ACID MINE DRAINAGE ABATEMENT AND TREATMENT (AMDAT) PLAN FOR THE LEADING CREEK WATERSHED


Confluence of Unnamed Tributary (TF1502) and Thomas Fork


Acid mine drainage discharge in Bailey Run


Mine Pool in Bailey Run


Acid mine drainage seep in Hysell Run

by

Cynthia Bauers
Michael Gosnell
Raina Ooten
Meigs County Soil and Water Conservation District

Jen Bowman
Ohio University's Voinovich Center, ILGARD

Barbara Flowers, Dave Vosefski, and Mary Ann Borch
Ohio Department of Natural Resources, Division of Mineral Resource Management

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ABSTRACT

The Leading Creek Acid Mine Drainage Abatement and Treatment Plan identifies all sources of acid mine drainage and prioritizes the sources for treatment. The Leading Creek basin does not have the severe and widespread AMD impacts that are common in many watersheds in Southeast Ohio. Based on extensive reconnaissance, very few tributaries are degraded due to mine drainage and only two tributaries, Paulins Run and Thomas Fork, have impacts that reduce the diversity and abundance of fish and macroinvertebrate communities. Likewise, the mainstem of Leading Creek is not directly affected by acid mine drainage, and it maintains good water quality even downstream from abandoned mine lands.

There are three subwatersheds, Thomas Fork, Paulins Run, and Titus Run that are affected by mine runoff. Thomas Fork and Paulins Run are affected chemically from AMD and will be addressed in detail in the plan. Titus Run impacts are from mine sediments and will not be addressed in this plan. Within these tributaries, mine drainage is produced by either diffuse seepage from strip mine pits and auger mine pits and/or subsurface drains that are above drainage and were installed by Mineral Resources Management during reclamation.

The highest priorities for remediation are to eliminate or reduce acid and metal loads from several tributaries of Thomas Fork. The major tributaries of concern are the unnamed tributary on Bailey Run Road (TF1500), Kinzel’s seep (TF1200), Casto’s (TF1100), Bailey Run (TF0400), Hysell Run (TF0300), and ODNR underdrains.

The total cost for remediation of all sites in the watershed is approximately $1,850,000 and estimated over a ten period is $2,560,000.

SECTION ONE- Introduction

The purpose of the Leading Creek AMDAT Plan is to detail the actions that are necessary to treat the sources of acid mine drainage (AMD) in order to restore stream segments and streams in the Leading Creek watershed to meet their designated aquatic life use. The objectives for the study are outlined below.

1. **Define current water quality conditions.** Water quality data was collected to adequately characterize current conditions in the watershed so that a comprehensive description is available for comparison in current and future monitoring. See Appendix G for a table of water quality information.

2. **Describe the extent to which AMD affects each of the subwatersheds that were mined before the passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977.** All existing acidic and metal impacted waters were located and described. Locations of AMD sources and water quality sample locations are found on the accompanying set of maps. The sites are described in Section Four (page 20). Tributaries impacted by mine drainage are described and their sources of AMD found during the study.

3. **Determine the projects and actions necessary to remediate impacted sites.** Section Four and Five, describe several actions that will abate and treat the acid mine drainage, providing conditions necessary for a healthy biological community. The treatment strategies for Thomas Fork were prioritized based on chemical loadings, environmental benefits and cost effectiveness.

To accomplish these objectives, an extensive watershed investigation was conducted by the Leading Creek Watershed Group from February 2003 to September 2004. In Addition, from October 2005 to March 2006 Ohio Univeristy'sVoinovich Center/ILGARD conducted further water quality investigations to gather the necessary information to complete the treatment strategy plans. Cost for the treatment suggestions were developed by Ohio Department of Natural Resources Division of Mineral Resources Management (ODNR-DMRM) engineers and project officers. These assessments included measurement of field and laboratory parameters in all the impacted subwatersheds and at all of the existing sources. Current monitoring was used along with historical sources of data to determine the existing impacted sites.

SECTION TWO- Hydrologic Unit

Name: Leading Creek Watershed, Ohio
Tributary to: Ohio River
Drainage Area: 150.1 square miles; 96,000 acres
Perennial Length: 31.9 miles *
Location: Athens (2.7%), Meigs (96.0%), and Gallia Counties (1.3%)
USGS Quadrangles: Vales Mill, Albany, Shade, Wilkesville,
Rutland, Pomeroy, Addison, and Cheshire

*Length is according to Ohio Environmental Protection Agency river mile maps

Watershed Description

The Leading Creek Watershed lies in the unglaciated Allegheny Plateau region of Southeastern Ohio (Map 1). The topography of the area is characterized by steep slopes with narrow valley floors. Rock outcrops and overhangs are common topographic features. The watershed consists of slightly more than 150 square miles (96,000 acres) and comprises most of the western half of Meigs County and small portions of Athens and Gallia counties. Leading Creek winds about 30 miles through the Appalachian foothills before discharging into the Ohio River near Middleport, Ohio. The two main tributaries flowing into Leading Creek are Little Leading Creek and Thomas Fork. The elevation within the watershed ranges from 540 feet above sea level at the mouth of Leading Creek to 1007 feet above sea level Northeast of Horner Hill along the watershed boundary (Gilmore and Bottrell, 1991).

According to the Gazetteer of Ohio Streams (Ohio DNR, 2001), there are a total of 9 named tributaries to Leading Creek (Table 1). The largest tributaries are Thomas Fork (32.4 square miles) and Little Leading Creek (25.6 square miles).

Table 1. Summary of Leading Creek tributaries and their characteristics

Water Body Segment	Length (mile)	Watershed Size (sq mile)	Estimated Mean Annual Flow* (GPM)	Gradient (ft/ mile)
Leading Creek	29.5	150.1	68723.5	8.4
Thomas Fork	10.2	32.4	14834.4	32.6
Hysell Run	4.8	4.5	2060.3	49.2
Bailey Run	2.3	1.8	824.1	55.6
East Branch of Thomas Fork	7.2	11.2	5127.9	25.8
Long Hollow	1.6	2.1	961.5	53.7
Little Leading Creek	10.6	25.6	11721.0	26.9
Malloons Run	3.4	3.9	1785.6	42.0
Parker Run	4.8	7.5	3433.9	35.6
Dexter Run	5.3	7.8	3571.2	70.5
Mud Fork	7.9	13.2	6043.6	31.1
Ogden Run	4.8	7.3	3342.3	31.5
Sisson Run	3.2	5.6	2564.0	29.7
Fivemile Run	4.2	4.9	2243.5	60.0

* Flow represents the mean annual flow, which was estimated at the site based on drainage area (Koltun, 2001)

The Leading Creek watershed is characterized by its temperate, humid conditions with well-defined winter and summer seasons. In winter, the average temperature is 32 degrees F and the average minimum daily temperature is 22 degrees F. The lowest temperature on record is –24 degrees F (January 17, 1977). In summer, the average temperature is 71 degrees F and the average maximum daily temperature is 84 degrees F. The highest temperature on record is 102 degrees F (July 26, 1964) (Gilmore and Bottrell 1991).

Average annual precipitation is 40.7 inches. About 57 percent of the precipitation usually falls in April through September. The heaviest 1-day rainfall during the period of record was 3.39 inches on September 21, 1966. Precipitation is well distributed over all calendar seasons with approximately 8 inches in winter, 11 inches in spring, 12 inches in summer, and 9 inches in fall.

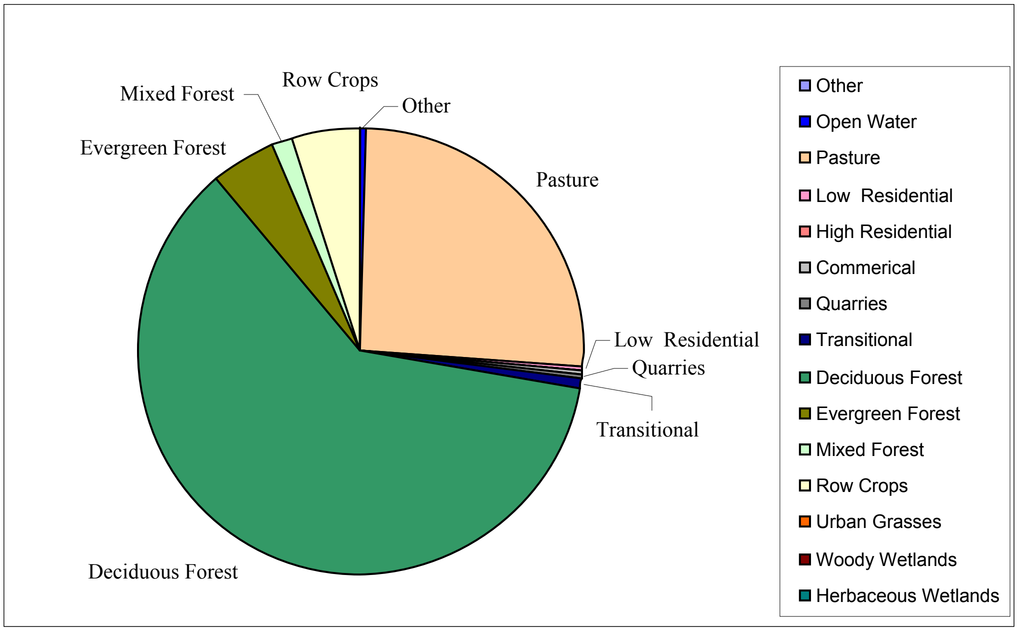
The Ohio Environmental Protection Agency lists several sources of water quality impairments to the Leading Creek Watershed (Ohio EPA, 2000). Sources include surface mining, subsurface mining, non-irrigated crop production, channelization, and pasture land. These sources cause multiple water quality problems, which are also listed in the 305(b) report. Causes of impairment include siltation, pH, salinity/TDS/chlorides, and habitat modifications.

Land Use Characterization

Historic land use practices have greatly modified the current condition of Leading Creek and many of its tributaries. Decades of unregulated coal mining left more than 2,000 acres of barren strip mined land in the watershed and contamination stemming from acid mine drainage affects more than 20 miles of stream in the watershed (Map 7). Extensive clearing of forestlands for agriculture and settlement left hillsides bare, and exposed highly erodible soils. Today, sediment resulting from abandoned mineland, agricultural use, and streambank clearing fills many of the stream channels.

Currently, the watershed is sparsely populated with several small communities, such as Rutland, Harrisonville, Langsville, Dexter, and Carpenter. In addition, Pomeroy, Middleport, and Albany are all partially located within the watershed. Streams meander through rolling and steep hills and flat bottoms where the prevalent land uses are forestland (68%), pasture/hay fields (26%), and row crops (5%) (United States EPA, 1992; Figure 1; Map 2). Historic mining (*i.e.* "pre-SMCRA") mostly occurred in the lower portion of the Leading Creek watershed, whereas, most of the agricultural activities occur in the headwaters (upper ~ 37 square miles). This causes mining impacts (chemical and physical) to be limited to the lower 50 square miles.

Figure 1. Land Uses within Leading Creek Watershed



Geology

The bedrock of the Leading Creek watershed includes the Conemaugh and Monogahela Formations from the Pennsylvanian Age. The majority of the watershed lies in the dissected Pennsylvanian rocks of the Conemaugh formation. The Conemaugh Group is characterized by layers of shale, siltstone, sandstone, mudstone, with lesser amounts of limestone and coal. This rock unit is concentrated in the western sections of the watershed (Gilmore and Bottrell, 1991).

The Monongahela Formation of Pennsylvanian age dominates the central and eastern parts of the watershed. The Group's rock composition consists of layers of shale, siltstone, limestone, sandstone, and coal. The Monongahela Group is characterized by its economic coal beds, and laterally extensive freshwater limestone layers (Gilmore and Bottrell, 1991). The eastern parts of the watershed (particularly within the East Branch of Thomas Fork sub-basin) are likely being buffered by the surrounding calcareous shale and thin layers of limestone creating net alkaline mine drainage (Gordon Gilmore, personal communication).

Groundwater

"The Leading Creek watershed contains Pennsylvanian aquifers in the Appalachian Plateaus Province mostly consisting of sandstone and limestone that are parts of repeating sequences of beds deposited during multiple sedimentary cycles. A complete, ideal cycle consists of the following sequence of beds, listed from bottom to top: underclay, coal, gray shale or black platy shale, freshwater limestone, and sandstone or silty shale. Not all the beds listed are present in each cycle. The coals, sandstones and limestones are the most productive aquifers. Upper Pennsylvanian aquifers are present in the Pennsylvanian Monongahela and Conemaugh. Strata that contain these aquifers are present in southeastern Ohio and a small part of northeastern Kentucky. In southeastern Ohio, Upper Pennsylvanian rocks are primarily interbedded sandstone, siltstone, and shale with minor coal; they grade to shale and siltstone in northeastern Kentucky. The dominant lithology is shale, although some limestone beds are present in the Monongahela Group. Together, the Monongehela and the Conemaugh Groups average about 1,000 feet in thickness. These rocks thicken slightly toward the southeast and exceed 1,500 feet in thickness along the Ohio River in Belmont, Monroe, and Washington Counties, Ohio.

Groundwater flow in Appalachian valleys occurs as vertical infiltration along valley walls via tensile stress-relief fractures, and lateral movement along bedding-plane fractures (Wyrich and Borchers, 1981). The primary permeability of sandstone in the region generally is low due to cementation and compaction, but secondary permeability due to fractures may cause an increase in hydraulic conductivity one to three orders of magnitude (Brown and Parizek, 1971). In fact, sandstone and coal are the most permeable of the Pennsylvanian rocks because they can support fractures.

The infiltration rate may be slowed by the rugged surface physiography, very low natural permeabilities of the rock, and the abundance of interbedded impermeable strata. The hydrologic regime is characterized by perched aquifers of limited lateral extent and typically limited groundwater yields.

The groundwater characteristics of the area have been mapped regionally by the ODNR, Division of Water, based on the interpretation of more than 2230 well records and the area's geology and hydrology. Most of the area encompassing Leading Creek typically yields less than one gallon per minute at depths of less than 125 feet. Deeper drilling is not recommended due to the presence of saline and poor water quality. Dry wells are common. Shallow wells in alluvial valleys will yield more water. Much of the population receives water supplies from Leading Creek private water supply. Springs are also a source of groundwater used to augment water for drinking and livestock, however, these sources are often subject to seasonal wetting and drying conditions."(Borch, 2004).

Mining History

The first reported mining in Ohio was in 1800 in Jefferson County. In 1806, mining was first reported in Pomeroy, the county seat of Meigs County. Recorded estimates show that early coal production in Meigs County was low in output and was fairly consistent. Production figures from 1806-1832 range only from 100 tons to 500 tons. By 1916, Meigs County was producing over one million tons of coal (Crowell 1995).

Early miners worked almost completely underground and most of the coal production was performed manually until the early 1900s. Three types of underground mine accesses were used: vertical mine shafts, drift entries, and tunnels sloping downward from the ground surface. Vertical mine shafts were up to 200 feet deep. For the first 150 years, coal mining was not regulated in Ohio. Early mines were small and poorly mapped. Several early practices to maximize profit left abandoned mines prone to subsidence and other problems (ODNR 2003).

As mechanization entered the coal industry, employment decreased, as production skyrocketed. In 1898, there were 1,155 underground mines operating in Ohio. In 1996, only ten mines still operated. However, in 1908, there were 50,267 coal miners working in Ohio, compared to 3,448 in 1996 (ODNR 1997). Surface mining came into practice in Meigs County in 1940 when a mere 177 tons of the total 168,442 tons was surface mined (Crowell 1995).

Coal mining in Meigs County ceased in 2002 with the closure of an underground mine complex operated by Southern Ohio Coal Company (SOCCO), a subsidiary of American Electric Power. These underground mines used a mechanized technique of mining called longwall mining. This machine removes large blocks of coal, causing the overburden to collapse in a controlled manner. Longwall mining significantly increases production, allowing underground mines to stay in the market with surface mining elsewhere in the United States (ODNR 2003). In 2000, Meigs County coal production was the second highest in the state of Ohio, second only to Belmont County with 4,306 short tons of coal mined (Energy Information Administration 2002). From 1806-1993, tons of coal mined from Meigs County are reported to be 113,803,955 (Crowell 1995).

Ohio ranks second nationally in the consumption of coal, following Texas. More than 87 percent of the electricity generated in Ohio is coal-derived. Ohio used 57,334 million tons in 2003. Most of Ohio's coal is used for the generation of electricity, while some is used for making steel (ODNR 2005).

Coal Seams

The Redstone (#8A) seam was the most important source of coal mined in the Leading Creek watershed. Early stratigraphers used the term "Pomeroy coal" to refer to this coal seam, however, more recently the coal has been termed the Redstone as it correlates with the Redstone Coal along Redstone Creek in Fayette County, Pennsylvania (Delong, 1955).

The Redstone coal of the Pomeroy field has been one of Ohio's most desired coals due to its proximity to the Ohio River and cheap barge transportation. The Redstone coal was mined for shipment as early as 1833. The salt industry that was centered in Pomeroy gave great impetus to the use of the Redstone coal in about 1847. Shipment by rail began upon completion of railroad connections to Pomeroy in 1892 (Delong, 1955).

The Redstone coal is extensive and well developed in Salisbury, Rutland, Scipio, and Bedford Townships of Meigs County where it occurs above drainage and thins towards the margins of the field. The coal beds occur high on the ridges and knobs of western Scipio and Rutland Townships and dips toward the southeast at 30 ft/mile where it disappears under cover below the Ohio River. Its occurrence and characteristic below drainage are not as well known. The above drainage coal is irregular but is relatively thick, with reserves up to 78 inches, which most averaging between 42 and 54 inches. The drainage from this mined coal seam is the primary cause of acid mine drainage impacts in the Leading Creek Watershed today.

The Redstone coal is usually overlain by a carbonaceous shale, which occasionally develops locally into a roof coal. The roof shale and coal are overlain by a shale, which is up to 15 feet thick and is succeeded by the massive Pomeroy sandstone, which is forty to ninety feet thick. The Pomeroy sandstone has an unconformable base and at some localities it replaces part of all of the shale and carbonaceous roof shale, and may rest directly on the coal. Subsidence of the underground mines is rarely a problem associated with the extraction of the Redstone due to the presence of this sandstone.

Extensive mining of the Redstone coal occurred by surface and underground mining, and to a smaller degree auger mining. Approximately 2,000 acres were surface mined in Salisbury, Rutland, and Scipio Townships during the period between 1940 and 1962. Over 3,000 acres in Salisbury and Rutland Townships are underlain by underground mines that were mined predominately between 1900 and 1960. The majority of which are located in the Thomas Fork subwatershed, where affects from acid mine drainage are prolific (Map 7).

The Pittsburgh (#8) and the Clarion (#4A) are other notable coal seams in the Leading Creek watershed. The Pittsburgh coal, however, was primarily mined south and east of the Leading Creek basin in Scipio and Bedford Townships in north-central Meigs County. The Clarion coal is located below drainage and was mined by Southern Ohio Coal Company (SOCCO) in Rutland and Salem Townships, in the extreme western edge of Meigs County.

Parker Run

Southern Ohio Coal Company, a subsidiary of American Electric Power operated the Meigs 31 mine complex, the largest underground coal mine in Ohio and it is found in the Leading Creek watershed (US Fish and Wildlife Service, 2001). In 1993, flooding in the mine caused contaminated acid mine water to be released into Parker Run (a tributary of Leading Creek) at an estimated rate of 35,042 gallons per minute (Currie, 1999). Approximately one billion gallons of mine water were released into the stream (Ohio EPA, 2005). The discharge ruined habitat and killed fish along a fifteen-mile stretch of Parker Run, into Leading Creek (US Department of Justice, 1996).

Through a Consent Decree, Southern Ohio Coal Company paid $1.9 million to complete the Leading Creek Improvement Plan (LCIP) in order to restore the quality of the watershed, in addition to several penalties paid to the EPA, and US Office of Surface Mining for various violations (US Department of Justice, 1996). A plan was created for the restoration and continued monitoring of the watershed's improvements (Currie, 1999). The US Fish and Wildlife Service undertook the implementation of the LCIP. The Service used the money provided to hire a watershed coordinator, purchase copies of "A Guide to Ohio Streams," organize the Leading Creek Advisory Committee, and to fund several conservation and restoration projects. The Service partnered with the Meigs Soil and Water Conservation District and provided $100,000 to be used towards erosion control projects implemented by the District in priority areas of the watershed (US Fish and Wildlife Service, 2001).

The Ohio EPA concluded in 2005 that American Electric Power had successfully done their part to restore the streams back to their conditions before the contamination, except for two sections of Parker Run and Leading Creek. American Electric Power will provide $57,630 for the Meigs County Soil and Water Conservation District's habitat restoration project in Little Leading Creek and $32,957 towards a Mussel Resurvey and Reintroduction to Leading Creek project at the Columbus Zoo (Ohio EPA, 2005).

SECTION THREE- Water Quality Overview

Acid Mine Drainage

Acid mine drainage (AMD) is a complex environmental stressor that impacts aquatic ecosystems with high levels of acidity, elevated concentrations of dissolved metals and/or the deposition of metal precipitants. Within the last twenty years the devastating environmental stress of acid mine drainage has developed into a prominent ecological issue. The United States Environmental Protection Agency (USEPA) has determined that AMD is the largest source of water pollution in the Appalachian Region affecting more than 6400 km of streams (United States EPA, 1995).

The production of acid mine drainage consists of several reactions beginning with the exposure of pyrite (FeS_2) to water and oxygen (Figure 2). Pyrite is typically found within the coal seams or surrounding shale and sandstone. The oxidation of pyritic minerals results in the production of sulfuric acid, which lowers the pH. As this highly acidic, sulfate-rich drainage passes over the surrounding rock strata, coal overburden, or the streambed, heavy metals such as iron, manganese and aluminum are mobilized.

Figure 2. Formation of Acid Mine Drainage

$$FeS_2 + 7/2O_2 + H_2O \rightarrow Fe^{+2} + 2SO_4^{-2} + 2H^+$$

$$Fe^{+2} + 1/4O_2 + H^+ \rightarrow Fe^{+3} + 1/2H_2O$$

$$Fe^{+3} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$$

$$FeS_2 + 14Fe^{+3} + 8H_2O \rightarrow 15Fe^{+2} + 2SO_4^{-2} + 16H^+$$

Acid mine drainage has one or more of the following characteristics: high acidity (low pH), high metal concentrations, elevated sulfate levels, and excessive suspended solids and/or siltation.

Acid mine drainage has many adverse effects on aquatic systems (Table 2). It often reduces biological diversity, eliminates sensitive aquatic life, and lowers ecosystem productivity.

Table 2. Major effects of acid mine drainage on lotic systems (Gray, 1997)

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

Water Quality Standards

The Ohio Water Quality Standards used for managing water resources consist of designated uses and physical, chemical, and biological criteria. The Ohio Environmental Protection Agency created standards that exist in the form of "aquatic life uses" and "non-aquatic life uses". Table 3 summarizes the use designations for streams in the Leading Creek watershed (Ohio Administrative Code, 2003).

Table 3. Designated uses and subcategories for surface water resources

Water Body Segment	Aquatic Life	Water Supply	Recreation
Leading Creek	WWH	AWS, IWS	PCR
Thomas Fork	WWH	AWS, IWS	PCR
Hysell Run	WWH	AWS, IWS	PCR
Bailey Run	WWH	AWS, IWS	PCR
East Branch of Thomas Fork	WWH	AWS, IWS	PCR
Long Hollow	WWH	AWS, IWS	PCR
Little Leading Creek	WWH	AWS, IWS	PCR
Malloons Run	WWH	AWS, IWS	PCR
Parker Run	WWH	AWS, IWS	PCR
Dexter Run	WWH	AWS, IWS	PCR
Mud Fork	WWH	AWS, IWS	PCR
Ogden Run	WWH	AWS, IWS	PCR
Sisson Run	WWH	AWS, IWS	PCR
Fivemile Run	WWH	AWS, IWS	PCR

WWH= Warmwater habitat
AWS= Agricultural water supply
IWS= Industrial water supply
PCR= Primary contact recreation

Ohio Water Quality Standards: Aquatic Life Uses

- ***Exceptional Warm Water Habitat (EWH)***
  Designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms. Water bodies are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (declining species). This use designation represents a protection goal for water resource management efforts in Ohio's best rivers and streams.

- ***Warm Water Habitat (WWH)***
  Designation defines the "typical" warm water assemblages of aquatic organisms for Ohio rivers and streams. This use is the principal restoration target for the majority of water resource management efforts in Ohio, including those of the Leading Creek Watershed. Biological criteria are stratified across five ecoregions for the WWH use designation.

- ***Modified Warm Water Habitat (MWH)***
  Designation applies to streams and rivers which have been subjected to extensive and irretrievable modifications of the physical habitat such that the biocriteria for the WWH use are not attainable. The activities causing the "irretrievable modifications" have been sanctioned and permitted by state or federal law. The representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat. Biological criteria for MWH have three major modification types: channelization, run-of-river impoundments, and extensive sedimentation due to non-acidic mine drainage. Biological criteria for MWH are stratified across five ecoregions

- ***Limited Resource Water (LRW)***
  Designation applies to small streams (usually <3 square mile drainage area) and other waterbodies which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported. Waters designated LRW are affected by one or more factors: acid mine drainage, small drainageway maintenance, or other specified conditions. No formal biological criteria have been established for the LRW use designation.

- ***Coldwater Habitat (CWH)***
  Designation applies to waters which support assemblages of native cold water fish and associated organisms and/or those which are stocked with salmonids sanctioned by the Ohio DNR, Division of Wildlife. No specific biological criteria have been developed for the CWH use.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to monitoring the health and status of aquatic life, each water quality survey also assesses non-aquatic life uses such as recreation, water supply, and human health concerns.

- ***Recreational Uses***- attainment status is based on bacterial indicators (*i.e.* fecal coliform, E. coli) which are specified in the Ohio Water Quality Standards.

  - **Primary contact**- Waters that during the recreational season are suitable for full-body contact recreation such as swimming, canoeing and scuba diving. Waters must have a depth >1 meter and an area >100 square feet.
  - **Secondary contact**- Waters that during the recreational season are suitable for partial body contact recreation such as wading. This recreational use is most common in the Leading Creek watershed.
  - **Bathing waters**- Waters that during the recreational season are suitable for swimming where a lifeguard and/or bathhouse facilities are present.

- ***Water Supply Uses***- attainment status is based on chemical criteria which are specified in the Ohio Water Quality Standards.

  - **Public Water Supply**- Waters that with conventional treatment will be suitable for human intake and meet federal regulations for drinking water. Waters are defined as segments within 500 yards of a potable water supply or food processing industry intake.
  - **Agricultural Water Supply**- Waters that are suitable for irrigation and livestock watering without treatment.
  - **Industrial Water Supply**- Waters that are suitable for commercial and industrial uses with or without treatment.

Biological Criteria

Ohio's Water Quality Standards are dependent on the biological integrity rather than water chemistry criteria to classify the health of a given stream segment (Table 4). Several structural multi-metric indices are used to assess the health of the biological community and determine habitat quality. Biological surveys are conducted to determine the condition of both fish (IBI and MIwb) and macroinvertebrate (ICI) populations.

- ***Index of Biologic Integrity (IBI)*** is a multi-metric index that represents the structural and functional integrity of the fish community. The index assesses fish community attributes that correlate with biotic integrity. The IBI consists of the following 12 metrics in wading sites (note some metrics are modified for headwater sites):
    - Metric 1. Total number of native fish species
    - Metric 2. Number of darter species
    - Metric 3. Number of sunfish species
    - Metric 4. Number of sucker species
    - Metric 5. Number of intolerant species
    - Metric 6. Percent abundance of tolerant species
    - Metric 7. Proportion of omnivores
    - Metric 8. Proportion of insectivores
    - Metric 9. Top carnivores
    - Metric 10. Number of individuals in a sample
    - Metric 11. Proportion of individuals as simple lithophilic spawners
    - Metric 12. Proportion of individuals with disease, eroded fins, lesions and tumors

- ***Invertebrate Community Index (ICI)*** is a multi-metric index used to evaluate the overall condition of benthic macroinvertebrates in a stream segment. The ICI consists of the following 10 metrics:
    - Metric 1. Total number of taxa
    - Metric 2. Total number of mayfly taxa
    - Metric 3. Total number of caddisfly taxa
    - Metric 4. Total number of dipteran taxa
    - Metric 5. Percent mayflies
    - Metric 6. Percent caddisflies
    - Metric 7. Percent tribe *Tanytarsini* midges
    - Metric 8. Percent other dipterans
    - Metric 9. Percent tolerant organisms
    - Metric 10. Total number of *Ephemeroptera, Plecoptera*, and *Trichoptera* (EPT) taxa

- ***Modified Index of Well Being (MIwb)*** is an index that incorporates the number of individuals, biomass, and the Shannon diversity index, in order to evaluate the relationship between fish abundance and development.

- ***Qualitative Habitat Evaluation (QHEI).*** QHEI scores are not adopted into the Ohio Water Quality Standards mandate as are the other indices described above. Physical features, such as type of substrate, amount and type of in-stream cover, channel width, sinuosity, and erosion, that affect fish communities are evaluated.

Table 4. Narrative ranges and biocriteria for the Western Allegheny Plateau

Western Allegheny Plateau wading sites.			
IBI	**MIwb**	**ICI**	**Narrative Evaluation**
50 -60	≥ 9.4	46 - 60	Exceptional
46 - 49	8.9 - 9.3	42 - 44	Very Good
44 - 45	**8.4** - 8.8	**36** - 40	Good
40 - 43	7.9 - 8.3	32 - 34	Marginally Good
28 - 39	5.9 - 7.8	14 - 30	Fair
18 - 27	4.5 - 5.8	8 - 12	Poor
12 -17	0 - 4.4	≤ 6	Very Poor

WWH criteria in bold
Ohio Adminstrative Code, 2004

Leading Creek Watershed Group Targets and Benchmarks

In addition to the biological criteria (Table 4), staff members of the Meigs Soil and Water Conservation District have evaluated water quality impairments using the standards and targets proposed by the Ohio EPA for the Western Allegheny Plateau (Table 5). Specific targets for the Leading Creek Watershed were determined by reviewing water quality data in reference reaches, the mainstem, the most heavily impacted sites, parameters in the Western Allegheny Plateau (WAP) which are attaining WWH, and other watershed group's targets. The following target values for water quality parameters were chosen: pH 6.5 – 7.5 s.u., Alkalinity 70 mg/L, TDS 500 mg/L, Sulfates 150 mg/L, Iron 1.0 mg/L, Aluminum 0.75 mg/L, and Manganese 0.60 mg/L.

Table 5. Ohio EPA standards and benchmarks organized by the Leading Creek Watershed Group

Parameter	Ohio EPA standard	Ohio EPA benchmark	Watershed Group target
pH	6.5 - 7.5 ‡		
Alkalinity	135 mg/L, 141 mg/L*		70 mg/l §
Total dissolved solids	1500 mg/L ‡		500 mg/l§
Total Iron	1.10 mg/L, 0.80 mg/L *		1.0 mg/l§
Total Manganese	0.60 mg/L, 0.20 mg/L*		0.6 mg/l §
Total Aluminum			0.75 mg/l §
Sulfate	204 mg/L, 191 mg/L *		150 mg/l§
IBI		44-49 Ω	
ICI		36-44 Ω	
MIwb		8.4-9.3 Ω	

‡ Ohio EPA water quality standard for Ohio River Basin, outside mixing zone

* Ohio EPA ***potential*** standard published in *Association Between Nutrients, Habitat and the Aquatic Biota in Ohio Rivers and Streams (OEPA, 1999)* for the WAP ecoregion. 1st number is for headwater sites and 2nd number is for wading sites (>20 square miles)

£ Ohio EPA water quality standard to meet the recreational use for primary contact

§ Target set by the LCW based on the median water quality concentration at WAP reference sites meeting partial and full attainment of WWH

Ω Ohio EPA benchmarks set for multimetric indices to meet Warmwater Habitat aquatic life use designation.

Historical Water Quality Data

The 2000 Ohio EPA 305(b) report outlines several sources of water quality impairments to the Leading Creek watershed. Ohio EPA lists known sources of impairment as follows: surface mining, subsurface mining, specialty crop production, pasture land, non-irrigated crop production, and channelization. Surface mining was listed as the source of water quality impairment in over half of the assessed stream segments.

The sources of water quality impairment, as proposed by the Ohio EPA, cause many problems for stream quality. Some of the causes of water quality impairment include siltation, pH, habitat alteration, and salinity/total dissolved solids/chlorides. Siltation is the main cause of impairment in the sampled areas, affecting 6 of the 9 stream segments. pH is suspected to affect 2 of the 9 surveyed streams.

The water quality impairments have obvious effects on the aquatic life in the streams. According to the historical attainment information, few streams and stream segments are achieving their aquatic life use designation (WWH) (Table 6), and there are extremely low abundances of macroinvertebrates and low diversity of macroinvertebrate taxa (Table 7 and Map 3). It is important to consider that while many of the sites are downstream of abandoned mine lands, most are affected by habitat conditions and excessive sediment deposition as well as mine drainage. River mile designations on Leading Creek and Thomas Fork are shown on Map 8.

Table 6. Historical attainment table for sites downstream of known or suspected AMD contamination

River mile	Surveyor	Year	IBI	Narrative Evaluation	MIWb	Narrative Evaluation	ICI	Narrative Evaluation	Status
Leading Creek									
7.2	AEP	1995	33	Fair			28	Fair	(Non-attainment)
7.2	AEP	1996	35	Fair			34	Marginally Good	(Partial)
7.2	AEP	1997	38	Fair			30	Fair	(Non-attainment)
7.1	OEPA	1994					24	Fair	(Non-attainment)
6.0	OEPA	1993	20	Poor	3.1	Very Poor			(Non-attainment)
6.0	OEPA	1993	12	Very Poor	2.6	Very Poor			(Non-attainment)
6.0	OEPA	1993	20	Poor	3.6	Very Poor			(Non-attainment)
6.0	OEPA	1994	26	Poor	3.3	Very Poor			(Non-attainment)
6.0	OEPA	1994	34	Fair	3.9	Very Poor			(Non-attainment)
6.0	OEPA	1995	14	Very Poor	2.1	Very Poor			(Non-attainment)
6.0	OEPA	1995	24	Poor	3.4	Very Poor			(Non-attainment)
6.0	OEPA	1996	36	Fair	4.2	Very Poor			(Non-attainment)
6.0	OEPA	1996	42	Marginally Good	7.1	Fair	36	Good	Partial
6.0	OEPA	1997	42	Marginally Good	8.1	Marginally Good	32	Marginally Good	Full
6.0	OEPA	1998	30	Fair	5.7	Poor	22	Fair	Non-attainment
6.0	OEPA	1999	38	Fair	6.9	Fair	28	Fair	Non-attainment
6.0	OEPA	2000					26	Fair	(Non-attainment)
6.0	OEPA	2002	46	Very Good	7.9	Marginally Good	26	Fair	Partial
3.5	AEP	1995	33	Fair					(Non-attainment)
3.5	AEP	1996	29	Fair					(Non-attainment)
3.5	AEP	1997	37	Fair			28	Fair	(Non-attainment)
1.8	AEP	1995	25	Poor			32	Marginally Good	(Partial)
1.8	AEP	1996	31	Fair			18	Fair	(Non-attainment)
1.8	AEP	1997	33	Fair					(Non-attainment)
1.7	OEPA	1993	12	Very Poor					(Non-attainment)
0.2	OEPA	1993	12	Very Poor	2.4	Very Poor			(Non-attainment)
0.2	OEPA	1993	14	Very Poor	3.6	Very Poor			(Non-attainment)
0.2	OEPA	1993	20	Very Poor	6.9	Fair			(Non-attainment)
0.2	OEPA	1994	28	Fair	6.0	Fair			(Non-attainment)
Thomas Fork									
4.4	OEPA	1995	12	Very Poor					(Non-attainment)
2.8	OEPA	1993	12	Very Poor					(Non-attainment)

NOTE: Many of the Leading Creek mainstem sites do not seem to be impaired by AMD but are probably limited by habitat conditions and excessive sediment deposition.

AEP = American Electric Power

Table 7. Macroinvertebrate assessments scores in the Leading Creek Watershed

Macroinvertebrate assessments for sites downstream of pre-law mining activities.

Location	Taxa diversity *	Percentage EPT** taxa
Titus Run, RM 0.1	9	21%
Leading Creek, RM 7.2	19	19%
Paulins Hill Run, RM 0.1	10	4%
Leading Creek, RM 3.5	22	22%
Leading Creek, RM 1.8	13	13%
Thomas Fork, RM 1.2	4	18%

* total number of different macroinvertebrate taxa collected

***Ephemeroptera, Plecoptera, Trichoptera*

NOTE: Many of the Leading Creek mainstem sites do not seem to be impaired by AMD but are probably limited by habitat conditions and excessive sediment deposition.

Other studies have also contributed helpful information about the condition of water quality and biological resources in the watershed. In 1996 and 1997, a comprehensive watershed study was directed by Dr. Donald S. Cherry of Virginia Polytechnic Institute and State University. The authors found that system-wide, abandoned mine lands (AML) presented the single greatest risk to aquatic ecology in the Leading Creek watershed, causing excessive sediment deposition, acid mine drainage, and metal toxicity.

In a 1985 survey of 30 Ohio counties impacted by mining, the Leading Creek watershed ranked highest for sediment damage, acreage of sediment deposition, total erosion and erosion rate (United States Department of Agriculture, 1985). When the 30 watersheds were ranked according to impacts, the Leading Creek Watershed was first in environmental impacts, second in agricultural impacts, and first overall based on affected population, health and safety issues, potential damage to infrastructure, agriculture, environment, and mining related impacts.

Historic biological surveys were conducted in many of the mined watersheds by the ODNR Division of Wildlife in the 1950s and 1960s. Fish diversity and abundance were evaluated along the mainstem of Leading Creek and in several of its tributaries. The health of fish communities corresponded very closely with the timing of surface mining activities. Abundances declined or were completely eliminated in the 1950s and 1960s when surface mining operations became widespread (Figure 3 and Figure 4). This trend was most likely caused by the increased sedimentation from exposed surface mines and/or increased acidity and metals concentrations. In 1953 and 1959, surveys were also completed at three locations in the Thomas Fork watershed, the mainstem upstream of East Branch, Hysell Run, and Bailey Run. No aquatic life was present during the surveys and the biologists reported very low pH readings (all measurements < 3.5).

Fish communities within Little Leading Creek and Mud Fork have somewhat recovered with a few tolerant species currently present, but aquatic life still remains limited by the excessive sediment deposition from surface mine lands. In contrast, fish communities within Thomas Fork remain severely degraded, and Ohio EPA biologists noted that “no fish were present” during their 1995 survey.

Figure 3. Trends in Mud Fork's Fish Abundance

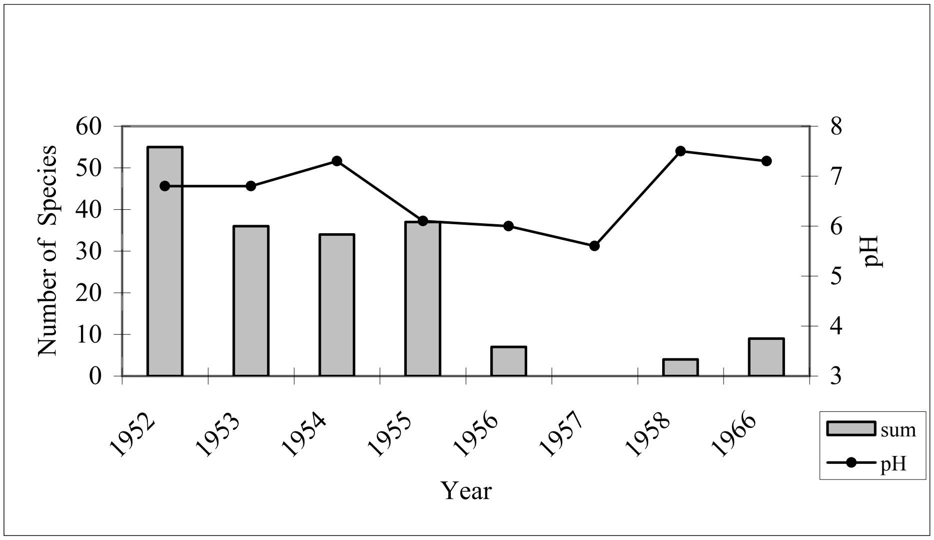
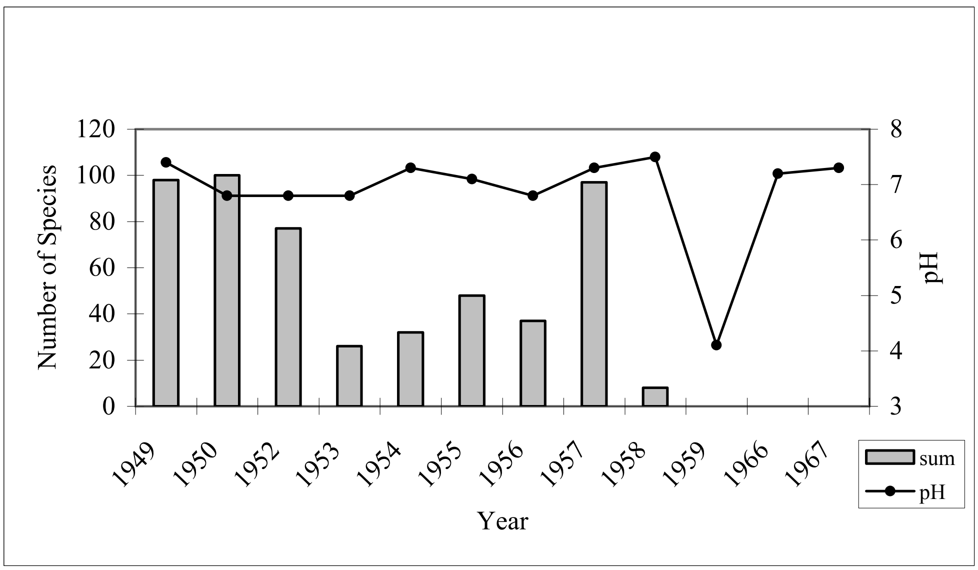


Figure 4. Trends in Little Leading's Fish Abundance



Compared to historical information, the water chemistry along the mainstem of Leading Creek does not show significant changes (United States EPA, 2003; Figure 5). Except at site RM 1.3 in 1967, this site is located downstream of the confluence with Thomas Fork. In general, Leading Creek seems to exhibit few, if any, impairments from acid mine drainage except downstream of Thomas Fork. Compared to historical information, Thomas Fork continues to maintain poor water chemistry, but the severity of impairments does fluctuate with different flow regimes (US Geological Survey, 2003; Table 8).

Figure 5. Most severe historical pH values at sites along Leading Creek

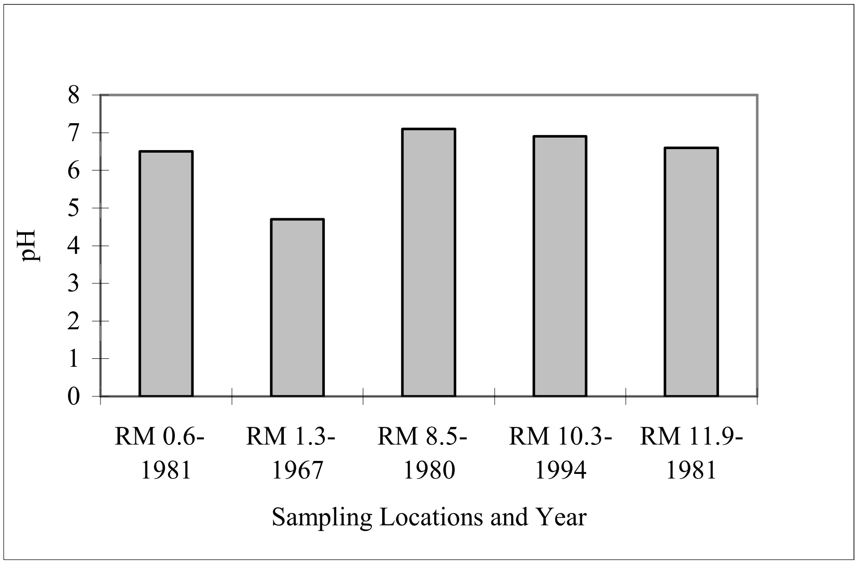


Table 8. Historical data recorded at the mouth of Thomas Fork

Thomas Fork RM 1.2	High Flow	Low Flow
Average pH (standard units)	5.2	3.8
Average Conductivity (μS/cm)	820	1550

Historical comparison of data near the mouth of Thomas Fork from United States Geological Survey (USGS) samples taken 1975 to 1992

Current Water Quality Data

Staff of the Meigs Soil and Water Conservation District (SWCD), with assistance from Ohio Department of Natural Resources Division of Mineral Resources Management (ODNR-DMRM), began to systematically test the water quality within the Leading Creek watershed in the spring 2003. The mainstem and all major tributaries were assessed using a three- phased approach which allowed the prioritization of sources based on acidity and heavy metal loads.

Phase I was used as an initial screening and consisted of locating abandoned surface and subsurface mines on USGS topographical mine maps, reviewing existing water quality information (Cherry *et al.*, 1999; Ohio EPA, 2000; United States DA, 1985; United States GS historical data, and United States EPA STORET data), and measuring field parameters such as pH, conductivity, and acidity, in the seven subwatersheds where mining occurred. This initial screening allowed us to determine which tributaries potentially carried mine impacted water and deserved additional monitoring. From this phase, water quality monitoring was narrowed to Lasher Run, Little Leading Creek, Titus Run, Paulins Run, and Thomas Fork (Map 4).

During Phase II, a mass balance approach was applied to the Titus Run, Paulins Run, and Thomas Fork subwatersheds (Map 5 and Map 6). These assessments allowed us to prioritize each of the tributaries based on their loading impact to the receiving stream. There are three main sources of AMD identified in the Paulins Run subwatershed: tributary one

(PH0100), tributary two (PH0200), and “seep” (Seep Ditch) (Figure 6). Figure 6 shows the average acid and metal loadings calculated from data collected May and June of 2004. Titus Run has only one site, tributary one (TR0100), which adds an acid loading (Figure 7). AMD impacts within the Thomas Fork subwatershed are much more widespread, and there are several streams that contribute significant acidity and metal loadings (Figure 8).

Phase II sampling was then conducted in each of these smaller basins (*i.e.* each of the “main sources” within the Titus Run, Paulins Run, and Thomas Fork subwatersheds) to identify project areas and compare loadings from the sources. Attempts were made to collect phase II samples during both a high water level and a low water level, but the unusual weather conditions in 2003 and early 2004 limited our ability to collect a “true” low flow in many cases. Therefore the project sampling was extended into 2005 and 2006 to capture a low flow sampling event. Ohio University’s Voinovich Center (ILGARD) was contracted to evaluate the Thomas Fork Subwatershed during low flow conditions and to work with the Leading Creek Watershed Group and ODNR-MRM to complete the AMDAT plan. Data collected during the low flow regime of 2005 proved to be extreme low flow conditions. Many perennial streams were dry and much of the mainstem held water only in the deep pools. Much of the flowing water in Thomas Fork was found near the sources of acid mine drainage. As the stream flowed downstream the mainstem of Thomas Fork acted as a losing stream with interstitial water moving through the substrate which increased with sediment towards the mouth (Figure 9).

Figure 6. Acidity and metal loadings in Paulins Hill Subwatershed

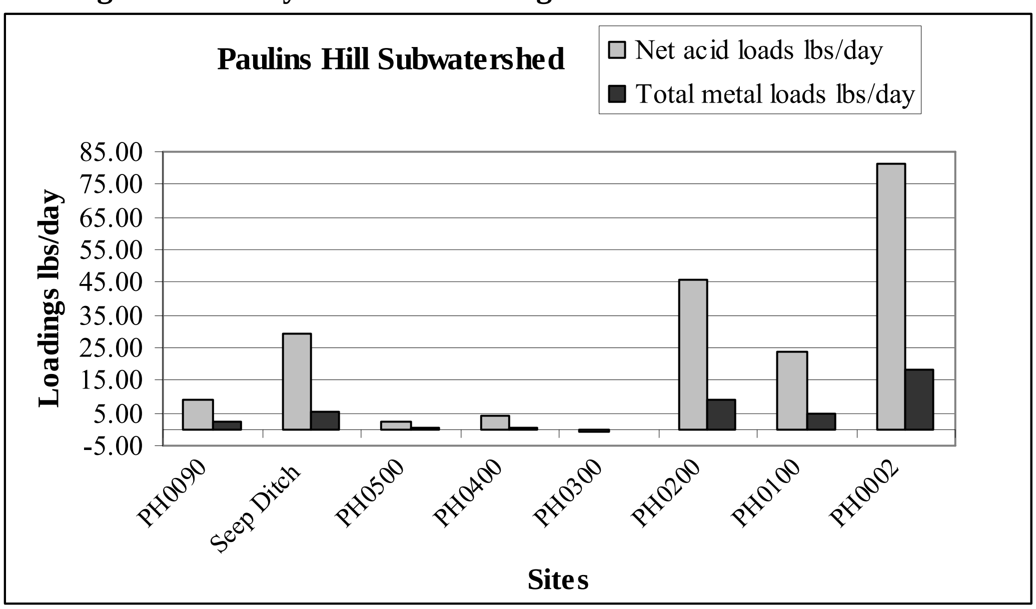


Figure 7. Acidity and metal loadings in the Titus Run Subwatershed

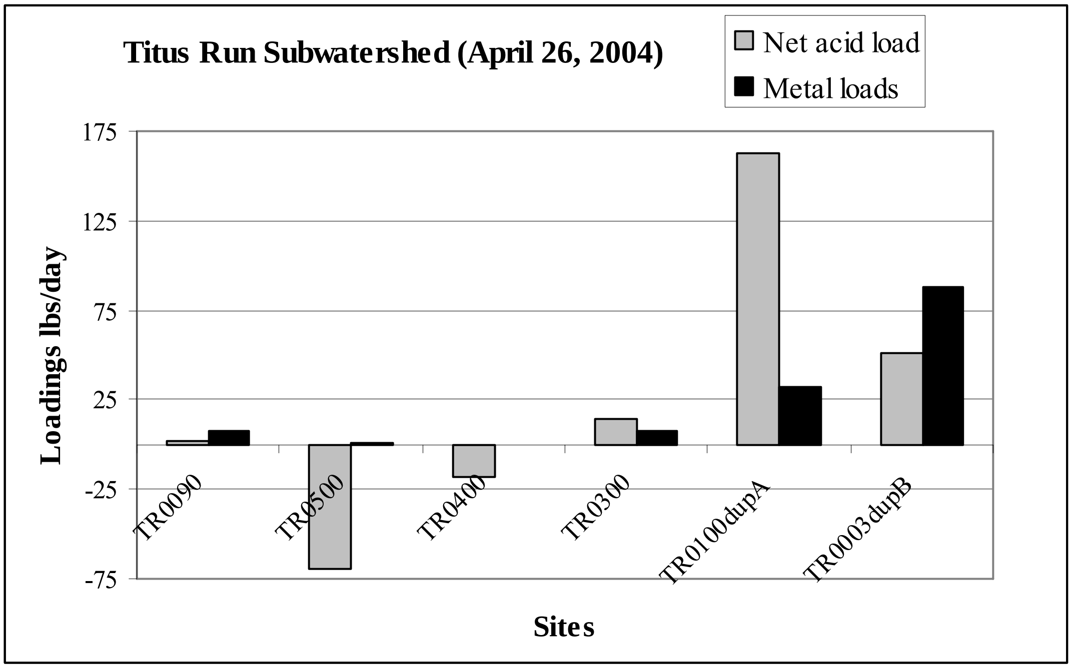


Figure 8. Acidity and metal loadings on Thomas Fork

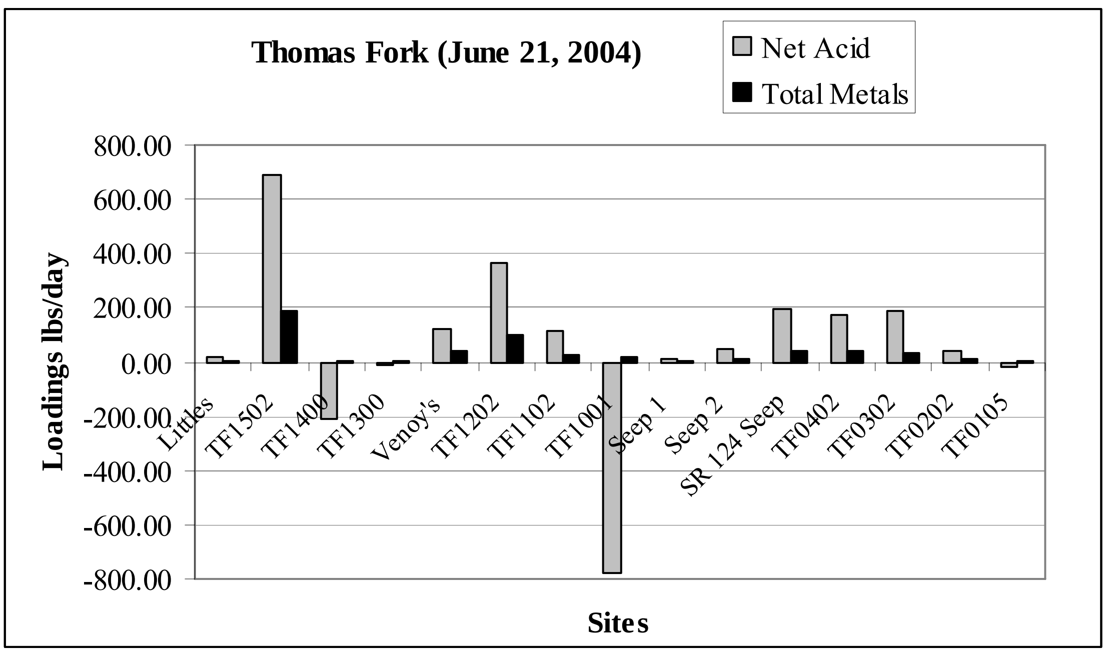
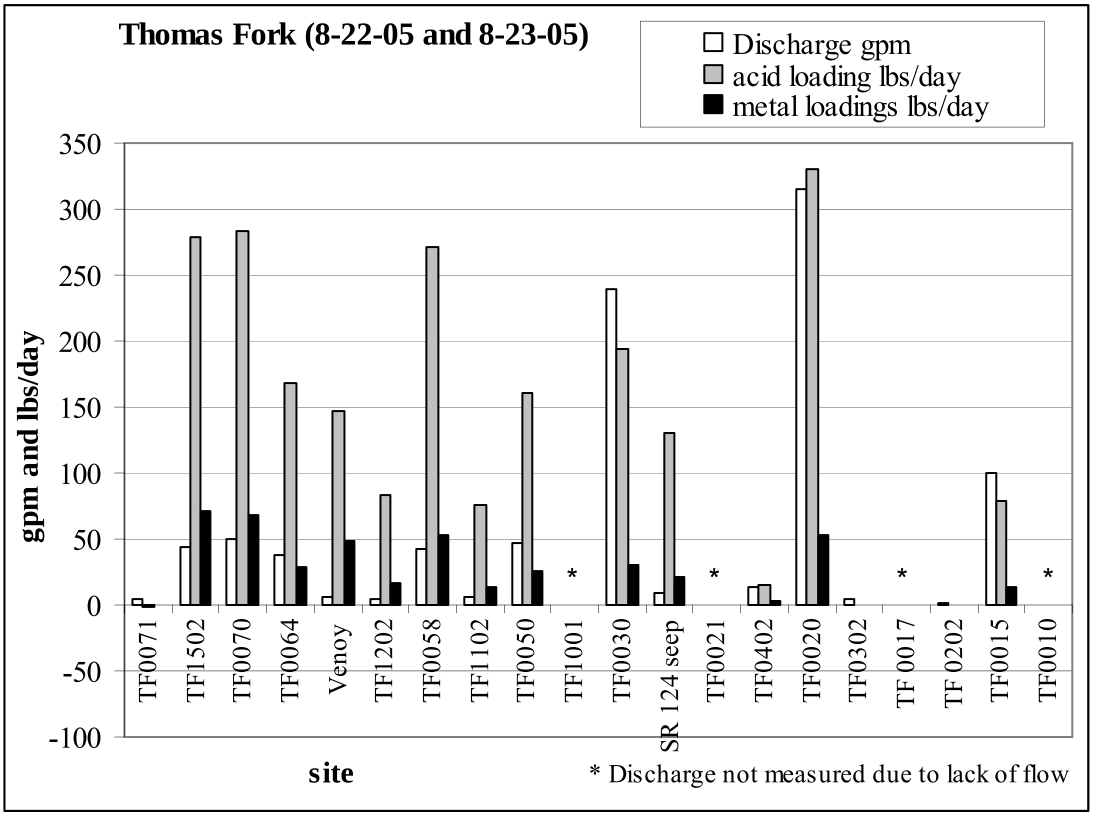


Figure 9. Extreme low flow, acid, and metal loadings on Thomas Fork



Phase III is designed to characterize potential remediation sites within the subwatershed or project area. Discrete point sources were sampled where possible, but identification of point sources was limited for most of the subwatersheds because of the diffuse nature of the problem. In such cases, it was determined that collecting samples within small tributaries receiving the drainage from the strip pits and/or auger pits was the best method for assessing the diffuse nature of the AMD problem.

Current water quality monitoring and biological studies allows the determination of significant sources of acid mine drainage and justification for treatment and abatement activities. Acid, metal, and flow budgets help determine the sources of acid mine drainage in the watershed and prioritize the treatment of those sources based on their relative effects on the watershed. Analyses allow the identification of the specific projects that are needed to restore streams and stream segments to Warmwater Habitat (WWH).

Biological Health

The biological survey was conducted by Midwest Biodiversity Institute (MBI). The following section is a summary written by Michelle Shively of Ohio University taken from the "Leading Creek Biological Study" (Rankin 2005).

Historically, underground and surface mining made significant impacts to the Leading Creek watershed, causing problems such as acid mine drainage, sedimentation, and metal loadings. Even where mining impacts do not affect the watershed, upstream of Mud Fork, agricultural activities and waste-water are potential impairments to watershed health. Other potential stressors of concern occurring often in SE Ohio include nonpoint pollution, including sediment and nutrients, and habitat destruction. AMD remediation efforts have already shown improvements in aquatic life in some Ohio watersheds including Leading Creek. This summary consists primarily of data collected in 2004 by the Midwest Biodiversity Institute and analyzed by Edward Rankin, although data dating back to the 1980s and early 1990s was referenced when discussing such events as the Southern Ohio Coal Co Meigs #31 Mine discharge. All the following biological health information has been summarized from that report (Rankin 2005). Biological assemblage data was collected at 39 sites in the Leading Creek watershed during 2004.

Meigs #31 Mine Incident

During the summer of 1993 Southern Ohio Coal Company's (SOCCO), Meigs #31 complex mine flooded due to a ruptured mine seal. Over 1.1 billion gallons of toxic mine water was discharged into the Leading Creek watershed. The collapse and pumping of the mine resulted in low pH water, dissolved metals and mine associated contaminants being deposited into Parker Run. After the flooding of contaminated mine water, the area downstream of Parker Run was devoid of most fish, macroinvertebrate, and amphibian populations. Monitoring stations were selected in the affected areas of the Leading Creek watershed to observe changes in fish and macroinvertebrate assemblage indicators. Patterns in these indicators were used to determine when the streams had recovered to their pre-discharge conditions. Although slight recovery in fish assemblages began in 1993, it took two to four years for substantial recovery to occur. The Ohio EPA considers the streams to have recovered from all the impacts directly related to the spill, however, other mine-related and nonpoint sources are still limiting full attainment of aquatic life uses in these same areas.

Leading Creek Mainstem

The fish assemblages in the mainstem of Leading Creek either attain or nearly attain the WWH criterion from the headwaters until reaching about RM 10. Here, sand sediments reached a peak and essentially smothered the stream bottom. Below the confluence of Thomas Fork, high acid loads add another major stress. Habitat in the mainstem is generally good to very good (60-75), but declines where sedimentation was severe. Macroinvertebrate data also generally attains the WWH goal, with the exception of the mayfly population being extremely low downstream of Parker Run. Water from SOCCO's slurry impoundment continues to be pumped and threated prior to discharge in Parker Run where total dissolved solids are exceeding effluent limits.

Thomas Fork Watershed

The Thomas Fork watershed is the most severely impaired and the most affected by AMD of all the Leading Creek subwatersheds. Five sites in the watershed were completely devoid of fish (Hysell Run, Bailey Run, and three of five sites on Thomas Fork), while the lower Thomas Fork site and the East Branch had poor fish communities. The other sites of the watershed either attain the WWH criterion (upper East Branch Thomas Fork sites, Long

Hollow Run), or nearly attain it (upper Thomas Fork site). Because there are fish communities intact within the watershed, especially the headwaters, rapid recovery of the impaired areas would be expected when chemical stressors are removed. Several of the fish species (e.g., fantail darter, least brooklamprey, and southern redbelly dace) found in these streams are high quality headwater species which indicates good water quality and flow in the upper area of these streams.

Little Leading Creek and Mud Fork

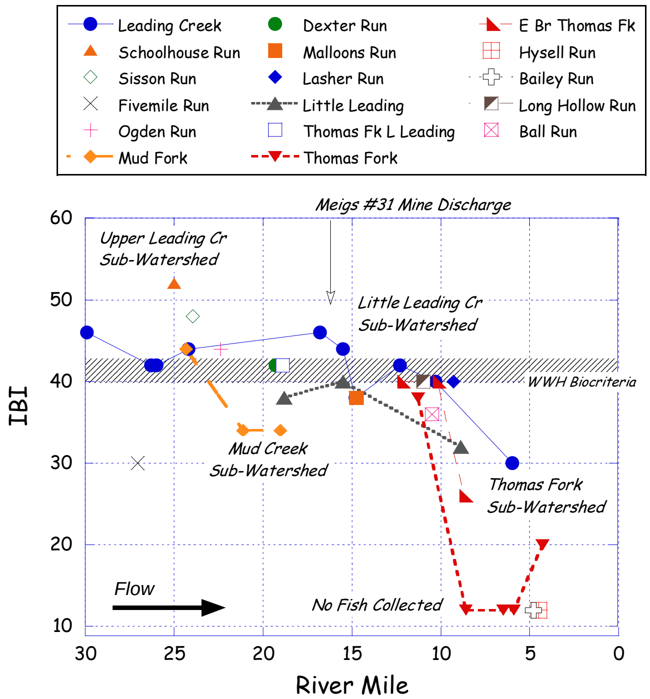
Biological ratings for the sites in the Little Leading Creek and Mud Fork subwatersheds range from fair to good. These watersheds generally have fine sandy substrates, originating from abandoned mine lands and bank erosion. The fish assemblage in Little Leading Creek did not become more diverse as stream size increased, as is normally expected. The mouth site (23 square miles) and the most upstream site (4 square miles) had the same number of fish species (14). High sand bedload fills pools, embedding larger substrates and creating unstable habitats in Little Leading Creek. High populations of "pioneering" fish species were found in all the sites in this subwatershed. These species can rapidly recolonize a stream after being eliminated and are not susceptible to the unstable sands and habitats characteristic of these streams. Conversely, sensitive species were found in low populations due to the unstable habitats.

Upper Watershed

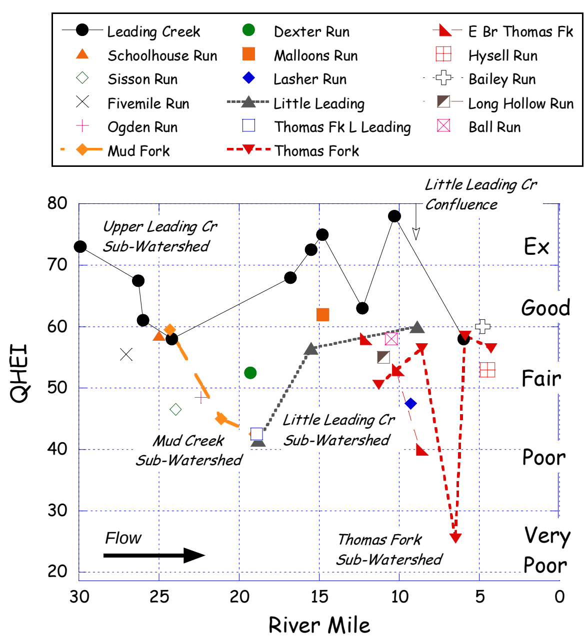
The upper part of the Leading Creek watershed has remained unaffected by mining activities. The presence of fish species that move long distances (sauger, freshwater drum, silver lamprey, channel shiner, emerald shiner) suggest that Leading Creek is not limited by recolonization barriers. Only one site, Fivemile Run, in the upper watershed did not meet the WWH standards. This site was thought to be substantially disturbed by cattle nearby. This was supported by the observation that the fish assemblage in Fivemile Run consisted of species tolerant to increased sediment and organic enrichment.

Conclusions

The quality of habitat conditions in the watershed ranges from very poor (scores <25) to excellent (scores >75). The poorest sites are affected by a combination of channelized conditions along with fine sediments. Sand substrates have had negative effects on much of the lower reaches of Leading Creek and in Little Leading Creek. Substrate scores in Leading Creek are finer and in poorer condition than other surrounding streams with more than 70% of the scores less than 14. In the middle part of Leading Creek which includes Little Leading Creek, all but Parker Run have > 50% of their surface substrates as sand with all of the Little Leading Creek sites having nearly 90% or more of their substrates as fines (silt to fine gravels). This watershed demonstrates good water quality, in part due to the absence of major development. Recorded biomass was the highest in 2004-2005 for the past 20 years of sampling. Samplers were even able to catch an adult mudpuppy which was eliminated in the 1993 mine discharge. With improvements in stream habitats and reductions in sediments, QHEI scores would improve and biological scores would be greatly enhanced through the restoration of habitats needed by sensitive species. Many of these species are now present, but in low abundance in the watershed, such as rainbow darter, redfin shiner, and possibly rosyface shiner and black redhorse.



IBI scores of streams sampled in the Leading Creek Watershed during 2004 and 2005.



QHEI scores of streams sampled in the Leading Creek Watershed during 2004 and 2005.

Attainment table for streams sampled by MBI in the Leading Creek watershed during 2004 and 2005 and associated causes and sources of impairment.

Station (Map #)	Fish RM	Macro RM	IBI	MIwb	ICI or Narrative	QHEI	Aquatic Life Uses Ex/Rec	Attain - ment -Status	Comment	Causes	Sources
Leading Creek (09-200)											
S09200 29.902004 (#32)	29.90	29.90	46	na	MG	73.0	WWH	**Full**	Dstrm Albany		
S09200 26.302004 (#33)	26.30	26.30	42	na	VG	67.5	WWH	**Full**	Upstrm Fivemile Cr		
S09200 26.002004 (#34)	26.00	26.00	42	na	G	61.0	WWH	**Full**	Dstrm Fivemile Cr		
S09200 24.202004 (#35)	24.20	22.10	44	na	G	58.0	WWH	**Full**	TR 13		
S09200 16.802004 (#6)	16.80		46	8.1	-	69.0	WWH	**Full**	Upstrm Parker; Historical Control		
S09200 15.502004 (#5)	15.50	15.50	44	8.6	26*	70.0	WWH	**Partial**	Immediately Dstrm Parker Run	TDS	Mining
S09200 14.802004 (#4)	14.80	14.80	38*	8.1	G	75.0	WWH	**Partial**	Dstrm Meigs Mine #31	TDS Sedimentation	Mining Agriculture
S09200 12.302004 (#3)	12.30	12.30	42	9.0	30*	63.0		**Full**	Langsville	TDS	Mining
S09200 10.302004 (#2)	10.30	10.30	40	8.7	G	78.0	WWH	**Full**	Historical Site		
S09200 6.002004 (#1)	6.00	6.00	30*	7.7*	24*	58.0	WWH	**Non**	Lower Creek	Sedimentation (Severe Sand Bedload)	Mining
Little Leading Creek (09-201)											
S09201 9.902004 (#9)	9.90	9.90	38*	<u>5.1</u>*	MG	41.5	WWH	**Partial**	Mouth	Sedimentation (Severe Sand Bedload)	Mining
S09201 6.602004 (#8)	6.60	6.60	40	na	MG	56.5	WWH	**Full**	County Road 60		
S09201 0.402004 (#7)	0.40	0.10	32*	na	MG	60.0	WWH	**Partial**	TR 177	Sedimentation (Severe Sand Bedload)	Mining
Malloons Run (09-202)											
S09202 0.102004 (#11)	0.10	0.10	38*	na	MG	62.0	WWH	**Partial**	Historical Site	Natural[1] (Low Flow)	Natural[1]
Parker Run (09-203)											
S09203 1.602004 (#12)	1.60	1.60	40	na	F*	72.5	WWH	**Partial**	Historical Site; Dst Meigs Mine #31	TDS	Mining

Station (Map #)	Fish RM	Macro RM	IBI	MIwb	ICI or Narr ative	QHEI	Aquatic Life Uses Ex/Rec	Attain - ment -Status	Comment	Causes	Sources
Dexter Run (09-205)											
S09205 0.802004 (#13)	0.80	0.80	42	na	MG	52.5	WWH	**Full**	Historical		
Mud Fork (09-206)											
S09206 5.402004 (#16)	5.40	5.40	44	na	MG	59.5	WWH	**Full**	State Route 692		
S09206 2.202004 (#15)	2.20	-	34*	na	-	45.0	WWH	**Non**	TR 52	Sedimentation (Sand Bedload)	Agriculture Mining
S09206 0.102004 (#14)	0.10	0.10	34*	na	MG	42.5	WWH	**Partial**	County Rd 17	Sedimentation (Sand Bedload)	Agriculture Mining
Ogden Run (09-207)											
S09207 0.502004 (#36)	0.50	0.50	44	na	MG	48.5	WWH	**Full**	Adj TR 25		
Sisson Run (09-208)											
S09208 0.102004 (#37)	0.10	0.10	48	na	MG	46.5	WWH	**Full**	Lane Off of C1		
Fivemile Run (09-209)											
S09209 0.902004 (#39)	0.90	-	30*	na	-	55.5	WWH	**NON**	Lane Across Stream	Sedimentation Nutrients Natural[1] (Low Flow)	Agriculture Livestock Natural[1]
Hysell Run (09-211)											
S09211 0.802004 (#29)	0.90	0.80	12*	na	MG	53.0	WWH	**NON**	Hysell Run Rd	pH, TDS (Severe AMD)	Mining
Bailey Run (09-212)											
S09212 0.502004 (#26)	0.50	0.50	12*	na	P*	60.0	WWH	**NON**	Adj Bailey Run Rd	pH, TDS (Severe AMD)	Mining
Thomas Fork (09-213)											
S09213 9.602004 (#27)	9.80	9.60	38*	na	VG	50.5	WWH	**Partial**	Upstream Site	Natural[1]	Natural[1]
S09213 7.102004 (#28)	7.10	7.10	12*	na	MG	56.5	WWH	**NON**	Ust. Ball Run	pH, TDS (Severe AMD)	Mining
S09213 5.002004 (#21)	5.00	5.00	12*	na	P*	25.5	WWH	**NON**	Ust East. Branch Thomas Fk	pH, TDS (Severe AMD)	Mining
S09213 4.402004 (#20)	4.40	4.40	12*	0.0*	2*	58.5	WWH	**NON**	Historical	pH, TDS (Severe AMD)	Mining
S09213 2.802004 (#19)	2.80	2.80	20*	1.4*	F*	56.5	WWH	**NON**	Historical	pH, TDS (Severe AMD)	Mining

Station (Map #)	Fish RM	Macro RM	IBI	MIwb	ICI or Narrative	QHEI	Aquatic Life Uses Ex/Rec	Attain-ment-Status	Comment	Causes	Sources
Long Hollow Run (09-214)											
S09214 0.102004 (#25)	0.10	0.10	40	na	MG	55.0	WWH	**Full**	Adj Long Hollow Road		
East Branch Thomas Fork (09-216)											
S09216 4.102004 (#24)	4.10	4.10	40	na	G	58.0	WWH	**Full**	County Road 20		
S09216 2.102004 (#18)	2.10	2.10	40	na	G	53.0	WWH	**Full**	Willow Creek Road		
S09216 0.602004 (#17)	0.60	0.60	26*	na	MG	40.0	WWH	**Partial**	Hiland Road	pH, TDS	Mining
Schoolhouse Run (09-217)											
S09222 0.602004 (#38)	0.60	0.60	52	na	G	58.5	WWH	**Full**	SR 143		
Ball Run (09-221)											
S09221 0.402004 (#22)	0.40	0.00	36*	na	G	58.0	None/ WWH	**Partial**	TR 20A	Natural[1] (Low Flow)	Natural[1]
Titus Run											
S09222 0.102004 (#31)	-	0.10	-	na	<u>P*</u>		WWH	**Non**	Titus Rd	- pH, TDS (Severe AMD)	Mining
Lasher Run (09-223)											
S09223 0.102004 (#23)	0.70	0.10	40	na	G	47.5	None/ WWH	**Full**	Lasher Road		
Thomas Fork of Little Leading Creek (09-224)											
S09224 0.302004 (#10)	0.30		42	na	-	42.5	None/ WWH	**Full**	County Road 3		
Unnamed Trib to Little Leading Creek (09-225)											
S09217 0.202004 (#30)	0.20	0.20	34*	na	MG	58.5	WWH	**Partial**	TR57	Sedimentation (Severe Sand Bedload)	Mining

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	22/30F	8/MF

Footnotes:

a - A qualitative narrative evaluation based on best professional judgment 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).

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.

d – Data not yet compiled for this site

na - 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 MIwb units). Underlined scores are in the Poor or Very Poor range.

[1] - Natural causes and sources of impairment are those that are relative to a least impacted reference condition with a typical level of landscape disturbance for a region (not necessarily compared to a “pristine” setting.

SECTION FOUR- Leading Creek Site Descriptions

Leading Creek

The Leading Creek basin does not have the severe and widespread AMD impacts that are common in many watersheds in Southeast Ohio. Based on extensive phase I reconnaissance, very few tributaries are degraded due to mine drainage and only two tributaries, Paulins Run and Thomas Fork, have AMD impacts that reduce diversity and abundance of fish and macroinvertebrate communities (Table 9). Likewise, the mainstem of Leading Creek is not directly affected by acid mine drainage, and it maintains good water quality even downstream from abandoned mine lands. Table 10 displays a summary of concentrations taken in the Leading Creek mainstem at areas downstream of AML. These water conditions can be attributed to reclamation activities, natural attenuation, and limited area where historical mining occurred (*i.e.* all historic subsurface mining occurred in the lower 1/3 of the watershed, see Map 7).

Table 9. Summary of field measurements in the Leading Creek Subwatersheds

Tributaries	**pH range*** units	**Conductivity range*** μS/cm
Mud Fork	6.08 to 6.75	278 to 450
Grass Run	6.23 to 6.81	314 to 420
Lasher Run	7.23 to 7.47	294 to 374
Little Leading Creek	6.43 to 7.65	309 to 379
Titus Run	5.83 to 7.00	247 to 359
Paulins Hill	3.18 to 5.36	275 to 1719
Thomas Fork	2.58 to 7.60	252 to 4540

*ranges represent all measurements taken throughout the subwatersheds

Table 10. Summary of water quality parameters

Site Location	**Average Concentration and Range**				**# of samples (total count)**
	pH units	**Conductivity μS/cm**	**Total Metals mg/L**	**Net Acidity mg/L**	
Leading Creek, RM 15.6	7.34 7.33 to 7.35	301 256 to 346	0.98 0.25* to 1.70	-82.28 -98.6 to -66.2	2
Leading Creek, RM 10.3	7.41 7.39 to 7.42	474 446 to 502	1.00 0.50* to 1.49	-81.20 -97.3 to -65.1	2
Leading Creek, RM 6.0	7.36 7.29 to 7.42	588 438 to 738	1.18 0.58 to 1.79	-72.54 -87.31 to -57.76	2

Overall, the most significant impact of abandoned surface and subsurface mining is not chemical contamination of the streams, but the erosion of exposed surface mined areas and the deposition of sands/fines within the stream channels. The Ohio EPA lists sedimentation as a high magnitude cause of impairment in the Leading Creek watershed and suggests that sedimentation from surface mines is the primary factor limiting aquatic life in the watershed (Ohio EPA, 2000). Several subwatersheds (*i.e.* Mud Fork, Little Leading Creek, Lasher Run) were extensively surface mined and are consequently inundated with several feet of mine sediment.

There are three subwatersheds, Thomas Fork, Paulins Run, and Titus Run that are chemically affected by mine runoff, and each will be addressed in detail in the following section. However, only Thomas Fork is evaluated for treatments and costs. Within this tributary, AMD is primarily produced by either diffuse seepage from strip mine pits, auger mine pits, deep mines, and/or subsurface drains that were installed by the Division of Mineral Resources Management during the 1980’s land reclamation.

Thomas Fork (TF00)

Name:	Thomas Fork
Tributary to:	Leading Creek
Confluence:	River Mile 1.49
USGS Quadrangles:	Pomeroy, Cheshire, Chester

Location/Access: Thomas Fork drains about 32 square miles in the southern portion of the Leading Creek watershed. Most of the stream parallels State Route 124 and State Route 143 and is easily accessible from the road. The lower 4.4 miles can be accessed by Bradbury Road (County Road 5) and State Route 7. The mouth of Thomas Fork is not accessible during all flow conditions (particularly during medium and high flow), therefore samples were taken near the mouth at the bridge on Leading Creek Road (RM 1.2).

Site Description: Decades of unregulated coal mining have left much of this watershed covered by barren stripmined lands, auger mined areas, abandoned deep mines, and lands reclaimed under the 1977 SMCRA law. The watershed was extensively surface mined (8% of the watershed) and deep mined (approximately12.5% to 15% of the watershed) leaving a severely disturbed landscape and widespread impacts of acid mine drainage (AMD). Within the basin, AMD is produced in a variety of ways including diffuse leakage from strip mine pits and auger mine pits, distinct underground mine discharges, and surface and subsurface drains that were installed during reclamation of surface mine lands.

Contamination from acid mine drainage impairs aquatic life in approximately 10 miles of streams in the basin. The major tributaries of concern are the unnamed tributary on Bailey Run Road (TF1500), Kinzel's (TF1200), Casto's (TF1100), Bailey Run (TF0400), Hysell Run (TF0300), and Venoy's and SR 124 underdrains.

Justification for Remediation: The Thomas Fork watershed is the most severely impaired and the most affected by AMD of all the Leading Creek subwatersheds. Five sites in the watershed were completely devoid of fish in the 2004 biological study conducted by Midwest Biodiversity Institute and the Voinovich Center (Hysell Run, Bailey Run, and three of five sites on Thomas Fork), while the lower Thomas Fork site and the East Branch had poor fish communities.

According to the Ohio EPA 305(b) report, "Thomas Fork is severely impaired by acid mine drainage", and pH is considered a high magnitude cause of impairment. Contamination from acid mine drainage affects the health and survival of aquatic life in more than 10 miles of stream in the watershed. The Ohio EPA 305(b) report also indicates that "water quality in Thomas Fork has a substrate effect on the lower part of Leading Creek" and that "Leading Creek is still limited from acid mine runoff from [Thomas Fork]".

The Ohio EPA and staff from Virginia Tech conducted biological surveys at three sites in the Thomas Fork watershed. Based on the biological sampling, aquatic life seems to be severely impaired in this subwatershed.

Ohio EPA found that the fish communities were severely degraded during biological surveys conducted in 1993 and 1995, and biologists noted that “no fish were present” during either surveys.

The Virginia Tech biologists collected macroinvertebrates near the confluence of Thomas Fork and Leading Creek. They found extremely low abundances of macroinvertebrates (a total of 16 macroinvertebrates were collected during 2 sampling events) and low diversity of macroinvertebrate taxa with only 4 different taxa collected.

Overview of Water chemistry: Extensive sampling performed within the Thomas Fork basin has provided detailed information about the severity and locations of AMD. Based on the monitoring, AMD impacts are most apparent during lower flows, and water chemistry does not seem to impact aquatic life during medium flow and high flow (Table 11). Most of the field reconnaissance and sampling events occurred in 2003, when there was higher than average rainfall (Average annual rainfall=40 inches; Average annual rainfall in 2003= 45.38 inches www.scalialab.com). The wet conditions sustained high stream levels and caused the severity of AMD impacts along the mainstem to seem minimal. Due to the weather conditions of 2003, all sites were sampled again in 2004 and 2005 during low to extreme low flow conditions to capture this critical condition. Prioritization of major tributary contributors were based on acid and metal loads from data collected during varying flow regimes from 2003 to 2005 (Figure 10).

Figure 10. Percent contribution of acid and metal loadings from Thomas Fork sources

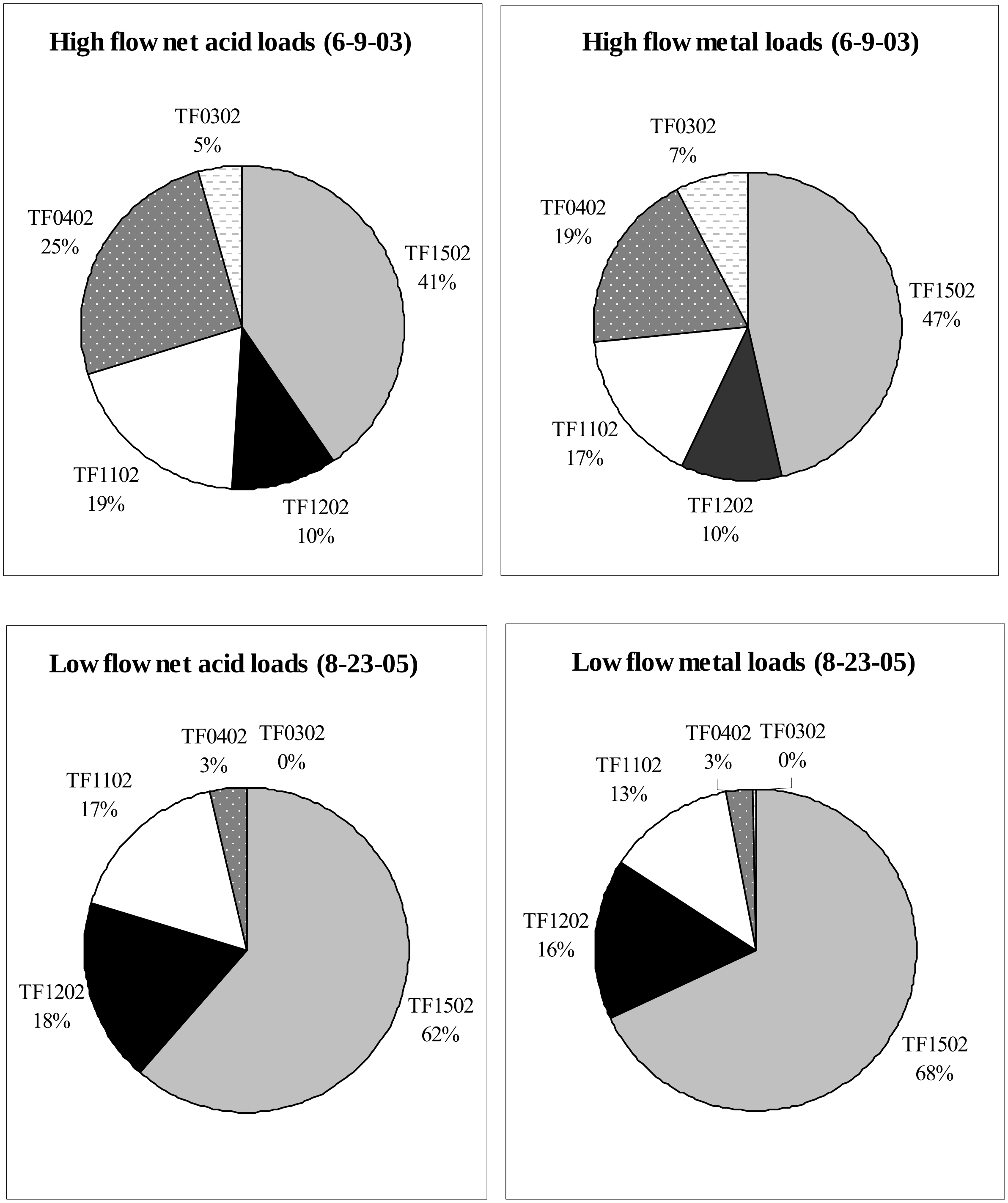
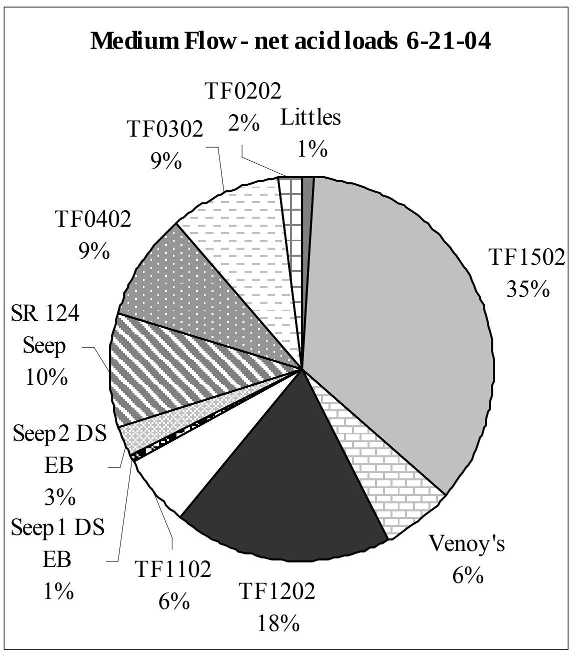


Figure 11 shows a comprehensive look at percent contribution of acid loads from all measured sources and tributaries in the Thomas Fork Subwatershed during one medium flow regime (6-21-04). Figure 11 shows a pie chart of the highest acid loaders in Thomas Fork. Consistently the number one highest loader is the Unnamed Tributary TF1502, followed by Kinzel TF1202.

Figure 11. Percent contribution of acid and metal loads from tributaries and sources in Thomas Fork



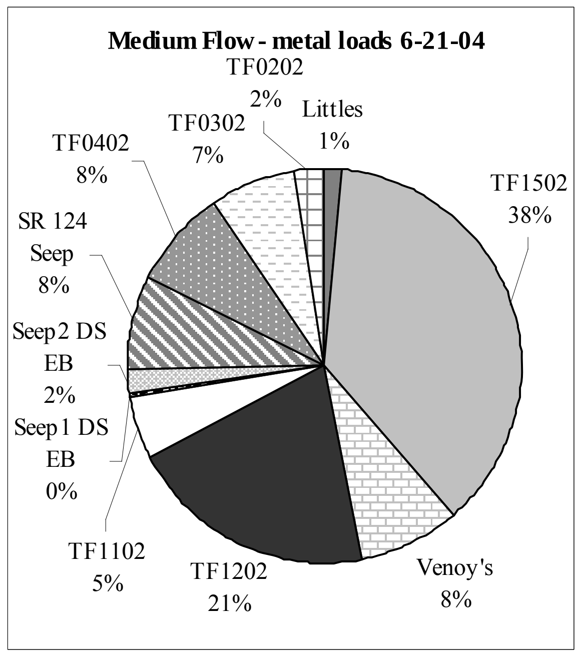


Table 11. Water chemistry fluctuations along Thomas Fork

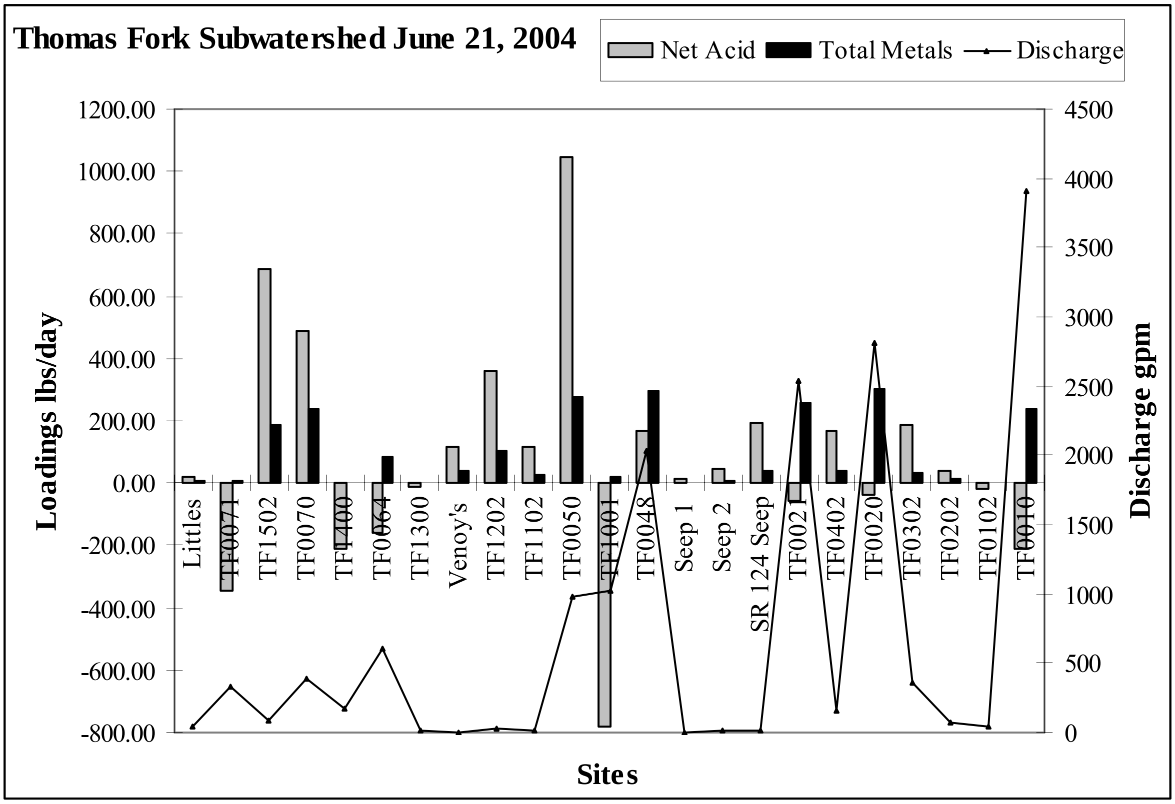
Water Chemistry Fluctuations along Thomas Fork during medium (10/03) and low flow (7/04).

River Mile	pH units	Specific Conductivity uS/cm	Net acidity lbs/day	Total metals lbs/day	Discharge GPM
Thomas Fork RM 7.6					
Medium Flow	7.42	739	-496.06	6.24	451.2
Low Flow	7.10	1175	-26.80	5.99	33.4
Thomas Fork RM 7.4					
Medium Flow	6.44	824	-243.77	24.14	717.8
Low Flow	2.95	2165	828.04	259.09	153.0
Thomas Fork RM 5.5					
Medium Flow	5.94	821	179.97	57.48	1231.3
Low Flow	3.18	1590	774.47	149.69	306.6
Thomas Fork RM 3.4					
Medium Flow	6.68	737	-964.91	291.29	3792.9
Low Flow	4.14	1050	807.66	182.65	1066.6
Thomas Fork RM 3.2					
Medium Flow	6.71	722	-649.69	305.22	3633.6
Low Flow	4.15	1090	977.12	239.85	1230.0
Thomas Fork RM 1.2					
Medium Flow	6.88	739	-957.87	224.98	4093.4
Low Flow	4.38	986	1057.18	198.52	1651.3

Note: negative numbers indicate alkaline conditions

Phase II sampling was conducted a total of six times within the Thomas Fork subwatershed from 2003-2006 (1 high flow, 3 medium flow, 2 low flow). The purpose of the evaluations was to prioritize the tributaries based on their relative effects on the aquatic health and based on their relative contribution of acidity and metals to Thomas Fork. The most comprehensive subwatershed assessment was completed in June 2004 and consisted of sampling seeps, tributaries, and eight mainstem sites (Figure 12). While the other Phase II evaluations were not conducted on as many sites (*i.e.* the smaller streams and seeps were not included because of personnel and time restraints), the overall results were similar and allowed the determination of the most significant contributors, which are described in detail in the following sections.

Figure 12. Acidity and metal loading along Thomas Fork



Potential for Restoration of Aquatic Life: According to the 2004 biological report, the Upper East Branch Thomas Fork sites, Long Hollow Run other sites of the watershed either attain the WWH criterion or nearly attain it (upper Thomas Fork site). Because there are fish communities intact within the watershed, especially the headwaters, rapid recovery of the impaired areas would be expected when chemical stressors are removed. Several of the fish species (e.g., fantail darter, least brook lamprey, and southern redbelly dace) found in these streams are high quality headwater species and indicate good water quality and flow in the upper area of these streams. Habitat conditions in Thomas Fork do not appear to be limiting aquatic life and seem to have great potential to support a healthy and diverse aquatic community. Habitat quality along Thomas Fork is extremely variable with some high quality reaches and some heavily degraded segments. Many of the reaches especially from RM 1.2 to RM 3.7 have moderate amounts of high quality instream cover (undercut banks, overhanging vegetation, deep pools) and have well developed channel morphology (sinuosity, deep pools, and higher quality riffles). While other areas, RM 0.0 to RM 1.2, are heavily impacted by mine sediment, have low channel stability and severe bank erosion. Despite having some degraded segments, the overall habitat condition does not seem to be a limiting factor affecting aquatic life. In addition, Thomas Fork maintains a moderate flow during the summer and was reported to even have continuous flow during the 1997 drought conditions (Cherry *et al.*,1999). However, in 2005 Thomas Fork behaved as a losing stream with interstitial flow near the mouth. In contrast to many other tributaries, Thomas Fork has many deep pools where aquatic life can find refuge during harsh summer conditions.

There are several isolated fish populations within the Thomas Fork subwatershed (*i.e.* East Branch of Thomas Fork, headwaters of Hysell Run, Ball Run, Wolfpen Run, and Thomas Fork upstream of the unnamed tributary on Bailey Run Road) that may be able to expand their ranges if remediation occurred. Fish communities are also likely to migrate from Leading Creek and the nearby Ohio River. Due to the abnormally wet weather in 2003, stream levels were higher reducing many of the impacts of AMD. In the spring 2003, several schools of fish and fry were observed in the lower segments of Thomas Fork (*e.g.* RM 1.2 to RM 3.7) that presumably migrated from Leading Creek and the Ohio River (Cynthia Bauers and Steve Jenkins, personal observation). This observation demonstrates that there is great potential to restore aquatic life and that the primary obstacle is likely the condition of the water chemistry.

Finally, Thomas Fork has great potential for restoration because one prominent source has been identified, the unnamed tributary on Bailey Run Road (TF1500), which impairs several river miles of Thomas Fork. Remediation of this one site would possibly permit suitable conditions for aquatic life in several river miles downstream and would allow two isolated fish populations to expand their ranges, the headwaters of Thomas Fork and East Branch of Thomas Fork.

<u>Recommendation for Abatement and/or Treatment</u>: Recommendations for abatement and treatment of AMD from Thomas Fork has been discussed by the Leading Creek Technical Advisory Committee (TAC), ODNR-DMRM, West Virginia University, and OSM (PA and OH). Three treatment scenarios have been developed to remediate and restore Thomas Fork.

Scenario 1 – Treat individual high acid and metal loading sources throughout the Thomas Fork Basin using a variety of restoration best management practices; open limestone channels (OLC), limestone leach beds (LLB), successive alkaline producing systems (SAPS), and wetlands.

Scenario 2 – Construct steel slag leach beds (SLB) in strategic freshwater tributaries to create a constant supply of highly alkaline water to the streams with high acid loads.

Scenario 3 – Install an active treatment system in the Unnamed Tributary TF15. A doser supplied with pebble quick lime will continually buffer the acidity generated from the AMD sources in TF15.

These treatment options are discussed in further detail in the next section, providing costs, alternatives, and design considerations.

Underdrain Systems Installed within the Leading Creek Watershed

History: Over 2000 acres were left unreclaimed by surface mining within the Leading Creek watershed. A number of tributaries (Little Leading Creek, Mudfork, Titus Run, Lasher Run, Paulins Run, and Thomas Fork) have been inundated with up to several feet of residual sand from these abandoned mined lands. Sediment has significantly impacted fish and macroinvertebrate habitat and has reduced the flow capacity and gradient of several channels, apparently increasing the frequency of flooding in many areas. Accumulation of sediment has also occurred widely across the floodplains, severely degrading agricultural land.

Since the 1980's, numerous Abandoned Mined Land (AML) reclamation projects have been directed toward stabilizing the sediment sources within the watershed. As the projects were funded under the federal AML program, they addressed the health and safety issues related to the increase in road and structure flooding, rather than purely environmental impacts, which were largely ignored

Site Description and Location: In the course of the reclamation of the surface-mined areas, the Ohio DNR, Division of Mineral Resources Management often installed underdrain systems in an attempt to stabilize existing landslides or to prevent instability problems along the regraded slopes (Map 9, Appendix E). The drains were installed on projects in the Thomas Fork, Little Leading Creek, Paulins Hill, Mudfork, and Grass Run subwatersheds. They consisted of 6 to 8-inch perforated pipe covered with washed river gravel that collected mine drainage either from the coal seam, auger holes, and/or mine entries. Unfortunately, numerous underdrains became clogged with iron precipitate resulting in the formation of landslides on some projects.

The drains remain as point sources of AMD throughout the watershed. Those installed in areas that contained little to no auger and underground mining have not impacted their receiving streams, such as Little Leading Creek. In areas such as Thomas Fork, where abundant underground and auger mining occurred, the drains appear to be causing an adverse and widespread impact on water quality, extent of which is unknown because the streams in these areas were acid prior to the installation. The reclamation and underdrain installation have successfully stabilized the hillside sediments. The point source discharges leave little room for treatment options.

Appendix E lists the projects that contain underdrains, the year they were installed and the locations of the outlet pipes. Two drains that drain directly to the mainstem of Thomas Fork that haven't been discussed in the previous subwatershed sections are Venoy's Underdrain and State Route 124 Underdrain pipes. Table 12 shows the deep mines that are in connection with these two sites.

Table 12. Underground mines in connection with underdrains directly to Thomas Fork

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-041	No. 1&3	1930	658	SR 124 seeps
MS-068	Adaudare	1966		Venoy's
MS-119	Harper	1932		Venoy's

Overview of Water Chemistry: In general, the underdrains have extremely poor water chemistry, and they have the highest acidity and metal concentrations of any sources in the watershed (See Appendix G for summary of concentrations and loadings). While all of the drains in the entire watershed have not been sampled, field observations and measurements of those in Thomas Fork indicate that the underdrains may have more significant effects during lower flow. The drains that have been sampled during different flow regimes (*i.e.* Venoy's and the unnamed tributary on Bailey Run Road) show little fluctuation in loadings at the different flow regimes (Table 17). Also, the drains maintain a more consistent flow and water chemistry concentration compared to the other tributaries and the Thomas Fork mainstem so as other streams have reduced flows; the drains are still contributing an almost constant loading.

Recommendation for Abatement and Treatment: Although Venoy's Underdrain and SR 124 Underdrains are significant AMD sources to the mainstem of Thomas Fork neither are suitable for reclamation due to restricted available space. Therefore the recommended treatment option is to add alkalinity with the use of steel slag beds. To buffer acidity generated from Venoy's underdrain SLB are suggested to be installed at TF14 and TF13, fresh water tributaries in the Thomas Fork basin. These two SLBs have been previously discussed in Kinzel's section. The acidity generated at SR 124 underdrains could be buffered by excess alkalinity generated from the SLB suggested to be installed the Bailey Run Subwatershed. Excess alkalinity (281 lbs/day) is expected to be generated from the SLB at site TF0490. Average acid load at the SR 124 underdrains is 161 lbs/day therefore sufficient excess alkalinity should be available to buffer this acid. See Bailey Run section for cost of the SLB at site TF0490.

Unnamed tributary on Bailey Run Road (TF15)

Name:	The Unnamed tributary on Bailey Run Road
Tributary to:	Thomas Fork
Confluence:	River Mile 7.49
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 15th tributary to Thomas Fork. It has a small drainage area (0.28 square mile) with moderate flow (average flow is 142 GPM). The unnamed tributary begins midway along Bailey Run Road (Township Road 165) and flows to the east in a rock-lined channel paralleling Bailey Run Road into Thomas Fork. The road's close proximity to the stream allows for easy access, but the location and limited area may restrict treatment methods.

Photo 1: Confluence of TF15 with Thomas Fork

Photo 2: TF15 mainstem

Site Description: Historically, the area was deep-mined, surface-mined, and auger-mined. The land was reclaimed in the 1980s at which time a series of surface and subsurface drains were installed to localize the movement of water from the area and to stabilize saturated reclaimed hillsides below the mines drains. The source of AMD in this tributary comes from seven functioning above drainage, sub-surface mine drains, 2 buried/clogged drains, and 2 seeps. The 8" under drains yield highly acidic, metal-laden water at an almost constant rate of flow.

Photo 3: TF15 Pipe #1

Photo 4: TF15 mainstem downstream of Pipe #2

Photo 5: TF 15 Seep #1

Photo 6: TF15 Seep #2

Above drainage underground mines located in the Unnamed Tributary (TF15) subwatershed are listed in the table below. All mines listed were mined from the #8A Pomeroy Coal seam.

Table 13. Underground mines found in the TF15 subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-110	Prosperity	1951		Seep 1, Pipe 1
MS-115	Seyfried	1947	696	
MS-114	Russell	1940		Seep 3
MS-085	Thomas Fork No.5	1952	726	
MS-134	Thomas Fork No.5	1947	721	

Justification for Remediation: The sole justification for remediation of this tributary is because of its devastating effects on the receiving stream, Thomas Fork. During each of the mass balances sampling events, this tributary is the largest contributor of acidity and heavy metals and is the top priority for remediation in the Thomas Fork subwatershed (Figure 10).

The unnamed tributary restricts the movement of an abundant fish population located upstream of TF15 in Thomas Fork.

Overview of Water Chemistry: The unnamed tributary on Bailey Run Road severely impacts Thomas Fork causing downstream water quality conditions to become unsuitable for aquatic life. Table 14 shows water quality conditions on Thomas Fork upstream and downstream of the Unnamed Tributary during low flow (July 20, 2004).

Table 14. Water quality conditions on Thomas Fork and the confluence with TF15

Site	River Mile	pH	Conductivity	Net Acidity	Aluminum	Iron	Manganese	Discharge
		units	uS/cm	mg/L	mg/L	mg/L	mg/L	GPM
Upstream (TF0071)	7.41	7.10	1175	-66.87	<0.25	0.20	1.02	33.4
Unnamed trib (TF1502)	7.40	2.88	2610	962.00	86.00	177.00	6.54	77.0
Downstream (TF0070)	7.39	2.95	2165	451.00	45.15	92.00	3.97	153.0

The tributary is the largest acidity and metal loader within the Thomas Fork basin. It contributes on average 46% of the acidity and metal loading throughout various flow regimes (Figure 10 and 11).

Water quality monitoring was conducted at all of the acid sources within this sub-basin during medium flow (March 29, 2004), low flow (June 21, 2004), and extreme low flow (August 23, 2005). During these sampling events, seep 1/pipe1, seep 3, and seep 2 account for 80% of the acidity (Table 15) and metal loading (Table 16). All these sites have low volume of flow, but extremely high acidity and metal concentrations (See Appendix G for summary of concentrations and loadings). The sources of acid in the TF15 tributary are from above drainage "hillside" mines and continually drain acid water into the underdrains that convey mine drainage to the road side ditches. The ditches carry constant water into the tributaries. All the hillsides are stabilizaed due to the underdrains and reclamation, there is little room upon which to install treatment scenarios.

Table 15. Summary of acid loading contributions from TF15 sources

	Mar-04		Jun-04		Aug-05		Average	
Site	Net acidity load lbs/day	Percent Acidity	Net acidity load lbs/day	Percent Acidity	Net acidity load lbs/day	Percent Acidity	Net acidity load lbs/day	Percent Acidity
TF15 pipe7	8.89	0.8%	8.99	1.7%	7.26	2.4%	8.38	1.7%
TF15 pipe 6	42.55	4.0%	46.80	8.9%	35.80	12.0%	41.72	8.3%
TF15 pipe 4	43.43	4.1%	25.09	4.8%	28.80	9.6%	32.44	6.2%
TF15 pipe 5	5.77	0.5%	2.15	0.4%	2.12	0.7%	3.35	0.6%
TF15 seep 4	1.35	0.1%	0.76	0.1%	dry	dry	1.06	0.00
TF15 seep 3	172.62	16.4%	87.44	16.7%	50.85	17.0%	103.64	16.7%
TF15 seep2	4.15	0.4%	-0.10	0.0%	dry	dry	2.02	0.00
TF15 pipe 3	-4.70	-0.4%	-1.60	-0.3%	-2.41	0.0%	-2.90	-0.3%
TF15 pipe 2	61.92	5.9%	70.75	13.5%	51.71	17.3%	61.46	12.2%
TF15 seep 1/pipe1	718.74	68.2%	283.19	54.1%	120.58	40.3%	374.17	54.2%

Major contributors are underlined

Table 16. Summary of metal loading contributions from TF15 sources

	Mar-04		Jun-04		Aug-05		Average	
Site	Total metal load lbs/day	Percent Metals	Total metal load lbs/day	Percent Metals	Total metal load lbs/day	Percent Metals	Total metal load lbs/day	Percent Metals
TF15 pipe7	2.64	0.9%	4.93	2.2%	2.58	2.6%	3.38	1.9%
TF15 pipe 6	13.46	4.6%	25.63	11.5%	13.96	14.3%	17.68	10.1%
TF15 pipe 4	14.25	4.8%	16.44	7.4%	8.55	8.7%	13.08	7.0%
TF15 pipe 5	2.46	0.8%	2.21	1.0%	1.14	1.2%	1.94	1.0%
TF15 seep 4	0.72	0.2%	0.60	0.3%	dry	dry	0.66	0.00
TF15 seep 3	53.72	18.2%	40.34	18.1%	11.65	11.9%	35.23	16.1%
TF15 seep2	0.84	0.3%	0.45	0.2%	dry	dry	0.64	0.00
TF15 pipe 3	11.64	0.0%	10.87	0.0%	4.03	4.1%	8.85	1.4%
TF15 pipe 2	20.02	6.8%	41.23	18.5%	16.21	16.6%	25.82	13.9%
TF15 seep 1/pipe 1	187.14	63.4%	91.43	41.0%	36.66	37.5%	105.08	47.3%

Major contributors are underlined

Table 17 shows the discharge rate measured at each TF15 source throughout the three sampling events. It is also important to note that the underdrains maintained consistent flow during the sampling events, but the flow from the "seeps" fluctuate. While the underdrains maintain almost constant flow, two of the seeps dried up during extreme low flow. With increasing percent acid and metal loading contributions, the underdrains' impacts are even more significant during extreme low flow conditions.

Table 17. Summary of discharge from TF15 sources

	Mar-04	Jun-04	Aug-05	
Site	**Discharge gpm**	**Discharge gpm**	**Discharge gpm**	**Average gpm**
TF15 pipe7	4.8	3.9	2.5	3.7
TF15 pipe 6	18.0	19.5	13.5	17.0
TF15 pipe 4	18.8	10.3	12	13.7
TF15 pipe 5	1.0	0.5	0.43	0.6
TF15 pipe 3	12.8	11.3	9.12	11.0
TF15 pipe 2	4.0	3.4	2.8	3.4
TF15 pipe 1	8.3	8.3	1.38	6.0
TF15 seep 4	2.1	1.1	dry	1.6
TF15 seep 3	15.0	4.6	3.28	7.6
TF15 seep2	7.1	2.4	dry	4.8
TF15 seep 1	22.5	9.0	1.5	11.0

<u>Potential for Restoration of Aquatic Life</u>: Current water quality conditions would indicate that biological communities are severely degraded within the TF15 tributary, but because of the stream's small size, poor habitat, and limited area for treatment, restoration goals for TF 15 include restoration of aquatic communities in the receiving stream, Thomas Fork, and do not intend to make in-stream improvements to the unnamed tributary.

<u>Recommendation for Abatement and Treatment</u>: Three treatment scenarios have been proposed for the Unnamed Tributary TF15. Scenario 1 identifies the treatment at the highest acid and metal loading sites: Pipe 1, Seep 1, and Seep 3. Scenario 2 suggests adding alkalinity to the Unnamed Tributary by utilizing steel slag beds and fresh water. Scenario 3 suggests installing an active treatment doser system near Seep #3 to allow retention time for the metals in the mainstem of the Unnamed Tributary.

The three scenarios identified above are organized into a strategic phased approach below. Construction of the treatment systems will be phased in allowing for monitoring and assessment before additional phases of the project are built. Phase I of abating acid mine drainage from the Unnamed Tributary (TF15) recommends two alternatives.

<u>Phase I</u>

<u>Alternative A:</u> Install an active dosing system near Seep 3 along the mainstem of the Unnamed Tributary (TF15). Water to turn the doser wheel can either be supplied from Pipe 2 and Seep 3 combined or directly from the mainstem. The goal is to treat all the acidity produced in TF15 by calculating needed lime material based on water quality measured at the

mouth TF1502. However placement of the doser will be upstream of the mouth near Seep 3 to allow ¾ of a stream mile to retain metals in the Unnamed Tributary (TF15). This will minimize the impact to Thomas Fork keeping most of the precipitated metals in the Unnamed Tributary (TF15), allowing for easier fish migration to upper Thomas Fork.

Alternative B: Install steel slag bed (SLB) at the mouth of TF1502 in the field north of the stream along the mainstem of Thomas Fork. Clean water will be siphoned from the mainstem of Thomas Fork to supply good water to leach through the SLB.

Phase II

Install a 300 ft. V-notch open limestone channel (OLC) with a series of six step pools created using J-trench limestone dams at Seep 1/ Pipe 1 at a 3 percent slope. Due to restriction on available space and extremely concentrated metals and acidity, a V-notch OLC at site Pipe1/Seep1 is expected to last 0.7 years and reduce acidity by 75 percent. The J-trench retention dams will increase alkalinity generation efficiencies but undeterminable as to how they would extend the lifetime of the system. At Seep 3 install a 300 ft trapezoidal OLC. An OLC at Seep 3 is expected to last 2.8 years while reducing acid loads by 57 percent. Due to the short lifetime of these systems to work effectively Phase II recommendations are supplemental to Phase I treatment systems and will only be installed if needed after Phase I construction has been monitored and assessed.

Estimated costs of abatement and treatment recommendations: Tables 18 – 21 lists major budget category totals. All project costs, calculations, and design details and considerations are listed in Appendix F.

Table 18: TF15 Phase I alternative A treatment costs –Doser near Seep 3

Task/item	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Site Preparation			$28,675		ODNR and ATC (Essex)
Chemical	Calcium Oxide Pebbles	377,556 lbs/yr	$28,317	$332,198	ODNR and ATC (Essex)
Silo	50 ton	1	$142,000		ODNR and ATC (Essex)
Site Construction			$28,195		ODNR and ATC (Essex)
Site Reclamation			$33,790		ODNR and ATC (Essex)
Maintenance			$5,000	$58,657	
Piping	from Seep #3 and Pipe #2		$12,116		ODNR and ATC (Essex)
Subtotal			$278,093		
Mobilization	8%		$22,247		
Contingency	10%		$30,034		
Total			**$330,374**	**$657,912**	

Table 19: TF15 Phase I alternative B treatment costs - Steel slag bed

Task/item	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Steel slag	$30/ton	1073 tons based on 1.6 years 3375 tons based on 5.0 years*	$32,190 $101,250	$201,188 $202,500	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			$4,329		ODNR
Site construction			$121,942		ODNR
Site reclamation			$325		ODNR
Sub Total			$126,596		ODNR
Mobilization			$10,128		ODNR
Contingencies			$13,672		ODNR
Total			**$150,396**		ODNR

***SLB designed for 1.6 years requires 19,876 ft^3 bed, SLB designed for 5.0 years requires 62,044 ft^3 bed.**

Table 20: TF15 Phase II - Pipe1/Seep1 V-notch OLC treatment costs

Task/item	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Limestone*		28.5 tons for 0.7 years			WVU spreadsheet
Site Preparation			$11,730		ODNR
Site Construction			$31,692		ODNR
Site Reclamation			$420		ODNR
Sub Total			$45,942		ODNR
Mobilization	8%		$3,675		ODNR
Contingencies	10%		$4,962		ODNR
Total			**$54,579**		ODNR

*Limestone determine from WVU spreadsheet based on neutralization potential for the site, limestone needed for structural construction of V-notch channels and J-trenches far exceeds the needed limestone for neutralization capacity.

Table 21: TF15 Phase II – Seep 3 Trapezoidal OLC treatment costs

Task/item	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Limestone*		28.5 tons for 2.8 years			WVU spreadsheet
Site Preparation			$11,730		ODNR
Site Construction			$31,692		ODNR
Site Reclamation			$420		ODNR
Sub Total			$45,942		ODNR
Mobilization	8%		$3,675		ODNR
Contingencies	10%		$4,962		ODNR
Total			**$54,579**		ODNR

*Limestone determine from WVU spreadsheet based on neutralization potential for the site, limestone needed for structural construction of V-notch channels and J-trenches far exceeds the needed limestone for neutralization capacity.

Kinzel's seep (TF12)

Name:	Kinzel (TF1202)
Tributary to:	Thomas Fork
Confluence:	River Mile 6.2
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 12th tributary to Thomas Fork. It has a small drainage area (<1 square mile) with relatively little flow (average 47 GPM). The mouth and lower 200 yards can be accessed from State Route 143 and Delong Road (Township Road 391). The remaining stream reach and drainage basin has not been surveyed due to access problems.

Site Description: This tributary is affected by abandoned above drainage underground mines, abandoned strip-mine lands, auger mining and associated un-reclaimed coalmine spoil. The landscape is characterized by steep and rugged hillsides with narrow ridge tops in the upper reaches of the basin where the majority of the slopes are forested. The valley floor widens near its mouth and is used for pasture. The lower 1,900 linear feet of stream channel lacks a riparian corridor. Approximately 10 acres of strip-mined land remain barren and in need of reclamation. Numerous auger holes are partially exposed along the perimeter of the northern highwall. A large erosion gully has developed from drainage collected along the southern highwall. The pits left after mining ceased have filled with sediment.

A steady flow of acid discharges from a collapsed mine entry associated with the Thomas Fork #5 Mine, abandoned in 1947 (Table 22). A portion of the AMD within the basin is also produced from auger holes that drain along the highwalls, a potential mine entry associated with the Vulcan Mine, and in a very diffuse manner by seepage through the spoil.

A potential historic preservation concern is located at the western end of the basin. The site consists of a freestanding stone fireplace of unknown origin. No foundation timbers or stones were found during the non-invasive reconnaissance of the area.

Table 22. Underground mines found in the Kinzel (TF1202) Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-134	Thomas Fork No.5	1947	721	Kinzel's Seep

Justification for Remediation: Improvements to this tributary are being sought because of its impacts on the receiving stream, Thomas Fork. During each of the mass balances, this tributary was among the top three contributors of acidity and heavy metals. This tributary, Venoy's underdrain, and Casto's are the three primary sources of acid mine drainage from RM 6.9 to RM 5.5.

Overview of Water Chemistry: Despite having relatively little flow, the tributary is among the largest acidity loaders within the Thomas Fork sub-basin (Table 23). The stream is impaired by both metals and acidity (Table 24 and Appendix G).

Table 23. Summary of loadings at Kinzel (TF1202)

Flow regime	Flow GPM	Acidity Loading lbs/day	Acidity Percent Loading to Thomas Fork*	Total Metals Loading lbs/day	Total Metals Percent Loading to Thomas Fork*
High Flow	136.7	321.46	22%	85.35	10%
Low Flow	4.58	83.21	11%	17.09	10%

*Percent contribution is relative to the other tributaries/sources in Thomas Fork

Table 24. Summary of water quality conditions at Kinzel (TF1202)

Site	pH units	Conductivity uS/cm	Net Acidity mg/L	Aluminum mg/L	Iron mg/L	Manganese mg/L	
TF1202	2.74	3113	836.17	66.72	117.25	7.74	average
	2.44 to 2.80	1110 to 6860	196 to 1514	15 to 125	34 to 175	3 to 11	range

Field reconnaissance and source evaluations have not been completed in this subwatershed during the development of the AMDAT. CTL Engineering, however, conducted two sampling events, within the basin in 2001, under the Thomas Fork Reclamation Project site reconnaissance (Table 25 and Appendix G).

Table 25. Summary of water quality at Kinzel's mine entry

Site	pH units	Conductivity uS/cm	Net Acidity mg/L	Aluminum mg/L	Iron mg/L	Manganese mg/L	
Mine Entry	2.84	3335	1202.00	77.60	302.00	7.77	average
	2.70 to 2.89	3110 to 3556	1175 to 1229	75.2 to 80	218 to 386	7.13 to 8.4	range

Potential for Restoration of Aquatic Life: Based on current water quality conditions, the biological communities are very poor and consist of only a few very tolerant macroinvertebrate taxa. This stream has limited potential to support diverse, healthy aquatic life because of its small size, low flow, and poor habitat. Thus, our overall goal is to improve the aquatic life use within the receiving stream, Thomas Fork, and not necessarily within this tributary. Remediation in Kinzel’s tributary combined with receiving good water from the East Branch of Thomas Fork and steel slag beds placed in TF14 and TF13 will ultimately improve water quality downstream (RM 5.5 to RM 4.4) to be suitable for aquatic life and permit movement of fish from the East Branch. In addition, if treatment is pursued upstream (particularly at the unnamed tributary of Bailey Run Road), steel slag at TF14 and TF 13 and Casto's (TF11), it would allow three isolated fish populations (*i.e.* upstream of the unnamed tributary, Ball Run, and the East Branch of Thomas Fork) to have unrestricted access to the upper 21.6 square miles of the watershed.

Recommendation for Abatement and Treatment: Kinzel's tributary is not suitable for reclamation due to access issues. Recommendation for treatment of this source of acid mine drainage is to buffer the acidity being released from this tributary with alkalinity generated from steel slag beds. Two tributaries have been identified upstream of Kinzel's Tributary for steel slag beds to generate alkalinity, TF14 and TF13. Alkalinity generated from these two SLB sites will produce on average 1,476 lbs/day and 178 lbs/day of alkalinity repectively. This amount of alkalinity is expected to buffer not only acid loads generated from Kinzel (TF1102 472 lbs/day) but also Venoy's underdrain (at the culvert 25 lbs/day) and residue acid sources upstream from TF15 unnamed tributary.

Phase I

Install steel slag bed (SLB) at TF14, Ball Run, and TF 13 Unnamed tributary. TF14 has a drainage area of 3.04 square miles (1,945 acres) and TF 13 is smaller with a drainage area of 0.24 square miles (154 acres). Steel slag beds will be constructed to siphoned clean water from these two tributaries to supply good water to leach through the SLB generating high alkaline water to buffer acid generated downstream. (If only one of these sites can be constructed TF14 is the better alternative, see Table 63).

Estimated costs of abatement and treatment recommendations: Table 26 and 27 shows all major budget category totals. Specific project costs, calculations, and design considerations are listed in Appendix F.

Table 26: TF14 Phase I alternative A treatment costs - steel slag bed

Task/item TF14	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Steel slag	$26/ton	925 tons based on 1.6 years 2909 tons based on 5.0 years*	$27,750 $87,270	$173,438 $174,540	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			$7,348		ODNR
Site construction			$105,136		ODNR
Site reclamation			$466		ODNR
Sub Total			$112,951		
Mobilization	8%		$9,036		
Contingencies	10%		$12,198		
Total			**$134,185**		

***SLB designed for 1.6 years requires 17,132 ft^3 bed, SLB designed for 5.0 years requires 53,478 ft^3 bed.**

Table 27: TF13 Phase I alternative B treatment costs - steel slag bed

Task/item TF13	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Steel slag	$30/ton	111 tons based on 1.6 years 350 tons based on 5.0 years*	$3,330 $10,500	$20,813 $21,000	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			$7348.15		ODNR
Site construction			$17,087		ODNR
Site reclamation			$337		ODNR
Sub Total			$24,773		
Mobilization	8%		$1,981		
Contingencies	10%		$2,675		
Total			**$29,429**		

***SLB designed for 1.6 years requires 2,061 ft^3 bed, SLB designed for 5.0 years requires 6,432 ft^3 bed.**

Casto's (TF11)

Name:	Casto's (TF1102)
Tributary to:	Thomas Fork
Confluence:	River Mile 5.9
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 11th tributary to Thomas Fork. It has a small drainage area (<1 square mile) with an average flow of 88 GPM. It can be accessed from State Route 143 to Old Landfill Road. It parallels Old Landfill Road and is accessible by vehicle. Old Landfill Road dead ends at the Humphreys' property; the sources of AMD are about 0.3 miles upstream and are accessible by foot.

Site Description: This stream is affected by abandoned deep-mines, abandoned strip-mine lands and associated un-reclaimed coalmine spoil (Table 28). The landscape consists of severely degraded areas (along the southern side) with un-reclaimed gob piles and acid pits along the parameter of the highwall, but it also has reclaimed areas (along the northern side) with thick grass cover and modest tree growth in the headwaters and the riparian area. (Note: the reclaimed areas are associated with the former Meigs County Landfill)

AMD is produced in a very diffuse manner leaking from strip mine pits, or entering the stream as base flow. Four sources have been identified: a small stream that flows in a rock-lined channel through the reclaimed area (TF1100-1), a seep where the water fans out and diffusely enters the stream (TF1100-2), a small stream draining a strip pit flowing through sharp-angled spoil banks and gob pile (TF1100-3), and surface mining impoundments in the headwaters (TF1180).

Photo 7: Casto site Old Landfill Road

Photo 8: Casto Seep #3

Table 28. Underground mines found in the Casto Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-032	No. 1,2,3	1923	NA	TF1100-1, TF1100-2, and TF1100-3
MS-33	Essex	1923	NA	TF1180
MS-030	Russel Run No.2 Yankee	1924	NA	

All listed mines are located in the Pomeroy #8A coal seam

Justification for Remediation: Improvements to this tributary are being sought because of its impacts on the receiving stream, Thomas Fork. During each sampling event for mass balance, this tributary was among the top four contributors of acidity and heavy metals. This tributary, Venoy's underdrain, and Kinzel's are the three primary sources of acid mine drainage from RM 6.9 to RM 5.5.

Overview of Water Chemistry: The sources of AMD are very diffuse in this hollow. The headwater site (TF1199) has very good water quality (pH = 8.07, conductivity= 736 µS/cm), but then it quickly (within 20 yards) becomes very acidic and has water chemistry typical in AMD streams (pH = 3.30, conductivity= 1630 µS/cm). Within this transitional stretch, the creek interfaces with the surface mine land. As a result acid water is entering from the subsurface. Likewise, analysis of the two mass balance sampling events indicates that 25% of the water measured at the mouth enters from four sources. The other 75% of the flow measured at the mouth (TF1102) is a combination of natural drainage and subsurface flow entering along the stream.

The stream is impaired by metals and acidity (Table 29) and contributes significant quantities of both to Thomas Fork (Table 30). Appendix G lists summary of concentrations and loadings.

Table 29. Summary of water quality conditions at Casto's Subwatershed (TF1102)

Site	pH units	Conductivity uS/cm	Net Acidity mg/L	Aluminum mg/L	Iron mg/L	Manganese mg/L	
TF1102	3.03	2473	505.38	64.90	23.30	11.10	average
	2.70 to 3.50	1030 to 6760	153 to 1135	18 to 149	6 to 29	4 to 20	range

Table 30. Summary of loadings at Casto's (TF1102)

Flow regime	Flow GPM	Acidity Loading lbs/day	Acidity Percent Loading to Thomas Fork*	Total Metals Loading lbs/day	Total Metals Percent Loading to Thomas Fork*
High Flow	320.0	587.51	41%	136.66	16%
Low Flow	5.5	75.45	10%	13.16	8%

*Percent contribution is relative to the other tributaries in Thomas Fork

Water quality monitoring was conducted at all of the distinct AMD sources within this sub-basin during medium flow (5-10-04) and high flow (1-25-06) (Table 31). TF1100-3 (draining the strip pit) is the largest acidity/metals loader of the "sources" sampled, but a large percentage of the acidity and metal loading was unaccounted for because of the diffuse seepage of water from pits through the overburden and "bench" to the stream. However this difference in accumulation of acid loadings from known sources compared to the mouth of Casto (TF1102) could be attributed to the factor of flow because the acidity concentrations at the mouth are less than the summation of the four acidity concentrations.

Table 31. Percent acid and metal load contributions in Casto's Subwatershed

	May-04		Jan-06		May-04		Jan-06		Average	
Site	Acidity Load lbs/day	Percent Acidity	Acidity Load lbs/day	Percent Acidity	Total Metal Load lbs/day	Percent Metals	Total Metal Load lbs/day	Percent Metals	Percent Acidity	Percent Metals
TF1180	16.98	10.0%	23.28	9.0%	4.39	9.8%	5.99	8.1%	9.6%	8.9%
<u>TF1100-3</u>	94.31	55.0%	108.51	43.0%	22.67	50.6%	24.34	32.8%	49.2%	41.7%
<u>TF1100-2</u>	44.71	26.0%	67.45	27.0%	13.48	30.1%	24.46	32.9%	26.5%	31.5%
TF1100-1	15.50	9.0%	52.07	21.0%	4.26	9.5%	19.52	26.3%	14.9%	17.9%

Major contributors are underlined

<u>Potential for Restoration of Aquatic Life:</u> Because of the acidity and heavy metal impairments, the biological communities are poor and consist of only a few tolerant macroinvertebrate taxa. This stream has limited potential to support diverse, healthy aquatic life because of its small size, low flow, and poor habitat. Thus, the overall goal is to make improvements to the receiving stream, Thomas Fork, and not to focus on improving the tributary to attain Warmwater Habitat. Remediation of this tributary coupled with alkalinity additions upstream to buffer discharges from Kinzel and Venoy and good water from the East Branch of Thomas Fork will ultimately improve water quality downstream (RM 6.2 to RM 5.5) to be suitable for aquatic life and permit movement of fish from the East Branch.

<u>Recommendation for Abatement and Treatment</u>: Casto tributary (TF11) will consist of two phases of reclamation. Phase I will focus on reclaiming sites TF1100-1 and TF1100-3 with V-notch OLC channels and reclaiming the TF1100-3 gob pile. After Phase I is complete and has been monitored for water quality changes Phase II could be implemented if needed. Phase II would require addressing the remaining diffuse sources (TF1100-2 and TF1180) by constructing J-trenches and a limestone channel in the mainstem of the valley floor. Additional considerations prior to the Casto reclamation is to contact the OEPA and conduct a water quality investigation in TF1100-1 to ensure no toxic contamination is leaching from the historic landfill present in the headwaters of TF1100-1.

<u>Phase I</u>

Install a 300 ft. V-notch open limestone channel (OLC) with a series of five step pools created using J-trench limestone dams at TF1100-1 and TF1100-3 at a 10 percent slope. V-notch OLC at site TF1100-1 is expected to last 9.8 years and reduce acid loads by 46 percent. Site

TF1100-3 is expected to last 2.8 years and reduce acid loads by 76 percent. Reclamation of the gob pile (approximately 1 acre) will reduce coal fines from eroding into the stream and reduce acidity at the TF1100-3 site.

Phase II

Install limestone J-trenches along the valley floor to intercept the subsurface flow, diffuse seepage from TF1100-2, and drainage from surface mine impoundments at TF1180.

Estimated costs of abatement and treatment recommendations: Table 32 lists major budget item costs for Phase I treatment options. All specific project costs, calculations, and design considerations are listed in Appendix F.

Table 32: Casto Phase I treatment costs - TF1100-1 and TF1100-3/gob pile

Task/item	TF1100-1	TF1100-3 and gob pile	Data Source
Limestone*	28.5 tons for 9.8 years	28.5 tons for 2.8 years	WVU spreadsheet
Site preparation	$5,725	$14,600	ODNR
Site construction	$29,825	$39,572	ODNR
Site reclamation	$3,076	$3,024	ODNR
Sub Total	$38,626	$57,196	ODNR
Mobilization	$3,090	$914	ODNR
Contingencies	$4,172	$5,811	ODNR
Total	$45,888	$63,921	ODNR

*Limestone determine from WVU spreadsheet based on neutralization potential for the site, limestone needed for structural construction of V-notch channels and J-trenches exceeds the needed limestone for neutralization capacity.

East Branch of Thomas Fork (TF10)

Name:	East Branch of Thomas Fork
Tributary to:	Thomas Fork
Confluence:	River Mile 5.5
USGS Quadrangles:	Pomeroy and Chester

Location/Access: This stream is the 10th tributary to Thomas Fork. It drains 11.3 square miles making it the largest tributary in the Thomas Fork subwatershed. The East Branch has a slightly larger drainage area (11.3 sq miles versus 10.3 sq miles) than the mainstem of Thomas Fork at its confluence near State Route 124 and State Route 143. Historically, East Branch was considered the mainstem and "Dirt Creek" (now Thomas Fork) flowed along State Route 143. The mouth of the East Branch can be accessed near the intersection of State Route 124/ State Route 143 by walking downstream in Thomas Fork about 100 feet. Most of the remaining stream parallels Laurel Cliff Road (County Road 22) and Willow Creek Road (Township Road 78) and is easily accessible by vehicle.

Site Description: Historically, the basin was deep-mined, auger-mined, and to a lesser extent surface mined (Table 33). The headwaters of East Branch have not been mined and have high quality habitat features and aquatic life present. Land on either side of the stream from RM 5.1 to the mouth has been heavily affected by mining (~3% surface mining, ~10-15% deep mining). The landscape is marked by some severely degraded areas with un-reclaimed surface mines and refuse piles (*e.g.* hollow east of Laurel Cliff and along Willow Creek Road, Township Road 78) and has several distinct mine seeps (along US Route 33 and SR 124). Despite these potential sources of contamination, acid mine drainage does not appear to be impacting the East Branch of Thomas Fork. It is thought that acidity is being buffered by the surrounding calcareous shale and thin layers of limestone creating net alkaline mine drainage (Gordon Gilmore, personal communication 2004). Biological samples indicate good water quality throughout the East Branch. However near the mouth of East Branch the biological samples were lower indicating impacts. No remediation activities are planned for this tributary, but monitoring should continue to evaluate any changes or trends in the water quality.

Table 33. Underground mines found in the East Branch of Thomas Fork Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-040	Logan	1926		
MS-124	Jacobs No.4	1965		
MS-036	No.7	1927		
MS-050	Charter Oak and Rolling Mill	1923		
MS-086	Willow Creek No. 1	1950		
MS-088	Grueser	1937	637	
MS-080	T.H. Davis	1932	634	
MS-052	Terrell	1939	633	
MS-113	Hood No. 2	1940	634	
MS-057	Willow Creek No. 2	1953		
MS-096	Kaspar No.2*	1950		
MS-060	Princess Pat No. 2	1959		
MS-125	Jeffers No. 11	1964		
MS-111	Pure Fuel	1940	617	
MS-083	Grueser	1948	614	
MS-063	Buckeye	1957		
MS-064	Folmer	1965		
MS-109	Princess Pat	1944		
MS-140	Sisson	1927		
MS-059	Princess Pat No. 7	1959	613	
MS-031	No. 6-8	1925		
MS-072	River Hill	1942	658	
MS-018	Peacock	1902		
MS-107	Sugar Run	1942	647	

*All listed mines were located in the Pomeroy #8A coal seam except MS-096 (Pittsburgh #8).

Overview of Water Chemistry: The East Branch of Thomas Fork has a positive effect on the mainstem of Thomas Fork contributing net alkaline water with relatively low concentrations of heavy metals (Table 34). On average, the East Branch contributes 1,298 lbs/day of alkalinity and causes downstream conditions to be suitable for aquatic life during medium and high flow. The East Branch is expected to make a more significant difference as projects are conducted upstream (*i.e.* at TF1502, TF1202, and/or TF1102) reducing the impacts in Thomas Fork to an even greater degree.

Table 34. Water quality conditions at the confluence of East Branch and Thomas Fork (7-20-04)

Site	River Mile	pH units	Conductivity uS/cm	Net Acidity mg/L	Aluminum mg/L	Iron mg/L	Manganese mg/L	Discharge GPM
Upstream (TF0050)	5.51	3.18	1590	210.50	27.60	8.04	5.05	360.6
East Branch (TF1001)	5.50	7.06	761	-43.57	<0.25	0.21	0.80	432.5
Downstream (TF0048)	5.49	4.41	1040	60.00	10.80	3.20	2.51	793.1

**Flow was taken in a rocky, channelized area and did not seem accurate; therefore, analysis was performed on the summation of flow at TF0050 and TF1001

<u>Recommendation for Abatement and Treatment</u>: While metal concentrations and conductivity are not a concern some metal flocculants have been observed and future monitoring should be conducted. No projects are planned for the East Branch of Thomas Fork.

Bailey Run (TF04)

Name:	Bailey Run
Tributary to:	Thomas Fork
Confluence:	River Mile 3.3
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 4th tributary to Thomas Fork and drains 1.7 square miles making it the third largest tributary in the Thomas Fork subwatershed. The mouth of Bailey Run can be accessed by State Route 124 and the remaining stream parallels Bailey Run Road (Township Road 165) making it easily accessible by vehicle. The watershed area is relatively populated with many residents along Bailey Run Road.

Site Description: Within this watershed, the extent of the area affected by surface mining and deep mining is large and the production of AMD is diffuse (Table 35). The headwaters of Bailey Run are not impacted for 0.3 river miles until tributary #12 enters the stream. After this tributary enters, the remaining stream reach is affected by AMD with impacts becoming more severe as the stream flows to the mouth. The landscape consists of severely degraded areas with un-reclaimed gob piles and numerous acid pits along the perimeter of highwalls, but it also has areas with modest tree growth. Hollow #2, hollow #4, hollow #6, and the Tobin's site have abandoned strip mine lands that remain un-reclaimed and barren with steep slopes and exposed gob as well as deep mine sources.

Table 35. Underground mines located in the Bailey Run Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-041	No.1 & 3	1938	658	Hollow #2, Hollow #4
MS-087	Bailey Run	1947	710	
MS-053	No.5	1935		Tobin's, Hollow #6
MS-033	Essex	1923		

Photo 9: Mine pool in hollow #4 of Bailey Run

Photo 10: Gob pile in Hollow #4 of Bailey Run

Justification for Remediation: The overall goal for remediation of this tributary is to reduce the negative effects on the receiving stream, Thomas Fork. During each of the mass balance sampling events, this tributary was among the top three contributors of acidity and heavy metals. There are also several areas within the sub-basin with exposed coal mine refuse and large acid pits. Attempts should be made to address these areas to avoid erosion of sediment and coal fines into Bailey Run and to avoid the future production of acid mine drainage.

Overview of Water Chemistry: Bailey Run contributes significant amounts of AMD to Thomas Fork and is a priority for remediation. It adds a significant quantity of metals and acidity during high flow and low flow, but overall the water chemistry indicates moderate impacts from acid mine drainage (Table 36 and See Appendix G for summary of concentrations and loadings).

Table 36. Summary of loadings at Bailey Run (TF0402)

	Flow	Acidity		Total Metals	
		Loading	Percent Loading	Loading	Percent Loading
	GPM	lbs/day	to Thomas Fork*	lbs/day	to Thomas Fork*
High Flow	1437.0	776.18	25%	158.34	18%
Low Flow	13.2	15.60	2%	2.88	2%

*Percent contribution is relative to the other tributaries in Thomas Fork

Based on Phase II assessment of Bailey Run, none of the tributaries act as a primary source of the metal and acidity loading, the sources are all diffuse and relatively equal in loadings (Table 37). The largest contributor of acidity during the April 2004 sampling event was TF040600. However this site only contributed 22 percent of the loading to Bailey Run. Six sites contribute 93% of the acidity however they all range between 11 and 22 percent leaving prioritization of treatment areas difficult. As a result, abatement of the problem may require a basin wide approach. During extreme low flow conditions most sources were dry leaving only site TF040400 (82%) and TF040600 (16%) as the main contributors.

Table 37. Percent acid and metal loads in the Bailey Run Subwatershed (5-5-04)

Site	Acidity Load lbs/day	Percent Acidity Loading to Bailey*	Total Metal Load lbs/day	Percent Metals Loading to Bailey*
TF041200	5.6	0.7%	2.35	1.4%
TF041100	104.3	13.2%	17.75	10.3%
TF041000	17.9	2.2%	6.10	3.5%
TF040900	-2.7	0.0%	0.92	0.5%
TF040800	86.8	11.0%	15.25	8.9%
TF040700	116.9	14.8%	24.82	14.4%
TF040600	176.0	22.2%	34.78	20.2%
Tobins	118.3	15.0%	27.73	16.1%
TF040400	135.3	17.1%	37.41	21.8%
TF040200	31.3	4.0%	4.86	2.8%

*Percent contribution is relative to the other tributaries in Bailey Run

Potential for Restoration of Aquatic Life: Water chemistry in Bailey Run inhibits survival of most aquatic organisms, but macroinvertebrates and small fish have been observed in one un-impacted tributary (TF040900). Unlike many of the other tributaries to Thomas Fork, Bailey Run has suitable flow and habitat conditions to support an aquatic community, but improvements to Bailey Run are not the overall goal for remediation. There are diffuse sources of AMD that impact Bailey Run and there is limited area for a treatment system, a basin-wide approach is required and the overall goal will be to reduce the impacts of Bailey Run on Thomas Fork. Habitat conditions along Thomas Fork near the confluence of Bailey Run have many high quality features (overhanging vegetation, deep pools, sinuosity, and higher quality riffles) and schools of fish and fry were observed in spring 2004 during a period of sustained higher flow when AMD impacts were reduced.

Recommendation for Abatement and Treatment: Bailey Run reclamation consists of two phases. The first phase consists of installing steel slag bed (SLB) in the headwaters where good water is available. This approach is recommended to buffer the acidity generated from the numerous and diffuse AMD sources in the Bailey Run subwatershed. Alkalinity generated from alternative site A TF040900 will produce on average 588 lbs/day alkalinity. Alternative site B TF490, is expected to produce an average 588 lbs/day as well. However Alternative A site TF040900 is the better location due to its close proximity to the acid mine drainage sources. This amount of alkalinity (588 lbs/day) is expected to buffer acid loads at the mouth of Bailey Run, TF0402, (307 lbs/day) as well as the upstream load from SR 124 seep underdrain (161 lbs/day). However, after installation of Phase I, monitoring and evaluation will be performed in Bailey Run and the receiving stream, Thomas Fork, if more reclamation is needed Phase II construction will be initiated. Phase II recommendations are to treat sources found in the two highest contributors of acidity and AMD metals in Bailey Run subwatershed, Hollow #4 (TF040400) and Hollow #6 (TF040600).

Phase I

Alternative A:

Install a steel slag bed (SLB) at TF040900. TF040900 is the 9th tributary to enter Bailey Run from the mouth and has a drainage area of 0.11 square miles (70 acres). Steel slag beds will be constructed to siphoned clean water from this tributary to supply good water to leach through the SLB generating high alkaline water to buffer acid generated downstream. Site TF040900, although similar in size and alkalinity generation potential as site TF0490, is located in closer proximity to the sources of acidity generating sources and therefore is the better alternative for steel slag placement.

Alternative B:

Install a steel slag bed (SLB) at TF0490. TF0490 is a mainstem site in the headwaters of Bailey Run and has a drainage area of 0.11 square miles (70 acres). Steel slag beds would be constructed in the mainstem where the water quality is good to generate high alkaline water to buffer acid generated downstream.

Phase II

Create positive drainage, install V-notch OLC, and J-trench wetlands to reclaim acidic water discharging from Hollow #4 (TF040400) (2,500 ft at 3% grade) and Hollow #6 (TF040600) (1,150 ft at 6% grade). (If only one of these projects is chosen, TF040400 is the better choice from the cost versus benefit table, see Table 62).

Estimated costs of abatement and treatment recommendations: Table 38 - 40 lists the estimated major budget categories for reclamation costs. All specific project costs, calculations, and design considerations are listed in Appendix F.

Table 38: Bailey Run Phase I Alternative A –site TF040900 steel slag bed (SLB)

Task/item	**Description**	**Quantity**	**Cost**	**Ten year cost**	**Data Source**
Steel slag	$30/ton	369 tons based on 1.6 years 1,139 tons based on 5.0 years*	$11,070 $34,170	$69,188 $68,340	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			$8,378		ODNR
Site constr.			$46,660		ODNR
Site reclamation			$492		ODNR
Sub Total			$55,531		
Mobilization	8%		$4,442		
Contingencies	10%		$5,997		
Total			**$65,970**		

***SLB designed for 1.6 years requires 6,825 ft^3, SLB designed for 5.0 years requires 21,086 ft^3.**

Table 39: Bailey Run Phase I Alternative B - site TF0490 steel slag bed (SLB)

Task/item	Description	Quantity	Cost	Ten year cost	Data Source
Steel slag	$30/ton	369 tons based on 1.6 years 1,139 tons based on 5.0 years*	$11,070 $34,170	$69,188 $68,340	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			5,999		ODNR
Site construction			46,660		ODNR
Site reclamation			415		ODNR
Sub Total			53,074		
Mobilization	8%		4,246		
Contingencies	10%		5,732		
Total			**63,052**		

***SLB designed for 1.6 years requires 6,824 ft^3, SLB designed for 5.0 years requires 21,086 ft^3.**

Table 40: Bailey Run Phase II - site TF040400 and TF040600 open limestone channels

Task/item	TF040400	TF040600	Data Source
Limestone*	237 tons for 13.2 years	109 tons for 43.1 years	WVU spreadsheet
Site preparation	18,102	11,527	ODNR
Site construction	91,363	47,695	ODNR
Site reclamation	723	333	ODNR
Sub Total	110,188	59,555	
Mobilization	8,815	4,764	
Contingencies	11,900	6,432	
Total	**13,0903**	**70,751**	

***Limestone determine from WVU spreadsheet based on neutralization potential for the site, limestone needed for structural construction of V-notch channels and J-trenches exceeds the needed limestone for neutralization capacity.**

Hysell Run (TF03)

Name:	Hysell Run
Tributary to:	Thomas Fork
Confluence:	River Mile 3.0
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 3rd tributary to Thomas Fork. It drains 3.5 square miles making it the second largest tributary in the Thomas Fork subwatershed. The mouth of Hysell Run can be accessed near Bradbury Road by walking south of Bradford Cemetery. Most of the remaining stream parallels Hysell Run Road (County Road 15) and is easily accessible by vehicle. The watershed area is relatively well populated with many residents along Hysell Run Road.

Site Description: The drainage area is affected by abandoned deep-mines, auger mining, abandoned stripmine lands and associated unreclaimed coalmine spoil (Table 41). The headwaters of Hysell Run have not been mined and have high quality habitat features with an abundant fish population. Land on either side of the stream from RM 3.4 to the mouth has been heavily affected by mining (~20% surface mining, ~10-15% deep mining). The landscape consists of severely degraded areas with un-reclaimed gob piles and numerous acid pits along the perimeter of the highwall, but it also has areas that have recovered from the mining disturbance and now have extensive forest cover.

Metals and acidity are primarily produced in 2 hollows (hollow #8 TF030800 and hollow #11 TF031100), but hollow #6 TF030600 and hollow #13 TF031300 also contribute acid mine drainage.

Hollow #13 –TF031300 consists of spoil and highwalls surrounding both sides of the creek. There is a gob pile in the head of the hollow with pooled water between the gob and highwall. There are no direct discharges to the creek. However water is likely infiltrating through the spoil/gob and entering the creek through the subsurface.

Hollow #11 – All previously mined areas are producing AMD in a very diffuse manner. No mine entrances are visible, and there are diffuse seeps along the bank of the stream. There are several pits along the highwall, but none are connected by surface flow to tributary #11. Most of the hollow is forested, but there is exposed gob on the north side of the hollow. The topography of the drainage area is degraded (*i.e.* much of the valley is filled and/or altered).

Photo 11: Seepage in Hysell Hollow #11

Photo 12: Trench in Hysell Hollow #11

<u>Hollow #8</u> – AMD production is caused by sub-surface drainage from leaking strip mine and auger mine pits. During higher flow, two additional sources are a seep on the north side of the hollow and a pit apparently fed by an underground mine on the south side. The landscape is characterized by modest tree growth, areas with unreclaimed coal refuse piles, exposed auger holes, and large pits of water along the highwall.

Photo 13: Seepage along highwall in Hysell Hollow #8

Photo 14: Seep #2 in Hysell Hollow #8

<u>Hollow #6</u> This hollow is located behind Hysell Run Holiness Church. The watershed area is predominantly forested, but there is a large area of exposed gob on the north side of the hollow. The topography of the drainage area is very degraded (*i.e.* much of the valley is filled and/or altered). The primary source of AMD is sub-surface drainage of strip mine pits and auger mine pits. There are several pits along the highwall, but none are connected by surface flow to tributary #6. There is evidence of diffuse seepage along the stream (*i.e.* metal precipitants and changes in pH and conductivity). During higher flow, 2 additional sources of AMD flow from pits located along the south side.

Table 41. Underground mines located in Hysell Run subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-077	Black Stone No.4	1933	743	Hollow #6, Hollow #8, Hollow #11
MS-123	Williams No.3	1946		Hollow #13
MS-051	Peacock	1948	714	
MS-53	No.5	1935		
MS-38	Skidmore	1929		TF030200

<u>Justification for Remediation:</u> Remediation in Hysell Run is being pursued for two reasons. Hysell Run negatively impacts Thomas Fork especially during low and medium flow. During June 2004 low flow mass balance, Hysell Run contributed 9% of the acidity loading and 6% of the metal loading. In addition to reducing the impacts in Thomas Fork, another goal is to reduce AMD conditions within Hysell Run. The sources are localized within the sub-basin making remediation feasible.

<u>Overview of Water Chemistry:</u> The degree to which AMD impacts Hysell Run fluctuates considerably with different flow regimes. During high-medium flow, impacts are very slight, whereas during medium-low flow the effects are more severe (Table 42).

Table 42. Summary of water quality at Hysell Run (TF0302)

Date	Flow regime	pH	Conductivity	Net Acidity	Aluminum	Iron	Manganese	Discharge
		units	uS/cm	mg/L	mg/L	mg/L	mg/L	GPM
6/9/2003	High	6.04	529	-2.86	<0.25	0.18	1.07	4080.0
8/25/2003	Medium	6.85	719	-14.68	1.01	0.59	1.41	457.3
10/23/2003	Medium	6.86	766	-12.00	0.76	0.64	1.57	568.0
4/5/2004	Medium	5.71	556	12.46	4.88	1.75	1.20	2301.7
6/21/2004	Medium-Low	4.64	897	42.25	4.78	0.94	2.37	365.3
7/20/2004	Low	4.39	980	47.60	5.46	0.58	3.25	227.3
8/22/2005	Extreme low	5.21	1050	11.47	1.08	1.07	4.69	4.58
9/12/2005	Extreme low	4.45	1480	36.4	2.24	0.83	4.25	5.54

Water quality monitoring was conducted at all of the sources within this sub-basin during medium flow (April 5, 2004) and extreme low flow (9/12/05). During the April sampling event, the two highest acid and metal loaders were hollow #11 and #8. Combined, these hollows contribute 94% of the net acidity loading and 70% of the metal loading. The next two highest loaders were hollow #13 and #6. Combined these hollows contribute 25% of the net acidity and 22% of the metal loading (Table 43). Analysis of the April 2004 September 2005 data shows an increase in acidity near the mouth between site TF0310 and TF0302 (Figure 13). Further reconnaissance conducted in February 2006 reveals a mine discharge (TF030200) emitting from the MS-38 Skidmore Mine. One water quality sample was collected from this site on 2-6-06. Water quality indicates poor water quality with elevated acidity and metals (Appendix G).

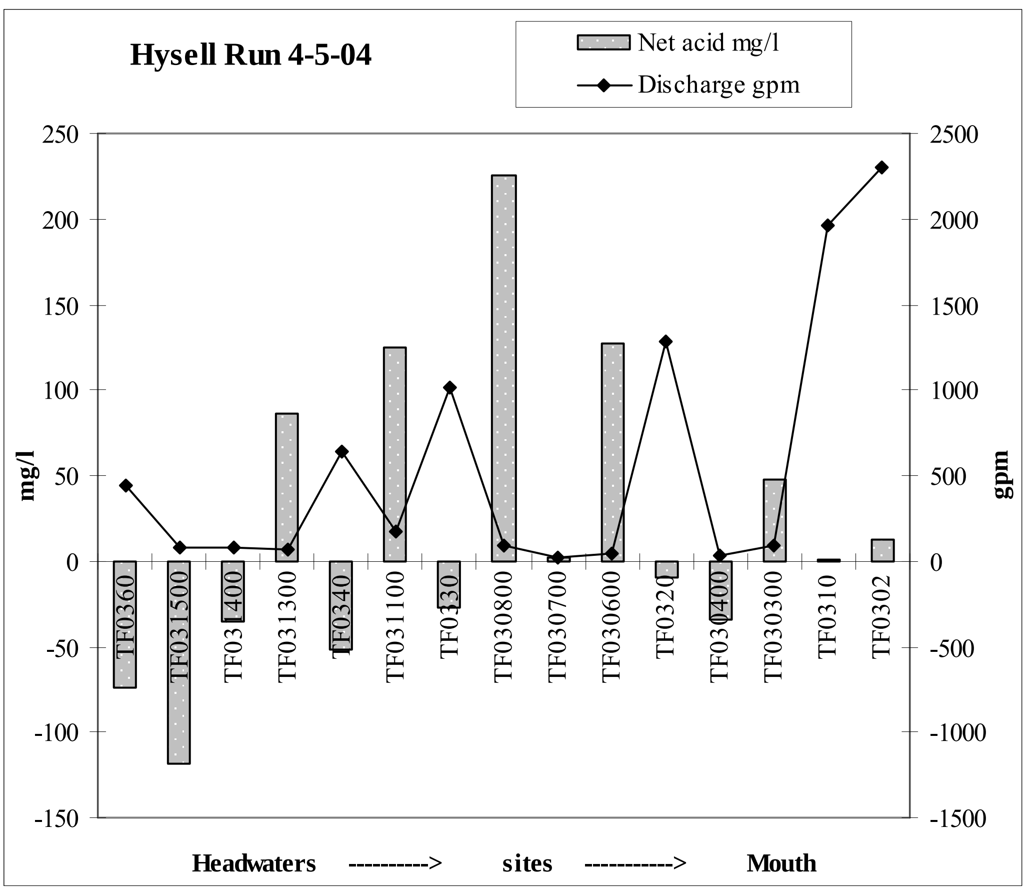
Table 43. Contributors of acid and metal loads in Hysell Run basin (4-5-04)

Site	Acidity Load lbs/day	Percent Acidity Loading to Hysell*	Total Metal Load lbs/day	Percent Metals Loading to Hysell*
TF031500	-119.58	-22.2%	1.68	1.4%
TF031400	-30.93	-5.7%	0.81	0.7%
TF031300	68.85	12.8%	11.10	9.0%
<u>TF031100</u>	256.50	47.8%	41.92	33.8%
<u>TF030800</u>	249.50	46.5%	44.84	36.2%
TF030700	0.48	0.1%	0.31	0.2%
TF030600	71.48	13.3%	11.87	9.6%
TF030400	-12.58	-2.3%	0.46	0.4%
TF030300	53.45	10.0%	10.88	8.8%

Major contributors are underlined

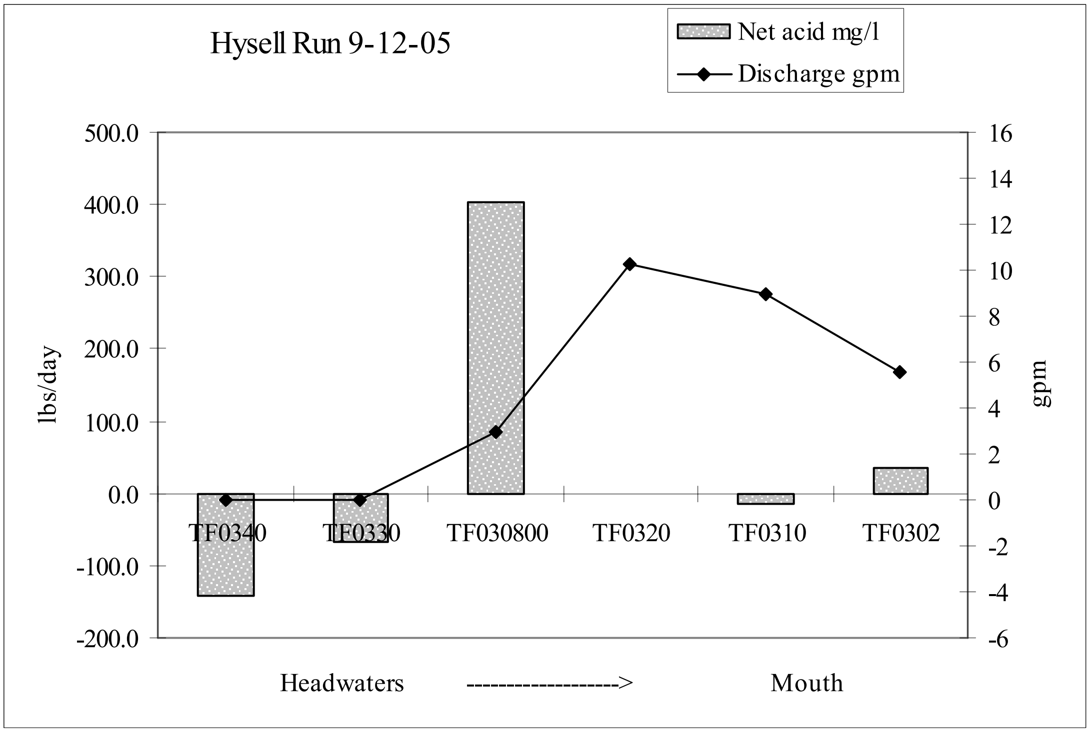
*Percent contribution is relative to the other tributaries in Hysell Run

Figure 13. Hysell Run acidity and discharge measured on 4-5-04



During the extreme low flow sampling event (9/12/05) most tributaries and sources in Hysell Run were dry. Hollow #8 was the only tributary that continued to discharge (Figure 14).

Figure 14. Hysell Run acidity and discharge measured on 9-12-05



Potential for Restoration of Aquatic Life: Unlike many other tributaries to Thomas Fork, Hysell Run has the habitat features and sustained flow to support aquatic life. There are currently isolated fish populations upstream of the acid mine drainage, treatment of mine drainage from two TF031100, TF030800, and TF030200 would likely permit fish movement throughout Hysell Run and possibly into Thomas Fork.

Recommendation for Abatement and Treatment: The goal is to restore the lower section of the mainstem of Hysell Run to connect Thomas Fork with the headwaters of Hysell Run where intact fish populations have been documented. A two-phased approach is recommended to remediate Hysell Run. Phase I recommends treating individual high loading sources within Hysell Run to improve the mainstem of Hysell Run. Phase II recommends installing SLB at site TF031400 or site TF030400 to generate alkalinity.

Phase I

Phase I consist of treating individual sources within two hollows (TF031100 and TF030800) and the deep mine discharge TF030200 near the mouth. Individual treatment recommendations in the two hollows consist of spoil reclamation, creating positive drainage, and installing OLCs. Deep mine source TF030200 will require a limestone pond with flushing mechanisms for aluminum precipitates, settling pond, and aerobic wetland. GAI consultants suggested treatment alternatives and estimates in 2005 for Hollow #8 (TF030800) and Hollow #11 (TF031100). GAI suggests "a potential treatment strategy for Hollow #8 would include the collection and circulation of the drainage from the auger holes through Successive Alkalinity Producing Systems (SAPS), augmented with the use of open limestone channels (OLC). A settling basin may be necessary for metal removal. Four OLC's will stabilize existing erosion gullies and serve to treat the AMD. The total length of rock channels is approximately 1,000 linear feet. The SAPS and associated aeration pond(s) would be approximately 0.8 acres in size. Areas along the highwall that will not be affected by the installation of the passive treatment structures will be backfilled to prevent standing water that may cause AMD by seeping through the mine spoil. The chemistry suggests that some buffering is occurring in Hollow 8 as the acidity and metal loadings are less than what would be expected considering the loadings from each seep. Options to address the production of AMD directly at the source(s) should also be explored. This may include the installation of permeable aggregate seals or air seals at any exposed and discharging auger hole. These structures would be designed to either discharge water through limestone placed in the opening or allow discharge of water while limiting air entry into the void. Sealing auger holes with impermeable material (i.e. clay) to flood the holes to limit pyrite oxidation have generally not been effective as there is a tendency for leakage. Completion of Hollow #8 reclamation, not only will address the AMD issues, but also will address a localized flooding problem due to sedimentation and several auger holes that are accessible to the public for exploration". GAI consultants suggest the same treatment alternatives for Hollow #11 with SAPS and OLCs. GAI states "the installation of three OLC's will stabilize existing erosion gullies and serve to treat the AMD. The total length of rock channels needed is approximately 1,500 linear feet. The SAPS and associated aeration pond(s) would be approximately 1.0 acre in size. Areas along the highwall that will not be affected by the installation of the passive treatment structures will be backfilled to prevent standing water that may cause AMD by seeping through the mine spoil. Completion of Hollow #11 not only will address the AMD issues, but will also address an accessible mine entry".

Phase II

Install SLB at site TF030400 (alternative B) or TF031400 (alternative A) to generate 372 lbs/day and 648 lbs/day respectively of alkalinity. This alkalinity may be needed to buffer the remaining acidity generated from other Hysell Run sources not addressed as part of Phase I. The evaluation of Phase I will indicate the effectiveness of the individual treatments installed at sites TF031100, TF030800 and TF030200.

Estimated costs of abatement and treatment recommendations: Table 44 - 47 list estimates of major budget categories for the recommended treatment alternatives. Project costs, calculations, and design considerations are listed in Appendix F.

Table 44: Hysell Run Phase I - site TF030800 SAPS and OLC

Task/item	Unit	Quantity	Cost per unit	Cost	Data Source
Mobilization/Clearing	Lump Sum	1	-	$6,000.00	GAI
Access Road (800'-stone)	Tons	300	$18.00/T	$5,400.00	GAI
Earthwork	Lump Sum	1	LS	$10,000.00	GAI
SAPS	Lump Sum	1	-	$100,000.00	GAI
Open Limestone Channels	Tons	700	$30.00/T	$21,000.00	GAI
Settling Ponds	Lump Sum	1	-	$10,000.00	GAI
Resoiling Material	Acres	2	$3000.00/A	$6,000.00	GAI
Standard Revegetation	Acres	4	$1500.00/A	$6,000.00	GAI
Monitoring	Samples	84	$220.00 each	$18,480.00	GAI
Engineering	Lump Sum	1	25%	$45,000.00	GAI
Contingency	Percentage		10%	$19,000.00	GAI
Total Cost Estimate				$246,880.00	GAI

Table 45: Hysell Run Phase I - site TF031100 SAPS and OLC

Task/item	Unit	Quantity	Cost per unit	Cost	Data Source
Mobilization/Clearing	Lump Sum	1	-	$6,000.00	GAI
Access Road (800'-stone)	Tons	300	$18.00/T	$5,400.00	GAI
Earthwork	Lump Sum	1	LS	$10,000.00	GAI
SAPS	Lump Sum	1	-	$120,000.00	GAI
Open Limestone Channels	Tons	1,000	$30.00/T	$30,000.00	GAI
Settling Ponds	Lump Sum	1	-	$10,000.00	GAI
Resoiling Material	Acres	2	$3000.00/A	$6,000.00	GAI
Standard Revegetation	Acres	4	$1500.00/A	$6,000.00	GAI
Monitoring	Samples	84	$220.00 each	$18,480.00	GAI
Engineering	Lump Sum	1	25%	$50,000.00	GAI
Contingency	Percentage		10%	$22,000.00	GAI
Total Cost Estimate				$283,880.00	GAI

Table 46: Hysell Run Phase II Alternative B - site TF030400 steel slag bed

Task/item	Description	Quantity	Cost	Ten year cost	Data Source
Steel slag	$30/ton	233 tons based on 1.6 years 720 tons based on 5.0 years*	$6,990 $21,600	$43,688 $43,200	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			5,999		ODNR
Site construction			37,197		ODNR
Site reclamation			498		ODNR
Sub Total			43,694		ODNR
Mobilization	8%		3,495		ODNR
Contingencies	10%		4,719		ODNR
Total			51,908		ODNR

***SLB designed for 1.6 years requires 4,316 ft^3 bed, SLB designed for 5.0 years requires 13,340 ft^3 bed.**

Table 47: Hysell Run Phase II Alternative A - site TF031400 steel slag bed

Task/item	Description	Quantity	Cost	Ten year cost	Data Source
Steel slag	$30/ton	406 tons based on 1.6 years 1,254 tons based on 5.0 years*	$7,613 $37,620	$76,125 $75,240	MEF & WVU spreadsheet MEF & WVU spreadsheet
Site preparation			7,028		ODNR
Site construction			52,394		ODNR
Site reclamation			462		ODNR
Sub Total			59,884		ODNR
Mobilization	8%		4,790		ODNR
Contingencies	10%		6,468		ODNR
Total			71,142		ODNR

***SLB designed for 1.6 years requires 7,521 ft^3 bed, SLB designed for 5.0 years requires 23,237 ft^3 bed.**

Unnamed tributary on McElhinney Hill (TF02)

Name:	The Unnamed tributary on McElhinney Hill Road
Tributary to:	Thomas Fork
Confluence:	River Mile 2.8
USGS Quadrangles:	Pomeroy

Location/Access: This stream is the 2nd tributary to Thomas Fork. It has a small drainage area (0.64 square mile) and moderate flow (average 74 GPM). It can be accessed from Bradbury Road (County Road 5) to Noble Summit Road (Township Road 174). It parallels Noble Summit Road and is easily accessible by vehicle.

Site Description: This tributary is affected by abandoned deep-mines, strip-mines and the associated un-reclaimed coalmine spoil (Table 48). Identification of specific sources of AMD has never been completed in this basin. Based on field measurements, the stream is affected by AMD. This stream is a low priority for remediation because it is only moderately impacted and does not affect Thomas Fork. Even during low flow, it does not have an affect on Thomas Fork (upstream pH= 4.85, conductivity= 930 µS/cm and downstream pH= 4.84, conductivity= 900 µS/cm).

Table 48. Underground mines located within the McElhinney Hill Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-099	Mines No.1&2	1923	729	
MS-021	Kings No.2	1906		
MS-038	Skidmore	1929		

Overview of Water Chemistry: Tributary, TF0202, is not a significant loader to Thomas Fork (Table 49) and water chemistry indicates that it has only moderate impacts (Table 50).

Table 49. Percent acid and metal loadings from TF0202

Site	Flow GPM	Acidity Load lbs/day	Percent Acidity to Thomas Fork*	Total Metal Load lbs/day	Percent Metals to Thomas Fork*
Medium flow	69.7	38.76	4.2%	12.11	2.3%
Low flow	1.65	-0.14	0.0%	0.13	0.1%

*Percent contribution is relative to the other tributaries in Thomas Fork

Table 50. Summary of water quality at McElhinney Hill Tributary (TF0202)

Date	Flow regime	pH units	Conductivity uS/cm	Net Acidity mg/L	Aluminum mg/L	Iron mg/L	Manganese mg/L	Discharge GPM
8/25/2003	High	4.99	824	33.65	3.92	0.59	4.29	89.3
10/23/2003	Medium	4.76	935	42.80	7.30	1.46	3.92	61.6
6/21/2004	Medium	4.63	866	46.34	6.80	2.05	5.63	69.7
8/23/2005	Extreme Low	6.03	1170	-7.1	0.3	2.3	4.16	1.65

Recommendation for Abatement and Treatment: AMD contamination is not an overall concern, but metal flocculants have been observed and future monitoring should be conducted.

Paulins Hill Run (PH00)

Name:	Paulins Hill Run
Tributary to:	Leading Creek
Confluence:	River Mile 6.40
USGS Quadrangles:	Pomeroy, Rutland, and Cheshire

Location/Access: Paulins Run drains about 1 square mile in the southern portion of the Leading Creek watershed. Most of the stream parallels Paulins Hill Road (County Road 352) and is easily accessible. The lower 0.4 miles can be accessed by four-wheel-drive vehicle from an abandoned township road running through the property of Lisa Dunst and Jimmie Griffith.

Site Description: The drainage area is affected by abandoned deep-mines, auger mining, abandoned stripmine lands and associated un-reclaimed coalmine spoil (Table 51). In the 1980s, Hollow #2 was reclaimed and a series of surface and subsurface drains were installed to localize the movement of water from the area. There are three main contributors of mine drainage in this watershed: near the headwaters two mine seeps enter a road ditch within close proximity of each other and then flow through a culvert and enter Paulins Run, hollow #2 is a reclaimed area that is producing AMD from sub-surface and surface drains and diffusely from discharging strip mine pits, and hollow #1 is contributing mine drainage from strip and auger pits.

Table 51. Underground mines located in Paulins Hill Tributary

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
GA-015	Peacock	1955	694	Ditch Seep
GA-067	Williams No.1	1947	689	PH0200
GA-014	Peacock No.7	1954	720	PH0200
				No Underground Mines for PH0100

Seeps flowing into Ditch ("Seep Ditch"): The two seeps flow from the hillside near the highwall, unlike other runoff in the watershed which flows from strip and/or auger pits. The flow was significant even during lower flows in June 2004. The seeps flow down the hill, through a road ditch, and then flow through a culvert and enter Paulins Run.

Tributary #2 ("PH0200"): The hollow surrounding tributary #2 (Long Hollow) was strip mined and auger mined. The hollow was reclaimed and the landscape is now forested along the southern ridge and riparian area and has grass cover along the highwall and the northern ridge. The entire reach has extremely poor water quality. On the southeast facing side of the hollow, there are three underdrains that flow into rock-lined channels. The first (*i.e.* the most northern one) has no water flowing in it, the second does not have water flowing from the underdrain but from a seep above the drain, the third has water flowing through the drain and in the rock channel. This side of the hollow (*i.e.* the southeast facing) has thick grass cover with a well-established path along the perimeter of the highwall. There is no evidence of any other seeps, pits, or outlets besides those associated with the underdrains.

The northwest facing slope has very diffuse production of AMD. During higher flow there is one seep close to the headwaters that has significant flow, but the majority of the flow reaches tributary #2 sub-surfacely from several large auger pits along the highwall. This area of the watershed is fairly densely forested with mature deciduous trees. Although the riparian area is forested, residual sand from the surface mining and highly eroded stream banks create a significant source of sedimentation.

<u>Tributary #1(“PH0100”):</u> The hollow surrounding tributary #1 (Dunst Hollow) was strip mined and auger mined. The hollow has not been reclaimed, but it is mostly forested and has only a few isolated areas with piles of coal refuse. There is very little surface flow that feeds tributary #1. The main sources are two branches of the headwaters and a small adjacent seep which all drain exposed auger holes and auger pits. The branches of the headwaters have considerable flow and are the primary sources of AMD. The ridge along the headwaters has a large auger pit with extremely poor water quality (pH= 2.83, conductivity= 1610). Another seep (flowing northeast) which is very close to the headwaters contributes a significant acidity and metal loading and is also fed by a large auger pit.

<u>Justification for Remediation:</u> Paulins Run is a small stream and has minimal affects on Leading Creek; therefore, the overall goal of remediation is to restore the biological and functional integrity within Paulins Run. The important ecological functions of smaller, headwater streams are developing as a prominent issue in the academic and regulatory communities. Besides having unique assemblages of aquatic organisms, headwater streams also function to control sediment, nutrients, and floods (Ohio Environmental Protection Agency, 2003).

Abatement and treatment can be focused on three locations within the sub-watershed, which may make the restoration feasible.

<u>Overview of Water Chemistry:</u> Paulins Run does not impact Leading Creek even during low flow (Table 52), but based on Phase II sampling, the impacts of AMD are severe within the Paulins Run subwatershed. The headwaters and each of the tributaries are affected by very high concentrations of acidity and moderate levels of heavy metals. Only Hollow #3 is not impacted by mine drainage (Table 53).

Table 52. Summary of water chemistry upstream and downstream of Paulins Run

Site Location	pH	Conductivity	Iron	Alkalinity
	Average Concentration and Range			
-	units	µS/cm	mg/L	mg/L
Leading Creek, RM 7.2 upstream	7.54	1947	1.56	122.00
	7.17 to 8.04	193 to 4720	0.33 to 11.60	89.00 to 154.00
Paulins Hill Run, RM 0.1	4.65	653	0.38	-34.96
	4.51 to 4.95	548 to 697	0.32 to 0.56	-44.92 to -30.20
Leading Creek, RM 3.5 downstream	7.46	1861	1.30	120.00
	7.01 to 8.10	187 to 5000	0.20 to 4.04	88.00 to 152.00

Measurements taken by Cherry *et al.* in 1996 and 1997

Table 53. Summary of water quality within Paulins Run sub-basin

Site	Site Description	pH	Conductivity	Net Acidity	Aluminum	Iron	Manganese	Discharge
		units	uS/cm	mg/L	mg/L	mg/L	mg/L	GPM
PH0090	Headwaters	4.4	543	36.9	4.6	2.2	3.2	21.2
Seep Ditch	Seeps in culvert	3.6	875	75.4	7.8	1.1	4.5	31.6
PH0500	Tributary #5	5.3	594	8.2	0.9	0.4	1.1	21.0
PH0400	Tributary #4	3.9	755	71.8	9.3	0.3	4.5	4.5
PH0300	Tributary #3	6.9	396	-14.5	below detection	0.1	0.1	5.9
PH0200	Tributary #2	3.6	1345	214	34.7	1.3	8.6	18.0
PH0100	Tributary #1	4.1	841	78.3	12.3	0.6	3.3	24.1
PH0002	Mouth	4.6	692	33.7	4.4	0.3	3.2	190.6

Values are averages from two sampling events (May 3, 2004 and June 14, 2004)

There are three primary contributors of acid mine drainage, tributary #1 (Dunst), tributary #2 (Longs), and "seep ditch", which account for more than 90% of the acidity and metal loading (Table 54).

Table 54. Percent contribution of AMD sources within Paulins Run Subwatershed

Site	May		June		May		June	
	Acid Load lbs/day	Percent Acidity to Paulins Run*	Acid Load lbs/day	Percent Acidity to Paulins Run*	Tot Metal Load lbs/day	Percent Metals to Paulins Run*	Tot Metal Load lbs/day	Percent Metals to Paulins Run*
Seep Ditch	37.6	26%	20.4	31%	6.70	24%	3.60	27%
PH0500	4.4	3%	1.5	2%	0.75	3%	0.45	3%
PH0400	7.7	5%	0.9	1%	1.34	5%	0.20	1%
PH0300	0.7	0%	0.1	0%	below detection	below detection	below detection	below detection
PH0200	60.1	41%	31.6	47%	12.02	43%	6.65	49%
PH0100	35.1	24%	12.3	18%	6.89	25%	2.68	20%

*Percent contribution is relative to the other tributaries in Paulins Run

Potential for Restoration of Aquatic Life: Achievement of Warmwater Habitat may not be an attainable goal for this stream. While Paulins Run does have sustained flow throughout a typical summer, other features (*e.g.* depth of pools, substrate type and quality) many limit the health and diversity of organisms that can inhibit it. During the extreme low flow conditions of Summer 2005, Paulins Run was dry. In general, it is possible for a diverse assemblage of fish, salamanders, and macroinvertebrates to be found in smaller, headwater streams, but a considerable investment would be required to fully restore this stream to be one that is suitable for sensitive aquatic life. Paulins Hill has limited impact on Leading Creek. However to potential restore Paulins Hill, future restoration projects could be considered if funds become available to conduct lower priority sites. Recommended treatment is to install a SLB in the headwaters to buffer the acidity generated downstream.

Titus Run (TR00)

Name:	Titus Run
Tributary to:	Leading Creek
Confluence:	River Mile 7.3
USGS Quadrangles:	Rutland

Location/Access: Titus Run drains about 3 square miles in the southern portion of the Leading Creek watershed. The stream parallels Titus Run Road (County Road 12) and is easily accessible by vehicle.

Site Description: Decades of unregulated surface mining left many areas in the subwatershed barren with un-reclaimed coal refuse (Table 55). Much of the abandoned mine land has been reclaimed. The impacts of acid mine drainage are localized in Titus Run and most of the tributaries in the subwatershed were not mined and do not appear to be limited by acidity or metals. The mainstem of Titus Run has low to moderate impacts from AMD and there appears to be just one main contributor of AMD, tributary #1.

Table 55. Underground mines located in the Titus Run Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
GA-021	Carson No.2	1954	692	Tributary #1

1. Titus Run, Tributary One: Within the hollow surrounding "Titus Run, Tributary One", four distinctive tributaries were surveyed. Tributary 1 begins in a large un-reclaimed area that has steep slopes and exposed gob. Tributary 2 did not have any distinct sources of mine drainage and AMD is most likely produced diffusely from large strip mine pits leaking through the mine spoil. Tributary 3 has significant flow and is the main contributor of AMD. Within this tributary, there is very diffuse production of mine drainage. Tributary 4 begins amid un-reclaimed coal refuse materials. The hollow is very disturbed with high, eroded banks and large acid pits along the perimeter of the high wall.

Justification for Remediation: Titus Run is only moderately impacted and has minimal affects on Leading Creek; therefore, the overall goal of remediation is to restore the biological and functional integrity within Titus Run. The main source of mine drainage within the basin is from the 1^{st} tributary, which enters Titus Run about 1000 feet upstream from the confluence with Leading Creek. The impacts of this tributary may limit fish migration to and from Leading Creek, but no studies or field observations have confirmed this.

The hollow surrounding the first tributary has a large un-reclaimed area with exposed coal mine refuse and large acid pits. Attempts should be made to address these areas to avoid erosion of sediment and coal fines entering Titus Run (and Leading Creek) and to reduce production of acid mine drainage.

Overview of Water Chemistry: Titus Run does not impact Leading Creek, and at its confluence, Titus Run exhibits only seasonal and slight effects of mine drainage (Table 56). Likewise, the effects within the Titus Run sub-basin are moderate and localized (*i.e.* only about 1000 feet of the mainstem are impacted) (Table 57).

Table 56. Summary of water chemistry at Titus Run (confluence 7.3) and downstream Leading Creek

	Average Concentration and Range			
Site Location	pH	Conductivity	Iron	Alkalinity
	units	µS/cm	mg/L	mg/L
Titus Run, RM 0.2	6.08	541	0.96	-0.1
	5.57 to 6.44	434 to 783	0.68 to 1.54	-5.0 to 19.7
Leading Creek, RM 7.2	7.54	1947	1.56	121.5
	7.17 to 8.04	193 to 4720	0.33 to 11.60	89.0 to 154.0

Note that the conductivity reading along the mainstem is affected by the Meigs Mine #31 discharge

Table 57. Summary of water quality conditions within Titus Run Subwatershed

Site	Site Description	pH	Conductivity	Net Acidity	Aluminum	Iron	Manganese	Discharge
		units	uS/cm	mg/L	mg/L	mg/L	mg/L	GPM
TR0090	Headwaters	6.31	253	-246.7	2.20	0.21	1.56	149.0
TR0500	Tributary #5	7.20	375	-367.8	<0.25	0.21	0.08	170.0
TR0400	Tributary #4	7.44	509	-501.6	0.26	0.45	0.23	24.2
TR0300	Tributary #3	4.83	533	-528.2	4.24	1.65	1.24	92.7
TR0100	Tributary #1	3.49	954	-950.5	17.50	2.95	4.91	106.0
TR0003	Mouth	5.59	497	-491.4	4.24	0.91	1.62	1090.2

The primary source of AMD within the basin is from the 1st tributary. Based on Phase II sampling within this hollow, the 3rd source ("TRH0300") is the main contributor of acidity and metals (Table 58).

Table 58. Percent contribution of AMD sources in the Titus Run Hollow #1 sub-basin

	March		April		March		April	
Site	Acidity Load lbs/day	Percent Acid to Titus Run*	Acidity Load lbs/day	Percent Acid to Titus Run*	Tot Metal Load lbs/day	Percent Metals to Titus Run*	Tot Metal Load lbs/day	Percent Metals to Titus Run*
TRH0500	13.99	2.9%	16.46	2.1%	1.70	1.9%	2.74	1.8%
TRH0400	40.49	8.5%	37.07	4.8%	6.97	7.7%	7.58	5.0%
TRH0300-3	210.38	44.2%	291.65	37.8%	42.97	47.4%	60.37	39.7%
TRH0300-1	3.49	0.7%	11.95	1.6%	0.58	0.6%	2.02	1.3%
TRH0300	172.75	36.3%	355.13	46.1%	32.34	35.7%	68.37	45.0%
TRH0200	23.77	5.0%	33.82	4.4%	4.04	4.5%	6.58	4.3%
TRH0100-2	1.39	0.3%	4.28	0.6%	0.27	0.3%	0.87	0.6%
TRH0100-1	9.95	2.1%	20.20	2.6%	1.75	1.9%	3.48	2.3%

*Percent contribution is relative to the other tributaries in Titus Run

Potential for Restoration of Aquatic Life: Achievement of Warmwater Habitat may not be an attainable goal for this stream. Titus Run is an intermittent stream, therefore, deep pools (*i.e.* > 0.7 meters) must be present to provide refuge for aquatic life during periods of interstitial flow. If Titus Run cannot maintain a community of aquatic organisms (because of flow and pool depth), remediation of the acid mine drainage may not be justified. Conversely, reclamation would be beneficial if it is decided that the consequences of the sediment runoff from the un-reclaimed coal refuse significantly impacts Leading Creek.

Other Streams affected by Acid Mine Drainage
Little Leading Creek (LL00)

Name:	Little Leading Creek
Tributary to:	Leading Creek
Confluence:	River Mile 8.5
USGS Quadrangles:	Pomeroy, Rutland, Shade, and Albany

Although acid mine drainage is not a major concern in this subwatershed, localized areas are affected by mining and AMD, future treatment could be explored if money and/or time make it feasible (Table 59). To determine which tributaries and mainstem segments were impacted by AMD, staff of the Meigs Soil and Water Conservation District conducted field measurements at more than 50 locations in the subwatershed. Based on our results, the effects of AMD seem to be isolated to three small tributaries (confluences at RM 2.7, RM 1.1, RM 0.1) with the remaining sites having pH scores ranging from 6.32 to 7.67 (Table 60).

Table 59. Underground mines located in the Little Leading Creek Subwatershed

Mine #	Mine Name	Date abandoned	Mine Elevation	Project Name
MS-103	Nelson	1947	712	
MS-038	Skidmore	1929		
MS-136	No. 4	1930	754	
MS-077	Black Stone No. 4	1933	743	
MS-020	Happy Hollow	1909		
MS-019	North	1909		
MS-081	Dennison Coal	1949	686	
MS-099	Mines No. 1&2	1932	729	

Table 60. Summary of field measurements collected in Little Leading Creek Subwatershed in 2003 and 2004

Sites	pH range	conductivity range
	units	µS/cm
Happy Hollow Road (confluence RM 2.7)	4.74 - 4.92	497 - 640
Brick Street (confluence RM 1.1)	4.00 - 4.65	526 - 710
Nichols Road (confluence RM 0.1)	4.08 - 5.25	623 - 880
Remaining Little Leading tributaries and mainstem sites	6.32 - 7.67	309 - 676

In addition to the field screening, laboratory analyzed samples taken near the mouth of Little Leading showed the stream had net alkaline water and low metal concentrations (Table 61).

Table 61. Summary of water chemistry near the mouth of Little Leading Creek (RM 0.2)

Site Location	pH	Conductivity	Total Metals	Net Acidity
	units	µS/cm	mg/L	mg/L
Little Leading Creek, RM 0.2	7.28	394	0.53	-63.8
	7.14 to 7.42	365 to 423	0.49 to 0.57	-85.7 to -41.9

Lasher Run (LR00)

Name:	Lasher Run
Tributary to:	Leading Creek
Confluence:	River Mile 8.9
USGS Quadrangles:	Rutland

Impacts associated with acid mine drainage, particularly acidity and heavy metals, were also evaluated in Lasher Run. Field measurements did not indicate the presence of AMD impacts from pH, conductivity, and acidity. PH readings ranged from 7.23 to 7.47 and conductivity varied from 294 to 374 (µS/cm) indicating that AMD is not impacting water quality. There are no subsurface mines in this subwatershed.

In addition to the field screening, laboratory analyzed samples taken near the mouth of Lasher Run showed the stream had an average net alkalinity of 64.5 mg/L and total metals were 0.2 mg/L, far below concentrations indicative of impacted sites. Although no impacts of AMD were present during our sampling, previous studies (*e.g.* Cherry *et al*., 1999) have suggested that AMD is affecting Lasher Run so future monitoring should be explored if money and/or time permit these actions.

SECTION FIVE- Cost-Benefit Analysis and treatment strategy

The recommended treatment alternatives and costs described in the Section Four are derived from a collaboration of technical partners and advisors. Costs for the recommended treatments are estimated from ODNR-DMRM, while load reductions are estimated from West Virginia University's Paul Ziemkiewicz's spreadsheet and OSM's AMD Treat program. As a result the estimated neutralizing material is higher than what is actually needed to neutralize the given acid load for open limestone channels. Amount of steel slag per bed is estimated at approximately a density of 1.5 tons per cubic yard. This estimate is almost equal to the estimated tonnage of steel slag derived from WUV's spreadsheet. For two sites in Hysell Run GAI consultants worked with ODNR-DMRM and the watershed group in 2005 to determine treatment alternatives and costs. These recommendations are included in the AMDAT.

The treatment strategy for each subwatershed in Thomas Fork is divided into different phases and within those phases are alternatives. The strategy is to begin with the Phase I recommendations first then follow up with water quality and biological monitoring to determine the success of the reclamation treatment. After evaluation is completed if additional treatment is needed then Phase II recommendations should be implemented. While considering Phase I and II recommendations some choices can be made by the watershed partnerships as to site location, landowner access, etc…thus the reason for listing multiple alternatives with each Phase. The treatment strategy was determined using site access, proximity to acid sources, and cost to benefit ratio analysis. Table 62 describes each project site, the load reduction, cost, cost to load reduction ratio, ten year cost and the phase strategy. The lower ration number indicates there will be more acid load reduction while spending less money, hence the lower the ratio the better the choice.

Table 62: Cost versus benefit analysis of all project sites

Subshed/sources	Max Load lbs/day	Sample Site	Treatment Type	Load reduction lbs/day	Tons Limestone or slag tons/yr	Cost	Ratio Cost for Calculated Reduction	lifetime yrs	10 yr cost	Phase I	Phase II
TF15	1249	TF15	doser	2592	104	$330,374.00	127	1.0	$657,912	alt.A	
		Pipe1/Seep1	OLC/J-trench	236	29	$54,579.00	231	7.0	$382,053		alt.A
		Seep 3	OLC	55	29	$54,579.00	992	2.8	$194,925		alt.B
		TF1502	SLB	856	3375	$150,395.43	176	5.0	$300,790	alt.B	
TF04	776	TF040400	OLC/J-trench	99	238	$130,903.40	1322	13.2	$99,169		alt.A
		TF040600	OLC/J-trench	14	109	$70,750.56	5054	43.1	$16,425		alt.B
		TF0490	SLB	588	1139	$63,052.35	107	5.0	$126,105	alt.B	
		TF040900	SLB	588	1139	$65,970.55	112	5.0	$131,941	alt.A	
TF11	588	TF1100-1	OLC/J-trench	16	29	$45,888.00	2868	9.8	$46,824	x	
		TF1100-3	OLC/J-trench/gob pile	56	29	$63,921.00	1141	2.8	$228,289	x	
		TF1100-2	J-trench valley floor			NA					x
		TF1180	J- trench valley floor			NA					x
TF03	185	TF031400	SLB	648	1255	$71,142.18	110	5.0	$142,284		alt.A
		TF030400	SLB	372	720	$51,907.79	140	5.0	$103,816		alt.B
		TF030800	SAPS/OLC			$246,880.00				x	
		TF031100	SAPS/OLC			$283,880.00				x	
Kinzel + Venoy	566	TF1400	SLB	1476	2909	$134,185.26	91	5.0	$268,371	alt.A	
		TF1300	SLB	178	350	$29,429.96	165	5.0	$58,860	alt.B	
Total	**3364**			**7774**		**$1,847,838.47**			**$2,757,763**		

Many of the treatment alternatives recommended in the Leading Creek Watershed include the use of a steel slag bed to add alkalinity to the acidic system. The beds have been designed for a five year lifetime. Table 63 compares just the project sites that are recommended for steel slag bed installation. The table shows the cost of the project and the expected alkaline load generation. The low ratio for site TF1400 indicates this site is the best choice when comparing the cost versus the benefit.

Table 63: Cost versus benefit at steel slag bed projects

Subshed	Treatment Type	alakline load generation lbs/day	% total reduction	Tons Slag	Cost	Ratio Cost for Calculated Reduction
TF0071	SLB	856	18.19	3375	$150,395.43	176
TF1400	SLB	1476	31.36	2909	$134,185.26	91
TF1300	SLB	178	3.78	350	$29,429.96	165
TF0490	SLB	588	12.49	1139	$63,052.35	107
TF040900	SLB	588	12.49	1139	$65,970.55	112
TF031400	SLB	648	13.77	1255	$71,142.18	110
TF030400	SLB	372	7.90	720	$51,907.79	140
Total		**4706**	**100**	**10887**	**$566,083.51**	

SECTION SIX- Future monitoring

Pre-construction monitoring

Prior to securing funds, reclamation of priority sites will receive intensive, short-term sampling to assist in the modeling and design of a suitable treatment. Each site selected for treatment should receive monthly or bimonthly sampling for six months capturing high and low flows before entering a design phase. The water quality data is important to determine needed neutralizing material and discharge is particularly important at sites where steel slag beds are recommended for installation.

Post-construction monitoring

The performance of the AMD projects will be monitored monthly or bimonthly for one year following remediation. ODNR Group I parameters will be monitored at multiple stations downstream of treatment sites in order to assess the effectiveness of the treatment system.

Long-term watershed monitoring

Long-term monitoring data will be used to determine how water quality is changing over time (*i.e.* tracking trends in "baseline" conditions) and to evaluate the effectiveness of specific AMD treatment and abatement projects. Long-term monitoring sites have been strategically located downstream of treatment sites and/or at the confluences with major tributaries where improvements in biological condition and metal and acidity loadings are expected (Table 64).

Biological communities should be monitored every 3 to 5 years to evaluate the overall goal of attaining the aquatic life use designation, warmwater habitat. Water chemistry (Group I parameters) and discharge will be sampled semi-annually at the LTM sites located throughout the restoration area.

Table 64: Longterm monitoring stations

Locations of long-term monitoring sites		
Site ID	River Mile	Reason to sample
TF0071	7.6	Monitor trends in reference conditions
TF0070	7.4	Monitor improvements in the mainstem downstream of the TF1502
TF0050	5.5	Monitor improvements in the mainstem downstream of the TF1202 and TF1102
TF1001	5.5	Monitor changes in alkaline addition over time
TF0048	5.4	Monitor upstream of seeps and pipes along SR 7/124
TF0030	4.4	Monitor changes in the seeps along SR 7/124 and the Pipe on SR 124
TF0021	3.4	Monitor upstream of Bailey Run and Hysell Run
TF0402	3.3 / 0.1	Monitor improvements in Bailey Run
TF0020		Monitor improvements in the mainstem downstream of Bailey Run
TF0302	3.1 / 0.1	Monitor improvements in Hysell Run
TF0015	2.8	Monitor improvements in the mainstem downstream of Hysell Run
TF0010	1.2	Monitor improvements near the mouth of Thomas Fork
PH0202	0.5	Monitor improvements in Paulins Run tributary #2 (Long's Hollow)
PH0102	0.3	Monitor improvements in Paulins Run tributary #1 (Dunst's Hollow)
PH0002	0.1	Monitor improvements near the mouth of Paulins Run
TR0002	0.1	Monitor water qualtiy near the mouth of Titus Run

Additional monitoring and low priority sites

Some sites that exhibited mild characteristics of AMD in the initial screening should be periodically sampled to ensure they are not more significant than originally estimated. The low priority sites should be monitored bi-annually for field parameters including pH, acidity, and conductivity. This data will serve to detect any changes in water chemistry that may undermine restoration efforts in the watershed.

Locations of low priority sites	
Site Name	Site Identification
East Branch of Thomas Fork	TF1001
Unnamed tributary on McElhinney Hill	TF0202
Titus Run	TR002
Little Leading Creek subwatershed	N/A
Lasher Run subwatershed	N/A

SECTION SEVEN- Funding Opportunities

Various funding opportunities are available for AMD abatement and treatment. The following list was compiled by Voinovich Center, ILGARD (2006) and provides some of the existing funding 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."

Alcoa Foundation

1) The Alcoa Foundation's primary areas of giving include conservation and sustainability; safe and healthy children and families; global education and workplace skills; and business and community partnerships.

American Land Conservancy

1) Founded in 1990, American Land Conservancy is a private, non-profit land trust dedicated to conserving the landscapes that represent the very best of our ecological, scenic, recreational, cultural and agricultural resources. Through land acquisition, conservation easements and land exchanges, ALC has conserved 195,000 acres through 332 projects across the country. ALC works in partnership with willing landowners, communities, public resource agencies, industry groups, and non-profit organizations.

Charles Stewart Mott Foundation

1) The Charles Stewart Mott Foundation's mission is to promote a just, equitable and sustainable society. The Foundation has two focus areas in their environmental grant making program: Reform of International Finance and Trade and the conservation of Freshwater Ecosystems. In the Conservation of Freshwater Ecosystems program, the Foundation focuses on the Great Lakes region and on Freshwater Ecosystems in the Southeast region of the U.S. Support is provided for three important elements of the Conservation of Freshwater Ecosystems: strengthening the environmental community, public policy work, and site-based conservation.

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 resource 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.
3) Water Pollution Control Loan Fund (WPCLF): Low interest loan financing is available through the State Revolving Fund for the purpose of funding water pollution control programs, both point and non-point sources.

4) Targeted Watershed Grants: The EPA recognizes outstanding watershed groups across the country by awarding these grants. These grants are designed to encourage community-based approaches and management practices to successfully protect and better the nation's watersheds.

Fish America Foundation

1) The Fish America Foundation funds research and conservation projects that have clear and identifiable benefits to sport fish populations and habitats. Funds are provided for the following conservation activities: habitat improvement, stream bank stabilization, aeration systems, fishing reefs, silt removal, planting of trees and vegetation, fish passage improvements, litter clean-ups, education related to enhancement activities, and heavy equipment rental and operation.

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.

Nathan Cummings Foundation

1) This foundation's Environmental Program's goal is to facilitate environmental justice and sustainable communities by holding corporations, governments, and other institutions accountable for their environmental practices. They do this through supporting projects related to environmental public policy, public education and the protection of communities from environmental degradation, especially those vulnerable due to income, race or ethnicity.

Natural Resource Conservation Services

1) Conservation Reserve Program (CRP): CRP is a voluntary land retirement program designed to reduce erosion and protect environmentally sensitive lands with grass, trees, and other long term cover. Landowners bid for annual rental payments during a sign-up period. If selected, landowners contract their land for a ten year period. Cost-sharing of 50 percent is available.
2) Conservation Reserve Enhancement Program is a voluntary program that encourages farmers to enroll in CRP in contracts of 10 to 15 years. The State provides approximately 20 percent of the total program costs and the Federal Government provides 80 percent.
3) Environmental Quality Incentive Program assists in the conservation of structural, vegetative, and land management practices on eligible land. Five to ten-year contracts are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices.
4) Forestry Incentives Program (FIP) aides in tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities.
5) Wildlife Habitat Incentive Program (WHIP): This program provides financial incentives to develop fish and wildlife habitat on private lands. Landowners agree to develop and carry out a wildlife habitat development plan and the USDA provides cost-share assistance for the implementation of practices such as seeding, fencing, and in-stream structures. Many types of land are eligible, including agricultural and non-agricultural land, woodlots, pastures, and stream banks.
6) Wetland Reserve Program: This program is a voluntary program to restore wetlands. Participating landowners can establish conservation easements of either permanent or 30- year

duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner receives payment up to the agricultural value of the land and 100 percent of the restoration costs for restoring the wetlands. The 30-year easement payment is 75 percent of what would be provided for a permanent easement on the same site and 75 percent of the restoration cost. The voluntary agreements are for a minimum ten year duration and provide for 75 percent of the cost of restoring the involved wetlands.

Office of Surface Mining (OSM). Reclamation and Enforcement

1) Direct Grants to Watershed Groups: A grant process for directly funding citizen watershed groups efforts to restore acid mine drainage impacted streams on a project basis.
2) Watershed Cooperative Agreement Program: OSM awards cooperative agreements to not-for-profit organizations, especially small watershed groups, that undertake local acid mine drainage (AMD) reclamation projects.

Ohio Department of Natural Resources

1) Nonpoint Source Watershed Projects: Funds are provided to help implement programs and projects, which protect or improve natural functions of water resources. Projects generally provide cost sharing to landowners or managers to apply nonpoint source pollution control policies. Soil and Water Conservation Districts or other local agencies in cooperation with SWCDs are eligible.

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 Mind Drainage Abatement Program: Watershed groups involved in the long-term cleanup of watersheds impacted by acid mine drainage may apply. Funds may be used for long-term monitoring of water quality changes resulting from an abatement project or for engineering design and construction costs for a priority reclamation project in the qualified hydrologic unit.
3) 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 government agencies.
4) 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 other partners.

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.

The Patagonia Foundation

1) Funding only environmental work, Patagonia is most interested in projects that address the root causes of problems and show a commitment to long-term change. Funding preference is given to programs with a clear agenda, a strategic plan for achieving goals and an emphasis on building a strong base of citizen support through grassroots organizing.

The Public Welfare Foundation

1) The Public Welfare Foundation supports work in disadvantaged communities to address a wide range of issues including the environment. Environmental support is focused on the following categories – grassroots and local organizations, technical assistance to grassroots and local organizations, advocacy and public development and sustainable development.

Turner Foundation

1) Water/Toxins Program: The program works to protect rivers, lakes, wetlands, aquifers, oceans and other water systems from contamination, degradation, and other abuses; to stop the further degradation of water-dependent habitats from new dams, diversions and other large infrastructure projects; to reduce wasteful water use via conservation; to support efforts to improve public policies affecting water protection, including initiatives to secure pollution prevention and habitat protection.

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 principal 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 to assist in identifying sustainable solutions to flooding problems by examining 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.

United States Fish and Wildlife Service

1) Natural Resources Damage Assessment (NRDA) Funds: The NRDA Funds can only be used to ‘restore, rehabilitate, replace, or acquire the equivalent’ of the natural resources damaged during a release/discharge of a hazardous substance. Any proposed projects would have to go through an approval process via the USFWS office since they are trustees of the NRDA Funds. The potential for spending some of this fund on AMD related projects is there; but it could not be used as ‘matching funds’ for grants that have Federal money associated with them. USFWS would mainly be able to help cost share on projects.
2) Partners for Fish and Wildlife Program: This program assists private landowners by providing technical and financial assistance to establish self-sustaining native habitats.
3) 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.
4) 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 source stewardship

SECTION EIGHT- Methodology

A three phased approach was used to identify and prioritize AMD sources based on acidity and metal loads.

Phase I: This phase of the sampling allowed us to identify water quality problems and potential problem areas. The initial screening consisted of reviewing historical chemical and biological data, conducting field reconnaissance, and collecting field parameters, such as pH, conductivity, dissolved oxygen, temperature, and acidity. Field measurements were taken at the mouth of each of the major tributaries where AML is present (*i.e.* a total 7 tributaries) and then additional measurements were taken along the mainstem and at several tributaries within the sub-basins of Mud Fork, Little Leading Creek, Lasher Run, Titus Run, Paulins Run, and Thomas Fork to determine areas of potential concern.

Specific conductivity, pH, and temperature were measured with the Oakton pH/Con10 multi-probe. The probe was inserted into the stream in flowing water so that the end of the probe was completely immersed in the water and held until the onscreen display value remains constant. Dissolved oxygen concentration and dissolved oxygen saturation were measured with the YSI 55 DO probe. The probe was immersed into moving stream water and held until the display stabilizes. Meters and equipment were maintained and calibrated according to guidelines specified in the operations manuals. When measuring water quality in-stream below a seep or source of pollution, samples were taken at least 50 feet downstream of the confluence or in a mixed zone downstream of any riffles.

Acidity was determined using a HACH model AC-6 in-field titration kit. A plastic vial and square mixing bottle was rinsed with the stream water two to three times before titration. The vial was filled with ten milliliters of stream water and then transferred to the square mixing bottle. One drop of phenalphthalein indicator was added to the sample and swirled to mix. Then it was titrated using 0.035M NaOH, which 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 NaOH and remains pink after mixing, the number of drops added to the sample was recorded. The total number of drops of NaOH added to the solution was multiplied by 20 to determine the concentration of acid in milligrams per liter.

Phase II: This phase of the sampling allowed us to describe the tributaries that exhibited AMD characteristics. AMD impacted sites were sampled in order to quantify the amount of AMD the tributary is contributing to the receiving stream. All phase II data was entered into a computer spreadsheet and sample sites were recorded on maps. Phase II data was used to determine potential treatment sites.

A qualitative description was recorded for each point source and water samples and discharge measurements were taken where possible. At each sampling site, a three to five gallon bucket was rinsed three times with stream water and then filled with stream water. All sample bottles were filled with water from the bucket. The samples were preserved with 5 milliliters 20% HNO_3. The acidified sample(s) was used to evaluate the concentration of manganese, iron and aluminum and hardness. The non-acidified sample was collected in a collapsible cube that was completely filled so that all oxygen was excluded. This non-acidified sample was evaluated for total acidity, total alkalinity, specific conductivity, total suspended solids, total dissolved solids and sulfates. Water was filtered only when it was turbid, thus avoiding the collection of colloidal particles and metals which may over estimate acidity and metals. At seep sites, an additional sample was collected for ferrous iron and preserved with 50% HCl. Ferric iron was then derived by subtracting the ferrous iron from the total iron. Water samples collected in the field for laboratory evaluation were preserved at 4 degrees Celsius during shipment to the Division of Mineral Resources Management laboratory in Cambridge, Ohio where they were analyzed.

Flow data were collected using a pygmy meter, preferentially in a "run" section of a stream where flow was smooth and fast, and the surface of the water is not visibly broken. During flow measurement, the stream was cross-sectioned and divided into intervals (20-25) of known areas of width and depth. Velocity measurements were collected for each interval and multiplied by the area of that interval to obtain a discharge measurement. The discharge rate for each site was defined as the sum of the discharge rates at each interval. A microsoft excel spreadsheet calculator was used to sum discharge rates.

In very shallow, fast moving streams or ditches, a flume was used to determine discharge rate. Flows in small tributaries were measured using either a 2-inch or 8-inch Baski Cutthroat Flume. The flume measurement was conducted by: 1. finding an area where all flow of the stream could be diverted through the flume neck 2. setting the flume firmly on the stream bottom 3. extending the wings out as fully as possible 4. confirming the flume was level from side to side and front to back 5. sealing the back of wings, front edge of the flume neck and wings with substrate material (preferably clay). The data was recorded on field measurement sheets, then also recorded in Microsoft excel spreadsheets.

Flows which were too small or too slow to utilize a flume, were measured using a pipe and bucket technique. This method was performed by damming the tributary and allowing the water to flow through a pipe. A stop watch was used to measure time as the water was captured from the pipe into a bucket. This process was repeated three times and the amount of water captured over the chosen time interval was averaged and a flow (gpm) was then derived. Where applicable, an existing culvert was utilized in place of using a temporary pipe set-up. The process for flow measurement is same as with the pipe.

Phase III: This phase of the sampling allowed us to identify and characterize AMD point sources in the tributaries studied during phase I and phase II. Water samples and flow rates were determined as described in the phase II section.

Naming System: The codes for each of the monitoring sites were modeled after methods described by Scott Miller for Monday Creek in "Acid Mine Drainage Abatement and Treatment (AMDAT) Plans" (Borch, 2003). This naming convention was used to define all monitoring locations along with river miles and GPS coordinates.

SECTION NINE- References

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SECTION TEN- Appendices

Appendix A – Historical water Quality
Appendix B – Landowner information
Appendix C – Photographs
Appendix D – Site descriptions
Appendix E – ODNR-MRM listing of underdrains
Appendix F – Reclamation costs and calculations
Appendix G – Water quality data

Appendix A: Historical Water Quality

Station name	Data Source	date	Latitude	Longitude	Temp ©	DO mg/l	Flow gpm	Acidity mg/l	Alkalinity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	Zinc mg/l
LC nr M'port - Rt 7 bypass	STORET	7/24/1978	38-59-02	82-04-28	26.0		6283				163	2.45		7.20	521		0.03
LC nr M'port - Rt 7 bypass	STORET	10/1/1980	38-59-02	82-04-28	17.0	9.7	2424				192	0.40	0.73	7.20	627	113	0.03
LC nr M'port - Rt 7 bypass	STORET	3/25/1981	38-59-02	82-04-28	7.0	11.5					192	0.86	0.43	7.60			0.03
Bailey Run, above Gob	STORET	9/19/1979	39-01-45	82-05-06				618	10	36.00	963	19.00	11.10			266	0.66
Bailey Run, above Gob	STORET	10/25/1979	39-01-45	82-05-06				198	10	28.00	842	20.00	8.60			840	0.53
Bailey Run, above Gob	STORET	11/7/1979	39-01-45	82-05-06				10	39	0.20	111	0.43	0.07	7.30	382	58	0.03
Bailey Run, below Gob	STORET	9/19/1979	39-02-14	82-05-00				224	10	27.00	1170	21.50	9.20			250	0.53
Bailey Run, below Gob	STORET	10/25/1979	39-02-14	82-05-00				148	10	0.20	1130	17.50	6.95			620	0.40
Bailey Run, below Gob	STORET	11/7/1979	39-02-14	82-05-00				10	43	0.20	149	0.05	0.03	7.50	601	58	0.03
LC W of Rutland, Twp rd 41	STORET	7/20/1990	39-02-22	82-09-33	22.8	6.4			85	0.40	240	1.09	0.25	7.47		573	0.01
LC W of Rutland, Twp rd 41	STORET	8/1/1990	39-02-22	82-09-33	20.8	7.6			83	0.55	340	1.05	0.32	7.54	3350	1390	0.01
LC W of Rutland, Twp rd 41	STORET	8/15/1990	39-02-22	82-09-33	20.1	6.5			99	0.57	245	1.07	0.32	7.67	1950	789	0.26
LC W of Rutland, Twp rd 41	STORET	8/28/1990	39-02-22	82-09-33	23.6	5.5			84	0.31	224	1.33	0.26	7.35	1770	633	0.01
LC W of Rutland, Twp rd 41	STORET	9/5/1990	39-02-22	82-09-33	22.3				107	0.20	149	0.52	0.24	7.70	420	169	0.21
LC W of Rutland, Twp rd 41	STORET	10/10/1990	39-02-22	82-09-33	18.3	8.5			94	0.42	144	1.10	0.20	7.39	310	103	0.07
LC above confl w/ LLC	STORET	6/27/1980	39-01-32	82-08-16	21.0	7.9	1845							7.10			
LC above confl w/ LLC	STORET	8/9/1989	39-01-32	82-08-16			4468				189						0.01
LLC just south of Rutland	STORET	6/27/1980	39-01-55	82-07-58	19.0	5.2	232							7.00			
LLC just south of Rutland	STORET	6/27/1980	39-01-55	82-07-58	28.0	17.8											
LLC just south of Rutland	STORET	6/27/1980	39-01-55	82-07-58	25.0	10.6	1898							7.50			
LLC @happy hollow	STORET	8/8/1989	39-03-00	82-07-36							195						0.01
LLC @ mouth - Rutland	STORET	8/9/1989	39-01-32	82-08-15							209						0.01
LC W of Rutland, Twp rd 41	STORET	1/11/1994	39-02-22	82-09-33	0.3	13.5			54	0.39	215	1.26	0.52	6.93	760	505	0.12
LC S of Rutland, C.R. 12	STORET	1/11/1994	39-00-46	82-08-17	1.8	13.6			48	0.47	231	1.00	0.65	8.90	900	556	0.35
LC SE of Dexter, Malloons rd	STORET	1/11/1994	39-03-43	82-11-59	0.3	13.5			57	0.38	180	0.94	0.41	7.03	1960	379	0.11
LC DST UPST RR/DST C.R.10	STORET	1/11/1994	39-04-58	82-12-51	0.2	13.7			59	0.34	111	0.73	0.22	6.80	360		0.11
Parker Run, sw of Dexter twp rd 18	STORET	1/11/1994	39-03-53	82-13-38	0.6	14.0			73	0.24	420	1.15	0.59	7.57	2800	1410	0.13
DEXTER RN NR DEXTER OH	USGS	5/25/1988			16.0	10.0		59		0.18		0.91	0.21	7.50	295	49	
DEXTER RN NR DEXTER OH	USGS	8/3/1989			17.0		1346	105		0.16		0.60	1.20	7.30	570	130	
E B THOMAS F NR POMEROY OH	USGS	4/25/1979			21.0		2379	41				1.80	1.90	6.60	700	260	
E B THOMAS F NR POMEROY OH	USGS	9/27/1979			17.0		2289	39				2.00	2.20	6.60	690	230	
E B THOMAS F NR POMEROY OH	USGS	3/25/1980			6.0		6283	56				2.90	1.20	7.00	500	165	
E B THOMAS F NR POMEROY OH	USGS	8/26/1980			22.0		1975	43				2.20	1.90	6.70	725	220	
LC NR MIDDLEPORT OH	USGS	7/2/1975			32.0	8.2	1346	116		0.30		0.61	0.55	7.00	645	110	
LC NR MIDDLEPORT OH	USGS	11/17/1975			8.5	10.6	6283	75		0.36		0.57	0.61	6.60	460	120	
Leading Creek at Carpenter OH	USGS	7/21/1987			27.0		31	155		0.51		1.10	0.62	7.60	490	52	
LC (12-10) AT MIDDLEPORT OH	USGS	9/25/1980			20.0	8.6	4219	66		1.46		0.90	1.20	7.20		183	

Appendix A: Historical Water Quality

Station name	Data Source	date	Latitude	Longitude	Temp ©	DO mg/l	Flow gpm	Acidity mg/l	Alkalinity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	Zinc mg/l
LC (12-10) AT MIDDLEPORT OH	USGS	4/8/1981			15.0		67320	55		1.10		1.44	0.38	7.50		134	
LC (12-10) AT MIDDLEPORT OH	USGS	7/28/1981			25.0	8.2	12566	13		0.02		0.17	3.36	6.50		285	
LC (12-10) AT MIDDLEPORT OH	USGS	8/24/1982			21.0			39						6.70		380	
Leading Creek below Carpenter OH	USGS	5/26/1988			12.5		763			0.02		1.30	0.49				
Leading Creek below Carpenter OH	USGS	8/3/1989			16.5					0.49		0.99	0.41				
Leading Creek below Carpenter OH	USGS	6/7/1990			18.0		1436			0.25		0.81	0.29				
Leading Creek below Carpenter OH	USGS	3/10/1991			20.7		76	274		0.14		0.79	0.69		623		
Leading Creek near Middleport OH	USGS	9/2/1966			22.2									6.30	657		
Leading Creek near Middleport OH	USGS	8/21/1967			21.1									4.70	867	406	
Leading Creek near Middleport OH	USGS	10/10/1968			13.0									6.90	483	162	
Leading Creek near Middleport OH	USGS	9/17/1969			20.0										540	118	
Leading Creek near Middleport OH	USGS	8/18/1971			20.5									7.10	521	110	
Leading Creek near Middleport OH	USGS	8/10/1972			18.0		898	75						7.60	512	120	
Leading Creek near Middleport OH	USGS	9/12/1973			15.5		942	48						6.80	657	190	
Leading Creek near Middleport OH	USGS	9/12/1974			25.0	7.0	5834	74						7.80	460	100	
Leading Creek near Middleport OH	USGS	7/2/1975			32.0	8.2	1346	116		0.30		0.61	0.55	7.00	645	110	
Leading Creek near Middleport OH	USGS	11/17/1975			8.5	10.6	6283	75		0.30		0.57	0.61	6.60	460	120	
Leading Creek near Middleport OH	USGS	7/21/1987			23.5		274	118		0.36		0.37	0.81	7.80	1200	280	
Leading Creek near Middleport OH	USGS	10/27/1987			10.5		81	104		0.02		0.07	0.13	6.90	1400	310	
Leading Creek near Middleport OH	USGS	6/8/1988			18.5		763	101		0.09		0.17	0.27	7.80	700	150	
Leading Creek near Middleport OH	USGS	10/5/1988			14.0		31	113		0.19		0.34	0.18	7.70	890	110	
Leading Creek near Middleport OH	USGS	8/16/1989			20.5		25582			8.80		18.00	0.60	7.40	325	91	
Leading Creek near Middleport OH	USGS	12/4/1989			0.5		20196	75		0.36		0.58	0.63	7.70	1250	320	
Leading Creek near Middleport OH	USGS	8/31/1990			23.5		3366	88		0.10		0.35	0.22	7.70	1600	490	
Leading Creek near Middleport OH	USGS	6/13/1991			19.7		1077	112		0.09		0.15	0.41	7.70	1410	390	
Leading Creek near Middleport OH	USGS	8/27/1991			22.5		1257	77		0.06		0.19	0.95	7.20	3100	1100	
Leading Creek near Middleport OH	USGS	10/24/1991			16.5		898	105		0.23		0.23	2.40	7.40	5170	2100	
LC (12-2) NR LANGSVILLE OH	USGS	9/4/1980			22.5	6.9	4443	85						7.00			
LC (12-2) NR LANGSVILLE OH	USGS	5/8/1981			13.5	12.2	29172	76		1.00		1.96	0.21	7.70		97	
LC (12-2) NR LANGSVILLE OH	USGS	8/20/1981			18.0	8.7	853	82		0.41		0.58	0.48	6.60		315	
LC (12-2) NR LANGSVILLE OH	USGS	8/23/1982			21.5		1661	61						7.00	1420	350	
LC (12-2) NR LANGSVILLE OH	USGS	7/21/1987			24.5		148	110		0.49		0.76	0.45	7.70	1060	270	
LC (12-2) NR LANGSVILLE OH	USGS	10/8/1987			10.0		18	122		0.17		0.45	0.67	7.90	1850	550	
LC (12-2) NR LANGSVILLE OH	USGS	5/26/1988			16.0	9.1	7181	73		0.14		0.51	0.15	7.80	440	48	
LC (12-2) NR LANGSVILLE OH	USGS	8/3/1989			17.0	10.2	2693	96		0.28		0.83	0.79	7.70	3500	1500	
LEADING C (12-7) NR RUTLAND OH	USGS	9/3/1980			24.5	7.7	8078	79						7.20			
LEADING C (12-7) NR RUTLAND OH	USGS	4/8/1981			15.1		50714	59		1.20		2.10	1.04	7.70		85	

Appendix A: Historical Water Quality

Station name	Data Source	date	Latitude	Longitude	Temp ©	DO mg/l	Flow gpm	Acidity mg/l	Alkalinity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	Zinc mg/l
LEADING C (12-7) NR RUTLAND OH	USGS	8/20/1981			23.0	9.6	1391	79		0.46		0.46	0.57	6.50		220	
LEADING C (12-7) NR RUTLAND OH	USGS	7/28/1982			23.0	7.4	2917	98						7.50		200	
LEADING C NR RUTLAND OH	USGS	7/3/1975			24.0	8.1	1795	118		0.52		1.30	0.62	7.10	682	97	
LEADING C NR RUTLAND OH	USGS	11/17/1975			8.5	10.8	6732	75		0.39		0.87	0.56	6.60	460	110	
LEADING C NR RUTLAND OH	USGS	11/1/1991			11.0		494	137		0.05		0.61	6.40	7.20	6250	2700	
L LEADING C NR RUTLAND OH	USGS	4/26/1979			17.5		4937	36				0.69	0.94	6.80	565	230	
L LEADING C NR RUTLAND OH	USGS	9/10/1979			18.0		763	75				0.41	1.00	6.90	590	140	
L LEADING C NR RUTLAND OH	USGS	3/8/1980			7.0		141821	17				14.00	0.93	6.40	300	100	
L LEADING C NR RUTLAND OH	USGS	8/26/1980			23.0		3590	326				0.61	0.66	7.20	900	150	
L LEADING C NR RUTLAND OH	USGS	11/1/1991			10.0		67	104		0.03		0.08	0.18	7.40	765	210	
L LEADING C (12-6) AT RUTLAND OH	USGS	9/3/1980			26.5	7.7	808	75						7.20			
L LEADING C (12-6) AT RUTLAND OH	USGS	5/8/1981			11.5	10.4	7630	52		0.50		0.80	0.21	7.70		158	
L LEADING C (12-6) AT RUTLAND OH	USGS	7/22/1981			26.0	9.5	718	74		0.78		3.14	0.17	7.60		435	
L LEADING C (12-6) AT RUTLAND OH	USGS	8/23/1982			20.0		162	98						7.60		120	
L LEADING C (12-5) NR H'VILLE OH	USGS	9/30/1980			26.0	7.8	215	75						6.90			
L LEADING C (12-5) NR H'VILLE OH	USGS	5/7/1981			17.5	8.7	5386	59		1.00		2.50	0.65	7.70		115	
L LEADING C (12-5) NR H'VILLE OH	USGS	7/23/1981			17.0	9.3	67	87		0.08		0.13	0.32	6.90		112	
MUD F LEADING C NR DEXTER OH	USGS	4/26/1979			19.0		1930	76				0.85	0.29	7.60	470	160	
MUD F LEADING C NR DEXTER OH	USGS	5/4/1979					37699										
MUD F LEADING C NR DEXTER OH	USGS	5/4/1979					47124										
MUD F LEADING C NR DEXTER OH	USGS	5/4/1979					50714										
MUD F LEADING C NR DEXTER OH	USGS	5/5/1979					37699										
MUD F LEADING C NR DEXTER OH	USGS	10/31/1979			11.0		942	100				0.77	0.49	7.50	595	160	
MUD F LEADING C NR DEXTER OH	USGS	3/25/1980			6.0		7181	66				1.00	0.42	7.20	410	120	
MUD F LEADING C NR DEXTER OH	USGS	8/26/1980			21.5		1481	94				1.30	0.16	7.60	430	120	
MUD F (12-1) NR H'VILLE OH	USGS	9/30/1980			24.0	8.5	341	46						7.00			
MUD F (12-1) NR H'VILLE OH	USGS	5/7/1981			14.0	9.7	2693	48		1.10		1.67	1.74	7.40		181	
MUD F (12-1) NR H'VILLE OH	USGS	7/23/1981			21.5	9.0	130	30		0.08		0.17	2.80	6.50		210	
MUD F (12-1) NR H'VILLE OH	USGS	7/26/1982			30.5	7.7	36	49						7.20	685		
UNNAMED TR TO OGDEN RN NR CARP	USGS	5/25/1988			18.5	9.5	180	85		0.15		1.00	0.85	8.00	380	53	
UNNAMED TR TO OGDEN RN NR CARP	USGS	8/3/1989			17.0	5.4		111		0.35		0.78		7.30	400	61	
THOMAS F (12-9) NR MIDDLEPORT OH	USGS	9/3/1980			25.5	8.7	2244							4.00			
THOMAS F (12-9) NR MIDDLEPORT OH	USGS	5/8/1981			11.0	11.4	10771	14		5.10		7.20	2.17	6.20		258	
THOMAS F (12-9) NR MIDDLEPORT OH	USGS	7/22/1981			25.5	8.5	2020			11.00		1.58	5.58	3.90		520	
THOMAS F (12-9) NR MIDDLEPORT OH	USGS	7/27/1982			27.0	7.3	2020	0		9.80		1.90	5.58	3.90	1520	540	
THOMAS F NR MIDDLEPORT OH	USGS	7/2/1975			31.5	7.3	1346	1		15.00		1.60	6.80	3.50	1380	590	
THOMAS F NR MIDDLEPORT OH	USGS	11/17/1975			11.0	10.2	4353	1		1.10		6.60	4.00	4.10	820	360	

Appendix A: Historical Water Quality

Station name	Data Source	date	Latitude	Longitude	Temp ©	DO mg/l	Flow gpm	Acidity mg/l	Alkalinity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	Zinc mg/l
THOMAS F NR MIDDLEPORT OH	USGS	11/1/1991			9.5		539			18.00		2.10	8.10	3.50	1750	850	
THOMAS F (12-8) NR POMEROY OH	USGS	9/3/1980			25.0	8.7	1616							4.00			
THOMAS F (12-8) NR POMEROY OH	USGS	5/8/1981			10.0	11.8	8078	33		4.30		9.30	1.52	7.00		211	
THOMAS F (12-8) NR POMEROY OH	USGS	7/22/1981			24.5	8.8	1436			12.70		2.00	3.72	4.10		415	
THOMAS F (12-8) NR POMEROY OH	USGS	7/27/1982			28.0	7.5	1302	0				4.40	4.70	3.80	1410	580	
UNAM TRIB TO LC (12-3) NR RUTLAND	USGS	9/3/1980			25.5	7.4	67	102						7.10			
UNAM TRIB TO LC (12-3) NR RUTLAND	USGS	5/11/1981			14.5	9.5	2827	43		3.40		4.35	0.36	7.20		88	
UNAM TRIB TO LC (12-4) AT H'ville	USGS	9/3/1980			26.5	7.6	67	121						7.30			
UNAM TRIB TO LC (12-4) AT H'ville	USGS	5/7/1981			17.5	9.3	898	59		0.50		1.07	1.02	7.60		134	
UNAM TRIB TO LC (12-4) AT H'ville	USGS	7/23/1981			20.0	9.4	40	125		0.08		0.09	0.69	6.90		290	
UNAM TRIB TO LC (12-4) AT H'ville	USGS	7/20/1982			28.0	8.3	135	98						8.00	510	140	
UNNAMED TR TO OGDEN RN NR CARP	USGS	5/25/1988			18.5	9.5	180	85		0.15		1.00	0.85	8.00	380	53	
UNNAMED TR TO OGDEN RN NR CARP	USGS	8/3/1989			17.0	5.4		111		0.35		0.78		7.30	400	61	

Appendix B: Landowner Contact Information for Priority Tributaries

Site Name	Site ID	Landowners' contact information within the subwatershed: Name	Address	Phone	Notes
Unnamed tributary on Bailey Run Road	TF1502	Andy Grover	34150 Bailey Run Rd Pomeroy, Oh 45769	740-992-3010	headwaters
		Ronald and Brenda Arms	34231 Bailey Run Rd Pomeroy, Oh 45769	740-992-5520	
		Greg and Linda Grover	34215 Bailey Run Rd Pomeroy, Oh 45769	740-992-0632	
		Robert and Esther Venoy	34284 Bailey Run Rd Pomeroy, Oh 45769	740-992-5422	
		Lewis and Virginia Humphrey	39220 SR 143 Pomeroy, Oh 45769	740-992-3508	
Bailey Run	TF0402				
Hollow 4		Facemyer Lumnber Co.	31940 Bailey Run Pomeroy, Oh 45769	740-992-5965	
		Virgil Parsons	37670 SR 124 Pomeroy, Oh 45769	740-992-5626	
Hollow 2		Facemyer & Salmons	Box 227 Midleport, Oh. 45760	not available	
		Virgil Parsons	37670 SR 124 Pomeroy, Oh 45769	740-992-5626	
Tobin's		Robert and Sheri Tobin	32425 Bailey Run Rd Pomeroy, Oh 45769	740-992-3117	
		Harold & Penny Brinker	32714 Bailey Run Rd Pomeroy, Oh 45769	740-992-6305	may have to be on their land
Kinzel's seep	TF1202	Boyd & Audry Kinzel	39483 SR 143 Pomeroy, Oh 45769		head of seep
		Lydia & Thompson DeLong	39721 DeLong Rd Pomeroy, Oh 45769	740-992-5890	mouth of seep
Casto's	TF1102	Marie Myra Wears	39649 SR 143 Pomeroy, Oh 45769		
		Mildred Humphry	39711 SR143 Pomeroy, Oh 45769	740-992-3859	
		James & Melinda McClain	39641 SR 143 Pomeroy, Oh 45769	740-992-7722 or 740-992-2580	
Hysell Run	TF0302				
Hollow 13		Brian & Jacqueline Justice	33841 Hysell Pomeroy, Oh 45769	740-992-2927	
		Alma Peterson	33845 Burney Hollow Rd. Rutland, Oh. 45775	740-742-2918	
		James Fenton Taylor	34111 Hysell Run Rd Pomeroy, Oh 45769		
		Larry and Rita Ball	31491 Noble Summit Middleport, Oh 45760 (or) 29553 Sanford Davis Rd Langsville, Oh	740-992-0662	

Appendix B: Landowner Contact Information for Priority Tributaries

Site Name	Site ID	Landowners' contact information within the subwatershed: Name	Address	Phone	Notes
Hollow 11		Alma Peterson	33845 Burney Hollow Rd. Rutland, Oh. 45775	740-742-2918	
		Larry and Rita Ball	31491 Noble Summit Middleport, Oh 45760 (or) 29553 Sanford Davis Rd Langsville, Oh	740-992-0662	
		Betty Williams	33561 Hysell Run Pomeroy, Oh 45769	740-992-7821	Hollow #11 located behind Tim Hood's house
Hollow 8		Dwaine & Sonia Allen	33277 Hysell Run Pomeroy, Oh 45769	740-992-5275	
		John & Amanda Clonch	33425 Hysell Pomeroy, Oh 45769	740-992-1009	
		Thomas Myers	31471 SR 325 Langsville, Oh.	740-742-2153	
Hollow 6		Thomas Myers	31471 SR 325 Langsville, Oh.	740-742-2153	
		Timmy Hood	33011 Hysell Pomeroy, Oh 45769	740-992-1176	
		John Casto	33201 Hysell Pomeroy, Oh 45769		Hollow #6 located behind Hysell Holiness Church
Mainstem source	TF030200	Anita and Mohammad (Moe) Hajivandi	37817 State Route 214 Pomeroy, Oh 45769	740-992-2615	
Titus Run Hollow One	TRH0002	Samuel Wamsley	35737 Titus Rd Middleport, Oh 45760	740-742-2872	
		Dale Ellis	35553 Titus Rd Rutland, Oh 45775	740-742-2686	
		Ann Dater Trustee	Morton I. Rosenbaum 711 Graynne Bldg. 602 Main St. Cincinnati, Ohio 45202 (or) J. Crain Norther Trust Bank 1100 E. Las Olas Blvd Ft. Lauderdale, Fl 33301		
		David Carson & Dixie Sayer	9110 Patty Pllace FT Wayne, In 46804		
		Mary Carson	3895 Sierra Drive Barnhart, Mo. 63012		
Dunst's Hollow	PH0100	Jimmy Griffith	30031 Twp.Rd 351 Middleport, Oh 45760	740-742-0528	
		George Wright	259 Union Ave Pomeroy, Oh 45769	740-992-2439	
		Charles Gardener- Lisa Dunst	30054 Paulins Hill Rd		
	Galia Cty Cheshire twp. Sect11				
Long's Hollow	PH0200 Gallia Cty Cheshire twp. Sect11	Tom Long	1153 Paulins Hill Rd Chesher Twp, Oh 45620	740-367-7191	
		Bonnie Baird			
		Susan Gormley			
		J&M Land Ltd			
		Frank Hearld Jr.	36394 Leading Cr Rd Middleport, Oh 45760	740-742-2994	

Appendix C. Photographs of Sampling Sites
Thomas Fork

TF 15: Confluence of the Unnamed Tributary on Bailey Run Road. with Thomas Fork
RM 7.4
Accessible from Bailey Run Road (Township Road 165)

Photo taken just upstream of TF 15 from standing below the bridge at Bailey Run Road (7-22-04)

TF 15: Confluence of the Unnamed Tributary on Bailey Run Road with Thomas Fork
RM 7.4
Accessible from Bailey Run Road (Township Road 165).

Photo taken from just downstream confluence TF 15, facing Bailey Run Road Bridge (upstream). The water upstream of TF 15 has populations of fish and good water quality. (8-6-04)

TF 15: Confluence of the Unnamed Tributary on Bailey Run Road. with Thomas Fork RM 7.4
Accessible from Bailey Run Road (Township Road 165).

Photo taken from standing on the bridge on Bailey Run Rd.
(4-2-04)

TF 1502: Unnamed Tributary on Bailey Run Road. Drains to Thomas Fork at RM 7.4
Accessible from Bailey Run Road (Township Road 165) .

Photo taken between Seep 1 and Mouth of TF 15, just upstream of bridge.
(8-6-04)

TF 1502: Unnamed Tributary on Bailey Run Road. Drains to Thomas Fork at RM 7.4
Accessible from Bailey Run Road (Township Road 165) .

Photo taken between Seep 1 and Mouth of TF 15, just upstream of bridge.
(4-2-04)

TF 0070: Downstream of TF 15 confluence
RM 7.4
Accessible from Bailey Run Road

Photo taken just downstream of TF 15. No fish ever noticed, poor water quality.
(7-22-04)

TF 15 Seep 1: Seep which combines with pipe 1, drains into the Unnamed Tributary on Bailey Run Road
Accessible by entrance through gates and up hill, just upstream of the first bridge on Bailey Run Road (Township Road 165).

Photo taken near the top of the hill at the base of the highwall
(8-23-04)

TF 15 Seep 1: First seep that enters the Unnamed Tributary on Bailey Run Road.
Accessible from parking at first gate past first bridge on Bailey Run Road (Township Road 165).

(4-21-03)

Pipe 1: Drains into the Unnamed Tributary on Bailey Run Road
Accessible by entrance through gates and up hill, just upstream of the first bridge on Bailey Run Road (Township Road 165).

Photo taken just below highwall at first pipe
(8-23-04)

TF 15: Mainstem of the Unnamed Tributary on Bailey Run Road (Township Road 165), just upstream of Seep 3.
Accessible from Bailey Run Road.

(4-21-03)

TF 11: Casto's mainstem, drains to Thomas Fork at
RM 5.9
Accessible from Old Landfill Road

Photo taken near the mouth (State Route 143 in view)
(7-22-04)

TF 1100-1 First Tributary to Casto's.
Accessible on foot, through private property, by following the tributary upstream past last trailer on Old Landfill Road.

Thomas Fork Mainstem, just upstream of the Hillside Baptist Church
RM 5.75
Accessible from SR 143, bridge to Baptist Church

(8-6-04)

TF0050: Thomas Fork between confluence of East Branch and State Route 7.
RM 5.5
Accessible by parking at pull-off along SR 143 and walking to bridge on State Route 7.

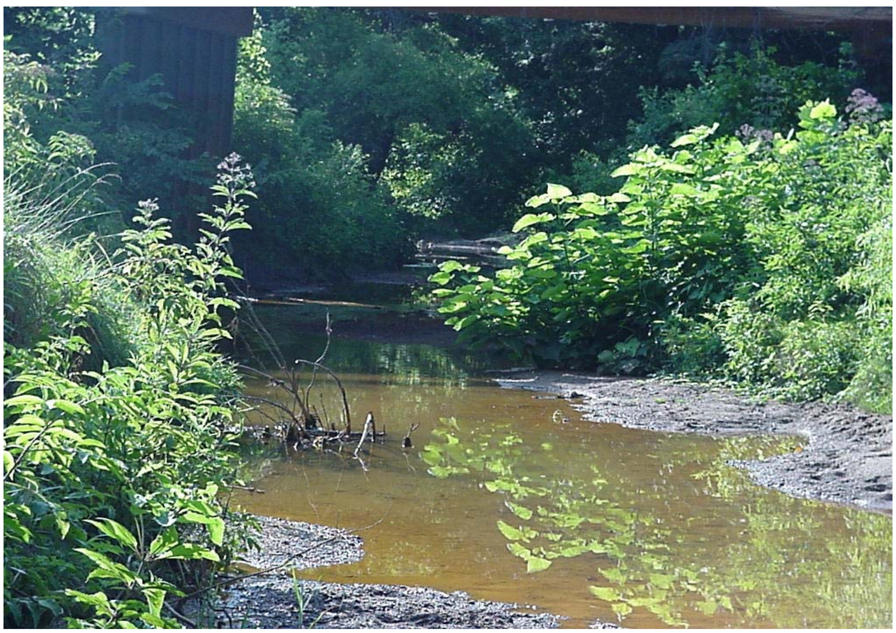

Photo taken facing downstream from between State Route 7 and the confluence of TF10- East Branch
(7-22-04)

TF0015: Thomas Fork upstream of the Unnamed Tributary on McElhinney Hill
RM 2.8
Accessible from Noble Summit Road (Township Road 174)

(8-6-04)

TF0015: Thomas Fork downstream of the Unnamed Tributary on McElhinney Hill
RM 2.8
Accessible from Noble Summit Road (Township Road 174)

(8-6-04)

TF0010: Thomas Fork near the mouth
RM1.2
Accessible from first bridge North of State Route 7 on Leading Creek Road (County Road 3)

Photo taken from downstream of the Leading Creek Road Bridge (County Road 3), facing downstream.
(8-25-04)

TF0010: Thomas Fork near the mouth
RM1.2
Accessible from first bridge North of SR 7 on Leading Creek Road (County Road 3)

Photo taken from under the Leading Creek Rd Bridge, facing downstream.
(6-10-03)

Little Leading Creek

Little Leading at New Lima Road (County Road 3)
RM 4.9
Accessible by parking at the Meigs County Soil and Water Conservation District Farm, just downstream from the bridge.

Photo taken from under the bridge of New Lima Road. Creek has a very sandy bottom. (8-25-04)

The 14th tributary of Little Leading Creek
Confluence RM 6.2
Accessible from McCumber Hill (County Road 4)

(7-15-03)

Appendix D: Site Locations

LC ID#	River Mile	Site Location	Parameter	Latitude	Longitude	Notes
LC0030	10.3	RM 10.3 Parkinson Rd. bridge	PI	39 02 21.9	82 09 32.4	
LC0020	6.0	Wells Rd.	PI	39 00 20.3	82 07 17.0	
LC0011	3.5	Leading Creek below sunbarn	F	39 00 31.4	82 05 07.0	
MF0050	0.8	Mud Fork- Cotterill Rd	S, N, F	39 07 6.0	82 11 28.5	
MF0002	0.1	Bridge on Cnty Rd 10	N	39 06 22.5	82 13 9.5	
GR0005		Grass Run	N	39 05 11.0	82 12 0.8	
LR0003		100' DS of bridge on Lasher Rd.	PI, S	39 01 43.9	82 08 54.4	
LR0030		Lasher Run- intersection of Swick and Lasher	N, F	39 01 16.6	82 09 17.0	
LL0002	0.4	Bridge on Higley Rd.	PI, N, F	39 01 51.9	82 08 12.3	
LL0004	1.4	L.Leading at Rutland Park	S	39 02 22.8	82 07 51.9	
LL0006	1.7	L. Leading at HS	F	39 02 31.4	82 08 01.9	
LL0010	2.6	L. Leading up- Happy Hollow	N	39 02 59.1	82 07 34.3	
LL0020	6.6	Bridge on County Rd 60	n	39 05 8.9	82 08 42.7	
LL0055	8.5	L. Leading Pauline's	S	39 06 30.7	82 07 55.7	
LL0060	9.4	Harrisonville	F	39 07 32.6	82 08 01.6	
LL0080	9.9	Bridge on Cty Rd 17	N	39 07 27.5	82 08 36.0	
LL1201		L. Leading trib	F	39 04 55.0	82 08 02.0	
TR0003		Approx 100' from Dale Ellis driveway on Titus Rd.	PI, N	39 00 41.0	82 08 33.8	
TR0100		Mouth of first tributary coming into Titus Run, "Ellis' hollow"	PII, PIII	39 00 38.5	82 09 34.7	MB
TRH0100		Mouth of first tributary coming into TRH00, "mud flat"	PIII	39 00 15.8	82 00 00.9	MB
TRH0100-1		Northeast branch of the first tributary, TRH01	PIII	39 00 19.9	82 09 04.5	SS
TRH0100-2		Southwest branch of the first tributary, TRH01	PIII	39 00 19.9	82 09 04.5	SS
TRH0200		Mouth of second tributary coming into TRH00, "wetland"	PIII	39 0012.5	82 09 02.4	MB
TRH0300		Mouth of third tributary coming into TRH00, "big hollow"	PIII	39 00 12.4	82 09 10.6	MB
TRH0300-1		Seep flowing into TRH03, flowing down from gob and pines	PIII	39 00 16.7	82 09 17.8	SS
TRH0300-2		Southwest headwater branch of the third tributary, TRH03	PIII	39 00 16.4	82 09 32.3	SS
TRH0300-3		Northeast headwater branch of the third tributary, TRH03	PIII	39 00 16.4	82 09 32.3	SS
TRH0400		Mouth of fourth tributary coming into TRH00, "beaver dam"	PIII	39 00 03.8	82 09 18.1	MB
TRH0500		Headwaters of TRH00, at culvert	PIII	39 00 04.2	82 09 13.1	MB
TR0005		Carson's field in between TR0003 and the bridge	S	39 00 42.2	82 08 41.3	
TR0300		Tributary to Titus Run that flows beside double wide (Kitchen's)	PII	39 00 43.7	82 09 25.9	MB
TR0400		Tributary to Titus Run that flows along Lasher Run Road	PII	39 00 49.0	82 09 27.8	MB
TR0500		Tributary to Titus Run that flows behind horse field "reference"	PII	39 00 45.9	82 09 41.7	MB
TR0090		Headwaters of Titus Run at the last culvert on Titus Run Rd	PII	39 01 05.5	82 11 05.9	MB
PT0010		Culvert of PH Road	PI	39 00 31.1	82 08 01.8	MB
PH0100		Behind Dunst's house, tributary 1 near the mouth	PIII	39 00 11.4	82 07 41.4	MB
PH0100-1		seep on right side walking upstr/ ~20 yards dstr of PH0100-2	PIII	39 00 01.6	82 07 30.6	SS
PH0100-2		small trib on right side as walking upstr, a branch of the HW	PIII	39 00 02.1	82 07 28.6	SS
PH0100-3		Furthest upstr (left side walking upstream), a branch of HW	PIII	39 00 02.1	82 07 28.6	SS
PH0200		Behind Long's house, tributary 2 near the mouth	PIII	39 00 06.6	82 07 53.8	MB
PH0200-1		The first seep coming in (rocklined channel)	PIII	39 00 07.8	82 08 00.6	SS
PH0200-2		Furthest upstream seep that could be sampled, very small flow	PIII	39 00 05.1	82 08 06.6	SS
PH0300		Hollow up from Long's, acrossed from trailor (Bradley's)	PIII	39 00 2.7	82 07 53.3	MB
PH0400		Hollow running adjacent to Schartiger. Large 2' drop at mth	PIII	39 59 52.7	82 07 59.3	MB
PH0500		Hollow across from Schartiger	PIII	38 59 54.1	82 08 0.4	MB
Seep Ditch		many seeps come into rd ditch, we collected them at culvert	PIII	38 59 46.1	82 08 5.8	MB
PH0090		Headwater of PH, just ds from wetland area	PIII	38 59 36.7	82 08 21.5	MB
TF0010	1.2	Thomas Fork at Leading Cr Road	PI, PII, N, F	39 00 17.0	82 04 25.0	
TF0015	2.8	Thomas Fork at Noble Summit Road	PII			

Appendix D: Site Locations

LC ID#	River Mile	Site Location	Parameter	Latitude	Longitude	Notes
TF0020	3.2	Downstream Bailey	PII	39 01 30.6	82 04 57.5	
TF0021	3.4	Upstream Bailey	PII	39 01 32.5	82 04 57.0	
TF0030	4.4	Bridge on SR 7 & SR 124 intersection	PII			
TF0048	5.5	MS 50' DS mouth of East Branch	PII	39 02 16.1	82 03 40.3	
TF0050	5.5	MS 50' US mouth of East Branch	PII, N	39 02 20.4	82 03 39.1	
TF0064	6.9	Downstream Ball Run	PII	39 03 25.3	82 03 31.2	
TF0070	7.4	MS 150' DS of Bailey Run Rd. bridge	PII	39 03 41.6	82 03 56.9	
TF0071	7.5	MS US of Bailey Run Rd. bridge	PII	39 03 42.2	82 03 59.4	
TF0090	10.1	Approx 30' DS of Smith Run Rd. bridge	N	39 05 14.9	82 05 36.6	
TF0100 or 05	1.3	Bone Hollow	PII	39 00 17.9	82 04 17.9	
TF0202	2.8	McElhinney Hill	PII	39 01 10.9	82 05 10.7	
TF0302	3.09/0.1	Hysell Run near mouth	PIII, PII, F	39 01 29.5	82 05 06.7	
TF0310	3.09/0.85	MS Hysell Run at first private drive after it crosses 124	PIII	39 01 42.4	82 05 43.9	MB
TF030300	3.09/1.18	Mouth of tributary coming in from broad open field	PIII	39 02 01.2	82 05 49.1	MB
TF030400	30.9/1.96	Mouth of tributary flowing along Jeffers Road	PIII	39 02 41.8	82 06 00.2	MB
TF0320	3.09/2.0	MS Hysell Run upstream from "Jeffers road trib"	PIII	39 02 42.2	82 05 57.7	MB
TF030600	3.09/2.19	Mouth of tributary flowing along the church	PIII	39 02 52.3	82 05 53.9	MB
TF030600-1		Mouth of first seep (from mth) coming into church seep (good flow)	PIII	39 02 52.9	82 06 05.4	SS
TF030600-2		Source of 2nd seep (from mth) coming into Allen's (good flow-auger)	PIII	39 02 53.7	82 06 06.9	SS
TF030600-HW		Headwaters of church seep	PIII	39 02 56.6	82 06 09.6	SS
TF030700	3.09/2.21	Mouth of tributary flowing from Smith's farm	PIII	39 02 52.4	82 05 51.1	MB
TF030800	3.09/2.33	Mouth of tributary flowing beside the Allen's	PIII	39 02 59.0	82 05 48.0	MB
TF030800-1		Source of first seep (from mth) coming into Allen's (feed by auger pits)	PIII	39 03 07.9	82 05 57.4	SS
TF030800-2		Source of 2nd seep coming into Allen's (good flow- auger)	PIII	39 03 04.8	82 06 04.5	SS
TF030800-3		North branch of HW coming into Allen's seep	PIII	39 03 09.1	82 06 07.8	SS
TF030800- HW		(South) Headwaters of tributary flowing into Allen's	PIII	39 03 06.1	82 06 06.8	SS
TF0330	3.09/2.4	MS Hysell Run at Herbal Life	PIII	39 03 00.9	82 05 44.7	MB
TF031100	3.09/2.71	Mouth of tributary flowing from Tim Hood's property ("Betty's")	PIII	39 03 19.0	82 05 42.6	MB
TF031100- HW		Headwaters of tributary flowing from Hood's property	PIII	39 03 26.9	82 06 07.4	SS
TF0340	3.09/2.90	MS Hysell Run at the bridge before Justice's	PIII	39 03 27.0	82 05 39.8	MB
TF031300	3.09/2.95	Tributary flowing beside the Justice's	PIII	39 03 30.4	82 05 46.0	MB
TF031400	3.09/3.25	Mouth of tributary flowing beside Rory Bartrum	PIII	39 03 42.6	82 05 43.4	MB
TF031500	3.09/3.34	Tributary flowing beside the Paterson's (brine complainer)	PIII	39 03 47.5	82 05 40.6	MB
TF0360	3.09/3.43	MS Hysell Run, headwater site above Musser bridge	PIII	39 03 52.0	82 05 42.0	MB
TF0402	3.3	Bailey Run near mouth	PIII, PII, F	39 01 35.2	82 04 56.6	
TF040200	3.32/0.4	Mouth of tributary coming from Facemyer's hollow	PIII	39 01 50.1	82 05 04.5	MB
TF040400	3.32/0.84	Mouth of tributary coming from "big hollow" (beside old house)	PIII	39 02 12.3	82 04 57.5	MB
TF0450	3.32/0.9	MS Bailey Run at bridge on road	PIII	39 02 15.8	82 04 59.1	MB
Tobin's	3.32/0.92	Mouth of small seep beside Tobin's	PIII	39 02 16.4	82 05 01.2	MB
TF040600	3.32/1.1	Mouth of tributary beside Brinker's (hollow behind logging)	PIII	39 02 24.0	82 05 02.7	MB
TF040700	3.32/1.2	Mouth of tributary (never walked)	PIII	39 02 30.0	82 05 01.8	MB
TF040800	3.32/1.21	Mouth	PIII	39 02 31.2	82 05 04.3	MB
TF040900	3.32/1.5	Mouth of tributary beside Thomas' pasture field	PIII	39 02 50.6	82 05 06.2	MB
TF041000	3.32/1.65	Mouth of tributary above pasture field	PIII	39 02 51.4	82 05 01.2	MB
TF041100	3.32/1.84	Mouth of tributary beside the church	PIII	39 03 04.5	82 05 01.5	MB
TF041200	3.32/1.98	Mouth of tributary beside trailers (sewage smell)	PIII	39 03 10.2	82 04 55.9	MB
TF0490	3.32/2.1	MS Bailey Run headwaters	PIII	39 03 17.0	82 04 54.0	MB

Appendix D: Site Locations

LC ID#	River Mile	Site Location	Parameter	Latitude	Longitude	Notes
SR124 pipe		Pipe located between Bailey Run and SR 7	PII	39 01 32.6	82 04 34.9	
TF1001	5.5	Mouth of East Branch	PII, N, F	39 02 20.9	82 03 37.2	
seep 1 DS EB	4.1	1st seep that crosses SR 7 DS of the East Branch	PII	39 02 11.3	82 03 44.7	
seep 2 DS EB	3.9	2nd seep that crosses SR 7 DS of the East Branch	PII	39 02 04.4	82 03 46.4	
TF1102	5.9	Approx 40' US on small trib below Casto's off SR 143	PII	39 02 45.6	82 03 53.4	
TF1100-1		1st seep (from mth). Small trib coming from behind trailor	PIII	39 02 45.2	82 04 17.5	SS
TF1100-2		2nd seep from mth. Colorful seep coming out of hillside	PIII	39 02 44.0	82 04 24.6	SS
TF1100-3		3rd seep coming in (from mouth)	PIII	39 02 49.2	82 04 34.9	SS
TF1180		Sample mainstem next to pits (diffuse seepage)	PIII	39 02 50.3	82 04 38.5	SS
TF1199		Water sample at waterfall. Flow collected before 1st big pool	PIII	39 02 52.4	82 04 41.1	SS
TF1202	6.2	Mouth of stream 50' US of Delong Rd. bridge	PII	39 02 57.8	82 03 43.9	
Venoy's	6.5	Pipe located behind Bob Venoy's	PII	39 03 11.8	82 03 42.1	
TF1300		Lee Rd. tributary	PII	39 03 11.4	82 03 33.9	
TF1400	7.0	Ball Run	PII	39 03 32.5	82 03 32.8	
TF1502	7.4	Approx 200' from intersection of SR 143 & Bailey Run Rd.	PII	39 03 43.5	82 03 59.4	
TF15 seep1		see map- estimated	PIII	39 03 39.6	82 04 02.1	
TF15 pipe1		see map- estimated	PIII	39 03 37.2	82 04 02.4	
TF15 pipe2		see map- estimated	PIII	39 03 37.5	82 04 10.2	
TF15 pipe3		see map- estimated	PIII	39 03 41.1	82 04 05.1	
TF15 seep2		see map- estimated	PIII	39 03 39.4	82 04 09.7	
TF15 seep3		see map- estimated	PIII	39 03 33.5	82 04 17.5	
TF15 seep4		see map- estimated	PIII	39 03 31.4	82 04 21.1	
TF15 pipe4		see map- estimated	PIII	39 03 33.0	82 04 28.2	
TF15 pipe5		see map- estimated	PIII	39 03 30.2	82 04 29.0	
TF15 pipe6		see map- estimated	PIII	39 03 32.6	82 04 34.2	
TF15 pipe7		see map- estimated	PIII	39 03 32.8	82 04 34.7	
Little's		Mouth of Seep located behind Goldie Little's	PII	39 03 50.6	82 04 07.3	
L seep1		Northern (uphill) seep located behind Goldie Little's	PIII	39 03 48.8	82 04 17.8	
L seep2		Southern (rock channel) seep located behind Goldie Little's	PIII	39 03 46.8	82 04 16.1	
TF1801		Wolfpen	N	39 04 31.1	82 04 39.1	
TF030200		Hysell Run mainstem deep mine source				
PH0095		Headwaters of Paulins Hill sampled from small wetland				
LC0024		Mainstem Leading Creek downstream Titus Run				
LC0020		Mainstem Leading Creek downstream Paulins Hill				
TF0017		Mainstem Thomas Fork upstream McElhinney Hill				
TF0015		Mainstem Thomas Fork downstream McElhinney Hill				
TF0030		Mainstem Thomas Fork at SR 7 and SR 124				
TF0058		Mainstem Thomas Fork upstream Casto's Tributary				
TF1504		Unnamed tributary mainstem upstream Seep #1 and Pipe #1				
TF1507		Unnamed tributary mainstem upstream Seep #3				
TF040408		Bailey Run Hollow #4 headwaters AMD pit				
Venoy mouth		Venoy discharge at the mouth sampled at the culvert				
TF0470		Bailey Run mainstem				
TF040406		Bailey Run Hollow #4 mainstem				
TF040410		Bailey Run Hollow #4 South Fork, good water				
TF040207		Bailey Run Hollow #2 headwaters mainstem Facemyer's property				

PI= Phase I AMDAT

MB= Mass Balance

SS= Seep Sampling

PII= Phase II AMDAT

PIII= Phase III AMDAT

S= Sediment

N= Nutrient

F= Fecal

Appendix E: Underdrain listing

Appendix E. Listing of outlet pipe locations of ODNR-MRM underdrains installed in the Leading Creek Watershed

Thomas Fork- Salisbury Township

Site Description	ODNR Project Name	Project Type	Year Installed	Coordinates Latitude Longitude
Unnamed Tributary on Bailey Run Road (see hand-drawn map)				
Pipe 1	Grover I	Strip Mine	1989	39 03 37.2 82 04 02.4 *
Pipe 2	Grover I	Strip Mine	1989	39 03 37.5 82 04 10.2 *
Pipe 3	Grover II	Strip Mine	2000	39 03 41.1 82 04 05.1 *
Pipe 4	Grover I	Strip Mine	1989	39 03 33.0 82 04 28.2 *
Pipe 5	Grover I	Strip Mine	1989	39 03 30.2 82 04 29.0 *
Pipe 6	Grover I	Strip Mine	1989	39 03 32.6 82 04 34.2 *
Pipe 7	Grover I	Strip Mine	1989	39 03 32.8 82 04 34.7 *
Little Property	Grover I	Strip Mine	1989	39 03 47.8 82 04 16.1
Fraction 24- Hillside across from Ball Run Humphrey Property	Roach Thompson	Strip Mine	1991	39 03 35 82 03 51
Fraction 24- Hillside across from Ball Run	Roach Thompson	Strip Mine	1991	39 03 31 82 03 39
Fraction 24 - West side of SR 143 Roach Property	Roach Thompson	Strip Mine	1991	39 03 24 82 03 44
Fraction 33 - West side of SR 143 Venoy Property	Roach Thompson - Reconstruction under Jones/Venoy	Strip Mine	2002	39 03 11.8 82 03 42.1
Fraction 33 - West side of SR 143 Spaun Property	Roach Thompson	Strip Mine	1991	39 03 15 82 03 42
Fraction 33 - West side of SR 143 Shank Property -1	Roach Thompson	Strip Mine	1991	39 03 14 82 03 45
Fraction 33 - West side of SR 143 Shank Property -2	Roach Thompson	Strip Mine	1991	39 03 14 82 03 46
Section 26 - East side of SR 143 Hillside Baptist Church	Acree Landslide - Emergency	Landslide	1992	39 02 32 82 03 40
Section 31, Bailey Run Road near SR 124 intersection	Neece	Landslide	1992	39 01 43.5 82 05 6.6
Section 31 - SR 124 Pipe 1 Underground Mine Drainage	Pickens	Landslide	1988	39 01 32.6 82 04 34.9
Section 31 - SR 124 Pipe 2 Underground Mine Drainage	Pickens	Landslide	1988	39 01 35 82 04 40
100 A 316 - Neece Road	SEO - Fry Site	Strip Mine	2004	39 00 52 82 04 58

Appendix E: Underdrain listing

Thomas Fork underdrains continued

Thomas Fork- Salisbury Township

Section 25 - West of SR 124/7 Pipe 1	Hoover Peacock	Strip Mine	1990	39 01 07 82 04 06
Section 25 - West of SR 124/7 Pipe 2	Hoover Peacock	Strip Mine	1990	39 00 57 82 04 06
100 A 304 - West of SR 124/7 Pipe 3	Hoover Peacock	Strip Mine	1990	39 00 50 82 04 06
100 A 305/306 - East of SR 124/7 Pipe 1	Hoover Peacock	Strip Mine	1990	39 00 46.8 82 03 57.7
100 A 305/306 - East of SR 124/7 Pipe 2	Hoover Peacock	Strip Mine	1990	39 00 49 82 03 53
100 A 305/306 - East of SR 124/7 Pipe 3	Hoover Peacock	Strip Mine	1990	39 00 48 82 03 54
100 A 315 - Across from Millie's Underground Mine Drainage	Bradbury Road Seep	Seepage	1995	39 00 44.2 82 04 19.6 *

* Coordinates field checked with GARMIN Etrex GPS unit. Remaining coordinates derived from topographical maps (NAD27).

East Branch of Thomas Fork- Salisbury Township

Section 26 - Series of mine drains	Meigs Underground #1 Johnson Site	Gob Pile/ Seepage	1987	39 02 37.5 82 03 27.3
South side of Long Long Hollow Road near Route 33	Morris Seep	Seepage	1988	39 04 23 82 01 15
Section 17 - Between Blake Hill Road and Route 33, Underground Mine Drainage	Morris Seep	Seepage	1988	39 04 29 82 01 11
West side of Willow Creek Road	Willow Creek Road	Seepage	1985	39 03 26 82 01 48

Other underdrain sites in Leading Creek

Site Description	**ODNR Project Name**	**Project Type**	**Year Installed**	**Coordinates Latitude Longitude**
Grass Run				
Section 29, Rutland Township	Rutland 2	Strip mine	1988	39 05 6.8 82 10 21.8
Section 29, Rutland Township	Rutland 2	Strip mine	1988	39 05 10.6 82 10 20.9
Mud Fork				
Section 25, Scipio Township	Rutland 3	Strip Mine	1989	39 06 56.1 82 10 22.5

Paulins Hill - Cheshire Township, Gallia County

Pipe 1	Paulins Hill Road	Strip Mine	1989/1990	39 0 14.4 82 7 59.6
Pipe 2	Paulins Hill Road	Strip Mine	1989/1990	39 0 12.7 82 8 3.9
Pipe 3	Paulins Hill Road	Strip Mine	1989/1990	39 0 8.3 82 8 80
Pipe 4	Paulins Hill Road	Strip Mine	1989/1990	39 0 6.0 82 8 13.7
Pipe 5	Paulins Hill Road	Strip Mine	1989/1990	39 0 4.8 82 8 14.0

Site Description	ODNR Project Name	Project Type	Year Installed	Coordinates Latitude Longitude
Little Leading Creek - Rutland Township				
Fraction 18	Rutland 1	Strip Mine	1985	39 03 45.7 82 09 23.4
Fraction 30	Rutland 1	Strip Mine	1985	39 03 35.4 82 09 26.6
Fraction 30	Rutland 1	Strip Mine	1985	39 03 36.3 82 09 22.1
Fraction 30	Rutland1	Strip Mine	1985	39 03 32.8 82 09 15.7
Fraction 30	Rutland1	Strip Mine	1985	39 03 36.8 82 09 9.3
Fraction 30	Rutland 1	Strip Mine	1985	39 03 21.4 82 09 9.3
Fraction 30	Rutland 1	Strip Mine	1985	39 03 22.3 82 09 16.9
Fraction 30	Rutland 1	Strip Mine	1985	39 03 19.2 82 09 20.6
Fraction 36	Rutland 1	Strip Mine	1985	39 03 36.3 82 08 34.2
Fraction 36	Rutland 1	Strip Mine	1985	39 03 34.2 82 08 24.7
Fraction 6	Rutland 1	Strip Mine	1985	39 03 35.5 82 08 19.4
Fraction 6	Rutland 1	Strip Mine	1985	39 03 20.6 82 08 20.2
Fraction 6	Rutland 1	Strip Mine	1985	39 03 18.6 82 08 13.1
Fraction 6	Rutland 1	Strip Mine	1985	39 03 21.6 82 08 9.1
Fraction 6	Rutland 1	Strip Mine	1985	39 03 17.9 82 08 6.2
Fraction 1	Rutland 1	Strip Mine	1985	39 03 6.3 82 07 55.4
Section 31	Rutland 1	Strip Mine	1985	39 02 42.5 82 09 3.0
Fraction 12	Rutland 1	Strip Mine	1985	39 03 44 82 07 30.0
Fraction 2	Rutland 1	Strip Mine	1985	39 03 31.2 82 07 31.5
Section 29	Rutland 2	Strip Mine	1988	39 05 38.7 82 10 26.6
Section 29	Rutland 2	Strip Mine	1988	39 05 36.0 82 10 29.0
Section 29	Rutland 2	Strip Mine	1988	39 05 30.7 82 10 27.4
Section 29	Rutland 2	Strip Mine	1988	39 05 29.1 82 10 23.5
Section 29	Rutland 2	Strip Mine	1988	39 05 27.6 82 10 17.0
Section 29	Rutland 2	Strip Mine	1988	39 05 19.1 82 10 13.1
Section 29	Rutland 2	Strip Mine	1988	39 05 7.9 82 10 11.6
Section 29	Rutland 2	Strip Mine	1988	39 05 8.4 82 10 6.8
Section 23	Rutland 2	Strip Mine	1988	39 05 19.5 82 09 34.8
Section 23	Rutland 2	Strip Mine	1988	39 05 20.8 82 09 31.0
Section 23	Rutland 2	Strip Mine	1988	39 04 44.4 82 09 50.2
Section 23	Rutland 2	Strip Mine	1988	39 04 39.7 82 09 56.4
Fraction 17	Rutland 2	Strip Mine	1988	39 04 17.8 82 09 58.2
Fraction 17	Rutland 2	Strip Mine	1988	39 04 14.8 82 09 55.3
Scipio Township				
Fraction 18 and 30	Little Leading II	Strip Mine	1986	Requires field check
Section 16	Mudfork	Strip Mine	1991	Requires field check
Section 19	Rutland 3	Strip Mine	1989	39 06 59.4 82 09 39.1
Section 19	Rutland 3	Strip Mine	1989	39 07 8.1 82 09 22.1

Appendix F: Estimated reclamation costs

Table #1
Site: TF1502 Doser Piping from Seep 3
Treatment: Pipe water from Seep 3 to Doser
Scope: Catch the water coming from Seep 3 and pipe to doser
Low flow: 3.4 gpm

Budget category	Item	Cost
Site preparation		
	Clear and grubbing	160
	Silt fence	600
Site construction		
	Drain-tile	25
	Trench	240
	Gravel backfill	356
	8" sch. 40 pipe	300
	Labor	80
	Misc. fittings	500
Site reclamation		
	Re-veg	600
	Lime	40
	Fertilizer	100
	Mowing	100
Sub Total		3101 go to Table #3

Table #2
Site: TF1502 Doser Piping from Pipe 2
Treatment: Pipe water from Pipe 2 to Doser
Scope: Intercept flow from Pipe 2 and pipe to doser site
Low flow: 2.5 gpm

Budget category	Item	Cost
Site preparation		
	Clear and grubbing	800
	Silt fence	1050
	Off-site disposal	3000
Site construction		
	Trench	2000
	Pipe	645
	Labor	600
	Misc. fittings	500
Site reclamation		
	Re-veg	300
	Lime	20
	Fertilizer	50
	Mowing	50
Sub Total		9015 go to Table #3

Table #3
Site: TF1502 Doser
Treatment: Doser near Seep 3
Scope: Install Doser with 50-ton silo. Use costs from Essex doser that apply, inflated from 2005 costs to 2006 by 3.5%

Budget category	**Item**	**Cost**	**Ten year cost (3.5% inflation ea. yr)**
Site preparation			
	Testing	5000	
	Clear and grubbing	4000	
	Maintain traffic	3000	
	Silt fence	1225	
	Off-site disposal	12450	
	Surveying	3000	
	Subtotal	**$28,675**	
Material	Calcium Oxide pebble 0.075/lb	**$28,317**	**$332,198**
Doser	Aquafix Silo 50 ton	**$142,000**	
Maintenance	4hrs. weekly at $12.50 plus travel	**$5,000**	**$58,657**
Site construction			
	Earthwork	3000	
	Type C rock	900	
	Channel lining	7750	
	Filter fabric	2265	
	Drainage system	3200	
	#1&2's rock	8375	
	Re-soil	1025	
	Off-site borrow	1680	
	Subtotal	**$28,195**	
Piping of water	See costs Table #1 and #2	**$12,116**	
Site reclamation			
	Re-veg	275	
	Lime	180	
	Fertilizer	200	
	Mowing	100	
	Concrete	16000	
	Aggregate	8235	
	Misc	8800	
	Subtotal	**$33,790**	
SubTotal		**$278,093**	
Mobilization	**8%**	**$22,247**	
		$300,340	
Contingencies	**10%**	**$30,034**	
Total		**$330,374**	**$657,912**

Table #4
Site: TF15 SLB at mouth
Treatment: Provide alkalinity through the use of steel slag leach beds in fresh water.
Scope: Install steel slag beds at the mouth of tributaries TF15. Designed for a five year lifetime the leach bed system requires the following size: TF15 62,500 cubic ft (4 x 125 x 125).
Estimated amount of alkalinity generated: TF15 856 lbs/day.
Average flow: Average flow needed is 147 gpm. Average flow measured at site TF0071 is 205 gpm however at low flow only 5 gpm was measured.

Budget category	Item	Cost TF15
Access road preparation		
	Clearing and grubbing	640
	Silt fence	450
	Off-site disposal	1388.89
	Culvert	600
	Stone	555.56
	Reclaim stone	694.44
Site construction		
	Clearing and grubbing	800
	Off-site disposal earthwork	5601.85
	Silt fence	450
	Leach bed	6944.44
	Drain	1660
	Steel slag material	101,250
	Fresh water piping	5235.56
Site reclamation		
	Revegetation	231.95
	Lime	15.46
	Maintenance Fertilizer	38.65
	Mowing	38.65
Sub Total		**126,595.48**
Mobilization	**8%**	**10,127.64**
Contingencies	**10%**	**13,672.31**
Total		**150,395.43**

Site: Mouth of TF15 at field on north side of tributary Steel slag bed	-1/8 EAF slag			
INPUT:	5 years	1.6 years		
inflow	142.7	142.7	gpm	average flow needed to siphon from mainstem to generate the needed alkalinity to buffer the acid load at the mouth
depth	6.4	4.0	ft	
design factor	1	1		recommended by Mitch Farley
DISCHARGE TO BE TREATED:				
acidity	506	506	mg/l	average acidity at TF1502
flow	141	141	gpm	average discharge at TF1502
acid load	856.2	856.2	lbs/day	average load at TF1502
acid load	157.0	157.0	tpy	
OUTPUT:				
infiltration rate	0.015	0.029	gpm/sq. ft.	
required surface area	9694.4	4969.1	sq ft	0.22 ac. needed to design for five years
side length	98.5	70.5	ft	
resulting alkalinity	500	500	mg/l	
alkaline load generation	856.2	856.2	lbs/day	
alkaline load generation	156.97	156.97	tpy	
required slag	3375.2	1073.3	tons	
life	5.0	1.6	years	Mitch recommended designing for 5 yrs.
	62044	19876.4	cubic feet	

Table #5
Site: TF1502 Seep 1/Pipe 1
Treatment: Provide alkalinity through the use of limestone.
Scope: Extend existing limestone channel approximately 300 linear feet and install 6 "J" trench dams within the channel.
Average flow: 8.7 gpm

Budget category	**Item**	**Cost**
Site preparation		
	Clearing and grubbing	1280
	Silt fence	450
	Off-site disposal	10000
Site construction		
	Channel Excavation	850
	Off-site disposal earthwork	14167
	Limestone (bedding, #1/#2, Type D riprap)	16675
	6 "J" Trenches	2100
Site reclamation		
	Revegetation	300
	Lime	20
	Maintenance Fertilizer	50
	Mowing	50
Sub Total		**$45,942**
Mobilization	**8%**	**$3,675**
Contingencies	**10%**	**$4,962**
Total		**$54,579**

Site: TF15 Pipe1/Seep1

Open Limestone Channel **Fixed length**

RBOLD			COMMENTS
INPUT	VALUE	UNITS	
original acidity	5,630.5	PPM	average acidity at pipe 1
flow	4.6	GPM	average flow at pipe 1
	0.010	CFS	
saturated cross section	0.8	SQ. FT.	
saturated thickness	0.5	FT.	
bed thickness	1.5	FT.	
width	1.5	FT.	
void ratio	50.0	%	
length	300.0	FT.	restricted to 300 ft
cost of limestone/placement	30.0	$/TON	
excavation cost	3.0	$/cu yd.	
design factor	5.0		
RESULTS			
velocity	0.0	FT./SEC.	
residence time	3.0	HOURS	
acidity final	1,382.6		there will still be remaining acidity
acid load original	57.0	TONS/YEAR	
acid load final	14.0	TONS/YEAR	
acid load reduction	75.4	%	
limestone required	28.5	TONS	
excavated volume	41.7	cu yd.	
limestone consumption rate	43.0	TONS/YEAR	
life of drain	0.7	YEARS	short lifetime
cost of limestone/placement	855.6		
cost of excavation	125.0		
Total cost of OLC	980.6		

Table #6
Site: TF1502 Seep 3
Treatment: Provide alkalinity through the use of limestone.
Scope: Extend existing limestone channel approximately 300 linear feet and install 6 “J” trench dams within the channel.
Low flow: 7.6 gpm

Budget category	**Item**	**Cost**
Site preparation		
	Clearing and grubbing	1280
	Silt fence	450
	Off-site disposal	10000
Site construction		
	Channel Excavation	850
	Off-site disposal earthwork	14167
	Limestone (bedding, #1/#2, Type D riprap)	16675
	6 “J” Trenches	2100
Site reclamation		
	Revegetation	300
	Lime	20
	Maintenance Fertilizer	50
	Mowing	50
Sub Total		**45942**
Mobilization	**8%**	**3675**
Contingencies	**10%**	**4962**
Total		**54579**

Site: TF15 Seep 3

Open Limestone Channel **Fixed length**

RBOLD			COMMENTS
INPUT	VALUE	UNITS	
original acidity	1,050.0	PPM	average acidity at seep 3
flow	7.6	GPM	average flow at seep 3
	0.017	CFS	
saturated cross section	0.8	SQ. FT.	
saturated thickness	0.5	FT.	
bed thickness	1.5	FT.	
width	1.5	FT.	
void ratio	50.0	%	
length	300.0	FT.	restricted to 300 ft
cost of limestone/placement	30.0	$/TON	
excavation cost	3.0	$/cu yd.	
design factor	5.0		
RESULTS			
velocity	0.0	FT./SEC.	
residence time	1.8	HOURS	
acidity final	448.8		there will still be remaining acidity
acid load original	17.6	TONS/YEAR	
acid load final	7.5	TONS/YEAR	
acid load reduction	57.3	%	
limestone required	28.5	TONS	
excavated volume	41.7	cu yd.	
limestone consumption rate	10.1	TONS/YEAR	
life of drain	2.8	YEARS	
cost of limestone/placement	855.6		
cost of excavation	125.0		
Total cost of OLC	980.6		

Table #7
Site: TF1102 Casto Phase 1, Sites 1100-1 and 1100-3
Treatment: Provide alkalinity through the use of limestone and reclaim 1 acre gob pile
Scope: Extend existing limestone channel approximately 300 linear feet and install 15 "J" trench dams within the channel. Regrade, resoil, and vegetate gob pile.
Flow: 4.6-16.5 gpm at 1100-1 and 4.6-9.0 gpm at 1100-3

Budget category	Item	1100-1 Costs	1100-3 Costs	Gob Pile Costs	Grand Total
Site preparation -					
Access Road	Clearing and grubbing	1600	4800	NA	6400
	Silt fence	1650	4200	NA	5850
	Temporary Culvert	600	600	NA	1200
	Stone Allowance	1875	5000	NA	6875
Site construction					
	Clearing and grubbing	1600	1600	0	3200
	Off-site disposal trees/brush	5000	5000	NA	10000
	Channel Excavation	850	850	NA	1700
	Limestone (bedding, #1/#2, Type D riprap)	16675	16675	NA	33350
	15 "J" Trenches	5250	5250	NA	10500
	Off-site disposal of trash	0	0	1000	1000
	Regrade gob pile	0	0	2420	2420
	Prelime regraded refuse	0	0	1600	1600
	Resoil gob with 1-foot borrow material	0	0	3227	3227
	Silt Fence	450	450	1500	2400
Site reclamation					
	Reclamation of Road	2344	0	0	2344
	Revegetation	523	960	1200	2683
	Lime	35	64	80	179
	Maintenance Fertilizer	87	160	200	447
	Mowing	87	160	200	447
Sub Total		**38626**	**45769**	**11427**	**95822**
Mobilization	**8%**	**3090**	**0**	**914**	**4004**
Contingencies	**10%**	**4172**	**4577**	**1234**	**9983**
Total		**45888**	**50346**	**13575**	**109809**

Site: TF1100-1 and TF1100-3 (Casto's tributary)

Open Limestone Channel   Fixed length

RBOLD	TF1100-1	TF1100-3	
INPUT	VALUE	VALUE	UNITS
original acidity	273.0	1,362.0	PPM
flow	10.5	4.5	GPM
	0.023	0.010	CFS
saturated cross section	0.8	0.8	SQ. FT.
saturated thickness	0.5	0.5	FT.
bed thickness	1.5	1.5	FT.
width	1.5	1.5	FT.
void ratio	50.0	50.0	%
length	300.0	300.0	FT.
cost of limestone/placement	30.0	25.0	$/TON
excavation cost	3.0	3.0	$/cu yd.
design factor	5.0	5.0	
RESULTS			
velocity	0.1	0.0	FT./SEC.
residence time	1.3	3.1	HOURS
acidity final	147.6	326.2	
acid load original	6.3	13.5	TONS/YEAR
acid load final	3.4	3.2	TONS/YEAR
acid load reduction	45.9	76.0	%
limestone required	28.5	28.5	TONS
excavated volume	41.7	41.7	cu yd.
limestone consumption rate	2.9	10.3	TONS/YEAR
life of drain	9.8	2.8	YEARS
cost of limestone/placement	855.6	713.0	
cost of excavation	125.0	125.0	
Total cost of OLC	980.6	838.0	

Table #8
Site: TF14 and TF13 SLB
Treatment: Provide alkalinity through the use of steel slag leach beds in fresh water.
Scope: Install steel slag beds at the mouth of each of the following tributaries TF14 and TF13.
Designed for a five year lifetime each leach bed system requires the following size: TF14 53,872 ft^3 and TF13 6,482 ft^3.
Estimated amount of alkalinity generated: TF14 1476 lbs/day and TF13 178 lbs/day.
Average flow: TF14 123 gpm and TF13 15 gpm

Budget category	Item	Cost TF14	Cost TF13
Access road preparation			
	Clearing and grubbing	1,600	1,600
	Silt fence	750	750
	Off-site disposal	2,314.81	2,314.81
	Culvert	600	600
	Stone	925.93	925.93
	Reclaim stone	1,157.41	1,157.41
Subtotal		**7,348**	**7,348**
Site construction			
	Clearing and grubbing	1280	640
	Off-site disposal earthwork	5,601.85	1,157.41
	Silt fence	450	300
	Leach bed	5,939.27	714.67
	Drain	1500	680
	Steel slag material	87,270	10,500
	Fresh water piping	3,095	3,095
Subtotal		**105,136**	**17,087**
Site reclamation			
	Revegetation	333.05	241.04
	Lime	22.2	16.06
	Maintenance Fertilizer	55.51	40.18
	Mowing	55.51	40.18
Subtotal		**466**	**337**
Sub Total		**112,951**	**24,773**
Mobilization	**8%**	**9,036**	**1,982**
Contingencies	**10%**	**12,198**	**2,675**
Total		**134,185**	**29,430**

Site: TF14, fresh water tributaries Steel slag bed	-1/8 EAF slag			
INPUT:				
inflow	123.0	123.0	gpm	based on ave. measured Q at TF 14
depth	6.4	4.0	ft	depth needed to design for 5 year lifetime
design factor	1	1		recommended by Mitch Farley
DISCHARGE TO BE TREATED:				
acidity	1242.2	1242.2	mg/l	Average Kinzel + Venoy's culvert (1-4-06)
flow	52.2	52.2	gpm	Average Kinzel + Venoy's culvert (1-4-06)
acid load	778.11	778.11	lbs/day	
acid load	142.65	142.65	tpy	
OUTPUT:				
infiltration rate	0.01	0.03	gpm/sq. ft.	
required surface area	8355.88	4283.11	sq ft	0.19 acres needed space to design for 5 yrs
side length	91.41	65.45	ft	
resulting alkalinity	1000.0	1000.0	mg/l	
alkaline load generation	1476.0	1476.0	lbs/day	1333 lbs/day excess to buffer other TF sources
alkaline load generation	270.60	270.60	tpy	
required slag	2909.1	925.2	tons	
life	5.0	1.6	years	Mitch recommended designing for 5 yrs.
	53477.6	17132.4	cubic feet	Total area needed in cubic feet

Site: TF13, fresh water tributaries Steel slag bed	-1/8 EAF slag			
INPUT:	5 years	1.6 years		
inflow	14.8	14.8	gpm	based on ave. measured Q TF13
depth	6.4	4.0	ft	depth needed to design for 5 year lifetime
design factor	1	1		recommended by Mitch Farley
DISCHARGE TO BE TREATED:				
acidity	1242.2	1242.2	mg/l	Average Kinzel + Venoy's culvert (1-4-06)
flow	52.2	52.2	gpm	Average Kinzel + Venoy's culvert (1-4-06)
acid load	778.11	778.11	lbs/day	
acid load	142.65	142.65	tpy	
OUTPUT:				
infiltration rate	0.01	0.03	gpm/sq. ft.	
required surface area	1005.45	515.37	sq ft	0.02 acres needed space to design for 5 yrs
side length	31.71	22.70	ft	
resulting alkalinity	1000.0	1000.0	mg/l	
alkaline load generation	177.6	177.6	lbs/day	
alkaline load generation	32.56	32.56	tpy	
required slag	350.1	111.3	tons	
life	5.0	1.6	years	Mitch recommended designing for 5 yrs.
	6434.0	2061.0	cubic feet	Total area needed in cubic feet

Table #9

Site: TF040900 (alternative A) and TF0490 (alternative B) SLB

Treatment: Provide alkalinity through the use of steel slag leach beds in fresh water.
Scope: Install steel slag beds at either of the following tributaries TF040900 or TF0490. Both of these tributaries have the same drainage area and therefore would require the same size dimensions and produce the same amount of alkalinity. However TF040900 is chosen as the better alternative due to its close proximity to the acid sources. Designed for a five year lifetime requires the following size: 21,086 ft^3
Estimated amount of alkalinity generated: 588 lbs/day
Average flow: 49 gpm

Budget category	Item	Cost TF040900	Cost TF0490
Access road preparation			
	Clearing and grubbing	1,600	1,280
	Silt fence	900	600
	Off-site disposal	2,777.78	1,851.85
	Culvert	600	600
	Stone	1,111.11	740.74
	Reclaim stone	1,388.89	925.93
Site construction			
	Clearing and grubbing	800	800
	Off-site disposal earthwork	2,604.17	2,604.17
	Silt fence	300	300
	Leach bed	2,342.56	2,342.56
	Drain	1,030	1030
	Steel slag material	34,154	34,154
	Fresh water piping	5,430	5,430
Site reclamation			
	Revegetation	351.24	296.14
	Lime	23.41	19.74
	Maintenance Fertilizer	58.54	49.36
	Mowing	58.54	49.36
Sub Total		**55,530.76**	**53,074.37**
Mobilization	**8%**	**4,442.46**	**4,245.95**
Contingencies	**10%**	**5,997.32**	**5,732.03**
Total		**65,970.55**	**63,052.35**

Site: TF040900 Bailey Run
Steel slag bed -1/8 EAF slag

INPUT:	5 years	1.6 years			Conservative flow inflow would yield
inflow	49.0	49.0	gpm	Inflow based on 70 acre drainage area, however two flow events indicted: one flow measured 35.9 gpm while the other was dry in the summer 2005, extreme low flow, average 17.95 gpm	17.95
depth	6.4	4	ft	depth needed to design for 5 year lifetime	6.4
design factor	1	1		recommended by Mitch Farley	1
DISCHARGE TO BE TREATED:					
acidity	81	81	mg/l	ave. acidity at mouth of Bailey Run TF0402	81
flow	446.0	446.0	gpm	ave. flow at mouth of Bailey Run TF0402	446.0
acid load	433.51	433.51	lbs/day		433.51
acid load	79.48	79.48	tpy		79.48
OUTPUT:					
infiltration rate	0.0	0.0	gpm/sq. ft.		0.0
required surface area	3294.72	1706.28	sq ft	0.08 acres needed space to desing for 5 yrs	1206.94
side length	57.40	41.31	ft		34.74
resulting alkalinity	1000	1000	mg/l		1000
alkaline load generation	588.0	588.0	lbs/day	155 lbs/day excess alkalinity	215.4
alkaline load generation	107.8	107.8	tpy		39.5
required slag	1138.65	368.56	tons		417.12
life	5	1.6	years	Mitch recommended designing for 5 yrs.	5
	21086.2	6825.1	cubic feet	Total area needed in cubic feet	7724.43

Site: TF0490 Bailey Run
Steel slag bed -1/8 EAF slag

INPUT:	5 years	1.6 years			Conservative flow inflow would yield
inflow	49.0	49.0	gpm	Inflow based on 70 acre drainage area, however the average of two sampling events measured flow at 11.24 gpm	11.2
depth	6.4	4	ft	depth needed to design for 5 year lifetime	6.4
design factor	1	1		recommended by Mitch Farley	1
DISCHARGE TO BE TREATED:					
acidity	81	81	mg/l	ave. acidity at mouth of Bailey Run TF0402	81
flow	446.0	446.0	gpm	ave. flow at mouth of Bailey Run TF0402	446.0
acid load	433.51	433.51	lbs/day		433.51
acid load	79.48	79.48	tpy		79.48
OUTPUT:					
infiltration rate	0.0	0.0	gpm/sq. ft.		0.0
required surface area	3294.72	1706.28	sq ft	0.08 acres needed space to desing for 5 yrs	755.77
side length	57.40	41.31	ft		27.49
resulting alkalinity	1000	1000	mg/l		1000
alkaline load generation	588.0	588.0	lbs/day	155 lbs/day excess alkalinity	134.9
alkaline load generation	107.8	107.8	tpy		24.7
required slag	1138.65	368.56	tons		261.19
life	5	1.6	years	Mitch recommended designing for 5 yrs.	5
	21086.2	6825.1	cubic feet	Total area needed in cubic feet	4836.91

Table #10
Site: Bailey Run TF040400 and TF040600
Treatment: Provide alkalinity through the use of limestone
Scope: Install open limestone channel at both sites as well as "J" trench dams. At TF040400 install 2,500 linear feet of channel with 50 "J" trenches and at TF040600 1,150 linear feet of channel.
Average Flow: TF040400 90.1 gpm and TF040600 15.3 gpm

Budget category	**Item**	**TF040400 Costs**	**TF040600 Costs**
Site preparation -			
Access Road	Clearing and grubbing	6,400	4,800
	Off-site disposal	3,472.22	1,597.22
	Silt fence	3,000	2,400
	Temporary Culvert	600	600
	Stone Allowance	4,629.63	2,129.63
Site construction			
	Clearing and grubbing	0	0
	Off-site disposal trees/brush	13,287.04	6,112.04
	Ditch Excavation	15,944.44	7,334.44
	Limestone (bedding, #1/#2, Type D riprap)	49,810.18	22,912.68
	"J" Trenches	12,321.39	11,335.67
	Silt Fence	0	0
Site reclamation			
	Revegetation	516.53	237.60
	Lime	34.44	15.84
	Maintenance Fertilizer	86.09	39.60
	Mowing	86.09	39.60
Sub Total		**110,188.05**	**59,554.34**
Mobilization	**8%**	**8,815.04**	**4,764.35**
Contingencies	**10%**	**11,900.31**	**6,431.87**
Total		**130,903.40**	**70,750.56**

Site: TF040400 and TF040600 Bailey Run

Open Limestone Channel **Fixed length**

RBOLD	TF040400	TF040600		COMMENTS
INPUT	VALUE	VALUE	UNITS	
original acidity	201.5	94.3	PPM	average acidity at mouth of TF040400 and TF040600
flow	90.2	15.2	GPM	average flow at mouth of TF040400 and TF040600
	0.201	0.034	CFS	
saturated cross section	0.8	0.8	SQ. FT.	
saturated thickness	0.5	0.5	FT.	
bed thickness	1.5	1.5	FT.	
width	1.5	1.5	FT.	
void ratio	50.0	50.0	%	
length	2,500.0	1,150.0	FT.	
cost of limestone/placement	30.0	30.0	$/TON	
excavation cost	3.0	3.0	$/cu yd.	
design factor	5.0	5.0		
RESULTS				
velocity	0.5	0.1	FT./SEC.	
residence time	1.3	3.5	HOURS	
acidity final	110.9	18.5		
acid load original	40.0	3.2	TONS/YEAR	
acid load final	22.0	0.6	TONS/YEAR	
acid load reduction	45.0	80.4	%	
limestone required	237.7	109.3	TONS	
excavated volume	347.2	159.7	cu yd.	
limestone consumption rate	18.0	2.5	TONS/YEAR	
life of drain	13.2	43.1	YEARS	
cost of limestone/placement	7,129.7	3,279.7		
cost of excavation	1,041.7	479.2		
Total cost of OLC	8,171.4	3,758.8		

Table #11
Site: Hysell Run TF030400 (alternative A) and TF031400 (alternative B) SLB
Treatment: Provide alkalinity through the use of steel slag leach beds in fresh water.
Scope: Install steel slag beds at either of the following tributaries TF030400 or TF031400.
Designed for a five year lifetime requires the following areas: TF030400 13,340 ft^3 and TF031400 23,237 ft^3.
Estimated amount of alkalinity generated: 372 lbs/day and 1254 lbs/day
Average flow: 31 gpm and 54 gpm

Budget category	Item	Cost TF030400	Cost TF031400
Access road preparation			
	Clearing and grubbing	1,280	1,280
	Silt fence	600	750
	Off-site disposal	1,851.85	2,314.81
	Culvert	600	600
	Stone	740.74	925.93
	Reclaim stone	925.93	1,157.41
Site construction			
	Clearing and grubbing	640	640
	Off-site disposal earthwork	1,400.46	2,604.17
	Silt fence	225	210
	Leach bed	1,479.68	2,581.99
	Drain	850	1,090
	Steel slag material	21,573.8	37,645.48
	Fresh water piping	11,028.14	7,622.59
Site reclamation			
	Revegetation	355.58	329.72
	Lime	23.71	21.98
	Maintenance Fertilizer	59.27	54.96
	Mowing	59.27	54.96
Sub Total		**43,693.42**	**59,883.99**
Mobilization	**8%**	**3,495.47**	**4,790.72**
Contingencies	**10%**	**4,718.89**	**6,467.47**
Total		**51,907.79**	**71,142.18**

Site: TF030400 Hysell Run				
Steel slag bed	**-1/8 EAF slag**			
INPUT:	5 years	1.6 yrs		
inflow	31.0	31.0	gpm	based on 0.07 sq.mile drainage area and Q measurement, these were the same
depth	6.4	4	ft	depth needed to design for 5 year lifetime
design factor	1	1		recommended by Mitch Farley
DISCHARGE TO BE TREATED:				
acidity	23.38	23.38	mg/l	ave. acidity at mouth of Hysell Run TF0302
flow	1001.2	1001.2	gpm	ave. flow at mouth of Hysell Run TF0302
acid load	280.90	280.90	lbs/day	
acid load	51.50	51.50	tpy	
OUTPUT:				
infiltration rate	0.0	0.0	gpm/sq. ft.	
required surface area	2084.41	1079.48	sq ft	0.05 acres needed to design for 5 yrs
side length	45.66	32.86	ft	
resulting alkalinity	1000	1000	mg/l	
alkaline load generation	372.0	372.0	lbs/day	92 lbs/day excess
alkaline load generation	68.2	68.2	tpy	
required slag	720.37	233.17	tons	
life	5	1.6	years	Mitch recommended designing for 5 yrs.
	13,340	4317.9	cubic ft	Total area needed in cubic feet

Site: TF031400 Hysell Run				
Steel slag bed	**-1/8 EAF slag**			
INPUT:	5 year	1.6 yrs		
inflow	54.0	54.0	gpm	based on 0.12 sq.mile drainage area, Q measurement 73 gpm 4/04
depth	6.4	4	ft	depth needed to design for 5 year lifetime
design factor	1	1		recommended by Mitch Farley
DISCHARGE TO BE TREATED:				
acidity	23.38	23.38	mg/l	ave. acidity at mouth of Hysell Run TF0302
flow	1001.2	1001.2	gpm	ave. flow at mouth of Hysell Run TF0302
acid load	280.90	280.90	lbs/day	
acid load	51.50	51.50	tpy	
OUTPUT:				
infiltration rate	0.0	0.0	gpm/sq. ft.	
required surface area	3630.91	1880.39	sq ft	0.08 acres needed space to design for 5 yrs
side length	60.26	43.36	ft	
resulting alkalinity	1000	1000	mg/l	
alkaline load generation	648.0	648.0	lbs/day	368 lbs/day excess
alkaline load generation	118.8	118.8	tpy	
required slag	1254.84	406.16	tons	
life	5	1.6	years	Mitch recommended designing for 5 yrs.
	23237.76	7521.55	cubic ft	Total area needed in cubic feet

Appendix G: Water quality data

Appendix F: Water Quality Data

Thomas Fork Mass Balances

Sampled during High Flow 6/9/2003

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0090	6/9/2003	4.48	74.80	-70.32	0.83	91	0.51	0.67	2.01	7.53	229	37	158	8	1868.4	-1576.66	45.16
TF1502	6/9/2003	244.00	0.00	244.00	22.20	406	50.10	2.77	75.07	3.14	1640	711	1010	83	426.6	1249.16	384.32
TF0070	6/10/2003	15.60	37.20	-21.60	<0.25	179	1.38	0.53	2.16	6.45	398	137	360	34	2767.2	-717.25	71.73
TF1202	6/9/2003	196.00	0.00	196.00	15.20	259	33.70	3.14	52.04	3.19	1110	490	692	30	136.7	321.46	85.35
TF1102	6/9/2003	153.00	0.00	153.00	17.60	304	14.00	3.99	35.59	3.50	1030	498	727	27	320.0	587.51	136.66
TF0050	6/10/2003	9.35	27.00	-17.65	<0.25	166	0.98	0.86	2.09	6.55	499	154	330	29	5960.0	-1262.32	149.19
TF1001	6/10/2003	4.75	64.30	-59.55	<0.25	147	0.08	0.51	0.84	7.23	396	101	244	11	6320.7	-4516.80	63.79
TF0402	6/9/2003	45.60	0.60	45.00	4.83	205	2.52	1.83	9.18	4.67	596	250	409	20	1437.4	776.18	158.34
TF0302	6/9/2003	9.82	6.96	2.86	<0.25	185	0.18	1.07	1.50	6.04	529	198	344	33	4080.0	140.03	73.59
TF0010	6/10/2003	5.85	25.20	-19.35	<0.25	181	0.33	1.20	1.78	6.74	546	180	341	29	18208.5	-4228.02	388.28

Sampled during Medium Flow 8/25/2003

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0090	8/25/2003	6.37	136.00	-129.63	<.25	160	0.22	0.22	0.68	7.49	419	38	244	8	94.8	-147.4	0.78
Little	8/25/2003	62.70	0.00	62.70	3.90	1149	4.55	6.43	14.88	3.60	4970	2371	2990	37	41.2	31.0	7.36
TF1502	8/25/2003	547.00	0.00	547.00	47.80	683	87.30	5.52	140.62	2.95	2250	1222	1830	26	109.9	721.5	185.48
TF0070	8/25/2003	21.70	36.20	-14.50	6.34	277	10.80	1.08	18.22	6.12	895	237	545	68	730.2	-127.0	159.64
Venoy	8/25/2003	1375.00	0.00	1375.00	139.00	1564	287.00	8.78	434.78	3.35	3650	2861	4340	93	2.9	48.3	15.29
TF1202	8/25/2003	748.00	0.00	748.00	56.60	685	95.70	7.67	159.97	2.69	2660	1424	2010	11	46.7	419.1	89.63
TF1102	8/25/2003	405.00	0.00	405.00	51.90	655	12.50	10.20	74.60	3.09	1880	1111	1620	10	60.5	294.2	54.19
TF0050	8/25/2003	17.20	4.44	12.76	4.29	275	4.59	1.78	10.66	5.48	774	281	545	37	1098.4	168.2	140.50
TF1001	8/25/2003	6.38	66.00	-59.62	0.52	223	1.00	0.85	2.38	7.18	597	180	406	6	824.5	-589.9	23.50
TF0402	8/25/2003	58.30	1.13	57.17	5.48	416	1.35	4.12	10.95	4.63	1040	472	752	13	176.4	121.0	23.18
TF0302	8/25/2003	6.92	21.60	-14.68	1.01	267	0.59	1.41	3.01	6.85	719	236	497	8	457.3	-80.5	16.51
TF0202	8/25/2003	35.90	2.25	33.65	3.92	345	0.59	4.29	8.80	4.99	824	387	634	14	89.3	36.1	9.43
TF0010	8/19/2003	5.25	22.00	-16.75	0.98	276	1.02	2.01	4.01	6.61	686	271	490	19	3388.3	-681.0	163.13

Appendix F: Water Quality Data

Sampled during Medium Flow 10/23/2003

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0071DupA	10/23/2003	11.90	101.00	-89.10	0.30	217	0.42	0.44	1.15	7.39	743	111	411	9	451.2	-482.5	6.24
TF0071DupB	10/23/2003	7.88	102.00	-94.12	0.30	216	0.42	0.44	1.15	7.44	735	111	411	4	451.2	-509.7	6.23
TF1502	10/23/2003	360.00	0.00	360.00	39.70	623	4.41	5.20	49.31	3.07	1870	1004	1450	77	76.8	331.6	45.41
TF0070	10/23/2003	21.90	50.20	-28.30	0.37	253	1.56	0.88	2.80	6.44	824	201	504	48	717.8	-243.8	24.14
TF1400	10/23/2003	6.08	102.00	-95.92	<0.25	138	0.43	0.17	0.84	7.51	457	40	238	4	137.2	-158.0	1.39
TF0064	10/23/2003	13.10	57.90	-44.80	0.26	225	0.95	0.74	1.95	6.97	722	155	435	28	739.3	-397.5	17.27
TF1300	10/23/2003	6.85	90.90	-84.05	<0.25	219	0.44	0.68	1.12	7.40	552	139	363	16	14.8	-14.9	0.20
TF1202	10/23/2003	620.00	0.00	620.00	49.40	561	83.10	6.62	139.12	2.80	2240	1284	1700	12	35.9	267.1	59.94
TF1102	10/23/2003	444.00	0.00	444.00	54.60	608	6.12	9.98	70.70	3.07	1970	1152	1570	14	41.2	219.5	34.96
TF0050 DupA	10/23/2003	18.70	7.58	11.12	<0.25	278	<0.05	1.79	2.09	5.95	822	273	531	34	1231.298	164.3	30.88
TF0050 DupB	10/23/2003	20.60	7.36	13.24	0.48	267	1.69	1.72	3.89	5.92	819	296	532	35	1231.298	195.6	57.48
TF1001	10/23/2003	9.08	75.10	-66.02	0.26	199	0.55	1.04	1.85	7.24	609	147	378	4	478.1	-378.7	10.60
TF0021	10/23/2003	13.70	34.90	-21.20	1.97	243	2.63	1.80	6.40	6.68	737	198	497	20	3792.9	-964.9	291.29
TF0402	10/23/2003	53.10	0.00	53.10	7.42	379	1.90	3.74	13.06	4.58	990	467	740	23	231.7	147.6	36.31
TF0020	10/23/2003	16.30	31.20	-14.90	2.36	251	2.73	1.91	7.00	6.71	722	237	497	19	3633.6	-649.7	305.22
TF0302	10/23/2003	10.80	22.80	-12.00	0.76	274	0.64	1.57	2.98	6.86	766	290	525	8	568.0	-81.8	20.28
TF0202	10/23/2003	44.00	1.21	42.79	7.30	330	1.46	3.92	12.68	4.76	935	375	661	21	61.6	31.6	9.37
TF0105	10/23/2003	13.00	36.70	-23.70	0.79	269	2.36	3.80	6.95	6.66	724	263	489	18	29.1	-8.3	2.42
TF0010	10/23/2003	10.40	29.90	-19.50	1.32	250	1.39	1.87	4.58	6.88	739	248	482	15	4093.4	-957.9	224.98

***doesn't inclued Fe or Al; both were below detection

Appendix F: Water Quality Data

Sampled during Medium Flow 6/21/2004

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
Littles	6/21/2004	38.00	0.00	38.00	2.76	821	4.01	4.42	11.19	3.84	1990	691	1530	7	46.9	21.4	6.30	
TF0071-Dup A	6/21/2004	4.55	90.90	-86.35	0.35	275	0.54	0.66	1.55	7.30	748	151	448	6	334.6	-346.7	6.22	
TF0071-Dup B	6/21/2004	4.28	91.30	-87.02	0.28	274	0.49	0.67	1.44	7.34	698	179	444	3	334.6	-349.4	5.77	
TF1502	6/21/2004	686.00	0.00	686.00	60.70	723	118.00	5.90	184.60	2.93	2130	1424	1990	31	83.8	689.8	185.63	
TF0070	6/21/2004	105.00	0.00	105.00	16.70	372	33.30	1.90	51.90	4.18	1090	482	748	119	387.3	488.0	241.20	
TF1400	6/21/2004	3.70	101.00	-97.30	<0.25	150	0.29	0.14	0.68	7.44	361	51	215	7	178.4	-208.3	1.45	
TF0064	6/21/2004	11.80	33.20	-21.40	5.41	257	5.55	0.97	11.93	6.22	639	222	464	36	608.2	-156.2	87.09	
TF1300	6/21/2004	5.37	82.40	-77.03	<0.25	226	0.22	0.40	0.88	7.31	512	162	329	4	14.8	-13.7	0.16	
Venoy's	6/21/2004	2196.00	0.00	2196.00	295.00	2101	472.00	14.90	781.90	3.67	4140	3869	5660	42	4.5	118.6	42.22	371.00
TF1202	6/21/2004	839.00	0.00	839.00	71.00	928	154.00	8.89	233.89	2.69	2460	1638	2230	14	35.9	361.4	100.76	
TF1102	6/21/2004	475.00	0.00	475.00	68.40	883	25.80	12.60	106.80	2.96	2090	1210	1680	7	20.2	115.1	25.89	
TF0050	6/21/2004	88.80	0.00	88.80	12.50	399	8.37	2.80	23.67	3.74	969	456	713	12	978.9	1043.1	278.06	
TF1001	6/21/2004	4.03	67.50	-63.47	<0.25	243	0.31	0.89	1.46	7.24	569	176	371	4	1025.0	-780.7	17.92	
TF0048	6/21/2004	14.50	7.57	6.93	6.14	295	4.20	1.64	11.98	5.57	726	291	500	44	2039.0	169.6	293.13	
SEEP1 DS TF10	6/21/2004	229.00	0.00	229.00	28.80	743	5.54	7.20	41.54	3.23	1580	947	1360	<2	4.6	12.6	2.28	
SEEP2 DS TF10	6/21/2004	455.00	0.00	455.00	58.70	828	14.40	8.42	81.52	2.96	1690	1243	1700	5	9.0	49.0	8.78	
SR 124 SEEP	6/21/2004	1083.00	0.00	1083.00	143.00	1813	63.10	13.80	219.90	2.98	4060	2832	4050	18	14.8	192.3	39.05	
TF0021	6/21/2004	7.66	9.49	-1.83	3.28	346	3.05	2.15	8.48	6.07	697	301	512	8	2537.0	-55.7	258.16	
TF0402	6/21/2004	88.40	0.00	88.40	13.70	578	1.85	5.24	20.79	4.22	1380	588	894	15	159.9	169.6	39.89	
TF0020	6/21/2004	7.94	9.10	-1.16	3.45	351	3.13	2.36	8.94	6.02	734	300	508	19	2809.6	-39.1	301.42	
TF0302	6/21/2004	43.50	1.25	42.25	4.78	420	0.94	2.37	8.09	4.64	897	400	706	3	365.3	185.2	35.45	
TF0202	6/21/2004	47.60	1.26	46.34	6.80	440	2.05	5.63	14.48	4.63	866	469	708	26	69.7	38.8	12.11	
TF0102	6/21/2004	7.40	43.50	-36.10	<0.25	289	0.65	3.68	4.33	6.78	669	249	446	2	41.2	-17.8	2.14	
TF0010-Dup A	6/21/2004	5.11	9.55	-4.44	1.78	326	1.28	2.04	5.10	6.28	706	307	513	7	3905.6	-208.1	239.03	
TF0010-Dup B	6/21/2004	6.88	9.29	-2.41	1.93	333	1.43	2.04	5.40	6.40	709	307	509	12	3905.6	-113.0	253.09	

Appendix F: Water Quality Data

Sampled during Low Flow 7/20/2004

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0071Dup-A	7/20/2004	5.84	71.90	-66.06	<0.25	396	0.20	1.02	1.47	7.08	1170	290	732	14	33.4	-26.5	0.59
TF0071Dup-B	7/20/2004	4.93	72.60	-67.67	<0.25	399	0.20	1.01	1.26	7.11	1180	305	731	8	33.4	-27.1	0.51
TF1502	7/20/2004	962.00	0.00	962.00	86.00	829	177.00	6.54	269.54	2.88	2610	1811	2660	42	77.0	888.9	249.05
TF0070 Dup-A	7/20/2004	449.00	0.00	449.00	45.30	621	92.00	3.98	141.28	2.94	2160	1078	1560	13	153.0	824.4	259.39
TF0070 Dup-B	7/20/2004	453.00	0.00	453.00	45.00	615	92.00	3.95	140.95	2.95	2170	1095	1560	17	153.0	831.7	258.78
TF1400	7/20/2004	4.32	116.00	-111.68	<0.25	162	0.43	0.50	1.18	7.40	426	39	256	9	14.8	-19.8	0.21
TF1202	7/20/2004	1100.00	0.00	1100.00	83.10	1001	162.00	9.12	254.22	2.60	3350	2149	2870	16	22.2	293.0	67.72
TF1150	7/20/2004	964.00	0.00	964.00	101.00	1052	96.20	15.70	212.90	2.77	3030	2025	2840	28	11.7	135.3	29.89
TF1102	7/20/2004	736.00	0.00	736.00	93.00	1060	24.90	15.50	133.40	2.82	2840	1819	2510	24	18.3	161.6	29.29
TF0050 Dup-A	7/20/2004	209.00	0.00	209.00	27.80	588	8.05	5.07	40.92	3.18	1580	804	1180	18	306.6	769.0	150.55
TF0050 Dup-B	7/20/2004	212.00	0.00	212.00	27.40	585	8.03	5.02	40.45	3.18	1600	810	1170	13	306.6	780.0	148.82
TF1001	7/20/2004	4.03	47.60	-43.57	<0.25	288	0.21	0.80	1.25	7.06	761	276	494	8	432.5	-226.1	6.49
TF0048	7/20/2004	60.00	0.00	60.00	10.80	405	3.20	2.51	16.51	4.41	1040	479	735	23	1257.9	905.7	249.22
TF0030	7/20/2004	42.40	0.00	42.40	7.10	398	1.57	2.75	11.42	4.45	1010	435	701	9	762.3	387.9	104.47
TF0021	7/20/2004	63.10	0.00	63.10	9.10	426	1.85	3.32	14.27	4.14	1050	505	752	10	1066.6	807.7	182.65
TF0402	7/20/2004	130.00	0.00	130.00	21.30	701	1.42	7.33	30.05	4.00	1490	848	1230	22	92.7	144.6	33.43
TF0020	7/20/2004	66.20	0.00	66.20	9.95	442	2.72	3.58	16.25	4.15	1090	533	802	14	1230.0	977.1	239.85
TF0302	7/20/2004	47.60	0.00	47.60	5.46	449	0.58	3.25	9.29	4.39	980	482	718	7	227.3	129.8	25.33
TF0015	7/20/2004	68.00	0.00	68.00	9.29	438	0.76	3.59	13.64	4.24	1060	512	766	7	1353.2	1104.2	221.43
TF0010 Dup-A	7/20/2004	52.90	0.00	52.90	6.45	428	0.29	3.34	10.08	4.35	983	469	709	11	1651.3	1048.3	199.68
TF0010-Dup B	7/20/2004	53.80	0.00	53.80	6.37	425	0.28	3.31	9.96	4.41	989	474	731	9	1651.3	1066.1	197.35

**This measurement seems to be in error according to the TF0050+TF1001 flow, was taken in a rocky channelized area; the measurement further downstream at TF0030 reflects a more accurate and reasonable reading.

Appendix F: Water Quality Data

Sampled during Low Flow 8/23/2005 by Jen Bowman, Mike Gosnell, Raina Ooten, and Barb Flowers

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Al mg/l	Hardness mg CaCO3/l	Iron mg/l	Mn mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF0071	8/23/2005	5.06	33.70	-28.64	0.05	801	0.14	0.24	0.42	6.8	1770	856	1500	3.0	4.58	-1.574	0.023	
TF1502	8/23/2005	529	0	529.00	46.8	945	81.7	5.93	134.43	2.94	3080	1342	2360	12	44	279.312	70.979	
TF0070	8/23/2005	473	0	473.00	43.6	940	64.7	6.05	114.35	2.94	2890	1301	2280	19	49.9	283.232	68.473	
TF0064	8/23/2005	365.00	0.00	365.00	41.10	958	14.2	8.62	63.92	3.01	2690	1218	2070	3	38.5	168.630	29.531	
Venoy	8/23/2005	2106.00	0.00	2106.00	223.00	1793	458	11.2	692.20	3.21	6530	3787	5490	18	5.83	147.336	48.426	38.8
TF1202	8/23/2005	1514.00	0.00	1514.00	125.00	1267	175.00	11.00	311.00	2.44	6860	2815	3600	14.0	4.58	83.209	17.093	
TF0058	8/23/2005	527.00	0.00	527.00	49.50	960	43.00	10.40	102.90	2.82	2580	1449	2080	6.0	42.8	270.667	52.849	
TF1102	8/23/2005	1135.00	0.00	1135.00	149.00	1389	28.50	20.40	197.90	2.7	6760	2420	3420	21.0	5.54	75.455	13.156	
TF0050	8/22/2005	281.00	0.00	281.00	33.10	715	4.46	8.20	45.76	3.28	1940	1128	1620	6.0	47.6	160.507	26.138	
TF1001	8/22/2005	4.68	33.70	-29.02	0.05	344	0.36	0.58	0.99	6.74	995	393	723	4.0	NA	NA	NA	
TF0030	8/22/2005	67.20	0.00	67.20	6.34	455	0.71	3.60	10.65	4.45	1260	595	925	2.0	240	193.536	30.660	
SR 124 seep	8/22/2005	1144.00	0.00	1144.00	130.00	1682	40.50	13.10	183.60	2.84	6450	3005	4350	21.0	9.45	129.730	20.820	0.27
TF0021	8/22/2005	86.30	0.00	86.30	8.67	476	0.85	4.34	13.86	4.02	1250	634	974	5.0	NA	NA	NA	
TF0402	8/22/2005	98.50	0.00	98.50	9.45	643	1.22	7.49	18.16	4.14	1520	848	1270	8.0	13.2	15.602	2.877	
TF0020	8/22/2005	87.30	0.00	87.30	8.69	496	0.80	4.53	14.02	4.03	1300	640	980	10.0	315	329.994	52.999	
TF0302	8/22/2005	14.80	3.33	11.47	1.08	436	1.07	4.69	6.84	5.21	1050	519	803	11.0	4.58	0.630	0.376	
TF 0017	8/22/2005	69.20	0.00	69.20	5.98	479	0.58	4.21	10.77	4.25	1250	617	936	5.0	NA	NA	NA	
TF 0202	8/22/2005	11.90	19.00	-7.10	0.30	526	2.30	4.16	6.76	6.03	1170	561	889	12.0	1.65	-0.141	0.134	
TF0015	8/22/2005	65.60	0.00	65.60	6.21	511	0.51	4.53	11.25	4.27	1230	613	941	4.0	100.6	79.192	13.583	
TF0010	8/22/2005	37.80	3.19	34.61	2.23	506	0.49	4.44	7.16	4.8	1150	553	870	3.0	NA	NA	NA	

Appendix F: Water Quality Data

TF 15- Unnamed Tributary on Bailey Run Road

Mouth of TF 15 2003-2006

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF1502	6/9/2003	244	0	244	22.2	406	50.10	2.77	75.07	3.14	1640	711	1010	83	426.6	1249.2	384.3	
TF1502	8/25/2003	547	0	547	47.8	683	87.30	5.52	140.62	2.95	2250	1222	1830	26	109.9	721.5	185.5	
TF1502	10/23/2003	360	0	360	39.7	623	4.41	5.20	49.31	3.07	1870	1004	1450	77	76.8	331.6	45.4	
TF1502	3/29/2004	567	0	567	47.1	662	91.30	4.88	143.28	2.95	2090	1210	1690	73	173.7	1181.7	298.6	
TF1502	6/21/2004	686	0	686	60.7	723	118.00	5.90	184.60	2.93	2130	1424	1990	31	83.8	689.8	185.6	
TF1502	7/20/2004	962	0	962	86.0	829	177.00	6.54	269.54	2.88	2610	1811	2660	42	77.0	888.9	249.1	
TF1502	8/23/2005	529	0	529	46.8	945	81.7	5.93	134.43	2.94	3080	1342	2360	12	44.0	279.3	71.0	
TF1502	1/4/2006	149	0	149	15.8	809	32.20	4.68	52.68	3.59	2620	794	1830	47	NA	NA	NA	
AVERAGE		**506**	**0**	**506**	**45.8**	**710**	**80.25**	**5.18**	**142.41**	**3.06**	**2286**	**1190**	**1853**	**49**	**141.7**	**763.13**	**202.78**	

Unnamed Tributary Sources Sampled on March 29, 2004

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF15 pipe7	3/29/2004	156.0	0.0	156.0	10.80	527	34.00	1.44	46.24	3.42	1520	774	1150	49	4.8	8.9	2.6	
TF15 pipe 6	3/29/2004	197.0	0.0	197.0	9.40	356	51.60	1.31	62.31	3.40	1350	677	1030	2	18.0	42.6	13.5	
TF15 pipe 4	3/29/2004	193.0	0.0	193.0	11.40	442	49.90	2.04	63.34	3.88	1390	757	1140	2	18.8	43.4	14.3	
TF15 pipe 5	3/29/2004	481.0	1.1	479.9	12.00	787	189.00	4.10	205.10	4.59	1970	1292	1980	42	1.0	5.8	2.5	
TF15 seep 4	3/29/2004	53.1	12.6	40.5	2.95	566	22.20	2.91	28.06	5.70	1090	590	884	34	2.1	1.0	0.7	
TF15 seep 3	3/29/2004	959.0	0.0	959.0	72.70	762	218.00	7.72	298.42	3.00	2400	1679	2450	56	15.0	172.6	53.7	
TF15 seep2	3/29/2004	48.5	0.0	48.5	2.34	528	4.11	3.39	9.84	4.17	1350	667	1040	21	7.1	4.1	0.8	
TF15 pipe 3	3/29/2004	89.5	120.0	-30.5	<.25	894	30.50	45.60	76.10	6.18	1880	914	1560	11	12.8	-4.7	11.6	
TF15 pipe 2	3/29/2004	1290.0	0.0	1290.0	100.00	882	311.00	6.13	417.13	3.09	2630	2058	3070	19	4.0	61.9	20.0	
TF15 pipe 1	3/29/2004	2706.0	0.0	2706.0	226.00	944	168.00	8.61	402.61	2.57	4400	3466	4900	15	8.3	267.9	39.9	
TF15 seep 1	3/29/2004	2662.0	0.0	2662.0	227.00	976	456.00	10.10	693.10	2.68	3720	3457	4980	14	22.5	718.7	187.1	
TF1502	3/29/2004	567.0	0.0	567.0	47.10	662	91.30	4.88	143.28	2.95	2090	1210	1690	73	173.7	1181.7	298.6	

Sampled on June 21, 2004

**Aluminum, Iron, Ferrous Iron, and Manganese

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals** mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF1590	6/21/2004	62.3	1.8	60.6	8.77	451	20.90	2.30	31.97	4.68	1140	540	817	41	6.6	4.8	2.5	
TF15 pipe7	6/21/2004	192.0	0.0	192.0	13.80	515	52.60	1.93	105.43	3.26	1410	769	1160	13	3.9	9.0	4.9	37.10
TF15 pipe 6	6/21/2004	200.0	0.0	200.0	10.90	419	62.90	1.61	109.51	3.34	1350	705	1040	7	19.5	46.8	25.6	34.10
TF15 pipe 4	6/21/2004	203.0	0.0	203.0	13.30	497	61.60	2.47	132.97	3.73	1450	789	1170	5	10.3	25.1	16.4	55.60
TF15 pipe 5	6/21/2004	359.0	2.1	357.0	10.70	903	186.00	4.35	369.05	4.51	1990	1251	1930	21	0.5	2.1	2.2	168.00
TF15 seep 4	6/21/2004	56.4	10.4	46.0	5.89	644	34.30	4.55	44.74	5.42	1220	645	992	48	1.1	0.6	0.6	
TF15 seep 3	6/21/2004	1591.0	0.0	1591.0	138.00	1125	583.00	12.90	733.90	2.86	3230	2568	3690	33	4.6	87.4	40.3	
TF15 seep2	6/21/2004	6.2	11.4	-5.2	2.99	595	6.77	5.87	15.63	6.51	1360	655	1030	56	2.4	-0.1	0.4	
TF15 pipe 3	6/21/2004	84.9	96.9	-12.0	<0.25	913	40.50	4.59	80.49	6.31	1790	897	1050	17	11.3	-1.6	10.9	35.40
TF15 pipe 2	6/21/2004	1747.0	0.0	1747.0	157.00	1180	495.00	10.10	1018.10	3.00	3420	2766	4040	15	3.4	70.8	41.2	356.00
TF15 pipe 1	6/21/2004	2123.0	0.0	2123.0	198.00	934	478.00	8.59	1012.59	2.59	3980	2889	4050	21	8.3	210.2	100.2	328.00
TF15 seep 1	6/21/2004	2628.0	0.0	2628.0	254.00	1134	583.00	11.50	848.50	2.70	3270	3548	5050	17	9.0	283.2	91.4	
TF1502	6/21/2004	686.0	0.0	686.0	60.70	723	118.00	5.90	184.60	2.93	2130	1424	1990	31	83.8	689.8	185.6	

Appendix F: Water Quality Data

Sampled during Low Flow 8-22-23-2005 by Jen Bowman, Mike Gosnell, Raina Ooten, and Barb Flowers

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF1590	dry			dry					dry						dry			
TF 15 south fork	8/23/2005	251.0	0.0	251.0	31.10	3769	3.2	15.00	49.29	3.39	22300	1029	13770	58.0	0.73	2.20	0.43	
TF15 pipe 7 duplicate	8/23/2005	250.0	0.0	250.0	13.90	472	70.5	1.95	86.35	3.46	1490	823	1290	9.0	2.5	7.50	2.59	
TF15 pipe7	8/23/2005	242.0	0.0	242.0	13.9	472	70.3	1.95	86.15	3.47	1430	822	1280	8	2.5	7.26	2.58	6.97
TF15 pipe 6	8/23/2005	221.0	0.0	221.0	10.6	417	74.0	1.57	86.17	3.44	1420	753	1170	9	13.5	35.80	13.96	7.02
TF15 pipe 4	8/23/2005	200.0	0.0	200.0	11.70	503	45.3	2.4	59.40	3.22	1530	811	1250	12	12	28.80	8.55	
TF15 pipe 5	8/23/2005	417.0	5.2	411.8	11.70	974	205.0	4.38	221.08	4.52	3960	1375	2180	30	0.43	2.12	1.14	18
TF15 seep 4	dry			dry					dry						dry			
TF15 seep 3	8/25/2005	1292.0	0.0	1292.0	83.10	1170	201.0	11.80	295.90	2.64	5670	2478	3370	20.0	3.28	50.85	11.65	
TF15 seep2	dry			dry					dry						dry			
TF15 pipe 3	8/23/2005	103.0	125.0	-22.0	0.05	809	32.6	4.21	36.86	6.04	1690	873	1480	4.0	9.12	-2.41	4.03	
TF15 pipe 2	8/23/2005	1539.0	0.0	1539.0	112.00	999	363.0	7.51	482.51	3.02	6120	2354	3570	40.0	2.8	51.71	16.21	19.30
TF15 pipe 1	8/23/2005	9704.0	0.0	9704.0	781.00	1925	2250.0	20.30	3051.30	2.25	16800	11278	16170	62.0	1.38	160.70	50.53	39.20
TF15 seep 1	8/23/2005	6699.0	0.0	6699.0	526.00	1733	1490.0	20.50	2036.50	2.54	13900	8150	11800	33.0	1.5	120.58	36.66	
TF1502	8/23/2005	529.0	0.0	529.0	46.8	945	81.7	5.93	134.43	2.94	3080	1342	2360	12	44	279.31	70.98	

Sampled during 1/04/06 by Jen Bowman, Mike Gosnell, Raina Ooten, and Jim Freedman

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF1507	1/4/2006	37.0	5.0	32.0	3.06	761	9.85	2.99	15.90	5.6	2840	543	1810	27.0				5.80
TF15 seep 3	1/4/2006	359.0	0.0	359.0	24.40	779	143.0	7.28	174.68	3.86	1780	1144	1760	27.0		0.00	0.00	126.00
TF1504	1/4/2006	95.1	0.0	95.1	9.55	793	22.9	4.11	36.56	4.52	2580	717	1730	26.0		0.00	0.00	13.70
TF15 seep 1	1/4/2006	2592.0	0.0	2592.0	230.00	1245	494.0	25.30	749.30	2.73	8300	3737	5300	28.0	1.875	58.32	16.86	98.00
TF15 pipe 1	1/4/2006	7989.0	0.0	7989.0	690.00	1978	2092.0	20.10	2802.10	2.49	15100	9878	14720	66.0	0.51	48.89	17.15	1835.00
TF1502	1/4/2006	149.0	0.0	149.0	15.8	809	32.20	4.68	52.68	3.59	2620	794	1830	47				15.30

Averages for AMDAT treat

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
TF15 pipe 1	3/29/2004	2706.0	0.0	2706.0	226.00	944	168.00	8.61	402.61	2.57	4400	3466	4900	15	8.3	267.9	39.9	
TF15 pipe 1	6/21/2004	2123.0	0.0	2123.0	198.00	934	478.00	8.59	1012.59	2.59	3980	2889	4050	21	8.3	210.2	100.2	328.00
TF15 pipe 1	8/23/2005	9704.0	0.0	9704.0	781.00	1925	2250.0	20.30	3051.30	2.25	16800	11278	16170	62.0	1.38	160.70	50.53	39.20
TF15 pipe 1	1/4/2006	7989.0	0.0	7989.0	690.00	1978	2092.0	20.10	2802.10	2.49	15100	9878	14720	66.0	0.51	48.89	17.15	1835.00
Average		5630.5	0.0	5630.5	473.8	1445.3	1247.0	14.4	1817.2	2.5	10070.0	6877.8	9960.0	41.0	4.6	171.9	51.9	734.1
TF15 seep 1	3/29/2004	2662.0	0.0	2662.0	227.00	976	456.00	10.10	693.10	2.68	3720	3457	4980	14	22.5	718.7	187.1	
TF15 seep 1	6/21/2004	2628.0	0.0	2628.0	254.00	1134	583.00	11.50	848.50	2.70	3270	3548	5050	17	9.0	283.2	91.4	
TF15 seep 1	8/23/2005	6699.0	0.0	6699.0	526.00	1733	1490.0	20.50	2036.50	2.54	13900	8150	11800	33.0	1.5	120.58	36.66	
TF15 seep 1	1/4/2006	2592.0	0.0	2592.0	230.00	1245	494.0	25.30	749.30	2.73	8300	3737	5300	28.0	1.875	58.32	16.86	98.00
Average		3645.3	0.0	3645.3	309.3	1272.0	755.8	16.9	1081.9	2.7	7297.5	4723.0	6782.5	23.0	8.7	295.2	83.0	98.0
TF15 seep 3	3/29/2004	959.0	0.0	959.0	72.70	762	218.00	7.72	298.42	3.00	2400	1679	2450	56	15.0	172.6	53.7	
TF15 seep 3	6/21/2004	1591.0	0.0	1591.0	138.00	1125	583.00	12.90	733.90	2.86	3230	2568	3690	33	4.6	87.4	40.3	
TF15 seep 3	8/25/2005	1292.0	0.0	1292.0	83.10	1170	201.0	11.80	295.90	2.64	5670	2478	3370	20.0	3.28	50.85	11.65	
TF15 seep 3	1/4/2006	359.0	0.0	359.0	24.40	779	143.0	7.28	174.68	3.86	1780	1144	1760	27.0		0.00	0.00	126.00
Average		1050.3	0.0	1050.3	79.6	959.0	286.3	9.9	375.7	3.1	3270.0	1967.3	2817.5	34.0	7.6	77.7	26.4	126.0

Appendix F: Water Quality Data

TF 14- Ball Run

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Load lbs/day	Metal Load lbs/day
TF1400	10/23/2003	6.08	102.00	-95.92	<0.25	138	0.43	0.17	0.83	7.51	457	40	238	4	137.2	-157.9572192	0.9715884
TF1400	6/21/2004	3.70	101.00	-97.30	<0.25	150	0.29	0.14	0.67	7.44	361	51	215	7	178.4	-208.3185216	0.92062656
TF1400	7/20/2004	4.32	116.00	-111.68	<0.25	162	0.43	0.50	1.17	7.40	426	39	256	9	14.8	-19.834368	0.165168
AVERAGE		**4.70**	**106.33**	**-101.63**	**0.25**	**150**	**0.38**	**0.27**	**0.89**	**7.45**	**415**	**43**	**236**	**7**	**110.1**	**-128.7033696**	**0.68579432**

TF 13

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Load lbs/day	Metal Load lbs/day
TF1300	10/23/2003	6.85	90.90	-84.05	<0.25	219	0.44	0.68	1.35	7.40	552	139	363	16	14.8		
TF1300	6/21/2004	5.37	82.40	-77.03	<0.25	226	0.22	0.40	0.87	7.31	512	162	329	4	14.80		
AVERAGE		**6.11**	**86.65**	**-80.54**	**0.25**	**223**	**0.33**	**0.54**	**0.87**	**7.36**	**532**	**151**	**346**	**10**	**14.8**		

Venoy's

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Load lbs/day	Metal Load lbs/day	Ferrous Iron mg/l
Venoy's	8/25/2003	1375	0	1375	139	1564	287	8.78	434.78	3.35	3650	2861	4340	93	2.9	48.3	15.3	
Venoy's	4/27/2004	1624	0	1624	189	1771	309	10.10	508.10	3.68	3780	3145	4620	39	7.5	146.2	45.7	
Venoy's	6/21/2004	2196	0	2196	295	2101	472	14.90	781.90	3.67	4140	3869	5660	42	4.50	118.6	42.2	371
Venoy's	8/23/2005	2106	0	2106	223	1793	458	11.2	692.20	3.21	6530	3787	5490	18	5.83	147.3	48.4	
Venoy's	1/4/2006	1475	0	1475	162	1743	302	9.75	473.75	3.59	6050	3128	4450	76	NA			276
AVERAGE		**1755**	**0**	**1825**	**202**	**1794**	**366**	**10.95**	**604.25**	**3.48**	**4525**	**3416**	**5028**	**48**	**5.19**	**115.11**	**37.92**	**371.00**
Venoy's culvert	1/4/2006	406	0	406	51	930	38	5.01	93.91	3.22	2040	1078	1900	14	NA			15.50

TF 12- Kinzel's

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Load lbs/day	Metal Load lbs/day
TF1202	6/9/2003	196.00	0.00	196.00	15.20	259	33.70	3.14	52.04	3.19	1110	490	692	30	136.7	321.46	85.35
TF1202	8/25/2003	748.00	0.00	748.00	56.60	685	95.70	7.67	159.97	2.69	2660	1424	2010	11	46.7	419.12	89.63
TF1202	10/23/2003	620.00	0.00	620.00	49.40	561	83.10	6.62	139.12	2.80	2240	1284	1700	12	35.9	267.14	59.94
TF1202	6/21/2004	839.00	0.00	839.00	71.00	928	154.00	8.89	233.89	2.69	2460	1638	2230	14	35.9	361.44	100.76
TF1202	7/20/2004	1100.00	0.00	1100.00	83.10	1001	162.00	9.12	254.22	2.60	3350	2149	2870	16	22.2	293.04	67.72
TF1202	8/23/2005	1514.00	0.00	1514.00	125.00	1267	175.00	11.00	311.00	2.44	6860	2815	3600	14.0	4.58	83.209	17.093
AVERAGE		**836.17**	**0.00**	**836.17**	**66.72**	**783.50**	**117.25**	**7.74**	**191.71**	**2.74**	**3113.33**	**1633.33**	**2183.67**	**16.17**	**46.99**	**290.90**	**70.08**

Appendix F: Water Quality Data

Kinzel TF 12

LC ID#	Location	Coordinates NAD27 (DeLorme)		Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm
NA	Upstream of apparent mining in hollow	39 3 11.4	82 4 21.2	5/15/2001														0.0
NA	Upstream of apparent mining in hollow	39 3 11.4	82 4 21.2	7/3/2001	20.3	104	-83.7	0.124	164	1.11	1.2	2.434	6.89	430	87.3	254	8	<112
NA	Mine Entry Discharge	39 3 13.0	82 4 15.0	5/15/2001	1229	0	1229	80	875	386	7.13	2.89	2.89	3560	2149	3130	70	NA
NA	Mine Entry Discharge	39 3 13.0	82 4 15.0	7/3/2001	1175	0	1175	75.2	903	218	8.4	301.6	2.78	3110	2025	2840	52	<112
NA	Subhollow south of mine entry diffuse flow	39 38.7	82 4 14.6	5/15/2001	29.3	2.14	27.16	5.69	285	1.48	2.44	9.61	4.61	611	299	464	17	NA
NA	Subhollow south of mine entry diffuse flow	39 38.7	82 4 14.6	7/3/2001	1726	0	1726	139	1178	441	15.6	595.6	3.02	3890	2988	4080	80	<224
NA	Main hollow downstream of previous samples	39 3 9.2	82 4 4.4	5/15/2001	1126	0	1126	79.1	912	261	8.87	348.97	2.77	3260	2132	2970	25	NA
NA	Main hollow downstream of previous samples	39 3 9.2	82 4 4.4	7/3/2001	1103	0	1103	75.2	903	218	8.4	301.6	2.78	3110	2025	2840	24	112
TF1202	Above SR 143			5/15/2001	973.00	0.00	973.00	73.30	892	171.00	8.63	252.93	2.67	2980	1910	2680	7	NA
TF1202	Above SR 143			7/3/2001	927	0	927	70.1	816	120	8.64	198.74	2.59	3240	1741	2324	12	224
NA	Thomas Fork between Venoy and TF12	39 2 55.3	82 3 43.7	5/15/2001	103	0	103	15.6	386	2.09	2.2	19.89	4.1	1080	517	823	9	NA
NA	Thomas Fork between Venoy and TF12	39 2 55.3	82 3 43.7	7/3/2001	62.1	0	62.1	6.7	313	8.27	1.97	16.94	3.82	884	382	574	12	2244.15
NA	Subhollow between Kinzel and Casto, west of SR 143	39 2 52.2	82 3 49.1	5/15/2001	1264	0	1264	150	1262	80.6	17	247.6	2.68	3800	2511	3550	16	NA
NA	Subhollow between Kinzel and Casto, west of SR 143	39 2 52.2	82 3 49.1	7/3/2001	1233	0	1233	152	1175	59.8	17	228.8	2.61	3690	2371	3300	36	<224

The samples and flows were taken by CTL Engineering of West Virginia. The flows were provided in cfs and were converted to gpm. The measurements appear to be suspect, however, the chemistry provides a snapshot of the Kinzel hollow.

Appendix F: Water Quality Data

TF 11- Casto's

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF1102	6/9/2003	153.00	0.00	153.00	17.60	304	14.00	3.99	35.59	3.50	1030	498	727	27	320.0	587.51	136.66
TF1102	8/25/2003	405.00	0.00	405.00	51.90	655	12.50	10.20	74.60	3.09	1880	1111	1620	10	60.5	294.19	54.19
TF1102	10/23/2003	444.00	0.00	444.00	54.60	608	6.12	9.98	70.70	3.07	1970	1152	1570	14	41.2	219.53	34.96
TF1102	5/10/2004	458.00	0.00	458.00	57.20	730	25.60	10.40	93.20	3.00	1970	1185	1700	13	66.1	363.29	73.93
TF1102	6/21/2004	475.00	0.00	475.00	68.40	883	25.80	12.60	106.80	2.96	2090	1210	1680	7	20.2	115.14	25.89
TF1102	7/20/2004	736.00	0.00	736.00	93.00	1060	24.90	15.50	133.40	2.82	2840	1819	2510	24	18.3	161.63	29.29
TF1102	8/23/2005	1135.00	0.00	1135.00	149.00	1389	28.50	20.40	197.90	2.7	6760	2420	3420	21.0	5.54	75.45	13.16
TF1102	1/25/2006	237.00	0.00	237.00	27.50	438	23.30	5.69	56.49	3.07	1240	683	982	13	177.1	503.56	120.03
AVERAGE		**505.38**	**0.00**	**505.38**	**64.90**	**758**	**20.09**	**11.10**	**96.09**	**3.03**	**2473**	**1260**	**1776**	**16**	**88.62**	**290.04**	**61.01**

Casto's Sources medium flow

LC ID#	Site	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF1199	5/10/2004	3.35	210.00	-206.65	<0.25	314	0.16	<0.05	0.46	8.07	736	60	412	12	2.5	-6.20	0.01
TF1180	5/10/2004	309.00	0.00	309.00	38.40	642	37.80	3.65	79.85	3.30	1630	906	1340	33	4.6	16.98	4.39
TF1100-3	5/10/2004	1716.00	0.00	1716.00	212.00	1643	181.00	19.40	412.40	2.89	3870	3260	4740	28	4.6	94.31	22.67
TF1100-2	5/10/2004	1433.00	0.00	1433.00	118.00	1228	295.00	19.10	432.10	2.75	3340	2626	3720	35	2.6	44.71	13.48
TF1100-1	5/10/2004	282.00	0.00	282.00	18.20	481	52.00	7.30	77.50	2.99	1680	816	1190	13	4.6	15.50	4.26
TF1102	5/10/2004	458.00	0.00	458.00	57.20	730	25.60	10.40	93.20	3.00	1970	1185	1700	13	66.1	363.29	73.93

Casto's Sources high flow

LC ID#	Site	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous iron mg/l
TF1199	1/25/2006	3.41	75.50	-72.09	0.93	111	0.58	<0.03	1.54	7.18	316	<50	172	5	7.7	-6.70	0.14	0.116
TF1180	1/25/2006	106.00	0.00	106.00	12.40	216	12.60	2.29	27.29	3.71	742	328	481	11	18.3	23.28	5.99	9.1
TF1100-3	1/25/2006	1007.00	0.00	1007.00	116.00	850	97.60	12.30	225.90	2.65	2660	1786	2480	14	9.0	108.51	24.34	33.9
TF1100-2	1/25/2006	3650.00	0.00	3650.00	323.00	2001	968.00	32.60	1323.60	2.72	8560	5359	8220	46	1.5	67.45	24.46	682
TF1100-1	1/25/2006	263.00	0.00	263.00	18.50	515	72.50	7.61	98.61	3.22	1580	806	1250	9	16.5	52.07	19.52	59.2
TF1102	1/25/2006	237.00	0.00	237.00	27.50	438	23.30	5.69	56.49	3.07	1240	683	982	13	177.1	503.56	120.03	10.7

Appendix F: Water Quality Data

Casto TF 11

LC ID#	Location	Coordinates NAD27 (DeLorme)	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm
NA	Main Hollow below trailer with dogs	39 2 44.3 82 4 8.9	5/15/2001	904.00	0.00	904.00	95.90	864	97.00	16.40	209.30	2.81	2690	1860	2690	11	NA
NA	Main Hollow below trailer with dogs	39 2 44.3 82 4 8.9	7/3/2001	1102	0	1102	106	926	133	16.7	255.7	2.8	2980	2058	2920	30	<112
NA	First subhollow west of mouth and north of road	39 2 45.6 82 4 3.1	5/15/2001														Dry
NA	First subhollow west of mouth and north of road	39 2 45.6 82 4 3.1	7/3/2001	1243	0	1243	136	1357	68.9	21	225.9	2.56	3960	2577	3600	30	112
TF1102	NA		5/15/2001	898.00	0.00	898.00	95.10	982	80.40	16.70	192.20	2.80	3220	1902	2730	15	NA
TF1102	NA		7/3/2001	775	0	775	83.8	899	51.5	15.9	151.2	2.76	2820	1712	2420	18	224
NA	Thomas Fork below Casto	39 2 43.5 82 3 50.7	5/15/2001	217	0	217	28	462	17.2	4.2	49.4	3.14	1440	725	1090	25	NA
NA	Thomas Fork below Casto	39 2 43.5 82 3 50.7	7/3/2001	102	0	102	10.1	337	7.86	2.64	20.6	3.6	996	662	668	12	2244.15

The samples and flows were taken by CTL Engineering of West Virginia. The flows were provided in cfs and were converted to gpm.
The measurements appear to be suspect, however, the chemistry provides a snapshot of the lower end of Castos

Appendix F: Water Quality Data

TF 10- East Branch Thomas Fork

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Loads lbs/day	Metal Loads lbs/day
TF1001	6/10/2003	4.75	64.30	-59.55	<0.25	147	0.08	0.51	0.59*	7.23	396	101	244	11	6320.7	-4516.80	44.75
TF1001	8/25/2003	6.38	66.00	-59.62	0.52	223	1.00	0.85	2.38	7.18	597	180	406	6	824.5	-589.87	23.50
TF1001	10/23/2003	9.08	75.10	-66.02	0.26	199	0.55	1.04	1.85	7.24	609	147	378	4	478.1	-378.75	10.60
TF1001	6/21/2004	4.03	67.50	-63.47	<0.25	243	0.31	0.89	1.20*	7.24	569	176	371	4	1025.0	-780.65	14.76
TF1001	7/20/2004	4.03	47.60	-43.57	<0.25	288	0.21	0.80	1.00*	7.06	761	276	494	8	432.5	-226.10	5.19
AVERAGE		**5.65**	**64.10**	**-58.45**	**0.39**	**220**	**0.43**	**0.82**	**2.11**	**7.19**	**586**	**176**	**379**	**7**	**1816.1**	**-1298.43**	**19.76**

SR 124 seep

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day	Ferrous Iron mg/l
SR 124 seep	6/21/2004	1083	0	1083	143	1813	63.10	13.80	219.90	2.98	4060	2832	4050	18	14.8	192.3	39.05	
SR 124 seep	8/22/2005	1144	0	1144	130	1682	40.50	13.10	183.60	2.84	6450	3005	4350	21	9.45	129.7	20.82	0.27
AVERAGE		**1113.50**	**0.00**	**1113.50**	**136.50**	**1747.50**	**51.80**	**13.45**	**201.75**	**2.91**	**5255.00**	**2918.50**	**4200.00**	**19.50**	**12.13**	**161.04**	**29.94**	**0.27**

Appendix F: Water Quality Data

TF 04- Bailey Run

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0402	6/9/2003	45.60	0.60	45.00	4.83	205	2.52	1.83	9.18	4.67	596	250	409	20	1437.4	776.18	158.34
TF0402	8/25/2003	58.30	1.13	57.17	5.48	416	1.35	4.12	10.95	4.63	1040	472	752	13	176.4	121.05	23.18
TF0402	10/23/2003	53.10	0.00	53.10	7.42	379	1.90	3.74	13.06	4.58	990	467	740	23	231.7	147.62	36.31
TF0402	4/5/2004	62.80	0.00	62.80	8.57	292	4.02	2.36	14.95	4.37	718	315	509	15	1006.1	758.23	180.50
TF0402	6/21/2004	88.40	0.00	88.40	13.70	578	1.85	5.24	20.79	4.22	1380	588	894	15	159.9	169.61	39.89
TF0402	7/20/2004	130.00	0.00	130.00	21.30	701	1.42	7.33	30.05	4.00	1490	848	1230	22	92.7	144.61	33.43
TF0402	10/4/2005	131	0	131	17.1	723	0.744	8.24	26.084	4.16	16.3	897	1360	9	20.2	31.75	6.32
AVERAGE		**81.31**	**0.25**	**81.07**	**11.20**	**470.57**	**1.97**	**4.69**	**17.87**	**4.38**	**890.04**	**548.14**	**842.00**	**16.71**	**446.35**	**307.01**	**68.28**

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0490	4/5/2004	8.48	88.00	-79.52	<.25	208	0.49	0.37	1.11	7.39	517	110	313	10	10.3	-9.83	0.14
TF041200	4/5/2004	78.00	0.00	78.00	7.93	186	23.90	0.76	32.59	4.46	553	226	399	29	6.0	5.62	2.35
TF041100	4/5/2004	155.00	0.00	155.00	20.30	413	4.10	1.96	26.36	3.46	1150	590	859	4	56.1	104.35	17.75
TF041000	4/5/2004	62.00	0.64	61.36	8.14	280	9.81	3.23	21.18	4.56	688	310	495	25	24.0	17.67	6.10
TF040900	4/5/2004	7.86	14.10	-6.24	<.25	146	0.61	1.29	2.15	6.46	411	128	250	6	35.9	-2.69	0.92
TF040800	4/5/2004	129.00	0.00	129.00	15.90	306	2.91	3.85	22.66	3.44	844	417	615	8	56.1	86.84	15.25
TF040700	4/5/2004	115.00	0.00	115.00	14.50	238	7.53	2.39	24.42	3.61	729	311	485	12	84.7	116.89	24.82
TF040600	4/5/2004	489.00	0.00	489.00	55.60	418	35.80	5.22	96.62	2.90	1530	840	1210	5	30.0	176.04	34.78
Tobins	4/5/2004	1314.00	0.00	1314.00	124.00	959	178.00	6.09	308.09	2.62	2980	2083	3050	20	7.5	118.26	27.73
TF0450	4/5/2004	85.10	0.00	85.10	11.00	259	6.00	1.90	18.90	3.88	715	328	500	16	887.0	905.82	201.18
TF040400	4/5/2004	66.30	0.00	66.30	8.51	353	6.67	3.16	18.34	4.46	812	398	606	23	170.0	135.25	37.41
TF040200	4/5/2004	59.20	0.00	59.20	4.41	390	1.57	3.22	9.20	4.41	835	410	620	25	44.0	31.26	4.86
TF0402	4/5/2004	62.80	0.00	62.80	8.57	292	4.02	2.36	14.95	4.37	718	315	509	15	1006.1	758.23	180.50

Sampled during Low Flow by Jen Bowman, Mike Gosnell, Raina Ooten, and Barb Flowers

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0490	10/4/2005	3.36	96.8	-93.44	0.262	277	0.906	0.261	1.4	7.47	666	177	445	15	12.18	-13.66	0.21
TF 040120	10/4/2005			0					0.0						dry	dry	dry
TF040110	10/4/2005	247	0	247	30.2	887	5.59	5.24	41.0	3.29	2360	1350	1970	9	0.183	0.54	0.09
TF040100	10/4/2005	6.83	101	-94.17	0.05	392	1.18	1.12	2.4	7.09	924	287	634	5	0.412	-0.47	0.01
TF040900	10/4/2005			0					0.0						dry	dry	dry
TF040800	10/4/2005			0					0.0						dry	dry	dry
TF0470	10/4/2005	3.52	71.5	-67.98	0.05	363	0.184	0.117	0.4	7.29	844	303	580	5	14.8	-12.07	0.06
TF040700	10/4/2005			0					0.0						dry	dry	dry
TF040600	10/4/2005	1965	0	1965	211	1252	203	14.9	428.9	2.75	6990	3268	4560	30	0.53	12.50	2.73
Tobins	10/4/2005			0					0.0						dry	dry	dry
TF0450	10/4/2005	68	12.8	55.2	1.96	384	2.32	2.16	6.4	5.83	1110	410	766	11	11.7	7.75	0.90
TF040400	10/4/2005	536	0	536	65.3	1188	13.8	14.8	93.9	2.93	2900	1885	2650	15	10.3	66.25	11.61
TF040200	10/4/2005	143	0	143	18.9	1063	0.22	12	31.1	4.32	2080	1309	1950	2	0.5	0.86	0.19
TF0402	10/4/2005	131	0	131	17.1	723	0.744	8.24	26.1	4.16	16.3	897	1360	9	20.2	31.75	6.32
TF040408	1/4/2006	852	0	852	90.2	1008	140	11.8	242	3.03	5550	1951	2750	44	NA	NA	NA

Appendix F: Water Quality Data

TF 03- Hysell Run

Mouth of Hysell Run

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0302	6/9/2003	9.82	6.96	2.86	0.25	185	0.18	1.07	1.50	6.04	529	198	344	33	4080.0	140.03	73.59
TF0302	8/25/2003	6.92	21.60	-14.68	1.01	267	0.59	1.41	3.01	6.85	719	236	497	8	457.3	-80.55	16.51
TF0302	10/23/2003	10.80	22.80	-12.00	0.76	274	0.64	1.57	2.98	6.86	766	290	525	8	568.0	-81.79	20.28
TF0302	4/5/2004	17.20	4.74	12.46	4.88	237	1.75	1.20	7.83	5.71	556	263	385	32	2301.7	344.14	216.26
TF0302	6/21/2004	43.50	1.25	42.25	4.78	420	0.94	2.37	8.09	4.64	897	400	706	3	365.3	185.23	35.45
TF0302	7/20/2004	47.60	0.00	47.60	5.46	449	0.58	3.25	9.29	4.39	980	482	718	7	227.3	129.83	25.33
TF0302	9/12/2005	36.4	0	36.4	2.24	538	0.833	4.250	7.323	4.45	1480	568	1050	10	5.54	2.42	0.49
AVERAGE		**22.64**	**9.56**	**13.08**	**2.86**	**305**	**0.78**	**1.81**	**5.45**	**5.75**	**741**	**312**	**529**	**15**	**1333.3**	**209.30**	**87.17**

Hysell Run mainstem and tributary mouths

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Tot metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0360	4/5/2004	4.17	78.40	-74.23	0.25	138	0.05	0.05	0.35	7.79	330	44.9	190	4	441.6	-393.33	1.85
TF031500	4/5/2004	6.09	125.00	-118.91	0.53	282	0.68	0.46	1.67	7.84	590	144	391	19	83.8	-119.58	1.68
TF031400	4/5/2004	5.84	41.00	-35.16	0.31	158	0.44	0.18	0.92	7.34	370	106	226	17	73.3	-30.93	0.81
TF031300	4/5/2004	86.80	0.00	86.80	9.95	260	2.10	1.95	14.00	3.64	698	325	507	8	66.1	68.85	11.10
TF0340	4/5/2004	8.91	60.60	-51.69	1.17	180	0.37	0.33	1.87	7.24	426	126	264	11	637.9	-395.70	14.31
TF031100	4/5/2004	125.00	0.00	125.00	14.10	301	4.45	1.88	20.43	3.31	914	397	601	6	171.0	256.50	41.92
TF0330	4/5/2004	12.30	39.10	-26.80	2.55	193	0.85	0.52	3.92	6.91	463	156	295	19	1011.5	-325.31	47.53
TF030800	4/5/2004	226.00	0.00	226.00	20.70	401	17.40	2.52	40.62	3.01	1320	580	868	3	92.0	249.50	44.84
TF030700	4/5/2004	6.80	4.39	2.41	0.31	183	0.21	1.03	1.55	5.95	419	177	290	9	16.5	0.48	0.31
TF030600	4/5/2004	127.00	0.00	127.00	15.60	400	3.06	2.43	21.09	3.45	996	500	728	2	46.9	71.48	11.87
TF0320	4/5/2004	10.40	19.50	-9.10	4.12	212	2.13	0.74	6.99	6.53	506	189	342	28	1284.4	-140.26	107.67
TF030400	4/5/2004	6.07	39.90	-33.83	0.53	193	0.48	0.22	1.23	7.31	444	147	282	23	31.0	-12.58	0.46
TF030300	4/5/2004	48.90	0.85	48.05	6.70	277	0.83	2.26	9.79	4.58	660	291	355	12	92.7	53.45	10.88
TF0310	4/5/2004	10.90	9.51	1.39	4.46	231	1.76	1.01	7.23	6.15	542	223	370	29	1964.0	32.76	170.40
TF0302	4/5/2004	17.20	4.74	12.46	4.88	237	1.75	1.20	7.83	5.71	556	263	385	32	2301.7	344.14	216.26

** Concentrations below laboratory detection

Hysell Run Sources

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net acid mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF031100	4/12/2004	231.00	0.00	231.00	25.10	315	10.90	2.48	38.48	2.82	1190	538	739	10	24.2	67.08	11.17
TF030800-HW	4/12/2004	116.00	0.00	116.00	15.30	393	1.90	2.45	19.65	3.28	1010	512	747	5	20.2	28.12	4.76
TF030800-3	4/12/2004	479.00	0.00	479.00	45.00	494	35.90	3.93	84.83	2.54	1930	947	1320	4	22.2	127.61	22.60
TF030800-1	4/12/2004	254.00	0.00	254.00	38.10	576	39.30	2.76	80.16	3.02	1480	748	1110	21	49.9	152.10	48.00
TF030800-2	4/12/2004	441.00	0.00	441.00	33.70	451	51.20	1.92	86.82	2.56	1820	897	1210	8	38.5	203.74	40.11
TF030800	4/12/2004	226.00	0.00	226.00	20.70	401	17.40	2.52	40.62	3.01	1320	580	868	3	92.01	249.53	44.85
TF030600-HW	4/12/2004	96.30	0.00	96.30	11.20	400	1.34	4.94	17.48	3.28	1030	577	753	6	16.5	19.07	3.46
TF030600-2	4/12/2004	395.00	0.00	395.00	45.80	602	17.10	4.2	67.10	2.80	1740	1004	1410	13	20.2	95.75	16.27
TF030600-1	4/12/2004	238.00	0.00	238.00	32.10	462	4.07	3.43	39.60	3.15	1260	706	1020	10	7.5	21.42	3.56
TF030600	4/12/2004	129.00	0.00	129.00	15.60	400	3.06	2.43	21.09	3.45	996	500	728	2	46.68	72.26	11.81

Appendix F: Water Quality Data

Hysell Run mainstem, tributary mouths, and sources
Sampled during Low Flow by Jen Bowman, Mike Gosnell, Raina Ooten, and Barb Flowers

LC ID#	Date	Acidity	Alkalinity	Net acid	Aluminum	Hardness	Iron	Manganese	Total metals	pH	Sp Cond	Sulfate	TDS	TSS	Discharge	Acid loads	Metal loads	Ferrous Iron
		mg/l	mg/l	mg/l	mg/l	mg CaCO3/l	mg/l	mg/l	mg/l		uS/cm	mg/l	mg/l	mg/l	gpm	lbs/day	lbs/day	mg/l
TF0340	9/12/2005	4.74	146	-141.3	0.05	353	0.123	0.184	0.357	7.55	993	225	615	8	0	0.00	0.00	
TF0330	9/12/2005	3.05	70.3	-67.3	0.05	618	0.05	0.054	0.154	7.75	1340	592	1020	11	0	0.00	0.00	
TF030800-HW	9/14/2005	495	0	495.0	39.1	691	46	2.410	87.51	2.72	2280	1235	1710	9	2.93	17.40	3.08	
TF030800-1	9/14/2005	569	0	569.0	59.5	929	19.8	5.150	84.45	2.74	2700	1531	2150	16	1.15	7.85	1.17	
TF030800	9/12/2005	403	0	403.0	41.9	736	9.79	4.860	56.55	2.78	2160	1169	1640	7	2.93	14.17	1.99	
TF0320	9/12/2005	7.93	7.42	0.5	0.754	673	0.569	3.980	5.303	5.84	1350	699	1090	17	10.3	0.06	0.66	
TF0310	9/12/2005	7.8	23.8	-16.0	0.05	666	0.49	2.000	2.54	6.36	1890	507	1270	13	8.98	-1.72	0.27	
TF0302	9/12/2005	36.4	0	36.4	2.24	538	0.833	4.250	7.323	4.45	1480	568	1050	10	5.54	2.42	0.49	
TF030200	2/6/2006	112	0	112.0	14.9	358	2.32	4.570	21.79	3.33	1050	504	661	<2.00	28.6	38.44	7.48	0.455

Appendix F: Water Quality Data

TF 02

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid Loads lbs/day	Metal Loads lbs/day
TF0202	8/25/2003	35.90	2.25	33.65	3.92	345	0.59	4.29	8.80	4.99	824	387	634	14	89.3	36.08	9.43
TF0202	10/23/2003	44.00	1.21	42.79	7.30	330	1.46	3.92	12.68	4.76	935	375	661	21	61.6	31.61	9.37
TF0202	6/21/2004	47.60	1.26	46.34	6.80	440	2.05	5.63	14.48	4.63	866	469	708	26	69.7	38.76	12.11
AVERAGE		**42.50**	**1.57**	**40.93**	**6.01**	**372**	**1.37**	**4.61**	**11.99**	**4.79**	**875**	**410**	**668**	**20**	**73.5**	**35.48**	**10.30**

TF 00 Thomas Fork Mouth

LC ID#	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm	Acid loads lbs/day	Metal loads lbs/day
TF0010	5/13/2003	5.77	30.50	-24.73	<0.25	183	0.34	1.33	1.91	6.86	515	174	336	40	15266.8	-4530.56	350.10
TF0010	6/10/2003	5.85	25.20	-19.35	<0.25	181	0.33	1.20	1.77	6.74	546	180	341	29	18208.5	-4228.02	386.09
TF0010	8/19/2003	5.25	22.00	-16.75	0.98	276	1.02	2.01	4.01	6.61	686	271	490	19	3388.3	-681.05	163.13
TF0010	10/23/2003	10.40	29.90	-19.50	1.32	250	1.39	1.87	4.58	6.88	739	248	482	15	4093.4	-957.87	224.98
TF0010-Dup A	6/21/2004	5.11	9.55	-4.44	1.78	326	1.28	2.04	5.10	6.28	706	307	513	7	3905.6	-208.09	239.03
TF0010-Dup B	6/21/2004	6.88	9.29	-2.41	1.93	333	1.43	2.04	5.40	6.40	709	307	509	12	3905.6	-112.95	253.09
TF0010 Dup-A	7/20/2004	52.90	0.00	52.90	6.45	428	0.29	3.34	10.08	4.35	983	469	709	11	1651.3	1048.26	199.68
TF0010-Dup B	7/20/2004	53.80	0.00	53.80	6.37	425	0.28	3.31	9.96	4.41	989	474	731	9	1651.3	1066.09	197.35
TF0010	8/22/2005	37.80	3.19	34.61	2.23	506	0.49	4.44	7.16	4.8	1150	553	870	3.0	NA	NA	NA
AVERAGE		**18.25**	**15.81**	**2.44**	**3.14**	**300**	**0.79**	**2.14**	**5.35**	**6.07**	**734**	**304**	**514**	**18**	**7752.3**	**-1075.52**	**251.68**

Appendix F: Water Quality Data

Thomas Fork

LC ID#	Location	Coordinates NAD27 (DeLorme)	Date	Acidity mg/l	Alkalinity mg/l	Net Acidity mg/l	Aluminum mg/l	Hardness mg CaCO3/l	Iron mg/l	Manganese mg/l	Total metals mg/l	pH	Sp Cond uS/cm	Sulfate mg/l	TDS mg/l	TSS mg/l	Discharge gpm
NA	Above mining in Thomas Fork	39 4 3.3 82 4 14.0	5/15/2001	3.89	118.00	-114.11	0.22	153	0.32	0.22	0.76	7.41	437	65	258	4	NA
NA	Above mining in Thomas Fork	39 4 3.3 82 4 14.0	7/3/2001	1.54	115	-113.46	0.272	145	0.324	0.181	0.777	7.74	386	41.2	202	8	1122
NA	First subhollow mined - Americar Legion	39 4 1.9 82 4 16.7	5/15/2001	7.54	59	-51.46	0.752	535	0.725	0.531	2.008	6.87	1070	480	807	26	NA
NA	First subhollow mined - Americar Legion	39 4 1.9 82 4 16.7	7/3/2001	2.78	53.8	-51.02	0.1	380	0.145	0.528	0.773	7.27	796	282	538	12	224
NA	Thomas Fork between American Legion and Little's	39 4 0.1 82 4 15.1	5/15/2001	4.91	112	-107.09	0.257	204	0.299	0.257	0.813	7.14	531	113	321	3	NA
NA	Thomas Fork between American Legion and Little's	39 4 0.1 82 4 15.1	7/3/2001	2.02	108	-105.98	0.471	172	0.385	0.185	1.041	7.62	461	59.3	248	32	1570
TF0071	NA		5/15/2001	4.88	76.00	-71.12	0.36	305	0.16	1.00	1.53	7.21	776	286	546	5	NA
TF0071	NA		7/3/2001	2.62	81.3	-78.68	0.549	252	0.318	0.66	1.527	7.47	665	187	414	10	1570

The samples and flows were taken by CTL Engineering of West Virginia. The flows were provided in cfs and were converted to gpm.
The measurements appear to be suspect, however, the chemistry provides a snapshot of Thomas Fork above the unnamed trib