

FINAL

BABB CREEK WATERSHED TMDL
Tioga and Lycoming Counties

For Acid Mine Drainage Affected Segments



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Pennsylvania Department of Environmental Protection

February 28, 2003

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TMDL¹
Babb Creek Watershed
Tioga and Lycoming Counties, Pennsylvania

Table 1. Section 303(d) Sub-List								
State Water Plan (SWP) Subbasin: 09-A Pine Creek								
Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1996	23	7105,7106	21681	Babb Creek	CWF	305(b) Report	RE	Metals
1998	0.99	7105	21681	Babb Creek	CWF	SWMP	AMD	Metals
1998	12.85	7106	21681	Babb Creek	CWF	SWMP	AMD	Metals
2000	7.77	980828-1130-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals & Ph
2000	2.59	980910-1030-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals & pH
2000	3.48	981020-1400-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals
2002	0.7	980820-1301-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals & Ph
2002	7.8	980828-1130-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals & pH
2002	2.6	980810-1030-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals & pH
2002	3.5	981020-1400-MAF	21681	Babb Creek	CWF	SWMP	AMD	Metals
2002	3.7	980831-1300-MAF	21681	Babb Creek, Rattler Run, Slide Hollow, Wilson Creek	CWF	SWMP	AMD	pH
1996	Not Currently on 303(d) List			Unt Babb Creek				
1998	Not Currently on 303(d) List			Unt Babb Creek				
2000	0.84	980831-1300-MAF	21757	Unt Babb Creek	CWF	SWMP	AMD	Ph
2002				Unt Babb Creek				
1996	Not Currently on 303(d) List			Unt Babb Creek				
1998	Not Currently on 303(d) List			Unt Babb Creek				

¹ Pennsylvania's 1996 and 1998 Section 303(d) lists were approved by the Environmental Protection Agency (EPA). The 2000 Section 303(d) list was not required by U. S. Environmental Protection Agency. The 1996 Section 303(d) list provides the basis for measuring progress under the 1996 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA*.

Table 1. Section 303(d) Sub-List

State Water Plan (SWP) Subbasin: 09-A Pine Creek

Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
2000	0.71	980837-1301-MAF	21775	Unt Babb Creek	CWF	SWMP	AMD	Metals & pH
2002				Unt Babb Creek				
1996	2.3	LAM-27	21730	Wilson Creek	CWF	305(b) Report	RE	Metals
1998	Part C of 303(d) List			Wilson Creek	CWF	305(b) Report	AMD	Metals
2000	2.26	980828-1400-MAF	21730	Wilson Creek	CWF	SWMP	AMD	Metals & pH
2000	0.86	980828-1401-MAF	21730	Wilson Creek	CWF	SWMP	AMD	Metals & pH
2002	2.3	980828-1400-MAF	21730	Wilson Creek	CWF	SWMP	AMD	Metals & Ph
2002	0.9	980828-1401-MAF	21730	Wilson Creek	CWF	SWMP	AMD	Metals & pH
1996	Not currently on 303(d) List			Unt Wilson Creek				
1998	Not currently on 303(d) List			Unt Wilson Creek				
2000	0.55	980831-1300-MAF	21735	Unt Wilson Creek	CWF	SWMP	AMD	pH
2002	0.9	980828-1401-MAF	21735 & 21736	Unt Wilson Creek	CWF	SWMP	AMD	Metals & pH
1996	Not currently on 303(d) List			Unt Wilson Creek				
1998	Not currently on 303(d) List			Unt Wilson Creek				
2000		980831-1300-MAF	21736	Unt Wilson Creek	CWF	SWMP	AMD	pH
2002				Unt Wilson Creek				
1996				Unt Wilson Creek				
1998				Unt Wilson Creek				
2000	3.3	980907-1230-MAF	21739	Unt Wilson Creek	CWF	SWMP	Ag	Siltation
2002	11.1	980907-1230-MAF	21739, 21740, 21741, 21742	Unt Wilson Creek	CWF	SWMP	Ag	Siltation
1996	Not currently on 303(d) List			Unt Wilson Creek				
1998	Not currently on 303(d) List			Unt Wilson Creek				
2000	1.82	980907-1230-MAF	21740	Unt Wilson Creek	CWF	SWMP	Ag	Siltation
2002				Unt Wilson Creek				
1996	Not currently on 303(d) List			Unt Wilson Creek				

Table 1. Section 303(d) Sub-List

State Water Plan (SWP) Subbasin: 09-A Pine Creek

Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1998	Not currently on 303(d) List			Unt Wilson Creek				
2000	0.57	980907-1230-MAF	21741	Unt Wilson Creek	CWF	SWMP	Ag	Siltation
2002				Unt Wilson Creek				
1996	Not currently on 303(d) List			Unt Wilson Creek				
1998	Not currently on 303(d) List			Unt Wilson Creek				
2000	2.54	980907-1230-MAF	21742	Unt Wilson Creek	CWF	SWMP	Ag	Siltation
2002				Unt Wilson Creek				
1996	Not currently on 303(d) List			Lick Creek				
1998	Not currently on 303(d) List			Lick Creek				
2000	3.56	980820-1300-MAF	21782	Lick Creek	CWF	SWMP	AMD	Metals & pH
2002	4.1	980820-1300-MAF	21782	Lick Creek	CWF	SWMP	AMD	Metals & pH
1996	Not currently on 303(d) List			Unt Lick Creek				
1998	Not currently on 303(d) List			Unt Lick Creek				
2000	0.61	980820-1030-MAF	21782	Unt Lick Creek	CWF	SWMP	AMD	Metals & pH
2002				Unt Lick Creek				
1996	Not currently on 303(d) List			Unt Lick Creek				
1998	Not currently on 303(d) List			Unt Lick Creek				
2000	0.2	980820-1300-MAF	21790	Unt Lick Creek	CWF	SWMP	AMD	Metals & pH
2002				Unt Lick Creek				
1996	Not currently on 303(d) List			Unt Lick Creek				
1998	Not currently on 303(d) List			Unt Lick Creek				
2000	0.37	980820-1300-MAF	21789	Unt Lick Creek	CWF	SWMP	AMD	Metals & pH
2002				Unt Lick Creek				
1996	Not currently on 303(d) List			Stony Fork Creek				

Table 1. Section 303(d) Sub-List

State Water Plan (SWP) Subbasin: 09-A Pine Creek

Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1998	Not currently on 303(d) List			Stony Fork Creek				
2000	0.42	980910-1401-MAF	21699	Stony Fork Creek	CWF	SWMP	AMD	Metals & pH
2002	0.4	980910-1401-MAF	21699	Stony Fork Creek	CWF	SWMP	AMD	Metals & pH
1996	Not currently on 303(d) List			West Branch Stony Fork Creek				
1998	Not currently on 303(d) List			West Branch Stony Fork Creek				
2000	3.21	980911-1200-MAF	21707	West Branch Stony Fork Creek	CWF	UP	Agriculture	Siltation
2002	3.6	980911-1200-MAF	21707 & 21710	West Branch Stony Fork Creek	CWF	SWMP	Agriculture	Siltation
1996	Not currently on 303(d) List			West Branch Stony Fork Creek				
1998	Not currently on 303(d) List			West Branch Stony Fork Creek				
2000	0.35	980911-1200-MAF	21710	West Branch Stony Fork Creek	CWF	UP	Agriculture	Siltation
2002				West Branch Stony Fork Creek				
1996	Not currently on 303(d) List			Basswood Run				
1998	Not currently on 303(d) List			Basswood Run				
2000	Not currently on 303(d) List			Basswood Run				
2002	1.0	980831-1300-MAF	21734	Basswood Run	CWF	SWMP	AMD	pH
1996	Not currently on 303(d) List			Red Run				
1998	Not currently on 303(d) List			Red Run				
2000	Not currently on 303(d) List			Red Run				
2002	3.0	980820-1530-MAF	21779	Red Run	CWF	SWMP	AMD	Metals & pH
1996	Not currently on 303(d) List			Rock Run				
1998	Not currently on 303(d) List			Rock Run				
2000	Not currently on 303(d) List			Rock Run				
2002	1.3	980827-1400-MAF	21758	Rock Run	CWF	SWMP	AMD	pH

Resource Extraction=RE

Cold Water Fishes = CWF

Surface Water Monitoring Program = SWMP

Unassessed Program = UP

Abandoned Mine Drainage = AMD

See Attachment E, *Excerpts Justifying Changes Between the 1996, 1998, 2000 and Draft 2002 Section 303(d) Lists*.

The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.

Introduction

This report presents the Total Maximum Daily Loads (TMDLs) developed for segments in the Babb Creek Watershed (Attachments A). These were done to address the impairments noted on the 1996 Pennsylvania Section 303(d) list of impaired waters, required under the Clean Water Act, and covers two segments on this list and twelve additional non-listed segments (shown in Table 1). High levels of metals, and in some areas depressed pH, caused these impairments. All impairments resulted from acid drainage from abandoned coalmines. The TMDL addresses the three primary metals associated with acid mine drainage (iron, manganese, aluminum) and pH. The 2002 listing for Agriculture/sediment in the West Branch Stony Creek will be addressed in a future TMDL.

Directions to the Babb Creek Watershed

The Babb Creek Watershed is located in North Central Pennsylvania, occupying the southern portion of Tioga County and a small portion of Lycoming County. The watershed area is found on United States Geological Survey maps covering portions of the Cherry Flats, Antrim, Tiadaghton, Cedar Run, Morris, and Nauvoo 7.5-Minute Quadrangles. The area within the watershed consists of 129 square miles, most of which is administered by the Tioga State Forest and the Pennsylvania Game Commission. Other land uses within the watershed include agriculture, abandoned mine lands, and rural residential properties with small communities scattered throughout the area.

The village of Morris, formerly a center for lumber, coal mining and tannery industries, is located at the mouth of Wilson Creek at the junction of State Routes 287 and 414 in the center of the watershed. The village of Arnot, formerly a large mining town, lies at the eastern margin of the watershed near State Route 15, while the formerly prosperous town of Antrim lies in the center of the watershed. In the western section is the village of Stony Fork and at the mouth of Babb Creek, at the southwest corner of the watershed, is the village of Blackwell.

Babb Creek is one of the principal tributary streams to Pine Creek, which is a nationally recognized fishery. In addition to fishing, the Pine Creek area is one of the state's year-round recreation areas that is celebrated for its wildlife, wilderness, and scenic beauty. The confluence of Babb Creek and Pine Creek is at the town of Blackwell and marks the southern end of "Pennsylvania's Grand Canyon" in the Pine Creek Gorge Natural Area. Recently, large sections

of an abandoned railroad in the Gorge, have been converted to a recreational trail and has resulted in an increased number of visitors to the area.

The watershed area is located in the glaciated upland plateau section of the Appalachian Physiographic Province. The plateau is strongly dissected by stream valleys, which drain the area to the south and west. Rolling glaciated uplands with 100 to 150 feet of relief characterize the upper reaches of the watershed. The lower portion of the watershed near the main trunks of Babb Creek, Stony Fork Creek, and Wilson Creek is deeply incised and forms steep-sided, V-shaped valleys. Elevations in the basin range from a low at the confluence of Babb Creek and Pine Creek of 860 feet above sea level to the valley ridges along the main trunk of Babb Creek at over 2200 feet above sea level.

Segments addressed in this TMDL

There are no active mining operations in the watershed. All of the discharges in the watershed are from abandoned mines and will be treated as non-point sources. The distinction between non-point and point sources in this case is determined on the basis of whether or not there is a responsible party for the discharge. Where there is no responsible party the discharge is considered to be a non-point source. Each segment on the Section 303(d) list will be addressed as a separate TMDL. These TMDLs will be expressed as long-term, average loadings. Due to the nature and complexity of mining effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations. See Attachment D for TMDL calculations.

Clean Water Act Requirements

Section 303(d) of the 1972 Clean Water Act requires states, territories, and authorized tribes to establish water quality standards. The water quality standards identify the uses for each waterbody and the scientific criteria needed to support that use. Uses can include designations for drinking water supply, contact recreation (swimming), and aquatic life support. Minimum goals set by the Clean Water Act require that all waters be “fishable” and “swimmable.”

Additionally, the federal Clean Water Act and the U.S. Environmental Protection Agency’s (USEPA) implementing regulations (40 CFR Part 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);
- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;
- States to submit the list of waters to USEPA every two years (April 1 of the even numbered years);

- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- USEPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Despite these requirements, states, territories, authorized tribes, and USEPA have not developed many TMDLs since 1972. Beginning in 1986, organizations in many states filed lawsuits against the USEPA for failing to meet the TMDL requirements contained in the federal Clean Water Act and its implementing regulations. While USEPA has entered into consent agreements with the plaintiffs in several states, many lawsuits still are pending across the country.

In the cases that have been settled to date, the consent agreements require USEPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., AMD, implementation of nonpoint source Best Management Practices (BMPs), etc.). These TMDLs were developed in partial fulfillment of the 1996 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA*.

Section 303(d) Listing Process

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be on the Section 303(d) list. With guidance from the USEPA, the states have developed methods for assessing the waters within their respective jurisdictions.

The primary method adopted by the Pennsylvania Department of Environmental Protection (Pa. DEP) for evaluating waters changed between the publication of the 1996 and 1998 Section 303(d) lists. Prior to 1998, data used to list streams were in a variety of formats, collected under differing protocols. Information also was gathered through the Section 305(b)² reporting process. Pa. DEP is now using the Unassessed Waters Protocol (UWP), a modification of the USEPA Rapid Bioassessment Protocol II (RPB-II), as the primary mechanism to assess Pennsylvania's waters. The UWP provides a more consistent approach to assessing Pennsylvania's streams.

The assessment method requires selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment can vary between sites. All the biological surveys included kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates are identified to the family level in the field.

² Section 305(b) of the Clean Water Act requires a biannual description of the water quality of the waters of the state.

After the survey is completed, the biologist determines the status of the stream segment. The decision is based on the performance of the segment using a series of biological metrics. If the stream is determined to be impaired, the source and cause of the impairment is documented. An impaired stream must be listed on the state's Section 303(d) list with the documented source and cause. A TMDL must be developed for the stream segment. A TMDL is for only one pollutant. If a stream segment is impaired by two pollutants, two TMDLs must be developed for that stream segment. In order for the process to be more effective, adjoining stream segments with the same source and cause listing are addressed collectively, and on a watershed basis.

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, there are basic processes or steps that apply to all cases. They include:

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using USEPA approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Submit draft report for public review and comments; and
6. USEPA approval of the TMDL.

Watershed History

Coal was discovered at Blossburg in 1792, with the first drift opening in 1815. The first mines in the Babb Creek Watershed were probably opened in the Arnot area around 1865. These mines included the Arnot #1, Arnot #2, and the Klondike Mines. Other mines were opened east of Arnot along Johnson Run, which flows east to the Tioga River. In 1866 the Blossburg Coal Mining and Railroad Company was formed to develop the mines. In 1881 a standard gauge railroad was built from Arnot to Morris. A year later a sawmill was built and the community of Landrus was established. Later, in 1888, the Bear Run Mines were opened on the northern flank of Babb Creek opposite Landrus. Favorable exploration on lands at the headwaters of Bridge Run resulted in the opening of the Antrim Mine around 1870 by the Fall Brook Coal Company. The same company opened the Anna S Mine on the west side of the Wilson Creek Valley in the late 1890's. The Rattler Mine was opened in the early 1900's by the Tioga Coal Company.

There is evidence that over 4,000 acres of coal were deep-mined in the Babb Creek Watershed, primarily on the Bloss (B) Coal Seam. Production of coal from mines in Tioga County declined at the turn of the century as a result of increased production in Clearfield County. (source, Babb Creek Mine Drainage Project, Operation Scarlift, 1976. Boyer Kantz and Assoc.)

In the 1970's and 1980's mining activities in the watershed became more widespread as companies including Eastern Mining, P & M Mining, and Antrim Mining began strip-mining previously unmined upper seams and daylighting portions of the seams deep-mined earlier. The

majority of the surface mining in the watershed was focused on the Antrim and Anna S Mine Complexes near Wilson Creek.

TMDL Endpoints

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment of applicable water quality. An instream numeric endpoint, therefore, represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards.

Because of the nature of the pollution sources in the watershed, the TMDLs' component makeup will be Load Allocations (LA) that are specified above a point in the stream segment. All allocations will be specified as long-term average daily concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time. PA Title 25 Chapter 96.3(c) specifies that the water quality standards must be met 99% level of the time. The iron TMDLs are expressed as total recoverable as the iron data used for this analysis was reported as total recoverable. The following table shows the applicable water-quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

<i>Parameter</i>	<i>Criterion Value (mg/l)</i>	<i>Total Recoverable/Dissolved</i>
Aluminum (Al)	0.75	Total Recoverable
Iron (Fe)	1.50 0.3	30 day average; Total Recoverable Dissolved
Manganese (Mn)	1.00	Total Recoverable
pH *	6.0-9.0	N/A

*The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality. These values are typically as low as 5.4 (Pennsylvania Fish and Boat Commission).

TMDL Elements (WLA, LA, MOS)

A TMDL equation consists of a wasteload allocation, load allocation and a margin of safety. The wasteload allocation is the portion of the load assigned to point sources. The load allocation is the portion of the load assigned to nonpoint sources. The margin of safety is applied to account for uncertainties in the computational process. The margin of safety may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Allocation Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each watershed. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. Table 3 presents the estimated reductions identified for all points in the watershed. Attachment D gives detailed TMDLs by segment analysis for each allocation point.

Table 3. Summary Table–Babb Creek Watershed

<i>Station</i>	<i>Parameter</i>	<i>Measured Sample Data</i>		<i>Allowable</i>		<i>Reduction Identified</i>
		<i>Conc. (mg/l)</i>	<i>Load (lb/day)</i>	<i>LTA Conc. (mg/l)</i>	<i>Load (lb/day)</i>	<i>Percent</i>
1						
	Al	0.56	34.5	0.39	23.9	31%
	Fe	0.27	16.3	0.26	16.3	0%
	Mn	0.24	14.7	0.24	14.7	0%
	Acidity	12.83	791.0	2.00	123.5	84%
	Alkalinity	9.29	572.6			
2						
	Al	0.16	19.5	0.16	19.5	0%
	Fe	0.18	21.9	0.18	21.9	0%
	Mn	0.02	2.7	0.02	2.7	0%
	Acidity	0.03	3.1	0.03	3.1	0%
	Alkalinity	21.98	2691.9			
4						
	Al	0.22	87.7	0.22	87.7	NA
	Fe	0.11	44.1	0.11	44.1	NA
	Mn	0.11	45.4	0.11	45.4	NA
	Acidity	3.23	1312.6	1.51	613.7	NA
	Alkalinity	13.40	5453.8			
5						
	Al	2.69	468.6	0.27	46.2	90%
	Fe	0.63	109.9	0.51	89.4	19%
	Mn	2.11	367.7	0.51	89.4	76%
	Acidity	6.90	1200.4	3.27	568.7	53%
	Alkalinity	12.83	2232.7			
7						
	Al	0.36	224.1	0.29	181.5	NA
	Fe	0.16	102.0	0.16	101.9	NA
	Mn	0.45	280.2	0.45	280.2	NA
	Acidity	3.49	2194.1	1.46	917.6	NA
	Alkalinity	13.63	8578.6			
8						
	Al	0.22	63.5	0.22	63.5	0%
	Fe	0.07	20.8	0.07	20.8	0%
	Mn	0.03	8.5	0.04	8.5	0%
	Acidity	0.00	0.0	0.0	0.0	0%
	Alkalinity	46.00	13132.9			
10						
	Al	0.35	341.2	0.27	268.1	NA
	Fe	0.17	166.6	0.17	166.5	NA
	Mn	0.22	217.2	0.22	217.0	NA
	Acidity	0.00	0.0	0.00	0.0	NA
	Alkalinity	19.4	19161.2			

Recommendations

Two primary programs that provide reasonable assurance for maintenance and improvement of water quality in the watershed are in effect. The PADEP's efforts to reclaim abandoned mine lands, coupled with its duties and responsibilities for issuing NPDES permits, will be the focal points in water quality improvement.

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by PADEP's Bureau of Abandoned Mine Reclamation, which administers and oversees the Abandoned Mine Reclamation Program in Pennsylvania, the United States Office of Surface Mining, the National Mine Land Reclamation Center, the National Environmental Training Laboratory, and many other agencies and individuals. Funding from EPA's Section 319(a) Grant program and Pennsylvania's Growing Greener program has been used extensively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

The PA DEP Bureau of Mining and Reclamation administers an environmental regulatory program for all mining activities, mine subsidence regulation, mine subsidence insurance, and coal refuse disposal; conducts a program to ensure safe underground bituminous mining and protect certain structures from subsidence; administers a mining license and permit program; administers a regulatory program for the use, storage, and handling of explosives; provides for training, examination, and certification of applicants for blaster's licenses; and administers a loan program for bonding anthracite underground mines and for mine subsidence. Administers the EPA Watershed Assessment Grant Program, the Small Operator's Assistance Program (SOAP), and the Remining Operators Assistance Program (ROAP).

Reclaim PA is DEP's initiative designed to maximize reclamation of the state's quarter million acres of abandoned mineral extraction lands. Abandoned mineral extraction lands in Pennsylvania constituted a significant public liability – more than 250,000 acres of abandoned surface mines, 2,400 miles of streams polluted with mine drainage, over 7,000 orphaned and abandoned oil and gas wells, widespread subsidence problems, numerous hazardous mine openings, mine fires, abandoned structures and affected water supplies – representing as much as one third of the total problem nationally.

Mine reclamation and well plugging refers to the process of cleaning up environmental pollutants and safety hazards associated with a site and returning the land to a productive condition, similar to DEP's Brownfields program. Since the 1960's, Pennsylvania has been a national leader in establishing laws and regulations to ensure reclamation and plugging occur after active operation is completed.

Pennsylvania is striving for complete reclamation of its abandoned mines and plugging of its orphaned wells. Realizing this task is no small order, DEP has developed concepts to make abandoned mine reclamation easier. These concepts, collectively called Reclaim PA, include

legislative, policy land management initiatives designed to enhance mine operator, volunteer land DEP reclamation efforts. Reclaim PA has the following four objectives.

- To encourage private and public participation in abandoned mine reclamation efforts
- To improve reclamation efficiency through better communication between reclamation partners
- To increase reclamation by reducing remaining risks
- To maximize reclamation funding by expanding existing sources and exploring new sources.

To date many projects have been constructed in order to address the affects of abandoned mines and abandoned mine lands in the watershed. The following table lists the different projects that have been accomplished or initiated. It is anticipated that completion of the Rattler Project along with construction of the Anna S Project will remove sufficient pollution loading to Babb Creek to achieve in-stream limits and also facilitate restoration of the watershed to a swimmable and fishable stream.

Table 4. Projects Completed to Address Affects of Abandoned Mines

Project	Type of Treatment	Mine Complex	Watershed Subbasin (mon. pt.)	Date completed
Lick Creek Diversion Wells	Diversion Wells (2)	Arnot	Lick Creek (1)	1990
Klondike Diversion Well	Small Diversion Well	Klondike	Lick Creek (1)	1994
Red Run Diversion Wells	Diversion Wells (2)	Klondike	Lick Creek (1)	1995
Arnot Treatment	Vertical Flow Treatment Sys.- Anoxic Limestone Drain	Arnot	Lick Creek (1)	1996
Klondike Treatment	Vertical Flow Treatment System	Klondike	Lick Creek (1)	1998
Klondike Refuse Pile	Regrading/Topsoil/Revegetation	Klondike	Lick Creek (1)	1999
State Yard Diversion Well	Diversion Well	Arnot	Lick Creek (1)	1999
State Yard Passive Treatment	Vertical Flow Treatment System/Settling Basin/Manganese Removal Pond	Arnot	Lick Creek (1)	2002
Babb Creek Railroad Grade Removal	Complete Removal of refuse pile from stream floodplain	Bear Run	Babb Creek (4)	2000
Bear Run Treatment Systems	Vertical Flow Treatment Systems (2)	Bear Run	Babb Creek (4)	2000
Antrim Treatment Plant	Chemical Treatment	Antrim/Backs witch	Wilson Creek (5)	1990 Reconstructed 1998
Anna S Growing Greener Grant	Diversion Well-Mitchell, Passive Treatment for Anna S No.'s 1 & 2 and Hunters Drift	Anna S	Wilson Creek (5)	2003
Rattler Mine Abatement	Limestone Injection, Passive Treatment, and Revegetation	Rattler	Stony Fork Creek (8)	2003

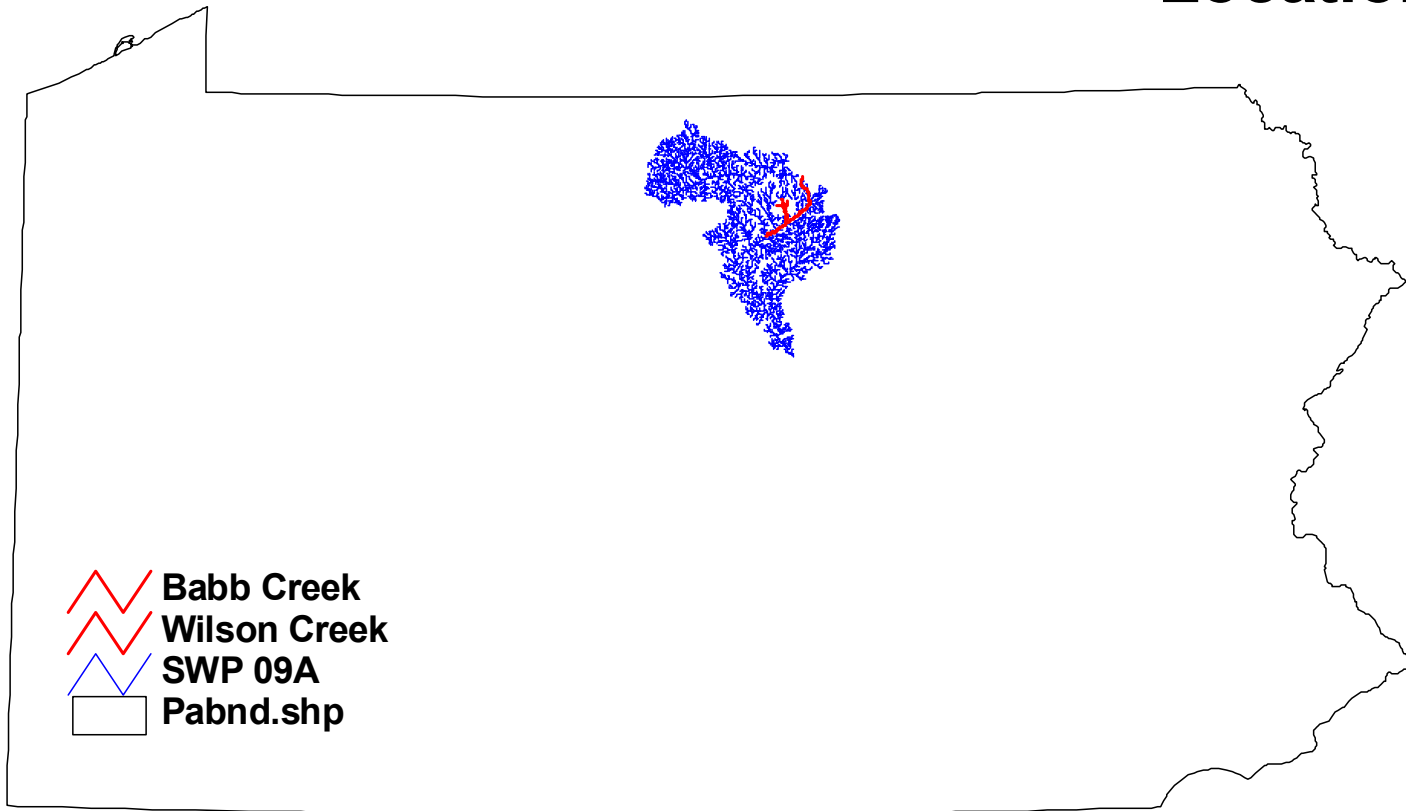
Public Participation

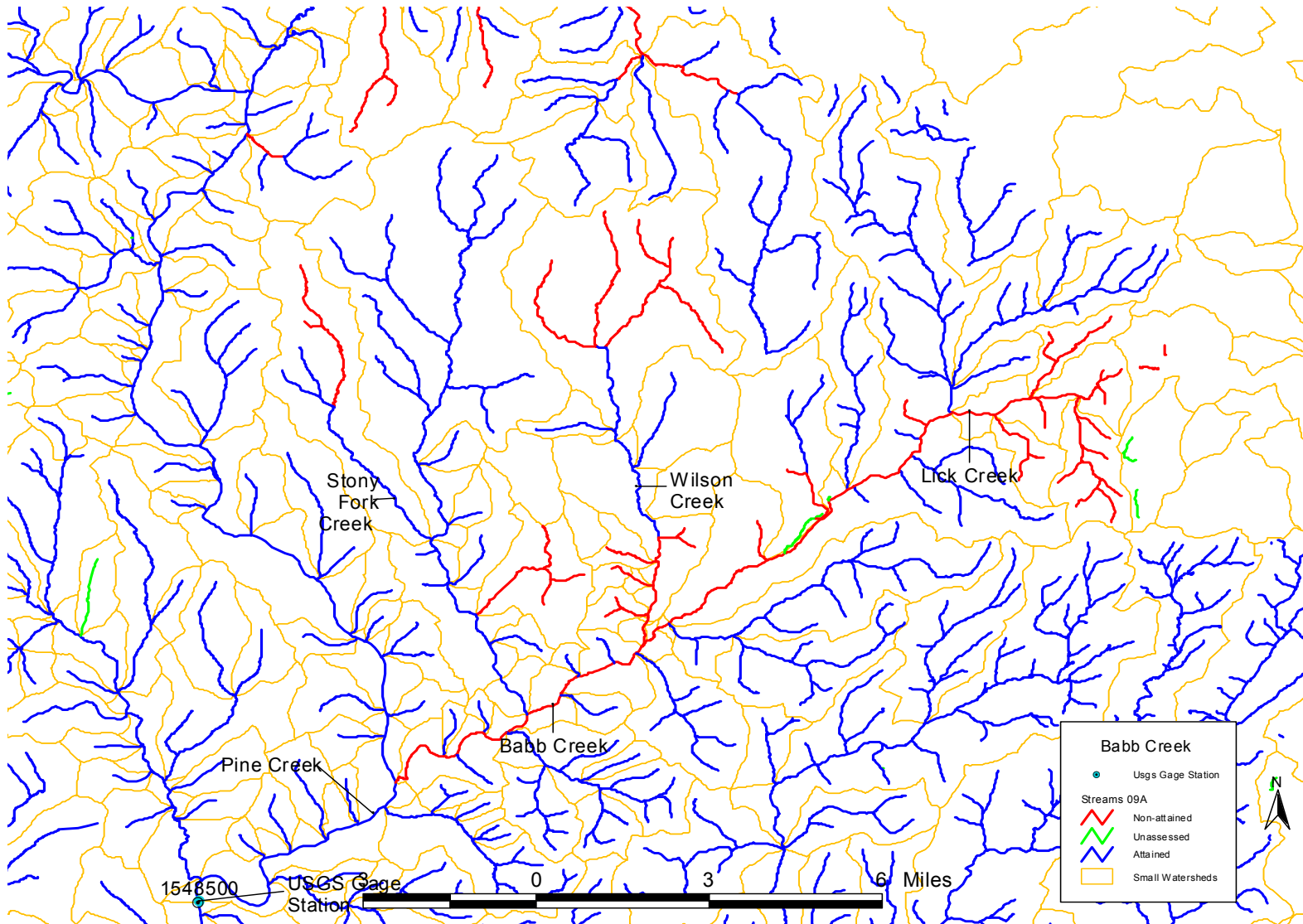
Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* on September 21, 2002 and the *Williamsport Sun Gazette* on September 18 and 25, 2002 and in the *Wellsboro Gazette* on September 18 and 25, 2002 to foster public comment on the allowable loads calculated. A public meeting was held on October 1, 2002, at the Arnot Sportsmens Club in Arnot, PA, to discuss the proposed TMDL. Seventeen people attended the public meeting including members or representatives of the following groups, organizations, or businesses: the Babb Creek Watershed Association, the Arnot Sportsmens Club, the Pine Creek Headwaters Protection Group, Waste Management Inc., Wolfes General Store, Signor Brothers Construction, the Tioga County Conservation District, the Tioga State Forest, Pennsylvania Dept. of Environmental Protection, and local concerned citizens.

Attachment A

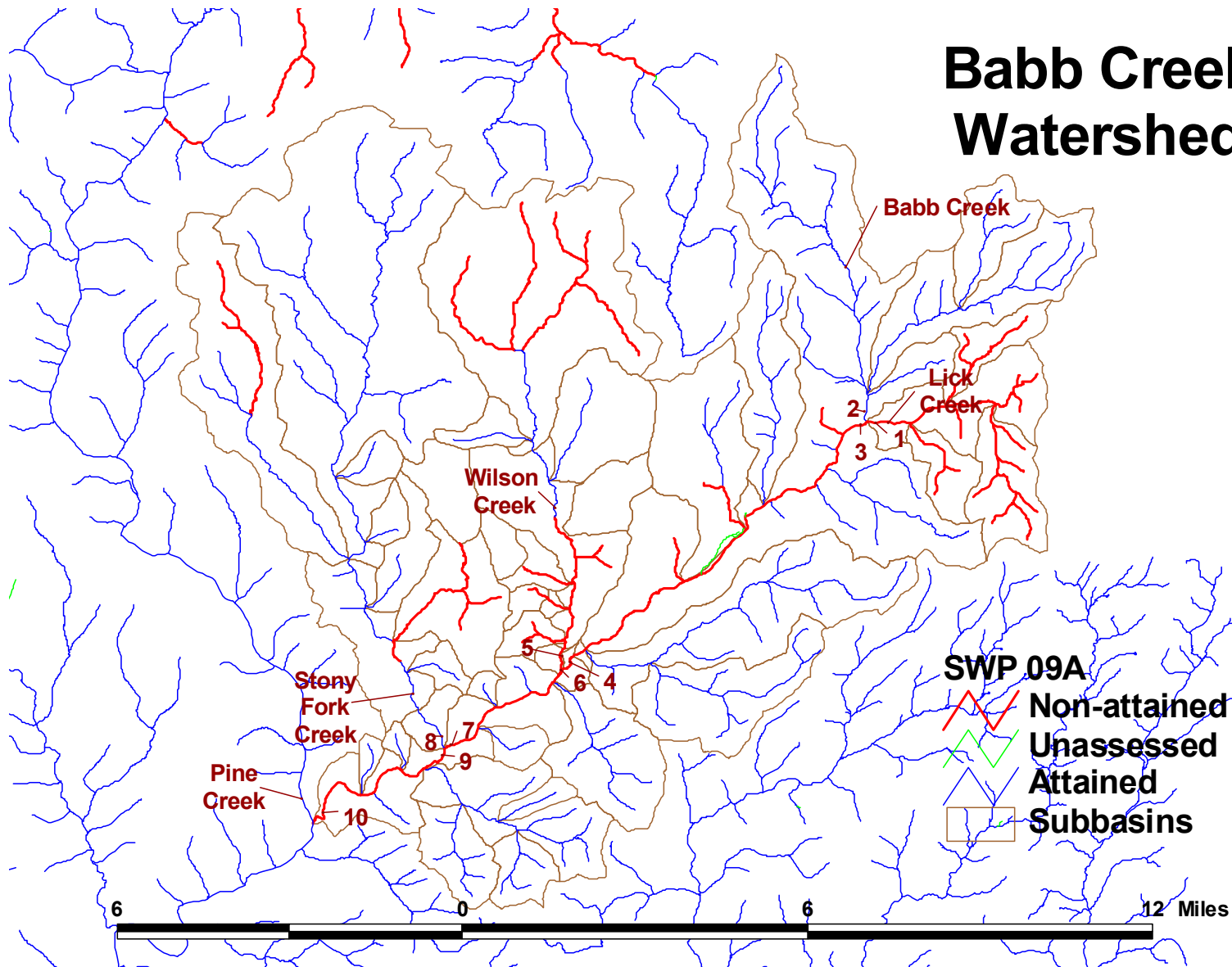
Babb Creek Watershed Maps

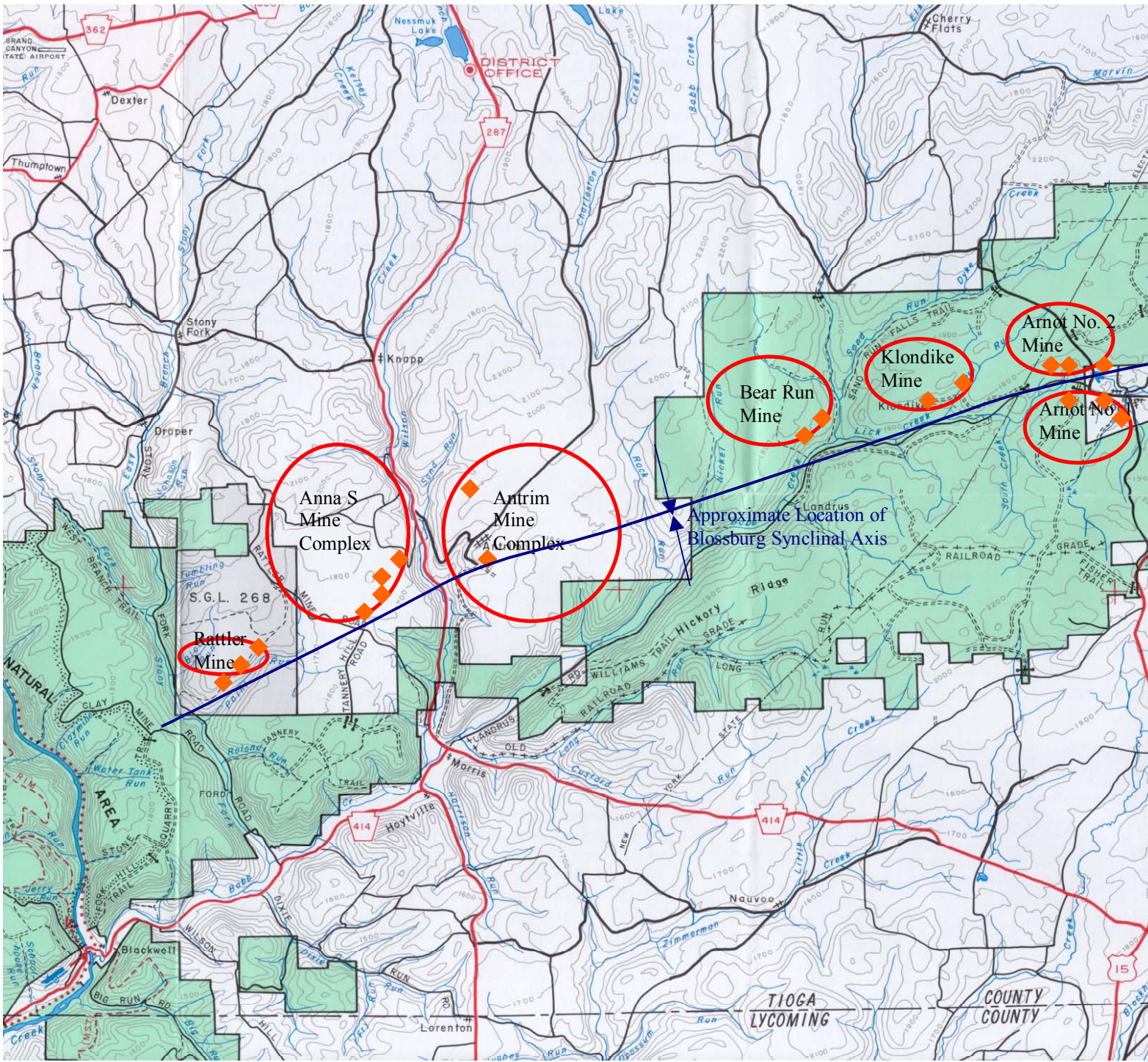
Babb Creek Location



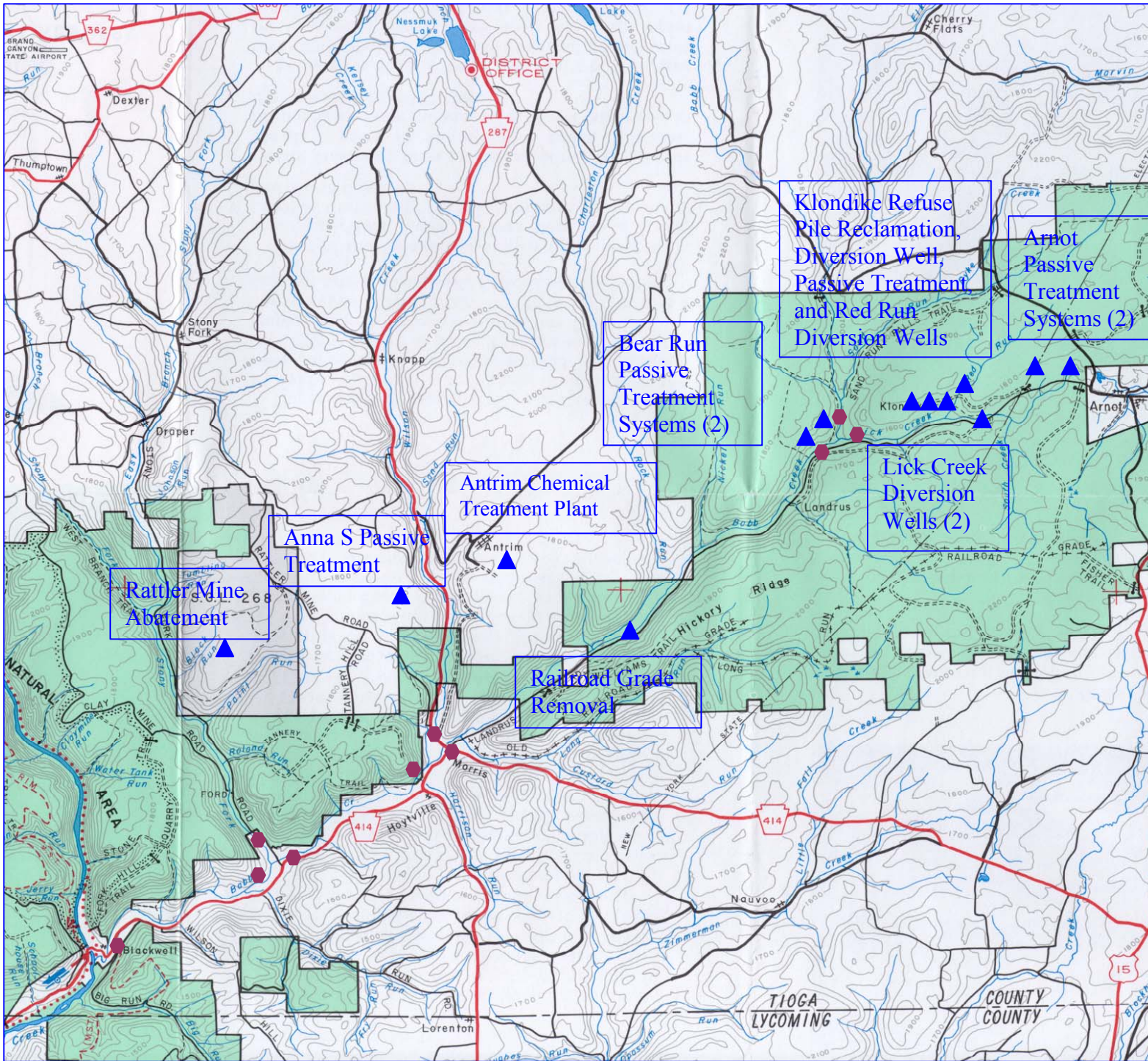


Babb Creek Watershed





Babb Creek Watershed Mine Location Map showing general location of: Abandoned Mines, Mine discharges, TMDL Sampling Points, and the Blossburg Synclinal Axis.



Babb Creek Watershed Project Location Map showing general location of: Acid Mine Drainage Treatment or Abatement Projects and TMDL Sampling Points.

Attachment B

**AMD Methodology, The pH Method And Surface
Mining Control and Reclamation Act**

AMD Methodology

Two approaches are used for the TMDL analysis of AMD-affected stream segments. Both of these approaches use the same statistical method for determining the instream allowable loading rate at the point of interest. The difference between the two is based on whether the pollution sources are defined as discharges that are permitted or have a responsible party, which are considered point sources. Nonpoint sources are then any pollution sources that are not point sources.

For situations where all of the impact is due to nonpoint sources, the equations shown below are applied using data for a point in the stream. The load allocation made at that point will be for all of the watershed area that is above that point. For situations where there are only point-source impacts or a combination of point and nonpoint sources, the evaluation will use the point-source data and perform a mass balance with the receiving water to determine the impact of the point source.

TMDLs and load allocations for each pollutant were determined using Monte Carlo simulation. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk³ by performing 5,000 iterations to determine any required percent reduction so that the water quality criteria will be met instream at least 99 percent of the time. For each iteration, the required percent reduction is:

$$PR = \text{maximum } \{0, (1-Cc/Cd)\} \quad \text{where} \quad (1)$$

PR = required percent reduction for the current iteration

Cc = criterion in mg/l

Cd = randomly generated pollutant source concentration in mg/l based on the observed data

$$Cd = \text{RiskLognorm}(\text{Mean}, \text{Standard Deviation}) \quad \text{where} \quad (1a)$$

Mean = average observed concentration

Standard Deviation = standard deviation of observed data

The overall percent reduction required is the 99th percentile value of the probability distribution generated by the 5,000 iterations, so that the allowable long-term average (LTA) concentration is:

$$LTA = \text{Mean} * (1 - PR99) \quad \text{where} \quad (2)$$

³ @Risk – Risk Analysis and Simulation Add-in for Microsoft Excel, Palisade Corporation, Newfield, NY, 1990-1997.

LTA = allowable LTA source concentration in mg/l

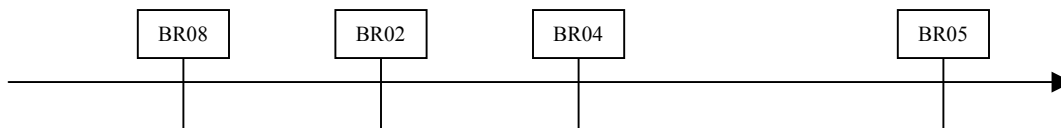
Once the required percent reduction for each pollutant source was determined, a second series of Monte Carlo simulations were performed to determine if the cumulative loads from multiple sources allow instream water quality criteria to be met at all points at least 99 percent of the time. The second series of simulations combined the flows and loads from individual sources in a step-wise fashion, so that the level of attainment could be determined immediately downstream of each source. Where available data allowed, pollutant-source flows used were the average flows. Where data were insufficient to determine a source flow frequency distribution, the average flow derived from linear regression was used.

In general, these cumulative impact evaluations indicate that, if the percent reductions determined during the first step of the analysis are achieved, water quality criteria will be achieved at all upstream points, and no further reduction in source loadings is required.

Where a stream segment is listed on the Section 303(d) list for pH impairment, the evaluation is the same as that discussed above; the pH method is fully explained in this Attachment. An example calculation from the Swatara Creek TMDL, including detailed tabular summaries of the Monte Carlo results, is presented for the Lorberry Creek TMDL in Attachment C. Information for the TMDL analysis performed using the methodology described above is contained in the TMDLs by segment section of this report in Attachment D.

Accounting for Upstream Reductions in AMD TMDLs

In AMD TMDLs, sample points are evaluated in headwaters (most upstream) to stream mouth (most downstream) order. As the TMDL evaluation moves downstream the impact of the previous, upstream, evaluations must be considered. The following examples are from the Beaver Run AMD TMDL (2003):



In the first example BR08 is the most upstream sample point and BR02 is the next downstream sample point. The sample data, for both sample points, are evaluated using @Risk (explained above) to calculate the existing loads, allowable loads, and a percentage reduction for aluminum, iron, manganese, and acidity (when flow and parameter data are available).

Any calculated load reductions for the upstream sample point, BR08, must be accounted for in the calculated reductions at sample point BR02. To do this (see table A) the allowable load is subtracted from the

Table A	Alum.	Iron	Mang.	Acidity
BR08	(#/day)	(#/day)	(#/day)	(#/day)
existing load=	3.8	2.9	3.5	0.0
allowable load=	3.8	2.9	3.5	0.0
TOTAL LOAD REDUCTION=	0.0	0.0	0.0	0.0

existing load, for each parameter, to determine the total load reduction.

In table B the Total Load Reduction BR08 is subtracted from the Existing loads at BR02 to determine the Remaining Load. The Remaining Load at BR02 has the previously calculated Allowable Loads at BR02 subtracted to determine any load reductions at sample point BR02. This results in load reductions for aluminum, iron and manganese at sample point BR02.

At sample point BR05 this same procedure is also used to account for calculated reductions at sample points BR08 and BR02. As can be seen in Tables C and D this procedure results in additional load reductions for iron, manganese and acidity at sample point BR04.

Table B. Necessary Reductions at Beaver Run BR02				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at BR02	13.25	38.44	21.98	6.48
Total Load Reduction BR08	0.00	0.00	0.00	0.00
Remaining Load (Existing Load at BR02 - BR08)	13.25	38.44	21.98	6.48
Allowable Loads at BR02	2.91	9.23	7.03	6.48
Percent Reduction	78.0%	76.0%	68.0%	NA
Additional Removal Required at BR02	10.33	29.21	14.95	0.00

At sample point BR05 (the most downstream) no additional load reductions are required, see Tables E and F.

Table C	Alum.	Iron	Mang.	Acidity
BR08 & BR02	(#/day)	(#/day)	(#/day)	(#/day)
Total Load Reduction=	10.33	29.21	14.95	0.0

Table E	Alum.	Iron	Mang.	Acidity
BR08 BR02 & BR04	(#/day)	(#/day)	(#/day)	(#/day)
Total Load Reduction=	10.3	29.2	14.9	0.0

Table D. Necessary Reductions at Beaver Run BR04				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at BR04	12.48	138.80	54.47	38.76
Total Load Reduction BR08 & BR02	10.33	29.21	14.95	0.00
Remaining Load (Existing Load at BBR04 - TLR Sum)	2.15	109.59	39.53	38.76
Allowable Loads at BR04	8.99	19.43	19.06	38.46
Percent Reduction	NA	82.3%	51.8%	0.8%
Additional Removal Required at BR04	0.00	90.16	20.46	0.29

Table F. Necessary Reductions at Beaver Run BR05				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at BR05	0.0	31.9	22.9	4.1
Total Load Reduction BR08, BR02 & BR04	10.3	119.4	35.4	0.3
Remaining Load (Existing Load at BBR05 - TLR Sum)	NA	NA	NA	3.8
Allowable Loads at BR05	0.0	20.4	15.1	4.1
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at BR05	0.0	0.0	0.0	0.0

Although the evaluation at sample point BR05 results in no additional removal this does not mean there are no AMD problems in the stream segment BR05 to BR04. The existing and allowable loads for BR05 show that iron and manganese exceed criteria and, any abandoned mine discharges in this stream segment will be addressed.

Method for Addressing Section 303(d) Listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published by the Pa. Department of Environmental Protection demonstrates that by plotting net alkalinity (alkalinity-acidity) vs. pH for 794 mine sample points, the resulting pH value from a sample possessing a net alkalinity of zero is approximately equal to six (Figure 1). Where net alkalinity is positive (greater than or equal to zero), the pH range is most commonly six to eight, which is within the USEPA's acceptable range of six to nine and meets Pennsylvania water quality criteria in Chapter 93.

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to standard statistics. Additionally, pH does not measure latent acidity. For this reason, and based on the above information, Pennsylvania is using the following approach to address the stream impairments noted on the Section 303(d) list due to pH. The concentration of acidity in a stream is at least partially chemically dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values, which would result from treatment of abandoned mine drainage. Therefore, net alkalinity will be used to evaluate pH in these TMDL calculations. This methodology assures that the standard for pH will be met because net alkalinity is a measure of the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable. Therefore, the measured instream alkalinity at the point of evaluation in the stream will serve as the goal for reducing total acidity at that point. The methodology that is applied for alkalinity (and therefore pH) is the same as that used for other parameters such as iron, aluminum, and manganese that have numeric water quality criteria.

Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both being in units of milligrams per liter (mg/l) CaCO₃. The same statistical procedures that have been described for use in the evaluation of the metals is applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for mine waters is not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

There are several documented cases of streams in Pennsylvania having a natural background pH below six. If the natural pH of a stream on the Section 303(d) list can be established from its upper unaffected regions, then the pH standard will be expanded to include this natural range. The acceptable net alkalinity of the stream after treatment/abatement in its polluted segment will be the average net alkalinity established from the stream's upper, pristine reaches added to the acidity of the polluted portion in question. Summarized, if the pH in an unaffected portion of a stream is found to be naturally occurring below six, then the average net alkalinity for that portion (added to the acidity of the polluted portion) of the stream will become the criterion for the polluted portion. This "natural net alkalinity level" will be the criterion to which a 99 percent confidence level will be applied. The pH range will be varied only for streams in which a natural unaffected net alkalinity level can be established. This can only be done for streams that have upper segments that are not impacted by mining activity. All other streams will be required to reduce the acid load so the net alkalinity is greater than zero 99% of time.

Reference: *Rose, Arthur W. and Charles A. Cravotta, III 1998. Geochemistry of Coal Mine Drainage. Chapter 1 in Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania. Pa. Dept. of Environmental Protection, Harrisburg, Pa.*

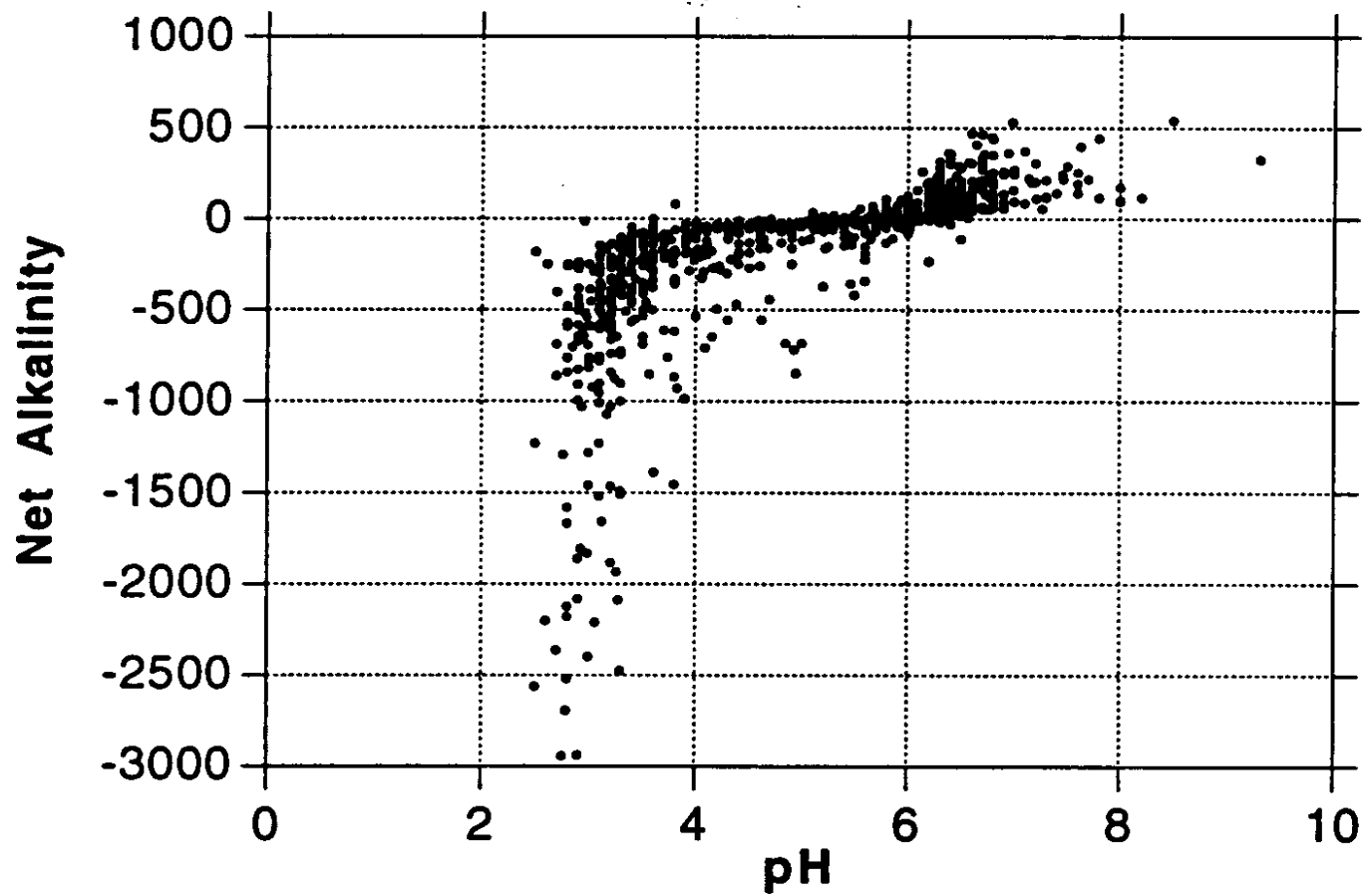


Figure 1. Net Alkalinity vs. pH. Taken from Figure 1.2 Graph C, pages 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

Surface Mining Control and Reclamation Act

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, among other things, protect the beneficial uses of land or water resources, and public 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. SMCRA requires a permit for the development of new, previously mined, or abandoned sites for the purpose of surface mining. Permittees are required to post a performance bond that will be sufficient to ensure the completion of reclamation requirements by the regulatory authority in the event that the applicant forfeits. Mines that ceased operating by the effective date of SMCRA, (often called “pre-law” mines) are not subject to the requirements of SMCRA.

Title IV of the Act is designed to provide assistance for reclamation and restoration of abandoned mines, while Title V states that any surface coal mining operations shall be required to meet all applicable performance standards. Some general performance standards include:

- Restoring the affected land to a condition capable of supporting the uses which it was capable of supporting prior to any mining,
- Backfilling and compacting (to insure stability or to prevent leaching of toxic materials) in order to restore the approximate original contour of the land with all highwalls being eliminated, and topsoil replaced to allow revegetation, and
- Minimizing the disturbances to the hydrologic balance and to the quality and quantity of water in surface and ground water systems both during and after surface coal mining operations and during reclamation by avoiding acid or other toxic mine drainage.

For purposes of these TMDLs, point sources are identified as NPDES-permitted discharge points, and nonpoint sources include discharges from abandoned mine lands, including but not limited to, tunnel discharges, seeps, and surface runoff. Abandoned and reclaimed mine lands were treated in the allocations as nonpoint sources because there are no NPDES permits associated with these areas. In the absence of an NPDES permit, the discharges associated with these land uses were assigned load allocations.

The decision to assign load allocations to abandoned and reclaimed mine lands does not reflect any determination by EPA as to whether there are, in fact, unpermitted point source discharges within these land uses. In addition, by establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

Related Definitions

Pre-Act (Pre-Law) - Mines that ceased operating by the effective date of SMCRA and are not subject to the requirements of SMCRA.

Bond – A instrument by which a permittee assures faithful performance of the requirements of the acts, this chapter, Chapters 87-90 and the requirements of the permit and reclamation plan.

Postmining pollution discharge – A discharge of mine drainage emanating from or hydrologically connected to the permit area, which may remain after coal mining activities have been completed, and which does not comply with the applicable effluent requirements described in Chapters 87.102, 88.92, 88.187, 88.292, 89.52 or 90.102. The term includes minimal-impact postmining discharges, as defined in Section of the Surface Mining Conservation and Reclamation Act.

Forfeited Bond – Bond money collected by the regulatory authority to complete the reclamation of a mine site when a permittee defaults on his reclamation requirements.

Attachment C

Example Calculation: Lorberry Creek

Lorberry Creek was evaluated for impairment due to high metals contents in the following manner: the analysis was completed in a stepwise manner, starting at the headwaters of the stream and moving to the mouth. The Rowe Tunnel (Swat-04) was treated as the headwaters of Lorberry Creek for the purpose of this analysis.

1. A simulation of the concentration data at point Swat-04 was completed. This estimated the necessary reduction needed for each metal to meet water quality criteria 99 percent of the time as a long-term average daily concentration. Appropriate concentration reductions were made for each metal.
2. A simulation of the concentration data at point Swat-11 was completed. It was determined that no reductions in metals concentrations are needed for Stumps Run at this time. Therefore, no TMDL for metals in Stumps Run is required at this time.
3. A mass balance of loading from Swat-04 and Swat-11 was completed to determine if there was any need for additional reductions as a result of combining the loads. No additional reductions were necessary.
4. The mass balance was expanded to include the Shadle Discharge (L-1). It was estimated that best available technology (BAT) requirements for the Shadle Discharge were adequate for iron and manganese. There is no BAT requirement for aluminum. A wasteload allocation was necessary for aluminum at point L-1.

There are no other known sources below the Shadle Discharge. However, there is additional flow from overland runoff and one unnamed tributary not impacted by mining. It is reasonable to assume that the additional flow provides assimilation capacity below point L-1, and no further analysis is needed downstream.

The calculations are detailed in the following section (Tables 1-8). Table 9 shows the allocations made on Lorberry Creek.

1. A series of four equations was used to determine if a reduction was needed at point Swat-04, and, if so the magnitude of the reduction.

	Field Description	Equation	Explanation
1	Swat-04 Initial Concentration Value (Equation 1A)	= Risklognorm (Mean, St Dev)	This simulates the existing concentration of the sampled data.
2	Swat-04 % Reduction (from the 99 th percentile of percent reduction)	= (Input a percentage based on reduction target)	This is the percent reduction for the discharge.
3	Swat-04 Final Concentration Value	= Sampled Value x (1-percent reduction)	This applies the given percent reduction to the initial concentration.
4	Swat-04 Reduction Target (PR)	= Maximum (0, 1- Cd/Cc)	This computes the necessary reduction, if needed, each time a value is sampled. The final reduction target is the 99 th percentile value of this computed field.

2. The reduction target (PR) was computed taking the 99th percentile value of 5,000 iterations of the equation in row four of Table 1. The targeted percent reduction is shown, in boldface type, in the following table.

Name	Swat-04 Aluminum	Swat-04 Iron	Swat-04 Manganese
Minimum =	0	0.4836	0
Maximum =	0.8675	0.9334	0.8762
Mean =	0.2184	0.8101	0.4750
Std. Deviation =	0.2204	0.0544	0.1719
Variance =	0.0486	0.0030	0.0296
Skewness =	0.5845	-0.8768	-0.7027
Kurtosis =	2.0895	4.3513	3.1715
Errors Calculated =	0	0	0
Targeted Reduction % =	72.2	90.5	77.0
Target #1 (Perc%)=	99	99	99

3. This PR value was used as the percent reduction in the equation in row three of Table 1. Testing was done to see that the water quality criterion for each metal was achieved at least 99 percent of the time. This verified the estimated percent reduction necessary for each metal. Table 3 shows, in boldface type, the percent of the time criteria for each metal was achieved during 5,000 iterations of the equation in row three of Table 1.

Name	Swat-04 Aluminum	Swat-04 Iron	Swat-04 Manganese
Minimum =	0.0444	0.2614	0.1394
Maximum =	1.5282	2.0277	1.8575
Mean =	0.2729	0.7693	0.4871
Std Deviation =	0.1358	0.2204	0.1670
Variance =	0.0185	0.0486	0.0279
Skewness =	1.6229	0.8742	1.0996
Kurtosis =	8.0010	4.3255	5.4404
Errors Calculated =	0	0	0
Target #1 (value) (WQ Criteria)=	0.75	1.5	1
Target #1 (Perc%)=	99.15	99.41	99.02

4. These same four equations were applied to point Swat-11. The result was that no reduction was needed for any of the metals. Tables 4 and 5 show the reduction targets computed for, and the verification of, reduction targets for Swat-11.

Name	Swat-11 Aluminum	Swat-11 Iron	Swat-11 Manganese
Minimum =	0.0000	0.0000	0.0000
Maximum =	0.6114	0.6426	0.0000
Mean =	0.0009	0.0009	0.0000
Std Deviation =	0.0183	0.0186	0.0000
Variance =	0.0003	0.0003	0.0000
Skewness =	24.0191	23.9120	0.0000
Kurtosis =	643.4102	641.0572	0.0000
Errors Calculated =	0	0	0
Targeted Reduction % =	0	0	0
Target #1 (Perc%) =	99	99	99

Name	Swat-11 Aluminum	Swat-11 Iron	Swat-11 Manganese
Minimum =	0.0013	0.0031	0.0246
Maximum =	1.9302	4.1971	0.3234
Mean =	0.0842	0.1802	0.0941
Std Deviation =	0.1104	0.2268	0.0330
Variance =	0.0122	0.0514	0.0011
Skewness =	5.0496	4.9424	1.0893
Kurtosis =	48.9148	48.8124	5.1358
Errors Calculated =	0	0	0
WQ Criteria =	0.75	1.5	1
% of Time Criteria Achieved =	99.63	99.60	100

5. Table 6 shows variables used to express mass balance computations.

Description	Variable Shown
Flow from Swat-04	Q_{swat04}
Swat-04 Final Concentration	C_{swat04}
Flow from Swat-11	Q_{swat11}
Swat-11 Final Concentration	C_{swat11}
Concentration below Stumps Run	C_{stumps}
Flow from L-1 (Shadle Discharge)	Q_{L1}
Final Concentration From L-1	C_{L1}
Concentration below L-1	C_{allow}

6. Swat-04 and Swat-11 were mass balanced in the following manner:

The majority of the sampling done at point Swat-11 was done in conjunction with point Swat-04 (20 matching sampling days). This allowed for the establishment of a significant correlation between the two flows (the R-squared value was 0.85). Swat-04 was used as the

base flow, and a regression analysis on point Swat-11 provided an equation for use as the flow from Swat-11.

The flow from Swat-04 (Q_{swat04}) was set into an @RISK function so it could be used to simulate loading into the stream. The cumulative probability function was used for this random flow selection. The flow at Swat-04 is as follows (Equation 1):

$$Q_{swat04} = \text{RiskCumul}(\text{min,max,bin range, cumulative percent of occurrence}) \quad (1)$$

The RiskCumul function takes four arguments: minimum value, maximum value, the bin range from the histogram, and cumulative percent of occurrence.

The flow at Swat-11 was randomized using the equation developed through the regression analysis with point Swat-04 (Equation 2).

$$Q_{swat11} = Q_{swat04} \times 0.142 + 0.088 \quad (2)$$

The mass balance equation is as follows (Equation 3):

$$C_{stumps} = ((Q_{swat04} * C_{swat04}) + (Q_{swat11} * C_{swat11})) / (Q_{swat04} + Q_{swat11}) \quad (3)$$

This equation was simulated through 5,000 iterations, and the 99th percentile value of the data set was compared to the water quality criteria to determine if standards had been met. The results show there is no further reduction needed for any of the metals at either point. The simulation results are shown in Table 7.

Table 7. Verification of Meeting Water Quality Standards Below Stumps Run			
Name	Below Stumps Run Aluminum	Below Stumps Run Iron	Below Stumps Run Manganese
Minimum =	0.0457	0.2181	0.1362
Maximum =	1.2918	1.7553	1.2751
Mean =	0.2505	0.6995	0.4404
Std Deviation =	0.1206	0.1970	0.1470
Variance =	0.0145	0.0388	0.0216
Skewness =	1.6043	0.8681	1.0371
Kurtosis =	7.7226	4.2879	4.8121
Errors Calculated =	0	0	0
WQ Criteria =	0.75	1.5	1
% of Time Criteria Achieved =	99.52	99.80	99.64

7. The mass balance was expanded to determine if any reductions would be necessary at point L-1.

The Shadle Discharge originated in 1997, and very few data are available for it. The discharge will have to be treated or eliminated. It is the current site of a USGS test

remediation project. The data that were available for the discharge were collected at a point prior to a settling pond. Currently, no data for effluent from the settling pond are available.

Modeling for iron and manganese started with the BAT-required concentration value. The current effluent variability based on limited sampling was kept at its present level. There was no BAT value for aluminum, so the starting concentration for the modeling was arbitrary. The BAT values for iron and manganese are 6 mg/l and 4 mg/l, respectively. Table 8 shows the BAT-adjusted values used for point L-1.

Parameter	Measured Value		BAT adjusted Value	
	<i>Average Conc.</i>	<i>Standard Deviation</i>	<i>Average Conc.</i>	<i>Standard Deviation</i>
Iron	538.00	19.08	6.00	0.21
Manganese	33.93	2.14	4.00	0.25

The average flow (0.048 cfs) from the discharge will be used for modeling purposes. There were not any means to establish a correlation with point Swat-04.

The same set of four equations used for point Swat-04 was used for point L-1. The equation used for evaluation of point L-1 is as follows (Equation 4):

$$C_{\text{allow}} = ((Q_{\text{swat04}} * C_{\text{swat04}}) + (Q_{\text{swat11}} * C_{\text{swat11}}) + (Q_{\text{L1}} * C_{\text{L1}})) / (Q_{\text{swat04}} + Q_{\text{swat11}} + Q_{\text{L1}}) \quad (4)$$

This equation was simulated through 5,000 iterations, and the 99th percentile value of the data set was compared to the water quality criteria to determine if standards had been met. It was estimated that an 81 percent reduction in aluminum concentration was needed for point L-1.

8. Table 9 shows the simulation results of the equation above.

Name	Below L-1 Aluminum	Below L-1 Iron	Below L-1 Manganese
Minimum =	0.0815	0.2711	0.1520
Maximum =	1.3189	2.2305	1.3689
Mean =	0.3369	0.7715	0.4888
Std Deviation =	0.1320	0.1978	0.1474
Variance =	0.0174	0.0391	0.0217
Skewness =	1.2259	0.8430	0.9635
Kurtosis =	5.8475	4.6019	4.7039
Errors Calculated =	0	0	0
WQ Criteria=	0.75	1.5	1
Percent of time achieved=	99.02	99.68	99.48

9. Table 10 presents the estimated reductions needed to meet water quality standards at all points in Lorberry Creek.

		Measured Sample Data		Allowable		Reduction Identified
Station	Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)	%
Swat 04						
	Al	1.01	21.45	0.27	5.79	73%
	Fe	8.55	181.45	0.77	16.33	91%
	Mn	2.12	44.95	0.49	10.34	77%
Swat 11						
	Al	0.08	0.24	0.08	0.24	0%
	Fe	0.18	0.51	0.18	0.51	00%
	Mn	0.09	0.27	0.09	0.27	00%
L-1						
	Al	34.90	9.03	6.63	1.71	81%
	Fe	6.00	1.55	6.00	1.55	0%
	Mn	4.00	1.03	4.00	1.03	0%

All values shown in this table are long-term average daily values

The TMDL for Lorberry Creek requires that a load allocation be made to the Rowe Tunnel Discharge (Swat-04) for the three metals listed, and that a wasteload allocation is made to the Shadle Discharge (L-1) for aluminum. There is no TMDL for metals required for Stumps Run (Swat-11) at this time.

Margin of Safety

For this study, the margin of safety is applied implicitly. The allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Other margins of safety used for this TMDL analysis include the following:

- None of the data sets were filtered by taking out extreme measurements. Because the 99 percent level of protection is designed to protect for the extreme event, it was pertinent not to filter the data set.
- Effluent variability plays a major role in determining the average value that will meet water quality criteria over the long term. This analysis maintained that the variability at each point would remain the same. The general assumption can be made that a treated discharge would be less variable than an untreated discharge. This implicitly builds in another margin of safety.

Attachment D

TMDLs By Segment

Lick Creek

Lick Creek is one of the principal headwater tributaries to Babb Creek. The Arnot #1, Arnot #2, and Klondike are three abandoned underground mines in this area. There is also a small reclaimed strip mine overlaying the Arnot #2 mine that is within the Lick Creek sub watershed. Please see the maps included in Attachment A.

Arnot #1 Mine

The Arnot #1 Mine is located south and west of the village of Arnot and on the southern flank of the Blossburg Syncline. This means that the mine is free flowing and drains to the north to Lick Creek on the western side of the mine and to Sawmill Creek (a tributary stream outside the watershed boundary) on the eastern side of the mine. The mine was developed on the Bloss Coal Seam and the mine lies on the Babb Creek-Johnson Run Drainage Divide. The result of this is that only a portion of the water discharging from the mine enters the Babb Creek Watershed (see the maps included in Attachment A).

A total of three discharges flow from the mine. A mine discharge on the western portion of the mine flows to Lick Creek. The 1976 Scarlift Report characterized this discharge as having very low flow (0.042 cfs/19 gpm), a pH of 5.6, low metals, acidity, and sulfate concentrations and a slightly net alkalinity.

An additional mine discharge is located just west of Arnot. Currently, the Arnot Sportsman's Club as a Pennsylvania Fish and Boat Commission cooperative nursery is raising trout in the excess water that is not used as drinking water for the town. More recent sampling revealed a pH of 5.8, low metals and acidity concentrations and a net alkalinity. This water flows to the pond on the east side of the state road that runs north-south across the valley floor connecting Arnot and Wellsboro. A culvert is present under the road allowing for interconnection and flow between the ponds on either side of the road. The watershed boundary is indistinct and may shift under different flow conditions and various stages of ponded water. This mine is not considered a contributor of pollution to the watershed.

Arnot #2 Mine

The Arnot #2 Mine was also developed on the Bloss Seam and was mined up-dip to the north. Three drift entries discharge mine drainage. Approximately 620 acres of coal that averaged 30 inches in thickness were mined. Mining was initiated on the eastern side of the mine and entries were developed as the mine progressed westward. Successive entry development was required because the mine developer robbed the pillars to the point that the mine collapsed. The easternmost discharge flows to the pond on the eastern side of the township road that runs across the valley floor. It appears that under most conditions the receiving stream of this discharge is Johnson Run and eventually the Tioga River, i.e., outside the Babb Creek Watershed. This discharge has an average flow of 0.51 cfs (230gpm). It has an average pH of 4.8, low metals concentration and an average net acidity of 20 mg/l.

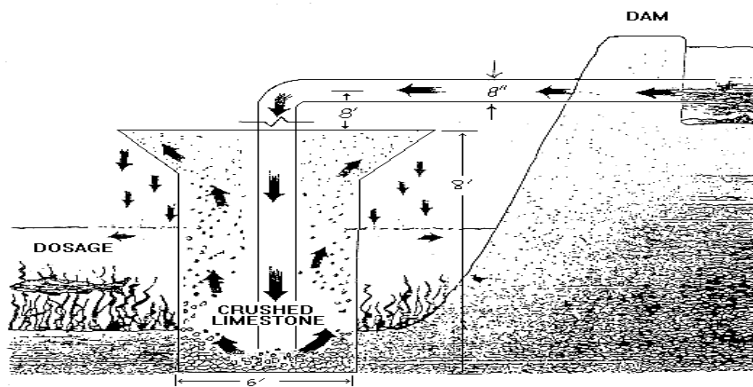
The center drift has the lowest average discharge rate (0.16 cfs or 72 gpm) and is referred to as discharge no. 2 of the Arnot No 2 Mine. It exhibits an average pH of 3.4, a net acidity of 75 mg/l, and low metal concentrations. This discharge lies in the Johnson Run Basin and flows to

the large headwater pond area. However, it has the potential to flow to Lick Creek under the right conditions. A diversion well has been constructed by Ed Signor of Arnot to treat the water at this mine discharge.

The diversion well treatment system captures the flow of acid mine drainage from the mine and pipes it to a concrete manhole or 'well' where the hydraulic pressure of the water is sufficient to cause grinding of limestone gravel that is placed within the 'well'. Grinding of the limestone generates bicarbonate alkalinity and neutralizes acidity and raises the pH of the water. Limestone gravel is consumed and must be replaced on a weekly basis.

A diversion well is a low-technology, high-maintenance treatment system that is capable of neutralizing low concentrations of acidity in large mine discharges or small streams. The technology was developed in Scandinavia to treat acid precipitation in streams and lakes. The technology was introduced to Pennsylvania in the late 1980's and in the Babb Creek watershed in 1990 where diversion wells have become common and an effective means of treating stream acidity where there is a dedicated watershed association to tend to the maintenance required as limestone is consumed and must be added periodically.

Figure 1. Schematic Diagram of a Limestone Diversion Well. From Sverdrup, H.U., "A Short Description of the Diversion Wells at Piggaboda, Sweden, Translation from the symposium proceedings Kalkning av Rinnande Vatten. Alvesta, Sweden (1983).



In 2000, Pennsylvania DEP awarded the Babb Creek Watershed Association a Growing Greener Grant to replace the diversion well with a passive treatment system that consists of two vertical flow systems followed by a settling basin and a manganese removal pond. Final engineering and design was accomplished in June 2001 and construction was completed during the winter of 2001 and spring of 2002. A photograph of the system is below.



Figure 2. Photograph of the Arnot (State Yard) Treatment System in Bloss Township, Tioga County. The top two ponds are vertical flow ponds that use limestone to generate alkalinity. The pond in the lower right is a settling basin for the precipitation of metal solids and the pond in the lower left is a manganese oxidation pond.

The Arnot #2 drift on the western end of the mine is referred to as discharge no. 4 and has a smaller average flow rate (0.40 cfs or 180 gpm) than discharge no. 2 (0.51 cfs) but it has a greater acidity concentration and is the greatest contributor of acid loading of all the Arnot #1 and #2 Mine Discharges. This discharge has an average pH of 3.3, a net acidity of 96 mg/l, and low metals concentrations (1 mg/l iron and 4 mg/l aluminum). Although this is the greatest headwater contributor of pollution loadings, the only significant pollutants are acidity and to a smaller extent aluminum. A Successive Alkalinity Producing System (SAPS) and Anoxic Limestone Drain (ALD) combination system was built in the late fall of 1996 to treat this mine drainage. The passive treatment system has had a very significant impact on the waters of Lick Creek, net alkalinity and pH have both markedly increased following its implementation.



Figure 3. Photograph of the successive alkalinity producing system (SAPS) or vertical flow system near Arnot, Bloss Township, Tioga County.

Water in the treatment system is treated initially by the successive alkalinity producing system (SAPS), which uses limestone dissolution and sulfate reduction in a compost layer to generate alkalinity. A buried bed of limestone called an anoxic limestone drain (ALD) further treats the water and aids in the neutralization of acid in the mine water. The SAPS contains approximately 1600 tons of high quality limestone gravel and the ALD contains approximately 2400 tons of limestone. Upon its discharge from the ALD, the water has a pH of 6.5-6.7.

Klondike Mine

The Klondike Mine is located approximately 2.5 miles west of Arnot. It was developed around the turn of the century and abandoned around 1930-1935. Access to the mine is along the abandoned railroad siding that connected the mining district to the main railroad near Blossburg. The Klondike Mine was also developed on the Bloss Seam and was mined in an up-dip direction to the north. The coal dips to the south at a very gentle angle in the southern portion of the mine and rises more sharply in the northern portion of the mine. There were three drift entries into the mine; two of them flow mine drainage today.

The easternmost discharge may have been a watercourse and was locally referred to as the Davis Drift and appears to be a watercourse designed to drain water from the mine. The discharge flows at an average rate of approximately 150 gpm, has a pH of 3.1, and flows directly into Red

Run, a tributary stream of Lick Creek. In September of 1995 two diversion wells were constructed to treat the waters of Red Run at a location approximately 600 feet below the discharge. Prior to the diversion well treatment, the entire length of Red Run was sterile and lifeless. The diversion well treatment has had a dramatic improvement on Red Run. The treatment is properly sized to provide treatment of the stream under almost all flow conditions. At the diversion well intakes, the stream has a pH of 4.0. Below the treatment system the stream has consistently had a pH above 6.0, generally around 6.5.

The second acid mine discharge is the main entry of the Klondike Mine. This point has a chemistry that is significantly different than the chemistry exhibited by the Davis Drift. The main entry flows water at an average rate of 180 gpm. The discharge exhibits a pH of 2.9, an acidity concentration of 170 mg/l, an iron concentration of 9 mg/l, and an aluminum concentration of 10 mg/l. A smaller scaled diversion well was constructed in 1993 to address this mine discharge. Diversion wells are capable of adding a fixed amount of alkalinity based on the amount of limestone that can be ground up by abrasion within the 'well'. This mine discharge proved to be too severe for complete treatment and pollution removal by diversion well treatment.

In 1998, the Babb Creek Watershed Association in conjunction with DEP secured a grant and private donations and constructed a large vertical flow treatment pond to treat the Klondike discharge. Space available for treatment was limited because of topography, so the system was designed for normal flows and flows beyond that were directed to the preexisting diversion well. A settling basin is planned for construction below the vertical flow treatment pond.

At the main entry of the Klondike Mine a huge pile of coal refuse was created as a result of the underground mining operation. Material was transported to the surface where rock and carboniferous material was separated from the marketable coal. This pile existed as a source of pollution and a scar on the landscape for many years. In 1999, the Babb Creek Watershed Association regraded the pile and applied beneficial use materials including composted tannery sludge to the surface to create a soil and establish vegetation. The project was accomplished through private funding. Today the area is covered with grasses, legumes and recently Tioga State Forest personnel planted trees on the site as well.

Lick Creek is the most upstream tributary stream of Babb Creek that has been affected by mining and the resulting acid mine drainage. The acid mine discharges producing the degradation in Lick Creek and subsequently in Babb Creek are the two Klondike discharges and the two westernmost discharges on the Arnot #2.



Figure 4. Photograph of the Klondike Treatment system at the former town of Klondike, Bloss Township, Tioga County.



Figure 5. Photographs of the abandoned Klondike Refuse Pile before and after reclamation, Bloss Township, Tioga County.

TMDL calculations-Sample Point 1

The TMDL for Lick Creek consists of a load allocation to all of the area above sampling point 1 (Attachment A). The load allocation for this stream segment was computed using water-quality sample data collected at point 1. In-stream flow measurements were not available for sample point 1. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 1 is 8.19 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 1 equals the flow of 11.44 cfs (7.39 MGD) at sample point 1.

There is currently no entry for this segment on the Pa 1996 Section 303(d) list for impairment due to pH. Sample data at point 1 shows pH ranging between 4.6 and 6.0; pH will be addressed as part of this TMDL because of the mining impacts. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

An allowable long-term average in-stream concentration was determined at sample point 1 for aluminum and acidity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Parameter	Measured Sample Data		Allowable		Reduction Identified
	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
Al	0.56	34.5	0.39	23.9	31%
Fe	0.27	16.3	0.26	16.3	0%
Mn	0.24	14.7	0.24	14.7	0%
Acidity	12.83	791.0	2.00	123.5	84%
Alkalinity	9.29	572.6			

Upstream Segment of Babb Creek – Above Sample Point 2

Prior to its confluence with Lick Creek, Babb Creek is considered by most to be a pristine mountain stream. The stream has its origin in farmlands Southeast of Wellsboro in the Cherry Flats area. Glacial materials and soils formed from weathered bedrock tend to lend alkalinity to the water. The stream flows through the farmlands and through a gap in the flank of the mountain to enter the Babb Creek Valley. There the stream flows through incised bedrock and pools, riffles and small falls form good fish habitat in the hemlock and hardwood forests.

TMDL Calculations-Sampling Point 2

The TMDL for sampling point 2 consists of a load allocation to all of the area above the sampling point shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point 2. In-stream flow measurements were not available for sample point 2. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 2 is 16.27 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq. mi. Multiplying the flow yield for the known point times the watershed area above point 2 equals the flow of 22.72 cfs (14.69 MGD) at sample point 2.

There is currently no entry for this segment on the Section Pa 303(d) list for impairment due to pH. No sample data is available above sample point 2 to establish an upstream pH. Sample data at point 2 shows pH ranging between 6.3 and 6.8; pH will not be addressed as part of this TMDL because this segment of Babb Creek is net alkaline.

No allowable long-term average in-stream concentration was determined at point 2 for aluminum, iron, manganese and acidity. The following table shows the load allocations for this stream segment.

All water quality analysis performed at Point 2 for these TMDLs met applicable water quality standards; therefore, the allocated concentration is equal to the existing concentration as shown in Table 2 below.

Table D2. Load Allocations at Point 2					
0	Measured Sample Data		Allowable		Reduction Identified
Parameter	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
Al	0.16	19.5	0.16	19.5	0%
Fe	0.18	21.9	0.18	21.9	0%
Mn	0.02	2.7	0.02	2.7	0%
Acidity	0.03	3.1	0.03	3.1	0%
Alkalinity	21.98	2691.9			

A TMDL was not calculated for Sample Point 3 because it is adjacent to sample points 1 and 2. The data collected at sample point 3 is shown in Attachment F.

Babb Creek upstream of Wilson Creek – Area Between Sample Point 4 and Sample Points 1 and 2

The Bear Run Mine is located on the northern flank of the Babb Creek Valley near the confluence of Babb Creek and Lick Creek. The mine has two discharges, these are the main entry and a secondary entry located one-quarter mile east of the main entry. Both discharges flow directly to Babb Creek.

Two passive treatment systems were constructed in 2000 to treat the two discharges through a cooperative agreement between DEP and Stott Mining Company. A smaller treatment system is located at the main entry where flows from the mine are lower. A secondary discharge point farther to the west discharges the bulk of the water from the mine and a large treatment system was constructed there. The mine water has a pH of 3.1, low iron and aluminum concentrations, and an acidity concentration of 100 mg/l. Water discharging from the two systems has a pH of over 7.0 (usually 7.2-7.3) and a net alkalinity of 130 mg/l. This is the only mine complex that has a significant discharge of water to this segment of the stream. Other streams flow to Babb Creek through this segment including Long Run and Nickel Run, which are both classified as High Quality Streams.

The smaller treatment system is located at the main entrance to the abandoned underground mine. The treatment pond is 165 feet long by 80 feet wide. The system includes 1,300 tons of limestone making a depth of two feet in the bottom of the pond. Overlaying the limestone is a two-foot compost layer composed of 275 cubic yards of spent mushroom compost amended with 650 tons of limestone and 275 cubic yards of wood chips. A system of perforated pipes is bedded within the lowermost layer of limestone. This serves to collect the water after it has percolated through the compost and limestone layers. The following is a photograph of the constructed system.



Figure 6. Treatment system at the main entry of the Bear Run Mine, Bloss Township, Tioga County.

The secondary entry is the larger of the two mine discharges from the Bear Run Mine. It has greater flow and greater flow variability. The treatment pond is 300 feet long by 150 feet wide. The system is constructed similarly to the other Bear Run treatment system, but with a total of 7,300 tons of limestone, 1,000 cubic yards of spent mushroom compost, and 1,000 cubic yards of wood chips. The system was designed to treat a maximum of 300 gallons/minute with an orifice installed in the inlet that excluded excess flow. Figure 7 is a photograph of the constructed treatment system.



Figure 7. Treatment system at the secondary entry of the Bear Run Mine, Bloss Township, Tioga County.

In October 1999 Pa DEP issued a surface mining permit that allowed removal of a 3000-foot section of an abandoned railroad grade. The section was originally constructed as an elevated trestle. It appears that over time the wooden trestle weakened and fill material was placed under the trestle to support the weight of the trains. The readily available material was coal and coal refuse that was being removed from the mines. Long after the railroad was abandoned, Babb Creek meandered and began eroding the railroad bed and washed large quantities of coal and shale into the stream. Flood events completely cut through the elevated bed which was twenty feet high and fifty feet wide in places. In the Spring of 2000, the project was completed and all the material that was causing siltation in Babb Creek was removed. A total of 10,000 cubic yards of coal and coal refuse were removed and sold as product to a power plant. The area is now stabilized and revegetated.



Figure 8. Before and after photographs of the now reclaimed railroad grade that was being washed into Babb Creek.

TMDL calculations-Sampling Point 4

The TMDL for sampling point 4 consists of a load allocation of the area between sample points 4 and 1 and 2. The load allocation for this stream segment was computed using water-quality sample data collected at point 4. In-stream flow measurements were not available for sample point 4. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 4 is 54.07 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 42 equals the flow of 75.49 cfs (48.8 MGD) at sample point 4.

There is currently no entry for this segment on the Pa 1996 Section 303(d) list for impairment due to pH. Sample data at point 4 shows pH ranging between 4.7 and 6.3; pH will be addressed as part of this TMDL because of the mining impacts. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

The existing and the allowable loading for sample point 4 for all parameters was computed using water quality sample data collected at the point. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample points 1 and 2 were summed and represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at point 4, and was compared to the allowable load at 4 for each parameter, to determine if any further reductions were needed at this point.

An allowable long-term average in-stream concentration was determined at sample point 4 for aluminum, iron, manganese and alkalinity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, five thousand iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Parameter	Measured Sample Data		Allowable	
	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
Al	0.22	87.7	0.22	87.7
Fe	0.11	44.1	0.11	44.1
Mn	0.11	45.4	0.11	45.4
Acidity	3.23	1312.6	1.51	613.7
Alkalinity	13.40	5453.8		

Babb Creek upstream of sample point 4 is adversely affected by AMD and one or more allocations may be necessary at sample point. In an effort to determine if there is a need for any allocations at this point the following procedure was used.

The loading reductions for sample points 1 and 2 were summed to show the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at sample point 4. This value was then compared to the allowable load at sample point 4. Reductions at point 4 are necessary for any parameter that exceeded the allowable load at this point. Table D4 shows a summary of all loads that affect point 4. Table D5 illustrates the necessary reductions at point 4. The results of this analysis show that reductions for acidity are necessary at this point.

Table D4. Summary of All Loads that Affect 4				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Sample Point (1)				
load reduction=	10.6	0.0	0.0	667.5
Sample Point (2)				
load reduction=	0.0	0.0	0.0	0.0

Table D5. Necessary Reductions at Sample Point 4				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at 4	87.7	44.1	45.4	1312.6
Total Load Reduction (Sum of 1& 2)	10.6	0.0	0.0	667.5
Remaining Load (Existing Loads at 4 – TLR Sum)	77.1	44.1	45.4	645.1
Allowable Loads at 4	87.1	44.1	45.4	613.7
Percent Reduction	NA	NA	NA	4.9%
Additional Removal Required at 4	NA	NA	NA	31.4

The flow, calculated at sample point 4 is used for these computations. The TMDL for 4 consists of no load allocations for all of the area upstream of 4 shown in attachment A. The percent reduction was calculated using below equation.

$$\left[1 - \left(\frac{\text{Allowable Loads at 4}}{\text{Remaining Load (Existing Loads at 4 - TLR Sum)}} \right) \right] \times 100 \%$$

No additional loading reductions were necessary for aluminum, iron, or manganese.

Wilson Creek Watershed – Above Sample Point 5

Antrim Mine Complex

The Antrim Mining Complex is located near the village of Antrim in Duncan Township, Tioga County. The coals in the complex are preserved on the hilltop on the northern flank of the Babb Creek Valley along the basinal geologic structure of the Blossburg Syncline. These are similar geologic conditions to the Bear Run and Klondike Mines. Here, the coal lies more than 450 feet above Wilson Creek to the West and Babb Creek which lies to the South. Four coal seams were mined in this mining complex, the Bloss (B), Cushing (C), Morgan (C'), and Seymour (D) coals.

The mines were operated from 1872 until the early 1900's when they were abandoned. Around 1940 the Antrim Coal Co. reopened the Antrim No. 1 Drift but coal removal was limited. The largest underground mine was the Antrim Mine, it contributed the greatest amount of pollution. Other mines included the Backswitch, Cope and Rock Run Mines.

In the late 1970's and through the 1980's the Antrim Mining Company (a different company than the Antrim Mining Co. of the 1940's) conducted surface mining of the coal reserves of the Antrim Mining Complex. Antrim's daylighting operations on the Antrim underground mine complex reaffected most of the mining complex that was originally mined underground. The mining resulted in increased production of acid mine drainage from the Antrim No. 1 and Backswitch discharges. While the Pennsylvania Department of Environmental Protection conducted an investigation of the degradation caused by Antrim Mining and prepared for litigation, Robert W. McCullough Jr. of the Pennsylvania Environmental Defense Foundation (PEDF) filed suit in federal court against Antrim Mining Co.

The investigation and intents of the Department along with the civil suit caused Antrim Mining to propose a negotiated settlement. In December 1991 Antrim Mining entered into a Consent Order and Agreement with PADEP to provide permanent treatment for the two mine discharges. Along with the permanent treatment of the Antrim No. 1 and Backswitch discharges, Antrim was required to: 1) cease strip mining operations and reclaim all its mining sites; 2) establish a Babb Creek Trust Fund with an initial payment of \$25,000, and \$0.25 paid to the trust fund for each ton of waste hauled in to Phoenix Resource's (a sister company of Antrim Mining) landfill; 3) the trust fund would be managed by two representatives from PEDF and one from Antrim Mining; and 4) the Trust Fund monies would be solely used for remediation of acid mine drainage within the Babb Creek Watershed.

James P. Barr and Robert McCullough were appointed by PEDF to be the organization's managers of the trust fund. In addition to them, Neil Hedrick of Antrim Mining is a member of the committee. The fund was instrumental in construction and long-term maintenance of diversion wells in the watershed as well as reclamation of the Klondike Refuse Pile and match money for the numerous passive treatment systems in the watershed.

Antrim Mining's initial treatment system collected the mine water, pumped it to a treatment plant and used hydrated lime for treatment. The plant treated the mine drainage to an average pH of 8. The average flow treated is 2.2 cfs (1000 gpm) and the treated flow is reported to be as

high as 11 cfs (5000 gpm) during high flow periods. The Antrim Mining Treatment Plant has a very significant impact on the water quality of Wilson Creek and Babb Creek. Were it not for the treatment at Antrim, the Babb Creek water quality below Wilson Creek would be severely degraded rather than the current state.

More recently, in 1998 Antrim Mining constructed a new treatment plant that uses a waste lime product and moved the plant location, so that pumping the mine water to the treatment site is not necessary. Antrim Mining's intention was to have a plant that will be more cost efficient to operate. This saved money for Antrim Mining in the short-term. More importantly to Antrim, it significantly decreases the treatment trust fund that Antrim was required to fund. The fund was required by the Commonwealth and was designed to be sufficient money to operate and maintain the treatment system for a minimum period of 50 years. Antrim Mining has no more mining interests and after the treatment system was functioning properly and the treatment trust fund was completely funded the Antrim Mining dissolved the company.



Figure 9. Photograph of the old and new Antrim Treatment Plants, Duncan Township, Tioga County.

In 1998 Phoenix Resources was sold to USA Waste and the landfill is receiving large quantities of waste. This is a source of income for the Babb Creek Trust Fund. The Babb Creek Trust Fund provided additional funds to the Antrim Trust with the intent of creating a fund that would be perpetually funded rather than funded for a 50-year period.

PADEP manages the Antrim Treatment Trust and the Babb Creek is under agreement to operate the treatment plant to the same treatment standards that were required of the Antrim Mining Company when it existed and was regulated under a surface mining permit.

Anna S Mine Complex

The Anna S Mine Complex is located in Morris Township approximately 2 miles north of the town of Morris. The mining complex lies north of Babb Creek and west of Wilson Creek. Mining took place on both flanks of the structural syncline whose axis parallels the main stem of Babb Creek and Lick Creek.

The underground mine was opened in the late 1800's and was abandoned in the late 1930's. Coal was transported across the Wilson Creek Valley to Antrim by means of an elevated cable car system. Later there were some surface mining operations that mined in the 1970's and early 1980's.

There are two main discharges of mine drainage from the mine, these include the main entry of the mine (referred to as Anna S No. 1) and Hunters Drift. Hunters Drift was a drift that was constructed to drain water out of the mine. Two other sources of mine drainage from the mine include a discharge for an abandoned surface mine cut referred to as the Anna S No. 2 discharge and the Mitchell discharge is the last source of acid mine drainage from the mine.



Figure 10. The Anna S No. 1 Discharge of the Anna S Mine Complex, Morris Township, Tioga County.

The Mitchell Mine is a small mine adjacent to the Anna S Mine complex, it has a mine discharge that has very high acidity and metals concentrations. The Babb Creek Watershed Association has plans to construct a diversion well to provide some measure of treatment for the mine water. The mine water is considered by most to be too severe for passive treatment. In addition there is

not sufficient space available for treatment. Funding for the project came from fines levied against a local trucker who was conducting illegal hauling activities. The trucker indicated that he would like a portion of the fines to go toward restoring Babb Creek and DEP was able to direct the funds in that manner.



Figure 11. Hunters Drift, Anna S Mine Complex, Morris Township, Tioga County.

The Babb Creek Watershed Association has applied for a PADEP Growing Greener Grant to treat the remaining three discharges of mine drainage from the mine complex. The treatment design includes passive treatment components designed to add alkalinity and remove dissolved metals from the mine drainage.

The treatment proposed for the combined flow of the Anna S No. 1 and No. 2 discharges, consists of four to five vertical flow treatment systems followed by an extensive constructed wetland and a polishing pond. The multicomponent system will be sized to treat a 90th percentile event, which is the equivalent of 420 gpm. Flows greater than 420 gpm will bypass the passive treatment and mix with the passively treated water prior to being discharged.

The treatment proposed for Hunter's Drift is slightly less rigorous because there is less space available for treatment. The Hunter's Drift treatment system will collect the mine drainage at the discharge point and pipe it to four vertical flow treatment systems. These alkalinity generating systems will be followed by a settling/flushing basin prior to discharge to the receiving stream. Announcement of the successful growing greener grants is anticipated sometime in July 2001. Treatment of the Anna S discharges will have big impact on Wilson Creek and also on the lower end of Babb Creek.

Construction of the Anna S No. 1, Anna S No. 2 and Hunter's Drift treatment systems was initiated in late 2002. Currently, the site has erosion and sedimentation controls for earth moving activities installed and the contractor is clearing stumps and large boulders from the site in preparation for pond construction when the weather is more favorable and the ground can be worked.

TMDL Calculations-Sample Point 5

The TMDL for Wilson Creek consists of a load allocation to all of the area above sample point 5 shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point 5. In-stream flow measurements were not available for sample point 5. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 5 is 23.11 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 5 equals the flow of 32.27 cfs (20.86 MGD) at sample point 5.

There is currently no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point 5 shows pH ranging between 4.7 and 6.4, pH will be addressed as part of this TMDL because of the mining impacts. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

An allowable long-term average in-stream concentration was determined at point 5 for aluminum, iron, manganese and acidity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards. The following table shows the load allocations for this stream segment.

Table D6. Load Allocations at Point 5					
	Measured Sample Data		Allowable		Reduction Identified
Parameter	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
Al	2.69	468.6	0.27	46.2	90%
Fe	0.63	109.9	0.51	89.2	19%
Mn	2.11	367.7	0.51	89.4	76%
Acidity	6.90	1200.4	3.27	568.7	53%
Alkalinity	12.83	2232.7			

A TMDL was not calculated for Sample Point 6 because it is adjacent to sample points 4 and 5. The data collected at sample point 6 is shown in Attachment F.

Babb Creek (upstream of the confluence of Stony Fork Creek with Babb Creek) – Area Between Sample Points 7 and Sample Points 4 and 5

TMDL Calculation-Sample Point 7

The TMDL for sample point 7 consists of a load allocation to all of the area between sample point 7 and sample points 4 and 5 shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point 7. In-stream flow measurements were not available for sample point 7. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 7 is 83.63 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 7 equals the flow of 116.76 cfs (75.47 MGD) at sample point 7.

The existing and the allowable loading for sample point 7 for all parameters were determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample points 1, 2, 4 and 5 were summed and represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at point 7, and was compared to the allowable load at 7 for each parameter, to determine if any further reductions were needed at this point.

There is currently no entry for this segment on the Pa 1996 Section 303(d) list for impairment due to pH. Sample data at point 7 shows pH ranging between 5.9 and 6.4; pH will be addressed as part of this TMDL because of the mining impacts. The objective is to reduce acid loading to the stream, which will in turn raise the pH to the desired range. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

No allowable long-term average in-stream concentration was determined at sample point 7 for aluminum, iron, manganese, or alkalinity.

Table D7. Load Allocations at Point 7				
	Measured Sample Data		Allowable	
Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
Al	0.36	224.1	0.29	181.5
Fe	0.16	102.0	0.16	101.9
Mn	0.45	280.2	0.45	280.2
Acidity	3.49	2194.1	1.46	917.6
Alkalinity	13.63	8578.6		

Babb Creek upstream of sample point 7 is adversely affected by AMD and one or more allocations may be necessary at sample point 7. In an effort to determine if there is a need for any allocations at this point the following procedure was used

The loading reductions for sample points 1, 2, 4 and 5 were summed to show the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at sample point 7. This value was then compared to the allowable load at sample point 7. Reductions at point 7 are necessary for any parameter that exceeded the allowable load at this point. Table D8 shows a summary of all loads that affect point 7. Table D9 illustrates the necessary reductions at point 7. The results of this analysis show that no reductions are necessary at this point.

Table D8. Summary of All Loads that Affect Point 7				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Sum of 1, 2	10.6	0.0	0.0	667.5
Additional Removal Required at 4	NA	NA	NA	31.4
5 load reduction	422.4	20.8	278.3	631.8

Table D9. Necessary Reductions at Sample Point 7				
	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at 7	224.1	102.0	280.2	2194.1
Total Load Reduction (Sum of 1 2, 4 & 5)	433.0	20.8	278.3	1330.6
Remaining Load (Existing Loads at 7– TLR Sum)	NA	81.2	1.9	863.5
Allowable Loads at 7	181.5	101.9	280.2	917.6
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at 7	NA	NA	NA	NA

The flow calculated at sample point 7, is used for these computations. The TMDL for 7 consists of no load allocations to all of the area upstream of 7 shown in Attachment A.

Stony Fork Creek Watershed – Above Sample Point 8

Stony Fork Creek is one of the largest subbasins in the watershed. The Wilson Creek subbasin bounds it on the east and the Pine Creek watershed on the west. Much of the headwaters area of the subbasin has a agriculture and rural residential land use while the lower part of the subbasin is largely forested. State Gamelands and State Forestlands are included in this area. Stony Fork Creek has good water chemistry and habitat that supports a viable aquatic community from its headwaters to its mouth at Babb Creek with the exception of a short segment where Paint Run impacts the stream.

Rattler Mine

The Rattler Mine composes the westernmost coal reserves in the watershed and in the Blossburg Coal Basin. Only the Bloss Seam is present in a limited area and it has been extensively mined both underground and on the surface. It is believed that the underground mine operated from early in the 1900's to 1958. The mining complex was approximately 250 acres in size and the Bloss seam was reported to be 42 inches thick. A northwest-southeast trending wrench fault extends through the Rattler Mine. Following deep mining activities, approximately 150 acres were daylighted around the perimeter of the mine.

Three mine discharges flow from the mine in the direction of the dip of the rocks and discharge along its southwest edge. These acid mine discharges are the most severely polluted of all mine discharges in the watershed. The water from the mine has a pH of 2.6-2.9 and very high metals concentrations. Flow rates are relatively low because of the limited extent of mining activities in the area. The mine drainage flows to Paint Run, a tributary of Stony Fork Creek. Even though the mine drainage is very severe in its nature, Stony Fork Creek is alkaline and absorbs the negative effects of Paint Run.

The Babb Creek Watershed Association applied for and was awarded a Growing Greener Grant to address the pollution of the Rattler Mine. The project will include injection of limestone slurry into the lower portion of the remaining underground mine where water is impounded in the mine. Testing of the mine water showed that it is possible to achieve a sufficiently high pH within the mine workings to precipitate most of the iron and some of the aluminum and have a mine water chemistry that is amenable to passive treatment. A series of passive treatment components will be constructed near the main discharge of mine drainage. These components will include vertical flow treatment ponds to generate alkalinity, settling basins to remove metals, and constructed wetlands for final metals removal. The limestone slurry injection is a new technology that has been successfully implemented on a limited scale in the field. This full-scale application may demonstrate that the technology may have use in other cases of abandoned underground coal mines. Injection of the alkaline material into the mine began during the summer of 2002, but was met with limited results. It was difficult to locate the mine voids without accurate mapping of the mine and where the rooms and passageways excavated underground were limited in size. Difficulties were also encountered in injecting the desired amount of slurry into the borehole before the hole rejected the material. The project will continue through the spring and early summer of 2003.



Figure 12. Photograph of limestone alkaline injection into the abandoned Rattler underground mine to pretreat the mine water prior to passive treatment.

In addition to treatment of the water, the project also included the application of beneficial-use biosolids (treated sewage sludge) as a soil amendment to poorly vegetated areas of the abandoned surface mine. This is a separate project from the Growing Greener Grant, but is being accomplished concurrently. Approximately 90 acres were identified where there was no vegetation or the vegetation was limited to isolated red pines or volunteer birch trees with no

under story vegetation or grasses. In these areas, biosolids were applied at a one-time, mine reclamation application rate. Application rates were calculated based on an analysis of existing soil material and an analysis of the biosolids to insure that no chemical constituent approached a concentration of concern. The rate is approximately five to ten times more conservative than EPA's guidance for biosolids application rates. The material was applied using a large manure spreader pulled behind a tractor. It was then incorporated into the soil using a large plow and disk. Seeding followed using a seed mix recommended by the Pennsylvania Game Commission, the landowner where the project lies. Areas were seeded with clover, trefoil, oats, sorghum, orchard grasses, rye grass, warm season grasses and other grasses and legumes. The project was completed and the Game Commission will monitor and maintain the vegetation. The Game Commission varied the seed mixtures and established food plots to benefit turkeys, grouse, deer, and other game and non-game species.



Figure 13. Surface restoration and revegetation of abandoned surface mine lands at the Rattler Mine in Morris Township, Tioga County.

TMDL Calculations-Sample Point 8

A critical flow condition could not be identified from the data used for this analysis. The unit hydrology method determined flow for this point was used to derive loading values for the TMDL.

The TMDL for Stony Fork Creek consists of a load allocation to all of the area above the sample point 8 shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point 8. In-stream flow measurements were not

available for sample point 8. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 8 is 37.93 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 8 equals the flow of 52.96 cfs (34.23 MGD) at sample point 8.

There is currently no entry for this segment on the Pa Section 303(d) list for impairment due to pH. Sample data at point 8 shows pH ranging between 6.7 and 7.1, pH need not be addressed as part of this TMDL because Stony Fork Creek is net alkaline.

Table D10. Load Allocations at Point 8					
Parameter	Measured Sample Data		Allowable		Reduction Identified
	Conc (mg/l)	Load (lbs/day)	LTA conc (mg/l)	Load (lbs/day)	%
Al	0.22	63.5	0.22	63.5	0%
Fe	0.07	20.8	0.07	20.8	0%
Mn	0.03	8.5	0.03	8.5	0%
Acidity	0.00	0.0	0.0	0.0	0%
Alkalinity	46.00	13132.9			

A TMDL was not calculated for Sample Point 9 because it is adjacent to sample points 7 and 8. The data collected at sample point 9 is shown in Attachment F.

Babb Creek (upstream of the confluence with Pine Creek) – Area Between Sample Point 10 and Sample Points 7 and 8

TMDL Calculation-Sample Point 10

The reductions specified in this TMDL apply at all flow conditions. A critical flow condition could not be identified from the data used for this analysis. The unit hydrology method determined flow for this point was used to derive loading values for the TMDL.

The TMDL for sample point 10 consists of a load allocation to all of the area between sample point 10 and sample points 7 and 8, shown in Attachment A. The load allocation for this stream segment was computed using water-quality sample data collected at point 10. In-stream flow measurements were not available for sample point 10. Flow for this point was estimated using the unit-area hydrology from a known point (USGS Station ID 01548500) on Pine Creek.

The watershed area above sample point 10 is 131.22 square miles. The known flow point on Pine Creek had an average flow of 843.3 cfs, and a watershed area of 604 square miles. This

gives a flow yield of 1.40 cfs/sq.mi. Multiplying the flow yield for the known point times the watershed area above point 10 equals the flow of 183.21 cfs (118.43 MGD) at sample point 10.

There is currently no entry for this segment on the PA 1996 Section 303(d) list for impairment due to pH. Sample data at point 10 shows pH ranging between 6.2 and 6.7; pH need not be addressed as part of this TMDL because this segment is net alkaline.

The existing and the allowable loading for sample point 10 for all parameters were determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from sample points 1, 2, 4, 5, 7 and 8 were summed and represent the upstream load reductions. The upstream load reduction was subtracted from the existing load at point 10, and was compared to the allowable load at 10 for each parameter, to determine if any further reductions were needed at this point.

Table D11. Load Allocations at Point 10				
	Measured Sample Data		Allowable	
Parameter	Conc (mg/l)	Load (lbs/day)	LTAConc (mg/l)	Load (lbs/day)
Al	0.35	341.2	0.27	268.1
Fe	0.17	166.6	0.17	166.5
Mn	0.22	217.2	0.22	217.0
Acidity	0.00	0.0	0.00	0.0
Alkalinity	19.40	19161.2		

Babb Creek upstream of sample point 10 is adversely affected by AMD and one or more allocations may be necessary at sample point 10. In an effort to determine if there is a need for any allocations at this point the following procedure was used.

The loading reductions for sample points 1, 2, 4, 5, 7 and 8 were summed to show the total load that was removed from upstream sources. This value, for each parameter, was then subtracted from the existing load at sample point 10. This value was then compared to the allowable load at sample point 10. Reductions at point 10 are necessary for any parameter that exceeded the allowable load at this point. Table D12 shows a summary of all loads that affect point 10. Table D13 illustrates the necessary reductions at point 10. The results of this analysis show that no reductions are necessary at this point.

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Sum of 1, 2	10.6	0.0	0.0	667.5
Additional Removal Required at 4	NA	NA	NA	31.4
5 load reduction	422.4	20.8	278.3	631.8
Additional Removal Required at 7	NA	NA	NA	NA
8 load reduction	NA	NA	NA	NA

	Al (#/day)	Fe (#/day)	Mn (#/day)	Acidity (#/day)
Existing Loads at 10	341.2	166.6	217.2	0.0
Total Load Reduction (Sum of 1, 2,4,5,7 & 8)	433.0	20.8	278.3	1330.6
Remaining Load (Existing Loads at 7– TLR Sum)	NA	145.9	NA	NA
Allowable Loads at 10	268.1	166.5	217.0	0.0
Percent Reduction	NA	NA	NA	NA
Additional Removal Required at 7	NA	NA	NA	NA

The flow calculated at sample point 10 is used for these computations. The TMDL for 10 consists of no load allocations to all of the area upstream of 10 shown in Attachment A.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Other margins of safety used for this TMDL analysis include the following:

- Effluent variability plays a major role in determining the average value that will meet water-quality criteria over the long-term. The value that provides this variability in our analysis is the standard deviation of the dataset. The simulation results are based on this variability and the existing stream conditions (an uncontrolled system). The general assumption can be made that a controlled system (one that is controlling and stabilizing the pollution load)

would be less variable than an uncontrolled system. This implicitly builds in a margin of safety.

- A MOS is also the fact that the calculations were done with a daily Fe average instead of the 30-day average

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represents all seasons.

Critical Conditions

The reductions specified in this TMDL apply at all flow conditions. A critical flow condition could not be identified from the data used for this analysis.

Attachment E

**Excerpts Justifying Changes Between the 1996,
1998, Draft 2000 and Draft 2002 Section 303(d)
Lists**

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, draft 2000, and Draft 2002 list. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

In the 1996 Section 303(d) narrative, strategies were outlined for changes to the listing process. Suggestions included, but were not limited to, a migration to a Global Information System (GIS), improved monitoring and assessment, and greater public input.

The migration to a GIS was implemented prior to the development of the 1998 Section 303(d) list. As a result of additional sampling and the migration to the GIS some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

1. mileage differences due to recalculation of segment length by the GIS;
2. slight changes in source(s)/cause(s) due to new EPA codes;
3. changes to source(s)/cause(s), and/or miles due to revised assessments;
4. corrections of misnamed streams or streams placed in inappropriate SWP subbasins; and
5. unnamed tributaries no longer identified as such and placed under the named watershed listing.

Prior to 1998, segment lengths were computed using a map wheel and calculator. The segment lengths listed on the 1998 Section 303(d) list were calculated automatically by the GIS (ArcInfo) using a constant projection and map units (meters) for each watershed. Segment lengths originally calculated by using a map wheel and those calculated by the GIS did not always match closely. This was the case even when physical identifiers (e.g., tributary confluence and road crossings) matching the original segment descriptions were used to define segments on digital quad maps. This occurred to some extent with all segments, but was most noticeable in segments with the greatest potential for human errors using a map wheel for calculating the original segment lengths (e.g., long stream segments or entire basins).

The most notable difference between the 1998 and Draft 2000 Section 303(d) lists are the listing of unnamed tributaries in 2000. In 1998, the GIS stream layer was coded to the named stream level so there was no way to identify the unnamed tributary records. As a result, the unnamed tributaries were listed as part of the first downstream named stream. The GIS stream coverage used to generate the 2000 list had the unnamed tributaries coded with the DEP's five-digit stream code. As a result, the unnamed tributary records are now split out as separate records on the 2000 Section 303(d) list. This is the reason for the change in the appearance of the list and the noticeable increase in the number of pages. After due consideration of comments from EPA and PADEP on the Draft 2000 Section 303(d) list, the Draft 2002 Pa Section 303(d) list was written in a manner similar to the 1998 Section 303(d) list.

Attachment F

Water Quality Data Used In TMDL Calculations

Data Table 1 Lick Creek (sample point 1)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/1/00		6.0	10.2	11.2	0.315	0.920	0.224
7/18/00		5.8	9.6	2.0	0.196	0.468	0.251
6/28/00		5.9	9.0	5.2	0.363	0.499	0.264
6/19/00		5.9	9.6	28.0	0.389	0.555	0.246
6/15/00		5.4	8.8	32.0	0.301	0.590	0.235
7/22/99		4.9	9.0	5.6	0.057	0.368	0.208
4/30/98		5.2	8.8	5.8	0.234	0.517	0.236
Avg=	7.39	5.6	9.28	12.82	0.26	0.56	0.23
stdev=				12.09	0.11	0.17	0.02

Data Table 2 Babb Creek (sample point 2)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/1/00		6.5	22.0	0.0	0.02	0.2	0.017
7/18/00		6.4	24.0	0.0	0.103	0.2	0.01
6/19/00		6.8	26.0	0.0	0.690	0.295	0.059
6/15/00		6.5	24.0	0.0	0.353	0.2	0.025
7/22/99		6.4	24.0	0.0	0.02	0.02	0.01
4/30/98		6.3	14.6	0.0	0.175	0.02	0.034
8/5/97		6.3	22.0	0.2	0.028	0.204	0.01
6/25/97		6.4	19.2	0.0	0.039	0.135	0.01
Avg=	14.69	6.5	21.975000	0.025	0.18	0.16	0.02
stdev=				0.07	0.24	0.09	0.02

Data Table 3 Babb Creek above Wilson Creek (sample point 4)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/00		6.0	11.6	0.2	0.047	0.200	0.087
7/18/00		6.2	13.6	0.0	0.073	0.200	0.081
6/29/00		6.0	11.8	0.4	0.180	0.260	0.113
6/28/00		6.3	16.4	0.0	0.095	0.200	0.029
6/15/00		6.2	12.8	20.0	0.168	0.283	0.118
7/22/99		6.4	22.0	0.0	0.137	0.020	0.115
3/24/99		5.7	11.2	2.2	0.060	0.298	0.175
4/30/98		5.7	7.8	3.0	0.107	0.263	0.174
Avg=	48.80	6.1	13.4	3.22	0.11	0.21	0.11
stdev=				6.87	0.05	0.09	0.05

Data Table 4 Wilson Creek (sample point 5)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/00		5.1	8.2	11.8	0.304	1.930	2.400
7/18/00		6.0	13.0	1.8	0.335	2.190	2.050
6/15/00		6.5	24.0	0.0	0.662	2.030	1.650
7/22/99		5.0	10.6	10.6	1.230	5.510	3.010
6/10/99		4.9	9.6	12.4	0.451	2.850	2.450
3/24/99		5.8	11.6	4.8	0.810	1.650	1.120
Avg=	20.86	5.55	12.83	6.90	0.63	2.69	2.11
stdev=				5.40	0.35	1.44	0.66

Data Table 5 Babb Creek above Stony Fork Creek (sample point 7)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/00		6.1	11.0	0.0	0.02	0.200	0.400
7/10/00		6.2	13.8	0.0	0.089	0.342	0.570
6/28/00		6.4	18.8	0.0	0.306	0.399	0.369
6/15/00		6.4	18.4	22.0	0.247	0.520	0.465
7/22/99		5.8	10.4	0.2	0.021	0.200	0.408
6/10/99		6.0	10.6	0.0	0.200	0.200	0.477
3/24/99		6.0	12.4	2.2	0.251	0.631	0.427
Avg=	75.47	6.13	13.63	3.49	0.16	0.36	0.44
stdev=				8.20	0.12	0.17	0.07

Data Table 6 Stony Fork Creek (sample point 8)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/00		7.0	44.0	0.0	0.020	0.200	0.013
7/10/00		7.0	44.0	0.0	0.042	0.200	0.055
6/15/00		6.9	46.0	0.0	0.262	0.312	0.056
7/22/99		7.1	54.0	0.0	0.020	0.200	0.013
6/10/99		6.8	42.0	0.0	0.020	0.200	0.011
Avg=	34.23	6.96	46.00	0.0	0.07	0.22	0.03
stdev=				0	0.11	0.05	0.02

Data Table 7 Babb Creek (sample point 10)							
Date	Flow (MGD)	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/00		6.4	17.4	0.0	0.020	0.200	0.030
6/28/00		6.5	24.0	0.0	0.265	0.326	0.260
6/15/00		6.7	28.0	0.0	0.188	0.374	0.254
7/22/99		6.3	18.0	0.0	0.020	0.200	0.016
6/10/99		6.3	16.2	0.0	0.020	0.200	0.135
3/24/99		6.2	17.0	0.0	0.189	0.421	0.261
4/30/98		6.3	15.2	0.0	0.479	0.697	0.583
Avg=	118.43	6.39	19.40	0.00	0.17	0.34	0.22
stdev=				0.00	0.17	0.18	0.19

Sample point

3

Babb Creek below Lick Creek

Area (square miles): 24.467

Date	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/1/2000	6.3	15.2	0.8	0.260	0.397	0.126
7/18/2000	6.3	18.2	0.0	0.147	0.253	0.115
6/28/2000	6.4	22.0	0.0	0.487	0.2	0.087
6/19/2000	6.7	22.0	0.0	0.631	0.318	0.091
6/15/2000	6.3	16.6	18.4	0.366	0.357	0.125
4/30/1998	6.2	11.6	0.4	0.159	0.228	0.101

Sample point

6

Babb Creek below Wilson Creek

Area (square miles): 77.186

Date	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/2000	6.0	11.0	1.8	0.366	0.973	0.535
7/18/2000	6.1	13.4	0.0	0.162	0.756	0.685
6/28/2000	6.3	17.4	0.0	0.437	0.498	0.344
3/24/1999	5.9	12.2	0.0	0.116	0.392	0.228

Sample point

9

Babb Creek below Stony Fork Creek

Area (square miles): 121.556

Date	pH	Alkalinity (mg/l)	Acidity (mg/l)	Iron (mg/l)	Aluminum (mg/l)	Manganese (mg/l)
8/2/2000	6.1	11.8	0.0	0.023	0.200	0.386
7/10/2000	6.3	16.8	0.0	0.080	0.300	0.520
6/28/2000	6.4	19.8	0.0	0.446	0.516	0.380

Attachment G

Comment and Response

Comment 1: *Introduction*, because in *Table 1* the 1996 Babb Creek listing is for 23 miles and the 1998 and 2000 are for 13.84 miles, a specific explanation is necessary. Also please consider adding 2002 Section 303(d) information to *Table 1*.

Response: See Attachment E. The 2002 Section 303(d) listings have been included in Table 1.

Comment 2: In the *Clean Water Act Requirements* section, please change the third bullet to read that the Section 303(d) list of impaired waters is required every *two* years under the current, applicable regulations.

Response: Change made.

Comment 3: *Basic Steps for Determining a TMDL*, last sentence says Cooks Run instead of Babb Creek.

Response: Correction made.

Comment 4: *TMDL Endpoints*, according to 40 CFR § 130.7(c), TMDLs must “attain and maintain the *applicable* the narrative and numerical,” not acceptable, water quality standards. Please correct.

Response: Correction made.

Comment 5: *Attachment A, Babb Creek Watershed Map*, more features mentioned in Attachment D should be located on the maps. For example, in Attachment D the Arnot #1 Mine description refers to the maps implying location information is shown on the maps; the USGS gage location on Pine Creek should be shown.

Response: Additional maps have been added to Attachment A.

Attachment D, TMDLs by Segment

Comment 6: *Lick Creek Watershed - Above Sample Point 1, Arnot #2*, 1st paragraph, “It appears that under most conditions the receiving stream of this discharge is Johnson Run and eventually the Tioga River.” Verify whether or not the discharge is outside Babb Creek Watershed.

Response: See the paragraph in question. Additional explanation added and yes this does occur.

Comment 7: Fourth paragraph, confirm whether or not the construction took place in the summer of 2001.

Response: Construction took place during the winter of 2001 and spring of 2002.

Comment 8: Fifth paragraph, add a brief description of the ALD treatment system.

Response: Added

Comment 9: *Klondike Mine*, 5th paragraph, the term, “beneficial use materials,” appears to have specific meaning, please define.

Response: Added

Upstream Segment of Babb Creek – Above Sample Point 2, Margin of Safety, an additional MOS is also the fact that the calculations were done with a daily Fe average instead of the 30-day average and should be identified.

Comment 10: *Babb Creek upstream of Wilson Creek – Area Between Sample Point 4 and Sample Points 1 and 2*, 3rd paragraph, identify the railroad grade location, either providing a text description and/or on map.

Response: Added

Comment 11: *Wilson Creek Watershed - Above Sample Point 5, Anna S Mine Complex*, please update the status of the proposed treatment of the Anna S No.1 and No.2 discharge.

Response: updated

Comment 12: *TMDL Calculations*, the map shows stream impairments on Wilson Creek from about Antrim to the confluence with Babb Creek and also the headwaters of Wilson Creek, although apparently not yet listed. The treatment seems to be located between Antrim and Babb Creek, and does not address the impacted headwaters. Unless the headwaters are specifically addressed in this TMDL, they will need to be listed on a future Section 303(d) of impacted waters.

Response: Neither the placement of the treatment between Antrim and Babb Creek nor this TMDL preclude the future placement of additional treatment in the headwaters or any where else in the Wilson Creek watershed as is seemingly implied by this comment. The headwaters of Wilson Creek (stream codes 21739, 21740, 21741, and 21742) are on both the 2000 and 2002 Section 303(d) lists and have been added to Table 1. The headwaters of Wilson Creek are listed for agriculture/siltation and a separate TMDL will be prepared in the future.

Comment 13: *Stony Fork Creek Watershed - Above Sample Point 8, Rattler Mine*, identify the location of Rattler Mine, the term, “beneficial use biosolids,” and whether or not the project recommended by the PA Game Commission was completed.

Response: Mine located on a map in Attachment A. Biosolids are added to a poorly vegetated area of an abandoned mine area and the area seeded. This provides nutrients for vegetation. The Babb Creek Watershed Association was awarded a Growing Greener grant to inject limestone

slurry into the lower portion of the remaining underground mine. This project is in operation at this time, February of 2003.

Comment 14: *TMDL Calculations*, the first paragraph is incorrect as no reductions are specified. It should be noted that West Branch Stony Fork Creek is impaired by siltation caused by agriculture practices.

Response: Corrected. Noted.

Comment 15: *Babb Creek (upstream of the confluence with Pine Creek) – Area Between Sample Point 10 and Sample Points 7 and 8*, same comments as previous sections.

Response: Corrected. Noted.

Comment 16: *Attachment F, Water Quality Data Used in TMDL Calculations*, the data for Sample Points 3, 6, and 9 should be shown.

Response: The data was added.

Comment 17: EPA and PADEP have not yet agreed on the proper implementation of the state's alkalinity standard, PA Title 25 Chapter 93.7, requiring a minimum alkalinity of 20 mg/l as CaCO₃, except where natural conditions are less. EPA interprets the "alkalinity" to mean "total alkalinity" and DEP has not provided evidence to show that DEP interprets "alkalinity" to mean "net alkalinity."

DEP addresses the pH criterion, PA Title 25 Chapter 93.7, by maintaining a net alkalinity equal to or greater than zero, and indicated that this will address the intent of the alkalinity criterion. (Lee McDonnell's September 3, 2002, e-mail to Evelyn MacKnight, Chief, PA/DE Branch.) DEP further states that when data shows upstream waters are not impacted by acid mine drainage (AMD), the average net alkalinity will be maintained.

The scenario not addressed is when the most upstream sample *is* impacted by AMD and the total alkalinity is expected to be less than 20 mg/l, even after treatment and when the net alkalinity is equal to or greater than zero. Therefore, EPA expects the alkalinity to be monitored after the TMDLs are implemented and, if necessary, list the streams for alkalinity and develop TMDLs.

Response: Relisting will occur if monitoring, subsequent to TMDL implementation, shows a waterbody is not meeting alkalinity criteria and, is meeting criteria for previously listed parameters.