WATERSHED ASSESSMENT AND REMEDIATION STRATEGY FOR ABANDONED MINE DRAINAGE IN THE UPPER TIOGA RIVER WATERSHED

Publication 230 *October 2003*

Prepared by
Jennifer Orr
Water Quality Specialist

Watershed Assessment and Protection Division
Susquehanna River Basin Commission

This report is prepared in cooperation with the Pennsylvania Department of Environmental Protection under Contract No. 350327.

SUSQUEHANNA RIVER BASIN COMMISSION

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

This report is available on our website (www.SRBC.net) by selecting Public Information/Technical Reports. For a CD Rom or for a hard copy, contact the Susquehanna River Basin Commission, 1721 N. Front Street, Harrisburg, Pa. 17102-2391, (717) 238-0423, FAX (717) 238-2436, E-mail: srbc@srbc.net.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACKNOWLEDGEMENTS

Funding for this study was provided through a grant from the Commonwealth of Pennsylvania's Growing Greener Program and matching funds from project partners. The Pennsylvania Department of Environmental Protection (Pa. DEP), Bureau of Abandoned Mine Reclamation (BAMR), provided sampling supplies and funding for analyses of all water quality samples collected at discharge points. The Tioga River Watershed Reclamation Projects, Inc., provided many hours of in-kind service in problem area identification. Additional in-kind services were provided by the Tioga County Conservation District.

The author would like to extend thanks to the following individuals:

Francis "Antek" Skolny, Hamilton Township Supervisor
Teresa Mahosky, Hamilton Township Supervisor
David Darby, Mansfield University
Ken Meyer, Mansfield University
Jim Lamonski, Hillside Rod & Gun Club
Charles Andrews, Tioga County Concerned Citizens Committee
Jason Weigle, formerly, Tioga County Conservation District
Terra Dillman, Tioga County Conservation District
John Backman, Mayor Blossburg
Todd Berguson, Berguson Trucking
Paul Otruba, Tioga River Watershed Reclamation Projects, Inc.
Brad Regester, Pa. Dept. of Natural Resources and Conservation (Pa. DCNR), Tioga State Forest
Todd Wood, Pa. DEP, BAMR Wilkes-Barre
J. Corey Cram, Pa. DEP, Hawk Run District Mining Office
Jennifer Means, Pa. DEP, Williamsport Regional Office
Joan Sattler, Pa. DEP, Williamsport, Regional Office
Ken Hughes, Blossburg citizen
Gary Dillman, U.S. Army Corps of Engineers, Tioga/Hammond Dam Complex
Andrew Gavin, Chief, Restoration and Protection Section, SRBC
Beth Dillon, Water Quality Chemist, SRBC
David Ladd, Water Management Contractor, SRBC
David Heicher, Chief, Watershed Assessment and Protection Division, SRBC
Darryl Sitlinger, Water Quality Technician, SRBC
Donna Gavin, GIS Analyst, SRBC
Holly Wolbert, formerly, GIS Technician, SRBC
Doreen McCabe, Administrative Specialist, SRBC
Kevin McGonigal, Water Quality Program Specialist, SRBC
Daryl Valley, Water Quality Intern, SRBC
Susan Obleski, Director of Communications, SRBC

EXECUTIVE SUMMARY

The Upper Tioga River Watershed in northcentral Pennsylvania is severely impacted by abandoned mine drainage (AMD) from Fall Brook to Bear Creek, impairing or eliminating aquatic life in approximately 13 miles of the mainstem extending downstream to the Tioga/Hammond Dam Complex. Other tributaries in the watershed show reduced pH due to non-AMD acidity sources, including tannins from natural headwaters wetlands and acid rain. Although AMD production will decline over time by depletion of the acid-forming minerals, this is a very slow process, particularly for underground mines, and significant impacts could continue for centuries without some form of abatement. The most common form of abatement is direct treatment of the AMD discharges by either active (chemical) or passive (wetland) systems. Other alternatives may include re-mining or land capping to limit infiltration on disturbed sites, alkaline addition to abandoned surface and underground mine works, streambed sealing to prevent infiltration to mine pools, or indirect treatment, such as increasing the alkalinity of reaches upstream of the AMD sources.

Local stakeholders have expressed a final goal of restoring the Tioga River to a natural ecological condition, with interim water quality and ecological improvements to the affected tributaries, contributing to the restoration of the mainstem. While the goal of complete ecosystem restoration may take decades to achieve through implementation of the recommendations of this study as funding and new technologies are made available, many other interim benefits would be realized with the progressive treatment of the mine drainage pollution. These include increased recreational opportunities and revenues in the watershed and at the Tioga/Hammond Complex, increased aesthetic value of the river (decreased staining), decreased maintenance costs for bridges and other man-made structures, and increased benefits to potable water supplies.

Under a Pennsylvania Growing Greener Grant, the Susquehanna River Basin Commission (SRBC) undertook a water monitoring program in 2001 and 2002 to identify and sample the primary sources of AMD in the watershed and collect instream data to characterize its impact on the mainstem and major tributaries. As part of the grant, the SRBC retained Gannett Fleming, Inc. to develop conceptual treatment plans for the identified AMD sources and prepare a progressive restoration plan for the watershed. The monitoring program identified 36 AMD features in the Upper Tioga River Watershed; 20 were flowing and able to be sampled within the study period. Based on field review, Gannett Fleming determined that a number of the AMD sources could be combined in common treatment systems for an economy of scale, resulting in ten treatment plans covering three combined and seven individual treatment systems. For each plan, conceptual passive and chemical system designs were prepared using the Tarco Technologies, Inc. Watershed Restoration Analysis Model (WRAM v1.2), which generated conceptual component sizing requirements, construction cost estimates, operation and maintenance cost estimates, 15-year present values, and construction area requirement estimates. The more appropriate of the two treatment alternatives was selected based on construction area constraints, cost considerations, and ability of the technologies to meet water quality goals. Following development of the conceptual treatment plans, another component of WRAM was used to predict the downstream water quality improvements that could result from implementing these plans and to guide development of the progressive restoration plan.

Analyses determined that treatment efforts on Fall Brook and Johnson Creek would yield the greatest benefit/cost ratio, and would be the best starting points for restoration efforts, followed by Morris Run, and finally the combined watersheds of Coal and Bear Creeks. If fully implemented, the conceptual treatment activities would cost about $9.3 million to construct, $2.6 million per year to operate, and have a 15-year present value of $41 million. This equates to about $130,000 per stream mile per year for 8.4 miles of tributaries and 13.1 miles of mainstem, or 21.5 miles of total stream improvements throughout the watershed. These costs are specific to the construction, operation, and maintenance of the selected treatment alternatives over a 15-year projection period. There are a number of other factors that could not be predicted at this level of assessment, including property acquisition, access development, electric service, and design and permitting costs. The conceptual construction costs include a 25 percent contingency to estimate these factors, but the ultimate costs of implementing the individual treatment projects may be greater than stated.

The WRAM modeling showed that treatment of AMD acidity alone may not result in consistently net alkaline conditions in Fall Brook or the Tioga River mainstem below its confluence due to the presence of the non-AMD acidity sources. The slightly acidic, low-metals flows in the headwaters of Fall Brook and Morris Run, and found in Fellows Creek, McIntosh Hollow, and Taylor Run, are ideal for passive treatment, which would benefit the overall restoration efforts at a comparatively low cost. Based on findings from other projects, net alkaline conditions could be restored in these streams using vertical flow wetlands, or other passive technologies. Current estimates to implement vertical flow wetland treatment in the headwaters of Fall Brook and Morris Run would cost $560,000 and $340,000, respectively. Non-AMD acidity treatment also may be necessary on additional tributaries to fully restore the Tioga River mainstem to net alkaline conditions.

PURPOSE

This report was prepared using funds from the Commonwealth of Pennsylvania's Growing Greener Program. The report is the result of a study to determine the extent and severity of mine drainage from abandoned surface and underground mining in the Upper Tioga River Watershed. Conceptual restoration plans to eliminate or treat these sources of mine drainage are recommended as a means to restore water quality to public use in the Tioga River and its tributaries. Cost estimates and priority rankings for abatement alternatives are provided.

GENERAL INFORMATION

Location

The Tioga River Watershed is located in Tioga and Bradford Counties about 35 miles north of Williamsport, Pennsylvania (Figure 1). The river originates in Armenia Township, Bradford County and travels southwest towards the town of Blossburg, flowing through the Northcentral Bituminous Coalfield. In Blossburg, the Tioga changes direction, flowing north through Mansfield and into Tioga Lake at the Tioga/Hammond Dam Complex. After exiting the Tioga/Hammond Dam Complex, the Tioga River flows into New York to its confluence with the Cohocton River to form the Chemung River.

Physical Characterization

The portion of the Upper Tioga River Watershed under investigation in this study encompasses an area of 402 square miles; including all the watershed area of the Tioga River and Crooked Creek upstream of the outlet of the Tioga/Hammond Dam Complex[1]. From its headwaters in Bradford County, the Tioga River flows southwest a distance of about 14 miles to Blossburg. In Blossburg, the Tioga River changes direction and flows north for a distance of about 17 miles to the outlet of Tioga Lake.

The Upper Tioga River Watershed can be divided into two distinct regions based on physiographic province, underlying geology, and land use. The upper region (from Marvin Creek upstream to the headwaters) lies in the glaciated high plateau section of the Northcentral Appalachian physiographic province (Figures 2 and 3). The topography of the section consists of forested hilltops with steep, narrow valleys. Its underlying geology is dominated by Mississippian and Devonian sandstones, along with deposits of Pennsylvanian Age coals. Forested land, mostly northern hardwoods, makes up a large percentage of the watershed in this region. Much of the land is managed by the Pa. DCNR as part of the Tioga State Forest.

---

[1] The total area of the Tioga River Watershed to its confluence with the Cohocton River to form the Chemung River near Corning, New York, is 1,391 square miles; it is 58 miles in length.

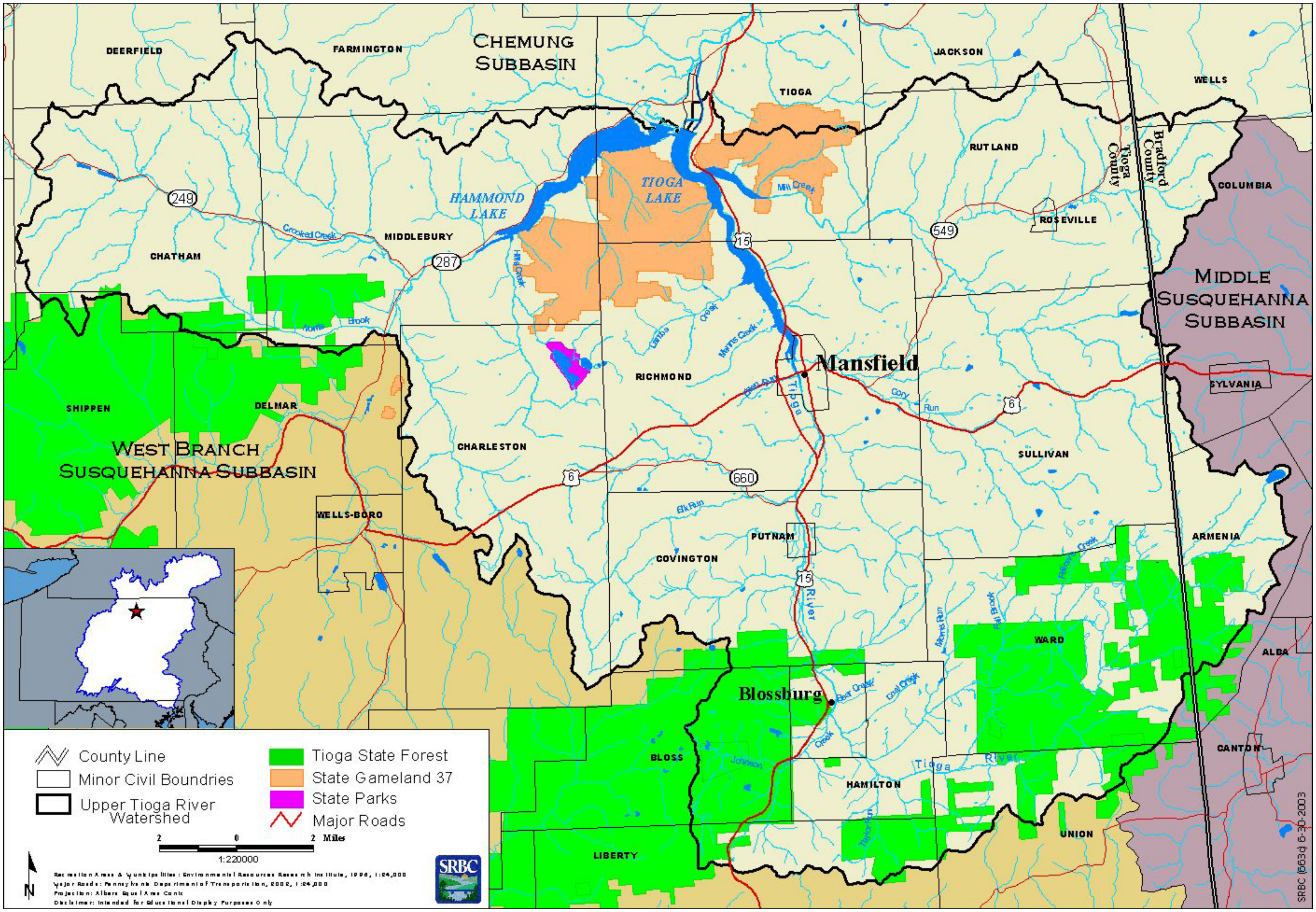

Figure 1. Upper Tioga River Watershed Location

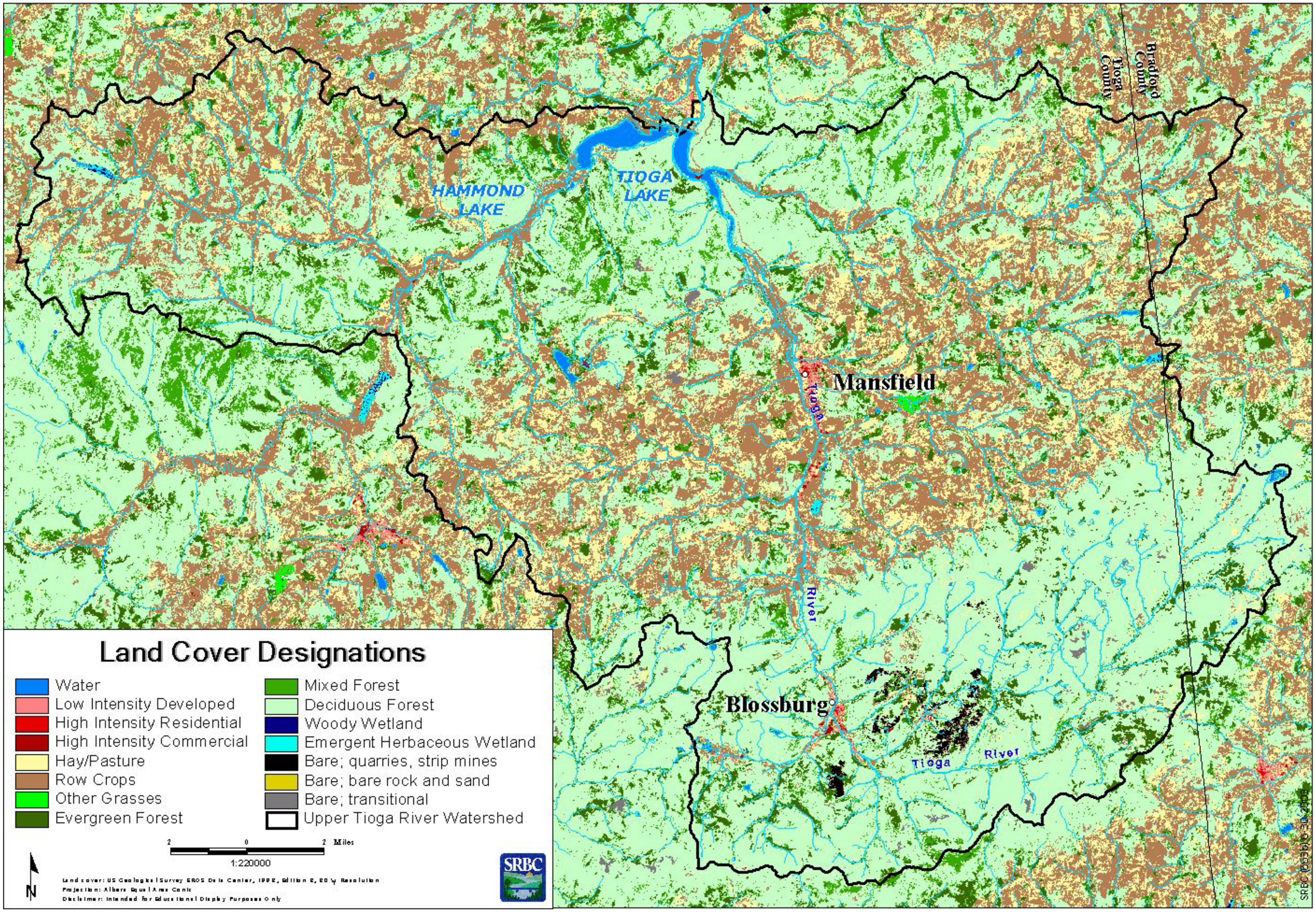

Figure 2. Land Use in the Upper Tioga River Watershed

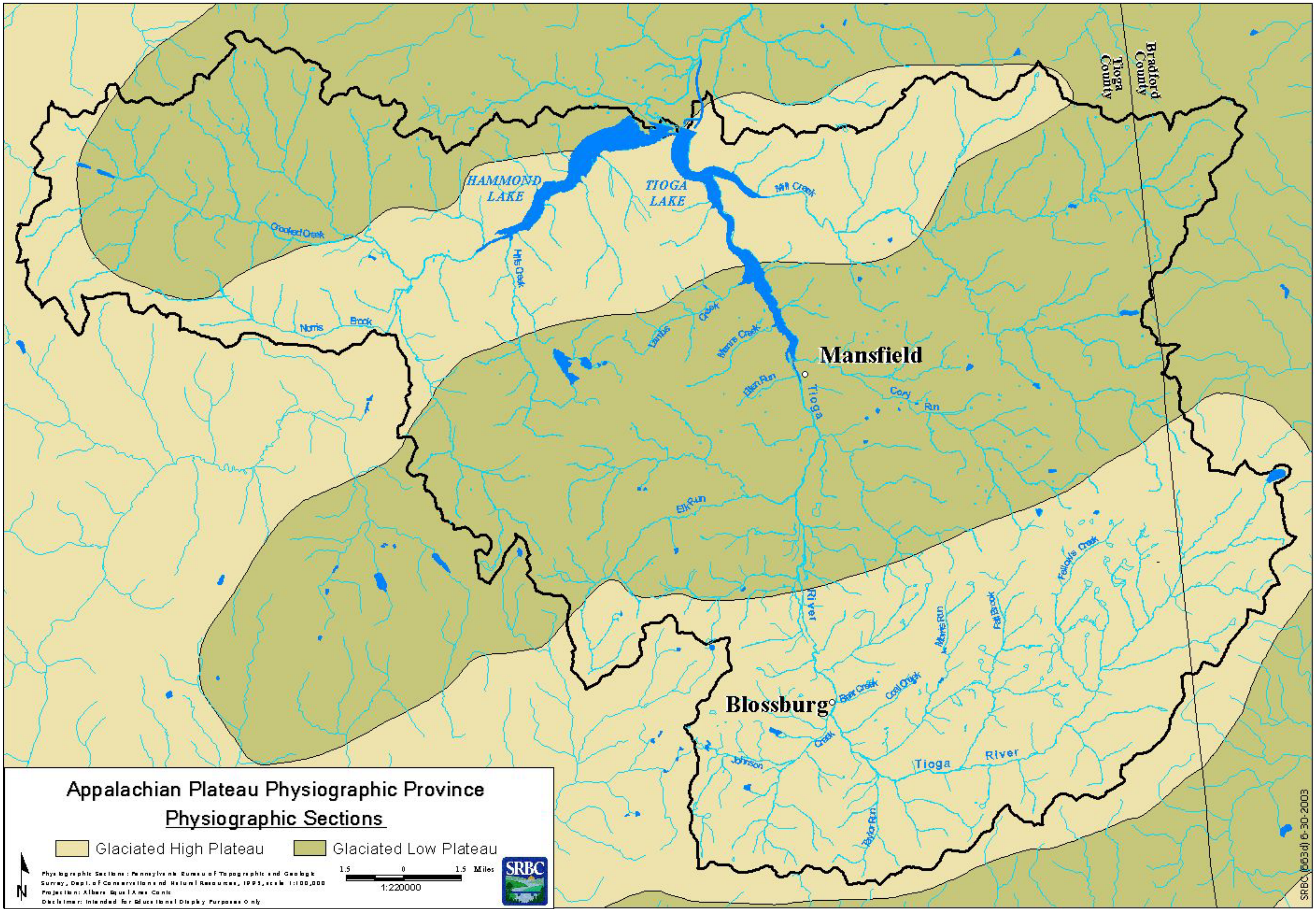

Figure 3. Appalachian Plateau Physiographic Province Designations in the Upper Tioga River Watershed

Reclaimed and abandoned surface mines and small population centers such as Blossburg, Arnot and Morris Run make up most of the remaining uses in the region. Many of the dwellings in this region of the watershed are used as seasonal or recreational dwellings.

The lower region (from Marvin Creek downstream to the Tioga/Hammond Complex) lies in the glaciated low plateau section of the Northern Appalachian Plateau physiographic province. In contrast to the topography of the upper region, the lower region consists of low, rolling hills with gentle slopes. The underlying geology is dominated by sandstones, siltstones, claystones, shales, and conglomerates of the Devonian Age. The lower region is a mosaic of pasturelands, croplands, and fields, with forested ridge tops. No mining uses occur in this region. The major population center of the watershed, Mansfield, is located in this region, along with other smaller population centers.

Demographic Characterization

According to the U.S. Census Bureau, Tioga County had a population of 41,373 in 2000, 0.34 percent of the population of the Commonwealth of Pennsylvania (U.S. Census Bureau, 2000). Although there are urban centers in the county (Mansfield, Blossburg, Wellsboro), only 16 percent of the population is considered urban, with the remaining 84 percent considered rural. Thus, it is considered a rural county by the U.S. Census designation, with a population density of 36.5 persons per square mile. The county is predominantly Caucasian (98 percent). Retired or disabled individuals constitute a large portion of the populace with 41 percent of the population aged 16 or older not included in the workforce. Industrial occupations consist of manufacturing (24 percent); education, health, and social services (22 percent); and retail trade (12 percent). Median household income is $32,020, lower than the state average household income of $40,106; per capita income is $15,549, also lower than the state average of $20,880. Poverty status is slightly higher in Tioga County with 9 percent of families, 28 percent of female households with no male present, and 13.5 percent of individuals living below the poverty line. This can be compared to the state average of 8 percent of families, 25 percent of female households with no male present, and 11 percent of individuals. Median property values are lower than the state average, $72,000 for the county compared to $97,000 for the state. However, a much larger percentage of housing units in Tioga County are for seasonal, recreational, or occasional use (15 percent compared to 3 percent). Ward Township in particular, with a total population of 128, contains 72 percent of housing units for seasonal, recreational, or occasional use.

Mineral Resources History and Characterization

Coal was discovered in the Tioga River Watershed near Blossburg in 1792, with the first deep mine opening in the Bear Creek Watershed between 1812 and 1815.[2] Settlement of the area was strongly driven by coal mining. The towns of Arnot, Morris Run, Blossburg, and Fall Brook (no longer existent) were all settled as coal mining communities; these towns were large enough to have their own amateur sports teams and have other characteristics of a large community. Coal mining was the primary industry in the upper section of the Tioga River

[2] More information on the history of coal mining in the watershed is available in Swisick 1994, Wellsboro Gazette 1932, and at www.Blossburg.com.

Watershed throughout the 18- and 1900s. Deep mining began in the Morris Run Watershed in 1853, in the Fall Brook Watershed in 1859, and in the Johnson Creek Watershed in 1865. Fall Brook, which exists as a few seasonal camps today, once supported a population of 2,300 (Swinsick, 1994). Morris Run once had a population of 2,500 and was so crowded that houses were built on stilts across Morris Run (Wellsboro Gazette, 1932). Arnot had a population of 3,500-4,000, the largest in Tioga County at the time (Boyer Kantz & Associates, 1976). Deep mining was the predominant form of mining in the watershed with its peak in 1886 with 1.4 million tons of coal produced from Tioga County deep mines (U.S. Army Corps of Engineers, 1977). At the turn of the century, production from deep mines in Tioga County began to decline as a result of increased production in other parts of Pennsylvania where coal was more economically mined. Starting around WWII, surface mining increased coal production until the early 1980s, when it began to again decline. Mining eventually ceased in 1990.

Six coal seams are present in the Upper Tioga River Watershed, four of which were mined. Table 1 lists the coal seams in stratigraphic order and gives their positions relative to the Bloss Coal, the major seam mined in the area. The coal seams occur as partially eroded layers overlying the ridge-forming Pottsville sandstone on the relatively flat mountaintops of a steeply-sided plateau. The coal seams are found in the Blossburg Syncline, which extends northeastward from Johnson Creek to Fellows Creek. All coal seams in the study area are close to the surface; the Bloss seam is only 250 feet below surface at its maximum depth (Gannett Fleming Corddry & Carpenter, Inc., 1968). Most of the coal seams are equivalent to coal seams of the Allegheny Group of the Pennsylvania System (Edmunds and others, 1979). It is possible that the lowest coal seam, Bear Creek, may be correlated with the Mercer Coal of the Pottsville Group; however, most studies identify it as the Brookville coal seam. All coal seams in the area have associated acid-producing materials (Gannett Fleming Corddry & Carpenter, Inc., 1968). Precise correlations between the coals of Tioga County and the standard named coals of western Pennsylvania have not been made due to disconformities, local dynamics, and faults; this has caused numerous inconsistencies in detailed stratigraphy and nomenclature.

Table 1. Stratigraphic Order of Coals in the Upper Tioga River Watershed

Coal Seam	Other Designation	Correlates With	Interval Above or Below Bloss Coal, Feet	
			Average	*Range*
Rock	E	Upper Freeport	+170	150-180
Seymour	D	Lower Freeport	+120	110-160
Morgan	C', Cannel – lower split only	Upper Kittanning	+80	70-100 indicated
Cushing	C, Foot	Middle Kittanning	+40	20-60
Bloss	B, Bear Creek – lower split only	Lower Kittanning	0	0
Bear Creek		Brookville (Mercer?)	-30	20-45

The bituminous coal region is generally characterized by mining of coal seams that lie in horizontal layers. When deep mining began in the watershed, entries (usually drifts) into the mines were dug from below the then-existing groundwater table. To keep the mines from filling with water, drifts were planned and dug to allow water to drain by gravity out of the mine using the naturally occurring geological dip in the Blossburg syncline. Barrier pillars used to separate different mines were used minimally. Thus, water entering one mine could travel for many miles downhill collecting drainage from many other mine areas along the drainage path before discharging in large volumes from a common opening as AMD. This type of deep mine drainage can be particularly difficult to treat with current passive treatment technologies. The problem is amplified due to extensive fracturing of overburden materials and subsidence into underground voids, creating a conduit for surface run-off and groundwater to enter mine workings.

In addition to water entering mine workings through methods mentioned previously, unreclaimed surface mines and infiltrating stream reaches create additional problems. Often these surface mines have open pits and other features that retain precipitation, groundwater, and surface run-off. Due to fractures in the bottom of the pits or through a direct connection to deep mine workings, much of this retained water infiltrates into the underlying deep mine workings. If the surface mines are not connected to the deep mine workings, mine drainage may discharge as surface overflows or seepage directly into surface streams. Many of the surface mined areas in the watershed have been reclaimed since the 1970s, but some pre-Act[3] areas have not. Four undermined stream reaches throughout the watershed lose flow by infiltration into deep mine workings through fractures in their channels.

Water Resource Characterization

The upper region of the Tioga River Watershed (from Blossburg upstream to Fall Brook) is severely impacted by both AMD and non-AMD acidity (impaired streams are shown in red in Figure 4). Historical studies identified the source of much of the AMD as originating from gravity discharge of abandoned deep mines in the Morris Run, Coal Creek, and Bear Creek Watersheds. Johnson Creek was identified as being moderately impacted by mining activities and AMD in earlier studies. However, Johnson Creek was cited as a major source of oil and coal fines to the Tioga River, neither of which were observed in the course of this study. Fall Brook was mentioned in reports in the early 1970s as being mildly impacted by AMD; however, the AMD in Fall Brook produced little to no documented effect on the Tioga River. In the late 1970s, a co-operative fish hatchery operated by the Hillside Rod and Gun Club using water from the Tioga River experienced a severe fish kill. Investigations found that the AMD in Fall Brook had worsened significantly, impacting both Fall Brook and the Tioga River between their confluence and Morris Run. The Pa. DEP Statewide Surface Water Assessment Program (formerly the Unassessed Waters Program) identified additional watersheds as being impaired by AMD, including the Fellows Creek Watershed. However, the current study determined that some of these watersheds are not impacted by AMD, but rather organic acids and/or atmospheric deposition.

---

[3] The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land or water resources, and pubic health and safety from the adverse effects of current surface coal mining operations, as well as promote the reclamation of mined areas left without adequate reclamation prior to August 3, 1977. Unreclaimed mines that ceased operating by the effective date of SMCRA (pre-Act or pre-Law) are considered abandoned and, in Pennsylvania, become the responsibility of the Commonwealth.

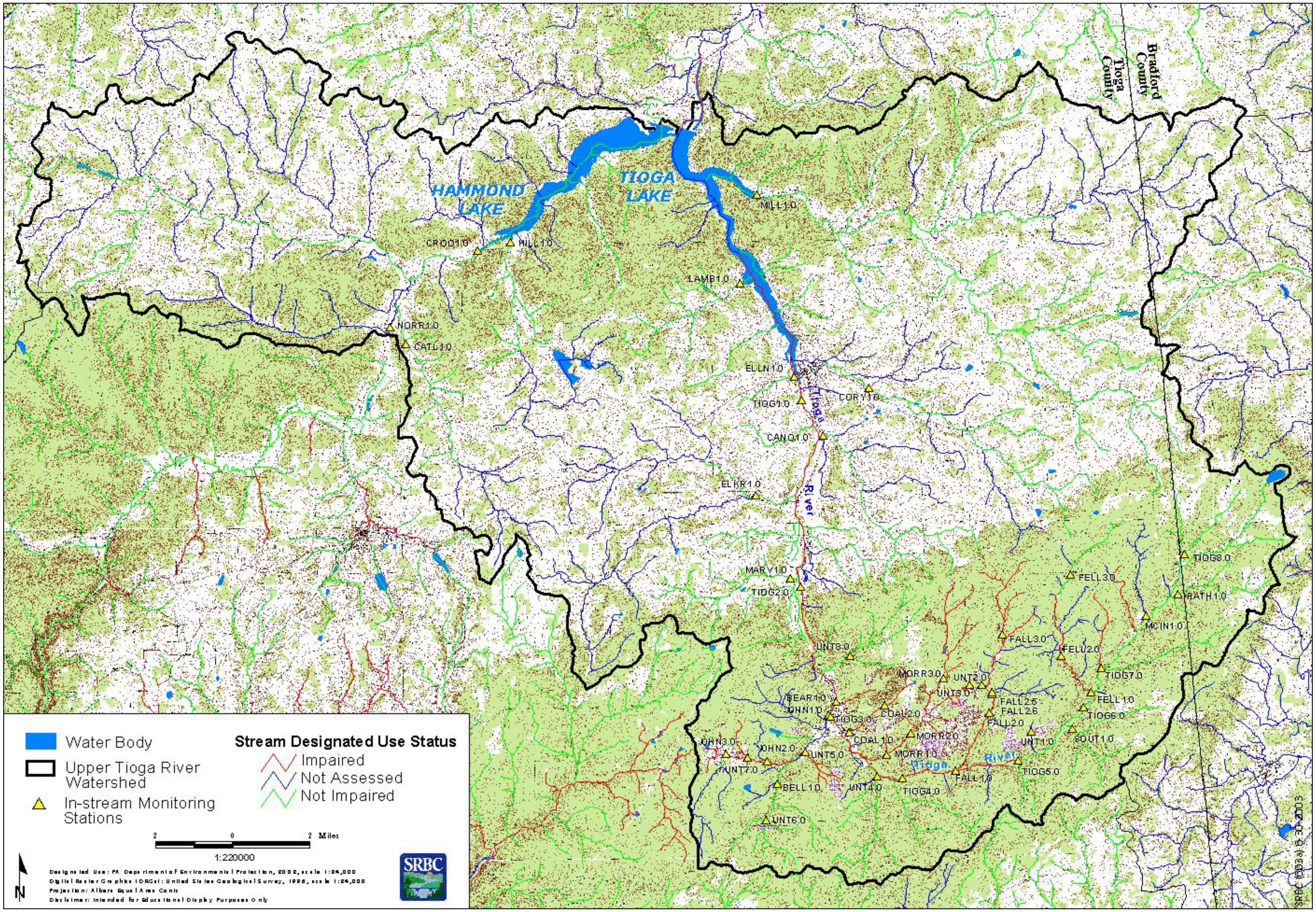

Figure 4. Use Attainment Status for Stream Reaches in the Upper Tioga River Watershed

Many of the tributaries in the headwaters of the watershed are small and intermittent; some originate in wetland areas. The headwaters of Fall Brook, Morris Run, and Fellows Creek, in addition to other tributaries that flow into the Tioga River from the north, are impacted by low pH due to tannic (organic) acids produced by extensive wetland areas in these watersheds, and by atmospheric deposition. Often, tannic acid causes the stream water to take on a deep orange hue that, without close inspection, can easily be mistaken for iron precipitates. Reaches impacted by non-AMD acidity possess low concentrations of metals and sulfates, and low conductivity (the combination of which are generally elevated in cases where impairments are due to AMD) but high concentrations of total organic carbon (TOC). Although TOC was not measured in this study, previous researchers have documented its elevation in the watershed (Hughey, 1993; Moase and others, 1999). Poorly buffered soils and cation leaching from soils due to the extremely low pH of precipitation in northern Pennsylvania provide little buffering capacity (alkalinity and acid neutralizing capacity) to streams (U.S. Environmental Protection Agency, 1999; Sharpe and Drohan, 1999). In addition to acidity, soils impacted by acid deposition also frequently leach toxic aluminum into streams. The combination of low pH and elevated aluminum concentrations, even episodically, precludes fish from inhabiting these streams. Gannett Fleming, Inc. determined that 25 percent of all the acidity in the watershed was not attributable to AMD but to these other sources (Rightnour and Hoover, 2003).

Many studies have been conducted to assess biological communities present in the Tioga River Watershed. As early as 1939, a Pennsylvania Fish and Boat Commission (PFBC) study noted that Morris Run contributed AMD to the Tioga River (Moase and others, 1999). In a U.S. Geological Survey (USGS) investigation previous to the construction of the Tioga/Hammond Dam Complex, the Tioga River was devoid of life from Morris Run to Crooked Creek, and was a recovering, but impaired, system all the way to the confluence with the Canisteo River in New York (Barker, 1971). In a 1993 aquatic biological investigation of the Tioga River headwaters, the macroinvertebrate community of the Tioga River was found to be severely impaired downstream of Fall Brook due to AMD (Hughey, 1993). The PFBC conducted an examination of the Upper Tioga River Watershed in 1999 and found no fish in Fall Brook, Morris Run, Coal Creek, Bear Creek, Fellows Creek, and McIntosh Hollow (Moase and others, 1999). In Pennsylvania, the entire Tioga River Watershed and all of its tributaries are classified as cold water fisheries (Commonwealth of Pennsylvania, 1999). Rathbone Creek and South Creek in the Tioga River headwaters were found to support Class A[4] wild brook trout populations. Rathbone Creek, South Creek, Coon Creek, Taylor Run, Dibble Run, Bellman Run, Long Run, and Frost Hollow were all recommended by the PFBC to be upgraded to high quality cold water fisheries based on excellent water quality, naturally reproducing fisheries, and/or use as a public water supply (Moase and others, 1999).

The mine drainage in the Tioga Watershed occurs in the upper one half of its length above the Tioga/Hammond Dam Complex; however, AMD impairs the Tioga River downstream to Tioga Lake, causing problems with both pH and metals (Figure 5a). The U.S. Army Corps of Engineers (USACE) operates the Tioga/Hammond Dam Complex, constructed in 1978 and filled

[4] Class A Wild Brook Trout fisheries are those that have: (1) total brook trout biomass of at least 30 kg/ha (26.7 lbs/acre); (2) total biomass of brook trout less than 15 cm (5.9 inches) in total length of at least 0.1 kg/ha (0.089 lb/acre); and (3) brook trout biomass must compromise at least 75 percent of the total trout biomass. Class A Wild Trout Fisheries represent the best naturally reproducing trout fisheries and are managed with no stocking.

in 1981, as a flood control and recreational project (Kulp and Pisarski, 1994). Tioga Lake impounds the Tioga River and controls a drainage area of 280 square miles; Hammond Lake impounds Crooked Creek and controls a drainage area of 122 square miles. Due to the degraded state of the water entering Tioga Lake, water from Hammond Lake, which is alkaline, must be mixed with the Tioga Lake water through a 2,700-foot connecting channel and released through multiple-elevation outlet gates before being discharged downstream as the Tioga River (Figure 5b). Studies completed in 1974, before construction, determined that the best abatement alternative would be to implement a suite of preventative measures throughout the watershed to reduce the volume of AMD produced and then build two chemical treatment plants to treat the remaining AMD (U.S. Army Corps of Engineers, 1977). However, this initiative was not funded and implementation was not initiated. To manage the degraded water entering Tioga Lake, a detailed operations plan was created by staff at the complex to ensure that water quality standards were being met downstream of the dam (U.S. Army Corps of Engineers, 1986). However, this plan took many years to develop and multiple fish kills occurred in both the Tioga River and Tioga Lake (U.S. Army Corps of Engineers, 1986). The USACE states that remediation of the mine drainage at its source would produce positive economic benefits for the operation of the Tioga/Hammond Complex by removing the source of impairment to Tioga Lake, while also restoring portions of the Tioga River and its tributaries (U.S. Army Corps of Engineers, 1986).

WATERSHED INVESTIGATION

Methods of Investigation

Initial investigation of the watershed included collection of all preexisting data, identification of mining-related problem areas, and establishment of a stream monitoring network. All pertinent USGS topographic maps, aerial photographs, mine maps, mining permits, and historical reports and records were reviewed. The watershed boundary was outlined and the study area divided into subwatersheds for separate investigation. Areas identified as impaired on Pennsylvania's Section 303(d) list (Pa. DEP, 2003) were delineated and targeted for field sampling. SRBC staff developed a volunteer-oriented problem area identification protocol and training manual for identifying mining-related problem areas for use by local stakeholders. Volunteers from the Tioga River Watershed Reclamation Projects, Inc. were trained in problem area identification. During spring through fall 2001, all AMD-impacted streams and the Tioga River mainstem from Bear Creek to the County Bridge Picnic Area (TIOG6) were walked to define sources of AMD and other mining-related problem areas. Discharge waters were identified and roughly characterized in the field. The field characterization included a test of pH and conductivity using portable meters, flow measurement (using portable flumes or buckets) or estimation, and completion of a problem area inventory checklist. Global Positioning System (GPS) measurements were taken at each problem area identified for entry into a GIS for mapping and analysis. During spring 2001 through fall 2002, field examination and verification of previously documented mining features was conducted.

Figure 5a. Aluminum Hydroxides in Water Column at Southern End of Tioga Lake

Figure 5b. Channel Connecting Tioga Lake and Hammond Lake to Allow Mixing

Water quality sampling points were established at two types of features: (1) instream monitoring stations at various points along streams and the river in the watershed (Figure 4), and (2) AMD discharge monitoring stations located at the groundwater/surface water interface where water was discharging (Figure 6). GPS measurements were taken at each monitoring station for entry into a GIS for mapping and analysis. Instream monitoring stations were chosen based on location above and below major impacted tributaries and discharges, at intervals along mainstem segments, and in areas necessary to show reference conditions and sources of alkaline loads. Instream monitoring stations were sampled six times, at least once in each season from spring 2001 through summer 2002. Discharge monitoring stations were chosen based on the results of the problem area identification inventory. The 20 worst stations, determined by either low pH or high volume or a combination of both, were chosen to be sampled to collect data necessary for use in the Gannett Fleming, Inc. conceptual treatment model. The chosen discharges were sampled at least six times from April through October 2002, including both low and high flow conditions. Discharges known to be major pollution sources based on historical reports were included in the instream sampling as well, allowing these discharges to be sampled up to 12 times. Some discharges were not able to be sampled six times due to: (1) their intermittent nature (only flowed in periods of high groundwater saturation) or (2) their late identification and inclusion in the sampling program. Discharges that were identified through the problem area inventory but not intensively sampled were determined to be contributing very small percentages of the pollutant loads to the watershed.

After the monitoring station network had been established, water quality sampling was initiated. Standard field and laboratory USEPA-approved quality assurance procedures were followed. Field water quality measurements included water temperature, dissolved oxygen, conductivity, and pH. Samples of water from each site were collected for laboratory analysis. Laboratory samples consisted of one 500 ml bottle for whole sample analysis, one 250 ml bottle for metals analysis, and one 250 ml bottle for ferrous iron analysis. The samples for metals analysis were fixed with nitric acid (HNO_3); samples for ferrous iron analysis were fixed with hydrochloric acid (HCl). All samples were chilled on ice and shipped within 24 hours to the Pa. DEP Bureau of Laboratories in Harrisburg, Pa., for analysis. Parameters analyzed for each type of laboratory water quality sample can be found in Table 2; acceptable ranges for selected parameters in AMD-impacted waters can be found in Table 3.

Stream flow was measured at all sampling sites using USGS standard methods for discharge measurement. A Scientific Instruments Pygmy-Type (or AA-Type) current meter was used to measure velocity at all instream stations; a top-set wading rod was used to measure stream depth. Tioga River flows at TIOG1 were recorded at the USGS gauge at Mansfield (#01516350); all other mainstem points (TIOG2-8) were calculated using linear regression based on discharge at TIOG1 and drainage area. A Marsh McBirney Digital Current Meter was used to measure velocity at all discharge stations except DMR001 and DFB100; a top-set wading rod was used to measure stream depth. A Marsh McBirney current meter and customized wading rod were used to measure flow at site DMR001 and a bucket was used to measure flow at site DFB100 due to unique physical features at these sites. Weirs were existent at a few discharge locations, but were not used to measure flow due to disrepair.

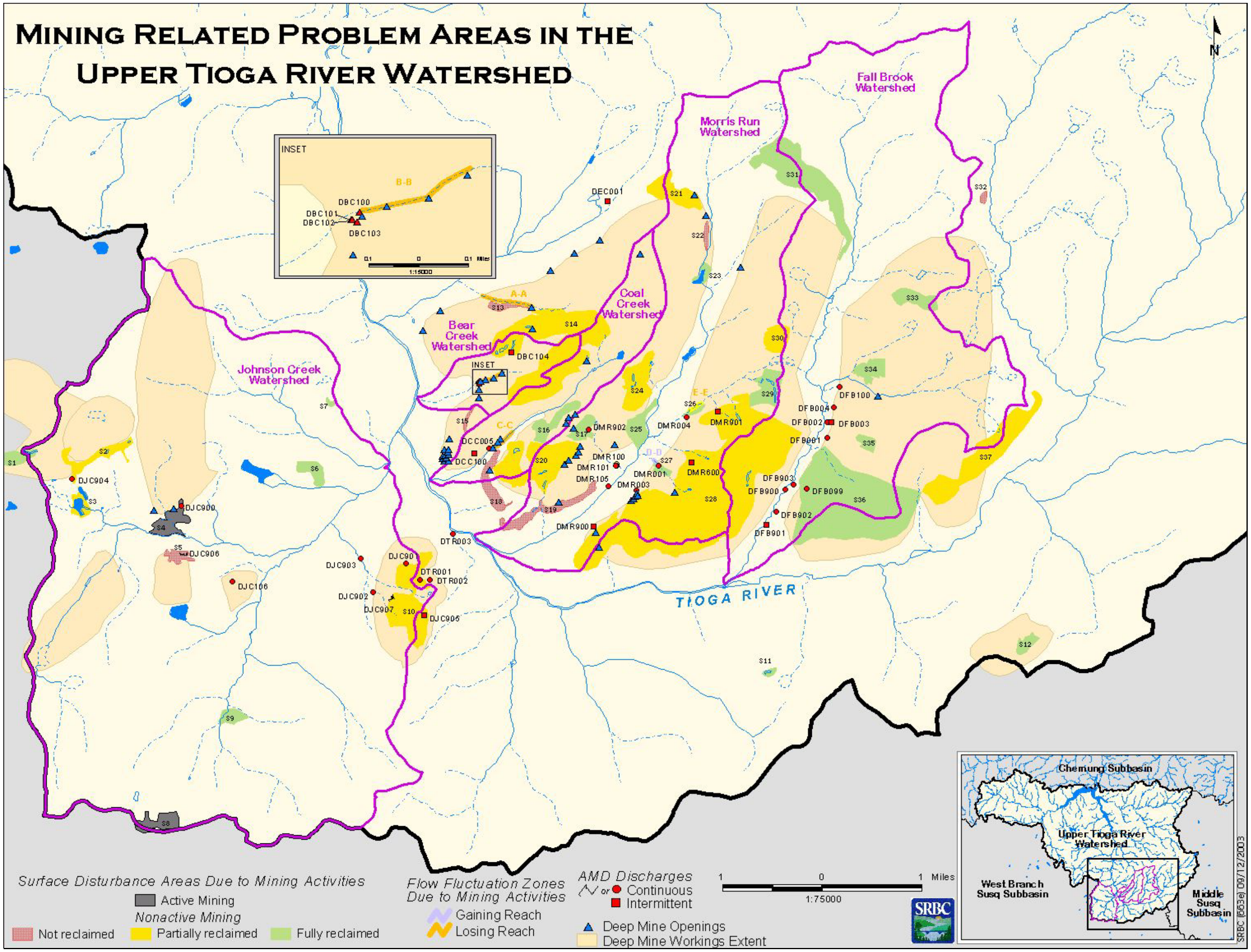

Figure 6. Mining Related Problem Areas in the Upper Tioga River Watershed

Table 2. Laboratory Water Quality Parameters Analyzed

Monitoring Station Type	Parameters Analyzed	Measurement Units
Instream	pH Hot Acidity Alkalinity Total Iron Total Manganese Total Aluminum Total Sulfates Total Calcium Total Magnesium Total Dissolved Solids	Standard Units (SU) Milligrams/liter (mg/l) Milligrams/liter (mg/l) Micrograms/liter (µg/l) Micrograms/liter (µg/l) Micrograms/liter (µg/l) Milligrams/liter (mg/l) Milligrams/liter (mg/l) Milligrams/liter (mg/l) Milligrams/liter (mg/l)
Discharge	pH Hot Acidity Acidity Alkalinity Total Iron Ferrous Iron Total Manganese Total Aluminum Total Sulfates Total Hardness	Standard Units (SU) Milligrams/liter (mg/l) Milligrams/liter (mg/l) Milligrams/liter (mg/l) Micrograms/liter (µg/l) Micrograms/liter (µg/l) Micrograms/liter (µg/l) Micrograms/liter (µg/l) Milligrams/liter (mg/l) Milligrams/liter (mg/l)

Table 3. Significant Physical, Chemical and Biological Parameters Used in Evaluating Mine Drainage Pollution of Streams[5]

Parameter	Range of Values of Concern	Major Water Use(s)	Usual Values in Unpolluted Waters	Pa. DEP Water Quality Standard[6]
pH	Less than 6.0	Aquatic life	6.0-9.0	6.0-9.0
Acidity	Sufficient to lower alkalinity below 20 mg/l	Aquatic life	Less than alkalinity	Less than alkalinity
Alkalinity	20 mg/l	Aquatic life	20 mg/l	20 mg/l (except where naturally lower)
Sulfates	250 mg/l	Domestic, industrial water supply	20 mg/l	250 mg/l
Hardness	250 mg/l	Domestic, industrial water supply	150 mg/l	150 mg/l
Total Iron	1.0 mg/l	Aquatic life, domestic and industrial water supply	0.3 mg/l	1.5 mg/l
Manganese	1.0 mg/l	Aquatic life, domestic and industrial water supply	0.05 mg/l	1.0 mg/l
Suspended Solids	250 mg/l	Aquatic life	100 mg/l (except during storm flow)	

The results of the watershed investigation were interpreted based on the location, concentration, and magnitude of mine drainage discharges; the topographical conditions in the area; and costs. Abatement methods and possible alternatives were considered; evaluation

[5] Source – *Stream Pollution by Coal Mine Drainage in Appalachia*, 1969, Federal Water Pollution Control Administration.
[6] Source – Pennsylvania Code, Title 25. Environmental Protection, Department of Environmental Protection, Chapter 93. Water Quality Standards. 1999, Commonwealth of Pennsylvania

placed emphasis on maximum stream improvement at minimum cost per pound of acid abated. Priorities for abatement were established using the cost-effectiveness ratio as well as other criteria such as: overall cost of reclamation, miles of stream improvement, the probability of abatement success, the potential and probability of future mining, as well as the aesthetics of each project area.

Results of Investigation

The results of the watershed investigation indicate that only three subwatersheds (Coal Creek, Bear Creek, and Johnson Creek) and the Tioga River are being affected by AMD from abandoned surface and underground mining. These watersheds include streams that are listed on the Clean Water Act Section 303(d) list of impaired waters of the Commonwealth (Pa. DEP 2003). Three watersheds (Fellows Creek, McIntosh Hollow, and Taylor Run) are chronically or episodically acidified by non-AMD sources (organic acids, atmospheric deposition). Two watersheds (Fall Brook and Morris Run) are being impacted by a combination of both AMD and non-AMD acidity. AMD impacts alone represent a conservative loss of $287,000 per year of fishery resources in the Tioga River and many of its tributaries (Arway, 1995)[7].

Mining-related problem areas summary

1. *Sources of abandoned mine drainage*
   Thirty-six mine drainage discharge points to surface streams exist in the watershed. The locations of all mine discharge points are shown in Figure 6. A description of each mine discharge point can be found in Table 4.
2. *Deep mine openings*
   Fifty-five deep mine entries exist in the watershed. The locations of deep mine openings are shown in Figure 6. A description of each deep mine opening can be found in Table 5. Also presented in Table 5 are the mine drainage discharge points with which the entries communicate.
3. *Surface mined areas*
   Thirty-seven surface mined areas exist in the watershed. The locations of all surface mined areas are shown in Figure 6. A description of each surface mined area can be found in Table 6.
4. *Stream flow fluctuation zones*
   Five areas of stream flow fluctuation exist in the watershed. Stream fluctuation zones are defined in this report as reaches of stream that are gaining or losing flow based on the influence of mining activities. Gaining reaches are most likely the result of an AMD discharge, while losing reaches are the result of stream flow loss to underground voids created by deep mining activity. The locations of all stream flow fluctuation zones are shown in Figure 6. A description of each fluctuation zone can be found in Table 7.

[7] Economic analysis was completed in 1995 using stream miles known at that time to be impaired by AMD. Since that time, many additional stream miles have been added to the list of AMD-impaired streams. Due to the increase in stream miles from 1995 to the present in the Tioga River Watershed, the loss figures given are a very conservative monetary estimate of the total fishery loss.

Table 4.   Abandoned Mine Discharge Points in the Upper Tioga River Watershed

Discharge Point	Source of Drainage	Type of Discharge
DBC100	Deep Mine	Continuous
DBC102	Deep Mine	Continuous
DBC103	Deep Mine	Intermittent
DBC104	Surface Mine	Intermittent
DCC005	Deep Mine	Continuous
DCC100	Deep Mine	Continuous
DEC001	Surface Mine	Intermittent
DFB099	Deep Mine	Continuous
DFB001	Deep Mine	Continuous
DFB002	Deep Mine	Continuous
DFB003	Deep Mine	Intermittent
DFB004	Deep Mine	Continuous
DFB100	Deep Mine	Continuous
DFB900	Groundwater Seep	Continuous
DFB901	Groundwater Seep	Intermittent
DFB902	Groundwater Spring	Continuous
DFB903	Groundwater Seep	Continuous
DMR001	Deep Mine	Continuous
DMR003	Deep Mine	Continuous
DMR004	Deep Mine	Continuous
DMR100	Deep Mine	Continuous
DMR101	Deep Mine	Continuous
DMR105	Groundwater Seep	Continuous
DMR600	Surface Mine	Intermittent
DMR900	Deep Mine	Continuous
DMR901	Surface Mine	Intermittent
DMR902	Deep Mine	Continuous
DTR001	Surface Mine	Continuous
DTR002	Surface Mine	Continuous
DJC106	Deep Mine	Continuous
DJC900	Deep Mine	Continuous
DJC901	Deep/Surface Mines	Continuous
DJC904	Deep Mine	Continuous
DJC905	Deep/Surface Mines	Continuous
DJC906	Deep Mine	Continuous
DJC907	Deep/Surface Mines	Continuous

* DBC101, DTR003, DJC902 and DJC903 (shown in Figure 6) are aggregations of upstream discharge waters and are not locations of actual abandoned mine discharges.

Table 5. Deep Mine Entries Identified in the Upper Tioga River Watershed

Deep Mine Entry Number	Type of Entry	Coal Seam Mined	Discharge Point With Which Entry Communicates
1	Slope	Bloss	DCC005
2	Drift	Bloss	DCC005
3	Drift	Bloss	DCC005
4	Drift	Bloss	DCC005
5	Drift	Bloss	DCC005
6	Drift	Bloss	DBC100, DBC102
7	Drift	Bloss	DBC100, DBC102
8	Drift	Bloss	DCC005
9	Drift	Seymour	DCC005
10	Drift	Seymour	DBC100, DBC102
11	Drift	Cannel	DBC100, DBC102
12	Drift	Bloss	DBC100, DBC102
13	Drift	Bloss	DBC102
14	Drift	Bloss	DCC005
15	Drift	Morgan	DCC005
16	Drift	Bear Creek	DCC100
17	Drift	Bear Creek	DCC100
18	Drift	Bear Creek	DCC100
19	Drift	Bloss	DCC005
20	Drift	Bloss	DCC005
21	Drift	Cannel	DCC005
22	Drift	Bloss	DCC005
23	Drift	Bloss	DCC005
24	Drift	Cannel	DCC005
25	Drift	Bloss	DCC005
26	Drift	Cannel	DCC005
27	Drift	Bloss	DCC005
28	Drift	Cannel	DCC005
29	Drift	Bloss	DCC005
30	Drift	Bloss	DCC005
31	Drift	Rock	DCC005
32	Drift	Rock	DCC005
33	Drift	Rock	DCC005
34	Drift	Rock	DCC005
35	Drift	Bloss	DCC005
36	Drift	Bloss	DCC005
37	Drift	Bloss	DMR004
38	Drift	Morgan	DCC005
39	Drift	Bloss	DMR003
40	Drift	Morgan	DMR003
41	Drift	Morgan	DMR003
42	Drift	Morgan	DMR003
43	Drift	Morgan	DMR003
44	Drift	Bloss	DCC005
45	Drift	Bloss	DMR900
46	Drift	Bloss	DMR900
47	Drift	Seymour	DMR001
48	Drift	Bloss	DFB004
49	Drift	Bloss	DJC900
50	Drift	Bloss	DJC900
51	Drift	Morgan	DCC005, DMR100-101
52	Drift	Morgan	DCC005, DMR100-101
53	Drift	Morgan	DCC005, DMR100-101
54	Drift	Morgan	DCC005, DMR100-101
55	Drift	Bloss	DCC005

Table 6. Areas of Surface Disturbance Due to Mining Activities Identified in the Upper Tioga River Watershed

Area Number	Coal Seam(s) Affected	Area Affected, square miles	Connection to Deep Mines	MD Discharge Point With Which Surface Area Communicates
S-1	Seymour	0.04	Indirect	In Babb Creek Watershed
S-2	Seymour	0.06	Indirect	DJC904, DJC900
S-3	Refuse Pile	0.04	*	DJC904
S-4	Refuse Pile	0.07	*	DJC900
S-5	Refuse Pile	0.02	Precipitation	DJC906
S-6	?	0.04	*	*
S-7	?	0.01	*	*
S-8	None Gravel Mine	0.06	*	*
S-9	?	0.03	*	*
S-10	Bloss, Morgan	0.22	Direct, Indirect	DJC901, DJC903, DJC907?, DTR001, DTR002
S-11	?	0.01	Precipitation	*
S-12	?	0.03	Precipitation	*
S-13	Bloss	0.02	Direct	DBC100, DBC102, DCC005
S-14	Morgan, Seymour, Rock	0.57	Direct, Indirect	DBC100, DBC102, DBC104, DCC005
S-15	Morgan	0.01	Direct	DCC005
S-16	Seymour, Rock	0.06	Precipitation	DCC005
S-17	Seymour, Rock	0.04	Precipitation	DCC005
S-18	Bloss	0.06	Indirect	DCC005
S-19	Bloss	0.08	Direct	DCC005
S-20	Morgan, Seymour, Rock	0.24	Precipitation	DMR100-101, DCC005
S-21	Bloss	0.09	Direct	DCC005
S-22	Bloss	0.01	Precipitation	DCC005
S-23	Bloss	0.02	Precipitation	DCC005
S-24	Seymour	0.12	Precipitation	DCC005
S-25	Bloss, Cannel	0.06	Precipitation	DCC005
S-26	Refuse Pile	0.01	*	*
S-27	Refuse Pile	0.01	*	*
S-28	Bear Creek, Bloss, Cannel, Morgan, Seymour	1.53	Precipitation	DMR004, DMR901, DMR001, DMR003, DMR900
S-29	Seymour	0.08	Precipitation	UNT3.0
S-30	Seymour	0.06	Precipitation	UNT3.0
S-31	Bloss, Cannel, Morgan	0.29	Precipitation	DMR004
S-32	Seymour	0.01	Indirect	*
S-33	Cannel, Morgan	0.06	*	*
S-34	Cannel, Morgan	0.05	*	*
S-35	Morgan, Seymour	0.02	Precipitation	DFB001, DFB002
S-36	Bloss, Morgan, Seymour	0.77	Precipitation	DFB099
S-37	Seymour	0.27	Indirect	DFB002, DFB003

* Direct connection - deep mine workings visible; indirect connection–apparent infiltration from bottom of pit; precipitation–groundwater infiltration into underlying deep mine workings

Table 7. Areas of Stream Flow Fluctuation Due to Mining Activities in the Upper Tioga River Watershed

Infiltration Area	Length, Feet	Losing or Gaining Reach	MD Discharge Point with Which Infiltration Area Communicates
A-A	2,700	Losing	DBC100
B-B	1,255	Losing	DBC100, DCC005
C-C	1,465	Losing	DCC005
D-D	390	Gaining	DMR001
E-E	772	Losing	DMR004

Subwatershed conditions

Streams in the Upper Tioga River Watershed can be classified into three different categories: (1) non-AMD acidified streams; (2) AMD acidified streams; and (3) non-acidified streams. Streams in the non-AMD acidified category are those streams which are average net acidic but have low levels of conductivity, metals, and sulfates, indicating a non-AMD acidity source. Streams in the AMD acidified category are those streams which are average net acidic with high levels of conductivity, metals, and/or sulfates, indicating an AMD acidity source. Streams in the non-acidified category are those that are not contained in the other two categories. These streams are generally net alkaline with low levels of metals and sulfates.

Non-AMD Acidified Streams - Fellows Creek, McIntosh Hollow, Taylor Run

Fellows Creek is a medium sized watershed that has been minimally impacted by past mining activities. Small areas of surface mining, one unreclaimed, are located in the middle and lower reaches of the stream. However, field investigation of the watershed found no water quality impacts to Fellows Creek from mining. Despite the absence of mine drainage impacts, Fellows Creek is a chronically acidified stream year-round and does not support a healthy macroinvertebrate or fish community (Moase and others, 1999). The acidity in the Fellows Creek Watershed is attributable to two sources: tannic acid and acid deposition. Large portions of the Fellows Creek Watershed are plateau wetlands with beaver activity. Beaver dams impound the water in Fellows Creek, creating large wetland areas. Decaying organic materials in these wetlands break down into organic acids causing a lowering of pH and an increase in total organic carbon (TOC), giving the water a reddish-orange hue. Past studies have noted that the upper Tioga River and its tributaries are naturally low pH, low conductivity, and high TOC streams, sometimes with a deep orange color, especially during times of low flow (Hughey, 1993; Moase and others, 1999). This condition was observed during the summer of 2002 when Fellows Creek appeared visually to be impacted by AMD due to its color but did not show the chemical characteristics of AMD. USEPA documented that rain in Pennsylvania can have a pH of as low as 4.3 due to acidification from atmospheric pollution originating from anthropogenic sources (power-plants, automobile exhaust, etc.) (U.S. Environmental Protection Agency, 1999). Rains with these low pH levels falling on soils that contain very little buffering capacity create acidic groundwater recharge to streams and cause stream pH levels to become chronically acidified (U.S. Environmental Protection Agency, 1999; Sharpe and Drohan, 1999). The acid inputs from these two sources are enough to create and maintain a chronically acidified condition in the Fellows Creek Watershed. Remediation activities directed at increasing stream pH levels would be necessary for Fellows Creek to establish and maintain a healthy aquatic community.

McIntosh Hollow and the unnamed tributary to Taylor Run (UNT4.0), although much smaller streams, are very similar in chemical characteristics to Fellows Creek. Similar remediation techniques would be necessary for a healthy aquatic community to exist in these streams. However, due to their size and the extremely high gradient of the unnamed tributary to Taylor Run, it is unlikely that they would support a fish community even with remediation.

AMD Impacted Streams - Fall Brook, Morris Run, Coal Creek, Bear Creek, Johnson Creek

Fall Brook

Fall Brook (Figure 7), an 8.9-square-mile watershed, is largely forested but was intensively deep and surface mined in its lower two-thirds, with small areas of residential development in the upper one-third. There are multiple major sources of AMD in the watershed, with a few additional minor sources. These discharges cause severe to very severe impacts from monitoring station FALL2.5 to the mouth. Above FALL2.5, there are no AMD impacts; however, the upper portions of Fall Brook are impacted by tannic acids and acid deposition. Due to this combination of impacts, Fall Brook is net acidic along its entire length and supports no fish (while the upper portions above FALL2.5 may be able to support acid-tolerant macroinvertebrate communities) (Moase and others, 1999).

Deep mining was conducted in the Fall Brook Watershed from 1859 to the early 1900s, with an estimated 4.95 million tons of coal removed from the watershed by 1904 (Swinsick, 1994). The town of Fall Brook, which exists as a few seasonal camps today, once supported a population of 2,300 (Swinsick, 1994). Mine drainage emerges from six sources in the watershed, all draining deep mine workings located below FALL2.5. In addition, contaminated stream recharge from impacted groundwater sources adds additional small amounts of AMD to Fall Brook in its lower reaches (DFB900-903). In addition to deep mining, surface mining was conducted extensively throughout the watershed. This surface mining sometimes cut into the abandoned deep mine workings below, causing them to form a hydraulic connection, increasing infiltration and thus the volume of AMD produced. If the surface mining did not directly connect the deep and surface mine workings, it significantly increased the rate of infiltration of precipitation into groundwater and, subsequently, into deep mine workings. All of the surface mined areas in the watershed have been at least minimally reclaimed (pits filled in, surfaces regraded, and vegetation planted). One surface mined area discharges AMD to Fall Brook during periods when the groundwater table is elevated; however, this discharge was only sampled once during the course of this study due to the absence of water and is considered a very minor source of AMD (sampled at monitoring station UNT2.0). Between FALL2 and FALL1, Fall Brook receives input from the largest and most severe discharge in the subwatershed, DFB099, which likely drains from or close to the abandoned Fall Brook Drift #1.

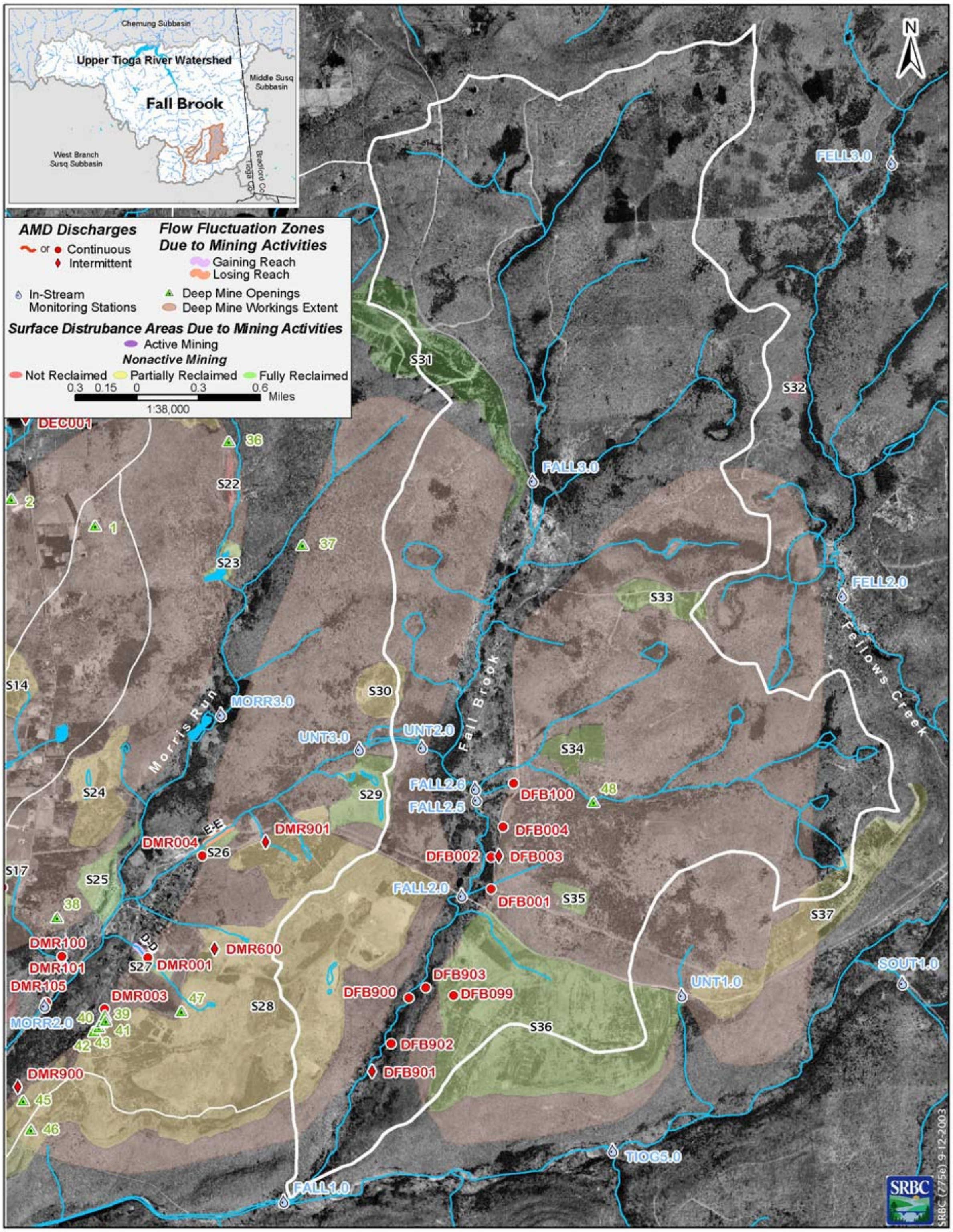

Figure 7. Mining Problem Area Features in the Fall Brook Watershed

Morris Run

Morris Run (Figure 8), a 7-square-mile watershed, is largely forested in its headwaters, with residential development in the village of Morris Run in its lower reaches. There are multiple major sources of AMD in the watershed, with additional minor sources also identified. Above MORR3 (above the Morris Run Reservoir), AMD impacts are not present; however, the upper portions of Morris Run are impacted by acid deposition and possibly tannic acid which causes them to be chronically acidified. USACE documented in the early 1970s that Morris Run above the reservoir lost significant amounts of its flow into underground mine workings through an unreclaimed surface mine, which was subsequently discharged as AMD at DCC005 (U.S. Army Corps of Engineers, 1972). Reclamation done in 1975 reclaimed the surface mine and restored the stream channel, resulting in a 15 percent reduction in flow and 10 percent reduction in acid loads at DCC005 (Miorin and others, 1979). During periods of low flow, Morris Run above the confluence with the DMR004 unnamed tributary is sometimes dry. Due to the combination of acidic impacts, Morris Run is net acidic along its entire length, often dry above the influence of large mine discharges in its lower reaches, and supports no fish (Moase and others, 1999), while Morris Run above MORR3 may be able to support acid-tolerant macroinvertebrate communities.

Deep mining was conducted in the Morris Run Watershed from 1853 to 1962, with an estimated 25 million tons of coal removed by 1931 (Wellsboro Gazette, 1932). Many entrances into the deep mines were located along both the eastern and western hillsides around the village of Morris Run. Due to the geological dip and the configuration of the deep mine workings, precipitation falling on sections of the western Morris Run Watershed contributes to mine drainage in the Coal Creek Watershed through DCC005. Between the Morris Run Reservoir and the SR2024 bridge, Morris Run receives drainage from three major deep mine discharges: the Lake Mine Discharge (DMR004), the East Mine Discharge (DMR001) and the Tioga Mine Discharge (DMR003). The Lake Mine Discharge drains the Lake Mine deep mine complex which underlies the watershed from eastern Morris Run to western Fall Brook. It is located behind the pallet factory in the village of Morris Run and is the largest volume discharge in the Morris Run Watershed. The unnamed tributary to Morris Run that runs parallel to the boundary of the reclaimed area near the Lake Mine loses flow as it travels the length of the reclaimed area (stream flow fluctuation zone E-E). It is assumed that this water contributes to the AMD volume at DMR004. The East Mine Discharge drains the East Mine deep mine complex underlying portions of the Morris Run and Fall Brook Watersheds. Historical reports document two mine openings and a refuse dump present in the area behind Saint Joseph's Catholic Church (U.S. Army Corps of Engineers, 1972; Gannett Fleming Corddry & Carpenter, Inc, 1968; U.S. Environmental Protection Agency, 1979). The discharge presently originates from a pipe in the reclaimed area (completed in 1990) behind the church. Downstream of the piped outlet, the discharge channel is lined with rip-rap. Flow volumes increase from the pipe opening to the end of the reclaimed area (stream flow fluctuation zone D-D). The increase in volume is most likely caused by fractures in the stream bottom allowing flow from the second mine opening that was in the area prior to reclamation to be added to the stream. This flow fluctuation zone was not discovered until late in the study, so the water quality data collected characterize only the discharge from the piped opening. The Tioga Mine Discharge drains the Tioga Mine deep mine complex underlying portions of the Morris Run and Fall Brook Watersheds. It originates from the bottom of a refuse pile below a series of mine openings at the end of Tioga Street in the village of Morris Run. Morris Run also receives drainage from some other minor

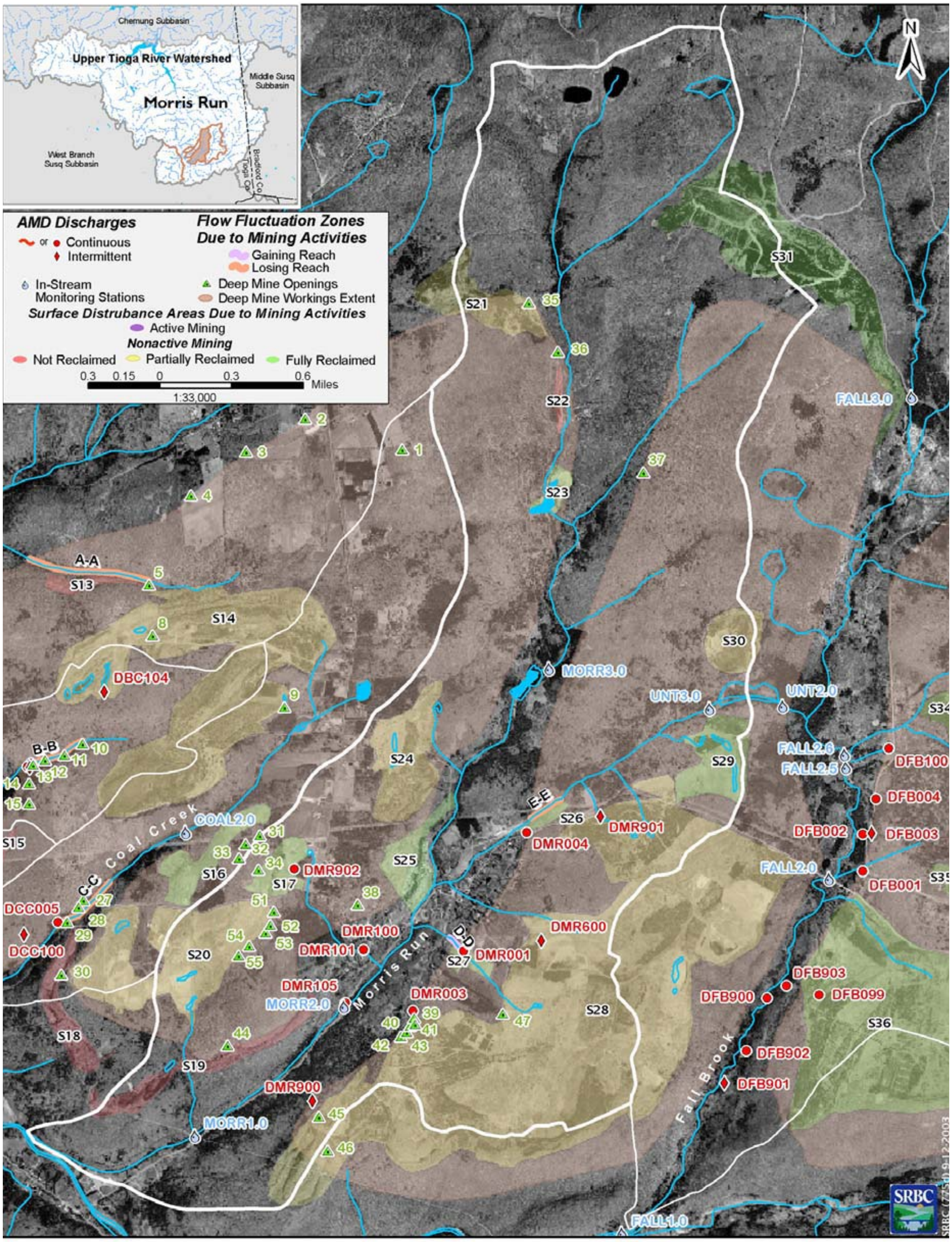

Figure 8. Mining Problem Area Features in the Morris Run Watershed

discharges in this segment, mostly along its western hillsides. Under low flow conditions, Morris Run is made up entirely of mine discharge water downstream of the confluence with the DMR004 unnamed tributary.

In addition to deep mining, surface mining was conducted extensively throughout the watershed. This surface mining sometimes formed a hydraulic connection to the abandoned deep mine workings below, increasing infiltration and thus the volume of AMD produced. If the surface mining did not directly connect the deep and surface mine workings, it significantly increased the rate of infiltration of precipitation into groundwater and subsequently into deep mine workings. Most of the surface mined areas in the watershed have been at least minimally reclaimed (pits filled in, surfaces regraded); however, many are still in need of more complete reclamation, including vegetation establishment. Two surface mined areas discharge AMD to Morris Run during periods when the groundwater table is elevated; however, these discharges were only sampled once during the course of this study due to the absence of flow and are insignificant sources of AMD (sampled at monitoring stations UNT 3.0 and DMR600).

Many projects have been conducted in the Morris Run Watershed to reclaim abandoned surface mined areas. Extensive surface reclamation of 27 acres was conducted to seal an existing mine opening, stabilize stream banks, and grade, shape, and vegetate an abandoned area near the Lake Mine entry (DMR004). Reclamation was completed by the Rural Abandoned Mine Program (RAMP) through the U.S. Department of Agriculture in 1982 at a cost of $138,000. Extensive surface reclamation of 21 acres was conducted to seal an existing mine opening, install subsurface drainage to create one discharge area, remove a refuse area, and grade, shape, and vegetate an abandoned area near the East Mine entry (referred to by USDA as the Church Site) (DMR001). Reclamation was completed by the RAMP program in 1990 at a cost of $133,000. Extensive surface mine reclamation of 40 acres was conducted to remove the Morris Run Coal Company tipple and remaining buildings, stabilize stream banks, and grade, shape, and vegetate a site in the middle of the village of Morris Run (referred to by USDA as the Jones Foundation Site). Reclamation was completed by the RAMP program in 1981 at a cost of $332,000. Surface mine reclamation of 7 acres was conducted to stabilize grades with structural timber cribbing and rock fill, stabilize stream banks, install subsurface drainage, and grade, shape, and vegetate another site in the middle of the village of Morris Run. Refuse banks at this site had previously burned and pieces of “red dog” (burnt refuse materials) the size of large cars were eroding from the site into Morris Run. Reclamation was completed by the RAMP program in 1981 at a cost of $192,000. In addition to the RAMP reclamation, additional pre-Act surface mined areas in the watershed were reclaimed by the Jones & Brague Mining Company.

Coal Creek

Coal Creek (Figure 9), a 1.6-square-mile subwatershed, is largely disturbed due to past mining activities. Much of the upper half of the watershed has been extensively surface and deep mined. Although most of the surface mines have been reclaimed, areas of pre-Act surface mining still exist. Almost the entire Coal Creek Watershed has been undermined, including portions of Coal Creek itself, allowing infiltration of stream water into underlying mine workings, contributing to AMD. Coal Creek above COAL2 represents the watershed area upstream of the Mohawk Lane crossing. Water quality data at this point show Coal Creek to be

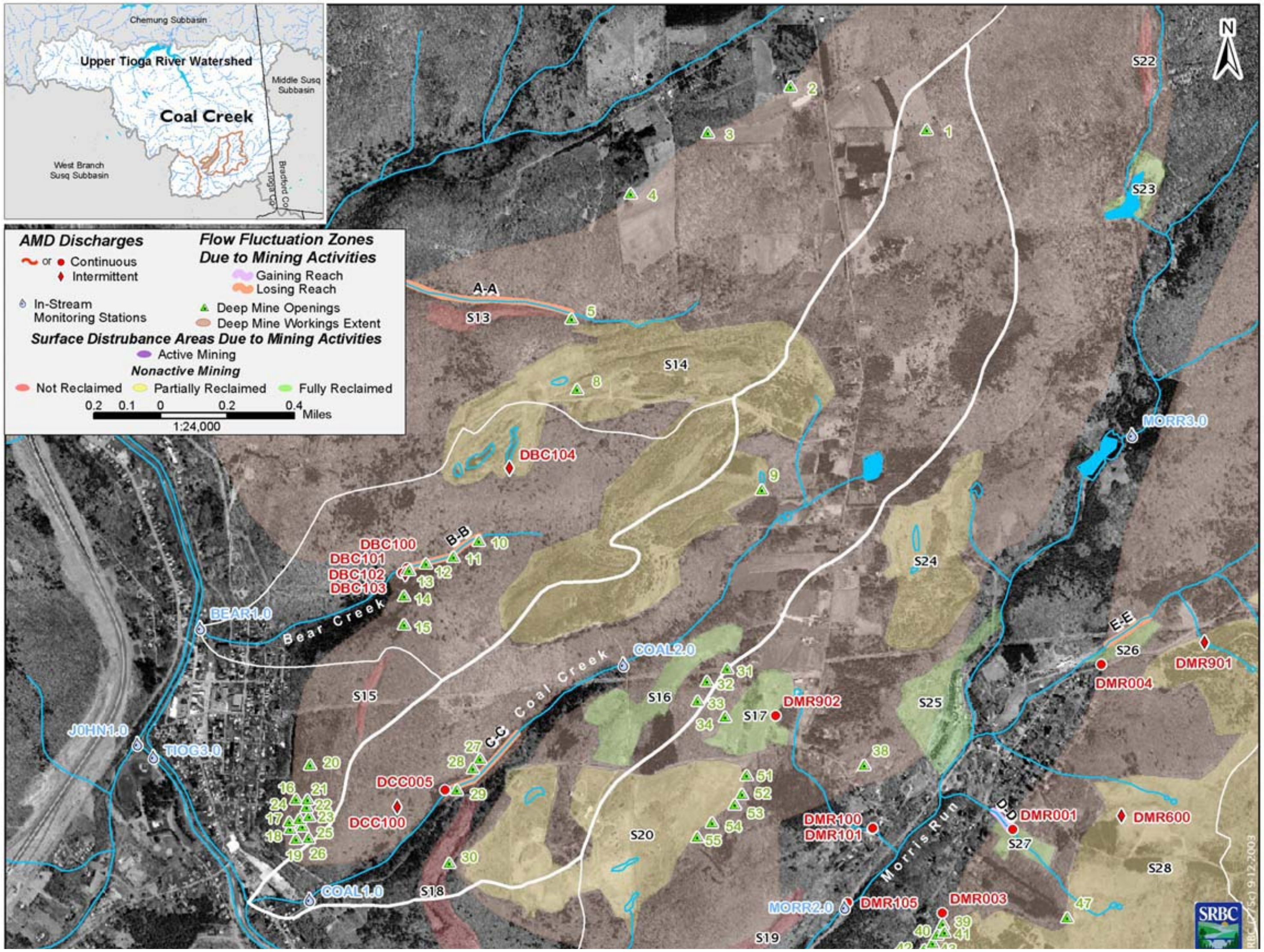

Figure 9. Mining Problem Area Features in the Coal Creek Watershed

minimally impacted by AMD. Approximately one-half mile downstream, DCC005 drains into Coal Creek. DCC005 is the largest volume discharge in the Tioga River Watershed and has the most degraded water quality; it is responsible for an average 45 percent of the total acidity load to the Tioga River (Rightnour and Hoover, 2003). It drains from an opening at the end of a railroad spur into a deep, steeply-sided ravine. According to historical reports, the underground watershed created by the deep mine workings for this discharge is almost twice the area of the topographical watershed, and extends significantly into the neighboring Morris Run Watershed (U.S. Army Corps of Engineers, 1972). Between points COAL2 and DCC005, Coal Creek loses most of its flow into underlying mine workings through fractures in the streambed and often is dry (stream flow fluctuation zone C-C). Much of the flow lost in this segment is assumed to re-emerge as AMD at DCC005. Below DCC005, Coal Creek receives drainage from one other small deep mine discharge (DCC100).

In addition to deep mining, surface mining was conducted extensively throughout the watershed. This surface mining sometimes cut into the abandoned deep mine workings below, increasing infiltration and thus the volume of AMD produced. If the surface mining did not directly connect the deep mine and surface mine workings, it significantly increased the rate of infiltration of precipitation into groundwater and, subsequently, into deep mine workings where it becomes AMD. A large portion of the surface mined areas in the watershed have been at least minimally reclaimed (pits filled in, surfaces regraded and vegetation planted).

Coal Creek is severely impaired below DCC005 by AMD and supports no fish or macroinvertebrate life (Moase and others, 1999; Hughey, 1993). Coal Creek above COAL2.0 is vulnerable to the affects of acid deposition and episodic acidification, likely able to support no fish and only acid-tolerant macroinvertebrates.

Johnson Creek

Johnson Creek (Figure 10), a 17-square-mile watershed, is largely forested with the town of Arnot in its headwaters. There is one major source of AMD in the watershed, with multiple minor sources also identified. Above JOHN3 (upstream of the town of Arnot), AMD impacts are minimal, although the landscape has been significantly altered by past mining activities. The Johnson Creek Watershed and the neighboring Babb Creek Watershed are almost connected through wetlands in their headwaters. In addition, two deep mine complexes (Arnot #1 and #2) straddle the watershed boundaries and each has discharges into both watersheds. The wetland substrates in this area are composed largely of coal fines and refuse material. Three mine discharges drain into Johnson Creek in this area. One drains from the north and drains portions of the Arnot #2 Mine (DJC904); two drain from the south and drain portions of the Arnot #1 Mine (Boyer Kantz & Associates, 1976). One of the southern discharges is used by the Arnot Sportsman's Club to feed a co-operative trout nursery and is also used as a public water supply for the village of Arnot; the second southern discharge was not identified during this study. Both discharges contribute minimally to AMD impacts in the Johnson Creek Watershed and need no remediation; therefore, they are not addressed further. The second largest volume discharge in the Tioga River Watershed, the #5 discharge, makes up the entire flow of the unnamed tributary to Johnson Creek measured at UNT7.0; however, it has relatively mild chemical characteristics.

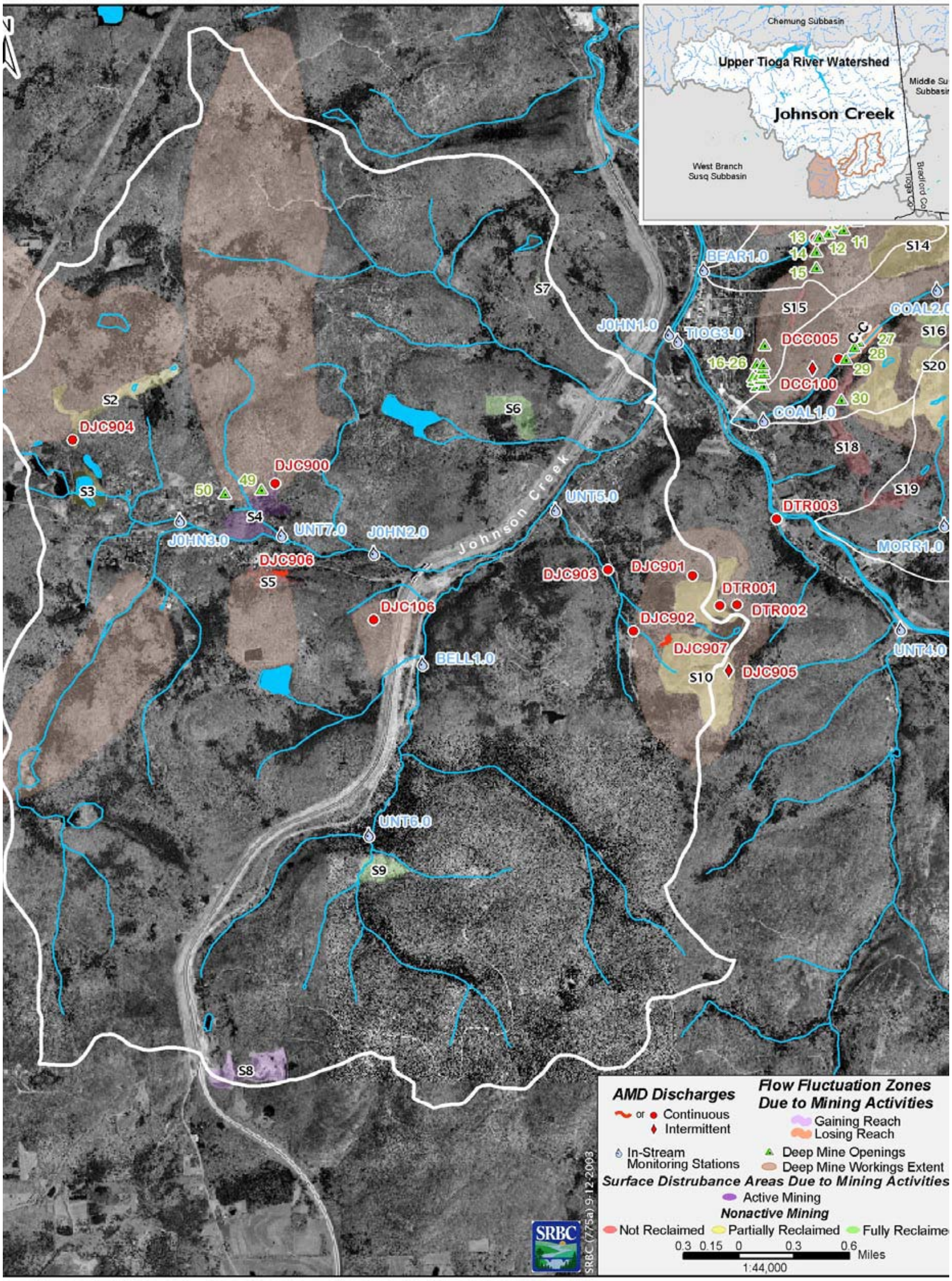

Figure 10. Mining Problem Area Features in the Johnson Creek Watershed

Additional discharges drain into Johnson Creek from: (1) a large abandoned refuse pile on state forest land just outside the village of Arnot, and (2) the Flower Run deep mine, a low flow but very low pH discharge that currently drains into a small wetland built by the Pennsylvania Department of Transportation (PennDOT) along the new Route 15 overpass. The last source of AMD to Johnson Creek is the South Mountain unnamed tributary, measured at monitoring station UNT5.0. South Mountain was both deep and surface mined, most recently surface mined by John Percival (Pa. DEP Mining Permit #4772SM7). However, after mining was completed on the permitted area, reclamation was not completed and bonds were eventually forfeited, leaving the area as a liability to the Commonwealth. Approximately half of the disturbed areas on the mountain have had surface reclamation completed; however, the other areas are not reclaimed. This includes large areas of acid-producing overburden material with no vegetation, an open dry pit with a dangerous highwall, and hazardous water-filled pits. In addition, along the edges of the surface mined area are toe-of-spoil discharges of mine drainage; the aggregated drainage from these sources are characterized at monitoring stations DJC902 and DJC903. The monitoring station DTR003 characterizes an additional small amount of drainage from South Mountain to the east (flows into the Tioga River). Johnson Creek is weakly net acidic along its entire length, but supports a small brook trout fishery (Moase and others, 1999).

Several reclamation projects have been completed in the Johnson Creek Watershed. The Arnot Sportsman's Club, in cooperation with the Babb Creek Watershed Association, have recently completed construction of a passive system to treat discharge from the #2 mine that flows into the Babb Creek Watershed (Zug, 2001); they are also designing a treatment system to treat discharge water from the #2 mine flowing into the Tioga River Watershed (shown as DJC904). One remining operation is active in the Johnson Creek Watershed. The Berguson Operation (Pa. DEP Mining Permit #6662-59-01-01) is a remining permit to remove 5 acres of refuse piles that are the waste from two abandoned deep mines (#4 and #5) located north of the piles. The last mining on this area was in 1924 by the Blossburg Mining Company. Surface reclamation at the #4 mine site was conducted by the RAMP program (Hensel project); the #5 mine currently is the second largest volume discharge of AMD in the Tioga River Watershed (measured at monitoring station DJC900). Reclamation of this site through remining, which would cost the Commonwealth $25,000 to complete itself, will reduce sedimentation to Johnson Creek and will remove the refuse pile; an unsightly landscape feature easily viewed from Arnot, but will not treat the discharging water. Another RAMP project was completed to remove a surface water supply reservoir on Saw Mill Creek that was hazardous and leaking water into underlying deep mine workings. The reservoir was originally built in the early 1900s by the Blossburg Coal Company, and included an earthen and timber dam; deterioration of the structure made it hazardous to the downstream community of Arnot. Currently, the town of Arnot uses one of the discharges from the #1 mine (South Drift Spring) as a potable water supply for 128 customers.

<u>Bear Creek</u>

The Bear Creek Watershed (Figure 11), a 0.7-square-mile watershed, is impacted by abandoned deep mine discharges in its mid-reaches. Mining in the Upper Tioga River Watershed was started in this subwatershed. At least five discharges impact the watershed, all occurring within a very small area. The largest in volume is an artesian discharge that emerges in the stream bottom (DBC100). Multiple collapsed drift entries, some with a discharge

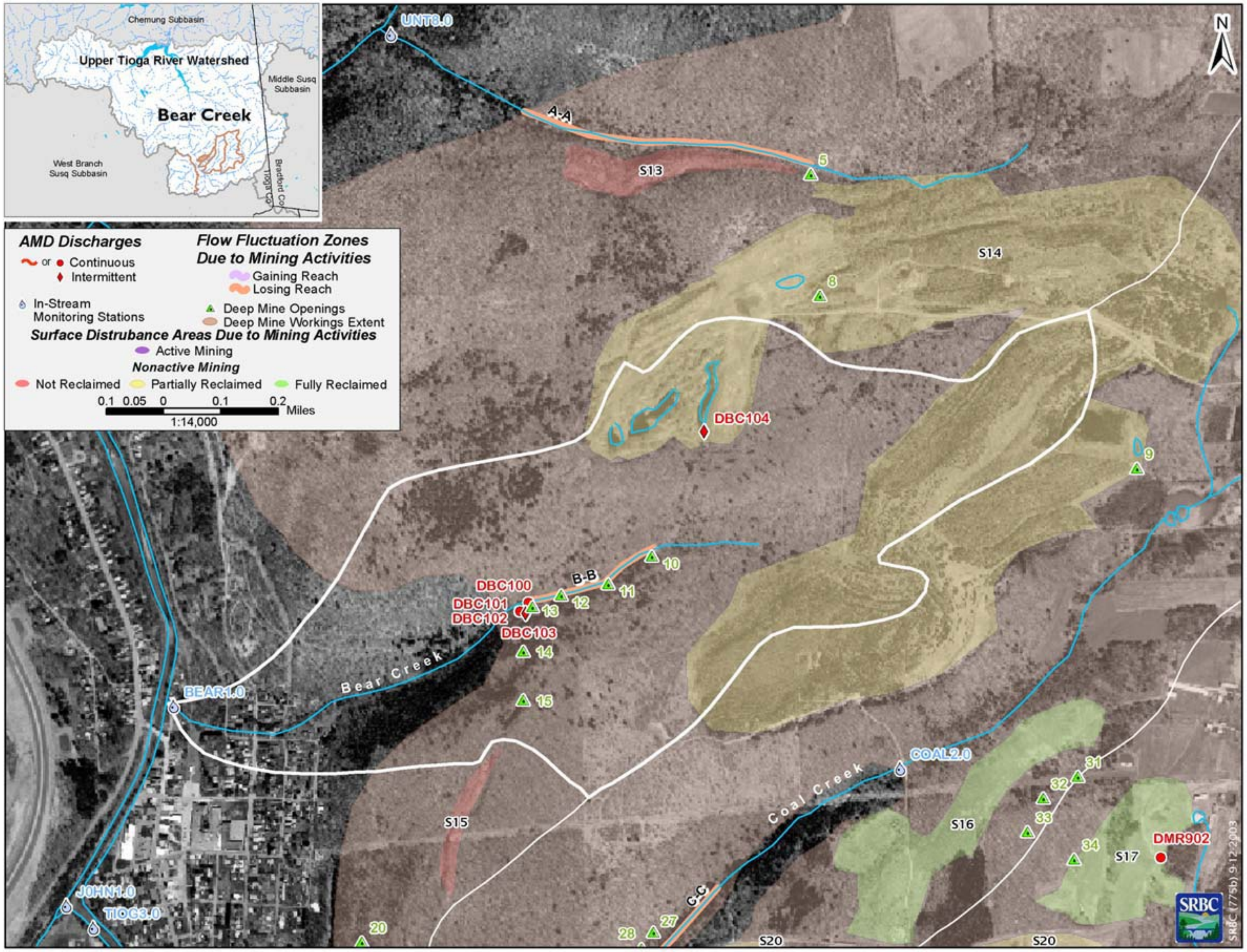

Figure 11. Mining Problem Area Features in the Bear Creek Watershed

(DBC102-103), line the steeply-sided valley. Upstream of DBC100, Bear Creek is dry due to infiltration of stream flow into underlying deep mine workings (stream flow fluctuation zone B-B). In the headwaters of the stream, above the fractured zone, water flows in the channel. In this reach (above the fractured zone), Bear Creek receives AMD from the surface overflow of a water-filled pit (DBC104) on a large, abandoned surface mine on the hilltop between the Bear Creek and East Creek Watersheds. In total, four unreclaimed pits are located on the surface mine, only one of which has a surface discharge (DBC104). Reclamation of this surface mine would likely have significant impact on the water quality of Bear Creek as a large portion of the water in the pits infiltrates into underlying deep mine workings and likely emerges as AMD in Bear Creek. In addition, the rolling topography of this area attracts ATV and other off-road vehicles and is used heavily as a recreational area. Large drops from refuse piles into water-filled pits and abrupt cliffs pose significant threats to public health and safety.

Non-Acidified Streams - Rathbone Creek, South Creek, Elk Run, Corey Creek, Lambs Creek, Canoe Camp Creek, Ellen Run, Marvin Creek, Crooked Creek, Mill Creek

Rathbone Creek (RATH1.0) and South Creek (SOUT1.0) are small streams located in the headwaters of the Tioga River Watershed that drain into the river from the southeast. They are clean streams with circumneutral pH, net alkalinity, and low levels of metals, conductivity, and sulfates. They are not impacted by AMD, tannic acids, or acid deposition. Surveys conducted by the PFBC in 1999 documented Class A wild brook trout fisheries in these watersheds and recommended that their designated use be upgraded from cold water fishes (CWF) to high quality-cold water fishes (HQ-CWF) to protect the fishery resources (Moase and others, 1999).

Marvin Creek (MARV1.0), Elk Run (ELKR1.0), Canoe Camp Creek (CANO1.0), Corey Creek (CORY1.), Ellen Run (ELLN1.0), Lambs Creek (LAMB1.0), and Mill Creek (MILL1.0) are streams of varying sizes that drain into the Tioga River between Bear Creek and Tioga Lake (Table 8). Most of the streams drain watersheds that are a mosaic of agricultural, forested, and residential lands; no abandoned mine lands are present in any of the watersheds. These streams maintained a net alkaline load and low levels of metals and sulfates through all seasons during the sampling period of the study. None of them are impacted by AMD, tannic acids, or acid deposition; however, some of them may be impacted by agricultural activities.

Table 8. Net Alkalinity Contribution from Monitored Tributaries to the Tioga River Mainstem Downstream of Blossburg

Stream Name	Average Net Alkaline Load, pounds per day	Net Alkalinity Range, pounds per day	Net Alkalinity Rank
Mill Creek	11,810	1,006-23,694	1
Crooked Creek	11,421	1,851-23,676	2
Elk Run	3,280	52-5,833	3
Corey Creek	2,510	27-5,880	4
Canoe Camp Creek	1,481	706-2,814	5
Lambs Creek	880	143-1,551	6
Marvin Creek	486	79-817	7
Ellen Run	288	41-661	8

Crooked Creek[8] is a large stream located in the lower Tioga River Watershed. Crooked Creek is impounded in the Hammond Lake portion of the Tioga/Hammond Complex. It is an agricultural and forested watershed, with some residential development. It is a net alkaline stream with circumneutral pH (6.83), net alkalinity, and low levels of metals, conductivity, and sulfates. It is not impacted by AMD, tannic acids, or acid deposition; however, higher levels of nutrients from agricultural sources in the watershed are suspected of causing nuisance algal blooms in Hammond Lake (U.S. Army Corps of Engineers, 2002). Alkaline water from Hammond Lake is drawn through a connecting channel to Tioga Lake and is mixed with the Tioga Lake water to improve water quality leaving the complex. The mixed, circumneutral pH water is released from the complex as the Tioga River.

Tioga River conditions

The Tioga River begins as a small stream on Armenia Mountain in Bradford County. Chemically, it possesses a near-neutral pH and net alkalinity when sampled near its origin at TIOG8 (Figure 12). From TIOG8 to TIOG6, the river receives drainage from many tributaries from both the north and the south. The tributaries from the south possess net alkalinity and near neutral pH levels; however, the tributaries from the north drain areas with headwater wetlands and possess net acidity and low natural pH. These tributaries, such as McIntosh Hollow and Fellows Creek, begin to erode at the small amount of net alkalinity the river possesses. This section of the Tioga River is stocked by the PFBC with brown trout. All sources of acidity upstream of TIOG5 are due to organic acids and atmospheric deposition.

The Tioga River begins to show adverse conditions from AMD acidity downstream of its confluence with Fall Brook. The Tioga River between points TIOG5 and TIOG4 changes drastically in its chemical composition due to AMD impacts in Fall Brook, including decreases in pH and increases in acidity, conductivity, sulfates, and metals. Sites in the watershed impacted by AMD are ranked according to concentration for each metal in Tables 9-11. Fall Brook at its confluence with the Tioga River is impaired by AMD and causes the Tioga River downstream of their confluence to be impaired as well. The bottom substrate in Fall Brook at its mouth is stained orange from iron hydroxide precipitates. When Fall Brook water mixes with the higher pH water of the Tioga River, it causes aluminum to precipitate, giving the Tioga River a white color downstream from Fall Brook to the confluence with Morris Run below point TIOG4. Point TIOG4 represents the Tioga River approximately one half mile upstream of the confluence with Morris Run, the next downstream AMD-impacted tributary. The Tioga River between TIOG4 and TIOG3 receives drainage from the Morris Run and Coal Creek Watersheds. These two watersheds are the most severely impacted tributaries to the Tioga River, containing most of the top five major AMD discharges in the Tioga River Watershed. This segment of the Tioga River travels through the town of Blossburg. The river is straightened and leveed for flood control and is usually a bright orange color from the mine drainage in the Morris Run and Coal Creek Watersheds. Point TIOG3 represents the Tioga River upstream of the confluence with Johnson Creek, a moderately impacted subwatershed. The Tioga River between TIOG3

[8] Loads at the mouth of Crooked Creek (CROO1.0) include contributions of upstream alkaline tributaries including Hills Creek (HILL1.0), Norris Creek (NORR1.0), and Catlin Hollow (CATL1.0).

and TIOG2 receives drainage from the Bear Creek and Johnson Creek Watersheds. Bear Creek is the most downstream source of AMD to the Tioga River.

After Bear Creek, the Tioga River flows out of the Blossburg area and into the agricultural section of the watershed; the river enters another physiographic province at this point, causing a significant difference between the upper and lower sections of the watershed. The Tioga River begins to receive inputs of alkaline water without AMD constituents, beginning the process of AMD neutralization that continues downstream and in Tioga Lake. TIOG2 represents the Tioga River downstream of the confluence with Bear Creek. The Tioga River between TIOG2 and TIOG1 is a long segment that stretches from below Blossburg to below Mansfield where the Tioga Lake begins to pool. Sampling using wadeable techniques is not feasible in this area. Many tributaries, some large and most of which flow through largely agricultural lands, drain into the river in this reach. TIOG1 represents the Tioga River below Mansfield where Tioga Lake begins, effectively the end of the flowing segment upstream of the complex. Precipitating metals (iron and aluminum hydroxides) can be observed in this segment that functions as the recovery zone for the upstream AMD impacts.

Table 9. Rank of Monitoring Stations Exceeding Pa. DEP Water Quality Criterion for Total Iron

Site Name	Average Total Iron Concentration, mg/l	Severity Rank
COAL1*	34.32	1
BEAR1*	6.54	2
MORR2	5.07	3
MORR1*	4.19	4

*Sites are at the mouths of tributaries that drain into the Tioga River

Table 10. Rank of Monitoring Stations Exceeding Pa. DEP Water Quality Criterion for Total Manganese

Site Name	Average Total Manganese Concentration, mg/l	Severity Rank
MORR2	17.45	1
MORR1*	16.95	2
UNT5	9.05	3
COAL1*	7.61	4
BEAR1*	6.62	5
FALL1*	6.15	6
UNT3	5.83	7
UNT2	4.64	8
TIOG3	3.96	9
TIOG2	2.56	10
TIOG1	2.02	11
FALL2	1.91	12
FALL2.6	1.57	13
FALL2.5	1.46	14
TIOG4	1.03	15

*Sites are at the mouths of tributaries that drain into the Tioga River

Table 11. Rank of Monitoring Stations Exceeding Pa. DEP Water Quality Criterion for Total Aluminum

Site Name	Average Total Aluminum Concentration, mg/l	Severity Rank
COAL1*	27.38	1
MORR2	15.85	2
BEAR1*	15.63	3
MORR1*	15.50	4
UNT5	10.22	5
TIOG3	5.75	6
FALL1*	4.36	7
UNT3	3.95	8
TIOG2	3.75	9
TIOG1	2.87	10
UNT2	2.54	11
FALL2	0.99	12
FALL3	0.98	13

*Sites are at the mouths of tributaries draining into the Tioga River

COMPARISON TO HISTORICAL ACCOUNTS

The most pronounced change in the Tioga River Watershed in comparison to historical accounts is in the reclamation of surface mined areas. Previous to this project, the most comprehensive assessment was completed by Gannett Fleming Corddry & Carpenter in 1968 for the Federal Water Pollution Control Administration. At that time, 41 surface mines were identified, 39 of which were abandoned and five of which had intermittent discharges of AMD to surface streams. Active surface mining was producing 300,000 tons of coal per year. However, surface mining ended in 1990 when the remaining mining company, Jones and Brague Coal Company, finished reclaiming its active surface mines, as well as some pre-Act surface mines. Since that time, no new surface mining has been conducted and further mining, with the exception of remining, is not anticipated in the watershed in the future. Thirty-seven areas of surface disturbance were identified in this study, including 18 new surface disturbance features not identified in the 1968 study. This increase was largely due to the expansion of the study area to include the entire Upper Tioga River Watershed, not just the Morris Run/Coal Creek/Bear Creek area. These areas not only included abandoned and reclaimed surface mines, but also problem refuse piles and a gravel mining operation. Many of the areas of surface disturbance are classified as partly reclaimed; these areas are still in need of some type of surface reclamation on at least part of their area. For this reason, a net gain/loss of square miles was not computed for disturbed surface areas between this study and historical reports.

Seventy-two deep mine entries were identified in the 1968 study; however, one of them was not identified on a map, so it was not included in the historical total. Many of these deep mine entries were visible in highwalls of abandoned surface mines, creating direct access for water accumulating in the pits to abandoned deep mine workings. Twenty-two of the openings identified in 1968 were no longer present during this study. The loss of these openings is due to reclamation of abandoned surface mines where openings were visible in the highwall. However, because of the larger scope of this project compared to the 1968 study, six additional mine openings were identified in this study that were not previously documented. Fifty-five deep mine entries were identified in this study, resulting in a net loss of 16 mine openings.

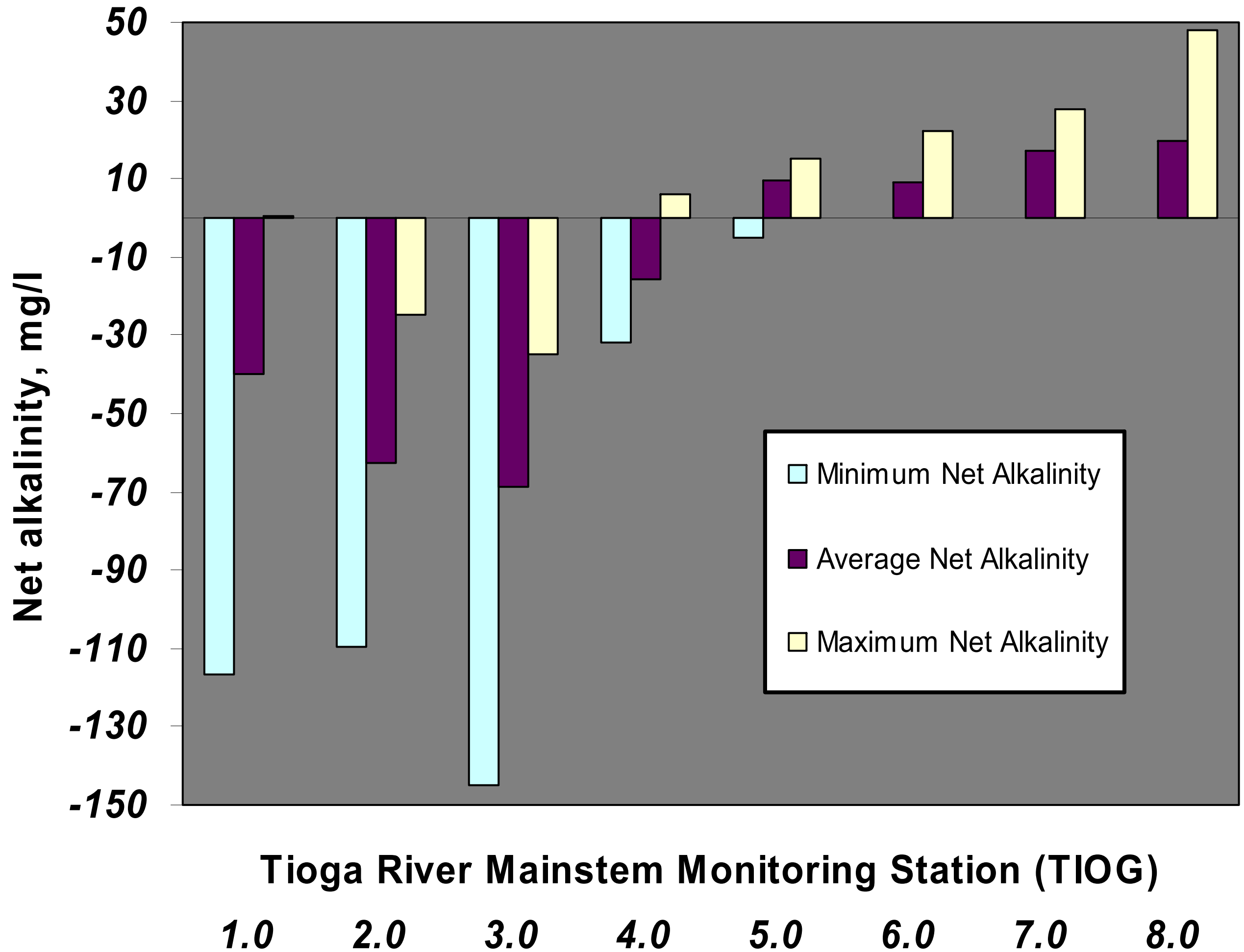

Figure 12. Net Alkalinity (Maximum, Average, Minimum) Change Along the Tioga River Mainstem

Sixteen major mine drainage discharges were identified in the 1968 study, six of which were from surface mine or refuse dump sources and 10 of which were from deep mines. Four of the mine discharges were associated with surface mines that have been reclaimed and no longer exist; one was associated with a refuse dump area that has been reclaimed and no longer exists; one discharge exists only as a deep mine opening but no longer discharges any water. An additional two discharges were confirmed that had significantly less impact than in 1968, being identified as intermittent discharges; eight discharges from 1968 were confirmed that are considered major discharges in this study. In addition to confirming the 16 previously identified discharges, 26 additional discharges were identified that were not previously documented. This net gain resulted in a total of 36 mine drainage discharges being identified in this study.

Four of five areas of stream infiltration identified in 1968 were confirmed in this study. One area of stream infiltration identified in 1968 was restored in 1975 through an extensive reclamation project that reclaimed an abandoned surface mine in the headwaters of Morris Run (Miorin and others, 1979). One additional zone of stream flow fluctuation was identified and delineated during this study resulting in a net total of five stream flow fluctuation zones identified in the Upper Tioga River Watershed.

THE WATERSHED RESTORATION PLAN[9]

Gannet Fleming, Inc. was contracted by SRBC to prepare a conceptual AMD restoration plan for the Upper Tioga River Watershed (Rightnour & Hoover, 2003). Thirty-six AMD features were identified by SRBC in the Upper Tioga River Watershed, of which 21 had at least intermittent flow and were able to be sampled within the study period. Based on field reviews, a number of the AMD sources could be combined in common treatment systems for an economy of scale. For each treatment plan developed, conceptual passive and chemical system designs were prepared using the Tarco Technologies, Inc. Watershed Restoration Analysis Model (WRAM v1.2), which generated conceptual component sizing requirements, construction cost estimates, operation and maintenance cost estimates, 15-year present values, and construction area requirement estimates[10]. The more appropriate of the two treatment alternatives was selected based on construction area constraints, cost considerations, and ability of the technologies to meet water quality goals. Of the 10 conceptual treatment plans, four were best addressed by chemical systems and six by passive systems. Following development of the conceptual treatment plans, another component of WRAM was used to predict the downstream water quality improvements that could result from implementing these plans and to guide development of the restoration plan.

Project Benefits/Endpoint

Local stakeholders have expressed a final goal of restoring the Tioga River to a natural ecological condition, with interim water quality and ecological improvements being made to the affected tributaries and contributing to the restoration of the mainstem. While the goal of

[9] The complete restoration plan is contained in the document "Upper Tioga River Watershed: Acid Mine Drainage Conceptual Treatment and Restoration Plan" prepared by Gannett Fleming, Inc., for SRBC.
[10] All costs mentioned are the prices for supplies, labor, operation, and maintenance of systems. They do not include monetary values for benefits from the project(s).

complete ecosystem restoration may take decades to achieve through implementation of the recommendations of this study as funding and new technologies are made available, many other interim benefits would be realized with the progressive treatment of mine drainage pollution. Ecosystem restoration in the watershed would include waters containing both cold and warm water fishery communities (trout waters and nontrout waters). Benefits from the restoration of the aquatic ecosystem will be realized in both ecosystem health and integrity, and in increased recreational use of the Tioga River and its tributaries. Fishing, swimming, canoeing, and other water-based recreational activities will likely all increase with pollution remediation. Another benefit of watershed restoration is to make operations at the Tioga/Hammond Dam Complex easier and more cost efficient. As conditions in the Tioga River improve, additional benefits will be realized at the Complex through increased recreational use due to ecosystem health and integrity. Additional benefits will be realized throughout the watershed in the areas of increased aesthetics of the river corridor system, decreased structural maintenance of bridges and other man-made structures, and improvements to existing and future supplies of potable water for area communities.

Restoration Technologies

Two general categories of restoration technologies are employed when abating AMD: active treatment and passive treatment. Active treatment-treatment of the AMD with a chemical (sodium hydroxide, calcium hydroxide, calcium oxide, sodium carbonate, ammonia)-is used extensively in the regulated coal industry to treat AMD to meet federally mandated effluent criteria. However, it is labor and maintenance intensive and is thus not a favored alternative for abandoned sites. Passive treatment technologies for AMD treatment have emerged in the past 20 years as the favored technology at abandoned sites due to decreased operation and maintenance costs and responsibilities (Hedin and others, 1989). In general, passive treatment systems have been shown to have a lower unit cost than treatment at the same sites with active treatment (Ziemkiewicz and others, 2000). However, some sources of severe AMD, especially those sources with large flow volumes and high metals concentrations, are not able to be adequately treated using current passive treatment technologies. For the conceptual restoration plan, both treatment (active, passive) approaches were evaluated to determine the requirements, cost and feasibility of each. Three general types of passive treatment technologies exist and were evaluated based on their appropriateness for the chemical conditions present at each discharge: aerobic wetlands, organic substrate wetlands, and anoxic limestone drains (Hedin and others, 1989).

In addition to active and passive treatment technologies, other techniques, often termed preventative techniques, can be used in the Tioga River Watershed where feasible (Gardener in Brady and others, 1998). These include such activities such as re-mining, land capping to limit infiltration on disturbed sites, alkaline addition to abandoned surface and deep mine workings, installation of underground drains, streambed sealing or lining to prevent infiltration into mine workings, or indirect treatment, such as increasing the alkalinity of reaches upstream of AMD sources. These measures will work to reduce the amount of AMD produced and provide additional treatment that cannot be accomplished at the AMD discharge site.

Prioritization for Restoration

The 20 discharges deemed to be the most severe in the Upper Tioga River Watershed were ranked by the average of the discharge's rank for loads of iron, manganese, aluminum, and acidity (Table 12). The single worst discharge, DCC005, contributes an average 42 percent of the total acidity and 38 percent of the total sulfates to the Tioga River (Rightnour and Hoover 2003; Figure 13). Seven discharges (DCC005, DMR004, DFB099, DMR001, DJC900, DBC101, and DMR003) contribute 94 percent of the total sulfate contribution to the watershed (Rightnour and Hoover 2003; Figure 14).

The recommended sequence of restoration begins in the Fall Brook and Johnson Creek Watersheds. These watersheds were chosen first because: (1) Fall Brook is the most upstream AMD-impacted tributary in the watershed; (2) Johnson Creek has marginal water quality and small amounts of reclamation would have a large effect; and (3) Morris Run, Coal Creek, and Bear Creek all presently require active treatment systems. The Fall Brook Watershed is the most upstream AMD-impacted tributary to the Tioga River; abatement of AMD sources in the watershed will not only treat the 4th worst-ranking discharge and restore Fall Brook, but also will restore a three-mile section of the Tioga River (to the confluence with Morris Run). Although the next AMD-impacted tributary downstream would be Morris Run, Johnson Creek also was chosen as a watershed in which to begin abatement measures. Water quality data for the Johnson Creek Watershed show the mainstem to be of marginal quality; however, with the installation of treatment systems for the discharges in the watershed, especially DJC900, and the surface reclamation of South Mountain, Johnson Creek will have sufficient water quality to support a recreational fishery. Brook trout were documented in the Johnson Creek Watershed in 1999 by the PFBC (Moase and others, 1999) and populations would likely increase with the abatement of AMD pollution.

Table 12. Severity Rank Based on Pollutant Load for the 20 Most Severe Discharges in the Upper Tioga River Watershed

Discharge	Iron Load Rank	Manganese Load Rank	Aluminum Load Rank	Acidity Load Rank	Overall Rank
DFB099	9	3	4	4	4
DFB001	19	18	19	19	20
DFB002	5	10	15	14	T-10
DFB100	14	20	20	20	19
DFB003	20	16	18	18	18
DFB004	17	11	13	13	14
DMR003	10	5	6	7	6
DMR001	3	4	3	3	3
DMR004	2	1	2	2	2
DCC005	1	2	1	1	1
DBC100	6	9	7	8	8
DBC101	4	6	5	6	5
DBC102	11	13	10	10	T-10
DBC103	12	15	11	11	12
DJC106	13	19	16	15	16
DJC900	7	8	9	5	7
DJC902	8	7	8	9	9
DJC903	15	12	12	12	13
DJC904	18	17	17	16	17
DTR003	16	14	14	17	15

Table 13. Summary of Treatments and Costs to Implement Technologies to Remediate AMD Impacts in the Upper Tioga River Watershed

Implementation Stage	Recommended Treatment Type By Area	Cost Factors		Stream Improvements		Annualized Cost/Mile Improved	
		Individual	**Cumulative**	**Individual**	**Cumulative**	**Individual**	**Cumulative**
Stage 1 Fall Brook	Upper Fall Brook- active or passive Lower Fall Brook-active	Construction $1,300,000 Operation $170,000 15-Year PV $3,500,000	Construction $1,300,000 Operation $170,000 15-Year PV $3,500,000	Tributaries 1.84 miles Main Stem 3.06 miles Total 4.90 miles	Tributaries 1.84 miles Main Stem 3.06 miles Total 4.90 miles	Total $48,000	Tributaries $48,000 Main Stem $48,000 Total $48,000
Stage 2 Johnson Creek	DJC904-passive DJC900-passive DJC106-passive South Mountain West-passive	Construction $2,600,000 Operation $10,000 15-Year PV $2,700,000	Construction $3,900,000 Operation $180,000 15-Year PV $6,200,000	Tributaries 4.01 miles Main Stem 0 miles Total 4.01 miles	Tributaries 5.85 miles Main Stem 3.06 miles Total 8.91 miles	Total $45,000	Tributaries $46,000 Main Stem $48,000 Total $46,000
Stage 3 Morris Run & DTR003	Morris Run-active DTR003-active	Construction $2,100,000 Operation $520,000 15-Year PV $8,500,000	Construction $6,000,00 Operation $700,000 15-Year PV $15,000,000	Tributaries 1.06 miles Main Stem 0.80 miles Total 1.86 miles	Tributaries 6.91 miles Main Stem 3.86 miles Total 10.77 miles	Total $300,000	Tributaries $85,000 Main Stem $100,000 Total $93,000
Stage 4 Coal Creek & Bear Creek	Bear and Coal Creeks-active	Construction $3,300,000 Operation $1,900,000 15-Year PV $26,000,000	Construction $9,300,00 Operation $2,600,000 15-Year PV $41,000,000	Tributaries 1.48 miles Main Stem 9.27 miles Total 10.75 miles	Tributaries 8.39 miles Main Stem 13.13 miles Total 21.52 miles	Total $160,000	Tributaries $99,000 Main Stem $140,000 Total $130,000

Table 13 modified from Table 7 – Summary of Stream Restoration Gains and Costs for the Tioga River Conceptual Progressive Restoration Plan in Rightnour and Hoover, 2003

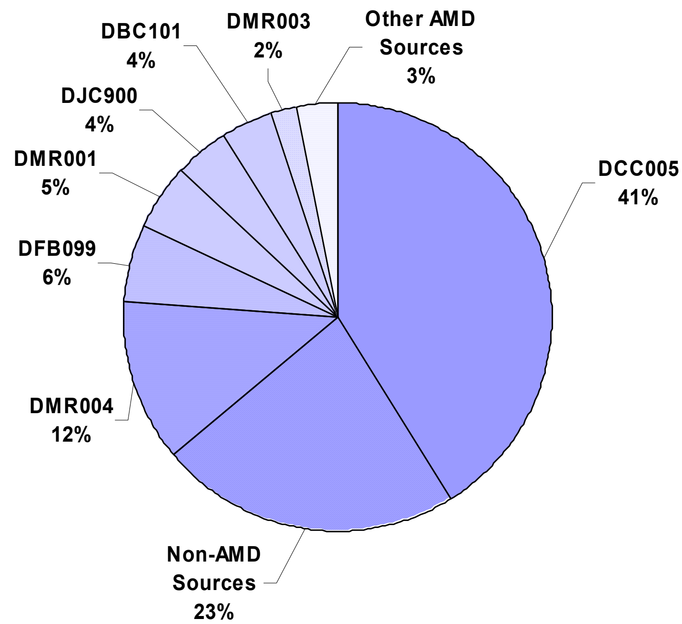

Figure 13. Acidity Contribution from AMD and Non-AMD Sources to Acid Load at TIOG2 in the Upper Tioga River Watershed

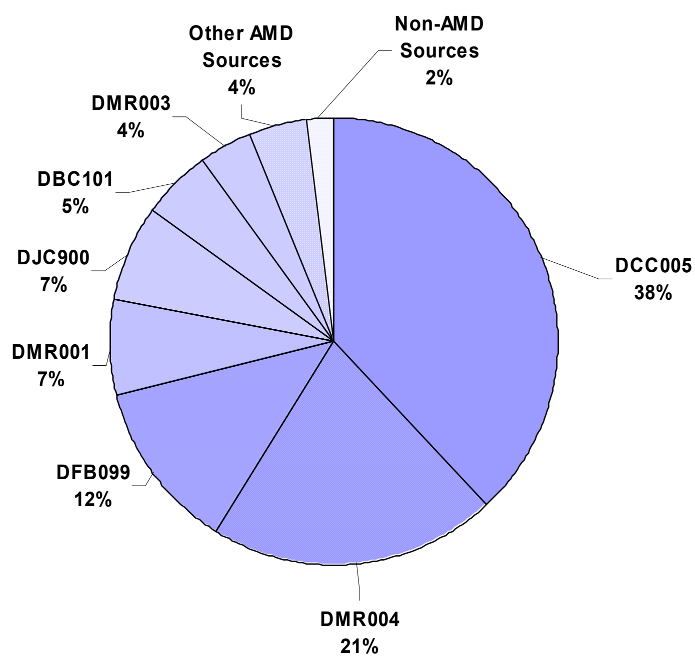

Figure 14. Sulfate Contribution from AMD and Non-AMD Sources to Sulfate Load at TIOG2 in the Upper Tioga River Watershed

Gannett Fleming determined that treatment efforts on Fall Brook and Johnson Creek would yield the greatest benefit/cost ratio, and would be the best starting points for restoration efforts (Table 13). Chemical treatment of sources along Fall Brook would produce significant water quality improvements for 1.8 miles of that tributary and 3 miles of the mainstem Tioga River, at an initial construction cost of $1.3 million, annual operating cost of $170,000, and 15-year present value of $3.5 million[11]. About 4 miles of stream in Johnson Creek, while already of relatively good quality, would benefit from passive treatment of five source areas, with a construction cost of $2.6 million, annual operating cost of $10,000, and 15-year present value of $2.7 million. Treatment costs in both tributaries would equate to about $46,000 per stream mile per year. In Morris Run, three large sources and several smaller sources would require a common chemical treatment system. The mainstem would also benefit from concurrent passive treatment of several small sources on the east side of South Mountain. These two projects would have a construction cost of about $2.1 million, annual operating cost of $520,000, and 15-year present value of $8.5 million. This work would improve 1 mile of Morris Run and an additional 0.8 miles of the mainstem, equating to about $300,000 per stream mile per year. The final two major AMD sources in Coal Creek and Bear Creek could be treated together in a large chemical system, with a construction cost of $3.3 million, annual operating cost of $1.9 million, and 15-year present value of $26 million. This would likely improve water quality downstream to the Tioga/Hammond Dam Complex, restoring 1.5 miles of the two tributaries and 9.3 miles of the mainstem at a cost of about $160,000 per stream mile per year. If fully implemented, the conceptual treatment activities would cost $9.3 million to construct, $2.6 million per year to operate, and have a 15-year present value of $41 million. This equates to about $130,000 per stream mile per year for 8.4 miles of tributaries and 13.1 miles of mainstem, or 21.5 miles of total stream improvements.

Recognition of the contribution of non-AMD acidity to the Tioga River is essential for restoration of the watershed. Almost one quarter of the acidity contribution in the watershed is due to non-AMD sources such as tannic acid and acid deposition (Rightnour and Hoover, 2003). It is critical to note that even if all AMD acidity sources were treated, the mainstem of the Tioga River and some tributaries in the headwaters of the watershed would still not be able to support viable fisheries due to limited buffering capacity to neutralize episodic acid inputs and toxic aluminum concentrations. The slightly acidic, low-metals flows in the headwaters of Fall Brook and Morris Run, and found in Fellows Creek, McIntosh Hollow, and Taylor Run, are ideal for passive treatment, which would benefit the overall restoration efforts at a comparatively low cost. Based on findings from other projects conducted by Gannett Fleming, net alkaline conditions could be restored in these streams using vertical flow wetlands and other passive technologies that may become available in the near future. Current estimates are that it would cost $560,000 to implement vertical flow wetland treatment in the headwaters of Fall Brook and $340,000 on Morris Run. Abatement of this non-AMD acidity is an integral component of the restoration of the Tioga River Watershed.

Implementation of AMD remediation technologies has already begun in the watershed. The Arnot Sportsmen's Club, in conjunction with the Babb Creek Watershed Association, is

[11] The costs presented above and in the report are specific to the construction, operation, and maintenance of the selected treatment alternatives over a 15-year projection period. There are a number of other factors that could not be predicted at this level of assessment, including property acquisition, access development, electric service, and design and permitting costs. The conceptual construction costs include a 25 percent contingency to estimate these factors, but the ultimate costs of implementing the individual treatment projects may be greater than stated.

installing a treatment system in the Johnson Creek Watershed at site DJC904. The Tioga County Concerned Citizens Committee (TCCCC), in conjunction with the Hillside Rod and Gun Club, will be submitting a proposal for funding to install passive treatment systems on discharges in the middle Fall Brook Watershed, as well as to treat non-AMD acidity in the watershed. These efforts should be encouraged and funding made available to support them.

RECOMMENDATIONS

The Upper Tioga River Watershed is severely impacted by AMD from Fall Brook to Bear Creek, impairing or eliminating aquatic life in about 13 miles of the mainstem extending downstream to the Tioga/Hammond Dam Complex. Staining from precipitating metals and high acidity also limit the river's socioeconomic value to the local community. Other tributaries in the watershed show reduced pH due to non-AMD acidity sources, including tannins from natural headwaters wetlands and acid precipitation. Although AMD production will decline over time by depletion of the acid-forming minerals, this is a very slow process, particularly for underground mines, and significant impacts could continue for centuries without some form of abatement. The most common form of abatement is direct treatment of the AMD discharges by either active (chemical) or passive (wetland) systems. Other alternatives may include re-mining or land capping to limit infiltration on disturbed sites, alkaline addition to abandoned surface and underground mine works, streambed sealing to prevent infiltration to mine pools, or indirect treatment, such as increasing the alkalinity of reaches upstream of the AMD sources. The scope of the mine drainage problem in the Upper Tioga River Watershed is large, with some extremely severe sources of AMD.

SRBC and Gannett Fleming, Inc. constructed the following recommendations for the Upper Tioga River Watershed based on data collected and conclusions made during the present study, the areas in which additional study should be conducted, current and relevant literature, and professional experience. These recommendations should be viewed as dynamic as implementation efforts proceed in the watershed and additional needs are discovered that are beyond the scope of this assessment and restoration plan.

1. Support the efforts of local stakeholder groups working on AMD abatement in the watershed. Continue to provide funding for implementation of proposed restoration activities. Encourage stakeholders to establish interim restoration goals, focusing on the concerns of the community. Coordinate restoration activities with goals in the Tioga River TMDL.
2. Implement an initial, modestly sized demonstration project. The project would be beneficial for organizing stakeholders into a working team and will provide justification for future, larger scale efforts.
3. Develop GIS coverage of surface property ownership and underground mineral rights for problem areas identified. Locate and digitize deep mine maps for the area. Use geophysical techniques, if necessary, to map extent of deep mine workings throughout the study area.
4. Prior to AMD treatment for selected discharges, determine feasibility and estimated effectiveness of implementing source reduction techniques in the watershed to reduce the volume and possibly increase the quality of AMD. These actions would include reclaiming select pre-Act surface mined areas identified as high priority areas for

restoration and sealing areas of stream infiltration into underlying abandoned workings.

5. Investigate feasibility of using innovative techniques for AMD treatment, including *in-situ* treatment using the deep mine complex and beneficial reuse of alkaline waste materials.
6. Conduct watershed restoration in a phased fashion as discussed in this report and the restoration plan, beginning with the Fall Brook Watershed and ending with the Coal and Bear Creek Watersheds. Changes may be necessary to the current sequence based on the findings of feasibility using source reduction and innovative techniques.

Potential partners for implementation and further studies in the Upper Tioga River Watershed could include, but are not limited to the following:

SRBC, Pa. DEP, Pa. DCNR, PFBC, PennDOT, Tioga County Conservation District, Mansfield University, The Pennsylvania State University, Tioga County Concerned Citizens Committee, Hillside Rod and Gun Club, Tioga River Watershed Reclamation Projects, Inc., Tioga County Planning Commission, U.S. Office of Surface Mining, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture, private consultants, government interests, local tourism and development interests

SRBC concludes that the restoration of the Upper Tioga River Watershed presents a formidable challenge. Strong, sustainable partnerships between local stakeholders and other entities will be crucial in assuring that the restoration of the watershed will be accomplished.

REFERENCES

Arway, John A. 1995. "Scope of the Nonpoint Source Pollution Problem." Presented at the Mine Drainage & Watersheds Conference, Panel Session #1: Assessment of the Problem, Clarion University of Pennsylvania, Clarion, Pa.

Barker, James L. 1971. Effects of Acid Mine Drainage on Fish and Macroinvertebrates of the Tioga River, Pennsylvania and New York. U.S. Geological Survey Administrative Report in cooperation with U.S. Army Corps of Engineers, Baltimore District.

Boyer Kantz & Associates. 1976. Babb Creek Mine Drainage Abatement Project, Tioga and Lycoming Counties, Pennsylvania. Commonwealth of Pennsylvania, Department of Environmental Resources, Operation Scarlift Project SL-145-1.

Brady, Keith B.C., Michael W. Smith, and Joseph Schueck, technical eds. 1998. Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania. Pennsylvania Department of Environmental Protection.

Brightbill, Robin A and Michael D. Bilger. 1999. Fish-community composition in Mill Creek, Crooked Creek, and Tioga River in the vicinity of Tioga-Hammond Dams, Tioga County, Pennsylvania, 1998. U.S. Geological Survey in cooperation with U.S. Army Corps of Engineers, Open-File Report 99-210.

Commonwealth of Pennsylvania. 1999. Pennsylvania Code, Title 25. Environmental Protection, Department of Environmental Protection, Chapter 93. Water Quality Standards. Pennsylvania Department of Environmental Protection, Harrisburg, Pa.

Edmunds, William E., Thomas M. Bero, William D. Sevon, Robert C. Pietrowski, Louis Heyman, and Lawrence V. Rickard. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States – Pennsylvania and New York. U.S. Geological Survey Professional Paper 1110-B.

Gannett Fleming, Inc. 2001. Detailed project description for Arnot #2 Mine #1 Discharge – Passive Treatment System Siting Alternatives Evaluation and Design.

Gannett Fleming Corddry and Carpenter, Inc. 1968. Acid Mine Drainage Abatement Measures for Selected Areas Within the Susquehanna River Basin. U.S. Department of the Interior, Federal Water Pollution Control Administration, Engineering Report Contract No. WA 66-21.

——. 1972. Mine Drainage Abatement Measures: Tioga River Watershed. Commonwealth of Pennsylvania, Department of Environmental Resources Project SL-136-1.

Hedin, Robert S. Robert W. Nairn, and Robert L.P. Kleinmann. 1989?. Passive Treatment of Coal Mine Drainage. U.S. Department of the Interior, Bureau of Mines Information Circular 9389.

Hughey, Ronald E. 1993. Aquatic Biological Investigation, Tioga River Headwaters. Commonwealth of Pennsylvania, Department of Environmental Resources File 30990.

Kulp, Kenneth P. and Dawn M. Pisarski. 1995. Effects of the Tioga-Hammond Lakes Project on the Water Quality of the Tioga River as Measured by Changes in the Aquatic Biota, in Water Quality '94 Proceedings of the 10^{th} Seminar, 15-18 February 1994, Savannah, Georgia. U.S. Army Corps of Engineers Waterways Experiment Station Miscellaneous Paper W-95-1, pp. 23-31.

Miorin, A.F., R.S. Klingensmith, R.E. Heizer and J.R. Saliunas. 1979. Tioga River Mine Drainage Abatement Project. U.S. Environmental Protection Agency (EPA 600/7-79/035) Interagency Energy/Environment R&D Program in cooperation with Pennsylvania Department of Environmental Resources.

Moase, Robert, Robert Wnuk and Louis Benzie. 1999. Upper Tioga River Basin (404A), (Upstream from River Mile 31.50 at Mansfield), Fisheries Management Report. Fish and Boat Commission, Bureau of Fisheries Management Division.

Pennsylvania Department of Environmental Protection. 2003. 2002 Section 303(d) List of Impaired Waterbodies. Department of Environmental Protection, Harrisburg, Pennsylvania.

Rhodes, Ralph L. and Robert S. Davis. 1968. Mine Drainage in the Susquehanna River Basin. Federal Water Pollution Control Administration, Middle Atlantic Region, Charlottesville, Virginia.

Rightnour, Terry A. and Kevin L. Hoover. 2003. Upper Tioga River Watershed Acid Mine Drainage Conceptual Treatment and Restoration Plan. Gannett Fleming, Inc., Clearfield, Pa.

Sharpe, W.E. and J.R. Drohan. 1999. The Effects of Acidic Deposition on Pennsylvania's Forest. Environmental Resources Research Institute, University Park, Pa.

Skelly & Loy. 1973. Coal Mine Drainage in the Susquehanna River Basin. Prepared by Skelly & Loy, Engineers – Consultants, Harrisburg, Pa., for the Susquehanna River Basin Commission.

Susquehanna River Basin Commission. 1975. Staff Review of Acid Mine Drainage Abatement in the Tioga River Basin (as amended).

Swinsick, Phyllis. 1994. Fall Brook and Ward Township, Tioga County, Pennsylvania. Tioga Printing Company, Wellsboro, Pa.

Town of Blossburg Homepage. www.blossburg.org.

Traver, Carrie L. 1998. Water Quality and Biological Assessment of the Chemung Subasin. Susquehanna River Basin Commission, Division of Water Quality and Monitoring Programs (Publication No. 198).

U.S. Army Corps of Engineers, Baltimore District. 1972. Investigative Survey: Occurrence and Effects of Mine Drainage in the Tioga River Basin.

_______. 1973. Susquehanna River Basin, Tioga-Hammond Lakes, Tioga River and Crooked Creek, Pennsylvania. Department of the Army, Baltimore District, Corps of Engineers. Design Memorandum No. 21, Environmental Analysis, Baltimore, Md.

_______. 1977. Susquehanna Mine Drainage Study, Interim Report, Tioga River Basin, Main Report.

_______. 1977. Susquehanna Mine Drainage Study, Interim Report, Tioga River Basin, Appendix 1: Technical Report.

_______. 1977. Susquehanna Mine Drainage Study, Interim Report, Tioga River Basin, Appendix 2: Pertinent Correspondence.

_______. 1987. Tioga Lake, Pennsylvania Investigation of Under Ice Hydrodynamics & Water Quality Conditions.

_______. 1997. Section 905(b) (WRDA 86) Analysis: Tioga River Basin Environmental Restoration Reconnaissance Study.

_______. 2002. Tioga, Hammond & Cowanesque Lakes Master Plan: 2001 Update/Programatic Environmental Assessment.

U.S. Census Bureau. 2000. Census 2000.

U.S. Department of Agriculture. 1986. Agreement and Watershed Plan – Environmental Impact Statement, Upper Tioga River Watershed, Tioga and Bradford Counties, Pa.

U.S. Department of the Interior. 1969. Water Supply and Water Quality Control Study, Tioga-Hammond-Cowanesque Reservoirs, Chemung River Basin, Pennsylvania and New York. Federal Water Pollution Control Administration, Middle Atlantic Region, Charlottesville, Va.

U.S. Environmental Protection Agency. 1999. Progress Report on the EPA Acid Rain Program. Air and Radiation Report EPA430-R-99-011.

Ward, Janice R. 1976. Preliminary Results of Preimpoundment Water-Quality Studies in the Tioga River Basin, Pennsylvania and New York. U.S. Geological Survey (Water Resources Investigation 76-66) in cooperation with U.S. Army Corps of Engineers, Baltimore District and the Susquehanna River Basin Commission.

_______. 1981. Preimpoundment Water Quality in the Tioga River Basin, Pennsylvania and New York. U.S. Geological Survey (Water Resources Investigation 81-1) in cooperation with U.S. Army Corps of Engineers, Baltimore District and Susquehanna River Basin Commission.

Wellsboro Gazette. 1932. Historical Highlights of Morris Run, Pa.

Wnuk, Robert, Robert Moase and Louis Benzie. 1999. Upper Tioga River Basin (404A) (Upstream from River Mile 31.50 at Mansfield) Fisheries Management Report. Commonwealth of Pennsylvania, Fish and Boat Commission, Bureau of Fisheries, Fisheries Management Division.

Ziemkiewicz, Paul, Jeff Skousen and Jennifer Simmons. 2001. Cost Benefit Analysis of Passive Treatment Systems *In* Proceedings of the West Virginia Surface Mine Drainage Task Force.

Zug, Roy. 2001. Fax on Arnot #2 Mine, #1 Discharge Passive Treatment System Siting Alternatives to Evaluation and Design.

GIS References

Arial Photographs – Tioga County Conservation District, 2000, scale 1:24,000
Streams – Environmental Resources Research Institute, 1996, scale 1:24,000
Waterbodies – SRBC, 2001, scale 1:24,000; U. S. Department of Commerce, Bureau of the Census, Geography Division TIGER/Line Files, 2000, scale 1: 100,000; and other sources.
Watersheds – United States Geological Survey, 1991, scale 1:24,000
Subbasins – United States Geological Survey, 1996, scale 1:24,000
Digital Raster Graphics – United States Geological Survey, 1996, scale 1:24,000
Stream Designated Uses – Pa. DEP, 2002, scale 1:24,000
Land Cover – US Geological Survey, EROS Data Center, 1992, Edition 3, 3.0 M resolution
Physiographic Provinces – Bureau of Topographic and Geologic Survey, Pa. DCNR, 1995, scale 1:100,000
Recreation Areas (Gamelands, Parks, Forests) – Environmental Resources Research Institute, 1996, scale 1:24,000
Minor Municipalities - Environmental Resources Research Institute, 1996, scale 1:24,000
Major Roads – PennDOT, 2002, 1:24,000
Counties: PennDOT, Cartographic Information Division, 1997, scale 1:24,000
State Lines – PennDOT, 1996, scale 1:24,000
Deep Mined Areas – Mansfield University, Department of Geography and Geology, "Upper Tioga River Watershed Acid Mine Drainage GIS", Version 3.0, May 2001
Surface Mined Areas – modified from

1. Mansfield University, Department of Geography and Geology, "Upper Tioga River Watershed Acid Mine Drainage GIS", Version 3.0, May 2001
2. Pa. DEP Bureau of Abandoned Mine Reclamation, Pennsylvania Abandoned Mine Land Program, September 2000

Appendix A

Location of Monitoring Stations

Table A1. Instream Monitoring Station Locations

Station Name	Stream Name	Station Description	North Coordinate	West Coordinate
Bear Creek Watershed				
BEAR1.0	Bear Creek	At mouth	41°40’59.725”	77°03’51.624”
Canoe Camp Creek Watershed				
CANO1.0	Canoe Camp Creek	Upstream of old Route 15 bridge	41°46’56.956”	77°04’08.736”
Coal Creek Watershed				
COAL1.0	Coal Creek	Upstream of St. Mary’s Cemetery	41°40’16.959”	77°03’29.302”
COAL2.0	Coal Creek	Upstream of “Mohawk Lane” bridge	41°40’53.195”	77°02’22.652”
Corey Creek Watershed				
CORY1.0	Corey Creek	Upstream of Route 549 bridge	41°48’01.398”	77°02’46.243”
Crooked Creek Watershed				
CROO1.0	Crooked Creek	Upstream of railroad bridge	41°51’22.228”	77°14’06.378”
CATL1.0	Catlin Hollow	Upstream of private drive on SR4035	41°49’07.139”	77°16’39.723”
HILL1.0	Hills Creek	Upstream of SR4039 bridge	41°51’23.287”	77°13’30.546”
NORR1.0	Norris Brook	Upstream of T584 bridge	41°49’29.621”	77°17’09.391”
East Creek Watershed				
UNT8.0	Unnamed tributary to East Creek	At mouth	41°42’00.741”	77°03’24.663”
Elk Run Watershed				
ELKR1.0	Elk Run	Upstream of Route 660 bridge	41°45’38.350”	77°06’11.942”
Ellen Run Watershed				
ELLN1.0	Ellen Run	Downstream of T754 bridge	41°48’17.442”	77°05’00.445”
Fall Brook Watershed				
FALL1.0	Fall Brook	At mouth	41°39’24.819”	77°00’17.139”
FALL2.0	Fall Brook	Upstream of SR2014 bridge	41°40’42.660”	76°59’15.780”
FALL2.5	Fall Brook	Downstream of unnamed tributary	41°41’06.517”	76°59’11.018”
FALL2.6	Fall Brook	Upstream of unnamed tributary	41°41’09.337”	76°59’10.979”
FALL3.0	Fall Brook	Upstream of T834 bridge	41°42’27.548”	76°58’50.426”
UNT2.0	Unnamed tributary to Fall Brook	At mouth of wetland	41°41’22.139”	76°59’29.400”
Fellows Creek Watershed				
FELL1.0	Fellows Creek	Upstream of T390 bridge	41°41’08.340”	76°56’13.320”
FELL2.0	Fellows Creek	Downstream of gated road	41°42’58.260”	76°57’07.200”
FELL3.0	Fellows Creek	Upstream of Old Possessions Road bridge	41°43’47.340”	76°56’47.400”
Johnson Creek Watershed				
JOHN1.0	Johnson Creek	At mouth	41°40’41.629”	77°04’04.832”
JOHN2.0	Johnson Creek	At trail crossing bridge	41°39’40.237”	77°05’56.755”
JOHN3.0	Johnson Creek	Downstream of Elm Street Bridge	41°39’49.061”	77°07’09.981”

Station Name	Stream Name	Station Description	North Coordinate	West Coordinate
UNT5.0	Unnamed tributary to Johnson Creek	At mouth	41°39’52.025”	77°04’49.774”
UNT7.0	Unnamed tributary to Johnson Creek	At mouth	41°39’43.553”	77°06’28.092”
BELL1.0	Bellman Run	Upstream of Blossburg water tower	41°39’10.275”	77°05’40.075”
UNT6.0	Unnamed tributary to Bellman Run	At mouth	41°38’20.409”	77°05’59.449”
Lambs Creek Watershed				
LAMB1.0	Lambs Creek	At mouth	41°50’29.142”	77°06’26.012”
Marvin Creek Watershed				
MARV1.0	Marvin Creek	Upstream of SR2025 bridge	41°43’46.105”	77°05’11.632”
McIntosh Hollow Watershed				
MCIN1.0	McIntosh Hollow	Upstream of T390 bridge	41°42’51.013”	76°54’30.497”
Mill Creek Watershed				
MILL1.0	Mill Creek	At end of SR1004	41°52’24.230”	77°06’05.475”
Morris Run Watershed				
MORR1.0	Morris Run	At pipeline crossing	41°39’46.964”	77°02’21.507”
MORR2.0	Morris Run	At SR2024 bridge	41°40’15.108”	77°01’37.704”
MORR3.0	Morris Run	Upstream of T800	41°41’31.071”	77°00’40.344”
UNT3.0	Unnamed tributary to Morris Run	At mouth of wetland	41°41’18.739”	76°59’49.759”
Rathbone Creek Watershed				
RATH1.0	Rathbone Creek	At mouth	41°43’17.996”	76°53’33.587”
South Creek Watershed				
SOUT1.0	South Creek	At mouth	41°40’18.900”	76°56’46.680”
Taylor Run Watershed				
UNT4.0	Unnamed tributary to Taylor Run	Upstream of SR2017	41°39’16.439”	77°02’39.419”
Tioga River Mainstem Watershed				
TIOG1.0	Tioga River	Upstream of USGS gauging station	41°47’46.638	77°04’48.392”
TIOG2.0	Tioga River	Upstream of Route 15 bridge	41°43’34.101”	77°41’53.628”
TIOG3.0	Tioga River	At Island Park	41°40’39.231”	77°04’01.545”
TIOG4.0	Tioga River	Upstream of Carpenter Run	41°39’13.621”	77°01’53.182”
TIOG5.0	Tioga River	Upstream of Bear Run	41°39’36.878”	76°58’25.439”
TIOG6.0	Tioga River	At County Bridge Picnic area	41°40’47.417”	76°56’27.117”
TIOG7.0	Tioga River	Upstream of T431 bridge	41°41’40.380”	76°55’53.400”
TIOG8.0	Tioga River	Upstream of SR3032	41°44’13.093”	76°53’21.797”
UNT1.0	Unnamed tributary to Tioga River	Downstream of T390	41°40’16.285”	76°58’01.570”

Table A2. Abandoned Mine Discharge Locations

Discharge Name	Discharge Description	North Coordinate	West Coordinate
Bear Creek Watershed			
DBC100	Continuous artesian discharge to stream bottom	41°41’08.905”	77°03’08.493”
DBC102	Continuous discharge from collapsed drift	41°41’08.108”	77°03’09.508”
DBC103	Intermittent discharge from collapsed drift	41°41’07.908”	77°03’08.820”
DBC104	Intermittent discharge from collapsed drift	41°41’24.360”	77°02’46.968”
Coal Creek Watershed			
DCC005	Continuous discharge from opening across stream from Journey’s End Camp	41°40’34.625”	77°03’00.451”
DCC100	Intermittent discharge from seepage area	41°40’15.918”	77°03’11.484”
East Creek Watershed			
DEC001	Intermittent discharge from refuse piles	41°42’44.596”	77°01’42.633”
Fall Brook Watershed			
DFB099	Continuous discharge from collapsed drift near State Forest boundary	41°40’18.020”	76°59’20.451”
DFB001	Continuous discharge from pipe in well at power line crossing	41°40’43.709”	76°59’06.055”
DFB002	Continuous artesian discharge into orange swamp	41°40’51.821	76°59’05.958”
DFB003	Intermittent discharge from collapsed drift above DFB002	41°40’52.014”	76°59’03.293”
DFB004	Continuous discharge from collapsed drift along T834	41°40’59.488”	76°59’01.922”
DFB100	Continuous discharge from pipe into pond behind Fall Brook Hunting Club	41°41’10.547”	76°58’58.093”
DFB900	Continuous discharge from diffuse dead tree area adjacent to stream (contaminated groundwater recharge)	41°40’16.140”	76°59’34.260”
DFB901	Intermittent discharge from along abandoned railroad grade (contaminated groundwater recharge)	41°39’57.540”	76°59’47.580”
DFB902	Continuous discharge from along abandoned railroad grade (contaminated groundwater recharge)	41°40’04.620”	76°59’40.380”
DFB903	Continuous discharge from mossy seep area on hillside (contaminated groundwater recharge)	41°40’18.780”	76°59’28.500”
Morris Run Watershed			
DMR001	Continuous discharge from Tioga Mine at end of Tioga Street	41°40’14.379”	77°01’16.563”
DMR003	Continuous discharge from East Mine behind St. Joseph’s Catholic Church	41°40’14.379”	77°01’16.563”
DMR004	Continuous discharge from Lake Mine behind pallet factory	41°40’53.131”	77°00’43.724”
DMR100	Continuous diffuse discharge from wooded area	41°40’28.560”	77°01’31.044”
DMR101	Continuous discharge from rusted well casing	41°40’28.452”	77°01’30.252”
DMR105	Continuous discharge at SR2024 bridge (contaminated groundwater recharge)	41°40’15.816”	77°01’37.272”
DMR600	Intermittent diffuse discharge from reclaimed surface mine	41°40’29.052”	77°00’39.995”
DMR900	Intermittent discharge from collapsed drift along jeep trail	41°39’54.340”	77°01’47.121”
DMR901	Intermittent discharge from toe of reclaimed surface mine	41°40’56.125”	77°00’22.391”
DMR902	Continuous discharge from pipe on reclaimed surface mine	41°40’45.200”	77°01’51.906”
Tioga River Mainstem			
DTR001	Continuous discharge from South Mountain	41°39’24.480”	77°03’46.584”
DTR002	Continuous discharge from South Mountain	41°39’24.696”	77°03’39.996”
Johnson Creek Watershed			
DJC106	Continuous discharge from Flower Run mine at collapsed drift	41°39’21.240”	77°05’57.192”
DJC900	Continuous discharge into bottom of strip cut; called #5 discharge	41°40’00.007”	77°06’34.091”
DJC901	Continuous discharge from toe of abandoned surface mine	41°39’33.000”	77°03’56.640”
DJC904	Continuous discharge from Arnot#2 mine into bottom of strip cut	41°40’12.794”	77°07’50.300”
DJC905	Intermittent discharge from bottom of refuse pile	41°39’53.341”	77°06’39.536”
DJC906	Continuous discharge from bottom of refuse pile	41°39’35.044”	77°06’34.494”
DJC907	Continuous discharge from toe of reclaimed surface mine and deep mine opening in impoundment	41°39’13.553”	77°04’08.816”

Table A3. Discharge Monitoring Station Locations

Station Name	Stream Name Station Description	North Coordinate	West Coordinate
	Bear Creek Watershed		
DBC101	Aggregation of discharge waters from DBC100-104; sampled in channel immediately below confluence of all discharges	41°41’07.489”	77°03’08.672°
DBC100	Continuous artesian discharge to stream bottom	41°41’08.905”	77°03’08.493”
DBC102	Continuous discharge from collapsed drift	41°41’08.108”	77°03’09.508”
DBC103	Intermittent discharge from collapsed drift	41°41’07.908”	77°03’08.820”
DBC104	Intermittent discharge from collapsed drift	41°41’24.360”	77°02’46.968”
	Coal Creek Watershed		
DCC005	Sampled in concrete weir at mine opening across stream from Journey’s End Camp	41°40’34.625”	77°03’00.451”
	Fall Brook Watershed		
DFB099	Continuous discharge from collapsed drift near state forest boundary	41°40’18.020”	76°59’20.451”
DFB001	Continuous discharge from pipe in well at power line crossing	41°40’43.709”	76°59’06.055”
DFB002	Continuous artesian discharge into orange swamp	41°40’51.821”	76°59’05.958”
DFB003	Intermittent discharge from collapsed drift above DFB002	41°40’52.014”	76°59’03.293”
DFB004	Continuous discharge from collapsed drift along T834	41°40’59.488”	76°59’01.922”
DFB100	Continuous discharge from pipe into pond behind Fall Brook Hunting Club	41°41’10.547”	76°58’28.093”
	Morris Run Watershed		
DMR001	Continuous discharge from Tioga Mine at end of Tioga Street	41°40’26.922”	77°01’02.407”
DMR003	Continuous discharge from East Mine behind St. Joseph’s Catholic Church	41°40’14.379”	77°01’16.563”
DMR004	Continuous discharge from Lake Mine behind pallet factory	41°40’53.131”	77°00’43.724”
	Tioga River Mainstem		
DTR003	Aggregation of discharge waters from DTR001, DTR002; sampled upstream of confluence of tributary with the Tioga River	41°39’48.900”	77°03’24.840”
	Johnson Creek Watershed		
DJC106	Continuous discharge from Flower Run mine at collapsed drift	41°39’21.240”	77°05’57.192”
DJC900	Continuous discharge into bottom of strip cut; called #5 discharge	41°40’00.007”	77°06’34.091”
DJC902	Aggregation of discharge waters from the DJC907 area; sampled at aggregation point	41°39’17.416”	77°04’19.246”
DJC903	Aggregation of discharge waters from the DJC901 area; sampled at mouth of tributary formed by discharge waters	41°39’35.040”	77°04’28.470”
DJC904	Continuous discharge from Arnot#2 mine into bottom of strip cut	41°40’12.794”	77°07’50.300”

APPENDIX B

WATER QUALITY Sampling DATA

Table B1 and B2 Acronyms

DO	Dissolved Oxygen
Cond.	Conductivity
TSS	Total Suspended Solids
Ca	Total Calcium
Mg	Total Magnesium
SO_4	Total Sulfate
Fe	Total Iron
Fer Fe	Total Ferrous Iron
Hard	Total Hardness
Mn	Total Manganese
Al	Total Aluminum
Alk	Total Alkalinity
Hot Acid	Total Hot Acidity
NMF	No measurable flow: water standing in small pools
PS	Pipe submerged: discharge pipe into pond underwater, unable to measure flow
D	Dry: no water in channel
*	No data available

- Flow is listed in units of cubic feet per second.
- Concentrations are listed in units of milligrams per liter (mg/l) with the exception of the metals iron, manganese and aluminum, which are listed in units of micrograms per liter (µg/l).
- pH is listed in specific units (SU).
- Conductivity is listed in units of micromhos (µΩ).
- Data recorded at the detection limit were included in computations as the value of the detection limit (<3.0 is used as 3.0 in computations for averages); this ensures that the average value is conservative of at least the concentration of the detection limit.

Table B1. Tioga Seasonal Data

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
TIOG1.0	4/23/2001	403.000	5.90	5.00	144.0	6.0	10.90	4.25	38.0	809.0	822.0	938.0	7.0	6.6
	6/4/2001	78.000	4.95	7.61	222.0	<3.0	16.50	7.75	80.9	<300.0	1680.0	1920.0	10.8	11.8
	10/9/2001	68.000	4.15	7.69	281.0	6.0	18.40	9.29	95.9	390.0	2200.0	2960.0	8.0	66.2
	3/5/2002	124.000	5.70	10.07	201.0	14.0	14.50	5.79	58.7	1060.0	1050.0	1660.0	8.6	27.2
	5/28/2002	177.000	4.50	8.97	220.0	<3.0	12.60	6.24	60.4	591.0	1370.0	1820.0	7.0	51.8
	8/20/2002	15.000	3.80	5.19	552.0	4.0	41.30	21.30	<20.0	<300.0	4970.0	7940.0	1.8	118.4
	Average	***144.167***	***4.83***	***7.42***	***270.0***	***6.0***	***19.03***	***9.10***	***59.0***	***575.0***	***2015.3***	***2873.0***	***7.2***	***47.0***
TIOG2.0	4/30/2001	349.510	3.50	5.70	258.0	<3.0	*	*	70.3	*	*	*	1.4	26.0
	6/11/2001	32.575	3.90	6.74	385.0	<3.0	20.40	11.60	100.1	520.0	2810.0	3880.0	0.0	49.0
	10/18/2001	59.028	4.10	7.02	178.0	<3.0	10.60	5.60	32.0	761.0	1370.0	1550.0	5.8	98.2
	3/19/2002	114.128	4.00	9.80	224.0	4.0	11.80	6.31	23.8	870.0	1470.0	1920.0	4.8	58.8
	6/13/2002	160.850	3.90	7.19	271.0	<3.0	13.40	7.97	50.2	941.0	1920.0	2640.0	2.0	46.8
	8/19/2002	14.589	3.40	5.25	633.0	<3.0	39.10	21.60	245.1	605.0	5230.0	8760.0	0.0	109.4
	Average	***121.780***	***3.80***	***6.95***	***324.8***	***3.2***	***19.06***	***10.62***	***86.9***	***739.4***	***2560.0***	***3750.0***	***2.3***	***64.7***
TIOG3.0	4/30/2001	282.100	3.40	6.49	278.0	<3.0	24.50	17.00	74.0	4070.0	4480.0	6390.0	0.0	36.0
	6/11/2001	23.848	3.50	6.97	446.0	<3.0	20.30	13.20	136.5	2440.0	3570.0	5610.0	0.0	64.6
	10/10/2001	43.013	3.75	7.70	243.0	4.0	13.80	9.48	68.2	436.0	2940.0	2560.0	7.6	59.6
	3/13/2002	73.542	3.70	10.55	273.0	<3.0	11.90	7.48	66.8	1960.0	1980.0	2590.0	0.0	79.6
	6/11/2002	123.380	3.60	5.85	270.0	<3.0	12.30	8.74	75.7	1890.0	2350.0	3030.0	0.0	34.8
	8/19/2002	8.851	3.10	5.89	897.0	<3.0	49.20	32.20	405.2	6960.0	8460.0	14300.0	0.0	145.2
	Average	***92.456***	***3.51***	***7.24***	***401.2***	***3.2***	***22.00***	***14.68***	***137.7***	***2959.3***	***3963.3***	***5746.7***	***1.3***	***70.0***
TIOG4.0	4/30/2001	172.680	4.80	6.65	89.0	<3.0	6.01	3.75	37.0	<300.0	973.0	790.0	7.6	5.4
	6/18/2001	13.916	6.65	6.58	70.0	4.0	5.34	2.33	<20.0	<300.0	473.0	<500.0	9.4	3.2
	10/10/2001	29.421	5.80	7.97	114.0	8.0	6.10	3.75	42.4	<300.0	1080.0	724.0	8.2	40.0
	3/18/2002	68.374	6.15	10.14	74.0	<3.0	5.00	2.63	37.1	<300.0	649.0	<500.0	8.2	27.6
	5/30/2002	78.842	6.05	7.96	86.0	<3.0	5.10	2.96	51.7	<300.0	792.0	559.0	7.8	35.4
	8/14/2002	3.947	5.70	5.47	212.0	4.0	13.20	8.64	88.0	<300.0	2190.0	1350.0	7.0	31.8
	Average	***61.197***	***5.86***	***7.46***	***107.5***	***4.2***	***6.79***	***4.01***	***46.0***	***300.0***	***1026.2***	***737.2***	***8.0***	***23.9***
TIOG5.0	4/30/2001	102.580	6.20	7.08	37.0	4.0	4.45	1.15	<20.0	<300.0	<50.0	<500.0	11.4	0.2
	6/12/2001	8.420	6.50	6.85	43.0	<3.0	4.18	1.02	<20.0	<300.0	<50.0	<500.0	12.8	0.0
	10/10/2001	19.734	6.65	7.49	42.0	8.0	4.05	0.96	<20.0	<300.0	<50.0	<500.0	15.6	2.4
	3/18/2002	37.451	6.30	10.13	37.0	<3.0	3.54	0.85	<20.0	<300.0	<50.0	<500.0	11.2	0.0
	5/29/2002	58.878	6.35	9.26	32.0	<3.0	2.87	0.73	<20.0	<300.0	<50.0	<500.0	10.0	15.0

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	8/14/2002	1.783	7.05	5.67	51.0	4.0	5.05	1.14	<20.0	<300.0	<50.0	<500.0	15.0	0.0
	Average	***38.141***	***6.51***	***7.75***	***40.3***	***4.2***	***4.02***	***0.97***	***20.0***	***300.0***	***50.0***	***500.0***	***12.7***	***2.9***
TIOG6.0	4/24/2001	93.610	6.60	5.69	31.0	<3.0	3.07	0.74	<20.0	<300.0	68.0	<500.0	9.2	0.0
	6/12/2001	7.329	6.80	7.18	41.0	<3.0	4.32	1.00	<20.0	<300.0	<50.0	<500.0	15.2	0.0
	10/2/2001	17.471	6.50	7.89	34.0	<3.0	3.56	0.81	<20.0	<300.0	66.0	<500.0	11.4	0.0
	3/18/2002	30.992	6.40	10.29	34.0	<3.0	3.53	0.82	<20.0	<300.0	<50.0	<500.0	11.2	0.0
	5/29/2002	43.648	6.70	9.30	29.0	<3.0	2.66	0.65	24.4	<300.0	74.0	<500.0	9.6	24.4
	8/14/2002	0.943	7.35	6.25	55.0	4.0	6.18	1.25	<20.0	<300.0	<50.0	<500.0	22.0	0.0
	Average	**32.332**	**6.73**	**7.77**	**37.3**	**3.2**	**3.89**	**0.88**	**20.7**	**300.0**	**59.7**	**500.0**	**13.1**	**4.1**
TIOG7.0	4/23/2001	50.683	6.50	5.74	34.0	<3.0	3.95	0.83	<20.0	<300.0	<50.0	<500.0	10.2	0.0
	6/12/2001	3.815	7.00	7.16	55.0	<3.0	6.10	1.19	<20.0	<300.0	<50.0	<500.0	22.0	0.0
	10/2/2001	9.759	6.70	7.58	42.0	<3.0	4.63	0.92	<20.0	<300.0	<50.0	<500.0	15.4	0.0
	3/18/2002	20.838	6.45	10.55	41.0	6.0	4.51	0.91	<20.0	<300.0	<50.0	<500.0	14.6	0.0
	5/28/2002	20.660	6.80	10.66	37.0	<3.0	4.27	0.88	25.2	<300.0	<50.0	<500.0	14.4	0.0
	8/13/2002	1.611	7.50	6.26	62.0	<3.0	7.65	1.44	41.0	<300.0	<50.0	<500.0	28.0	0.0
	Average	***17.894***	***6.83***	***7.99***	***45.2***	***3.5***	***5.19***	***1.03***	***24.4***	***300.0***	***50.0***	***500.0***	***17.4***	***0.0***
TIOG8.0	4/23/2001	6.793	6.80	5.49	40.0	<3.0	4.58	0.97	22.3	<300.0	<50.0	<500.0	11.0	0.0
	6/4/2001	1.053	7.10	8.71	57.0	<3.0	6.92	1.28	23.4	<300.0	<50.0	<500.0	26.0	0.0
	10/1/2001	1.859	6.75	8.02	48.0	<3.0	5.79	1.16	27.9	<300.0	<50.0	<500.0	18.6	18.4
	3/6/2002	2.133	6.30	10.71	51.0	<3.0	5.50	1.10	<20.0	<300.0	<50.0	<500.0	17.6	2.8
	5/28/2002	2.522	7.10	9.42	51.0	4.0	5.75	1.14	<20.0	<300.0	<50.0	<500.0	19.4	0.0
	8/13/2002	0.189	7.90	6.42	99.0	<3.0	14.00	2.37	20.7	<300.0	<50.0	<500.0	48.0	0.0
	Average	***2.425***	***6.99***	***8.13***	***57.7***	***3.2***	***7.09***	***1.34***	***22.4***	***300.0***	***50.0***	***500.0***	***23.4***	***3.5***
MCIN1.0	4/23/2001	5.985	4.15	5.57	34.0	<3.0	1.63	0.45	<20.0	<300.0	236.0	<500.0	5.2	4.6
	6/4/2001	1.157	5.30	8.56	28.0	<3.0	1.37	0.36	<20.0	<300.0	145.0	<500.0	7.6	1.6
	10/1/2001	2.092	4.60	7.49	31.0	<3.0	1.77	0.46	<20.0	<300.0	203.0	<500.0	7.0	13.6
	3/6/2002	1.632	4.50	10.89	30.0	<3.0	1.58	0.44	<20.0	<300.0	140.0	<500.0	6.2	5.2
	5/28/2002	2.214	4.50	10.43	30.0	<3.0	1.57	0.44	<20.0	<300.0	172.0	<500.0	7.2	9.2
	8/13/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***2.616***	***4.61***	***8.59***	***30.6***	***3.0***	***1.58***	***0.43***	***20.0***	***300.0***	***179.2***	***500.0***	***6.6***	***6.8***
FELL1.0	4/23/2001	20.769	4.10	5.17	35.0	<3.0	1.50	0.53	<20.0	<300.0	210.0	<500.0	5.8	4.8
	6/4/2001	6.141	5.10	8.08	29.0	<3.0	1.57	0.45	<20.0	<300.0	137.0	<500.0	7.4	4.2
	10/2/2001	7.349	4.10	7.63	33.0	<3.0	1.52	0.53	32.6	<300.0	246.0	<500.0	6.2	28.2
	3/14/2002	5.215	5.00	10.01	31.0	<3.0	1.50	0.56	<20.0	<300.0	149.0	<500.0	6.8	16.2

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	5/28/2002	9.650	4.75	9.68	30.0	<3.0	1.38	0.50	<20.0	<300.0	155.0	<500.0	6.4	19.4
	8/13/2002	0.104	5.40	4.78	32.0	<3.0	1.72	0.58	<20.0	<300.0	267.0	<500.0	7.6	8.4
	Average	***8.205***	***4.74***	***7.56***	***31.7***	***3.0***	***1.53***	***0.52***	***22.1***	***300.0***	***194.0***	***500.0***	***6.7***	***13.5***
FELL2.0	4/24/2001	15.089	4.20	6.91	35.0	<3.0	15.10	2.50	<20.0	511.0	<50.0	<500.0	3.8	7.4
	6/4/2001	5.406	5.20	8.23	29.0	<3.0	1.57	0.51	<20.0	<300.0	183.0	<500.0	7.4	4.2
	10/1/2001	6.354	4.50	7.76	34.0	<3.0	1.52	0.50	<20.0	<300.0	261.0	<500.0	6.8	30.6
	3/14/2002	4.957	4.70	10.43	31.0	<3.0	1.54	0.53	<20.0	<300.0	160.0	<500.0	6.6	28.6
	5/28/2002	9.130	5.00	10.03	31.0	<3.0	1.34	0.46	<20.0	<300.0	155.0	<500.0	6.6	27.2
	8/14/2002	0.080	6.30	4.24	26.0	4.0	1.51	0.45	<20.0	902.0	717.0	<500.0	8.8	56.8
	Average	***6.836***	***4.98***	***7.93***	***31.0***	***3.2***	***3.76***	***0.82***	***20.0***	***435.5***	***254.3***	***500.0***	***6.7***	***25.8***
FELL3.0	4/23/2001	7.381	4.15	5.47	33.0	<3.0	1.65	0.49	<20.0	<300.0	185.0	<500.0	6.0	4.8
	6/4/2001	1.462	5.80	8.80	26.0	<3.0	1.86	0.53	<20.0	<300.0	163.0	<500.0	7.4	2.6
	10/1/2001	3.372	5.30	8.15	31.0	<3.0	1.75	0.51	<20.0	<300.0	206.0	<500.0	6.8	28.2
	3/6/2002	2.748	4.80	11.33	27.0	<3.0	1.55	0.48	<20.0	<300.0	119.0	<500.0	6.6	17.4
	5/28/2002	3.229	4.70	10.65	29.0	<3.0	1.56	0.49	<20.0	<300.0	143.0	<500.0	7.0	22.0
	8/13/2002	0.033	6.00	5.65	20.0	<3.0	1.51	0.43	<20.0	<300.0	98.0	<500.0	8.4	33.4
	Average	***3.038***	***5.13***	***8.34***	***27.7***	***3.0***	***1.65***	***0.49***	***20.0***	***300.0***	***152.3***	***500.0***	***7.0***	***18.1***
FALL1.0	4/30/2001	19.047	3.75	7.03	290.0	<3.0	13.00	12.50	80.0	465.0	4120.0	3300.0	4.0	32.0
	6/18/2001	4.436	3.90	6.87	459.0	4.0	25.10	21.60	164.4	<300.0	7610.0	4760.0	2.2	48.2
	10/10/2001	6.388	3.40	8.28	393.0	<3.0	18.70	17.10	112.5	575.0	6130.0	4330.0	3.2	63.2
	3/18/2002	9.884	4.00	10.19	257.0	<3.0	11.60	10.30	63.0	451.0	3520.0	2480.0	3.2	69.2
	5/30/2002	13.966	3.75	8.26	309.0	<3.0	14.00	13.20	116.2	427.0	4440.0	3100.0	4.0	70.6
	8/14/2002	0.899	3.90	5.91	604.0	<3.0	34.50	31.00	235.2	<300.0	11100.0	8200.0	0.0	108.2
	Average	***9.103***	***3.78***	***7.76***	***385.3***	***3.2***	***19.48***	***17.62***	***128.6***	***419.7***	***6153.3***	***4361.7***	***2.8***	***65.2***
FALL2.0	4/24/2001	15.391	3.90	5.91	85.0	<3.0	3.85	2.27	26.0	375.0	997.0	742.0	6.0	10.6
	6/18/2001	2.000	4.00	6.40	194.0	<3.0	9.68	6.06	44.6	1130.0	2740.0	1270.0	2.4	24.0
	10/2/2001	5.184	3.75	7.38	125.0	<3.0	<0.10	0.10	<20.0	<300.0	<50.0	<500.0	4.4	41.6
	3/6/2002	8.005	4.20	10.38	100.0	<3.0	4.49	2.74	<20.0	527.0	1140.0	954.0	5.2	40.6
	5/28/2002	11.341	4.20	9.89	89.0	<3.0	4.17	2.38	20.6	348.0	972.0	667.0	7.6	50.6
	8/13/2002	0.728	4.70	5.34	299.0	<3.0	17.20	9.84	60.2	1490.0	5590.0	1820.0	0.0	35.0
	Average	***7.108***	***4.13***	***7.55***	***148.7***	***3.0***	***6.58***	***3.90***	***31.9***	***695.0***	***1914.8***	***992.2***	***4.3***	***33.7***
FALL2.5	6/13/2002	8.140	4.50	7.15	59.0	3.0	2.85	1.53	20.0	300.0	581.0	526.0	7.2	45.4
	8/21/2002	0.523	4.20	5.35	136.0	3.0	7.27	4.41	110.9	533.0	2340.0	500.0	5.6	57.4

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	Average	***4.332***	***4.35***	***6.25***	***97.5***	***3.0***	***5.06***	***2.97***	***65.5***	***416.5***	***1460.5***	***513.0***	***6.4***	***51.4***
FALL2.6	6/13/2002	5.860	4.60	6.98	60.0	<3.0	2.74	1.56	<20.0	<300.0	584.0	552.0	6.6	44.4
	8/21/2002	0.376	4.50	5.41	139.0	<3.0	8.07	4.74	26.9	531.0	2560.0	<500.0	5.6	59.0
	Average	***3.118***	***4.55***	***6.20***	***99.5***	***3.0***	***5.41***	***3.15***	***23.5***	***415.5***	***1572.0***	***526.0***	***6.1***	***51.7***
FALL3.0	4/23/2001	4.087	4.20	5.37	62.0	<3.0	3.21	1.88	<20.0	<300.0	596.0	<500.0	6.0	7.0
	6/4/2001	1.407	5.25	8.84	79.0	<3.0	4.30	2.78	22.9	<300.0	829.0	1040.0	7.8	7.4
	10/1/2001	1.376	4.30	8.24	71.0	<3.0	3.46	2.18	109.0	<300.0	783.0	965.0	7.2	33.8
	3/6/2002	3.212	4.50	10.98	58.0	<3.0	3.04	1.84	29.7	<300.0	478.0	755.0	6.8	15.6
	5/28/2002	3.012	4.50	10.55	61.0	<3.0	2.99	1.80	<20.0	<300.0	518.0	612.0	6.8	21.2
	8/13/2002	0.193	5.25	6.23	136.0	<3.0	6.29	4.89	24.3	<300.0	2000.0	2000.0	7.4	41.4
	Average	***2.215***	***4.67***	***8.37***	***77.8***	***3.0***	***3.88***	***2.56***	***37.7***	***300.0***	***867.3***	***978.7***	***7.0***	***21.1***
SOUT1.0	4/23/2001	16.531	6.90	5.37	36.0	<3.0	3.41	0.88	<20.0	<300.0	<50.0	<500.0	7.8	0.0
	6/4/2001	2.816	6.95	8.73	42.0	<3.0	3.55	0.90	<20.0	<300.0	<50.0	<500.0	12.0	0.0
	10/2/2001	5.658	6.80	7.70	38.0	<3.0	3.46	0.88	<20.0	<300.0	<50.0	<500.0	10.0	0.0
	3/6/2002	7.370	6.35	11.11	40.0	<3.0	3.16	0.83	<20.0	<300.0	<50.0	<500.0	9.2	0.0
	5/28/2002	4.459	6.65	10.29	35.0	<3.0	3.20	0.85	<20.0	<300.0	<50.0	<500.0	10.2	1.6
	8/13/2002	0.266	7.00	5.81	49.0	<3.0	5.21	1.29	<20.0	<300.0	<50.0	<500.0	14.2	0.6
	Average	***6.183***	***6.78***	***8.17***	***40.0***	***3.0***	***3.67***	***0.94***	***20.0***	***300.0***	***50.0***	***500.0***	***10.6***	***0.4***
UNT1.0	4/24/2001	0.104	4.70	4.92	53.0	<3.0	4.00	1.25	<20.0	<300.0	187.0	<500.0	7.4	3.6
	6/5/2001	0.024	6.50	7.22	218.0	4.0	22.30	5.47	56.4	<300.0	257.0	<500.0	15.8	0.0
	10/2/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	3/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	5/29/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	8/14/2002	NMF	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.064***	***5.60***	***6.07***	***135.5***	***3.5***	***13.15***	***3.36***	***38.2***	***300.0***	***222.0***	***500.0***	***11.6***	***1.8***
UNT2.0	4/24/2001	0.099	3.20	4.02	291.0	<3.0	10.60	6.90	68.0	917.0	4640.0	2540.0	0.0	42.0
	6/19/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	10/2/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	3/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	5/29/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	8/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.099***	***3.20***	***4.02***	***291.0***	***3.0***	***10.60***	***6.90***	***68.0***	***917.0***	***4640.0***	***2540.0***	***0.0***	***42.0***
UNT3.0	4/24/2001	0.135	3.20	4.37	349.0	<3.0	13.10	10.20	78.0	836.0	5830.0	3950.0	0.0	46.0

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	6/19/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	10/2/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	3/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	5/29/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	8/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.135***	***3.20***	***4.37***	***349.0***	***3.0***	***13.10***	***10.20***	***78.0***	***836.0***	***5830.0***	***3950.0***	***0.0***	***46.0***
UNT4.0	4/24/2001	0.865	4.05	7.32	45.0	<3.0	1.68	1.06	38.0	<300.0	298.0	532.0	6.6	4.8
	6/5/2001	0.057	5.30	8.68	43.0	<3.0	2.14	1.19	<20.0	<300.0	195.0	<500.0	9.4	1.4
	10/4/2001	0.334	3.80	7.55	45.0	<3.0	1.74	1.02	37.6	<300.0	295.0	508.0	6.8	10.4
	3/6/2002	0.403	4.35	11.49	48.0	<3.0	1.64	1.15	31.6	<300.0	212.0	716.0	8.0	11.8
	5/29/2002	0.310	4.60	9.40	44.0	<3.0	1.75	1.02	<20.0	<300.0	245.0	510.0	5.2	11.2
	8/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.394***	***4.42***	***8.89***	***45.0***	***3.0***	***1.79***	***1.09***	***29.4***	***300.0***	***249.0***	***553.2***	***7.2***	***7.9***
UNT5.0	4/25/2001	1.315	3.15	7.10	429.0	4.0	14.50	17.00	156.0	612.0	6920.0	6990.0	0.0	58.0
	6/11/2001	0.083	4.00	7.23	447.0	<3.0	19.80	19.30	196.3	<300.0	7830.0	8410.0	4.6	74.4
	10/10/2001	0.439	2.80	8.06	788.0	<3.0	27.40	33.90	325.9	956.0	14000.0	16700.0	0.0	168.0
	3/13/2002	0.776	3.60	10.90	484.0	<3.0	16.30	18.70	133.8	682.0	7570.0	8000.0	0.0	137.2
	6/11/2002	1.276	3.30	5.97	589.0	<3.0	19.20	24.30	154.1	1140.0	8940.0	11000.0	0.0	101.2
	8/19/2002	NMF	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.778***	***3.37***	***7.85***	***547.4***	***3.2***	***19.44***	***22.64***	***193.2***	***738.0***	***9052.0***	***10220.0***	***0.9***	***107.8***
UNT6.0	4/25/2001	3.628	7.20	7.38	32.0	<3.0	3.05	0.74	<20.0	<300.0	<50.0	<500.0	8.6	0.0
	6/11/2001	0.382	7.55	7.63	45.0	<3.0	5.07	0.95	<20.0	<300.0	<50.0	<500.0	19.0	0.0
	10/10/2001	0.994	7.20	7.81	37.0	4.0	4.04	0.81	32.9	<300.0	<50.0	<500.0	15.4	3.0
	3/13/2002	1.672	6.40	10.63	34.0	<3.0	3.64	0.77	<20.0	<300.0	50.0	<500.0	12.8	7.2
	5/30/2002	1.437	6.70	7.59	48.0	<3.0	3.43	0.70	42.3	<300.0	<50.0	<500.0	12.2	3.4
	8/15/2002	0.224	6.10	5.86	80.0	<3.0	11.10	1.77	<20.0	<300.0	<50.0	<500.0	32.0	0.0
	Average	***1.390***	***6.86***	***7.82***	***46.0***	***3.2***	***5.06***	***0.96***	***25.9***	***300.0***	***50.0***	***500.0***	***16.7***	***2.3***
UNT7.0	4/25/2001	7.282	6.35	7.05	224.0	<3.0	18.80	9.56	76.2	435.0	499.0	720.0	11.0	0.0
	6/11/2001	2.015	7.10	8.01	246.0	<3.0	22.60	9.91	99.7	784.0	474.0	<500.0	19.2	0.0
	10/9/2001	1.976	7.00	8.09	264.0	6.0	24.30	10.70	76.4	477.0	491.0	<500.0	16.6	32.2
	3/13/2002	3.413	6.65	9.19	247.0	4.0	21.70	9.82	89.8	574.0	512.0	522.0	15.2	45.6
	6/13/2002	8.325	6.95	7.91	229.0	<3.0	20.30	9.04	78.8	648.0	532.0	522.0	15.8	41.6
	8/15/2002	1.627	6.25	7.17	249.0	<3.0	27.20	11.00	108.8	683.0	625.0	<500.0	20.0	28.0
	Average	***4.106***	***6.72***	***7.90***	***243.2***	***3.7***	***22.48***	***10.01***	***88.3***	***600.2***	***522.2***	***544.0***	***16.3***	***24.6***

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
UNT8.0	4/30/2001	0.801	5.75	6.99	58.0	<3.0	9.58	4.04	25.3	<300.0	93.0	<500.0	8.2	2.2
	6/5/2001	0.035	6.75	8.38	68.0	<3.0	5.64	2.22	<20.0	<300.0	<50.0	<500.0	10.2	0.0
	10/11/2001	0.224	6.55	6.96	67.0	<3.0	5.01	1.90	<20.0	<300.0	<50.0	<500.0	9.4	12.0
	3/13/2002	0.301	5.70	10.65	70.0	<3.0	5.11	2.12	35.1	<300.0	<50.0	<500.0	7.2	12.4
	5/29/2002	0.209	6.25	9.56	67.0	<3.0	4.43	1.80	34.4	<300.0	<50.0	<500.0	6.4	6.0
	8/19/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.314***	***6.20***	***8.51***	***66.0***	***3.0***	***5.95***	***2.42***	***27.0***	***300.0***	***58.6***	***500.0***	***8.3***	***6.5***
CORY1.0	4/24/2001	28.703	8.85	5.79	137.0	4.0	12.60	2.31	20.9	<300.0	<50.0	<500.0	38.0	0.0
	6/18/2001	3.021	8.20	6.12	272.0	<3.0	32.20	5.19	57.7	<300.0	<50.0	<500.0	88.0	0.0
	10/17/2001	4.154	7.85	7.96	242.0	<3.0	27.40	4.54	29.0	<300.0	<50.0	<500.0	82.0	0.0
	3/12/2002	8.134	7.55	9.51	176.0	<3.0	20.40	3.33	<20.0	<300.0	<50.0	<500.0	50.0	0.0
	6/12/2002	13.702	7.45	7.40	153.0	<3.0	17.00	2.67	<20.0	<300.0	<50.0	<500.0	50.0	0.0
	8/20/2002	0.039	8.20	6.52	398.0	8.0	47.10	8.34	<20.0	<300.0	50.0	<500.0	128.0	0.0
	Average	***9.626***	***8.02***	***7.22***	***229.7***	***4.0***	***26.12***	***4.40***	***27.9***	***300.0***	***50.0***	***500.0***	***72.7***	***0.0***
LAMB1.0	4/30/2001	4.704	7.20	6.33	151.0	<3.0	*	*	40.0	*	*	*	48.0	0.0
	6/12/2001	1.038	7.10	6.27	204.0	12.0	24.30	3.80	*	<300.0	<50.0	<500.0	72.0	0.0
	10/18/2001	2.427	7.40	6.78	270.0	4.0	28.20	4.61	52.8	<300.0	<50.0	<500.0	82.0	0.0
	3/12/2002	2.675	7.60	9.72	178.0	12.0	24.20	3.60	<20.0	<300.0	<50.0	<500.0	62.0	0.0
	6/12/2002	5.330	7.50	7.79	149.0	<3.0	16.40	2.43	32.3	<300.0	<50.0	<500.0	54.0	0.0
	8/19/2002	0.301	8.00	7.14	241.0	<3.0	31.70	4.15	33.1	<300.0	<50.0	<500.0	88.0	0.0
	Average	***2.746***	***7.47***	***7.34***	***198.8***	***6.2***	***24.96***	***3.72***	***35.6***	***300.0***	***50.0***	***500.0***	***67.7***	***0.0***
CANO1.0	4/30/2001	6.535	9.20	6.61	154.0	<3.0	*	*	48.7	*	*	*	48.0	0.0
	6/12/2001	1.212	7.80	6.73	303.0	<3.0	32.10	6.15	50.7	<300.0	<50.0	<500.0	108.0	0.0
	10/11/2001	2.018	9.20	8.47	239.0	<3.0	26.40	4.97	46.2	<300.0	<50.0	<500.0	82.0	0.0
	3/12/2002	4.824	7.40	9.49	172.0	<3.0	18.90	3.70	<20.0	<300.0	<50.0	<500.0	50.0	0.0
	6/12/2002	8.157	7.50	6.57	191.0	4.0	19.40	3.55	<20.0	334.0	<50.0	<500.0	64.0	0.0
	8/19/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***4.549***	***8.22***	***7.57***	***211.8***	***3.2***	***24.20***	***4.59***	***37.1***	***308.5***	***50.0***	***500.0***	***70.4***	***0.0***
ELLN1.0	4/23/2001	1.802	9.20	5.03	346.0	8.0	25.90	4.60	43.0	763.0	<50.0	649.0	68.0	0.0
	6/4/2001	0.048	7.80	7.48	1048.0	6.0	71.00	12.30	81.7	321.0	<50.0	<500.0	156.0	0.0
	10/10/2001	0.331	8.05	8.26	846.0	4.0	58.20	10.60	68.7	<300.0	<50.0	<500.0	166.0	0.0
	3/12/2002	0.578	8.90	9.52	425.0	4.0	36.90	7.49	30.2	<300.0	<50.0	<500.0	84.0	0.0
	5/29/2002	0.292	8.30	8.06	422.0	<3.0	36.90	6.22	156.3	305.0	<50.0	<500.0	114.0	0.0
	8/20/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.610***	***8.45***	***7.67***	***617.4***	***5.0***	***45.78***	***8.24***	***76.0***	***397.8***	***50.0***	***529.8***	***117.6***	***0.0***

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
MARV1.0	4/30/2001	4.455	6.95	6.02	100.0	20.0	11.30	1.85	30.2	591.0	64.0	607.0	34.0	0.0
	6/11/2001	0.216	7.50	6.84	177.0	<3.0	19.70	2.98	29.3	<300.0	<50.0	<500.0	68.0	0.0
	10/11/2001	0.674	7.65	7.44	164.0	<3.0	18.40	2.79	33.0	<300.0	<50.0	<500.0	62.0	0.0
	3/12/2002	3.685	7.10	9.76	121.0	<3.0	11.60	1.75	45.0	<300.0	<50.0	<500.0	34.0	0.0
	6/12/2002	2.669	7.50	6.74	108.0	4.0	12.20	1.80	<20.0	367.0	<50.0	<500.0	44.0	0.0
	8/21/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***2.340***	***7.34***	***7.36***	***134.0***	***6.6***	***14.64***	***2.23***	***31.5***	***371.6***	***52.8***	***521.4***	***48.4***	***0.0***
JOHN1.0	4/25/2001	39.071	6.30	6.96	172.0	4.0	11.60	4.90	34.6	<300.0	440.0	<500.0	9.0	0.0
	6/11/2001	5.396	7.05	6.33	244.0	<3.0	20.00	6.52	75.4	<300.0	192.0	<500.0	22.0	0.0
	10/11/2001	8.423	6.80	6.65	246.0	<3.0	19.00	7.31	20.9	<300.0	823.0	566.0	16.6	37.4
	3/13/2002	19.676	6.50	10.01	190.0	<3.0	14.50	5.58	49.6	<300.0	512.0	<500.0	12.8	41.2
	6/11/2002	44.940	6.70	5.88	176.0	4.0	13.30	5.50	65.8	352.0	570.0	610.0	11.4	36.4
	8/19/2002	3.732	5.80	5.40	280.0	<3.0	26.60	8.25	47.7	<300.0	153.0	<500.0	28.0	0.0
	Average	**20.206**	**6.53**	**6.87**	**218.0**	**3.3**	**17.50**	**6.34**	**49.0**	**308.7**	**448.3**	**529.3**	**16.6**	**19.2**
JOHN2.0	4/25/2001	18.313	6.15	6.98	185.0	<3.0	14.40	7.18	53.9	<300.0	457.0	<500.0	7.8	1.0
	6/11/2001	3.061	6.90	7.85	218.0	<3.0	18.80	8.16	76.2	<300.0	291.0	<500.0	16.0	0.0
	10/9/2001	6.491	7.10	7.74	223.0	8.0	17.80	7.75	69.4	<300.0	367.0	<500.0	13.4	24.8
	3/13/2002	9.611	6.70	10.03	203.0	4.0	16.30	7.09	52.7	319.0	371.0	<500.0	14.0	41.4
	6/11/2002	21.360	7.00	5.83	184.0	<3.0	16.20	7.12	49.3	632.0	453.0	<500.0	12.0	40.8
	8/19/2002	3.571	5.80	6.81	253.0	<3.0	25.00	9.85	70.7	<300.0	324.0	<500.0	19.8	14.4
	Average	***10.401***	***6.61***	***7.54***	***211.0***	***4.0***	***18.08***	***7.86***	***62.0***	***358.5***	***377.2***	***500.0***	***13.8***	***20.4***
JOHN3.0	4/25/2001	6.086	6.70	6.31	244.0	<3.0	18.80	9.06	72.4	<300.0	566.0	<500.0	7.4	1.6
	6/11/2001	0.248	7.05	6.92	243.0	16.0	17.00	5.50	50.8	351.0	224.0	<500.0	20.0	5.0
	10/9/2001	2.932	7.15	7.06	248.0	6.0	20.90	9.27	62.1	<300.0	501.0	<500.0	13.2	20.0
	3/13/2002	2.633	6.70	9.64	259.0	4.0	21.10	8.36	85.8	507.0	325.0	<500.0	16.2	0.0
	6/11/2002	6.360	6.70	5.52	195.0	6.0	17.70	7.01	45.4	760.0	357.0	<500.0	15.2	32.0
	8/15/2002	0.840	6.30	5.56	321.0	<3.0	37.00	12.30	81.8	2220.0	850.0	559.0	26.0	21.6
	Average	***3.183***	***6.77***	***6.84***	***251.7***	***6.3***	***22.08***	***8.58***	***66.4***	***739.7***	***470.5***	***509.8***	***16.3***	***13.4***
BELL1.0	4/25/2001	11.774	7.30	7.59	107.0	<3.0	7.60	1.75	<20.0	<300.0	<50.0	<500.0	12.8	0.0
	6/11/2001	1.305	7.50	7.21	147.0	<3.0	12.00	2.36	22.3	<300.0	<50.0	<500.0	26.0	0.0
	10/9/2001	2.617	7.35	7.97	124.0	<3.0	10.10	2.04	*	<300.0	<50.0	<500.0	22.0	0.0
	3/13/2002	4.958	6.60	10.82	98.0	<3.0	7.45	1.55	<20.0	<300.0	<50.0	<500.0	16.2	4.0
	6/11/2002	10.230	7.10	5.95	95.0	<3.0	7.50	1.60	<20.0	<300.0	74.0	<500.0	15.8	0.0
	8/15/2002	0.488	*	5.68	162.0	<3.0	14.90	2.61	<20.0	<300.0	<50.0	<500.0	36.0	0.0

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. μΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe μg/l	Lab Total Mn μg/l	Lab Total Al μg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	Average	***5.229***	***7.17***	***7.54***	***122.2***	***3.0***	***9.93***	***1.99***	***20.5***	***300.0***	***54.0***	***500.0***	***21.5***	***0.7***
COAL1.0	4/25/2001	8.337	2.50	7.12	1315.0	<3.0	40.40	28.50	394.0	27200.0	4970.0	18600.0	0.0	278.0
	6/5/2001	2.828	2.55	8.95	1613.0	<3.0	76.60	50.00	>638.6	37200.0	9160.0	31600.0	0.0	416.0
	10/4/2001	3.480	2.10	7.78	1752.0	<3.0	67.00	42.80	357.2	35600.0	8130.0	33100.0	0.0	457.0
	3/13/2002	4.700	2.80	9.33	1465.0	<3.0	55.50	34.90	266.2	30700.0	6630.0	22800.0	0.0	381.8
	5/30/2002	5.948	2.60	12.90	1399.0	54.0	52.30	31.60	276.3	29800.0	5860.0	18700.0	0.0	313.8
	8/14/2002	2.704	2.65	7.43	1866.0	8.0	94.70	54.60	770.8	45400.0	10900.0	39500.0	0.0	507.2
	Average	***4.666***	***2.53***	***8.92***	***1568.3***	***12.3***	***64.42***	***40.40***	***450.5***	***34316.7***	***7608.3***	***27383.3***	***0.0***	***392.3***
COAL2.0	4/25/2001	0.923	4.90	6.48	67.0	<3.0	5.02	1.47	<20.0	<300.0	532.0	<500.0	6.2	3.0
	6/5/2001	0.017	6.25	6.44	77.0	<3.0	6.35	2.09	41.5	<300.0	389.0	<500.0	11.4	0.0
	10/4/2001	0.090	6.40	6.15	91.0	<3.0	7.11	2.47	35.6	<300.0	421.0	<500.0	10.8	30.2
	3/13/2002	0.254	5.75	10.11	63.0	<3.0	5.02	1.49	31.1	<300.0	399.0	<500.0	8.0	25.6
	5/30/2002	0.126	6.30	7.27	72.0	<3.0	5.29	2.01	<20.0	544.0	376.0	<500.0	11.4	37.4
	8/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.282***	***5.92***	***7.29***	***74.0***	***3.0***	***5.76***	***1.91***	***29.6***	***348.8***	***423.4***	***500.0***	***9.6***	***19.2***
BEAR1.0	4/25/2001	1.483	2.65	6.99	788.0	<3.0	25.20	16.70	220.0	5330.0	3550.0	8870.0	0.0	120.0
	6/5/2001	0.107	2.95	8.78	1190.0	<3.0	57.00	40.80	428.5	8310.0	8590.0	19100.0	0.0	226.0
	10/4/2001	0.312	2.30	7.51	1222.0	<3.0	49.70	33.80	320.4	7730.0	7640.0	18900.0	0.0	227.8
	3/13/2002	0.534	2.85	9.68	1034.0	<3.0	35.00	23.30	214.3	6350.0	5050.0	11800.0	0.0	206.8
	5/29/2002	1.303	2.80	10.07	802.0	4.0	26.70	17.00	205.1	4490.0	3500.0	8630.0	0.0	125.4
	8/19/2002	0.129	2.90	6.29	1376.0	<3.0	72.40	49.40	476.9	7030.0	11400.0	26500.0	0.0	265.8
	Average	***0.645***	***2.74***	***8.22***	***1068.7***	***3.2***	***44.33***	***30.17***	***310.9***	***6540.0***	***6621.7***	***15633.3***	***0.0***	***195.3***
HILL1.0	5/1/2001	11.615	6.85	6.34	151.0	<3.0	*	*	29.4	*	*	*	50.0	0.0
	6/19/2001	3.225	7.35	5.41	229.0	<3.0	30.50	3.98	30.5	<300.0	<50.0	<500.0	80.0	0.0
	10/17/2001	5.694	7.25	6.35	253.0	<3.0	28.90	4.08	50.1	<300.0	<50.0	<500.0	84.0	0.0
	3/13/2002	6.912	7.05	10.26	181.0	<3.0	22.30	3.11	42.0	<300.0	<50.0	<500.0	58.0	0.0
	6/12/2002	14.383	7.60	7.02	151.0	<3.0	16.40	2.25	<20.0	<300.0	<50.0	<500.0	54.0	0.0
	8/20/2002	2.433	7.20	5.08	201.0	<3.0	27.10	3.32	<20.0	<300.0	<50.0	<500.0	80.0	0.0
	Average	***7.377***	***7.22***	***6.74***	***194.3***	***3.0***	***25.04***	***3.35***	***32.0***	***300.0***	***50.0***	***500.0***	***67.7***	***0.0***
CROO1.0	5/1/2001	49.624	6.90	5.59	165.0	6.0	*	*	26.8	*	*	*	52.0	0.0
	6/19/2001	9.953	6.75	4.95	254.0	8.0	30.60	4.06	29.0	615.0	117.0	<500.0	80.0	0.0
	10/17/2001	22.408	7.50	6.08	315.0	12.0	31.10	4.48	42.4	<300.0	<50.0	<500.0	100.0	0.0
	3/13/2002	42.135	6.95	10.96	175.0	<3.0	20.30	2.90	22.8	<300.0	<50.0	<500.0	56.0	0.0
	6/12/2002	75.730	7.30	6.61	164.0	4.0	17.90	2.46	<20.0	<300.0	<50.0	<500.0	58.0	0.0
	8/20/2002	3.653	8.60	6.74	326.0	32.0	27.40	4.02	60.8	526.0	113.0	<500.0	94.0	0.0

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. μΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe μg/l	Lab Total Mn μg/l	Lab Total Al μg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	Average	***33.917***	***7.33***	***6.82***	***233.2***	***10.8***	***25.46***	***3.58***	***33.6***	***408.2***	***76.0***	***500.0***	***73.3***	***0.0***
NORR1.0	5/1/2001	8.266	6.65	6.65	68.0	<3.0	*	*	<20.0	*	*	*	20.0	0.0
	6/19/2001	1.030	7.50	5.62	100.0	<3.0	11.80	1.88	23.9	<300.0	<50.0	<500.0	32.0	0.0
	10/17/2001	1.963	7.10	6.79	145.0	4.0	14.90	2.53	23.0	<300.0	<50.0	<500.0	42.0	0.0
	3/13/2002	6.844	6.70	9.99	76.0	<3.0	8.45	1.47	<20.0	<300.0	<50.0	<500.0	24.0	0.0
	6/12/2002	13.947	7.30	8.06	72.0	<3.0	7.25	1.26	<20.0	<300.0	<50.0	<500.0	26.0	0.0
	8/20/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***6.410***	***7.05***	***7.42***	***92.2***	***3.2***	***10.60***	***1.79***	***21.4***	***300.0***	***50.0***	***500.0***	***28.8***	***0.0***
CATL1.0	5/1/2001	10.032	8.10	7.21	186.0	<3.0	*	*	23.0	*	*	*	58.0	0.0
	6/19/2001	D	*	*	*	*	*	*	*	*	*	*	*	*
	10/17/2001	3.317	7.50	6.34	341.0	<3.0	32.70	4.56	39.8	<300.0	<50.0	<500.0	90.0	0.0
	3/13/2002	5.863	7.15	10.48	215.0	<3.0	22.30	3.26	23.0	<300.0	<50.0	<500.0	62.0	0.0
	6/12/2002	8.364	7.50	7.81	187.0	<3.0	18.50	2.75	<20.0	<300.0	<50.0	<500.0	66.0	0.0
	8/20/2002	0.113	7.00	5.14	275.0	<3.0	29.40	3.97	48.0	<300.0	<50.0	<500.0	92.0	0.0
	Average	***5.538***	***7.45***	***7.40***	***240.8***	***3.0***	***25.73***	***3.64***	***30.8***	***300.0***	***50.0***	***500.0***	***73.6***	***0.0***
RATH1.0	4/23/2001	9.556	6.80	5.52	37.0	<3.0	4.18	0.82	<20.0	<300.0	<50.0	<500.0	9.6	0.0
	6/4/2001	1.407	7.00	8.64	45.0	<3.0	4.44	0.84	23.1	<300.0	<50.0	<500.0	14.8	0.0
	10/1/2001	2.433	6.90	8.14	43.0	<3.0	4.88	0.93	22.8	<300.0	<50.0	<500.0	14.2	7.6
	3/14/2002	2.513	6.20	10.29	42.0	<3.0	4.47	0.86	<20.0	<300.0	<50.0	<500.0	11.8	5.6
	5/28/2002	2.127	6.80	9.64	40.0	<3.0	4.47	0.86	20.7	<300.0	<50.0	<500.0	13.8	0.0
	8/13/2002	NMF	7.30	6.33	52.0	<3.0	6.54	1.17	36.6	<300.0	<50.0	<500.0	19.8	0.0
	Average	***3.607***	***6.83***	***8.09***	***43.2***	***3.0***	***4.83***	***0.91***	***23.9***	***300.0***	***50.0***	***500.0***	***14.0***	***2.2***
MORR1.0	4/24/2001	19.182	3.00	6.17	761.0	<3.0	35.80	30.90	*	2600.0	10000.0	10000.0	0.0	96.0
	6/5/2001	3.722	3.15	8.99	1250.0	<3.0	74.10	>50.00	523.0	4700.0	20300.0	17300.0	0.0	196.0
	10/4/2001	4.458	2.70	7.59	1302.0	<3.0	67.90	>50.00	520.0	5040.0	19200.0	18900.0	0.0	204.0
	3/14/2002	4.727	3.10	9.57	1013.0	<3.0	52.90	43.50	306.0	4040.0	14400.0	12000.0	0.0	146.6
	5/29/2002	8.878	3.00	9.75	1095.0	<3.0	55.40	49.30	470.9	4000.0	15300.0	15200.0	0.0	155.2
	8/14/2002	2.474	2.90	6.71	1360.0	10.0	83.90	64.80	731.7	4750.0	22500.0	19900.0	0.0	195.6
	Average	***7.240***	***2.98***	***8.13***	***1130.2***	***4.2***	***61.67***	***48.08***	***510.3***	***4188.3***	***16950.0***	***15550.0***	***0.0***	***165.6***
MORR2.0	4/24/2001	14.220	3.00	6.02	780.0	<3.0	36.20	31.10	314.0	2860.0	10100.0	9990.0	0.0	98.0
	6/5/2001	2.829	3.20	8.93	1298.0	<3.0	77.80	>50.00	663.2	6790.0	21900.0	18600.0	0.0	196.0
	10/4/2001	3.434	2.60	7.58	1316.0	<3.0	68.30	>50.00	568.0	5830.0	19800.0	19100.0	0.0	216.6
	3/14/2002	3.657	3.10	9.26	1043.0	<3.0	54.10	45.40	*	4550.0	15100.0	12600.0	0.0	160.4
	5/29/2002	8.098	2.95	9.85	1124.0	<3.0	54.10	48.90	372.9	4240.0	15300.0	15100.0	0.0	164.8

Monitoring Station	Date	Flow ft^3/s	Field pH	Field DO mg/l	Field Cond. µΩ	Lab TSS mg/l	Lab Total Ca mg/l	Lab Total Mg mg/l	Lab Total SO_4 mg/l	Lab Total Fe µg/l	Lab Total Mn µg/l	Lab Total Al µg/l	Lab Alk mg/l	Lab Hot Acid mg/l
	8/14/2002	2.083	4.10	7.35	1398.0	20.0	80.70	65.50	707.1	6140.0	22500.0	19700.0	0.0	203.2
	Average	***5.720***	***3.16***	***8.17***	***1159.8***	***5.8***	***61.87***	***48.48***	***525.0***	***5068.3***	***17450.0***	***15848.3***	***0.0***	***173.2***
MORR3.0	4/24/2001	5.034	4.25	5.02	43.0	<3.0	2.34	0.95	22.0	<300.0	229.0	<500.0	6.8	3.4
	6/5/2001	1.102	5.30	7.20	54.0	<3.0	3.18	1.39	<20.0	<300.0	284.0	<500.0	8.8	3.0
	10/2/2001	1.627	4.80	7.13	47.0	<3.0	2.71	1.04	<20.0	<300.0	261.0	<500.0	6.2	16.6
	3/14/2002	1.738	4.60	10.16	45.0	<3.0	2.81	1.14	<20.0	<300.0	161.0	<500.0	7.2	13.2
	5/29/2002	1.717	4.60	9.08	50.0	<3.0	2.58	1.18	<20.0	<300.0	235.0	<500.0	6.0	18.0
	8/14/2002	D	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***2.244***	***4.71***	***7.72***	***47.8***	***3.0***	***2.72***	***1.14***	***20.4***	***300.0***	***234.0***	***500.0***	***7.0***	***10.8***
MILL1.0	4/24/2001	122.100	7.65	6.93	120.0	4.0	11.70	2.14	23.7	<300.0	<50.0	<500.0	36.0	0.0
	6/18/2001	13.600	8.20	6.06	188.0	3.0	23.70	3.57	31.2	<300.0	<50.0	<500.0	66.0	0.0
	10/17/2001	17.070	7.30	6.83	214.0	12.0	25.20	3.90	31.2	<300.0	<50.0	<500.0	80.0	0.0
	3/19/2002	52.868	7.20	9.75	168.0	<3.0	18.30	3.02	55.2	<300.0	<50.0	<500.0	54.0	0.0
	6/12/2002	63.810	7.30	7.02	163.0	<3.0	16.60	2.48	<20.0	<300.0	<50.0	<500.0	54.0	0.0
	8/20/2002	2.028	7.50	5.91	237.0	<3.0	33.40	4.58	24.3	<300.0	<50.0	<500.0	92.0	0.0
	Average	***45.246***	***7.53***	***7.08***	***181.7***	***4.7***	***21.48***	***3.28***	***30.9***	***300.0***	***50.0***	***500.0***	***63.7***	***0.0***
ELKR1.0	4/23/2001	28.477	9.05	5.07	155.0	6.0	14.90	2.44	25.0	417.0	<50.0	<500.0	38.0	0.0
	6/12/2001	2.226	8.60	6.80	259.0	<3.0	24.70	3.90	33.4	<300.0	<50.0	<500.0	74.0	0.0
	10/18/2001	9.566	7.95	7.46	364.0	<3.0	32.00	5.13	33.6	<300.0	<50.0	<500.0	86.0	0.0
	3/19/2002	15.055	7.15	10.32	218.0	6.0	21.00	3.39	<20.0	<300.0	<50.0	<500.0	58.0	0.0
	6/13/2002	10.918	7.40	6.96	184.0	<3.0	19.20	3.07	<20.0	<300.0	<50.0	<500.0	64.0	0.0
	8/19/2002	0.110	8.50	6.25	244.0	<3.0	28.10	4.02	63.6	<300.0	<50.0	<500.0	88.0	0.0
	Average	***11.059***	***8.11***	***7.14***	***237.3***	***4.0***	***23.32***	***3.66***	***32.6***	***319.5***	***50.0***	***500.0***	***68.0***	***0.0***

Table B2. Tioga Discharge Data

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., μΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, μg/l	Lab Total Fer Fe, μg/l	Lab Total Mn, μg/l	Lab Total Al, μg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
DFB099	6/18/2001	0.469	3.4	7.63	1166.0	12.0	51.4	>50.0	*	462.2	1660.0	*	22700.0	15800.0	0.0	168.2
	11/7/2001	0.670	2.6	6.75	746.0	6.0	48.7	>50.0	*	479.6	1420.0	*	20300.0	14700.0	0.0	196.8
	3/18/2002	1.496	3.3	8.35	1059.0	4.0	44.4	60.1	*	351.6	1400.0	*	18800.0	13500.0	0.0	177.8
	4/8/2002	2.624	3.0	9.70	1102.0	<2.0	52.5	69.5	418.0	433.0	1600.0	360.0	23000.0	17800.0	0.0	130.8
	5/23/2002	5.477	2.6	8.82	1019.0	<2.0	41.4	56.8	338.0	425.0	1230.0	470.0	18500.0	14300.0	0.0	172.8
	5/29/2002	2.991	3.2	9.62	1027.0	<3.0	40.3	55.3	*	441.6	1250.0	*	17000.0	13200.0	0.0	137.8
	6/19/2002	2.240	3.9	8.70	1070.0	12.0	40.9	58.9	345.0	443.0	1380.0	240.0	18100.0	14300.0	0.0	190.2
	7/18/2002	0.709	3.1	7.40	1257.0	4.0	68.2	93.6	556.0	587.0	1890.0	230.0	31100.0	22700.0	0.0	185.6
	8/7/2002	0.636	3.0	6.10	1391.0	10.0	64.1	67.5	438.0	654.0	2170.0	390.0	31100.0	19900.0	0.0	218.2
	8/21/2002	0.544	3.3	7.02	1353.0	4.0	64.5	84.8	*	904.0	2170.0	*	29500.0	22700.0	0.0	222.4
	9/17/2002	0.567	2.9	6.80	1476.0	2.0	72.2	106.0	617.0	603.0	2440.0	460.0	34300.0	23100.0	0.0	249.0
	Average	***1.675***	***3.1***	***7.90***	***1151.5***	***5.5***	***53.5***	***68.4***	***452.0***	***525.8***	***1691.8***	***358.3***	***24036.4***	***17454.5***	***0.0***	***186.3***
DFB001	4/8/2002	0.089	3.1	9.20	480.0	6.0	20.3	17.8	124.0	131.0	662.0	<20.0	6210.0	2340.0	0.0	77.4
	5/23/2002	0.099	2.5	6.24	462.0	<2.0	18.5	17.2	117.0	135.0	582.0	330.0	5760.0	1960.0	0.0	75.8
	6/20/2002	0.164	4.1	8.44	388.0	14.0	16.6	14.1	100.0	131.0	281.0	70.0	5220.0	1770.0	0.0	77.4
	7/18/2002	0.033	3.1	6.10	522.0	6.0	26.9	23.8	165.0	173.0	616.0	260.0	8470.0	2550.0	0.0	78.6
	8/7/2002	0.079	3.2	5.30	644.0	6.0	32.5	24.3	181.0	303.0	187.0	<20.0	10900.0	3160.0	0.0	80.6
	9/17/2002	0.030	3.0	5.90	861.0	2.0	46.6	42.6	292.0	314.0	553.0	170.0	15400.0	5650.0	0.0	151.0
	Average	***0.082***	***3.2***	***6.86***	***559.5***	***6.0***	***26.9***	***23.3***	***163.2***	***197.8***	***480.2***	***145.0***	***8660.0***	***2905.0***	***0.0***	***90.1***
DFB002	4/8/2002	0.452	3.3	7.10	776.0	92.0	50.7	32.1	259.0	313.0	58200.0	3430.0	16800.0	5250.0	0.0	109.2
	5/23/2002	0.147	2.7	5.20	606.0	4.0	36.3	23.0	186.0	236.0	13700.0	9550.0	12900.0	5040.0	0.0	97.0
	6/20/2002	0.108	3.9	4.20	677.0	18.0	45.9	28.3	231.0	299.0	23600.0	*	16000.0	5350.0	0.0	109.0
	7/18/2002	0.133	3.2	3.70	758.0	16.0	51.7	32.0	261.0	328.0	25600.0	19460.0	17000.0	6070.0	0.0	123.2
	8/7/2002	0.105	3.3	4.40	821.0	68.0	51.2	26.2	236.0	326.0	43600.0	13940.0	17600.0	5760.0	0.0	142.6
	9/17/2002	0.093	3.3	4.50	803.0	8.0	63.0	40.2	323.0	360.3	33400.0	26890.0	21400.0	7430.0	0.0	165.0

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., µΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, µg/l	Lab Total Fer Fe, µg/l	Lab Total Mn, µg/l	Lab Total Al, µg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	Average	***0.173***	***3.3***	***4.85***	***740.2***	***34.3***	***49.8***	***30.3***	***249.3***	***310.4***	***33016.7***	***14654.0***	***16950.0***	***5816.7***	***0.0***	***124.3***
DFB100	4/8/2002	0.033	6.2	7.20	593.0	32.0	51.0	25.3	232.0	231.0	39900.0	25930.0	8680.0	<200.0	26.0	63.0
	5/24/2002	PS	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	6/20/2002	PS	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	7/18/2002	0.023	7.0	4.00	595.0	10.0	51.9	26.0	237.0	259.0	34400.0	31330.0	8130.0	<200.0	36.0	54.6
	8/7/2002	0.028	6.3	4.40	592.0	14.0	45.5	18.9	192.0	237.0	30800.0	23920.0	7940.0	<200.0	34.0	76.0
	9/17/2002	0.030	6.3	4.00	586.0	18.0	51.8	26.0	237.0	267.4	40600.0	32500.0	8240.0	<200.0	30.0	83.6
	Average	***0.028***	***6.5***	***4.90***	***591.5***	***18.5***	***50.1***	***24.1***	***224.5***	***248.6***	***36425.0***	***28420.0***	***8247.5***	***200.0***	***31.5***	***69.3***
DFB003	5/23/2002	0.079	2.8	9.67	390.0	<2.0	19.6	14.7	110.0	151.0	423.0	80.0	10400.0	5940.0	0.0	119.0
	6/20/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	7/18/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	8/7/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	9/17/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.079***	***2.8***	***9.67***	***390.0***	***2.0***	***19.6***	***14.7***	***110.0***	***151.0***	***423.0***	***80.0***	***10400.0***	***5940.0***	***0.0***	***119.0***
DFB004	8/8/2002	0.240	3.0	5.50	683.0	6.0	30.7	19.8	158.0	278.0	742.0	80.0	18400.0	9670.0	0.0	151.6
	9/17/2002	0.036	3.2	6.50	736.0	<2.0	37.4	29.8	216.0	277.2	537.0	390.0	22600.0	12000.0	0.0	184.0
	Average	***0.138***	***3.1***	***6.00***	***709.5***	***4.0***	***34.1***	***24.8***	***187.0***	***277.6***	***639.5***	***235.0***	***20500.0***	***10835.0***	***0.0***	***167.8***
DMR003	5/9/2001	0.594	2.9	5.59	1587.0	10.0	90.5	>50.0	*	*	4050.0	*	24400.0	17700.0	0.0	206.0
	6/18/2001	0.233	3.2	7.54	1652.0	26.0	103.0	>50.0	*	771.4	3560.0	*	27600.0	18500.0	0.0	206.0
	11/7/2001	0.203	2.4	6.76	1803.0	8.0	113.0	>50.0	*	810.2	3950.0	*	30400.0	21700.0	0.0	277.4
	3/19/2002	0.411	3.1	8.50	1650.0	<3.0	94.0	94.7	*	626.8	3880.0	*	25600.0	17300.0	0.0	269.6
	4/9/2002	0.500	2.8	6.00	1694.0	2.0	107.0	116.0	745.0	732.0	6210.0	1160.0	30200.0	23000.0	0.0	206.8
	5/29/2002	0.870	2.9	9.94	1530.0	<3.0	85.4	88.4	*	668.5	3950.0	*	21500.0	16100.0	0.0	184.2
	6/19/2002	0.758	3.0	7.33	1607.0	10.0	93.3	95.4	626.0	642.0	5380.0	650.0	25400.0	19600.0	0.0	243.2

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., µΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, µg/l	Lab Total Fer Fe, µg/l	Lab Total Mn, µg/l	Lab Total Al, µg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	7/17/2002	0.279	3.1	7.20	1678.0	12.0	115.0	120.0	782.0	789.0	6580.0	500.0	32100.0	22300.0	0.0	223.6
	8/8/2002	0.204	2.8	6.60	1781.0	10.0	115.0	81.5	623.0	880.0	6640.0	840.0	33600.0	20000.0	0.0	246.2
	8/21/2002	*	3.2	6.87	1669.0	<3.0	104.0	95.1	*	617.4	3300.0	*	28100.0	19400.0	0.0	227.2
	9/17/2002	0.122	2.9	6.50	1876.0	<2.0	125.0	122.0	815.0	1021.3	7700.0	1380.0	36100.0	24100.0	0.0	262.2
	Average	***0.417***	***2.9***	***7.17***	***1684.3***	***8.1***	***104.1***	***87.6***	***718.2***	***755.9***	***5018.2***	***906.0***	***28636.4***	***19972.7***	***0.0***	***232.0***
DMR001	5/9/2001	1.000	2.7	4.53	1825.0	10.0	76.5	>50.0	*	960.0	9400.0	*	26400.0	35000.0	0.0	362.0
	6/18/2001	0.254	3.6	6.04	1931.0	10.0	92.6	>50.0	*	*	8930.0	*	31400.0	41100.0	0.0	387.0
	11/7/2001	0.390	2.1	6.00	1990.0	<3.0	96.2	>50.0	*	880.3	9590.0	*	32300.0	42400.0	0.0	443.2
	3/19/2002	1.500	2.9	7.56	1916.0	4.0	81.4	87.6	*	630.9	8340.0	*	27700.0	35300.0	0.0	441.4
	4/9/2002	0.804	2.7	6.90	1999.0	2.0	91.4	103.0	653.0	827.0	10900.0	1240.0	32800.0	43700.0	0.0	373.2
	5/29/2002	1.910	2.7	8.49	1805.0	8.0	69.6	78.3	*	480.6	8690.0	*	22500.0	31300.0	0.0	351.6
	6/20/2002	1.076	3.4	6.85	1822.0	12.0	81.3	85.5	556.0	699.0	10200.0	*	28300.0	37900.0	0.0	364.8
	7/17/2002	0.797	3.0	7.40	1941.0	16.0	103.0	111.0	715.0	814.0	10000.0	680.0	33600.0	44800.0	0.0	383.4
	8/8/2002	0.442	2.7	7.00	2080.0	12.0	98.2	73.2	547.0	858.0	9530.0	840.0	33000.0	39800.0	0.0	413.4
	8/21/2002	*	3.0	5.30	2020.0	6.0	98.6	93.8	*	335.7	9330.0	*	31900.0	45800.0	0.0	419.8
	9/17/2002	0.293	2.8	6.50	2210.0	<2.0	111.0	35.8	425.0	1130.7	10600.0	1120.0	28700.0	46800.0	0.0	439.6
	Average	***0.847***	***2.9***	***6.60***	***1958.1***	***7.7***	***90.9***	***74.4***	***579.2***	***761.6***	***9591.8***	***970.0***	***29872.7***	***40354.5***	***0.0***	***398.1***
DMR004	5/9/2001	3.950	3.0	2.68	1338.0	8.0	71.9	>50.0	*	724.0	7790.0	*	21900.0	19300.0	0.0	224.0
	6/18/2001	1.512	3.3	3.26	1294.0	6.0	81.1	>50.0	*	475.3	8760.0	*	23400.0	16500.0	0.0	210.8
	11/7/2001	1.407	2.4	2.49	1427.0	<3.0	90.0	>50.0	*	635.6	10100.0	*	25000.0	18800.0	0.0	266.2
	3/19/2002	2.199	3.1	3.88	1290.0	4.0	70.8	57.2	*	396.5	7340.0	*	20400.0	14500.0	0.0	248.6
	4/10/2002	3.633	2.8	7.60	1392.0	<2.0	91.1	79.4	555.0	607.0	7140.0	2300.0	28800.0	24400.0	0.0	206.4
	5/23/2002	5.422	2.0	5.12	1472.0	<2.0	80.1	74.5	507.0	610.0	7230.0	1540.0	26500.0	23600.0	0.0	262.4
	5/29/2002	4.114	2.9	6.91	1324.0	4.0	64.7	59.4	*	309.6	5520.0	*	19800.0	17900.0	0.0	203.2
	6/19/2002	3.418	3.8	5.36	1372.0	8.0	74.6	75.2	496.0	582.0	7090.0	1660.0	25400.0	23900.0	0.0	278.2
	7/17/2002	5.614	3.2	5.70	1340.0	6.0	93.8	81.8	572.0	599.0	8030.0	3230.0	30400.0	22100.0	0.0	207.6
	8/8/2002	1.318	2.8	6.00	1357.0	6.0	78.9	51.1	408.0	469.0	9460.0	1080.0	25300.0	15200.0	0.0	203.2

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., μΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, μg/l	Lab Total Fer Fe, μg/l	Lab Total Mn, μg/l	Lab Total Al, μg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	8/20/2002	1.013	3.2	2.77	1312.0	8.0	85.1	68.9	*	508.7	9660.0	*	24700.0	16900.0	0.0	265.4
	9/17/2002	1.108	3.0	5.00	1386.0	2.0	90.5	73.0	527.0	617.5	11100.0	4200.0	27400.0	16000.0	0.0	218.8
	Average	***2.892***	***3.0***	***4.73***	***1358.7***	***4.9***	***81.1***	***64.2***	***510.8***	***544.5***	***8268.3***	***2335.0***	***24916.7***	***19091.7***	***0.0***	***232.9***
DCC005	5/9/2001	5.350	2.6	5.16	1540.0	6.0	55.4	36.6	*	506.0	37500.0	*	6930.0	24000.0	0.0	374.0
	6/18/2001	3.615	2.9	7.13	1718.0	10.0	78.1	49.1	*	564.9	39700.0	*	9500.0	34000.0	0.0	446.6
	11/7/2001	2.866	2.0	6.12	1258.0	<3.0	79.5	49.7	*	571.8	42800.0	*	9660.0	37100.0	0.0	494.8
	3/19/2002	4.508	2.9	7.65	1556.0	4.0	57.9	36.7	*	*	37600.0	*	12000.0	29700.0	0.0	414.6
	4/10/2002	7.199	2.5	9.60	1619.0	<2.0	63.9	42.4	334.0	588.0	42500.0	4130.0	7430.0	28600.0	0.0	361.6
	5/24/2002	11.751	3.9	9.70	1524.0	<2.0	59.5	37.2	302.0	470.0	39600.0	4030.0	6920.0	25500.0	0.0	342.2
	5/30/2002	7.145	2.6	8.29	1452.0	<3.0	51.7	31.6	*	293.1	30800.0	*	5920.0	18800.0	0.0	327.0
	6/19/2002	8.782	3.4	9.69	1566.0	12.0	51.0	36.1	276.0	423.0	31500.0	3760.0	6900.0	23300.0	0.0	352.0
	7/18/2002	4.111	2.6	7.30	1770.0	12.0	85.8	57.5	451.0	616.0	44500.0	4040.0	10600.0	34600.0	0.0	456.0
	8/8/2002	3.565	2.6	7.50	1972.0	8.0	101.0	50.3	460.0	747.0	51600.0	1520.0	13200.0	40000.0	0.0	521.4
	8/20/2002	2.804	2.9	6.55	1946.0	10.0	107.0	66.3	*	128.4	53400.0	*	12400.0	44800.0	0.0	578.0
	9/18/2002	2.360	2.6	6.50	2120.0	<2.0	117.0	73.9	597.0	987.4	63600.0	3180.0	14300.0	51500.0	0.0	619.0
	Average	***5.338***	***2.8***	***7.60***	***1670.1***	***6.2***	***75.7***	***47.3***	***403.3***	***536.0***	***42925.0***	***3443.3***	***9646.7***	***32658.3***	***0.0***	***440.6***
DBC100	5/22/2002	*	2.8	9.70	768.0	*	*	*	*	*	*	*	*	*	*	*
	6/20/2002	1.161	3.6	9.42	799.0	18.0	28.8	19.6	153.0	220.0	6930.0	300.0	4260.0	9890.0	0.0	132.0
	7/18/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	8/8/2002	0.188	2.7	8.20	1514.0	12.0	74.3	43.5	365.0	617.0	16500.0	470.0	13200.0	25200.0	0.0	307.8
	9/18/2002	0.124	2.8	7.00	1773.0	4.0	92.2	69.1	515.0	788.5	20700.0	450.0	16500.0	34800.0	0.0	408.2
	Average	**0.491**	**3.0**	**8.58**	**1213.5**	**11.3**	**65.1**	**44.1**	**344.3**	**541.8**	**14710.0**	**406.7**	**11320.0**	**23296.7**	**0.0**	**282.7**
DBC101	4/10/2002	0.999	2.9	10.00	1109.0	<2.0	37.1	26.0	200.0	307.0	8020.0	570.0	5060.0	13900.0	0.0	174.2
	5/22/2002	2.177	2.7	9.80	843.0	<2.0	24.9	17.7	135.0	216.0	5900.0	520.0	3700.0	9280.0	0.0	140.4
	6/20/2002	1.760	3.8	10.29	867.0	16.0	29.5	20.2	157.0	234.0	6430.0	240.0	4270.0	10200.0	0.0	131.4
	7/18/2002	0.234	2.7	7.90	1228.0	18.0	54.8	40.0	302.0	471.0	10700.0	440.0	8880.0	19100.0	0.0	230.2

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., µΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, µg/l	Lab Total Fer Fe, µg/l	Lab Total Mn, µg/l	Lab Total Al, µg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	8/8/2002	0.281	2.7	8.20	1523.0	8.0	74.3	43.5	365.0	545.0	16000.0	450.0	13200.0	25300.0	0.0	305.2
	9/18/2002	0.188	2.8	7.20	1786.0	4.0	92.4	68.3	512.0	771.3	20600.0	450.0	16600.0	34800.0	0.0	405.6
	Average	***0.940***	***2.9***	***8.90***	***1226.0***	***8.3***	***52.2***	***36.0***	***278.5***	***424.1***	***11275.0***	***445.0***	***8618.3***	***18763.3***	***0.0***	***231.2***
DBC102	5/22/2002	*	2.7	9.30	916.0	*	*	*	*	*	*	*	*	*	*	*
	6/20/2002	0.599	3.6	9.08	972.0	14.0	32.2	21.3	168.0	219.0	6780.0	190.0	4700.0	11800.0	0.0	148.2
	7/18/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	8/8/2002	0.093	2.7	7.20	1405.0	8.0	64.0	37.6	315.0	501.0	6390.0	280.0	10700.0	22400.0	0.0	270.4
	9/18/2002	0.064	2.7	5.80	1655.0	<2.0	88.1	64.1	484.0	710.4	9380.0	400.0	14700.0	33800.0	0.0	347.6
	Average	***0.252***	***2.9***	***7.85***	***1237.0***	***8.0***	***61.4***	***41.0***	***322.3***	***476.8***	***7516.7***	***290.0***	***10033.3***	***22666.7***	***0.0***	***255.4***
DBC103	5/22/2002	*	2.8	9.21	828.0	*	*	*	*	*	*	*	*	*	*	*
	6/20/2002	0.300	3.6	9.12	908.0	14.0	28.7	19.4	152.0	219.0	4690.0	140.0	4230.0	9980.0	0.0	135.6
	7/18/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	8/8/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	9/18/2002	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Average	***0.300***	***3.2***	***9.17***	***868.0***	***14.0***	***28.7***	***19.4***	***152.0***	***219.0***	***4690.0***	***140.0***	***4230.0***	***9980.0***	***0.0***	***135.6***
DJC106	4/10/2002	0.099	2.4	8.90	1193.0	<2.0	19.9	13.3	105.0	256.0	17300.0	770.0	1900.0	8180.0	0.0	208.4
	5/22/2002	0.296	2.7	9.70	1001.0	26.0	14.7	11.0	82.0	192.0	9910.0	370.0	1480.0	6510.0	0.0	160.0
	6/19/2002	0.155	3.5	9.41	826.0	8.0	15.6	11.4	86.0	189.0	6280.0	440.0	2230.0	6490.0	0.0	145.0
	7/17/2002	0.027	2.9	7.40	1038.0	4.0	26.9	18.0	141.0	246.0	5620.0	410.0	3170.0	10300.0	0.0	182.0
	8/7/2002	0.077	2.6	8.00	1122.0	6.0	28.1	18.8	148.0	215.0	5570.0	210.0	3730.0	12100.0	0.0	195.2
	9/18/2002	0.027	2.6	8.50	1077.0	<2.0	37.2	24.3	193.0	266.6	5610.0	430.0	5720.0	17200.0	0.0	218.8
	Average	***0.114***	***2.8***	***8.65***	***1042.8***	***8.0***	***23.7***	***16.1***	***125.8***	***227.4***	***8381.7***	***438.3***	***3038.3***	***10130.0***	***0.0***	***184.9***
DJC900	4/10/2002	4.526	5.7	7.80	252.0	8.0	26.0	12.9	118.0	96.9	736.0	420.0	721.0	810.0	9.8	44.2
	5/23/2002	12.519	4.0	5.80	251.0	8.0	22.1	11.0	101.0	97.2	921.0	600.0	710.0	793.0	11.8	40.2

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., µΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, µg/l	Lab Total Fer Fe, µg/l	Lab Total Mn, µg/l	Lab Total Al, µg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	6/19/2002	8.457	6.3	9.18	235.0	10.0	20.7	10.5	95.0	88.4	746.0	500.0	652.0	683.0	10.0	46.4
	7/17/2002	2.763	5.9	6.30	258.0	2.0	26.4	12.1	116.0	90.5	910.0	480.0	695.0	594.0	16.0	38.4
	8/7/2002	2.165	6.4	7.50	271.0	8.0	25.7	11.0	110.0	90.7	878.0	70.0	609.0	575.0	15.6	40.6
	9/18/2002	1.122	6.4	8.70	271.0	<2.0	28.2	13.0	124.0	111.9	886.0	420.0	677.0	450.0	15.6	44.6
	Average	***5.259***	***5.8***	***7.55***	***256.3***	***6.3***	***24.9***	***11.8***	***110.7***	***95.9***	***846.2***	***415.0***	***677.3***	***650.8***	***13.1***	***42.4***
DJC902	5/22/2002	0.336	2.8	8.50	1305.0	4.0	34.5	53.8	308.0	491.0	8020.0	450.0	18600.0	21700.0	0.0	278.6
	6/19/2002	0.231	3.5	8.29	1412.0	48.0	37.6	58.8	336.0	460.0	9230.0	1680.0	20500.0	21400.0	0.0	281.8
	7/17/2002	0.169	2.5	8.40	1695.0	14.0	67.6	98.1	573.0	666.0	18200.0	2300.0	36600.0	27400.0	0.0	353.6
	8/7/2002	0.085	2.6	7.40	1728.0	12.0	60.4	79.6	479.0	576.0	21600.0	1150.0	34300.0	24200.0	0.0	353.4
	9/18/2002	0.069	2.6	8.00	1758.0	<2.0	63.1	83.7	503.0	722.8	63100.0	2520.0	34800.0	25300.0	0.0	392.2
	Average	***0.178***	***2.8***	***8.12***	***1579.6***	***16.0***	***52.6***	***74.8***	***439.8***	***583.2***	***24030.0***	***1620.0***	***28960.0***	***24000.0***		
DJC903	5/22/2002	0.252	3.0	9.90	1215.0	<2.0	40.0	55.7	329.0	485.0	4820.0	630.0	18400.0	21200.0	0.0	243.8
	6/19/2002	0.173	3.6	9.18	1385.0	36.0	45.4	63.3	374.0	505.0	6450.0	550.0	21300.0	25000.0	0.0	284.8
	7/17/2002	0.016	2.8	8.30	1269.0	8.0	60.6	75.5	463.0	449.0	3470.0	450.0	30000.0	26400.0	0.0	242.0
	8/7/2002	0.043	2.7	7.40	1246.0	6.0	53.8	63.8	397.0	423.0	3980.0	360.0	29500.0	23100.0	0.0	265.8
	9/18/2002	0.026	2.7	8.00	1550.0	4.0	68.0	80.4	501.0	722.0	3370.0	360.0	34800.0	29800.0	0.0	334.4
	Average	***0.102***	***2.9***	***8.56***	***1333.0***	***11.2***	***53.6***	***67.7***	***412.8***	***516.8***	***4418.0***	***470.0***	***26800.0***	***25100.0***	***0.0***	***274.2***
	8/8/2002	0.301	4.2	8.10	489.0	2.0	46.4	18.7	193.0	199.0	292.0	<20.0	2980.0	2660.0	1.4	63.0
DJC904	9/18/2002	0.131	4.2	9.60	537.0	<2.0	54.2	26.3	244.0	239.8	190.0	110.0	3300.0	3720.0	1.8	77.0
	Average	***0.216***	***4.2***	***8.85***	***513.0***	***2.0***	***50.3***	***22.5***	***218.5***	***219.4***	***241.0***	***65.0***	***3140.0***	***3190.0***	***1.6***	***70.0***
DTR003	8/7/2002	0.040	3.2	6.50	1266.0	12.0	72.6	52.3	397.0	590.0	3090.0	520.0	29800.0	23600.0	0.0	246.8
	9/17/2002	0.044	3.3	7.20	1296.0	<2.0	81.2	79.8	532.0	739.1	3070.0	960.0	34900.0	33300.0	0.0	280.6

Monitoring Station	Date	Flow, ft^3/s	Field pH	Field DO, mg/l	Field Cond., μΩ	Lab TSS, mg/l	Lab Total Ca, mg/l	Lab Total Mg, mg/l	Lab Total Hardness, mg/l	Lab Total So4, mg/l	Lab Total Fe, μg/l	Lab Total Fer Fe, μg/l	Lab Total Mn, μg/l	Lab Total Al, μg/l	Lab Alk, mg/l	Lab Hot Acid, mg/l
	Average	***0.042***	***3.3***	***6.85***	***1281.0***	***7.0***	***76.9***	***66.1***	***464.5***	***664.6***	***3080.0***	***740.0***	***32350.0***	***28450.0***	***0.0***	***263.7***

APPENDIX C

SOURCES OF FUNDING FOR RESTORATION PROJECTS

Sources of Funding	Organization	Grant Description
Coldwater Heritage Partnership	PA Trout (814)359-5233 dnardone@patrout.org www.patrout.org	Targeted towards cold-water stream systems.
Regional Watershed Support Initiative	Eastern Pennsylvania Coalition for Abandoned Mine Reclamation (EPCAMR) www.AMRclearinghouse.org	Small grants (to $5,000) to support activities related to abandoned mine reclamation.
Waterways Conservation Grants	Pennsylvania Fish and Boat Commission (717)657-4444	Fund aquatic resource protection and enhancement projects including riparian restoration, access acquisition and instream habitat enhancement.
Watershed Assistance Grants	River Network WAG Program 520 SW 6th Ave., Suite 1130 Portland, OR 97204	Grants to support the growth and sustainability of local watershed partnerships that work to promote watershed protection and restoration by resolving watershed problems and issues.
Chesapeake Bay Small Watershed Grants	National Fish & Wildlife Foundation www.nfwf.org/programs.htm	Grants to protect and improve watersheds in the Chesapeake Bay basin.
	Center For Rural Pennsylvania 200 N. Third St., Suite 600 Harrisburg, PA 17101 (717)787-9555 info@ruralpa.org www.ruralpa.org	
Rivers Conservation Program	Pennsylvania Department of Conservation and Natural Resources Division of Conservation Partnerships P.O. Box 8475 Harrisburg, PA 17105-8475 (717)787-2316	Grants to stakeholder groups to carry out planning, implementation, acquisition and development activities.
Chesapeake Bay Program Grants	U.S. Environmental Protection Agency Chesapeake Bay Program Office, Region III 410 Severn Ave., Suite 109 Annapolis, MD 21403 1(800)YOUR-BAY www.chesapeakebay.net	Grants to reduce and prevent pollution and improve the living resources in the Chesapeake Bay.
Pennsylvania Watershed Assistance Grants	U.S. Environmental Protection Agency www.epa.gov/epahome/locatez.htm	
	U.S. Army Corps of Engineers Planning Division Washington, DC 20314-1000 (202)761-0115 www.usace.army.mil	
Abandoned Mine Land Reclamation Program (including Appalachian Clean Streams Initiative)	U.S. Department of the Interior Office of Surface Mining Division of Reclamation Support 1951 Constitution Ave., NW Washington, DC 20240 (202)208-2937 www.osmre.gov	Grants to address problems such as dangerous highwalls, slides, subsidence, dangerous portals and polluted water on eligible abandoned mine lands.
Watershed Protection and Flood Prevention Program (also know as Small Watershed Program/PL566 Program)	U.S. Department of Agriculture Natural Resources Conservation Service P.O. Box 2890 Washington, DC 20013-9770 National: (202)720-3534 Pennsylvania: (717)782-4429 www.ftw.nrcs.usda.gov/programs.html	Grants for projects related to watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland restoration and creation, fish and wildlife habitat enhancement and public recreation.
Nonpoint Source Management Grants (319 Program)	Pennsylvania Department of Environmental Protection (717)787-5259 www.dep.state.pa.us	Grants for planning and nonpoint source pollution control projects.

Sources of Funding	Organization	Grant Description
Five-Star Restoration Challenge Grant Program	National Association of Counties www.naco.org/programs/environ/water	
	Canaan Valley Institute West Virginia 1(800)922-3601	Grants to promote the development and growth of local associations committed to improving or maintaining the natural resources of their watersheds.
Nonpoint Source Mini-Grant Program	Pennsylvania Association of Conservation Districts www.pacd.org	
Community Grants	Pennsylvania Power and Light www.pplweb.com/community	
	Turner Foundation One CNN Tower South Tower, Suite 1090 Atlanta, GA 30303 (404)681-9900 www.turnerfoundation.org/turner/water.html	Grants for the protection of rivers, lakes, wetlands, aquifers, oceans and other water systems from contamination, degradation and other abuses.
	Charles A. and Anne Morrow Lindburgh Foundation Minneapolis, MN (612)338-1703	Grants awarded for the conservation of natural resources and water resource management.
	The Leo Model Foundation, Inc. Philadelphia, Pa (215)546-8058	Grants for habitat, watershed and species conservation.
	The William Bingham Foundation 20325 Center Ridge Road, Suite 629 Rocky River, OH 44116 info@WbinghamFoundation.org	Grants to preserve and protect the environment.
	Richard and Rhoda Goldman Fund One Lombard Street, Suite 303 San Francisco, CA 94111 (415)788-1090 info@goldmanfund.org	Grants to support their environmental program.
	The George Gund Foundation 1845 Guildhall Building 45 Prospect Avenue, West Cleveland, OH 44115 (216)241-3114 info@gundfnd.org	Grants to support their environmental programs.
	The Henry P. Kendall Foundation 176 Federal Street Boston, MA 02110 (617)951-1977	Grants to fund projects related to the environment, natural resources and pollution.
	Ferguson (Michael D.) Charitable Foundation 124 E. Main Street Rexburg, ID 83440-1912	Grants to fund projects related to the environment, wildlife and fisheries.
	Mott (Charles Stewart) Foundation Office of Proposal Entry 1200 Mott Foundation Building Flint, MI 48502-1851 infocenter@mott.org www.mott.org	Grants to fund projects related to the environment and fresh water ecosystems.
	The William C. Kenney Watershed Protection Foundation 1001 Bridgeway, Suite 703 Sausalito, CA (415)332-1363	Grants to fund projects related to the environment.

Sources of Funding	Organization	Grant Description
	Max & Anna Levinson Foundation 1411 Paseo de Peralta Santa Fe, NM 87501 (505)982-3662	Grants to fund projects related to ecosystem preservation and the environment.

Other Funding Sources

Directory of Pennsylvania Foundations. 1998. Triadvocates Press in cooperation with the Free Library of Philadelphia. P.O. Box 336, Springfield, Pa., 19064-0336. Call: (610)433-6927.

Profiles of more than 1,500 foundations in Pennsylvania with assets of $150,000 or more and/or total grant support of more than $7,500, based on 1996 or 1997 records.

Pennsylvania Grants Guide. 1998-2000. Pennsylvania Association of Nonprofit Organizations. 132 State Street, Harrisburg, Pa., 17101. www.pano.org. Call: (717)236-8584.

Profiles of more than 600 funding sources in Pennsylvania.

The United Environmental Fund fosters growth of environmental organization throughout the United States by helping them develop a stronger, more diversified funding base. www.uef.org.