" culvert, up silt, orange water
ER7	10/11/2004	5.68	639	13.1	20	20	4.8	mainstem at bridge on Elk Run - aqua blue water - heavy sediment
ER8	10/11/2004	4.65	738	11.5	60			mouth of Elk Run upst. Conf. w/ RR - back-side of Hoofs Farm slight orange settled on bottom
RR1	10/11/2004	4	919	11.7	80			confluence of Elk and Rider's Run
RR2	10/11/2004	3.72	1005	11.8	80			Riders Run upst. confluence with Elk Run
RR3	10/11/2004	6.18	709	11.3	40	8	3.84	Mine # mm-278 tributary from East Toth Reclamation
RR4	10/11/2004	3.18	2760	15.8	400	5	24	Old tipple site MM-170 Bryan property
RR5	10/11/2004	3.38	1085	13.8	140	5	8.4	MM-191 at culvert on Athens Rd.
RR6	10/11/2004	5.88	282	14.3	20			MM-206 tributary from northeast box culvert bedrock visble
RR7	10/11/2004	5.8	1290	13.1	200	10	24	Mainstem Rider's Run MM-206
RR8	10/11/2004	5.39	953	11.9	80			Mainstem RR dst #6 & #7 Dorthy Rayl property * road seepage along bank
RR9	10/11/2004	3.97	936	13.9	40	15	7.2	mainstem RR on Athens Rd @ bridge Evans property
RR10	10/11/2004	3.21	1253	14.4	180	5	10.8	trib crossing along Cannalville rd culvert filled with silt
RR11	10/11/2004	5.81	932	16.3	80	1	0.96	4 ' box culvert mainstem from north of Cannalville rd Gils Hollow
RR12	10/11/2004	4.9	850	13	40			Roseville mainstem RR at Biological sampling station
RR13	10/11/2004	4.41	841	13.4	40			mouth of Rider's Run slight orange and silt

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	2/26/04	5.01	1136	4.3	80	NA	NA	mouth of Bear Creek, SR 13 bridge
2	2/26/04	3.27	1930	6.3	NA	2	NA	small seepage south of Dennis Clay, 2nd stream crossing
3	2/26/04	6.1	317	3.7	NA	5	NA	flow on W. side of Dennis clay property, N. side of BC
4	2/26/04	4.77	1200	NA	NA	NA	NA	Bear Creek upst. site #3
5	2/26/04	6.02	769	4.8	NA	2	NA	Flow north of BC, originates from wetland in floodplain
6	2/26/04	6.08	1079	10	80	7	8.4	seepage from reclaim into pond, S. side of BC
7	2/26/04	6.06	297	5.5	NA	30	NA	Spillway from large pit lake, N. of fire hydrant
8	2/26/04	6.4	260	6.2	NA	35	NA	drainage E. of #7 off reclaim, enters small pool before BC
9	2/26/04	6.62	483	5.1	NA	15	NA	small creek beside trailer (backyard)
10	2/26/04	6.66	1600	10.4	60	20	18	seepage on S. bank of BC, just dst. of storage facility
11	2/26/04	4.09	1273	5.8	80	NA	NA	Bear Creek upst. #10, dst. storage facility road
12	2/26/04	6.48	1640	10.4	60	NA	NA	same source as #10, 100 yds from east of culvert
13	2/26/04	3.88	1261	7.1	80	NA	NA	Fairly large trib N. side of BC, dst. old church with green roof on steeple
14	2/26/04	5.55	463	5	NA	5	NA	N. of BC, wetland discharge behind 1st home W. of church
15	2/26/04	3.32	589	6.8	100	30	45	wetland area in floodplain N. side of BC
16	2/26/04	6.02	2178	11.2	180	30	81	seepage from S. hillside, 10 yds upst. #15
17	2/26/04	3.3	770	11.2	160	40	96	E. of TR 312, drains reclaim through 18" culvert under Hwy
18	3/3/04	3.9	1999	10.5	240	20	72	AMD seep in Jamestown Rd. ditch (E. ditch) on s. side of BC.
19	3/3/04	2.99	2970	7.9	400	5	30	series of 5-6 seepage points on S. hillside, channel before beaver dam dst.
20	3/3/04	4.63	3389	11.6	400	2	12	dst. #19, seepage from S. bank, flows into same channel as #19
21	3/3/04	3.7	1050	8.5	120	NA	NA	Bear Creek dst. #19 and 2nd beaver dam
22	3/3/04	5.28	2686	12.8	400	20	120	seepage from S. hillside, pvc pipes present from old attempt to measure Q
23	3/3/04	4.7	1430	8.3	120	NA	NA	large beaver pond, outflow is likely seepage through spoil bank
24	3/3/04	5.61	1580	12	120	20	36	AMD seep
25	3/3/04	4.14	490	10.2	40	100	60	discharge from culvert under SR. 93-37-13; SW of house @ 9730 address
26	3/3/04	3.77	1406	8.5	80	100	120	culvert under SR. 93-37-13, drainage from pit north of road
27	3/3/04	3.08	1412	11.9	180	5	13.5	collection of seeps going under culvert SR 93-37-13, box culvert with backwater (PER-13-1588)
28	3/3/04	3	1178	12.9	120	5	9	road ditch N. side of SR, dropos into coll. Basin w/metal grate
29	3/3/04	3.3	1710	12.1	240	100	360	drainage N. side of SR, 6X6 box culvert
30	3/3/04	3.84	1076	11.6	100	30	45	sample S. of road, 12X6 box culvert (PER-13-1632)
31	3/3/04	6	697	8.3	20	NA	NA	Bear Creek upst. of #30 discharge
32	3/3/04	4.87	710	9.9	60	2	1.8	Culvert under SR between Jamestown Rd. and TR 231
33	3/3/04	6.27	1095	7.2	NA	30	NA	drainage along east side of TR 231, S. side of Bear Creek
34	3/3/04	6.6	322	7.3	NA	NA	NA	Bear Creek upst. of culvert under TR 231
35	3/3/04	5.9	3680	9.1	20	NA	NA	drainage W. side of Jamestown Rd, drainage AMD area to the south
36	6/8/2004	5.92	430.00	21.90	0.00			good water quality strip pond, lots of fish
37	6/8/2004	5.00	685.00	13.70	260.00	30		pipe - artisian flow from deep mine PY-299
38	6/8/2004	0.00	0.00	0.00	0.00			mainstem
39	6/2/2004	5.60	280.00	22.30	40.00		0	Water from good strip pond runs across old spoil
52	6/2/2004	2.93	2097.00	22.90	340.00		0	Seepage through spoil
41	6/2/2004	3.55	795.00	22.00	60.00		0	Flow from strip pit
42	6/2/2004	3.43	834.00	21.60	80.00		0	Flow from strip pit color turing orange
43	6/2/2004	3.83	913.00	22.30	0.00		0	Flow from west before entering strip pit, to the north wetland areae
44	6/2/2004	3.39	1430.00	22.10	100.00		0	Flow from strip pit, highwall to north east

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
45	6/2/2004	5.70	124.00	28.00	10.00		0	Strip pit water on Eli Sumner's property
46	6/2/2004	3.76	424.00	23.30	0.00		0	Marshy wet area on Eli Sumner's property
47	6/2/2004	5.79	260.00	22.30	40.00		0	Headwaters - water flowing from series of ponds and beaver dams
48	6/9/2004	3.46	568.00	16.80	0.00		0	Bruce's property trib - mainstem
49	6/9/2004	6.06	120.00	18.20	30.00		0	Bruce's property trib - mainstem near color change
50	6/9/2004	5.96	97.00	18.90	0.00		0	Bruce's property trib - mainstem near color change
51	6/9/2004	6.21	99.00	18.80	10.00		0	Bruce's property trib headwaters
53	3/8/2005	3.66	855.00	4.80	40.00			strip pit water east side of BR-13, near mouth
54	3/8/2005	3.89	1219.00	4.40	60.00	100.00	72	discharge to mainstem of BR-13 from east side strip pit
55	3/8/2005	4.57	925.00	2.80	40.00			strip pit on east side of BR-13
56	3/8/2005	5.83	518.00	3.60	NA			previously flooded strip pit bottom, now a stream flows thorugh bottom at base of highwall
57	3/8/2005	6.45	147.00	3.60	20.00			Natural ground upst of strip pit trib to from the west
58	3/8/2005	6.40	139.00	3.10	20.00			Natural ground upst of strip pit trib to from the east
59	3/8/2005	2.97	1184.00	6.10	160.00			headwaters of west side strip pit, possible deep mine feed warmer temperature
60	3/8/2005	3.00	1715.00	5.60	120.00			Mouth of upper trib on the west side, seepage through spoil (natural drainage pattern was dry)
61	3/8/2005	2.95	1085.00	4.80	120.00	75.00	108.00	discharge to mainstem of BR-13 from west side strip pit
62	3/8/2005	6.09	2210.00	6.09	NA	30.00		seepage from ground at base of east side strip pits, near mouth of BR-13 west of yellow house
13	3/8/2005	3.65	1430.00	3.65	80.00			mouth of BR-13 at bridge on ST RT 93

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
1	3/5/2004	3.45	972	10	100	NA	NA	Mouth of McLuney Creek at SR 97
2	3/5/2004	3.1	891	10.1	220	30	79.2	1st culvert under TH rd, past RR crossing, sample S. of tracks
3	3/5/2004	3.54	526	10.5	80	100	96	1st trib N. of TR 448
4	3/5/2004	2.91	1278	12.5	260	20	62.4	Small drainage w/ culvert under CR 48, 1st culvert W. of TH rd
5	3/5/2004	2.51	1277	12.5	320	35	134.4	drainage from N., next culvert to W. of #4, next to junky yard, deep mine discharge (landowner)
6	3/5/2004	3.18	1419	12.8	200	200	480	large drainage from N., twin 48" culverts, next to old mine road heading N. (reclaim?), next to brick house
7	3/5/2004	4.11	1058	13.1	60	10	7.2	1st culvert W. of #6 trib, metal culvert, source is hillside to N. of road, flows into wetland S. of road
8	3/5/2004	3.28	1241	13	120	3	4.32	W. of small coal mining operation (#5 coal), culvert under road, flows into wetland S. of road
9	3/5/2004	3.5	1070	12.5	80	NA	NA	mainstem McLuney Creek, dst. large wetland and #8, busted culver on 4-wheeler path
10	3/5/2004	3.8	1357	12.2	80	12	11.52	upst. #8, next culvert under CR 48, flows into wetland S. road, highwall to N.
11	3/5/2004	5.06	500	13.3	60	4	2.88	Culvert under CR 48, flow from N. is from hillside recently clear cut
12	3/5/2004	4.89	652	12.2	40	40	19.2	S. side of McL. Creek, pond discharge in large hollow that enters upst. road crossing (flow = two discharge points)
13	3/5/2004	3.72	1045	12.9	60	NA	NA	McL Creek @ road crossing, upst. of culvert & site #12
14	3/5/2004	2.89	1690	13.2	260	60	187.2	upst. #13, source is wetland on N. side of road, 300' W. of power lines (large hollow unreclaimed)
15	3/5/2004	NA	NA	NA	NA	NA	NA	Large pit in hollow of #14 source (GPS only)
16	3/5/2004	2.94	1707	17	300	100	360	large culvert to W. (200 yds) of #15 but same source, flows into large wetland
17	3/5/2004	5.49	962	15.1	40	NA	NA	McL Creek @ #8 hollow rd bridge, wetland on both sides (Clayton twp)
18	3/5/2004	3.61	1347	17	140	30	50.4	New culvert undre CR 48, @ intersection of CR 48 and #8 hollow rd., upst. #17
19	3/5/2004	3.6	1370	13.5	60	30	21.6	Upst. #18, hollow next to only trailor, 36" concrete culvert, flows into wetland area
20	3/5/2004	3.37	1332	15.2	140	250	420	Intersection of Twp Rd 162A and CR 48, culvert draining valley to N.
21	3/5/2004	6.7	870	13.9	20	NA	NA	McL. Creek upst. #20, across floodplain, lot's of sediment/sand in stream
22	3/5/2004	6.36	481	16.2	NA	40	NA	1st trib W. of #20, W. of exposed sandstone face, culvert under CR 84, hollow to N.
23	3/9/2004	6.8	233	7.1	NA	15	NA	Tunnel Hill trib (unnamed) 1st culvert under TH rd from W., draining S.
24	3/9/2004	3.66	1617	8.2	80	90	86.4	Tunnel Hill trib dst. of diffuse seepage from spoil in floodplain, dst. of #23
25	3/9/2004	3	931	7	100	2	2.4	seepage from N. side of creek in floodplain, source is S. side next to road.
26	3/9/2004	3.29	529	7.3	60	60	43.2	upst. loggging access road, trib to N., dual clay tile culverts under TH rd
27	3/9/2004	6.26	226	5.7	NA	5	NA	Trib draining hollow to S., flowing under RR tracks, flows through gob/spoil
28	3/9/2004	5.97	203	6.6	NA	15	NA	trib 200 yds E. of #27, metal culvert under RR, dst. #26 also
29	3/9/2004	3.05	799	9.1	100	10	12	Culvert under TH rd., dst. #26, visible seepage on N. side of TH rd., upst. green house
30	3/9/2004	3.37	520	7.7	60	15	10.8	culvert under TH rd., 100' dst. of green house on N. side of road, concrete culvert
31	3/9/2004	6.7	144	5.6	NA	20	NA	flow from S. drainage, RR tie structure for support on tracks to S. of site
32	3/9/2004	2.65	1064	8.3	160	15	28.8	large plastic culvert under TH rd., drains seep from W. along ditch & hollow to N. (10483 address)
33	3/9/2004	3.36	506	7.5	80	25	24	trib through large culvert under RR, flows through pasture next to log cabin house w/ red roof
34	3/9/2004	2.83	997	8.1	160	25	48	culvert under TH rd., drains from N., tree culvert before road culvert in gob, across from log cabin
35	3/9/2004	2.75	1180	7.9	240	5	14.4	small hollow to N., next to white house w/ metal attached garage, concrete culvert
36	3/9/2004	3.62	382	6.5	60	15	10.8	Hollow to S., culvert under RR next to gray house w/ wheelchair access - lions on driveway, across from #35
37	3/9/2004	2.48	2585	8.7	400	5	24	small trib from N. hillside, 100 yds from large garage to S. of road, 36" concrete culvert
38	3/9/2004	3.24	672	7.3	100	NA	NA	mouth of Tunnel Hill trib, across field from large brick house
39	3/9/2004	3.42	1310	6.2	80	NA	NA	McLuney Creek upst. Tunnel Hill trib. McL 3X flow of Tunnel Hill trib
40	3/9/2004	3.42	1165	6.8	80	NA	NA	Mouth of McLuney Creek at SR 97
41	3/11/2004	7.1	982	5.7	NA	5	NA	Shale waterfall, 1000 yds upst. of CR 48 (#8 hollow rd) on S. side of creek
42	3/11/2004	7.04	969	5.2	NA	90	NA	trib from SW upst. CR 48, flows along CR 48 after road turns SW and up hill, sample upst. wetland area @ confluence
43	3/11/2004	6.43	171	4.4	NA	NA	NA	small trib E. of CR 48 on S. side, dst. bridge
44	3/11/2004	4.49	354	3.2	NA	2	NA	small trib. Dst. of #43, really steep banks with slippage, sample upst. of logging road
45	3/11/2004	5.45	470	3.8	NA	2	NA	trib from hollow to S. of McLuney (clear cut area) approx. 100' E. of #44
46	3/11/2004	3.29	878	6	160	3	5.76	South of McL Creek, 300' W. of #12 - flow overbank
47	3/11/2004	3.78	1991	8.2	100	10	12	Trib from hollow S. of McL Creek, small drainage, S. of #11
48	3/11/2004	3.88	1746	5.4	220	3	7.92	S. of McL Creek, small trib, SE qtr of Sec. 25
49	3/11/2004	3.7	1120	7.3	100	300	360	Large drainage from S., discharge from large impoundment
50	3/11/2004	3.55	1795	5.9	NA	1	NA	Small discharge from hillside
51	3/11/2004	3.2	1442	7.1	120	20	28.8	trib S. of access road across McLuney Creek site #9 (about 400')

Site #	Date	pH	Conductivity uS/cm	Temp. ©	Acidity	Est. Flow gpm	Acid load lbs/day	Description
52	3/12/2004	3.62	1270	2	80	15	14.4	small trib w/gob pile to west, S. side of McL. Creek, dst. brick house on N. side of road
53	3/12/2004	4.47	1047	2.2	40	2	0.96	next trib. E. of #52, large drainage from S.
54	3/12/2004	3.52	1122	3.6	80	NA	NA	McLuney Creek upst. mouth @ Twp. Rd 1180 crossing
55	3/12/2004	3.05	1470	4.5	320	10	38.4	1st trib. W. of #54 (TR 1180), flows through backyard of log cabin house to N. of Creek
56	3/12/2004	3.5	890	5	120	20	28.8	trib. From S., across stream from wood-sided house w/shop to East, upst. last house on S. side
57	4/21/2004	3.14	1495.00	20.00	280.00		0	Low flow seep
58	4/21/2004	2.94	1628.00	21.70	440.00		0	strip pit backed up to a spoil pile
59	4/21/2004	3.32	816.00	15.90	160.00		0	drainage off of spoil pile
60	4/21/2004	2.94	2061.00	20.00	400.00		0	strip pit
61	4/21/2004	2.96	2016.00	20.80	380.00		0	Strip pit
62	4/21/2004	3.11	1715.00	18.00	320.00		0	edge of larger pond
63	4/21/2004	2.60	1443.00	21.50	280.00		0	drainage across fire clay north of spoil island
64	4/21/2004	3.21	1351.00	19.50	0.00		0	strip pond
65	4/21/2004	2.91	1163.00	21.60	200.00		0	drainage off spoil bank
66	4/21/2004	4.86	437.00	14.30	60.00		0	seepage through spoil bank
67	4/28/2004	3.93	358.00	9.90	40.00		0	Trib west of Treadway house
68	4/28/2004	2.99	1473.00	11.10	220.00		0	Trib to the east north of powerline
69	4/28/2004	2.97	1437.00	0.00	240.00		0	strip pit upstr of spoil
70	4/28/2004	2.70	0.00	0.00	0.00		0	
71	4/28/2004	2.66	1928.00	16.90	400.00		0	dst of strip pit with spoil
72	4/28/2004	0.00	0.00	0.00	0.00		0	fresh water with fish
73	4/28/2004	3.04	2570.00	16.20	400.00		0	delta of iron fan
74	4/28/2004	2.57	2442.00	20.20	400.00		0	
75	6/9/2004	5.15	1131.00	15.40	260.00	400	0	Large AMD discharge Mr. Rort's propoerty
76	6/9/2004	0.00	0.00	0.00	0.00		0	Strip/beaver pond, no deep mine discharge

Appendix D: Phase II high and low flow data

Appendix D: Andrews Creek High and Low Flow Merged

Site Number	RM Confluence w/ MS	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring
AC-20	24.79	Andrew	mrm93	8/23/2004	4/7/2004	3.15	3.19	1620	1350	117	123	0	0	117	123
AC-33	24.79	Andrew	mrm92	8/23/2004	4/7/2004	2.83	3.01	2710	1640	790	386	0	0	790	386
AC-36	24.79	Andrew	mrm91	8/23/2004	4/7/2004	2.77	2.74	3840	3660	1282	1427	0	0	1282	1427
AC-37	24.79	Andrew	mrm90	8/23/2004	4/7/2004	3.44	3.07	3260	3280	1341	1569	0	0	1341	1569
AC-44	24.79	Andrew	mrm85	8/23/2004	4/7/2004	3.15	3.18	2470	1950	848	631	0	0	848	631
AC-29	24.79	Andrew	mrm83	8/23/2004	4/7/2004	2.87	2.81	2940	2470	519	432	0	0	519	432
AC-45	24.79	Andrew	mrm84	8/23/2004	4/7/2004	2.96	3.07	2150	1710	390	321	0	0	390	321
AC-13	24.79	Andrew	mrm81	8/23/2004	4/7/2004	3.98	3.94	946	845	34	59.2	0	0	34	59.2
AC-46	24.79	Andrew	mrm82	8/23/2004	4/7/2004	2.93	3.1	2180	1700	386	327	0	0	386	327
AC-32	24.79	Andrew	mrm021	8/23/2004	4/7/2004	3.75	3.51	2210	2280	810	946	0	0	0	946
AC-31	24.79	Andrew	mrm022	8/23/2004	4/7/2004	3.79	3.44	2950	629	1559	112	0	0	0	112
AC-30	24.79	Andrew	mrm023	8/23/2004	4/7/2004	3.46	3.2	2400	2090	718	548	0	0	0	548
AC-24	24.79	Andrew	mrm024	8/23/2004	4/7/2004	2.97	3.27	2080	2530	331	901	0	0	0	901
AC-01	24.79	Andrew	mrm94	8/23/2004	4/7/2004	2.97	3.15	2080	1620	331	252	0	0	331	252

Site Number	ACID LOADING lbs/day fall	ACID LOADING lbs/day spring	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fall	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall
AC-20	1192.9	3830.6	805	678	11.3	17	5.74	5.34	12	10.5	296.09	1022.74	1170	984	4
AC-33	1662.7	3436.0	1655	897	206	104	50.6	22	19.9	9.46	581.94	1205.80	2540	1290	36
AC-36	307.7	NA	2865	2832	208	222	123	124	38.8	37.6	88.75	NA	4120	4030	23
AC-37	517.4	3046.8	2486	2445	528	576	73.6	82.1	24.8	18.3	241.67	1313.47	3860	3740	19
AC-44	1832.0	3797.5	1605	1202	377	261	31.3	24.7	13.2	9.4	910.59	1776.00	2460	1810	21
AC-29	889.0	1066.6	1786	1457	152	97.6	18.6	17.7	24	20.7	333.33	335.77	2520	2040	16
AC-45	7953.8	15427.1	1218	938	86.7	85.1	22.4	16.8	16.2	11.9	2555.43	5469.17	1790	1350	8
AC-13	120.9	97.3	477	403	2.29	1	3.09	6.57	5.29	4.13	37.93	19.23	677	580	7
AC-46	7119.5	17108.7	1259	963	89.1	81.6	21.6	16.3	16.7	11.9	2349.80	5744.75	1820	1400	7
AC-32	32.20	215.01	1457	1581	456	455	12.5	19.8	11.2	10.8	132.023	110.3708	2340	2490	17
AC-31	227.52	200.06	2321	254	667	31.9	85.8	4.56	15.3	1.94	221.2128	68.59215	3610	386	15
AC-30	291.37	244.09	1531	1243	364	244	13.8	10.6	13.2	8.72	88.86648	117.2877	2360	1900	22
AC-24	26068.72	NA	1136	1696	60	394	17.9	22.4	14.2	15.4	1790.402	NA	1660	2620	12
AC-01	6434.6	16194.8	1136	864	60	59.4	17.9	14	14.2	10.1	1790.40	5366.13	1660	1250	12

Site Number	Total Suspended Solids spring	Flowrate CFS fall	Flowrate CFS spring	GPM fall	GPM spring	Site Number
AC-20	8	1.893	5.782	849.66	2595.258	AC-20
AC-33	19	0.391	1.653	175.39	741.7939	AC-33
AC-36	18	0.0446	NA	20.00	NA	AC-36
AC-37	16	0.0716	0.361	32.15	161.8212	AC-37
AC-44	25	0.401	1.117	180.03	501.5249	AC-44
AC-29	15	0.318	0.458	142.74	205.7414	AC-29
AC-45	11	3.787	8.923	1699.54	4004.955	AC-45
AC-13	5	0.66	0.305	296.23	136.9672	AC-13
AC-46	27	3.425	9.714	1537.02	4360.013	AC-46
AC-32	15	0.0511	0.0422	22.94	18.94063	AC-32
AC-31	43	0.0535	0.33165	24.00	148.8545	AC-31
AC-30	11	0.0422	0.0827	18.94	37.11824	AC-30
AC-24	18	3.609	NA	1619.98	NA	AC-24
AC-01	15	3.609	11.932	1619.98	5355.414	AC-01

Appendix D: Bear Run High and Low Flow Merged

Site Number	RM Confluence w/ MS	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring	ACID LOADING lbs/day fall	ACID LOADING lbs/day spring
BR-34	21.95	Bear	mrm115	9/1/2004	6/8/2004	6.19	6.54	1800	906	41	8.1	26.9	33.5	14.1	-25.4	3.03	-38.00
BR-18	21.95	Bear	mrm117	9/1/2004	6/8/2004	4.23	4.17	2030	2160	271	292	0	0	271	292	24.72	43.80
BR-36	21.95	Bear	mrm116	9/1/2004	6/8/2004	6.58	6.63	471	418	3.26	7.23	14.6	17.7	-11.34	-10.47	0.00	NA
BR-30	21.95	Bear	mrm114	9/1/2004	6/8/2004	3.19	3.48	1740	1630	159	135	0	0	159	135	116.89	178.49
BR-29	21.95	Bear	mrm113	9/1/2004	6/8/2004	2.93	3.19	1620	1760	197	216	0	0	197	216	179.45	230.74
BR-22	21.95	Bear	mrm112	9/1/2004	6/8/2004	5.16	5.37	2900	2730	400	378	15	11.3	385	366.7	34.65	132.01
BR-26	21.95	Bear	mrm111	9/1/2004	6/8/2004	2.99	3.46	2450	1810	165	94.3	0	0	165	94.3	55.92	174.78
BR-25	21.95	Bear	mrm109	9/1/2004	6/8/2004	3.05	3.77	964	660	92.1	30.4	0	0	92.1	30.4	58.03	48.73
BR-37	21.95	Bear	mrm110	9/1/2004	6/8/2004	4.24	4.87	774	679	150	88.5	0	4.03	150	84.47	16.88	9.53
BR-38	21.95	Bear	mrm108	9/1/2004	6/8/2004	2.92	3.42	1870	1550	168	104	0	0	168	104	1046.87	1372.15
BR-17	21.95	Bear	mrm107	9/1/2004	6/8/2004	2.74	3.35	1050	703	196	107	0	0	196	107	0.59	12.07
BR-15	21.95	Bear	mrm105	9/1/2004	6/8/2004	2.82	3.23	906	739	159	112	0	0	159	112	102.08	58.78
BR-16	21.95	Bear	mrm106	9/1/2004	6/8/2004	5.98	6	1930	2170	86.4	112	107	113	-20.6	-1	-6.49	-0.43
BR-01	21.95	Bear	mrm104	9/1/2004	6/8/2004	3.19	3.54	1800	1480	103	77.3	0	0	103	77.3	565.27	4092.94
BR-40	21.95	Bear	mrm132	11/1/2004	NA	3.52	NA	1630	NA	111	NA	0	NA	111	NA	1091.66	NA
BR-13	21.95	Bear	mrm133	11/1/2004	NA	3.61	NA	1950	NA	122	NA	0	NA	122	NA	375.85	NA
BR-01	21.95	Bear	mrm131	11/1/2004	NA	3.80	NA	1540	nA	74.9	NA	0	nA	74.9	NA	1263.88	NA

Site Number	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fal	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall	Total Suspended Solids spring	Flowrate CFS fall	Flowrate CFS spring	GPM fall
BR-34	1021	384	17.1	6.02	0.451	1.2	20.4	5.64	8.17	19.24	1560	641	21	25	0.04	0.28	17.94
BR-18	1284	1441	97.7	103	8.89	16.4	14.9	18.9	11.08	20.75	1960	2140	13	18	0.02	0.03	7.60
BR-36	144	119	0.065	<.05	<0.25	<0.25	0.173	0.574	NA	NA	284	262	5	8		NA	NA
BR-30	1013	881	29.1	23.9	6.5	7.27	18.9	16	40.06	62.36	1510	1310	13	16	0.14	0.25	61.26
BR-29	823	955	60.1	74	2.22	4.26	17.4	20	72.62	104.97	1190	1370	8	8	0.17	0.20	75.91
BR-22	1976	1836	238	203	1.89	1.73	30.1	29.7	24.30	84.39	2990	2810	15	20	0.02	0.06	7.50
BR-26	1548	1037	12.6	5.45	3.52	5.41	30.6	16.8	15.83	51.27	2200	1480	9	13	0.06	0.34	28.24
BR-25	443	277	13.3	4.25	3.32	1.28	9.15	5.18	16.24	17.17	658	438	11	9	0.12	0.30	52.51
BR-37	403	3.27	59.5	40.6	6.82	3.51	4.38	4.36	7.95	5.47	643	529	3	9	0.02	0.02	9.38
BR-38	1087	820	18.7	16.4	6.5	4.7	21	14.6	287.89	471.02	1570	1190	12	5	1.16	2.45	519.28
BR-17	429	287	26.9	21.2	11.7	6.25	3.18	2.54	0.13	3.38	610	406	6	12	0.00	0.02	0.25
BR-15	392	288	23.3	18.2	10.4	7.69	3.38	2.63	23.81	14.97	557	430	3	5	0.12	0.10	53.50
BR-16	1095	1284	23.5	25.9	0.24	0.24	16.3	18.5	NA	NA	1660	1950	18	9	0.05	0.08	26.25
BR-01	1029	804	6.7	6.46	4.99	4.37	18.7	13	166.78	1261.77	1520	1180	13	17	1.02	9.83	457.34
BR-40	980	NA	17.2	NA	5.39	NA	16.1	NA	380.51	NA	1310	NA	10.00	NA	1.83	NA	819.56
BR-13	1210	NA	17.2	NA	6.33	NA	21.3	NA	138.11	NA	1750	NA	16.00	NA	0.57	NA	256.73
BR-01	881	NA	8.06	NA	4.17	NA	15.6	NA	469.61	NA	1250	NA	10.00	NA	3.13	NA	1406.18

Site Number	GPM spring	Site Number
BR-34	124.67	BR-34
BR-18	12.50	BR-18
BR-36	NA	BR-36
BR-30	110.18	BR-30
BR-29	89.02	BR-29
BR-22	30.00	BR-22
BR-26	154.45	BR-26
BR-25	133.57	BR-25
BR-37	9.40	BR-37
BR-38	1099.48	BR-38
BR-17	9.40	BR-17
BR-15	43.74	BR-15
BR-16	36.00	BR-16
BR-01	4412.39	BR-01
BR-40	NA	BR-40
BR-13	NA	BR-13
BR-01	NA	BR-01

Appendix D: McLuney Creek High and Low Flow Merged

Site Number	M Confluence w/ N	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring	ACID LOADING lbs/day fall
ML-21	18.4	McLuney	mrm126	9/27/2004	5/25/2004	6.94	7.03	1010	1030	3.14	3.76	42.2	43.1	-39.06	-39.34	-197.80
ML-Upst.Rort seep	18.4	McLuney	mrm127	9/27/2004	6/16/2004	3.09	3.22	1910	1580	179	77.2	0	0	179	77.2	477.89
ML-Rort Seep	18.4	McLuney	mrm128	9/27/2004	6/16/2004	4.19	4.93	1650	1430	86.0	78.5	0	8.35	86	70.15	226.90
ML-20	18.4	McLuney	mrm125	9/27/2004	5/25/2004	3.38	3.47	1720	1630	106	83.9	0	0	106	83.9	680.52
ML-16	18.4	McLuney	mrm124	9/27/2004	5/25/2004	3.03	3.03	2030	1990	223	225	0	0	223	225	916.26
ML-14	18.4	McLuney	mrm123	9/27/2004	5/25/2004	2.96	3.04	2040	2010	225	224	0	0	225	224	323.73
ML-13	18.4	McLuney	mrm122	9/27/2004	5/25/2004	3.73	4.98	1360	1340	43.4	40.4	0	0	43.4	40.4	977.77
ML-49	18.4	McLuney	mrm129	9/27/2004	5/25/2004	3.49	3.62	1260	1350	85.9	99.3	0	0	85.9	99.3	162.07
ML-06	18.4	McLuney	mrm121	9/27/2004	5/25/2004	3.14	3.23	1880	1830	200	166	0	0	200	166	856.80
ML-39	18.4	McLuney	mrm120	9/27/2004	5/25/2004	3.49	3.49	1400	1330	67.9	66.6	0	0	67.9	66.6	2220.57
ML-38	18.4	McLuney	mrm119	9/27/2004	5/25/2004	3.10	3.41	911	641	148	68.6	0	0	148	68.6	516.28
ML-01	18.4	McLuney	mrm118	9/27/2004	5/25/2004	3.43	3.48	1310	1220	71.9	68.4	0	0	71.9	68.4	2956.66

Site Number	ACID LOADING lbs/day spring	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fall	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall	Total Suspended Solids spring	Flowrate CFS fall
ML-21	-348.03	508	503	0.659	0.789	0	0.249	1.39	1.09	10.4	18.8	778	773	14.0	5	0.94
ML-Upst.Rort seep	421.36	1062	848	23.1	17.4	12.7	8.03	6.5	4.9	112.9	165.5	1530	1220	13.0	2	0.50
ML-Rort Seep	286.55	980	809	41.8	38.5	1.05	1.06	3.99	3.27	123.6	175.0	1430	1210	13.0	<2	0.49
ML-20	811.19	972	889	23.4	18.3	6.22	4.79	4.76	4.03	220.7	262.2	1380	1300	30.0	20	1.19
ML-16	542.78	1169	1103	25.6	25.1	17.5	17.4	13.4	12.2	232.1	132.0	1680	1580	13.0	<2	0.76
ML-14	746.58	1144	1103	20.7	22.9	18	17.4	12.8	12.5	74.1	176.0	1640	1530	12.0	7	0.27
ML-13	815.53	745	711	5.98	2.82	3.47	2.87	5.69	4.98	341.1	215.4	1080	1040	17.0	7	4.18
ML-49	552.68	685	731	1.83	1.63	8.51	9.9	12.7	14.1	43.5	142.6	1010	1060	10.0	5	0.35
ML-06	924.66	1111	1045	11.7	7.64	22.4	18.2	12.4	11.4	199.2	207.4	1600	1460	7.00	3	0.80
ML-39	3605.68	792	733	3.44	2.69	6.64	5.81	7.45	6.95	573.3	836.5	1140	1030	5.00	3	6.07
ML-38	640.25	398	226	13.7	6.42	14.5	6.1	1.76	0.979	104.5	126.0	611	350	5.00	<2	0.65
ML-01	5168.15	704	611	3.54	3.14	7.39	6.13	6.47	5.42	715.5	1109.9	1020	903	9.00	<2	7.64

Site Number	Flowrate CFS spring	GPM fall	GPM spring	Site Number	
ML-21	1.64	422.00	737.23	ML-21	
ML-Upst.Rort seep	1.01	222.48	454.84	ML-Upst.Rort seep	
ML-Rort Seep	0.76	219.86	340.40	ML-Rort Seep	
ML-20	1.80	535.00	805.71	ML-20	
ML-16	0.45	342.40	201.03	ML-16	
ML-14	0.62	119.90	277.75	ML-14	
ML-13	3.75	1877.44	1682.21	ML-13	
ML-49	1.03	157.23	463.81	ML-49	
ML-06	1.03	357.00	464.19	ML-06	
ML-39	10.05	2725.30	4511.61	ML-39	
ML-38	1.73	290.70	777.76	ML-38	
ML-01	14.03	3426.82	6296.48	ML-01	

Appendix D: Snake Run High and Low Flow Merged

Site Number	RM Confluence w/ MS	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring	ACID LOADING lbs/day fall
SN- Headwaters	15.9	Snake	mrm103	8/25/2004	5/5/2004	3.41	5.93	973	174	162	13.1	0	27.8	162	-14.7	2.62
SN- source	15.9	Snake	mrm101	8/25/2004	5/5/2004	3.4	3.32	1180	829	148	136	0	0	148	136	2.22
SN- mouth	15.9	Snake	mrm100	8/25/2004	5/5/2004	3.17	3.05	1270	806	133	106	0	0	133	106	153.22

Site Number	ACID LOADING lbs/day spring	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fall	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall	Total Suspended Solids spring	Flowrate CFS fall
SN- Headwaters	-3.00	491	51.9	35.8	0.982	12.1	0.506	3.97	0.085	0.84	0.32	769	120	2	6	0.0030
SN- source	486.42	566	451	52.9	39.4	6.02	6.88	3.05	2.66	0.93	175.04	896	717	12	3	0.0022
SN- mouth	704.54	616	387	13.6	12.2	10.2	7.38	3.65	2.14	31.62	144.36	938	591	14	6	0.2140

Site Number	Flowrate CFS spring	GPM fall	GPM spring	Site Number
SN- Headwaters	0.03786	1.35	16.99	SN- Headwaters
SN- source	0.664	1.25	298.05	SN- source
SN- mouth	1.234	96	553.88	SN- mouth

Appendix D: Burley Run High and Low Flow Merged

Site Number	RM Confluence w/ MS	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring	ACID LOADING lbs/day fall
BU-25	15.4	Burly	mrm40	NA	5/26/2004	NA	3.42	NA	1180	NA	83.2	NA	0	NA	83.2	NA
BU-19	15.4	Burly	mrm77	8/16/2004	NA	6.53	NA	806	NA	18.9	NA	41.6	NA	-22.7	NA	-0.94
BU-24	15.4	Burly	mrm79	8/16/2004	5/26/2004	3.04	3.13	1750	1480	223	199	0	0	223	199	68.45
BU-3	15.4	Burly	mrm78	8/16/2004	5/26/2004	3.42	4.24	1260	880	95.3	43	0	0	95.3	43	339.32
BU-26	15.4	Burly	mrm80	8/16/2004	5/26/2004	3.22	3.29	1630	1540	179	161	0	0	179	161	422.81
BU-4	15.4	Burly	mrm76	8/16/2004	5/26/2004	3.18	3.29	1570	1430	176	152	0	0	176	152	482.23
BU-1	15.4	Burly	mrm75	8/16/2004	5/26/2004	3.42	3.8	1380	1080	121	75.8	0	0	121	75.8	504.98

Site Number	ACID LOADING lbs/day spring	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fall	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall	Total Suspended Solids spring	Flowrate CFS fall
BU-25	603.06	NA	589	NA	2.95	NA	7.17	NA	6.2	NA	118.29	NA	885	NA	5	NA
BU-19	NA	286	NA	0.267	NA	0.24	NA	4.02	NA	0.19	NA	515	NA	8	NA	0.01
BU-24	202.43	996	755	5.14	4.82	29	23.1	13.1	9.37	14.50	37.93	1410	1140	3	6	0.06
BU-3	515.80	674	452	1.9	0.975	9.75	5.96	7.97	4.83	69.86	141.13	959	678	<2	6	0.66
BU-26	1350.89	955	840	3.1	3.7	17.8	18.1	13.4	12	81.02	283.60	1350	1260	<2	9	0.44
BU-4	1651.65	914	769	3.32	3.94	18.8	17.5	13.7	11.5	98.15	357.93	1260	1150	<2	7	0.51
BU-1	1678.47	749	549	2.72	1.9	13.3	10.2	10.3	6.91	109.84	420.95	1080	835	2	9	0.78

Site Number	Flowrate CFS spring	GPM fall	GPM spring	Site Number
BU-25	1.35	NA	604.03	BU-25
BU-19	NA	3.46		BU-19
BU-24	0.02	25.58	84.77	BU-24
BU-3	2.23	296.71	999.611	BU-3
BU-26	1.56	196.84	699.22	BU-26
BU-4	2.02	228.33	905.51	BU-4
BU-1	4.11	347.78	1845.282	BU-1

Appendix D: Riders Run High and Low Flow Merged

Site Number	M Confluence w/ M	basin	Sample Number	Date fall	Date spring	pH fall	pH spring	cond fall	cond spring	acidity fall	acidity spring	alkalinity fall	alkalinity spring	net acidity fall	net acidity spring	ACID LOADING lbs/day fall	ACID LOADING lbs/day spring
RR-4	10.85	Riders Run	mrm134	11/1/2004	NA	4.27	NA	1820	NA	391	NA	0	NA	391	NA	69.50	NA
RR-5	10.85	Riders Run	mrm135	11/1/2004	NA	4.91	NA	535	NA	40.3	NA	1.47	NA	38.83	NA	32.63	NA
RR-2	10.85	Riders Run	mrm140	11/1/2004	NA	4.93	NA	732	NA	49.1	NA	1.54	NA	47.56	NA	309.95	NA
RR-15	10.85	Riders Run	mrm136	11/1/2004	NA	3.08	NA	1270	NA	322	NA	0	NA	322	NA	21.74	NA
RR-16	10.85	Riders Run	mrm137	11/1/2004	NA	2.75	NA	1660	NA	312	NA	0	NA	312	NA	28.08	NA
RR-10	10.85	Riders Run	mrm138	11/1/2004	NA	3.37	NA	1120	NA	118	NA	0	NA	118	NA	109.95	NA
RR-13	10.85	Riders Run	mrm139	11/1/2004	NA	5.94	NA	678	NA	26.5	NA	7.29	NA	19.21	NA	273.04	NA

Site Number	sulfate fall	sulfate spring	IRON fall	IRON spring	ALUMINUM fall	ALUMINUM spring	MANGANESE fall	MANGANESE spring	METALS LOADING lbs/day fall	METALS LOADING lbs/day spring	Total Dissolved Solids fall	Total Dissolved Solids spring	Total Suspended Solids fall	Total Suspended Solids spring	Flowrate CFS fall	Flowrate CFS spring	GPM fall
RR-4	1111	NA	196	NA	14.8	NA	4.24	NA	38.22	NA	1680	NA	33.00	NA	0.03	NA	14.81
RR-5	223	NA	7.91	NA	2.97	NA	2.24	NA	11.02	NA	368	NA	12.00	NA	0.16	NA	70.02
RR-2	358	NA	11.8	NA	3.64	NA	2.28	NA	115.48	NA	524	NA	20.00	NA	1.21	NA	543.08
RR-15	683	NA	63.1	NA	26	NA	2.39	NA	6.18	NA	967	NA	5.00	NA	0.01	NA	5.63
RR-16	662	NA	7.06	NA	28.8	NA	2.64	NA	3.47	NA	1000	NA	4.00	NA	0.02	NA	7.50
RR-10	556	NA	6.41	NA	12	NA	3.03	NA	19.98	NA	771	NA	5.00	NA	0.17	NA	77.65
RR-13	313	NA	6.34	NA	1.64	NA	1.96	NA	141.28	NA	465	NA	9.00	NA	2.64	NA	1184.46

Site Number	GPM spring	Site Number
RR-4	NA	RR-4
RR-5	NA	RR-5
RR-2	NA	RR-2
RR-15	NA	RR-15
RR-16	NA	RR-16
RR-10	NA	RR-10
RR-13	NA	RR-13

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Appendix E: Photographs Moxahala sites

Appendix E – Moxahala Photos

Black Fork

BF-10 The Whitehouse seep at its source

BF-10 The Whitehouse seep clearing

DR-2 upstream from Rosefarm road

DR-3 lower stream 1.5 ft deep 7 ft wide

DR-3 right confluence with other run left, entering lower channel

DR-3 first run from source

Misco gobpile

Misco gobpile

Misco gobpile

Andrews Reconnaissance photos

Site # 57  4/15/2004 Strip pit with noticeable upwelling next to service road on western ridge	Site # 57  4/15/2004 Seep behind pump jack feeding the pool of 57	Site # 48  4/15/2004 Large standing pond north of 57. Water running off of spoil.
Site # 47  4/15/2004 Swampy area formed by poorly contoured mine land	Site # 59  4/15/2004 First of series of strip pits along western edge of hollow	Site # 59  4/15/2004 channel that connects the series of pits separated by beaver dams
Site # 58 4/15/2004 Southern most tip of the series of strip pits. Last pit in the hollow	Site #58 upst.  4/15/2004 Upstream of 58 showing the highwall on the western edge	Site upst of 31  4/15/2004 Lake with good pH and Cond. Northwest of #31

McCluney Recon

Site # 1

3/5/04 SR 93 Bridge ~300 yds upstream of confluence with Moxie Creek

Site # 2

3/5/04 5 ft. diam outlet beneath RR tracks & Tunnel Hill road

Site # 3

3/5/04 Trib. At Tunnel Hill Road bridge ~100 ft west of intersection with TR448 (~600 yds west of Tolley TV Repair

Site# 4

3/5/04 24 inch concrete culvert discharge; ~ 150 ft east of address 11027 CR48

Site # 5

3/5/04 24 inch culvert inlet along road; ~ 75 ft west of address 10759 CR 48 (Gottke prop.)

Site # 6

3/5/04 Twin 48 inch diameter culverts adjacent to property access gate at 10650 CR48 (Treadway prop.)

Site# 7

3/5/04 24 inch CMP discharge on south side of CR

Site # 8

3/5/04 12 inch PE inlet north side of CR48; discharges into main trib wetland type structure; drainage may come from #5 coal mining

Site # 9

3/5/04 Main stem McCluney at access road in SW qtr section 30; collapsed pipe system of 48 inch concrete culverts (close to Foraker/Pillsbury PL)

Site# 10

3/5/04 18 inch concrete culvert inlet along CR48; north side of road; (Foraker prop.)

Site # 11

3/5/04 18 inch culvert inlet north side CR48; backwater on discharge end; SE qtr section 25
(no picture)

Site # 12

3/5/04 1/2 of pond discharge leading to McCluney Creek along access road to Oxford Mining property.
SW qtr section 25

Site# 13

3/5/04 96 inch coated CMP inlet at access road over main stem McCluney. Same access road noted at Site #12

Site # 14

3/5/04 12 inch HDPE smooth wall inlet side on north side of CR48; ~300 yds west of KV power lines (Oxford prop)

Site # 15

3/5/04 Site is located on north side of CR48 and is aml area on #6 coal seam

McCluney Recon

Site# 16  3/5/04 16 inch coated CMP discharge on south side of CR48; North portion of SW qtr section 25 (Smith prop.)	Site # 17  3/5/04 McCluney Creek at downstream side of #8 Hollow Bridge; East side of SE qtr section 26 (Oxford prop.)	Site # 18  3/5/04 18 inch inlet along north side CR84 at intersection of CR84 & #8 Hollow Road; (Dennis prop.)
Site# 19  3/5/04 36 inch concrete culvert inlet on north side of CR84; NE qtr section 26; (Howard prop.)	Site # 20  3/5/04 60 inch concrete culvert discharge at intersection of CR84 & TR162A. Drainage from north of TR162AA; (Fister prop.)	Site # 21  3/5/04 McCluney Creek above confluence with Site #20; (Fister prop.)
Site# 22  3/5/04 24 inch concrete culvert discharge; NE qtr section 26; (Wooten & Aver prop.)	Site # 23  309-154, 155, 156	Site # 24  309-157, 159
Site# 25  309-160, 161	Site # 26  309-162	Site # 27  309-163, 164-167
Site# 28  309-168	Site # 29  169, 170	Site # 30  171, 172

McCluney Recon

Site# 31  174, 173,175,176	Site # 32  177, 178	Site # 33  179, 180
Site# 34  182, 181, 183	Site # 35  184,	Site # 36  186, 185
Site# 37  187, 188	Site # 38  189, 190	Site # 39  191, 192
Site# 40  193, 194	Site # 41  <u>3/11/04</u> Trib south side of McCluney; ~1,000 yds NW of CR48; (Fister prop)	Site # 42  <u>3/11/04</u> Trib to McCluney directly NW of CR48 bridge; notice black gasline tied up in trees crossing stream; (Oxford prop.)
Site# 43  <u>3/11/04</u> Trib directly east of CR48 on access road directly above CR48 bridge; (Oxford prop.)	Site # 44  <u>3/11/04</u> Small trib south side of McCluney along logging road; Appears to be drainage off spoil; not a natural channel; severely eroded (Oxford prop.)	Site # 45  <u>3/11/04</u> Small trib from hollow south of McCluney; ~ 100 feet east of Site #44 (Oxford prop.)

McCluney Recon

<table>
<tr>
<td>Site# 46

<u>3/11/04</u> Drainage of AML area south McCluney; ~300 feet west of Site #12 (Oxford prop.)</td>
<td>Site # 47

<u>3/11/04</u> Small drainage south of McCluney; South central section 25; South of Site #11; (Oxford prop.)</td>
<td>Site # 48

<u>3/11/04</u> Small drainage south of McCluney; SE qtr Sect 25; (Oxford prop)</td>
</tr>
<tr>
<td>Site# 49

<u>3/11/04</u> Large drainage south of McCluney; drains another large pond; Near SE qtr 25 / NE qtr 36 section line; (Oxford prop.)</td>
<td>Site # 50

<u>3/11/04</u> Drainage from AML area south of McCluney; possible #5 coal seam underground entry; SW qtr 30; (Foraker prop.)</td>
<td>Site # 51

<u>3/11/04</u> Trib south McCluney; ~ 400 feet south of Site #9 which is crossing access road over creek; (Foraker prop)</td>
</tr>
</table>

Site	52	195, 196
Site	53	197, 198
Site	54	200, 201, 199
Site	55	202, 203
Site	56	204, 205

Burley Recon

Site # 1

3/17/04 Main stem Burley in Crooksville at N.Buckeye Street bridge

Site # 2

3/17/04 24 inch CMP discharge at TR161; drainage from the north

Site # 3

3/17/04 Main stem Burley at TR161 bridge; SW corner section 17; (Ruff prop.)

Site# 4

3/17/04

Site # 5

3/17/04 Trib from south along lane to landowner Bates house(10963 TR161) NE corner section 19

Site # 6

3/17/04 North side of TR161; drainage ditch collects drainage from small trib; 12 inch CMP inlet; NE corner Section 19 (Brown prop.)

Site # 7

3/17/04 30 inch concrete culvert discharge on south side of TR161; (Love prop. / 10990 TR161)

Site # 8

3/17/04 Drainage entering steam from AML area on south side of stream; NW qtr of NE qtr section 19; (Brown prop.)

Site # 9

3/17/04

Site# 10

3/17/04

Site # 11

3/17/04

Site # 12

3/17/04

Site# 13

3/17/04

Site # 14

3/17/04

Site # 15

3/17/04

Burley Recon

Site# 16  3/17/04	Site # 17  3/17/04	Site # 18  3/17/04
Site# 19  3/17/04	Site # 20  3/17/04	Site # 21  3/17/04
Site# 22  3/17/04	Site # 23  3/19/04	Site # 24  3/19/04

Snake Run Recon

Site # 1  3/12/04 Lower end of Snake; west of SR93; along TR445 at driveway bridge to Edgell residence	Site # 2  3/12/04 Small trib north side of TR445 3 ft concrete culvert; across road from 11763 TR445	Site # 3  3/12/04 Small trib north side of TR445; Adjacent to access road to 11454 TR445
Site# 4  3/12/04 Trib on south side of Snake; Access road to 11621 TR445	Site # 5  3/12/04 Trib running alongside of TR445 as it starts upgradient; SW qtr section 20; (Yonis prop.)	Site # 6  3/12/04 Main stem Snake on north side TR445(~100 ft); (Moore prop.)
Site# 7  3/12/04 Trib on SW side of Snake; NW qtr of SW qtr section 20; (Moore prop.)	Site # 8  3/12/04 Main stem Snake; NW qtr. of qtr. Section 20; (Moore prop.)	Site # 9  3/12/04 Trib on NW side of Snake; NW qtr of SW qtr section 20

Deep mine discharge directly upstream of and on SW side of run. Along 19/20 section line. (Moore prop.)

Rider Recon

Site # 1  3/19/04 Rider Run mainstream at Cannelville Road bridge	Site # 2  3/19/04 Rider Run ~ 200 ft upstream of confluence with Moxie	Site # 3  3/19/04 Elk Run ~ 100 ft upstream of confluence with Rider Run
Site# 4  3/19/04 Rider Run ~ 50 upstream of confluence with Elk Run		

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Appendix F: Black Fork Phase I data

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Field Data Location	Date	pH	Water Description	Temp (°C)	ORP (mV)	TDS (mg/L)	Peroxide pH	Peroxide ORP
BF1	9/11/1998	6.3	Slight Orange Sed.	NA	280	NA	6.3	325
BF2	9/11/1998	5.7	Clear - Orange Sed.	NA	280	NA	5.8	370
BF3	9/11/1998	6	Clear - Orange Sed.	NA	290	NA	6.2	340
BF4	9/11/1998	2.7	Clear	NA	480	NA	2.6	495
BF5	9/12/1998	5.5	Slightly Cloudy Orange	24	220	NA	6	350
BF6	9/12/1998	6.3	Clear -w/ Fish & Algae	22	340	NA	6.4	320
BF7	9/12/1998	3.7	Clear - Orange Sed.	14	285	NA	2.6	430
BF8	9/12/1998	5.9	Slightly Cloudy Orange	20	200	NA	5.7	350
BF9	9/12/1998	2.9	Clear - Orange Sed.	24.4	400	NA	2.9	480
BF10	9/12/1998	5.6	Slightly Cloudy Orange	14	190	NA	3	480
BF11	9/12/1998	6.2	Clear - Orange Sed.	14.3	30	NA	3.2	470
BF12	9/12/1998	6.7	Clear	24.6	270	NA	6.5	295
BF13	9/11/1998	7.5	Clear	NA	270	NA	7.6	250
BF14	9/11/1998	7.3	Clear	NA	270	NA	7.2	270
BF15	9/11/1998	7.3	Clear - No Flow	NA	270	NA	7	280
BF16	9/11/1998	6.9	Clear	NA	310	NA	7.2	290
BF17	9/11/1998	7.5	Clear	NA	280	NA	7.5	270
BR1	9/12/1998	6.2	Clear - Orange Sed.	22.4	300	NA	6.7	340
BR3	9/11/1998	2.4	Clear	24.5	455	950	2.4	520
BR4	9/11/1998	2.4	Clear	26.2	455	921	2.5	480
BR5	9/11/1998	2.4	Clear - Orange Sed.	23.6	450	1000	2.5	520
BR7	9/14/1998	7.1	Clear - Slightly Muddy	26.6	180	NA	7.2	270
BR9	9/11/1998	2.6	Cloudy Orange	22.6	400	1400	2.5	520
BR11	9/11/1998	2.5	Clear	21.5	420	1260	2.5	530
BR12	9/11/1998	2.5	Clear	19.2	480	650	2.5	520
BR13	9/11/1998	6.7	Clear	14.7	430	215	7	330
BR14	9/11/1998	6.8	Clear w/ Film	11.8	320	730	7	315
BR15	9/11/1998	7.6	Clear - Stagnant	NA	285	NA	7.9	265
BR16	9/11/1998	7.2	Clear	NA	300	NA	7.6	280
DR1	9/12/1998	2.4	Clear - Orange Sed	19.9	520	NA	2.4	500
DR2	9/12/1998	2.7	Clear - Orange Sed	25	370	NA	2.5	440
DR3	9/12/1998	2.3	Clear - Orange Sed	21.2	530	NA	2.3	500
DR4	9/12/1998	2.7	Clear - Orange Sed	22.3	400	NA	2.6	500
DR5	9/12/1998	4.1	Clear - Orange Sed	12.3	300	NA	2.8	500
DR6	9/12/1998	3.8	Clear - Stagnant	19.8	380	NA	3.8	450
DR7	9/12/1998	3.1	Clear - Orange Sed	19.7	465	NA	3.1	475
DR8	9/12/1998	4.5	Clear - Stagnant	17.7	300	NA	3.7	450
DR9	9/12/1998	5.7	Clear	22.8	405	NA	6.3	340
DR10	9/12/1998	6.7	Clear	24.3	325	NA	7	300
TW1	9/12/1998	5.8	Clear	13.5	<10	NA	2.9	500
TW2	9/12/1998	5.7	Very Cloudy Orange	19.9	50	NA	2.7	520
TW3	9/12/1998	2.6	Clear - Orange Sed.	26.1	500	NA	2.6	480
OC1	9/12/1998	7.2	Slightly Cloudy Orange	22.6	290	NA	7.2	280
OC2	9/12/1998	6.9	Clear - Orange Sed.	21	320	NA	7.1	310
OC4	9/11/1998	6.6	Clear	NA	335	1230?	7.1	315
OC5	9/11/1998	3.2	Clear	NA	470	NA	3.2	470
OC6	9/11/1998	2.2	Clear - Orange Sed.	NA	520	NA	2.2	530
OC8	9/11/1998	6.4	Clear	NA	390	NA	6.8	333

Appendix G: Black Fork Phase II data

Appendix G: Black Fork Phase II Data

Site.	Sample Date	Flow cfs	Flow gpm	Lab pH	Lab Cond. uS/cm	Acidity mg/l	Alkalinity mg/l	Net acidity	Acidity Load kg/day	Acid loading lbs/day	Sulfate mg/l	Iron mg/l	Aluminum mg/l	Manganese mg/l	Metal loading lbs/day
BF 1	3/6/1999	Too High	NA	6.25	236	0	37.6	-37.6	NA	NA	90.6	4.53	5.18	0.181	NA
BF 1	4/10/1999	14.044	6303.369	6.06	605	0	32.7	-32.7	0.00	-2473.44	211	11.5	1.53	0.818	1047.47
BF 1	5/8/1999	6.357	2853.212	6.09	804	47	8.2	38.8	730.99	1327.09	499	20.7	11.7	1.97	1176.78
BF 1	6/10/1999	5.286	2372.515	5.89	971	11.3	16.6	-5.3	146.14	-150.89	339	5.01	6.26	1.64	367.55
BF 1	7/13/1999	1.831	821.808	6.52	1140	19.3	22.2	-2.9	86.46	-28.60	546	1.05	0.009	1.96	29.77
BF 1	8/24/1999	1.746	783.657	6.50	1300	0	45.9	-45.9	0.00	-431.64	733	1.75	5.3	1.66	81.91
BF 1	9/21/1999	1.101	494.099	6.51	1380	0	45.2	-45.2	0.00	-268.00	715	1.83	2.47	2.21	38.60
BF 1	10/16/1999	0.884	396.541	3.77	1450	59	0.0	59.0	127.53	280.75	914	1.48	8.23	2.75	59.29
BF 1	11/20/1999	0.537	240.842	3.10	1500	87.8	0.0	87.8	115.27	253.75	840	8.96	8.02	3.05	57.89
BF 1	1/15/2000	7.758	3482.023	5.84	819	8.05	56.6	-48.6	152.79	-2028.63	336	29.6	6.79	1.55	1585.30
BF 1	2/12/2000	55.375	24853.916	5.91	361	0.7	30.6	-29.9	94.84	-8917.59	104	6.28	9.25	0.568	4801.18
BF 1	3/11/2000	9.708	4357.228	4.41	948	84.8	0.0	84.8	2014.11	4433.92	442	30.6	1.78	1.39	1765.72
BF 10	3/6/1999	1.675	751.790	5.37	1100	84.4	19.7	64.7	345.87	583.69	539	84.9	4.16	1.4	816.08
BF 10	4/10/1999	2.374	1065.522	5.82	1280	135	33.0	102.0	784.10	1304.20	650	109	1.55	2.24	1442.16
BF 10	5/8/1999	2.188	982.040	5.64	1350	138	15.5	122.5	738.73	1443.60	619	106	12.6	2.65	1428.87
BF 10	6/10/1999	1.115	500.445	5.47	1320	115	14.4	100.6	313.71	604.14	668	107	9.06	2.45	711.69
BF 10	7/13/1999	0.547	245.510	5.87	1420	174	19.8	154.2	232.86	454.29	799	118	0.459	2.89	357.51
BF 10	8/24/1999	0.250	112.360	5.66	1470	251	16.8	234.2	153.73	315.78	914	153	2.47	3.59	214.46
BF 10	9/21/1999	0.158	70.915	5.60	1660	277	9.7	267.3	107.08	227.45	1021	165	3.58	4.01	146.87
BF 10	10/16/1999	0.079	35.278	6.01	1780	288	6.5	281.5	55.38	119.17	1144	180	3.67	3.4	79.19
BF 10	11/20/1999	0.105	47.262	4.77	1880	383	0.0	383.0	98.67	217.22	1350	190	4.62	4.71	113.05
BF 10	1/15/2000	1.519	681.773	5.38	1570	217	20.2	196.8	806.45	1610.07	914	153	6.21	3.05	1327.49
BF 10	2/12/2000	1.277	572.954	5.95	1350	136	13.2	122.8	424.75	844.30	647	102	16.1	2.35	828.15
BF 10	3/11/2000	1.570	704.663	6.21	1380	107	12.9	94.1	411.00	795.71	598	98.1	<.25	1.73	NA
BF 13	3/6/1999	Too High	NA	6.38	197	0	43.6	-43.6	NA	NA	72.9	1.53	8.09	0.167	NA
BF 13	4/10/1999	5.016	2251.331	5.96	260	0	66.7	-66.7	0.00	-1801.97	65.9	0.819	1.16	0.217	59.327
BF 13	5/8/1999	0.002	0.898	6.53	356	2.93	80.7	-77.8	0.01	-0.84	105	1.79	11.5	0.94	0.153
BF 13	6/10/1999	0.002	0.898	6.60	306	0	84.2	-84.2	0.00	-0.91	60.1	0.766	6.9	0.553	0.089
BF 13	7/13/1999	0.002	0.898	7.30	637	0	134.0	-134.0	0.00	-1.44	105	1.72	1.4	1.16	0.046
BF 13	8/24/1999	0.002	0.898	6.87	540	0	126.0	-126.0	0.00	-1.36	145	1.42	6.04	0.792	0.089
BF 13	9/21/1999	0.002	0.898	6.08	1550	0	87.6	-87.6	0.00	-0.94	963	1.65	2.84	2.78	0.078
BF 13	10/16/1999	0.002	0.898	6.21	1630	0	64.2	-64.2	0.00	-0.69	1054	0.699	2.74	1.8	0.056
BF 13	11/20/1999	0.002	0.898	5.97	653	0	77.0	-77.0	0.00	-0.83	232	0.82	3.67	0.937	0.058
BF 13	1/15/2000	NA	NA	6.03	288	0	56.9	-56.9	NA	NA	64.2	1.63	6.22	0.2	NA
BF 13	2/12/2000	22.485	10092.077	6.48	254	0	45.5	-45.5	0.00	-5510.27	41.2	1.05	9.95	0.301	1368.61
BF 13	3/11/2000	NA	NA	6.87	282	0	63.8	-63.8	NA	NA	59.3	2.03	0.416	0.147	NA

Appendix G: Black Fork Phase II Data

Site.	Sample Date	Flow cfs	Flow gpm	Lab pH	Lab Cond. uS/cm	Acidity mg/l	Alkalinity mg/l	Net acidity	Acidity Load kg/day	Acid loading lbs/day	Sulfate mg/l	Iron mg/l	Aluminum mg/l	Manganese mg/l	Metal loading lbs/day
TW 1	3/6/1999	0.602	270.016	5.38	3070.00	546	49.6	496.4	803.64	1608.43	1833	392	2.49	6.15	1298.15
TW 1	4/10/1999	0.413	185.367	6.03	3030.00	433	193	240	437.52	533.86	1770	314	0.44	5.48	711.62
TW 1	5/8/1999	0.390	175.044	5.78	2600.00	349	36.9	312.1	333.00	655.57	1408	195	11.07	4.14	441.55
TW 1	6/10/1999	0.101	45.466	5.79	1900.00	363	44.4	318.6	89.97	173.83	1704	13	2.09	1.42	9.01
TW 1	7/13/1999	0.105	47.037	6.04	3400.00	551	87.7	463.3	141.28	261.51	1819	420	0.22	1.55	238.07
TW 1	8/24/1999	0.136	61.041	6.02	3780.00	602	102	500	200.31	366.25	2107	463	1.64	2.13	341.90
TW 1	9/21/1999	0.084	37.612	5.92	3950.00	603	85.2	517.8	123.63	233.71	2116	458	0.48	1.45	207.58
TW 1	10/16/1999	0.077	34.380	5.82	3740.00	641	29.6	611.4	120.13	252.24	2223	474	0.53	1.13	196.24
TW 1	11/20/1999	0.098	44.165	5.29	3680.00	647	13.9	633.1	155.76	335.53	2239	434	0.80	1.54	231.25
TW 1	1/15/2000	0.050	22.307	5.79	1400.00	643	79.1	563.9	78.19	150.95	2297	454	0.61	0.81	121.91
TW 1	2/12/2000	0.128	57.585	5.85	2440.00	365	28.1	336.9	114.57	232.80	2650	470	4.55	2.10	329.38
TW 1	3/11/2000	0.118	52.962	6.01	2610.00	533	11.1	521.9	153.87	331.69	2099	450	NA	1.82	NA
TW 2	3/6/1999	NA	NA	4.93	2810	461	11.9	449.1	NA	NA	1833	333	1.80	4.04	NA
TW 2	4/10/1999	NA	NA	5.39	2310	327	3.24	323.76	NA	NA	1786	179	0.43	5.53	NA
TW 2	5/8/1999	NA	NA	5.04	2540	327	1.57	325.43	NA	NA	1605	114	11.50	4.69	NA
TW 2	6/10/1999	NA	NA	3.89	2700	331	0	331	NA	NA	1589	163	8.51	5.35	NA
TW 2	7/13/1999	NA	NA	5.77	2840	529	19	510	NA	NA	1811	324	0.30	6.27	NA
TW 2	8/24/1999	NA	NA	5.87	2570	598	25.3	572.7	NA	NA	2149	420	5.15	6.55	NA
TW 2	9/21/1999	NA	NA	5.48	2590	585	11.3	573.7	NA	NA	2132	409	1.87	6.87	NA
TW 2	10/16/1999	NA	NA	5.51	2570	611	2.74	608.26	NA	NA	2239	389	2.66	6.02	NA
TW 2	11/20/1999	NA	NA	4.84	2560	630	2.73	627.27	NA	NA	2231	375	3.33	6.33	NA
TW 2	1/15/2000	NA	NA	5.51	2930	589	5.6	583.4	NA	NA	2330	397	5.55	6.66	NA
TW 2	2/12/2000	NA	NA	5.32	2990	578	1.19	576.81	NA	NA	2321	408	15.80	6.76	NA
TW 2	3/11/2000	NA	NA	5.48	2920	527	1.57	525.43	NA	NA	2132	362	<.25	6.20	NA
TW 3	3/6/1999	0.279	125.224	3.07	2530	320	0	320	218.4302647	480.86	1560	95.9	2.49	3.6	153.26
TW 3	4/10/1999	0.0544	24.416	2.97	2950	158	0	158	21.02880613	46.29	1745	24.6	1.15	6.29	9.39
TW 3	5/8/1999	0	0.000	3.19	2530	97.1	0	97.1	0	0.00	1688	11.5	12.8	5.71	0
TW 3	6/10/1999	0.0245	10.996	3.73	2950	35.3	0	35.3	2.115920861	4.66	1926	7.59	8.99	5.25	2.88
TW 3	7/13/1999	0.0627	28.142	2.88	3420	272	0	272	41.72487798	91.85	2190	44.3	0.657	7.19	17.61
TW 3	8/24/1999	0.087	39.048	2.95	3260	428	0	428	91.10068701	200.55	2420	122	5.9	7.22	63.31
TW 3	9/21/1999	0.119	53.411	2.78	3280	374	0	374	108.8872912	239.71	2231	126	2.83	7.54	87.40
TW 3	10/16/1999	0.0934	41.921	3.02	3080	302	0	302	69.0100671	151.92	2033	84.5	3.64	5.55	47.13
TW 3	11/20/1999	0.1022	45.870	2.78	3020	445	0	445	111.2678092	244.95	2083	132	3.49	6.11	77.94
TW 3	1/15/2000	NA	#VALUE!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TW 3	2/12/2000	0.1539	69.075	2.81	2250	285	0	285	107.3104733	236.24	1292	115	18	5.16	114.52
TW 3	3/11/2000	0.0881	39.542	2.92	3260	247	0	247	53.23919647	117.20	2025	61.3	0.503	6.98	32.64
TW 4	3/6/1999	0.222	99.640	3.01	2260	241	0	241	130.90	288.16	1239	71.80	3.54	3.38	94.12
TW 4	4/10/1999	0.016	7.181	3.00	2850	166	0	166	6.50	14.31	1655	23.30	1.77	6.23	2.70
TW 4	5/8/1999	0.000	0.000	2.87	2550	276	0	276	0.00	0.00	1358	39.40	17.90	6.54	0
TW 4	6/10/1999	0.000	0.000	3.19	2430	85.7	0	85.7	0.00	0.00	1268	5.66	9.68	4.23	0
TW 4	7/13/1999	0.008	3.523	2.72	3440	398	0	398	7.64	16.83	2000	73.80	0.47	7.28	3.45
TW 4	8/24/1999	0.032	14.318	2.90	3150	429	0	429	33.48	73.71	2330	114.00	5.15	7.23	21.71
TW 4	9/21/1999	0.150	67.325	2.77	3310	377	0	377	138.35	304.58	2140	88.10	2.52	6.98	78.85
TW 4	10/16/1999	0.072	32.495	2.93	3170	445	0	445	78.82	173.52	2033	159.00	3.10	5.53	65.37

Appendix G: Black Fork Phase II Data

Site.	Sample Date	Flow cfs	Flow gpm	Lab pH	Lab Cond. uS/cm	Acidity mg/l	Alkalinity mg/l	net acidity	Acidity Load kg/day	Acid loading lbs/day	Sulfate mg/l	Iron mg/l	Aluminum mg/l	Manganese mg/l	Metal loading lbs/day
TW 4	11/20/1999	0.094	41.966	2.67	2820	473	0	473	108.20	238.20	2025	170.00	3.30	5.89	90.24
TW 4	1/15/2000	NA	#VALUE!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TW 4	2/12/2000	0.110	49.282	3.84	2480	386	0	386	103.69	228.27	1572	204.00	17.60	5.79	134.47
TW 4	3/11/2000	0.052	23.160	2.92	3250	337	0	337	42.54	93.66	1967	110.00	<.25	6.19	NA
BR 1	3/6/1999	Too High	NA	6.23	271	0	22.5	-22.5	NA	NA	138	7.96	7.06	0.19	NA
BR 1	4/10/1999	5.430	2437.147	5.76	655	0	48.2	-48.2	0.00	-1409.65	270	19.10	8.67	0.78	834.94
BR 1	5/8/1999	3.646	1636.434	5.82	773	19.5	35.3	-15.8	173.94	-310.27	471	25.50	21.20	1.16	939.84
BR 1	6/10/1999	2.549	1144.068	6.38	769	0	91.2	-91.2	0.00	-1252.07	281	17.70	14.50	1.19	458.41
BR 1	7/13/1999	1.132	508.076	7.21	1140	0	192	-192	0.00	-1170.61	379	4.33	3.81	1.02	55.85
BR 1	8/24/1999	0.626	280.968	7.16	1050	0	330	-330	0.00	-1112.63	305	1.32	1.20	0.72	10.93
BR 1	9/21/1999	0.403	181.083	7.23	1120	0	334	-334	0.00	-725.78	224	1.52	2.42	0.81	10.32
BR 1	10/16/1999	0.490	219.779	6.72	1200	0	175	-175	0.00	-461.54	445	3.26	3.82	1.05	21.44
BR 1	11/20/1999	0.002	0.898	6.37	1060	0	88.6	-88.6	0.00	-0.95	510	2.58	6.22	1.62	0.11
BR 1	1/15/2000	2.815	1263.636	5.70	871	51.5	19.7	31.8	354.74	482.20	412	28.40	15.90	1.09	688.28
BR 1	2/12/2000	11.566	5191.100	6.32	472	0	36.7	-36.7	0.00	-2286.16	137	10.90	12.50	0.65	1498.09
BR 1	3/11/2000	4.084	1833.171	4.58	1070	146	0	146	1458.92	3211.72	536	35.20	19.90	1.08	1235.85
BR 3	3/6/1999	0.38	170.466	2.70	2770	2141.00	0.00	2141	1989.44	4379.60	2054.00	485.00	221.00	1.46	1447.17
BR 3	4/10/1999	0.17	75.763	2.79	2400	1550.00	0.00	1550	640.12	1409.18	1811.00	388.00	73.20	2.23	421.33
BR 3	5/8/1999	0.24	109.111	2.77	2840	1858.00	0.00	1858	1105.07	2432.73	2074.00	314.00	133.00	2.63	588.71
BR 3	6/10/1999	0.12	54.757	2.89	2350	1628.00	0.00	1628	485.93	1069.74	1712.00	402.00	212.00	2.72	405.24
BR 3	7/13/1999	0.06	28.613	2.70	2540	1648.00	0.00	1648	257.04	565.85	1762.00	399.00	106.00	2.77	174.35
BR 3	8/24/1999	0.04	18.312	2.75	2160	1683.00	0.00	1683	168.00	369.83	1836.00	411.00	122.00	3.39	117.87
BR 3	9/21/1999	0.03	11.872	2.73	2960	2627.00	0.00	2627	170.00	374.24	2840.00	649.00	226.00	5.03	125.37
BR 3	10/16/1999	0.03	13.914	2.51	2720	2063.00	0.00	2063	156.47	344.45	2346.00	541.00	148.00	3.72	115.66
BR 3	11/20/1999	0.03	14.834	2.41	3580	3480.00	0.00	3480	281.39	619.46	3829.00	853.00	274.00	5.44	201.58
BR 3	1/15/2000	0.07	30.947	2.00	6360	6894.00	0.00	6894	1162.96	2560.17	6051.00	1478.00	618.00	6.25	780.70
BR 3	2/12/2000	0.05	22.429	2.08	5370	1093.00	0.00	1093	133.63	294.18	5450.00	1432.00	621.00	7.28	554.52
BR 3	3/11/2000	0.08	35.906	2.42	5270	890.00	0.00	890	174.20	383.48	5975.00	1139.00	341.00	4.22	639.52
BR 9	3/6/1999	33.21	14905.644	NA	174	0.00	36.70	-36.7	0.00	-6564.45	11.50	1.38	5.80	0.06	1295.36
BR 9	4/10/1999	4.18	1876.738	6.30	368	0.00	70.30	-70.3	0.00	-1583.22	55.20	1.59	1.45	0.28	74.68
BR 9	5/8/1999	1.06	477.241	7.02	342	8.63	54.20	-45.57	22.45	-260.97	118.00	1.85	4.50	1.11	42.72
BR 9	6/10/1999	0.16	73.518	6.20	457	0.00	37.10	-37.1	0.00	-32.73	70.80	3.66	9.39	1.21	12.58
BR 9	7/13/1999	0.02	7.738	3.70	895	81.10	0.00	81.1	3.42	7.53	272.00	9.90	5.23	3.18	1.70
BR 9	8/24/1999	0.01	5.476	2.70	2270	1004.00	0.00	1004	29.97	65.97	1432.00	119.00	72.70	9.75	13.24
BR 9	9/21/1999	0.01	3.016	3.50	886	92.10	0.00	92.1	1.51	3.33	296.00	19.70	10.50	3.84	1.23
BR 9	10/16/1999	0.02	10.301	3.60	864	59.10	0.00	59.1	3.32	7.31	251.00	4.32	6.95	4.52	1.95
BR 9	11/20/1999	0.11	49.371	3.90	689	53.40	0.00	53.4	14.37	31.64	217.00	3.04	4.71	2.99	6.36
BR 9	1/15/2000	0.61	275.357	6.30	378	1.18	30.80	-29.62	1.77	-97.87	94.70	5.11	5.77	0.59	37.88
BR 9	2/12/2000	7.04	3159.651	7.60	273	6.12	30.10	-23.98	105.41	-909.22	58.40	2.11	13.40	0.39	602.94
BR 9	3/11/2000	0.95	425.859	6.00	347	0.00	44.10	-44.1	0.00	-225.36	80.00	1.56	1.02	0.31	14.78

Appendix G: Black Fork Phase II Data

Site.	Sample Date	Flow cfs	Flow gpm	Lab pH	Lab Cond. uS/cm	Acidity mg/l	Alkalinity mg/l	Net Acidity	Acidity Load kg/day	Acid loading lbs/day	Sulfate mg/l	Iron mg/l	Aluminum mg/l	Manganese mg/l	Metal loading lbs/day
BR 14	3/6/1999	75.450	33864.224	6.46	166	0	37.5	-37.5	0.00	-15238.90	34.2	0.693	6.5	0.042	2940.09
BR 14	4/10/1999	1.128	506.280	6.00	270	0	74.5	-74.5	0.00	-452.61	53.5	0.293	0.795	0.05	6.91
BR 14	5/8/1999	0.315	141.202	6.51	379	0	91.9	-91.9	0.00	-155.72	28	1.56	11.3	0.617	22.84
BR 14	6/10/1999	0.000	0.000	6.89	356	0	114	-114	0.00	0.00	47.7	1.16	7.43	0.297	0
BR 14	7/13/1999	0.000	0.000	6.74	492	0	126	-126	0.00	0.00	32.9	0.312	0.043	0.22	0
BR 14	8/24/1999	0.000	0.000	7.07	590	0	201	-201	0.00	0.00	42.8	1.77	6.11	2.44	0
BR 14	9/21/1999	0.000	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BR 14	10/16/1999	0.000	0.000	6.17	705	0	107	-107	0.00	0.00	158	0.51	1.41	0.127	0
BR 14	11/20/1999	0.000	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BR 14	1/15/2000	0.233	104.622	5.74	269	0	51	-51	0.00	-64.03	41.2	0.602	3.82	0.026	5.58
BR 14	2/12/2000	3.494	1568.425	5.60	240	0	32.7	-32.7	0.00	-615.45	44.5	0.867	15.7	0.28	317.08
BR 14	3/11/2000	0.000	0.000	7.88	439	0	94.1	-94.1	0.00	0.00	56.8	2.06	7.07	0.139	0
OC 1	3/6/1999	Too High	NA	6.51	214	0	38.5	-38.5	NA	NA	84.4	4.95	8.49	0.149	NA
OC 1	4/10/1999	4.599	2064.169	5.96	805	0	49	-49	0.00	-1213.73	253	18.8	8.32	0.833	692.40
OC 1	5/8/1999	3.423	1536.345	6.00	743	13.9	34.8	-20.9	116.41	-385.32	244	26.8	21.1	1.6	912.59
OC 1	6/10/1999	2.549	1144.068	6.68	960	0	85.9	-85.9	0.00	-1179.30	333	16.3	13.6	1.54	431.63
OC 1	7/13/1999	0.865	388.238	7.24	1090	0	189	-189	0.00	-880.52	404	5.66	3.15	1.3	47.10
OC 1	8/24/1999	0.626	280.968	7.34	1110	0	321	-321	0.00	-1082.29	263	1.87	0.642	0.89	11.47
OC 1	9/21/1999	0.403	180.878	7.36	1160	0	321	-321	0.00	-696.74	403	2.38	2.76	1.01	13.35
OC 1	10/16/1999	0.490	219.792	6.69	1240	0	156	-156	0.00	-411.45	503	4.42	4.2	1.33	26.24
OC 1	11/20/1999	0.002	0.898	6.38	1150	0	177	-177	0.00	-1.91	461	3.12	5.35	1.42	0.11
OC 1	1/15/2000	2.815	1263.636	5.76	858	0	63	-63	0.00	-955.31	344	25.5	13.1	1.12	602.30
OC 1	2/12/2000	13.077	5869.417	5.64	468	28.8	37	-8.2	921.43	-577.55	138	10.6	14.1	0.662	1786.32
OC 1	3/11/2000	3.717	1668.297	4.67	1040	113	0	113	1027.61	2262.21	467	52.2	14.3	1.07	1352.72
OC 4	3/6/1999	Too High	NA	6.56	173	19.6	47.7	-28.1	NA	NA	12.8	1.09	7.04	0.062	NA
OC 4	4/10/1999	8.071	3622.642	6.32	259	0	82.6	-82.6	0.00	-3590.76	7	0.424	0.846	0.163	62.29
OC 4	5/8/1999	1.705	765.121	6.67	310	0	92.4	-92.4	0.00	-848.37	70	1.44	4.59	0.816	62.86
OC 4	6/10/1999	0.064	28.797	6.96	313	0	123	-123	0.00	-42.50	43.6	1.16	8.16	0.195	3.29
OC 4	7/13/1999	0.000	0.000	8.15	476	0	172	-172	NA	0.00	56	0.859	0.773	0.352	0
OC 4	8/24/1999	0.000	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OC 4	9/21/1999	0.000	0.000	7.24	388	0	84.9	-84.9	0.00	0.00	46.1	1.1	1.67	0.39	0
OC 4	10/16/1999	0.000	0.000	6.28	570	0	138	-138	0.00	0.00	137	0.085	2.06	0.174	0
OC 4	11/20/1999	0.075	33.707	6.62	435	52.4	109	-56.6	9.63	-22.89	63.4	0.276	0.158	0.085	0.21
OC 4	1/15/2000	0.992	445.060	6.82	308	0	74	-74	0.00	-395.21	48.6	0.824	3.35	0.035	22.48
OC 4	2/12/2000	16.812	7545.528	5.85	261	0	50.1	-50.1	0.00	-4536.37	37.9	0.515	13.2	0.316	1270.46
OC 4	3/11/2000	1.312	588.887	7.25	294	0	73.2	-73.2	0.00	-517.28	45.3	0.385	<0.25	0.154	NA
DR 1	3/6/1999	31.930	14331.142	6.18	202	0	25.5	-25.5	0.00	-4385.33	77	3.53	6.32	0.174	1723.86
DR 1	4/10/1999	0.920	412.744	2.86	890	115	0	115	258.74	569.59	340	18	8.64	1.61	139.92
DR 1	5/8/1999	0.492	220.869	3.07	964	168	0	168	202.27	445.27	405	19.6	19	1.69	106.79
DR 1	6/10/1999	0.278	124.775	3.01	1700	275	0	275	187.04	411.76	691	24.2	25	3.42	78.79
DR 1	7/13/1999	0.308	138.060	2.71	2100	459	0	459	345.43	760.44	1095	22.2	32.3	4.71	98.09
DR 1	8/24/1999	0.223	99.865	2.65	2330	590	0	590	321.17	707.04	1235	24.3	48.5	5.32	93.62
DR 1	9/21/1999	0.129	58.034	2.59	2600	648	0	648	204.99	451.27	1441	44.2	49.8	6.67	70.11
DR 1	10/16/1999	0.096	43.133	2.71	2700	660	0	660	155.18	341.61	1465	60.4	48.6	5.61	59.32
DR 1	11/20/1999	0.115	51.571	2.42	2250	597	0	597	167.82	369.45	1309	61.1	41	5.11	66.35

Appendix G: Black Fork Phase II Data

Site.	Sample Date	Flow cfs	Flow gpm	Lab pH	Lab Cond. uS/cm	Acidity mg/l	Alkalinity mg/l	Net Acidity	Acidity Load kg/day	Acid loading lbs/day	Sulfate mg/l	Iron mg/l	Aluminum mg/l	Manganese mg/l	Metal loading lbs/day
DR 1	1/15/2000	0.709	318.400	2.64	1290	325	0	325	564.07	1241.76	678	40.6	21.5	2.95	248.54
DR 1	2/12/2000	3.049	1368.460	4.16	477	61	0	61	455.03	1001.71	205	10.9	13	0.931	407.76
DR 1	3/11/2000	0.460	206.263	3.06	1290	191	0	191	214.75	472.76	552	30	8.39	1.58	98.93
DR 2	3/6/1999	0.08	37.118	2.99	1510	438.00	0.00	438	88.62	195.09	766.00	193.00	23.70	1.66	97.26
DR 2	4/10/1999	0.03	15.350	3.12	3490	1443.00	0.00	1443	120.74	265.80	2700.00	583.00	66.40	6.77	120.87
DR 2	5/8/1999	0.03	13.240	2.85	3110	1392.00	0.00	1392	100.47	221.17	2247.00	386.00	52.40	5.75	70.57
DR 2	6/10/1999	0.03	11.719	2.96	3320	1212.00	0.00	1212	77.39	170.44	2124.00	424.00	53.50	5.98	67.99
DR 2	7/13/1999	0.02	10.301	2.80	3050	1395.00	0.00	1395	78.33	172.43	2338.00	423.00	49.40	6.21	59.16
DR 2	8/24/1999	0.03	11.311	2.96	3120	1591.00	0.00	1591	98.09	215.94	2535.00	548.00	62.90	6.19	83.76
DR 2	9/21/1999	0.02	7.271	2.95	3150	1472.00	0.00	1472	58.34	128.44	2552.00	549.00	57.00	6.50	53.44
DR 2	10/16/1999	0.02	10.727	3.15	3180	1535.00	0.00	1535	89.76	197.59	2642.00	586.00	60.30	5.35	83.88
DR 2	11/20/1999	0.03	12.271	2.57	3080	1568.00	0.00	1568	104.88	230.89	2601.00	578.00	63.60	5.91	95.35
DR 2	1/15/2000	0.03	12.078	2.77	3370	1637.00	0.00	1637	107.78	237.26	2725.00	599.00	61.10	6.39	96.60
DR 2	2/12/2000	0.03	15.081	2.79	3020	257.00	0.00	257	21.13	46.51	2445.00	499.00	54.70	5.16	101.14
DR 2	3/11/2000	0.03	12.599	3.20	3580	253.00	0.00	253	17.37	38.25	2828.00	529.00	44.70	6.04	87.65
DR 3	3/6/1999	4.980	2235.173	3.70	398	44.9	0	44.9	547.06	1204.31	86.4	11.5	8.71	0.494	555.32
DR 3	4/10/1999	0.123	55.206	2.54	1560	357	0	357	107.43	236.50	873	53.2	28.6	3.29	56.37
DR 3	5/8/1999	0.152	68.357	2.76	1480	394	0	394	146.81	323.19	750	51.3	31.6	2.63	70.16
DR 3	6/10/1999	NA	NA	2.76	2040	442	0	442	NA	NA	1037	62.8	37.9	4.48	NA
DR 3	7/13/1999	0.095	42.589	2.74	2380	586	0	586	136.04	299.49	1004	79.3	33.5	4.97	60.19
DR 3	8/24/1999	0.129	57.899	2.82	1920	564	0	564	178.00	391.86	1128	80.3	33.9	4.79	82.67
DR 3	9/21/1999	0.072	32.136	2.50	2380	729	0	729	127.70	281.13	1408	122	41.3	6.59	65.52
DR 3	10/16/1999	0.059	26.571	2.77	2460	778	0	778	112.68	248.06	1564	153	46.6	5.88	65.52
DR 3	11/20/1999	0.067	30.251	2.40	2470	807	0	807	133.07	292.95	1643	130	49.3	6.64	67.50
DR 3	1/15/2000	0.101	45.184	2.47	2120	1507	0	1507	371.17	817.10	1391	147	41.1	6.23	105.37
DR 3	2/12/2000	0.578	259.289	2.50	1120	207	0	207	292.57	644.07	473	47.8	23	2.27	227.36
DR 3	3/11/2000	0.083	37.124	2.86	2120	571	0	571	115.55	254.37	1235	107	29.7	5.46	63.33
DR 7	3/6/1999	12.87	5776.442	6.38	172	0.00	39.40	-39.4	0.00	-2731.10	4.15	0.83	6.89	0.08	540.54
DR 7	4/10/1999	0.23	104.577	5.97	314	5.35	24.50	-19.15	3.05	-24.03	83.60	2.93	1.64	0.71	6.63
DR 7	5/8/1999	0.17	75.763	5.96	334	36.80	4.51	32.29	15.20	29.36	41.20	6.17	12.70	1.31	18.35
DR 7	6/10/1999	0.04	18.941	3.60	565	52.90	0.00	52.9	5.46	12.02	303.00	11.90	13.20	1.95	6.15
DR 7	7/13/1999	0.00	0.898	3.66	704	68.20	0.00	68.2	0.33	0.73	384.00	5.60	5.57	3.78	0.16
DR 7	8/24/1999	0.00	0.898	3.34	1060	181.00	0.00	181	0.89	1.95	585.00	34.70	19.70	4.52	0.63
DR 7	9/21/1999	0.00	0.898	3.04	1070	142.00	0.00	142	0.69	1.53	553.00	6.66	13.90	4.78	0.27
DR 7	10/16/1999	0.00	0.898	4.14	569	56.60	0.00	56.6	0.28	0.61	259.00	8.04	3.34	3.35	0.16
DR 7	11/20/1999	0.00	0.898	3.05	900	75.50	0.00	75.5	0.37	0.81	403.00	2.81	10.30	3.13	0.17
DR 7	1/15/2000	0.06	26.980	4.86	387	45.70	2.36	43.34	6.72	14.03	182.00	6.09	6.74	1.20	4.54
DR 7	2/12/2000	1.42	637.159	5.69	231	26.90	29.90	-3	93.43	-22.94	65.00	0.64	14.00	0.44	115.28
DR 7	3/11/2000	0.08	34.520	5.15	374	26.80	2.89	23.91	5.04	9.90	140.00	2.95	2.16	0.80	2.45

Appendix H: Biological sampling site data

Appendix H: Bio-site Data

Site Number	basin	Sample Number	Date	pH	COND. mS/cm	ACIDITY mg/l	ALK. mg/l	Net Acidity	ACIDITY LOADING lbs/day	sulfate	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day	Total Dissolved Solids	Total Suspended Solids	Flowrate CFS	GPM	Site Number
biosite #01	Keskington bridge	MRM071	8/11/2004	7.54	838	3.87	76.5	-72.63	NA	324	0.096	0.329	2.47	NA	627	9	NA	NA	biosite #01
biosite #02	Mainstream Lambert R[	MRM070	8/11/2004	4.64	1090	55.7	2.05	53.65	NA	608	0.455	3.87	5.88	NA	888	10	NA	NA	biosite #02
biosite #03	UPST. Crooksville	MRM063	8/9/2004	3.77	1230	64	0	64	NA	689	5.35	5.4	7.38	NA	981	22	NA	NA	biosite #03
biosite #04	UPST. Blackfork	MRM062	8/9/2004	3.51	1320	79.4	0	79.4	7397.47	782	5.88	6.87	9.19	2044.09	1140	31	17.30	7763.93	biosite #04
biosite #05	T196	MRM061	8/9/2004	3.12	1490	135	0	135	8584.72	848	9.79	7.98	11.3	1848.58	1250	24	11.81	5299.21	biosite #05
biosite #06	DST. Andrew	MRM060	8/9/2004	3	1570	183	0	183	7085.35	881	31.1	11.1	9.64	2007.13	1270	32	7.19	3226.48	biosite #06
biosite #07	Downtown MOX	MRM059	8/9/2004	6.5	919	6.62	24.9	-18.28	-28.20	484	0.393	0.24	3.5	6.38	748	11	0.29	128.56	biosite #07
biosite #08	Riders run	MRM068	8/11/2004	3.97	849	53.6	0	53.6	230.61	458	4.98	4.58	2.58	52.23	675	9	0.80	358.54	biosite #08
biosite #09	Rainer	MRM064	8/11/2004	6.62	1220	5.73	20.2	-14.47	-56.58	697	0.509	0.24	2.12	11.22	1040	9	0.73	325.83	biosite #09
biosite #10	McLuney (low flow)	MRM095	8/25/2004	3.28	1520	95.8	0	95.8	1878.26	823	3.81	7.75	8.36	390.55	1250	9.00	3.64	1633.84	biosite #10
biosite #11	McLuney upst																		
biosite #12	Burly	MRM075	8/16/2004	3.42	1380	121	0	121	504.98	749	2.72	13.3	10.3	109.84	1080	2	0.78	347.78	biosite #12
biosite #13	Porter	MRM065	8/11/2004	6.94	854	4.19	38.5	-34.31	-93.01	449	0.421	0.24	1.44	5.70	688	10	0.50	225.90	biosite #13
biosite #14	Payne Run	MRM57	8/4/2004	5.81	790	5.14	5.49	-0.35	-1.28	317	0.202	0.716	2.27	11.70	604	13	0.68	305.79	biosite #14
biosite #15	Mainstream	MRM069	8/11/2004	4.15	1130	67.5	0	67.5	9979.33	628	1.3	4.74	6.11	1796.28	896	8	27.45	12320.16	biosite #15
biosite #16	MORRISON	MRM58	8/4/2004	5.53	573	10.1	6.91	3.19	3.47	246	1.42	2.83	2.63	7.47	418	20	0.20	90.54	biosite #16
biosite #17	ELK RUN	MRM067	8/11/2004	6.06	624	10.3	12.8	-2.5	-1.44	340	2.4	3.48	0.92	3.91	518	26	0.11	47.96	biosite #17
biosite #18	Andrew	MRM094	8/23/2004	2.97	2080	331	0	331	6434.56	1136	60	17.9	14.2	1790.40	1660	12	3.61	1619.98	biosite #18
biosite #19	CLAY PIT	MRM066	8/11/2004	7.37	836	4.1	53.4	-49.3	-201.56	404	0.159	0.24	0.281	2.78	659	3	0.76	340.70	biosite #19
biosite #20	Snake	MRM100	8/25/2004	3.17	1270	133	0	133	153.22	616	13.6	10.2	3.65	31.62	938	14	0.21	96.00	biosite #20
biosite #21	Bear	MRM104	9/1/2004	3.19	1800	103	0	103	565.27	1029	6.7	4.99	18.7	166.78	1520	13	1.02	457.34	biosite #21
biosite #22	Glenford - Bio site	MRM072	8/16/2004	7.93	506	48.5	181	-132.5	-8100.53	49.4	0.475	0.24	0.054	47.01	268	16	11.35	5094.67	biosite #22
biosite #23	Kent RUN - Bio site	MRM073	8/16/2004	7.7	683	21.8	107	-85.2	-853.26	65	0.346	0.24	0.059	6.46	354	16	1.86	834.57	biosite #23
biosite #23	Kent RUN - QAQC	MRM074	8/16/2004	7.72	683	18.1	106	-87.9	-880.30	56.8	0.349	0.24	0.06	6.50	363	9	1.86	834.57	biosite #23

Appendix I: Surface mine information

Appendix I: Surface Mine Information

Permit No.	Company Name	Dates	County	Township	Sections	Descrition
A-465	Brown Mining Co	8-14-68/69	Musk	Brush Creek	NW 6	Moxy Ridge
A-631	Brown Mining Co	8-14-69/70	Musk	Brush Creek	NW 6	Moxy Ridge
A-390	Cambridge Coal Co	12-15-67/68	Musk	Clay	10, 11, 3	
B-1193	City Enterprises Inc	8-15-75/76	Musk	Clay	3	
C-536	Horizon Coal Co	3-14-77/88	Musk	Clay	11,2	
C-861	Horizon Coal Co	4-26-78/81	Musk	Clay	11,2	
3819	Carson Coal Co	11/1/1960	Musk	Newton	NE 23	Morrison Run
4094	Carson Coal Co	11/1/1961	Musk	Newton	NE 23	Morrison Run
4402	Carson Coal Co	3/15/1963	Musk	Newton	NE 23	Morrison Run
4677	Carson Coal Co	6/2/1964	Musk	Newton	NE 23	Morrison Run
4917	Carson Coal Co	8-10-65/66	Musk	Newton	NE 23	Morrison Run
A-877	Larry E Carson & FR Vandenbark	11-20-70/71	Musk	Newton	23	
4719	Friel Coal Co	8/15/1964	Musk	Newton	N 35	NE Ironspot
4937	Friel Coal Co	8-15-65/66	Musk	Newton	26	NE Ironspot
A-83	Friel Coal Co	8-15-66/67	Musk	Newton	26	NE Ironspot
A-284	Friel Coal Co	8-15-67/68	Musk	Newton	23, 26	NE Ironspot
A-466	Friel Coal Co	8-15-68/69	Musk	Newton	23, 26	NE Ironspot
A-635	Friel Coal Co	8-15-69/70	Musk	Newton	23	NE Ironspot
A-793	Friel Coal Co		Musk	Newton		
A-995	Friel Coal Co		Musk	Newton		
A-731	F.R. Vandenbark	10-10-66/67	Musk	Newton	23	Morrison Run
A-631	Brown Mining Co	8-14-69/70	Musk	Newton	11, 12, 13, 14, 23	Across from Jonathan Creek
A-744	Raymond Rucker	5-1-70/71	Musk	Newton	13	
A-927	Raymond Rucker	5-1-71/72	Musk	Newton	13	
B-0012	Raymond Rucker	5-30-72/73	Musk	Newton	13	
B-0396	Raymond Rucker	4/18/1973	Musk	Newton	13	
B-1148	Rucker Coal Co	7-17-75/76	Musk	Newton	13	
C-454	Rucker Coal Co	11-5-76/79	Musk	Newton	13	
A-717	Nucci Coal Co	1-8-70/71	Musk	Newton	26	
A-820	Muskingum Valley Augering	9/23-70/71	Musk	Newton	23, 24, 25, 26	
A-1015	Muskingum Valley Augering	9-25-71/72	Musk	Newton	11,14	
A-1001	Dressler Coal Co	8-28-71/72	Musk	Newton	24	
A-1084	Dressler Coal Co	12-30-71/72	Musk	Newton	24	
C-614	Lyle Construction, Inc	6-22-77/80	Musk	Newton	14	
C-938	Lyle Construction, Inc	10-10-78/81	Musk	Newton	30	
C-610	Zanesville Coal Co	6-17-77/80	Musk	Newton	13	
C-633	Wells Mining Co	7-15-77/78	Musk	Newton	1	S&W So Zanesville
C-737	Wells Mining Co	10-31-77/80	Musk	Newton	13	
C-907	Wells Mining Co	8-29-78/81	Musk	Newton	14	
C-1139	Wells Mining Co	10-5-79/82	Musk	Newton	13	
C-751	Horizon Coal Co	11-14-77/80	Musk	Newton	21, 28	Avondale Area
C-1017	Horizon Coal Co	1-24-79/82	Musk	Newton	23	
D-0724	Thompson Mining Co	12-3-87/92	Musk	Newton	13	
5011	Peabody Coal Co	11-1-65/66	Perry	Bearfield	17	
A-163	Peabody Coal Co	11-1-66/67	Perry	Bearfield	5, 6, 7, 8, 17, 18	
A-338	Peabody Coal Co	11-1-67/68	Perry	Bearfield	5, 6, 7, 7, 17, 18	
A-424	Peabody Coal Co	5-1-68/69	Perry	Bearfield	6,7	
A-585	Peabody Coal Co	5-1-69/70	Perry	Bearfield	6, 7	
B-0243	Crooksville Coal Co	2/27/1974	Perry	Bearfield	3	
B-0527	Crooksville Coal Co	1-27-74/75	Perry	Bearfield		
B-0940	Crooksville Coal Co	1-27-75/76	Perry	Bearfield		
C-125	Crooksville Coal Co	2-10-76/79	Perry	Bearfield		
C-1106	Crooksville Coal Co	6-12-79/82	Perry	Bearfield	8, 9	
C-1454	Crooksville Coal Co	6-23-81/84	Perry	Bearfield	5	
C-1517	Crooksville Coal Co	10-1-81/84	Perry	Bearfield	3	
D-0057	Crooksville Coal Co	8-10-82/87	Perry	Bearfield	4, 9, 5	
D-0085	Crooksville Coal Co	12-15-82/87	Perry	Bearfield	2, 3	

Appendix I: Surface Mine Information

Permit No.	Company Name	Dates	County	Township	Sections	Descrition
D-0189	Crooksville Coal Co	9-8-83/88	Perry	Bearfield	4, 9, 5, 8	
341	Henry W Strietelmeier	10/1/1950	Perry	Clayton	14	File # 797
A-1026	Ohio Amco Inc	10-18-71/72	Perry	Clayton	22, 23, 26, 27, 35	So Clover Hill
D-0461	Crooksville Coal Co	4-2-85/90	Perry	Clayton	13, 14	Clover Hill/ Redfield
D-0610	Transpacific Tech	8-26-86/91	Perry	Clayton	33, 34	Rehoboth area
A-334	Larry E Carson & FR Vandenbark	10-20-67/68	Perry	Harrison	NE 21	Possum Hollow
A-726	Sidwell Bros, Inc	2-6-70/71	Perry	Harrison	21, 28, 29	Brigglesville
A-768	Crooksville Coal Co	6-28-71/72	Perry	Harrison	18, 9, 17, 20	Burley Run
A-960	Crooksville Coal Co	6-28-71/72	Perry	Harrison	20	Snake Run
B-0855	Crooksville Coal Co	12-9-74/75	Perry	Harrison	33	
D-0461	Crooksville Coal Co	4-2-85/90	Perry	Harrison	13, 14	
A-1026	Ohio Amco Inc	10-18-71/72	Perry	Harrison	25, 30, 31, 36	McLuney north
C-640	Lominco Inc	7-26-77/78	Perry	Harrison	13	Burley Run
D-0019	Wills Creek Energy	4-9-82/87	Perry	Harrison	5	across from Roseville
D-0490	Carson Prod. Inc	8-26-85/90	Perry	Harrison	18	Burley Run
D-0721	Tri State Coal Sales Inc	11-16-87/92	Perry	Harrison	13	Burley Run/ McLuney north
157	Sunnyhill Coal Company	1/1/1948	Perry	Pike	34	Clayton 27, 28, 33, 34
371	Sunnyhill Coal Company	1/1/1949	Perry	Pike	34	Clayton 20, 21, 26, 27, 28, 29, 32, 33, 34, 35
530	Sunnyhill Coal Company	1/1/1950	Perry	Pike		
860	Sunnyhill Coal Company	1/1/1951				
1211	Sunnyhill Coal Company	1/1/1952	Perry	Clayton	9, 15, 16, 17	
1526	Sunnyhill Coal Company	1/1/1953	Perry			
1941	Sunnyhill Coal Company	1/1/1954	Perry			
2267	Sunnyhill Coal Company	1/1/1955	Perry			
2591	Sunnyhill Coal Company	1/1/1956	Perry	Clayton	26, 35, 20, 21, 23, 26, 27, 28, 14, 15	Harrison 25, 30, 31, 36
2843	Sunnyhill Coal Company	1/1/1957	Perry			
3091	Sunnyhill Coal Company	1/1/1958	Perry			
3351	Sunnyhill Coal Company	1/1/1959	Perry	Clayton	2, 10, 11, 12, 13, 14, 30	Pike, Harrison, Bearfield 19, 25, 26, 24, 18, 7, 23 - #81 to Peabody St. Louis
4298	Peabody Coal Co	11/1/1962	Perry	Pike		
4539	Peabody Coal Co	11/1/1963	Perry	Pike		
4764	Peabody Coal Co	11/1/1964	Perry	Pike		
5011	Peabody Coal Co	11/1/1965	Perry	Pike	23	
A-163	Peabody Coal Co	11-1-66/67	Perry	Pike	1, 12	north SR 93, drains to Bear Creek
A-338	Peabody Coal Co	11-1-67/68	Perry	Pike	1, 12	
A-424	Peabody Coal Co	5-1-68/69	Perry	Pike	1, 12	
A-585	Peabody Coal Co	5-1-69/70	Perry	Pike	12, 1, 11, 13, 14	
A-745	Peabody Coal Co	5-1-70/71	Perry	Pike	11, 12, 13, 22	22 - HWL area
A-934	Peabody Coal Co	5-1-71/72	Perry	Pike	22	Congo Mine?
A-984	Ed Funk Coal Co	8-4-71/72	Perry	Pike	32, 33	headwaters, East SR 93, So Bristol
A-1026	Ohio Amco Inc	3-7-75/76	Perry	Pike	27, 33, 34	main stem area So CR 11
D-0602	Daft Coal Co	8-8-86/91	Perry	Pike	33	
D-1050	Allen Imler Coal Sales	11-12-93/98	Perry	Pike	32	
5011	Peabody Coal Co	11-1-65/66	Perry	Pike	24, 25, 31, 36, 20, 29, 30	
A-882	Merckle Mining Co, Inc	12-2-70/71	Perry	Pike	30	
A-1071	Merckle Mining Co, Inc	12-2-71/72	Perry	Pike	30	
C-1309	Merco Mining, Inc	5-30-80/83	Perry	Pike	30	
D-0085	Crooksville Coal Co	12-15-82/87	Morg	York	34	

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Appendix J: Basic Reclamation data and maps

Appendix J: Basic Reclamation Data

Minimal basic cost estimation for - standard reclamation of pit impoundments
goal: Reduce water contact time with spoil and coal floor
Andrew Creek

Site	Area of pond	area of po	length	Transition Channel	re-veg area	1% grade	Total cubic feet (area of pond x depth of cover)	Total cubic yards	cost of earthwork	re-veg	lime material	2:1 slope transitional rock	C rock	sub-total	mobilization	final cost	
	acres	square feet	ft	ft	acres	plus 2 ft. cover (ft)	(ft3)	(yd3)	$1.10/cubic yard	$750/ac	$440/ac	1.66tons/linear ft.	$28/ton		10% final cost		Project total
Andrews Project #33				3068								$ 5,093	$ 142,601	$ 142,601	$ 14,260	$ 156,861	
59	1.4	60,984	806		4.2	6.0	367,733.5	13,619.8	14,982	$ 3,150	$ 1,848			$ 19,980	$ 1,998	$ 21,978	
58	2.1	91,476	1721		7.7	10.6	970,103.0	35,929.7	39,523	$ 5,775	$ 3,388			$ 48,686	$ 4,869	$ 53,554	
47	0.4	17,424	361		1.2	3.8	66,298.3	2,455.5	2,701	$ 900	$ 528			$ 4,129	$ 413	$ 4,542	
48	1.1	47,916	307		2.3	3.5	169,383.1	6,273.4	6,901	$ 1,725	$ 1,012			$ 9,638	$ 964	$ 10,602	
57	0.5	21,780	483		1.9	4.4	96,158.7	3,561.4	3,918	$ 1,425	$ 836			$ 6,179	$ 618	$ 6,796	
43	0.3	13,068	290		0.7	3.5	45,084.6	1,669.8	1,837	$ 525	$ 308			$ 2,670	$ 267	$ 2,937	$ 257,269
Andrews Project #44				2239								$ 3,717	$ 104,069	$ 104,069	$ 10,407	$ 114,476	
30	13.2	574,992	2372		18.9	13.9	7,969,389.1	295,162.6	324,679	$ 14,175	$ 8,316			$ 347,170	$ 34,717	$ 381,887	
31a	14.3	622,908	4883		26.2	26.4	16,454,114.8	609,411.7	670,353	$ 19,650	$ 11,528			$ 701,531	$ 70,153	$ 771,684	
31b	1.3	56,628	632		2.9	5.2	292,200.5	10,822.2	11,904	$ 2,175	$ 1,276			$ 15,355	$ 1,536	$ 16,891	
31c	5.6	243,936	1188		8.7	7.9	1,936,851.8	71,735.3	78,909	$ 6,525	$ 3,828			$ 89,262	$ 8,926	$ 98,188	
24	9.4	409,464	2530		17.7	14.65	5,998,647.6	222,172.1	$ 244,389	$ 13,275	$ 7,788.00			$ 265,452	$ 26,545	$ 291,998	$ 1,675,123
Andrews Howard William Lake				1897								$ 3,149	$ 88,173	$ 88,173	$ 8,817	$ 96,990	
a	7.7	335,412	3152		19.5	17.76	5,956,917.1	220,626.6	$ 242,689	$ 14,625	$ 8,580.00			$ 265,894	$ 26,589	$ 292,484	
b	7.2	313,632	3566		23.9	19.83	6,219,322.6	230,345.3	$ 253,380	$ 17,925	$ 10,516.00			$ 281,821	$ 28,182	$ 310,003	
c	7.4	322,344	2732		16.1	15.66	5,047,907.0	186,959.5	$ 205,655	$ 12,075	$ 7,084.00			$ 224,814	$ 22,481	$ 247,296	
d	6.5	283,140	3068		14.7	17.34	4,909,647.6	181,838.8	$ 200,023	$ 11,025	$ 6,468.00			$ 217,516	$ 21,752	$ 239,267	
e	4.6	200,376	1673		8.6	10.365	2,076,897.2	76,922.1	$ 84,614	$ 6,450	$ 3,784.00			$ 94,848	$ 9,485	$ 104,333	
f	5.9	257,004	1774		12.7	10.87	2,793,633.5	103,467.9	$ 113,815	$ 9,525	$ 5,588.00			$ 128,928	$ 12,893	$ 141,820	
g	3.8	165,528	1675		6.5	10.375	1,717,353.0	63,605.7	$ 69,966	$ 4,875	$ 2,860.00			$ 77,701	$ 7,770	$ 85,471	$ 1,517,664

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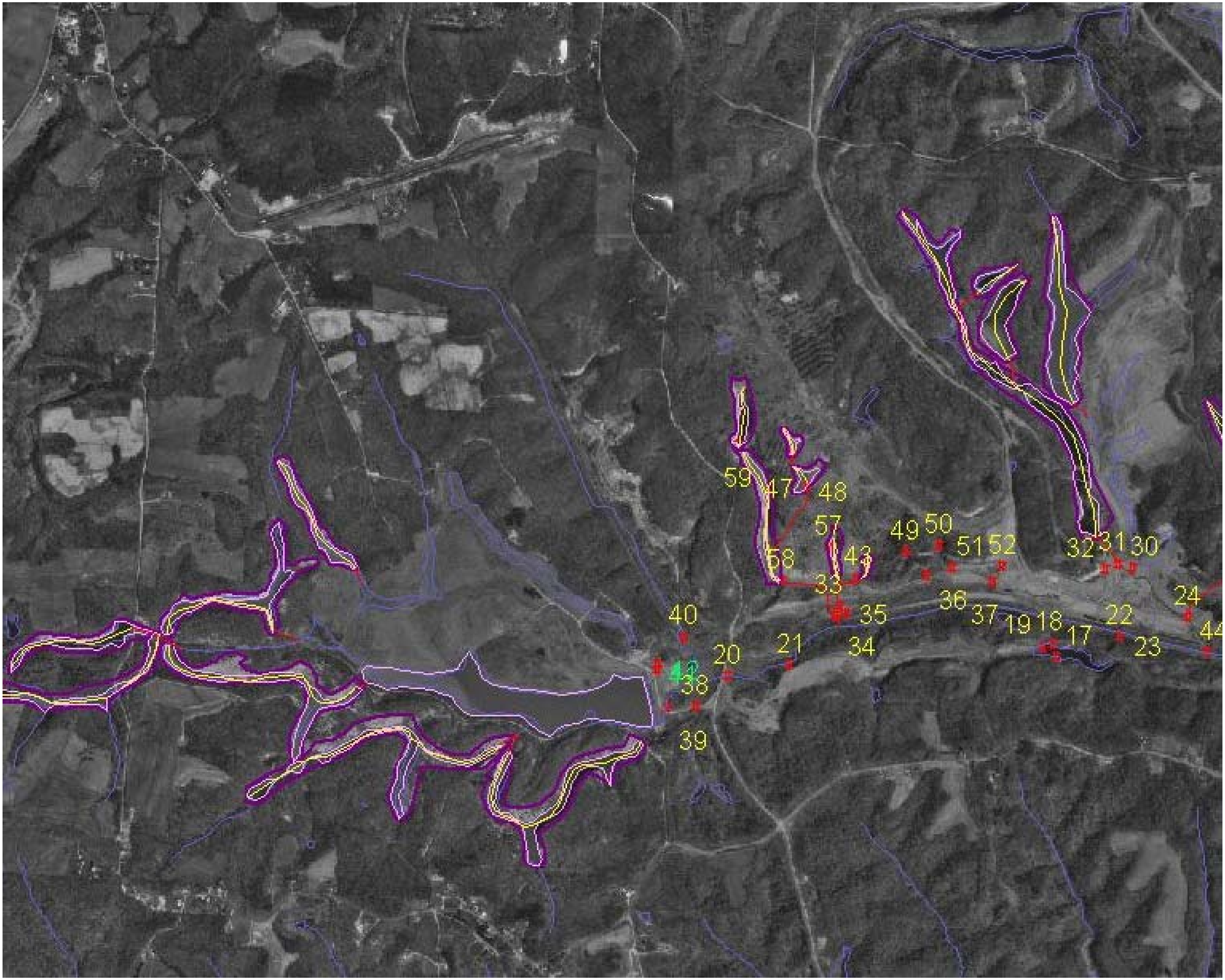
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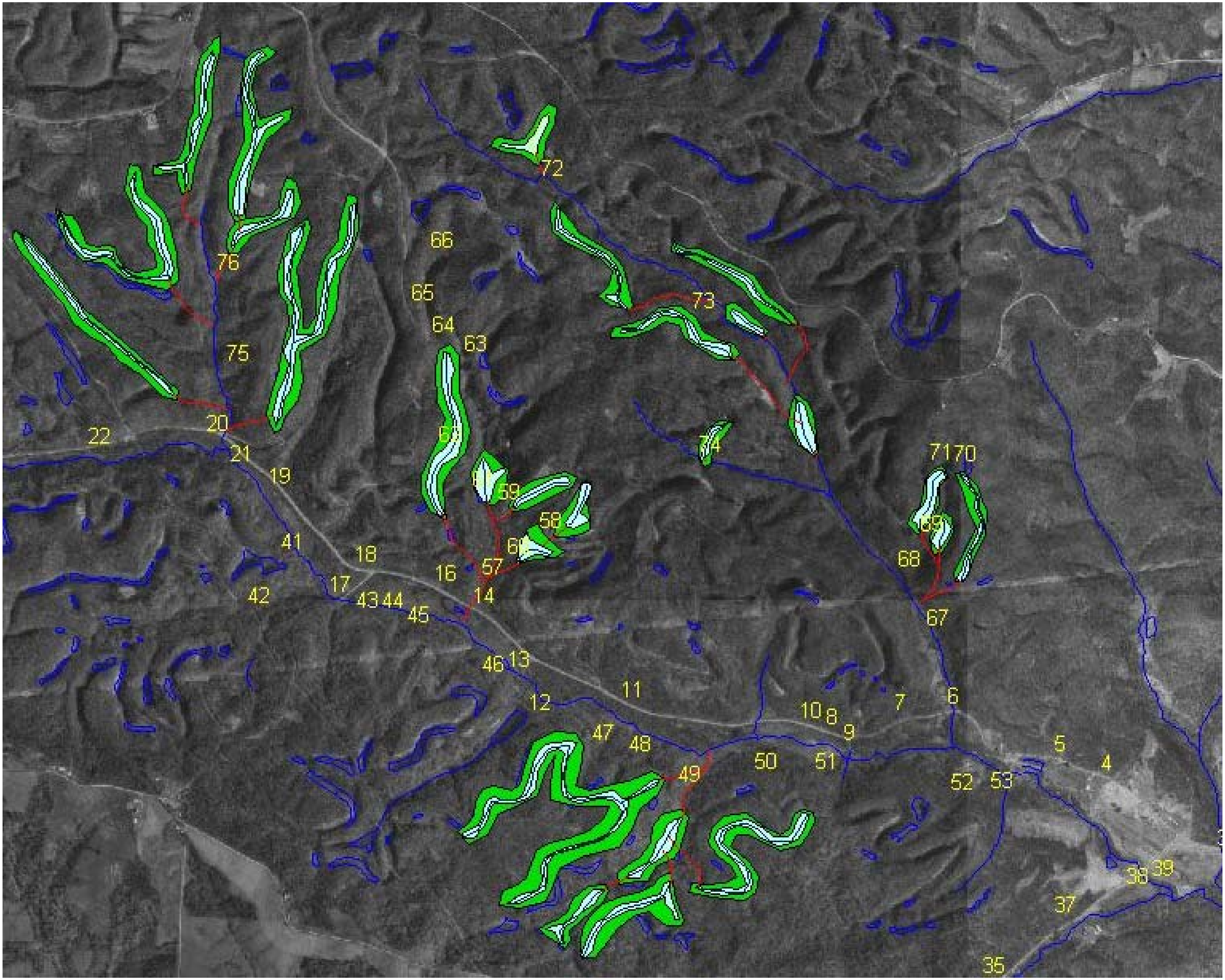
Appendix J: Basic Reclamation Data

Minimal basic cost estimation for - standard reclamation of pit impoundments
goal: Reduce water contact time with spoil and coal floor
McLuney Creek

Site	Area of pond	area of pond	length	Trans. Chan-nel	re-veg area	1% grade	Total cubic feet (area of pond x depth of cover)	Total cubic yards	cost of earthwork	re-veg	lime material	2:1 slope transitional rock channel	C rock	sub-total	mobilization	final cost	
	acres	square feet	ft	ft	acres	plus 2 ft. cover (ft)	(ft3)	(yd3)	$1.10/cubic yard	$750/ac	$440/ac	1.66tons/linear ft.	$28/ton		10% final cost		Project total
McLuney #20				3862								$ 6,411	$ 179,506	$ 179,506	$ 17,951	$ 197,456	
a	4.7	204,732	3067		15.3	17.3	3,549,029.2	131,445.5	144,590	$ 11,475	$ 6,732			$ 162,797	$ 16,280	$ 179,077	
b	6.3	274,428	3538		19.8	19.7	5,403,487.3	200,129.2	220,142	$ 14,850	$ 8,712			$ 243,704	$ 24,370	$ 268,074	
c	4.1	178,596	1867		12.5	11.3	2,024,385.7	74,977.2	82,475	$ 9,375	$ 5,500			$ 97,350	$ 9,735	$ 107,085	
d	5.9	257,004	2371		15.5	13.9	3,560,790.4	131,881.1	145,069	$ 11,625	$ 6,820			$ 163,514	$ 16,351	$ 179,866	
e	3	130,680	1227		7.6	8.1	1,063,081.8	39,373.4	43,311	$ 5,700	$ 3,344			$ 52,355	$ 5,235	$ 57,590	
f	11.2	487,872	5098		30.2	27.5	13,411,601.3	496,726.0	546,399	$ 22,650	$ 13,288			$ 582,337	$ 58,234	$ 640,570	$ 1,629,719
McLuney #14&16				4282								$ 7,108	$ 199,027	$ 199,027	$ 19,903	$ 218,930	
62	7.4	322,344	2,402		17.8	14.0	4,516,039.4	167,260.7	183,987	$ 13,350	$ 7,832			$ 205,169	$ 20,517	$ 225,686	
61	3.1	135,036	574		6.2	4.9	657,625.3	24,356.5	26,792	$ 4,650	$ 2,728			$ 34,170	$ 3,417	$ 37,587	
59	2.2	95,832	844		5.9	6.2	596,075.0	22,076.9	24,285	$ 4,425	$ 2,596			$ 31,306	$ 3,131	$ 34,436	
58	2.2	95,832	623		5.4	5.1	490,180.7	18,154.8	19,970	$ 4,050	$ 2,376			$ 26,396	$ 2,640	$ 29,036	
60	2.1	91,476	513		4.4	4.6	417,587.9	15,466.2	17,013	$ 3,300	$ 1,936			$ 22,249	$ 2,225	$ 24,474	$ 570,149
McLuney #6				6155								10217.3	286084.4	$ 286,084	$ 28,608	$ 314,693	
70	2.4	104,544	1608		6.6	10.0	1,049,621.8	38,874.9	42,762	$ 4,950	$ 2,904			$ 50,616	$ 5,062	$ 55,678	
69	1.4	60,984	398		2.7	4.0	243,326.2	9,012.1	9,913	$ 2,025	$ 1,188			$ 13,126	$ 1,313	$ 14,439	
71	3.1	135,036	905		4.9	6.5	881,109.9	32,633.7	35,897	$ 3,675	$ 2,156			$ 41,728	$ 4,173	$ 45,901	
a	2.9	126,324	762		5	5.8	733,942.4	27,183.1	29,901	$ 3,750	$ 2,200			$ 35,851	$ 3,585	$ 39,436	
74	1.2	52,272	580		3	4.9	256,132.8	9,486.4	10,435	$ 2,250	$ 1,320			$ 14,005	$ 1,401	$ 15,406	
73	1.2	52,272	550		3	4.8	248,292.0	9,196.0	10,116	$ 2,250	$ 1,320			$ 13,686	$ 1,369	$ 15,054	
b	3.7	161,172	1825		9.7	11.1	1,793,038.5	66,408.8	73,050	$ 7,275	$ 4,268			$ 84,593	$ 8,459	$ 93,052	
c	2.6	113,256	1932		8.8	11.7	1,320,565.0	48,909.8	53,801	$ 6,600	$ 3,872			$ 64,273	$ 6,427	$ 70,700	
d	2.9	126,324	1875		9.5	11.4	1,436,935.5	53,219.8	58,542	$ 7,125	$ 4,180			$ 69,847	$ 6,985	$ 76,831	
72	1.9	82,764	658		6.5	5.3	437,821.6	16,215.6	17,837	$ 4,875	$ 2,860			$ 25,572	$ 2,557	$ 28,129	$ 769,320
McLuney #49				3444								5717.04	160077.12	$ 160,077	$ 16,008	$ 176,085	
a	6.5	283,140	3154		17.5	17.8	5,031,397.8	186,348.1	204,983	$ 13,125	$ 7,700			$ 225,808	$ 22,581	$ 248,389	
b	3.2	139,392	1639		9.7	10.2	1,421,101.4	52,633.4	57,897	$ 7,275	$ 4,268			$ 69,440	$ 6,944	$ 76,384	
c	4.4	191,664	973		14.9	6.9	1,315,773.4	48,732.3	53,606	$ 11,175	$ 6,556			$ 71,337	$ 7,134	$ 78,470	
d	2.3	100,188	1108		6.7	7.5	755,417.5	27,978.4	30,776	$ 5,025	$ 2,948			$ 38,749	$ 3,875	$ 42,624	
e	11	479,160	6537		48.4	34.7	16,619,664.6	615,543.1	677,097	$ 36,300	$ 21,296			$ 734,693	$ 73,469	$ 808,163	$ 1,430,114
																	$ 4,399,302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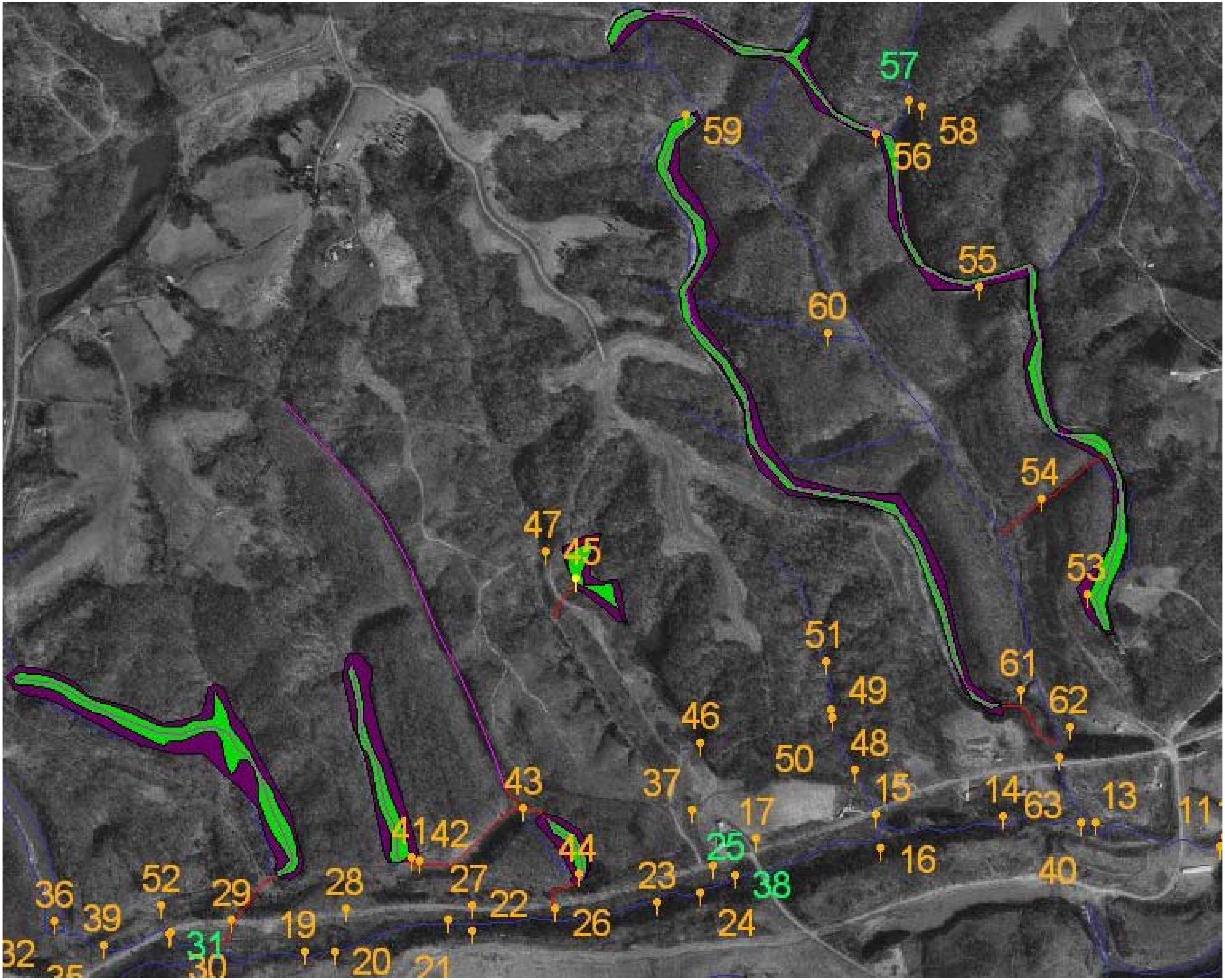
Appendix J: Basic Reclamation Data

Minimal basic cost estimation for - standard reclamation of pit impoundments
goal: Reduce water contact time with spoil and coal floor
Bear Creek

Site	Area of pond	area of pond	length	max. depth	volume of water in strip pit	Dewatering chemical required (quicklime)	Trans. Channel	re-veg area	1% grade	Total cubic feet (area of pond x depth of cover)	Total cubic yards	cost of earthwork	re-veg	lime material	2:1 slope transitional rock channel	C rock	dewatering quicklime material	sub-total	mobilization	final cost	
	acres	square feet	ft	ft.	gallons	tons	ft	acres	plus 2 ft. cover (ft)	(ft3)	(yd3)	$1.10/cubic yard	$750/ac	$440/ac	1.66tons/linear ft.	$28/ton	~$120/ton		10% final cost		Project total
Bear Creek #30							770								$ 1,278	$ 35,790		$ 35,790	$ 3,579	$ 39,369	
29	7	304,920	2867	8	18,245,026	0.4		15	16.3	4,980,868.2	184,476.6	$ 202,924	$ 11,250	$ 6,600			$ 51	$220,825	$ 22,083	$ 242,908	$ 282,276
Bear Creek #26							1951								$ 3,239	$ 90,682		$ 90,682	$ 9,068	$ 99,751	
41	2.7	117,612	1483	9	7,917,038	1		6.7	9.4	1,107,317.0	41,011.7	$ 45,113	$ 5,025	$ 2,948			$ 115	$ 53,201	$ 5,320	$ 58,521	
44	0.9	39,204	560	6	1,759,342	0.5		2.1	4.8	188,179.2	6,969.6	$ 7,667	$ 1,575	$ 924			$ 54	$ 10,220	$ 1,022	$ 11,242	
43*	1.2	52,272	2538		0			1.2	14.7	767,875.7	28,439.8	$ 31,284	$ 900	$ 528				$ 32,712	$ 3,271	$ 35,983	$ 205,496
Bear Creek #25							312								$ 518	$ 14,502		$ 14,502	$ 1,450	$ 15,952	
45**	1.2	52,272	712	8	3,127,719	0.1		2.8	5.6	290,632.3	10,764.2	$ 11,841	$ 2,100	$ 1,232			$ 10	$ 15,173	$ 1,517	$ 16,690	$ 32,642
Bear Creek #13							1528								$ 2,536	$ 71,021		$ 71,021	$ 7,102	$ 78,124	
54**	9.4	409,464	7268	8	24,500,464	3.8		15.8	38.3	15,698,849.8	581,438.9	$ 639,583	$ 11,850	$ 6,952			$ 457	$658,385	$ 65,838	$ 724,223	
61**	6.8	296,208	5560	8	17,723,740	5.5		13.7	29.8	8,826,998.4	326,925.9	$ 359,618	$ 10,275	$ 6,028			$ 661	$375,921	$ 37,592	$ 413,514	$ 1,215,860

43* Strip pit bottom marshy with braided channel no ponds are present, channel length multiplied by 20ft wide to calculate area to determine costs. $ 1,736,275
**45, 54, 61 estimated strip pit maximum depth of 8ft



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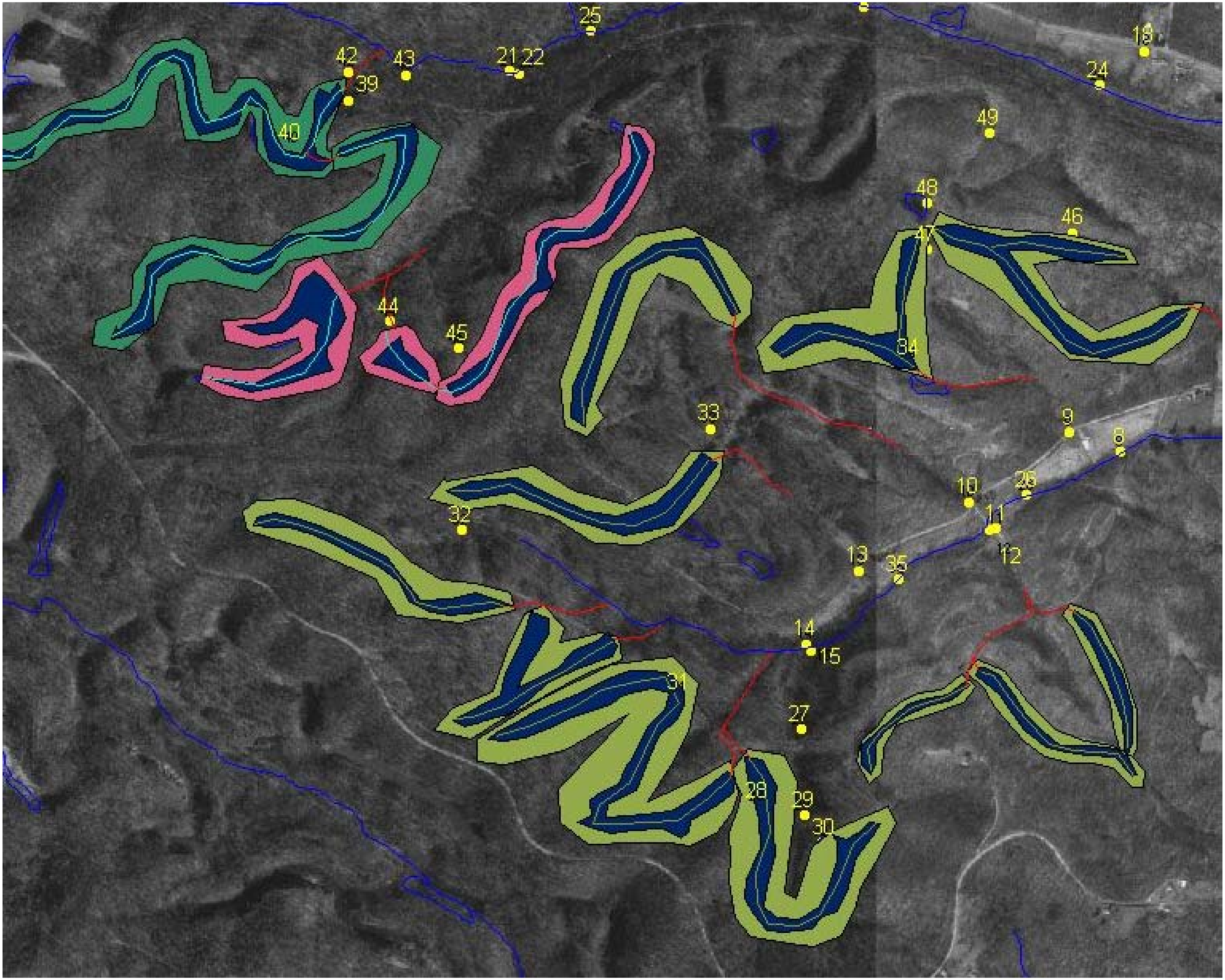
Minimal basic cost estimation for - standard reclamation of pit impoundments
goal: Reduce water contact time with spoil and coal floor
Burley Run

Site	Area of pond	area of pond	length	max. depth	volume of water in strip pit	Dewatering chemical required (quicklime)	Trans. Chan-nel	re-veg area	1% grade	Total cubic feet (area of pond x depth of cover)	Total cubic yards	cost of earthwork	re-veg	lime material	2:1 slopetransitio nal rock channel	C rock	dewatering quicklime material	sub-total	mobilization	final cost	
	acres	square feet	ft	ft.	gallons	tons	ft	acres	plus 2 ft. cover (ft)	(ft3)	(yd3)	$1.10/cubic yard	$750/ac	$440/ac	1.66tons/line ar ft.	$28/ton	$12-14/ton		10% final cost		Project total
Burley - Lewis Hollow							7366								$ 12,228	$ 342,372		$ 342,372	$ 34,237	$ 376,609	
11a	2	87,120	1046	4.5	2,932,236	0.3		4.4	7.2	629,877.6	23,328.8	25,662	$ 3,300	$ 1,936			$ 373	$ 31,271	$ 3,127	$ 34,398	
11b	2.2	95,832	1367	4.5	3,225,460	0.3		5.8	8.8	846,675.7	31,358.4	34,494	$ 4,350	$ 2,552			$ 616	$ 42,012	$ 4,201	$ 46,213	
11c	1.3	56,628	999	6	2,541,272	0.1		3.5	7.0	396,112.9	14,670.8	16,138	$ 2,625	$ 1,540			$ 36	$ 20,339	$ 2,034	$ 22,373	
15a	6.2	270,072	2337	5	10,099,925	1.6		20.3	13.7	3,695,935.3	136,886.5	150,575	$ 15,225	$ 8,932			$ 39	$ 174,771	$ 17,477	$ 192,248	
15b	9.9	431,244	3568	5	16,127,300	2.5		29.8	19.8	8,555,881.0	316,884.5	348,573	$ 22,350	$ 13,112			$ 12	$ 384,047	$ 38,405	$ 422,452	
15c	4.5	196,020	1237	5	7,330,591	1.1		9.9	8.2	1,604,423.7	59,423.1	65,365	$ 7,425	$ 4,356			$ 188	$ 77,334	$ 7,733	$ 85,068	
15d	3.3	143,748	1966	5	5,375,767	0.8		12.6	11.8	1,700,538.8	62,982.9	69,281	$ 9,450	$ 5,544			$ 301	$ 84,576	$ 8,458	$ 93,034	
13	5.5	239,580	2034	5	8,959,611	3.7		13.1	12.2	2,915,688.6	107,988.5	118,787	$ 9,825	$ 5,764			$ 137	$ 134,513	$ 13,451	$ 147,965	
10	5.1	222,156	2178	5	8,308,003	3.4		16.5	12.9	2,863,590.8	106,058.9	116,665	$ 12,375	$ 7,260			$ 100	$ 136,400	$ 13,640	$ 150,040	
9a	4.6	200,376	1849	5	7,493,493	3.1		14	11.2	2,253,228.1	83,452.9	91,798	$ 10,500	$ 6,160			$ 445	$ 108,903	$ 10,890	$ 119,794	
9b	7.6	331,056	3107	5	12,380,553	5.1		17.3	17.5	5,805,067.0	215,002.5	236,503	$ 12,975	$ 7,612			$ 413	$ 257,503	$ 25,750	$ 283,253	$ 1,973,445
Burley #22							1119								$ 1,858	$ 52,011		$ 52,011	$ 5,201	$ 57,212	
a	4.9	213,444	1341	5	7,982,199	3.7		12.8	8.7	1,858,030.0	68,815.9	75,698	$ 9,600	$ 5,632			$ 447	$ 91,377	$ 9,138	$ 100,514	
44	1.2	52,272	530	5	1,954,824	0.9		3.8	4.7	243,064.8	9,002.4	9,903	$ 2,850	$ 1,672			$ 109	$ 14,534	$ 1,453	$ 15,987	
45	5	217,800	2541	5	8,145,101	3.8		13.7	14.7	3,202,749.0	118,620.3	130,482	$ 10,275	$ 6,028			$ 456	$ 147,241	$ 14,724	$ 161,966	$ 335,679
Burley #21							710								$ 1,179	$ 33,001		$ 33,001	$ 3,300	$ 36,301	
40a	5.8	252,648	3381	5	9,448,317	4.4		20.3	18.9	4,776,310.4	176,900.4	194,590	$ 15,225	$ 8,932			$ 529	$ 219,276	$ 21,928	$ 241,204	
40b	7.4	322,344	3846	5	12,054,749	5.6		22.4	21.2	6,843,363.1	253,457.9	278,804	$ 16,800	$ 9,856			$ 675	$ 306,135	$ 30,613	$ 336,748	$ 614,253
																					$ 2,923,377

15,13,10,9 estimated max depth 5 ft.
44,45,40,24 estimated max depth 5 ft.



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Appendix K: River mile and drainage area information

Appendix K: River Miles and Drainage Areas

Site Number	RM 0	RM 1	RM 2	RM 3	RM 4	RM5	drainage basin area	RM Confluence w/ MS	basin
AC-20	809.19	73.49	24.79	3.21			2.402	24.79	Andrew
AC-33	809.19	73.49	24.79	2.85	0.1		0.537	24.79	Andrew
AC-36	809.19	73.49	24.79	2.61	0.1		0.028	24.79	Andrew
AC-37	809.19	73.49	24.79	2.51	0.1			24.79	Andrew
AC-44	809.19	73.49	24.79	2.1			4.073	24.79	Andrew
AC-29	809.19	73.49	24.79	1.58	0.05		0.148	24.79	Andrew
AC-45	809.19	73.49	24.79	1.6			4.71	24.79	Andrew
AC-13	809.19	73.49	24.79	1.3	0.05		0.09	24.79	Andrew
AC-46	809.19	73.49	24.79	1.4			4.712	24.79	Andrew
AC-32	809.19	73.49	24.79	2.1	0.14			24.79	Andrew
AC-31	809.19	73.49	24.79	2.1	0.12		0.234	24.79	Andrew
AC-30	809.19	73.49	24.79	2.1	0.1			24.79	Andrew
AC-24	809.19	73.49	24.79	2.1	0.05			24.79	Andrew
AC-01	809.19	73.49	24.79	0.32			5.69	24.79	Andrew
BR-34	809.19	73.49	21.95	3.24			0.204	21.95	Bear
BR-18	809.19	73.49	21.95	3.05	0.05			21.95	Bear
BR-36	809.19	73.49	21.95	2.9	0.15			21.95	Bear
BR-30	809.19	73.49	21.95	2.9	0.05		0.024	21.95	Bear
BR-29	809.19	73.49	21.95	2.8	0.05		0.0168	21.95	Bear
BR-22	809.19	73.49	21.95	2.5	0.05			21.95	Bear
BR-26	809.19	73.49	21.95	2.35	0.05		0.217	21.95	Bear
BR-25	809.19	73.49	21.95	2.15	0.1		0.204	21.95	Bear
BR-37	809.19	73.49	21.95	2.15	0.2			21.95	Bear
BR-38	809.19	73.49	21.95	2.1			1.976	21.95	Bear
BR-17	809.19	73.49	21.95	1.89	0.05			21.95	Bear
BR-15	809.19	73.49	21.95	1.71	0.05		0.083	21.95	Bear
BR-16	809.19	73.49	21.95	1.71			2.151	21.95	Bear
BR-01	809.19	73.49	21.95	0.09			3.879	21.95	Bear
BR-40	809.19	73.49	21.95	1.5			2.211	21.95	Bear
BR-13	809.19	73.49	21.95	1.5	0.05		0.859	21.95	Bear
BR-01	809.19	73.49	21.95	0.09			3.879	21.95	Bear
BU-25	809.19	73.49	15.4	2.25			0.79	15.4	Burly
BU-19	809.19	73.49	15.4	1.9	0.05		0.115	15.4	Burly
BU-24	809.19	73.49	15.4	1.6	0.05		0.071	15.4	Burly
BU-3	809.19	73.49	15.4	0.89			1.8	15.4	Burly
BU-26	809.19	73.49	15.4	0.85	0.9		0.805	15.4	Burly
BU-4	809.19	73.49	15.4	0.85	0.01		1.154	15.4	Burly
BU-1	809.19	73.49	15.4	0.1			3.332	15.4	Burly
SN- Headwaters	809.19	73.49	15.9	1.25			0.045	15.9	Snake
SN- source	809.19	73.49	15.9	1.16	0.02			15.9	Snake
SN- mouth	809.19	73.49	15.9	0.2			0.473	15.9	Snake
ML-21	809.19	73.49	18.4	4.57			0.743	18.4	McLuney
ML-Upst.Rort seep	809.19	73.49	18.4	4.53	0.25			18.4	McLuney
ML-Rort Seep	809.19	73.49	18.4	4.53	0.15			18.4	McLuney
ML-20	809.19	73.49	18.4	4.53	0.05		0.636	18.4	McLuney
ML-16	809.19	73.49	18.4	3.7	0.05		0.472	18.4	McLuney
ML-14	809.19	73.49	18.4	3.62	0.05		0.472	18.4	McLuney
ML-13	809.19	73.49	18.4	3.5			2.936	18.4	McLuney
ML-49	809.19	73.49	18.4	2.85	0.08		0.39	18.4	McLuney
ML-06	809.19	73.49	18.4	2.18	0.1		1.164	18.4	McLuney
ML-39	809.19	73.49	18.4	1.5			5.96	18.4	McLuney
ML-38	809.19	73.49	18.4	1.42	0.05		0.953	18.4	McLuney
ML-01	809.19	73.49	18.4	0.1			8.088	18.4	McLuney
RR-4	809.19	73.49	10.85	1.37	0.42	0.22	0.704	10.85	Riders Run
RR-5	809.19	73.49	10.85	1.37	0.42	0.21	0.803	10.85	Riders Run
RR-2	809.19	73.49	10.85	1.37	0.01		2.391	10.85	Riders Run
RR-15	809.19	73.49	10.85	0.5	0.5		0.181	10.85	Riders Run
RR-16	809.19	73.49	10.85	0.5	0.6		0.125	10.85	Riders Run
RR-10	809.19	73.49	10.85	0.5	0.19		0.272	10.85	Riders Run
RR-13	809.19	73.49	10.85	0.1			5.145	10.85	Riders Run
BF-01	809.19	73.49	16.96	0.05			NA	16.96	Black Fork
BF-10	809.19	73.49	16.96	2.15	0.01		NA	16.96	Black Fork
BF-13	809.19	73.49	16.96	3			NA	16.96	Black Fork
DR-01	809.19	73.49	16.96	1.27	0.05		NA	16.96	Black Fork
DR-02	809.19	73.49	16.96	1.27	0.65	0.01	NA	16.96	Black Fork
DR-03	809.19	73.49	16.96	1.27	0.7	0.01	NA	16.96	Black Fork
DR-07	809.19	73.49	16.96	1.27	1.1		NA	16.96	Black Fork
OC-01	809.19	73.49	16.96	2.64	0.2		NA	16.96	Black Fork
OC-04	809.19	73.49	16.96	2.64	1.2		NA	16.96	Black Fork
BR-01bf	809.19	73.49	16.96	2.64	0.88	0.1	NA	16.96	Black Fork
BR-03bf	809.19	73.49	16.96	2.64	0.88	0.75	NA	16.96	Black Fork
BR-09bf	809.19	73.49	16.96	2.64	0.88	1.2	NA	16.96	Black Fork
BR-14bf	809.19	73.49	16.96	2.64	0.88	1.5	NA	16.96	Black Fork

Appendix K: River Miles of 97-98 sites

Site Number	Source data ID	RM 0	RM 1	RM 2	RM 3	basin
MXMS0001		809.19	73.49			Moxahala Creek
MXRR0005	1	809.19	73.49	6.3		Moxahala Creek
MXMS0010	2	809.19	73.49	6.1		Moxahala Creek
MXRR0010		809.19	73.49	8.12	0.1	Ut to Moxahala
MXRR0020		809.19	73.49	8.38	0.8	Claypit Hollow
MXRR0030	12	809.19	73.49	9.1	0.1	Ut at Payne Rd
MXRR0040		809.19	73.49	9.4	0.2	Ut to Moxahala
MXRR0050		809.19	73.49	10.19	0.8	Porter
MXRR0055	9	809.19	73.49	10.8	0.1	UT b/w Rider and Porter
MXMS0020	11	809.19	73.49	11		Moxahala Creek
RR0010	10	809.19	73.49	10.85	0.1	Rider Run
MXBF0010	18	809.19	73.49	12.91	0.1	UT to Moxahala
MXBF0013	19	809.19	73.49	13.45	0.1	UT to Moxahala
MXBF0017	20	809.19	73.49	14.83	0.1	UT to Moxahala
MXBF0019	23	809.19	73.49	14.35	0.1	UT to Moxahala
MXBF0020	22	809.19	73.49	14.66	0.1	Possum Hollow
MXBF0030	21	809.19	73.49	15.4	0.1	Burley Run
MXMS0030		809.19	73.49	15.7		Moxahala Creek
MXBF0040	26	809.19	73.49	15.9	0.1	Snake Run
MXBF0045	27	809.19	73.49	16.6	0.1	Ut to Moxahala
BF0010	24	809.19	73.49	16.96	0.1	Black Fork
MXMS0037	25	809.19	73.49	17.1		Moxahala Creek
MXMS0040		809.19	73.49	17.9		Moxahala Creek
MXMC0010	28	809.19	73.49	17.15	0.1	Ut to Moxahala
MXMC0020	29	809.19	73.49	17.71	0.1	Ut to Moxahala
MC0010	30	809.19	73.49	18.84	0.1	Mcluney Creek
MXMS0050		809.19	73.49	19		Moxahala Creek
MXBC0010	33	809.19	73.49	19.05	0.1	Pussy Hollow
MXBC0020		809.19	73.49	19.3	0.1	Ut to Moxahala
MXBC0030		809.19	73.49	19.94	0.1	Ut to Moxahala
MXMS0053	35	809.19	73.49	20.1		Moxahala Creek
MXBC0040	36	809.19	73.49	20.55	0.1	Ut to Moxahala
MXBC0050	37	809.19	73.49	21.23	0.1	Ut to Moxahala
MXBC0060	38	809.19	73.49	21.93	0.1	Ut to Moxahala
MXMS0055	39	809.19	73.49	21.95		Moxahala Creek
BC0010	40	809.19	73.49	21.95	0.1	Bear Creek
MXAC0010		809.19	73.49	22.42	0.1	Ut to Moxahala
MXAC0015	49	809.19	73.49	24.05	0.1	Ut to Moxahala
MXAC0020		809.19	73.49	24.06	0.1	Ut to Moxahala
AC0010	56	809.19	73.49	24.79	0.1	Andrews Creek
MXMS0059	55	809.19	73.49	24.6		Moxahala Creek
MXMS0060	57	809.19	73.49	25.9		Moxahala Creek
MXMS0070	60	809.19	73.49	30		Moxahala Creek

Appendix K: River Miles of Biosites

Site Number	RM0	RM1	RM2	RM3	RM4	basin
biosite #01	809.19	73.49	3.3			Keskington bridge
biosite #02	809.19	73.49	6.7			Mainstream Lambert R[
biosite #03	809.19	73.49	16.1			UPST. Crooksville
biosite #04	809.19	73.49	17.9			UPST. Blackfork
biosite #05	809.19	73.49	20			T196
biosite #06	809.19	73.49	24			DST. Andrew
biosite #07	809.19	73.49	25.4			Downtown MOX
biosite #08	809.19	73.49	10.85	1.3		Riders run
biosite #09	809.19	73.49	12.91	0.2		Rainer
biosite #10	809.19	73.49	18.84	0.1		McLuney (low flow)
biosite #11	809.19	73.49	18.84	1.64		
biosite #12	809.19	73.49	15.4	0.8		Burly
biosite #13	809.19	73.49	10.19	0.7		Porter
biosite #14	809.19	73.49	9.1	0.8		Payne Run
biosite #15	809.19	73.49	10.8			Mainstem
biosite #16	809.19	73.49	5.24	0.7		MORRISON
biosite #17	809.19	73.49	10.85	1.37	0.1	ELK RUN
biosite #18	809.19	73.49	24.79	0.3		Andrew
biosite #19	809.19	73.49	8.38	0.5		CLAY PIT
biosite #20	809.19	73.49	15.9	0.1		Snake
biosite #21	809.19	73.49	21.95	0.1		Bear
biosite #22	809.19	73.49	4.54	21.1		Glenford - Bio site
biosite #23	809.19	73.49	4.54	3.22	0.9	Kent RUN - Bio site
biosite #23	809.19	73.49	4.54	3.22	0.9	Kent RUN - QAQC

Appendix L: AMD Treat project costs

Printed on 03/16/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrew -20 -all

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**0**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	120,721
Ammonia	0
Soda Ash	0
Active Subtotal:	**120,721**
Ancillary Cost	
Primary Retention Pond	114,004
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	23,623
Other Cost (Capital Cost)	1,500
Ancillary Subtotal:	**139,127**
Total Capital Cost:	**259,848**
Annual Costs	
Sampling	3,472
Labor	10,920
Maintenance	8,268
Pumping	0
Chemical Cost	46,649
Sludge Removal	27,927
Other Cost (Annual Cost)	0
Total Annual Cost:	**97,236**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

○ Calculate Net Acidity (Acid-Alkalinity)
◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	187.00	mg/L

Design Flow	2595.00	gpm
Average Flow	1722.00	gpm
Total Iron	14.00	mg/L
Aluminum	5.50	mg/L
Manganese	11.00	mg/L
pH	3.17	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	741.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1485.00	uS/cm
Total Dissolved Solids	1077.00	mg/L
Dissolved Oxygen	10.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrew -20 -all

Printed on 03/16/2005

AMD TREAT

PEBBLE QUICK LIME

1. Annual Pebble Quick Lime	466.4	tons/yr
2. Pebble Quick Lime 50 Lbs Bags	51.1	per day
3. Pounds per Hour of Pebble Quick Lime	106.504348	lbs/hr
4. Refill Frequency for 1 Ton Bin	0.782	days
5. Refill Frequency for 35 Ton Silo	27.385	days
6. Purity of Pebble Quick Lime	94.00	%
7. Mixing Efficency of Pebble Quick Lime	90.00	%
☐ 8. Titration?		
9. Pebble Quick Lime Titration Amount		lbs of Pebble Lime /gal of H2O
10. Excavation Unit Cost	4.50	$/yd3
11. Aggregate Unit Cost	18.00	$/yd3
12. Aggregate Placement Unit Cost	12.00	$/yd3

13. Ditching System

◉ **Default Ditching System Based on Flow**

14. Default Ditch Length	700	ft
15. Default Ditch Bottom Width	10	ft
16. Default Ditch Depth	3	ft

○ **Custom Ditching System**

17. Ditch Length		ft
18. Ditch Bottom Width		ft
19. Ditch Depth		ft
20. Slope Ratio of Ditch Sides	Run : Rise	
21. Rock Depth in Ditch		ft
22. Length of Rock Lined Ditch		ft

☑ **23. Clearing and Grubbing?**

◉ 24a. Land Multiplier	1.5	ratio
○ 24b. Clear/Grub Acres		acres
25. Clear and Grub Cost	1256	$/acre

26. Select One Storage System

○ 1 Ton Bin Storage System		$
◉ 35 Ton Silo Storage System	85000	$

☑ 27. Electric Mixer ?

28. Electric Mixer System Cost	2500	$

Pebble Quick Lime Sub-Totals

29. Clear Grub Area	0.2	acres
30. Storage System Cost	85,000	$
31. Electric Mixer Cost	2,500	$
32. Aggregate Cost	27,318	$
33. Ditch Excavation Cost	5,599	$
34. Clear and Grub Cost	302	$
35. Total Cost	120,721	$

Printed on 03/16/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrew -20 -all

AMD TREAT

CHEMICAL COST

A. Hydrated Lime ?

1 Titration?

2. Hydrated Lime Titration Amount		lbs of hydrated lime / gal of H_2O
3. Hydrated Lime Purity		%
4. Mixing Efficiency of Hydrated Lime		%
5. Hydrated Lime Unit Cost		$/lb

B. Pebble Quick Lime ?

6. Titration?

7. Pebble Lime Titration Amount		lbs of Pebble Lime / gal of H_2O
8. Pebble Lime Purity	94.00	%
9. Mixing Efficiency of Pebble Lime	90.00	%

Delivered in Bags

10. Pebble Lime Bag Unit Cost		$/lb

Bulk Delivery

11. Pebble Lime Bulk Unit Cost	0.0500	$/lb

C. Caustic Soda ?

12. Titration?

13. Caustic Titration Amount		gal ofcaustic / gal H_2O
14. Caustic Purity		purity of 20% caustic solution
15. Mixing Efficiency of Caustic		%

Non-Bulk Delivery

16. Caustic Non-Bulk Unit Cost		$/gal

Bulk Delivery

17. Caustic Bulk Unit Cost		$/gal

D. Limestone ?

18. Limestone Purity		%
19. Limestone Efficiency		%
20 Limestone Unit Cost		$/ton

E. Anhydrous Ammonia ?

21. Titration?

22. AmmoniaTitration Amount		lbs of ammonia / gal H_2O
23. Ammonia Purity		%
24. Mixing Efficiency of Ammonia		%

Non-Bulk Delivery

25. Ammonia Non-Bulk Unit Cost		$/lb

Bulk Delivery

26. Ammonia Bulk Unit Cost		$/lb

F. Soda Ash ?

27. Titration?

28 Soda Ash Titration Amount		lbs of soda ash / gal of H_2O
29. Soda Ash Purity		%
30. Mixing Efficiency of Soda Ash		%
31 Soda Ash Unit Cost		$/lb

Chemical Cost Sub-Totals			Annual Amount of Chemicals Consumed	
32. Total Hydrated Lime Cost	60,359	$	1,207,179	lbs
33. Total Pebble Lime Cost	46,649	$	932,978	lbs
34. Total Caustic Soda Cost	316,378	$	632,755	gals
35. Total Limestone Cost	15,661	$	1,305	tons
36. Total Anhydrous Ammonia Cost	203,814	$	509,534	lbs
37. Total Soda Ash Cost	352,129	$	2,515,203	lbs

38. Selected Chemical: **PEBBLE QUICK LIME**

Annual Chemical Cost 46,649 $

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrew -20 -all

Printed on 03/16/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (●) **No Liner**
- ( ) **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ( ) **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☑ 16. Clearing and Grubbing?

(●) 17a. Land Multiplier	1.50	ratio
( ) 17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost	1256.00	$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	577	ft
22. Width at Top of Freeboard	292	ft
23. Estimated Annual Sludge	4,557	yd3/yr
24. Volume of Sludge per Removal	4,557	yd3/ removal
25. Freeboard Volume	12,284	yd3
26. Water Volume	18,501	yd3
27. Excavation Volume	23,059	yd3
28. Excavation Volume	14.29	ac ft
29. Clear and Grub Area	5.83	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	103,765	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	7,322	$
35. Revegetation Cost	2,915	$
36. Estimated Cost	114,004	$

Printed on 03/16/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrew -20 -all

AMD TREAT

SLUDGE REMOVAL

1. Select One — Selection for Method of Removing Sludge

- (selected) Sludge Removal by $ per Gallon
  - 2. Sludge Removal Unit Cost: 0.05 $/gal
- Sludge Removal by Vacuum Truck
  - 3. Vacuum Truck Unit Cost: $/hr
  - 4. Mobilization Cost: $
  - 5. Hours to be Used: hr
- Sludge Removal by Mechanical Excavation
  - 6. Mechanical Excavation Unit Rate: $/hr
  - 7. Mobilization Cost: $
  - 8. Hours to be Used: hr
- Sludge Removal by Lagoon Cleaner
  - 9. Lagoon Cleaning Unit Rate: $/hr
  - 10. Mobilization Cost: $
  - 11. Hours to be Used: hr
- Actual Sludge Removal Cost
  - 12. Actual Sludge Removal Cost: $

13. Off Site Disposal Cost: 0.00 $

14. Iron Concentration	14.00	mg/L
15. Manganese Concentration	11.00	mg/L
16. Aluminum Concentration	5.50	mg/L
17. Total Miscellaneous Concentration	0	mg/L
18. Percent Solids	5.00	%
19. Sludge Density	8.33	lbs/gal
20 Titration?	☐	
21. Gal. of Sludge per Gal of Water Treated		gal
22. Estimated Sludge Volume	2,765	yd3/yr

Cost for Sludge Removal Types

23. Removal by $ per Gallon	27,926	$
24. Removal by Vacuum Truck	0	$
25. Removal by Mechanical Excavation	0	$
26. Removal by Lagoon Cleaner	0	$
27. Actual Sludge Removal Cost	0	$

Sludge Removal Sub-Totals

28. Currently Selected Removal Cost Plus Off Site Disposal Cost	27,927	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrews 46 - all

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**0**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	120,419
Ammonia	0
Soda Ash	0
Active Subtotal:	**120,419**
Ancillary Cost	
Primary Retention Pond	302,090
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	42,401
Other Cost (Capital Cost)	1,500
Ancillary Subtotal:	**345,991**
Total Capital Cost:	**466,410**
Annual Costs	
Sampling	3,472
Labor	10,920
Maintenance	14,840
Pumping	0
Chemical Cost	180,710
Sludge Removal	185,032
Other Cost (Annual Cost)	0
Total Annual Cost:	**394,974**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ● Enter Net Acidity manually

Net Acidity (Hot Acidity)	423.00	mg/L
Design Flow	4360.00	gpm
Average Flow	2949.00	gpm
Total Iron	85.00	mg/L
Aluminum	19.00	mg/L
Manganese	14.00	mg/L
pH	3.01	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	1111.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1940.00	uS/cm
Total Dissolved Solids	1610.00	mg/L
Dissolved Oxygen	10.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrews 46 - all

Printed on 03/16/2005

AMD TREAT

PEBBLE QUICK LIME

1. Annual Pebble Quick Lime	1,807.0	tons/yr
2. Pebble Quick Lime 50 Lbs Bags	198.0	per day
3. Pounds per Hour of Pebble Quick Lime	412.579578	lbs/hr
4. Refill Frequency for 1 Ton Bin	0.201	days
5. Refill Frequency for 35 Ton Silo	7.069	days
6. Purity of Pebble Quick Lime	94.00	%
7. Mixing Efficency of Pebble Quick Lime	90.00	%
☐ 8. Titration?		
9. Pebble Quick Lime Titration Amount		lbs of Pebble Lime /gal of H2O
10. Excavation Unit Cost	4.50	$/yd3
11. Aggregate Unit Cost	18.00	$/yd3
12. Aggregate Placement Unit Cost	12.00	$/yd3

13. Ditching System

◉ **Default Ditching System Based on Flow**

14. Default Ditch Length	700	ft
15. Default Ditch Bottom Width	10	ft
16. Default Ditch Depth	3	ft

○ **Custom Ditching System**

17. Ditch Length		ft
18. Ditch Bottom Width		ft
19. Ditch Depth		ft
20. Slope Ratio of Ditch Sides	Run : Rise	
21. Rock Depth in Ditch		ft
22. Length of Rock Lined Ditch		ft

☐ **23. Clearing and Grubbing?**

○ 24a. Land Multiplier		ratio
○ 24b. Clear/Grub Acres		acres
25. Clear and Grub Cost		$/acre

26. Select One Storage System

○ 1 Ton Bin Storage System		$
◉ 35 Ton Silo Storage System	85000	$

☑ 27. Electric Mixer ?

28. Electric Mixer System Cost	2500	$

Pebble Quick Lime Sub-Totals

29. Clear Grub Area	0.0	acres
30. Storage System Cost	85,000	$
31. Electric Mixer Cost	2,500	$
32. Aggregate Cost	27,318	$
33. Ditch Excavation Cost	5,599	$
34. Clear and Grub Cost	0	$
35. Total Cost	120,419	$

Printed on 03/16/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrews 46 - all

AMD TREAT

CHEMICAL COST

A. Hydrated Lime ?

1 Titration?

2. Hydrated Lime Titration Amount		lbs of hydrated lime / gal of H2O
3. Hydrated Lime Purity		%
4. Mixing Efficiency of Hydrated Lime		%
5. Hydrated Lime Unit Cost		$/lb

B. Pebble Quick Lime ?

6. Titration?

7. Pebble Lime Titration Amount		lbs of Pebble Lime / gal of H2O
8. Pebble Lime Purity	94.00	%
9. Mixing Efficiency of Pebble Lime	90.00	%

Delivered in Bags

10. Pebble Lime Bag Unit Cost		$/lb

Bulk Delivery

11. Pebble Lime Bulk Unit Cost	0.0500	$/lb

C. Caustic Soda ?

12. Titration?

13. Caustic Titration Amount		gal ofcaustic / gal H2O
14. Caustic Purity		purity of 20% caustic solution
15. Mixing Efficiency of Caustic		%

Non-Bulk Delivery

16. Caustic Non-Bulk Unit Cost		$/gal

Bulk Delivery

17. Caustic Bulk Unit Cost		$/gal

D. Limestone ?

18. Limestone Purity		%
19. Limestone Efficiency		%
20 Limestone Unit Cost		$/ton

E. Anhydrous Ammonia ?

21. Titration?

22. AmmoniaTitration Amount		lbs of ammonia / gal H2O
23. Ammonia Purity		%
24. Mixing Efficiency of Ammonia		%

Non-Bulk Delivery

25. Ammonia Non-Bulk Unit Cost		$/lb

Bulk Delivery

26. Ammonia Bulk Unit Cost		$/lb

F. Soda Ash ?

27. Titration?

28 Soda Ash Titration Amount		lbs of soda ash / gal of H2O
29. Soda Ash Purity		%
30. Mixing Efficiency of Soda Ash		%
31 Soda Ash Unit Cost		$/lb

Chemical Cost Sub-Totals			Annual Amount of Chemicals Consumed	
32. Total Hydrated Lime Cost	233,820	$	4,676,405	lbs
33. Total Pebble Lime Cost	180,710	$	3,614,197	lbs
34. Total Caustic Soda Cost	1,225,594	$	2,451,187	gals
35. Total Limestone Cost	60,667	$	5,055	tons
36. Total Anhydrous Ammonia Cost	789,540	$	1,973,850	lbs
37. Total Soda Ash Cost	1,364,086	$	9,743,468	lbs

38. Selected Chemical: **PEBBLE QUICK LIME**

Annual Chemical Cost 180,710 $

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrews 46 - all

Printed on 03/16/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (●) **No Liner**
- ( ) **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ( ) **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☑ 16. Clearing and Grubbing?

(●) 17a. Land Multiplier	1.50	ratio
( ) 17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost	1256.00	$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	929	ft
22. Width at Top of Freeboard	468	ft
23. Estimated Annual Sludge	30,191	yd3/yr
24. Volume of Sludge per Removal	30,191	yd3/ removal
25. Freeboard Volume	31,862	yd3
26. Water Volume	31,085	yd3
27. Excavation Volume	61,276	yd3
28. Excavation Volume	37.98	ac ft
29. Clear and Grub Area	15.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	275,743	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	18,844	$
35. Revegetation Cost	7,501	$
36. Estimated Cost	302,090	$

Printed on 03/16/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Andrews 46 - all

AMD TREAT

SLUDGE REMOVAL

1. Select One — Selection for Method of Removing Sludge

(•) Sludge Removal by $ per Gallon

2. Sludge Removal Unit Cost	0.05	$/gal

( ) Sludge Removal by Vacuum Truck

3. Vacuum Truck Unit Cost		$/hr
4. Mobilization Cost		$
5. Hours to be Used		hr

( ) Sludge Removal by Mechanical Excavation

6. Mechanical Excavation Unit Rate		$/hr
7. Mobilization Cost		$
8. Hours to be Used		hr

( ) Sludge Removal by Lagoon Cleaner

9. Lagoon Cleaning Unit Rate		$/hr
10. Mobilization Cost		$
11. Hours to be Used		hr

( ) Actual Sludge Removal Cost

12. Actual Sludge Removal Cost		$

13. Off Site Disposal Cost	0.00	$

14. Iron Concentration	85.00	mg/L
15. Manganese Concentration	14.00	mg/L
16. Aluminum Concentration	19.00	mg/L
17. Total Miscellaneous Concentration	0	mg/L
18. Percent Solids	5.00	%
19. Sludge Density	8.33	lbs/gal

☐ 20 Titration?

21. Gal. of Sludge per Gal of Water Treated		gal
22. Estimated Sludge Volume	18,323	yd3/yr

Cost for Sludge Removal Types

23. Removal by $ per Gallon	185,032	$
24. Removal by Vacuum Truck	0	$
25. Removal by Mechanical Excavation	0	$
26. Removal by Lagoon Cleaner	0	$
27. Actual Sludge Removal Cost	0	$

Sludge Removal Sub-Totals

28. Currently Selected Removal Cost Plus Off Site Disposal Cost	185,032	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name Bear-01

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**0**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	120,419
Ammonia	0
Soda Ash	0
Active Subtotal:	**120,419**
Ancillary Cost	
Primary Retention Pond	171,730
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	0
Other Cost (Capital Cost)	750
Ancillary Subtotal:	**172,480**
Total Capital Cost:	**292,899**
Annual Costs	
Sampling	3,472
Labor	10,920
Maintenance	10,251
Pumping	0
Chemical Cost	55,359
Sludge Removal	34,815
Other Cost (Annual Cost)	0
Total Annual Cost:	**114,817**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

○ Calculate Net Acidity (Acid-Alkalinity)
◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	157.00	mg/L
Design Flow	4412.00	gpm
Average Flow	2434.00	gpm
Total Iron	6.50	mg/L
Aluminum	4.60	mg/L
Manganese	15.80	mg/L
pH	3.36	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	916.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1640.00	uS/cm
Total Dissolved Solids	1350.00	mg/L
Dissolved Oxygen	10.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name Bear-01

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**0**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	120,419
Ammonia	0
Soda Ash	0
Active Subtotal:	**120,419**
Ancillary Cost	
Primary Retention Pond	171,730
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	0
Other Cost (Capital Cost)	750
Ancillary Subtotal:	**172,480**
Total Capital Cost:	**292,899**
Annual Costs	
Sampling	3,472
Labor	10,920
Maintenance	10,251
Pumping	0
Chemical Cost	55,359
Sludge Removal	34,815
Other Cost (Annual Cost)	0
Total Annual Cost:	**114,817**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

○ Calculate Net Acidity (Acid-Alkalinity)
◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	157.00	mg/L
Design Flow	4412.00	gpm
Average Flow	2434.00	gpm
Total Iron	6.50	mg/L
Aluminum	4.60	mg/L
Manganese	15.80	mg/L
pH	3.36	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	916.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1640.00	uS/cm
Total Dissolved Solids	1350.00	mg/L
Dissolved Oxygen	10.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name Bear-01

Printed on **03/22/2005**

AMD TREAT

PEBBLE QUICK LIME

1. Annual Pebble Quick Lime	553.5	tons/yr
2. Pebble Quick Lime 50 Lbs Bags	60.6	per day
3. Pounds per Hour of Pebble Quick Lime	126.390029	lbs/hr
4. Refill Frequency for 1 Ton Bin	0.659	days
5. Refill Frequency for 35 Ton Silo	23.076	days
6. Purity of Pebble Quick Lime	94.00	%
7. Mixing Efficency of Pebble Quick Lime	90.00	%
☐ 8. Titration?		
9. Pebble Quick Lime Titration Amount		lbs of Pebble Lime /gal of H2O
10. Excavation Unit Cost	4.50	$/yd3
11. Aggregate Unit Cost	18.00	$/yd3
12. Aggregate Placement Unit Cost	12.00	$/yd3

13. Ditching System

(•) **Default Ditching System Based on Flow**

14. Default Ditch Length	700	ft
15. Default Ditch Bottom Width	10	ft
16. Default Ditch Depth	3	ft

( ) **Custom Ditching System**

17. Ditch Length		ft
18. Ditch Bottom Width		ft
19. Ditch Depth		ft
20. Slope Ratio of Ditch Sides	Run : Rise	
21. Rock Depth in Ditch		ft
22. Length of Rock Lined Ditch		ft

☐ **23. Clearing and Grubbing?**

( ) 24a. Land Multiplier		ratio
( ) 24b. Clear/Grub Acres		acres
25. Clear and Grub Cost		$/acre

26. Select One Storage System

( ) 1 Ton Bin Storage System		$
(•) 35 Ton Silo Storage System	85000	$

☑ 27. Electric Mixer ?

28. Electric Mixer System Cost	2500	$

Pebble Quick Lime Sub-Totals

29. Clear Grub Area	0.0	acres
30. Storage System Cost	85,000	$
31. Electric Mixer Cost	2,500	$
32. Aggregate Cost	27,318	$
33. Ditch Excavation Cost	5,599	$
34. Clear and Grub Cost	0	$
35. Total Cost	120,419	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name Bear-01

Printed on 03/22/2005

AMD TREAT

CHEMICAL COST

A. Hydrated Lime ?

1 Titration?

2. Hydrated Lime Titration Amount		lbs of hydrated lime / gal of H2O
3. Hydrated Lime Purity		%
4. Mixing Efficiency of Hydrated Lime		%
5. Hydrated Lime Unit Cost		$/lb

B. Pebble Quick Lime ?

6. Titration?

7. Pebble Lime Titration Amount		lbs of Pebble Lime / gal of H2O
8. Pebble Lime Purity	94.00	%
9. Mixing Efficiency of Pebble Lime	90.00	%

Delivered in Bags

10. Pebble Lime Bag Unit Cost		$/lb

Bulk Delivery

11. Pebble Lime Bulk Unit Cost	0.0500	$/lb

C. Caustic Soda ?

12. Titration?

13. Caustic Titration Amount		gal ofcaustic / gal H2O
14. Caustic Purity		purity of 20% caustic solution
15. Mixing Efficiency of Caustic		%

Non-Bulk Delivery

16. Caustic Non-Bulk Unit Cost		$/gal

Bulk Delivery

17. Caustic Bulk Unit Cost		$/gal

D. Limestone ?

18. Limestone Purity		%
19. Limestone Efficiency		%
20 Limestone Unit Cost		$/ton

E. Anhydrous Ammonia ?

21. Titration?

22. AmmoniaTitration Amount		lbs of ammonia / gal H2O
23. Ammonia Purity		%
24. Mixing Efficiency of Ammonia		%

Non-Bulk Delivery

25. Ammonia Non-Bulk Unit Cost		$/lb

Bulk Delivery

26. Ammonia Bulk Unit Cost		$/lb

F. Soda Ash ?

27. Titration?

28 Soda Ash Titration Amount		lbs of soda ash / gal of H2O
29. Soda Ash Purity		%
30. Mixing Efficiency of Soda Ash		%
31 Soda Ash Unit Cost		$/lb

	Chemical Cost Sub-Totals		Annual Amount of Chemicals Consumed	
32. Total Hydrated Lime Cost	71,629	$	1,432,574	lbs
33. Total Pebble Lime Cost	55,359	$	1,107,176	lbs
34. Total Caustic Soda Cost	375,450	$	750,899	gals
35. Total Limestone Cost	18,585	$	1,548	tons
36. Total Anhydrous Ammonia Cost	255,306	$	638,264	lbs
37. Total Soda Ash Cost	417,875	$	2,984,823	lbs

38. Selected Chemical: **PEBBLE QUICK LIME**

Annual Chemical Cost 55,359 $

Company Name	ILGARD	Printed on 03/22/2005
Project	Moxahala AMDAT	
Site Name	Bear-01	

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (•) **No Liner**
- ( ) **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ( ) **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☐ 16. Clearing and Grubbing?

17a. Land Multiplier		ratio
17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	728	ft
22. Width at Top of Freeboard	368	ft
23. Estimated Annual Sludge	5,681	yd3/yr
24. Volume of Sludge per Removal	5,681	yd3/ removal
25. Freeboard Volume	19,523	yd3
26. Water Volume	31,455	yd3
27. Excavation Volume	37,137	yd3
28. Excavation Volume	23.01	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	167,117	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	4,613	$
36. Estimated Cost	171,730	$

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Company Name ILGARD

Project Moxahala AMDAT

Site Name Bear-01

AMD TREAT

SLUDGE REMOVAL

1. Select One — Selection for Method of Removing Sludge

(•) Sludge Removal by $ per Gallon

2. Sludge Removal Unit Cost	0.05	$/gal

( ) Sludge Removal by Vacuum Truck

3. Vacuum Truck Unit Cost		$/hr
4. Mobilization Cost		$
5. Hours to be Used		hr

( ) Sludge Removal by Mechanical Excavation

6. Mechanical Excavation Unit Rate		$/hr
7. Mobilization Cost		$
8. Hours to be Used		hr

( ) Sludge Removal by Lagoon Cleaner

9. Lagoon Cleaning Unit Rate		$/hr
10. Mobilization Cost		$
11. Hours to be Used		hr

( ) Actual Sludge Removal Cost

12. Actual Sludge Removal Cost		$
13. Off Site Disposal Cost	0.00	$

14. Iron Concentration	6.50	mg/L
15. Manganese Concentration	15.80	mg/L
16. Aluminum Concentration	4.60	mg/L
17. Total Miscellaneous Concentration	0	mg/L
18. Percent Solids	5.00	%
19. Sludge Density	8.33	lbs/gal
☐ 20 Titration?		
21. Gal. of Sludge per Gal of Water Treated		gal
22. Estimated Sludge Volume	3,447	yd3/yr

Cost for Sludge Removal Types

23. Removal by $ per Gallon	34,814	$
24. Removal by Vacuum Truck	0	$
25. Removal by Mechanical Excavation	0	$
26. Removal by Lagoon Cleaner	0	$
27. Actual Sludge Removal Cost	0	$

Sludge Removal Sub-Totals

28. Currently Selected Removal Cost Plus Off Site Disposal Cost	34,815	$

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Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-18

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	20,109
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**20,109**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	5,000
Secondary Pond	0
Roads	437
Land Access	0
Ditching	0
Engineering Cost	2,555
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**7,992**
Total Capital Cost:	**28,101**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	0
Sludge Removal	0
Other Cost (Annual Cost)	0
Total Annual Cost:	**3,472**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	348.00	mg/L
Design Flow	12.50	gpm
Average Flow	10.00	gpm
Total Iron	100.00	mg/L
Aluminum	12.60	mg/L
Manganese	16.90	mg/L
pH	4.20	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	1362.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	2095.00	uS/cm
Total Dissolved Solids	2050.00	mg/L
Dissolved Oxygen	1.00	mg/L

Company Name ILGARD | Printed on 03/22/2005

Project Moxahala AMDAT

Site Name BR-18

AMD TREAT

ROADS

1. Road Length	60	ft
2. Road Width	15	ft
3. Road Depth	1.00	ft
4. Aggregate Unit Cost	12.00	$/yd3
5. GeoTextile Length	0	ft
6. GeoTextile Unit Cost	0.50	$/yd2
7. Length of Silt Fence	0	ft
8. Unit Cost of Silt Fence	1.00	$/ft
☐ 9. Surveying?		
10. Survey Rate		acres/day
11. Survey Unit Cost		$/day
☑ 12. Clearing and Grubbing?		
13. Clear and Grub Cost	1256	$/acre

14. Reveg Unit Cost	1500.00	$/acre
15. Culvert Unit Cost	30.00	$/ft
16. Culvert Length	0	ft

Roads Sub-Totals

17. Road Surface Cost	400	$
18. GeoTextile Cost	0	$
19. Silt Fence Cost	0	$
20. Culvert Cost	0	$
21. Revegetation Cost	6	$
22. Survey Cost	0	$
23. Clear and Grub Cost	31	$

24. Total Cost 437 $

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-18

Printed on 03/22/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (•) **No Liner**
- ( ) **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ( ) **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☐ 16. Clearing and Grubbing?

17a. Land Multiplier		ratio
17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	71	ft
22. Width at Top of Freeboard	39	ft
23. Estimated Annual Sludge	112	yd3/yr
24. Volume of Sludge per Removal	112	yd3/ removal
25. Freeboard Volume	181	yd3
26. Water Volume	89	yd3
27. Excavation Volume	201	yd3
28. Excavation Volume	0.12	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	906	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	49	$
36. Estimated Cost	956	$

☑ 37. Accept Minimum Pond Cost?

The Recommended Minimum Construction Cost of Building a Pond is $ 5,000

38. Recommended Minimum Cost	5,000	$
39. Total Cost	5,000	$

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Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-18

AMD TREAT

VERTICAL FLOW POND (VFP)

SIZING METHODS Select One

1. Tons of Limestone Needed	352	○ VFP Based on Acidity Neutralization			
2. Tons of Limestone Needed	246	○ VFP Based on Retention Time	6. Retention Time		hours
3. Tons of Limestone Needed	1,646	○ VFP Based on Alkalinity Generation Rate	7. Alkalinity Generation Rate		g/m2/day
4. Tons of Limestone Needed	599	◉ VFP Based on Tons Limestone Entered	8. Limestone Needed	599	tons
5. Tons of Limestone Needed	1,921	○ VFP Based on Dimensions	9. Length at Top of Freeboard		ft
			10. Width at Top of Freeboard		ft

11. % Void Space of LS. Bed	35.00	%
12. System Life		years
13. Limestone Purity	90.00	%
14. Limestone Efficiency		%
15. Density of Loose Limestone	107.53	lbs/ft3
16. Limestone Unit Cost	12.00	$/ton
17. LS Placement Unit Cost	0.00	$/yd3
18. Slope of Pond Sides (Run of Slope : Rise of Slope)	2.0 : 1	
19. Freeboard Depth	3.00	ft
20. Free Standing Water Depth	2.0	ft
21. Organic Matter Depth	1.0	ft
22. Organic Matter Unit Cost	19.00	$/yd3
23. Organic Matter Spreading Unit Cost	3.50	$/yd3
24. Limestone Depth	3.0	ft
25. Excavation Unit Cost	4.50	$/yd3

Liner Cost

◉ **No Liner**

○ **Clay Liner**

11. Clay Liner Unit Cost		$/yd3
12. Thickness of Clay Liner		ft

○ **Synthetic Liner**

13. Synthetic Liner Unit Cost		$/yd2

☐ **29. Clearing and Grubbing?**

○ 30a. Land Multiplier		ratio
○ 30b. Clear/Grub Acres		acres
31. Clear and Grub Unit Cost		$/acre
32. Nbr. of Valves	0	nbr
33. Unit Cost of Valves	0.00	$ ea.

◉ **AMDTreat Piping Costs**

34. Total Length of Effluent / Influent Pipe	20	ft
35. Pipe Install Rate	11.00	ft/hr
36. Labor Rate	35.00	$/hr
37. Segment Len. of Trunk Pipe	20	ft/pipe seg.
38. Trunk Pipe Cost	6.70	$/ft
39. Trunk Coupler Cost	6.60	$/coupler
40. Spur Cost	1.83	$/ft
41. Spur Coupler Cost	2.43	$/spur
42. "T" Connector Cost	90.00	$/T coupler
43. Segment Len. of Spur Pipe	20	ft/pipe seg.
44. Spur Pipe Spacing	10.0	ft

○ **Custom Piping Costs**

	Length	Diameter	Unit Cost
45. Pipe #1	ft	in	
46. Pipe #2	ft	in	
47. Pipe #3	ft	in	

VFP Sizing Summaries

48. Length at Top of Freeboard	119.09	ft
49. Width at Top of Freeboard	71.54	ft
50. Freeboard Volume	825	yd3
51. Water Surface Area	6,377	ft2
52. Total Water Volume	424	yd3
53. Organic Matter Volume	178	yd3
54. Limestone Surface Area	4,521	ft2
55. Limestone Volume	412.64	yd3
56. Excavation Volume	1,015.4	yd3
57. Clear and Grub Area	0.0	acres
58. Liner Area	0.0	ft2
59. Theoretical Retention Time	38.89	hrs

VFP Cost Summaries

60. Organic Matter Cost	3,386	$
61. Limestone Cost	7,188	$
62. Limestone and Organic Matter Placement Cost	623	$
63. Excavation Cost	4,570	$
64. Liner Cost	0	$
65. Clear and Grub Cost	0	$
66. Valve Cost	0	$
67. Pipe Cost	4,342	$
68. Total Cost	20,109	$

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Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-22

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	51,913
Anoxic Limestone Drain	0
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**51,913**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	5,000
Secondary Pond	0
Roads	1,458
Land Access	0
Ditching	0
Engineering Cost	5,837
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**12,295**
Total Capital Cost:	**64,208**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	0
Sludge Removal	0
Other Cost (Annual Cost)	0
Total Annual Cost:	**3,472**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	456.00	mg/L
Design Flow	30.00	gpm
Average Flow	18.00	gpm
Total Iron	220.00	mg/L
Aluminum	1.80	mg/L
Manganese	29.90	mg/L
pH	5.26	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	1906.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	2815.00	uS/cm
Total Dissolved Solids	2900.00	mg/L
Dissolved Oxygen	2.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-22

Printed on 03/22/2005

AMD TREAT

ROADS

1. Road Length	200	ft
2. Road Width	15	ft
3. Road Depth	1.00	ft
4. Aggregate Unit Cost	12.00	$/yd3
5. GeoTextile Length	0	ft
6. GeoTextile Unit Cost	0.50	$/yd2
7. Length of Silt Fence	0	ft
8. Unit Cost of Silt Fence	1.00	$/ft
☐ 9. Surveying?		
10. Survey Rate		acres/day
11. Survey Unit Cost		$/day
☑ 12. Clearing and Grubbing?		
13. Clear and Grub Cost	1256	$/acre

14. Reveg Unit Cost	1500.00	$/acre
15. Culvert Unit Cost	30.00	$/ft
16. Culvert Length	0	ft

Roads Sub-Totals

17. Road Surface Cost	1,333	$
18. GeoTextile Cost	0	$
19. Silt Fence Cost	0	$
20. Culvert Cost	0	$
21. Revegetation Cost	21	$
22. Survey Cost	0	$
23. Clear and Grub Cost	104	$
24. Total Cost	1,458	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-22

Printed on 03/22/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (•) **No Liner**
- ( ) **Clay Liner**
  - 13. Clay Liner Unit Cost: ____ $/yd3
  - 14. Thickness of Clay Liner: ____ ft
- ( ) **Synthetic Liner**
  - 15. Synthetic Liner Unit Cost: ____ $/yd2

☐ 16. Clearing and Grubbing?

17a. Land Multiplier		ratio
17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre

19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	110	ft
22. Width at Top of Freeboard	59	ft
23. Estimated Annual Sludge	392	yd3/yr
24. Volume of Sludge per Removal	392	yd3/ removal
25. Freeboard Volume	434	yd3
26. Water Volume	213	yd3
27. Excavation Volume	606	yd3
28. Excavation Volume	0.37	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	2,728	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	112	$
36. Estimated Cost	2,841	$

☑ 37. Accept Minimum Pond Cost?

The Recommended Minimum Construction Cost of Building a Pond is $ 5,000

38. Recommended Minimum Cost	5,000	$
39. Total Cost	5,000	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-22

Printed on 03/22/2005

AMD TREAT

VERTICAL FLOW POND (VFP)

SIZING METHODS Select One

1. Tons of Limestone Needed	1,108	○ VFP Based on Acidity Neutralization
2. Tons of Limestone Needed	591	○ VFP Based on Retention Time
3. Tons of Limestone Needed	5,178	○ VFP Based on Alkalinity Generation Rate
4. Tons of Limestone Needed	1,700	◉ VFP Based on Tons Limestone Entered
5. Tons of Limestone Needed	1,921	○ VFP Based on Dimensions

6. Retention Time		hours
7. Alkalinity Generation Rate		g/m2/day
8. Limestone Needed	1,700	tons
9. Length at Top of Freeboard		ft
10. Width at Top of Freeboard		ft

11. % Void Space of LS. Bed	35.00	%
12. System Life		years
13. Limestone Purity	90.00	%
14. Limestone Efficiency		%
15. Density of Loose Limestone	107.53	lbs/ft3
16. Limestone Unit Cost	12.00	$/ton
17. LS Placement Unit Cost	0.00	$/yd3
18. Slope of Pond Sides (Run of Slope : Rise of Slope)	2.0 : 1	
19. Freeboard Depth	3.00	ft
20. Free Standing Water Depth	2.0	ft
21. Organic Matter Depth	1.0	ft
22. Organic Matter Unit Cost	19.00	$/yd3
23. Organic Matter Spreading Unit Cost	3.50	$/yd3
24. Limestone Depth	3.0	ft
25. Excavation Unit Cost	4.50	$/yd3

Liner Cost

◉ **No Liner**

○ **Clay Liner**

11. Clay Liner Unit Cost		$/yd3
12. Thickness of Clay Liner		ft

○ **Synthetic Liner**

13. Synthetic Liner Unit Cost		$/yd2

☐ **29. Clearing and Grubbing?**

○ 30a. Land Multiplier		ratio
○ 30b. Clear/Grub Acres		acres
31. Clear and Grub Unit Cost		$/acre
32. Nbr. of Valves	0	nbr
33. Unit Cost of Valves	0.00	$ ea.

◉ **AMDTreat Piping Costs**

34. Total Length of Effluent / Influent Pipe	20	ft
35. Pipe Install Rate	11.00	ft/hr
36. Labor Rate	35.00	$/hr
37. Segment Len. of Trunk Pipe	20	ft/pipe seg.
38. Trunk Pipe Cost	6.70	$/ft
39. Trunk Coupler Cost	6.60	$/coupler
40. Spur Cost	1.83	$/ft
41. Spur Coupler Cost	2.43	$/spur
42. "T" Connector Cost	90.00	$/T coupler
43. Segment Len. of Spur Pipe	20	ft/pipe seg.
44. Spur Pipe Spacing	10.0	ft

○ **Custom Piping Costs**

	Length		Diameter		Unit Cost
45. Pipe #1		ft		in	
46. Pipe #2		ft		in	
47. Pipe #3		ft		in	

VFP Sizing Summaries

48. Length at Top of Freeboard	178.14	ft
49. Width at Top of Freeboard	101.07	ft
50. Freeboard Volume	1,819	yd3
51. Water Surface Area	14,799	ft2
52. Total Water Volume	1,022	yd3
53. Organic Matter Volume	457	yd3
54. Limestone Surface Area	11,880	ft2
55. Limestone Volume	1,171.25	yd3
56. Excavation Volume	2,650.8	yd3
57. Clear and Grub Area	0.0	acres
58. Liner Area	0.0	ft2
59. Theoretical Retention Time	45.99	hrs

VFP Cost Summaries

60. Organic Matter Cost	8,690	$
61. Limestone Cost	20,403	$
62. Limestone and Organic Matter Placement Cost	1,600	$
63. Excavation Cost	11,929	$
64. Liner Cost	0	$
65. Clear and Grub Cost	0	$
66. Valve Cost	0	$
67. Pipe Cost	9,291	$
68. Total Cost	51,913	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-37

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	3,153
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**3,153**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	5,000
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	815
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**5,815**
Total Capital Cost:	**8,968**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	0
Sludge Removal	0
Other Cost (Annual Cost)	0
Total Annual Cost:	**3,472**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ● Enter Net Acidity manually

Net Acidity (Hot Acidity)	186.00	mg/L
Design Flow	9.40	gpm
Average Flow	9.30	gpm
Total Iron	50.00	mg/L
Aluminum	5.00	mg/L
Manganese	4.00	mg/L
pH	4.50	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	203.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	726.00	uS/cm
Total Dissolved Solids	586.00	mg/L
Dissolved Oxygen	2.00	mg/L

Printed on **03/22/2005**

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-37

AMD TREAT

ANOXIC LIMESTONE DRAIN (ALD)

SIZING METHODS Select One

1. Tons of Limestone Needed	141	(•) ALD Based on Acidity Neutralization			
2. Tons of Limestone Needed	173	( ) ALD Based on Retention Time	5. Retention Time		hours
3. Tons of Limestone Needed	0	( ) ALD Based on Tons Limestone Entered	6. Limestone Needed		tons
4. Tons of Limestone Needed	0	( ) ALD Based on Dimensions Entered	7. Top Length ALD		ft
			8. Top Width ALD		ft

9. System Life	20.0	years
10. Limestone Purity	90.00	%
11. Limestone Efficiency	60.00	%
12. % Void Space of Limestone Bed	35.00	%
13. Limestone Depth	4.00	ft
14. Density of Loose Limestone	107.53	lbs/ft3
15. Limestone Unit Cost	12.00	$/ton
16. Limestone Placement Unit Cost	0.00	$/yd3
17. Soil Cover Depth	2.00	ft
18. Length to Width Ratio (Length : Width)	4.00 : 1	
19. Excavation Unit Cost	4.50	$/yd3
20. Soil Replacement Unit Cost	4.50	$/yd3
21. Liner Unit Cost	2.60	$/yd2
22. Total Length of Effluent / Influent Pipe	0.00	ft
23. Unit Cost of Pipe	0.00	$/ft

☐ **24. Clearing and Grubbing?**

( ) 25a. Land Multiplier		ratio
( ) 25b. Clear/Grub Acres		acres
26. Clear and Grub Unit Cost		$/acre

ALD Sizing Summaries

27.Top Width	12.83	ft
28. Top Length	51.34	ft
29. Limestone Surface Area	658.9	ft2
30. Limestone Volume	97	yd3
31. Excavation Volume	146.4	yd3
32. Clear & Grub Area	0.00	acres
33. Liner Area	220	ft2
34. Theoretical Retention Time	12.23	hrs

ALD Cost Summaries

35. Limestone Cost	1,700	$
36. Excavation Cost	658	$
37. Limestone Placement Cost	0	$
38. PipeCost	0	$
39. Liner Cost	573	$
40. Clear and Grub Cost	0	$
41. Soil Replacement Cost	219	$
42. Total Cost	**3,153**	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name BR-37

Printed on 03/22/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (•) **No Liner**
- ( ) **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ( ) **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☐ 16. Clearing and Grubbing?

17a. Land Multiplier		ratio
17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	58	ft
22. Width at Top of Freeboard	33	ft
23. Estimated Annual Sludge	47	yd3/yr
24. Volume of Sludge per Removal	47	yd3/ removal
25. Freeboard Volume	120	yd3
26. Water Volume	67	yd3
27. Excavation Volume	114	yd3
28. Excavation Volume	0.07	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	515	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	34	$
36. Estimated Cost	550	$

☑ 37. Accept Minimum Pond Cost?

The Recommended Minimum Construction Cost of Building a Pond is $ 5,000

38. Recommended Minimum Cost	5,000	$
39. Total Cost	5,000	$

Printed on 03/23/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name ML-RORT discharge

AMD TREAT

AMD TREAT MAIN FORM

Costs

Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	86,807
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**86,807**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	16,282
Secondary Pond	0
Roads	5,873
Land Access	0
Ditching	0
Engineering Cost	10,896
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**33,051**
Total Capital Cost:	**119,858**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	1,643
Pumping	0
Chemical Cost	0
Sludge Removal	0
Other Cost (Annual Cost)	0
Total Annual Cost:	**5,115**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	149.00	mg/L

Design Flow	340.00	gpm
Average Flow	280.00	gpm
Total Iron	40.00	mg/L
Aluminum	1.00	mg/L
Manganese	3.63	mg/L
pH	4.56	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	895.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1540.00	uS/cm
Total Dissolved Solids	1320.00	mg/L
Dissolved Oxygen	1.00	mg/L

Printed on 03/23/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name ML-RORT discharge

AMD TREAT

ANOXIC LIMESTONE DRAIN (ALD)

SIZING METHODS Select One

1. Tons of Limestone Needed	4,106	(•) ALD Based on Acidity Neutralization			
2. Tons of Limestone Needed	6,283	( ) ALD Based on Retention Time	5. Retention Time		hours
3. Tons of Limestone Needed	0	( ) ALD Based on Tons Limestone Entered	6. Limestone Needed		tons
4. Tons of Limestone Needed	0	( ) ALD Based on Dimensions Entered	7. Top Length ALD		ft
			8. Top Width ALD		ft

9. System Life	20.0	years
10. Limestone Purity	90.00	%
11. Limestone Efficiency	60.00	%
12. % Void Space of Limestone Bed	35.00	%
13. Limestone Depth	4.00	ft
14. Density of Loose Limestone	107.53	lbs/ft3
15. Limestone Unit Cost	12.00	$/ton
16. Limestone Placement Unit Cost	0.00	$/yd3
17. Soil Cover Depth	2.00	ft

	Length		Width
18. Length to Width Ratio	4.00	:	1

19. Excavation Unit Cost	4.50	$/yd3
20. Soil Replacement Unit Cost	4.50	$/yd3
21. Liner Unit Cost	2.60	$/yd2
22. Total Length of Effluent / Influent Pipe	0.00	ft
23. Unit Cost of Pipe	0.00	$/ft

☐ **24. Clearing and Grubbing?**

( ) 25a. Land Multiplier		ratio
( ) 25b. Clear/Grub Acres		acres
26. Clear and Grub Unit Cost		$/acre

ALD Sizing Summaries

27.Top Width	69.09	ft
28. Top Length	276.36	ft
29. Limestone Surface Area	19,094.2	ft2
30. Limestone Volume	2,828	yd3
31. Excavation Volume	4,243.1	yd3
32. Clear & Grub Area	0.00	acres
33. Liner Area	4,642	ft2
34. Theoretical Retention Time	9.80	hrs

ALD Cost Summaries

35. Limestone Cost	49,276	$
36. Excavation Cost	19,094	$
37. Limestone Placement Cost	0	$
38. PipeCost	0	$
39. Liner Cost	12,070	$
40. Clear and Grub Cost	0	$
41. Soil Replacement Cost	6,364	$
42. Total Cost	86,807	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name ML-RORT discharge

Printed on **03/23/2005**

AMD TREAT

ROADS

1. Road Length	600	ft
2. Road Width	15	ft
3. Road Depth	1.00	ft
4. Aggregate Unit Cost	12.00	$/yd3
5. GeoTextile Length	600	ft
6. GeoTextile Unit Cost	1.50	$/yd2
7. Length of Silt Fence	0	ft
8. Unit Cost of Silt Fence	1.00	$/ft
☐ 9. Surveying?		
10. Survey Rate		acres/day
11. Survey Unit Cost		$/day
☑ 12. Clearing and Grubbing?		
13. Clear and Grub Cost	1256	$/acre
14. Reveg Unit Cost	1500.00	$/acre
15. Culvert Unit Cost	30.00	$/ft
16. Culvert Length	0	ft

Roads Sub-Totals

17. Road Surface Cost	4,000	$
18. GeoTextile Cost	1,500	$
19. Silt Fence Cost	0	$
20. Culvert Cost	0	$
21. Revegetation Cost	62	$
22. Survey Cost	0	$
23. Clear and Grub Cost	311	$
24. Total Cost	5,873	$

Company Name ILGARD
Project Moxahala AMDAT
Site Name ML-RORT discharge

Printed on 03/23/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- (•) **No Liner**
- ( ) **Clay Liner**
  - 13. Clay Liner Unit Cost ____ $/yd3
  - 14. Thickness of Clay Liner ____ ft
- ( ) **Synthetic Liner**
  - 15. Synthetic Liner Unit Cost ____ $/yd2

☐ 16. Clearing and Grubbing?

17a. Land Multiplier		ratio
17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	237	ft
22. Width at Top of Freeboard	122	ft
23. Estimated Annual Sludge	1,082	yd3/yr
24. Volume of Sludge per Removal	1,082	yd3/ removal
25. Freeboard Volume	2,054	yd3
26. Water Volume	2,424	yd3
27. Excavation Volume	3,506	yd3
28. Excavation Volume	2.17	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	15,779	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	502	$
36. Estimated Cost	16,282	$

Printed on 03/24/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name SN-source

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	106,596
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**106,596**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	13,186
Secondary Pond	0
Roads	1,958
Land Access	0
Ditching	0
Engineering Cost	12,174
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**27,318**
Total Capital Cost:	**133,914**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	0
Sludge Removal	0
Other Cost (Annual Cost)	0
Total Annual Cost:	**3,472**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	209.00	mg/L
Design Flow	298.00	gpm
Average Flow	149.00	gpm
Total Iron	46.00	mg/L
Aluminum	6.40	mg/L
Manganese	2.80	mg/L
pH	3.36	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	508.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1004.00	uS/cm
Total Dissolved Solids	806.00	mg/L
Dissolved Oxygen	2.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name SN-source

Printed on 03/28/2005

AMD TREAT

ROADS

1. Road Length	200	ft
2. Road Width	15	ft
3. Road Depth	1.00	ft
4. Aggregate Unit Cost	12.00	$/yd3
5. GeoTextile Length	200	ft
6. GeoTextile Unit Cost	1.50	$/yd2
7. Length of Silt Fence	0	ft
8. Unit Cost of Silt Fence	1.00	$/ft
☐ 9. Surveying?		
10. Survey Rate		acres/day
11. Survey Unit Cost		$/day
☑ 12. Clearing and Grubbing?		
13. Clear and Grub Cost	1256	$/acre
14. Reveg Unit Cost	1500.00	$/acre
15. Culvert Unit Cost	30.00	$/ft
16. Culvert Length	0	ft

Roads Sub-Totals

17. Road Surface Cost	1,333	$
18. GeoTextile Cost	500	$
19. Silt Fence Cost	0	$
20. Culvert Cost	0	$
21. Revegetation Cost	21	$
22. Survey Cost	0	$
23. Clear and Grub Cost	104	$
24. Total Cost	1,958	$

Company Name	ILGARD
Project	Moxahala AMDAT
Site Name	SN-source

Printed on 03/28/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.
7. Slope Ratio of Pond Sides (Run : Rise)	2.0 : 1	
8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- ◉ **No Liner**
- ○ **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ○ **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☐ 16. Clearing and Grubbing?

○ 17a. Land Multiplier		ratio
○ 17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	215	ft
22. Width at Top of Freeboard	111	ft
23. Estimated Annual Sludge	713	yd3/yr
24. Volume of Sludge per Removal	713	yd3/ removal
25. Freeboard Volume	1,691	yd3
26. Water Volume	2,124	yd3
27. Excavation Volume	2,837	yd3
28. Excavation Volume	1.75	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	12,770	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	415	$
36. Estimated Cost	13,186	$

Printed on 03/28/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Dry Run Seeps DR-3

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	546,365
Anoxic Limestone Drain	308,029
Anaerobic Wetlands	750,877
Aerobic Wetlands	457,236
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**2,062,507**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	57,919
Ammonia	0
Soda Ash	0
Active Subtotal:	**57,919**
Ancillary Cost	
Primary Retention Pond	12,179
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	0
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**12,179**
Total Capital Cost:	**2,132,605**
Annual Costs	
Sampling	0
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	6,674
Sludge Removal	4,738
Other Cost (Annual Cost)	0
Total Annual Cost:	**11,412**

Water Quality

Calculated Acidity	0.00	mg/L
Alkalinity	0.00	mg/L

○ Calculate Net Acidity (Acid-Alkalinity)

◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	698.00	mg/L

Design Flow	259.00	gpm
Average Flow	66.00	gpm
Total Iron	94.00	mg/L
Aluminum	36.00	mg/L
Manganese	5.00	mg/L
pH	2.65	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	1137.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	2005.00	uS/cm
Total Dissolved Solids	0.00	mg/L
Dissolved Oxygen	0.00	mg/L

Printed on 03/28/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name Dry Run seeps DR-2

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	49,887
Anoxic Limestone Drain	29,590
Anaerobic Wetlands	140,138
Aerobic Wetlands	91,043
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**310,659**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	94,739
Ammonia	0
Soda Ash	0
Active Subtotal:	**94,739**
Ancillary Cost	
Primary Retention Pond	5,000
Secondary Pond	0
Roads	0
Land Access	0
Ditching	0
Engineering Cost	0
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**5,000**
Total Capital Cost:	**410,398**
Annual Costs	
Sampling	0
Labor	0
Maintenance	0
Pumping	0
Chemical Cost	2,289
Sludge Removal	3,707
Other Cost (Annual Cost)	0
Total Annual Cost:	**5,996**

Water Quality

Calculated Acidity	1317.00	mg/L
Alkalinity	0.00	mg/L

○ Calculate Net Acidity (Acid-Alkalinity)

◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	1317.00	mg/L

Design Flow	13.00	gpm
Average Flow	12.00	gpm
Total Iron	518.00	mg/L
Aluminum	57.00	mg/L
Manganese	6.00	mg/L
pH	2.92	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	2522.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	3225.00	uS/cm
Total Dissolved Solids	0.00	mg/L
Dissolved Oxygen	0.00	mg/L

Printed on 03/30/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name BF-10 whitehouse seep

AMD TREAT

AMD TREAT MAIN FORM

Costs	
Passive Treatment	
Vertical Flow Pond	0
Anoxic Limestone Drain	460,809
Anaerobic Wetlands	0
Aerobic Wetlands	0
Manganese Removal Bed	0
Oxic Limestone Channel	0
Passive Subtotal:	**460,809**
Active Treatment	
Caustic Soda	0
Hydrated Lime	0
Pebble Quick Lime	0
Ammonia	0
Soda Ash	0
Active Subtotal:	**0**
Ancillary Cost	
Primary Retention Pond	61,528
Secondary Pond	35,221
Roads	0
Land Access	0
Ditching	0
Engineering Cost	55,756
Other Cost (Capital Cost)	0
Ancillary Subtotal:	**152,505**
Total Capital Cost:	**613,314**
Annual Costs	
Sampling	3,472
Labor	0
Maintenance	7,994
Pumping	0
Chemical Cost	0
Sludge Removal	34,915
Other Cost (Annual Cost)	0
Total Annual Cost:	**46,381**

Water Quality

Calculated Acidity	269.00	mg/L
Alkalinity	15.00	mg/L

- ○ Calculate Net Acidity (Acid-Alkalinity)
- ◉ Enter Net Acidity manually

Net Acidity (Hot Acidity)	254.00	mg/L
Design Flow	1066.00	gpm
Average Flow	456.00	gpm
Total Iron	135.00	mg/L
Aluminum	6.00	mg/L
Manganese	3.00	mg/L
pH	5.60	su
Ferric Iron	0.00	mg/L
Ferrous Iron	0.00	mg/L
Sulfate	848.00	mg/L
Filtered Fe	0.00	mg/L
Filtered Al	0.00	mg/L
Filtered Mn	0.00	mg/L
Specific Conductivity	1496.00	uS/cm
Total Dissolved Solids	0.00	mg/L
Dissolved Oxygen	0.00	mg/L

Company Name ILGARD

Project Moxahala AMDAT

Site Name BF-10 whitehouse seep

Printed on 03/30/2005

AMD TREAT

SECONDARY POND

Pond Design Based On:

Retention Time (selected)

1. Desired Retention Time	24.0	hours

Pond Size

2. Pond Length at Top of Freeboard		ft
3. Pond Width at Top of Freeboard		ft

	Run		Rise
4. Slope Ratio of Pond Sides	2.0	:	1

5. Freeboard Depth	2.0	ft
6. Water Depth	4.0	ft
7. Excavation Unit Cost	4.50	$/yd3
8. Total Length of Effluent / Influent Pipe	0.00	ft
8. Unit Cost of Pipe	0.00	$/ft

Liner Cost

No Liner (selected)

Clay Liner

10. Clay Liner Unit Cost		$/yd3
11. Thickness of Clay Liner		ft

Synthetic Liner

12. Synthetic Liner Unit Cost		$/yd2

☐ 13. Clearing and Grubbing?

14a. Land Multiplier		ratio
14b. Clear/Grub Acres		acres
15. Clear and Grub Unit Cost		$/acre
16. Revegetation Cost	1500.00	$/acre
17. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

18. Length at Top of Freeboard	340	ft
19. Width at Top of Freeboard	174	ft
20. Freeboard Volume	11,838	yd3
21. Water Volume	7,600	yd3
22. Excavation Volume	4.71	acre ft
23. Excavation Volume	7,600	yd3
24. Clear and Grub Area	2.04	acres
25. Liner Area	0	yd2

Secondary Settling Ponds Sub-Totals

26. Excavation Cost	34,200	$
37. Pipe Cost	0	$
28. Liner Cost	0	$
29. Clearing and Grubbing Cost	0	$
30. Revegetation Cost	1,020	$
31. Estimated Cost	35,221	$

Company Name ILGARD

Project Moxahala AMDAT

Site Name BF-10 whitehouse seep

Printed on 03/30/2005

AMD TREAT

PRIMARY RETENTION POND

1. Sludge Removal Frequency	1.00	times/year
2. Desired Retention Time	24.00	hours
☐ 3. Titration?		
4. Sludge Rate		gal sludge/ gal H2O
5. Percent Solids	3.00	%
6. Sludge Density	8.35	lbs./gal.

	Run		Rise
7. Slope Ratio of Pond Sides	2.0	:	1

8. Freeboard Depth	2.0	ft
9. Water Depth	4.0	ft
10. Excavation Unit Cost	4.50	$/yd3
11. Total Length of Effluent / Influent Pipe	0.00	ft
12. Unit Cost of Pipe	0.00	$/ft

Liner Cost

- ◉ **No Liner**
- ○ **Clay Liner**

13. Clay Liner Unit Cost		$/yd3
14. Thickness of Clay Liner		ft

- ○ **Synthetic Liner**

15. Synthetic Liner Unit Cost		$/yd2

☐ 16. Clearing and Grubbing?

○ 17a. Land Multiplier		ratio
○ 17b. Clear/Grub Acres		acres
18. Clear and Grub Unit Cost		$/acre
19. Revegetation Cost	1500.00	$/acre
20. Number of Ponds for this Design	1	number

Calculated Pond Dimensions per Pond

21. Length at Top of Freeboard	443	ft
22. Width at Top of Freeboard	225	ft
23. Estimated Annual Sludge	5,689	yd3/yr
24. Volume of Sludge per Removal	5,689	yd3/ removal
25. Freeboard Volume	7,220	yd3
26. Water Volume	7,600	yd3
27. Excavation Volume	13,289	yd3
28. Excavation Volume	8.23	ac ft
29. Clear and Grub Area	0.00	acres
30. Liner Area	0	yd2

Primary Settling Ponds Sub-Totals

31. Excavation Cost	59,804	$
32. Pipe Cost	0	$
33. Liner Cost	0	$
34. Clearing and Grubbing Cost	0	$
35. Revegetation Cost	1,724	$
36. Estimated Cost	61,528	$

Printed on 03/30/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name BF-10 whitehouse seep

AMD TREAT

ANOXIC LIMESTONE DRAIN (ALD)

SIZING METHODS Select One

1. Tons of Limestone Needed	21,947	(selected) ALD Based on Acidity Neutralization			
2. Tons of Limestone Needed	19,701	ALD Based on Retention Time	5. Retention Time		hours
3. Tons of Limestone Needed	0	ALD Based on Tons Limestone Entered	6. Limestone Needed		tons
4. Tons of Limestone Needed	0	ALD Based on Dimensions Entered	7. Top Length ALD		ft
			8. Top Width ALD		ft

9. System Life	20.0	years
10. Limestone Purity	90.00	%
11. Limestone Efficiency	60.00	%
12. % Void Space of Limestone Bed	35.00	%
13. Limestone Depth	4.00	ft
14. Density of Loose Limestone	107.53	lbs/ft3
15. Limestone Unit Cost	12.00	$/ton
16. Limestone Placement Unit Cost	0.00	$/yd3
17. Soil Cover Depth	2.00	ft

18. Length to Width Ratio — Length 4.00 : Width 1

19. Excavation Unit Cost	4.50	$/yd3
20. Soil Replacement Unit Cost	4.50	$/yd3
21. Liner Unit Cost	2.60	$/yd2
22. Total Length of Effluent / Influent Pipe	0.00	ft
23. Unit Cost of Pipe	0.00	$/ft

☐ **24. Clearing and Grubbing?**

25a. Land Multiplier		ratio
25b. Clear/Grub Acres		acres
26. Clear and Grub Unit Cost		$/acre

ALD Sizing Summaries

27.Top Width	159.72	ft
28. Top Length	638.91	ft
29. Limestone Surface Area	102,053.6	ft2
30. Limestone Volume	15,119	yd3
31. Excavation Volume	22,678.5	yd3
32. Clear & Grub Area	0.00	acres
33. Liner Area	23,602	ft2
34. Theoretical Retention Time	16.71	hrs

ALD Cost Summaries

35. Limestone Cost	263,372	$
36. Excavation Cost	102,053	$
37. Limestone Placement Cost	0	$
38. PipeCost	0	$
39. Liner Cost	61,365	$
40. Clear and Grub Cost	0	$
41. Soil Replacement Cost	34,017	$
42. Total Cost	460,809	$

Printed on 03/30/2005

Company Name ILGARD

Project Moxahala AMDAT

Site Name BF-10 whitehouse seep

AMD TREAT

SLUDGE REMOVAL

1. Select One — Selection for Method of Removing Sludge

(•) Sludge Removal by $ per Gallon

2. Sludge Removal Unit Cost	0.05	$/gal

( ) Sludge Removal by Vacuum Truck

3. Vacuum Truck Unit Cost		$/hr
4. Mobilization Cost		$
5. Hours to be Used		hr

( ) Sludge Removal by Mechanical Excavation

6. Mechanical Excavation Unit Rate		$/hr
7. Mobilization Cost		$
8. Hours to be Used		hr

( ) Sludge Removal by Lagoon Cleaner

9. Lagoon Cleaning Unit Rate		$/hr
10. Mobilization Cost		$
11. Hours to be Used		hr

( ) Actual Sludge Removal Cost

12. Actual Sludge Removal Cost		$
13. Off Site Disposal Cost	0.00	$

14. Iron Concentration	135.00	mg/L
15. Manganese Concentration	3.00	mg/L
16. Aluminum Concentration	6.00	mg/L
17. Total Miscellaneous Concentration	0	mg/L
18. Percent Solids	5.00	%
19. Sludge Density	8.33	lbs/gal
☐ 20 Titration?		
21. Gal. of Sludge per Gal of Water Treated		gal
22. Estimated Sludge Volume	3,457	yd3/yr

Cost for Sludge Removal Types

23. Removal by $ per Gallon	34,915	$
24. Removal by Vacuum Truck	0	$
25. Removal by Mechanical Excavation	0	$
26. Removal by Lagoon Cleaner	0	$
27. Actual Sludge Removal Cost	0	$

Sludge Removal Sub-Totals

28. Currently Selected Removal Cost Plus Off Site Disposal Cost	34,915	$

Appendix M:

Moxahala acid mine drainage treatment cost summary by sub-watershed

Andrew Creek

	Treatment	**Sites**	**Cost (based on 10 year lifetime)**
Phase I	Two 75 ton silo pebble quick lime dosers (includes settling ponds, sludge removal)	AC-20 and AC-46	$5,648,358
Phase II	Steel slag beds	AC-6, 26, 8, 9, 25	NA
Phase III	Basic surface strip pit reclamation	AC-33, 44, 20	$3,461,853*
TOTAL			$9,110,211 (includes 50-yr lifetime treatment cost for phase III)

* based on a 50-yr lifetime

Bear Creek

	Treatment	**Sites**	**Cost (based on 10 year lifetime)**
Phase I	One 75 ton silo pebble quick lime dosers (includes settling ponds, sludge removal)	BR-01	$1, 440,809
Phase II	Basic surface strip pit reclamation	BR-13, 29, 26	$1,703,632*
Phase III	ALD and vertical flow ponds	BR-37 and BR18, 22	$205,346
TOTAL			$3,349,787 (includes 50-yr lifetime treatment cost for phase II)

* based on a 50-yr lifetime

McLuney Creek

	Treatment	**Sites**	**Cost (based on 10 year lifetime)**
Phase I	Aerobic wetland enhancement in mainstem	ML-20 to ML-39	$50,000 - $700,000
Phase II	Basic surface strip pit reclamation	ML-14&16, ML-6 (sites 69, 70, 71), ML-20	$2,359,868*
Phase III	ALD	ML-20	$171,008
TOTAL			$2,580,926 – 3,230,926 (includes 50-yr lifetime treatment cost for phase II)

* based on a 50-yr lifetime

Snake Run

	Treatment	Sites	Cost (based on 10 year lifetime)
Phase I	Mine sealing	SN-8	NA
Phase II	ALD and/or OLC	SN-8 t0 SN-1	$198,341
TOTAL			$198,341

Burley Run

	Treatment	Sites	Cost
Phase I	Batch treatment strip pit impoundments	Lewis Hollow	NA
Phase II	Basic surface strip pit reclamation	Lewis Hollow, Jenkins Hollow	$2,923,377*
TOTAL			$2,923,377 (includes 50-yr lifetime treatment cost for phase II)

* based on a 50-yr lifetime

Riders Run

	Treatment	Sites	Cost (based on 10 year lifetime)
Phase I	OLC	RR 4, 5, 15, 16	$8,819
TOTAL			$8,819

Black Fork

	Treatment	Sites	Cost (based on 10 year lifetime)
Phase I	Aerobic wetland and ALD	BF-10	$1,077,124
Phase II	OLC	DR-2, 3	$114,102
Phase III	Enhance Tropic wetland	ML-20	$104,916
Phase IV	Gob pile reclamation	Misco East Gob pile	NA
TOTAL			$1,296,142

Total cost of all phases of reclamation projects proposed in the priority subwatersheds described in the Moxahala AMDAT plan April 2005 is estimated at $19,467,603 to $20,117,603.