Shamokin Creek Watershed TMDL

Prepared for:
Bureau of Watershed Conservation
Pennsylvania Department of Environmental Protection

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In Cooperation with
The Susquehanna River Basin Commission

March 2, 2001

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ACKNOWLEDGEMENTS

The authors of this TMDL document would like to thank Dr. Charles Cravotta, Geochemist with the United States Geological Survey, and Dr. Carl Kirby, Associate Professor and Chair of Geology at Bucknell University, for their assistance in this project. Both Dr. Cravotta and Dr. Kirby shared data from assessments that they had conducted of the Shamokin Creek Watershed, provided invaluable assistance in locating discharges, and were helpful in gathering background information about the watershed.

TMDLs
Shamokin Creek Watershed
Northumberland, Columbia, and Montour Counties, Pennsylvania

INTRODUCTION

This Total Maximum Daily Load (TMDL) calculation has been prepared for segments in the Shamokin Creek Watershed including several subwatersheds (Attachment A). It was done to address the impairments noted in the 1996, 1998, and 2000 Pennsylvania 305(b) reports, required under the Clean Water Act, and covers six segments on the 1996, 1998 and draft 2000 303(d) lists (Table 1). High levels of metals, and in some areas depressed pH, caused these impairments. All impairments resulted from drainage from abandoned coalmines. The TMDL addresses the three primary metals associated with acid mine drainage (iron, manganese, aluminum) and pH.

Table 1. Shamokin Creek Segments Addressed

State Water Plan (SWP) Subbasin: 06-B Lower Central Susquehanna River								
Year	*Miles*	*Segment ID*	*DEP Stream Code*	*Stream Name*	*Designated Use*	*Data Source*	*EPA 305(b) Source Code*	*EPA 305(b) Cause Code*
1996	34.7	7088	18489	Shamokin Creek	WWF	305(b) Report	Resource Extraction	Metals
1998	32.8	7088	18489	Shamokin Creek	WWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals
2000	32.78	No additional assessment data collected		Shamokin Creek				
1996	3.7	7089	18647	Carbon Run	CWF	305(b) Report	Resource Extraction	Metals
1998	3.8	7089	18647	Carbon Run	CWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals
2000	3.8	No additional assessment data was collected		Carbon Run				
1996	3.0	7090	18651	Coal Run	CWF	305(b) Report	Resource Extraction	Metals
1998	4.7	7090	18651	Coal Run	CWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals
2000	4.7	No additional assessment data collected		Coal Run				
1996	1.3	7091	18652	Quaker Run	CWF	305(b) Report	Resource Extraction	Metals
1998	1.29	7091	18652	Quaker Run	CWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals

Table 1. Shamokin Creek Segments Addressed								
State Water Plan (SWP) Subbasin: 06-B Lower Central Susquehanna River								
Year	*Miles*	*Segment ID*	*DEP Stream Code*	*Stream Name*	*Designated Use*	*Data Source*	*EPA 305(b) Source Code*	*EPA 305(b) Cause Code*
2000	1.29	No additional assessment data collected		Quaker Run				
1996	1.6	7092	18655	Locust Creek	CWF	305(b) Report	Resource Extraction	Metals
1998	1.69	7092	18655	Locust Creek	CWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals
2000	1.69	No additional assessment data collected		Locust Creek				
1996	4.6	Not placed on GIS.	18657	North Branch Shamokin Creek	CWF	305(b) Report	Resource Extraction	Metals
1998	4.6	On Section C of list.	18657	North Branch Shamokin Creek	CWF	Surface Water Monitoring Program	Abandoned Mine Drainage	Metals
2000	Not on list			North Branch Shamokin Creek				
Not currently on 303(d) list				Buck Run Watershed	CWF	USGS Data	Abandoned Mine Drainage	Metals

WWF = Warm Water Fishery
CWF = Cold Water Fishery

DIRECTIONS TO THE SHAMOKIN CREEK WATERSHED

Shamokin Creek is a 137-square-mile watershed located in eastern Northumberland and western Columbia Counties, Pennsylvania (Attachment A). It is located approximately 55 miles north of Harrisburg, Pennsylvania, and contains the towns of Sunbury, Shamokin, and Mt.Carmel. It can be accessed by driving Routes 11&15 or Route 147 north from the Harrisburg area. State Route 61 parallels the mainstem for much of its length.

SEGMENTS ADDRESSED IN THIS TMDL

There are numerous active mining operations in the watershed (Attachment B); however, none of them produce a discharge. All of the discharges in the watershed are from abandoned mines and will be treated as nonpoint sources. The distinction between nonpoint 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 nonpoint source. Each segment on the 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.

Stream segments evaluated in this TMDL have different use designations. The designations for these segments are shown in Table 1 and can be found in Pennsylvania Chapter 25, Chapter 93.

WATERSHED BACKGROUND

Shamokin Creek has a long history of mining in the Anthracite region. Today, anthracite coal mining, once the mainstay of watershed economy, continues, but at a lesser rate. The watershed headwaters area of about 51.5 square miles situated south of the crest of Big Mountain is underlain by a portion of the Western Middle Field. At peak production in 1917, the watershed contributed approximately 6,200,000 tons of coal annually through the efforts of 4,400 men (Gannett Fleming Corddry and Carpenter 1972). Although significant amounts of coal remain, mining is not expected to increase substantially in the near future. Past mining has flooded many deep mines leaving the remaining coal in now inactive major underground mines.

Conglomerates, sandstones, and shales comprise the major watershed rock types, and significant amounts of coal in 15 persistent mineable beds are also found. An additional 19 locally occurring veins of coal have been discovered in this area. Virtually all these 34 coal veins have been deep or strip-mined to some extent (Gannett Fleming Corddry and Carpenter 1972).

The methods used for deep mining in the watershed were largely a function of the orientation of the coal veins, which pitch steeply as deep as 2,600 feet beneath the ground surface from their outcrops along watershed ridges (Gannett Fleming Corddry and Carpenter 1972). Slope entries were driven down the steeply pitching veins for a few hundred feet where tunnels were driven through intervening rock to intercept other coal veins (Gannett Fleming Corddry and Carpenter 1972). Several veins were mined from that level to the ground surface through those tunnels and slopes. Where mining was extended too close to the ground surface, subsidence into the underlying voids occurred. When the mineable coal had been removed from that area, the slopes were extended to deeper levels where the same procedures were repeated (Gannett Fleming Corddry and Carpenter 1972). In some instances shafts were constructed at strategic places throughout the rock. As deep mining was extended throughout the area, a system of interconnected slopes, shafts, and rock tunnels was formed. Barriers of unmined coal, called barrier pillars, were left between mines being developed by different owners. Thus, originally each mine had its own system of shafts, slopes, and rock tunnels connecting the veins being mined (Gannett Fleming Corddry and Carpenter 1972).

As deep mining developed and continued in the various mines, surface and ground water were encountered. This water flowed down the mined veins to the levels being worked. It became necessary to pump the water to the surface. As mining progressed to even deeper levels, more water was intercepted. Eventually the mine operators established pump relay stations to remove water in stages from the deepest levels (Ash *et al*. 1950; Gannett Fleming Corddry and Carpenter 1972). As a result of this pumping, costs of mining and mine dewatering increased as mining progressed to deeper levels. Some mine operators eventually decided to discontinue mining because of increased costs, the depressed market for coal, and other reasons. These discontinued mines began to fill with water (Ash *et al.* 1950).

As the large mine operators discontinued mining, independent miners opened small operations within the large mines to recover remaining available coal. In some instances, coal left in barrier pillars was removed, thus allowing mines and their waters to come in contact with one another. In addition, coal left as ground support by the large mine operators was removed, causing more surface subsidence and creating additional locations through which surface water could enter the mine workings. Vast underground pools have formed in these mines since water could flow from one mine to another through various interconnections. These pools have found relief to surface streams through openings in the ground surface and old mining structures (slope and shaft openings, etc.).

Historical records indicate that in certain areas along the perimeter of the watershed headwaters areas, precipitation (through infiltration into the mine pools) is conveyed both into and out of the watershed. This condition results from deep mine workings extending under the watershed divide. In a 1972 study done by Gannett Fleming Corddry and Carpenter, water in the Shamokin Creek Watershed was determined to be discharging into Mahanoy Creek through the Douteyville, Helfenstein, Locust Gap, and Centralia Discharges. It is disputed if all of these discharges are still actively draining mine pools from Shamokin Creek into Mahanoy Creek. The Douteyville Tunnel, one of the pathways between the two watersheds, has historically discharged water from the Shamokin Creek Watershed. However, it is unknown if this tunnel continues to deliver drainage to the Mahanoy Creek Watershed. According to the Gannett Fleming Corddry Carpenter report, drainage from the Mahanoy Creek Watershed is reported to flow into connected mine workings to become a part of the overflow from the Henry Clay Stirling Discharge. More study would be necessary to determine the current status of interconnections through mine workings between the two watersheds.

Because of past inadequate restoration, abandoned strip mines serve as catch basins, which collect precipitation, surface runoff, and communicate with groundwater (Gannett Fleming Corddry and Carpenter 1972). Considerable volumes of water so collected enter underlying deep mine workings into which the strip mines have cut through direct contact with mine workings or through fissures in the intervening rock. Partial restoration and sedimentation within portions of some strip mines allow some water to collect in the pits from which overflows to adjacent surface streams sometimes occur, as is the case with the Excelsior Strip Pit Overflow. In certain watershed areas, almost all water that would flow on the surface as stream flow has been intercepted by surface mines and interconnected deep mines. Water collected in this way comes in contact with acid-producing materials in the mines before being discharged as mine drainage to streams.

Little or no aquatic life associated with unpolluted streams exists in the watershed headwaters area. Carbon Run, one of the AMD-impacted tributaries to Shamokin Creek, was found to contain only one fish species, *Semotilis atramaculatus*, the creek chub, in an ecological survey of the stream conducted by the USGS in October 1999. The North Branch Shamokin Creek and Quaker Run were found to contain no fish in the survey. Several tributary streams in Shamokin Creek's middle and lower reaches, including Trout Run, Buddys Run, Millers Run, Lick Creek, and those locally known as Kulps Run, Sunnyside Run, and Elysburg Run have historically supported healthy aquatic communities (Gannett Fleming Corddry and Carpenter 1972). Shamokin Creek's mainstem does not support such aquatic life above its confluence with Carbon Run in Shamokin. Shamokin Creek supports six species of fish (spotfin shiner, creek chub, fallfish, white sucker, brown bullhead, pumpkinseed) downstream of the USGS near SC6 and eleven species of fish (spotfin shiner, fallfish, white sucker, gizzard shad, spottail shiner, Northern hog sucker, rockbass, green sunfish, green sunfish hybrid, pumpkinseed, smallmouth bass) near the mouth in Sunbury. It is assumed that some of the fish community members migrate into and out of Shamokin Creek according to prevailing water quality. According to the Pennsylvania Fish and Boat Commission, Little Shamokin Creek is the only stream in the watershed that is stocked. The North Branch of Shamokin Creek, Quaker Run, Coal Run, and Carbon Run all are not stocked by the Fish and Boat Commission due to either small size or pollution. A sportsman's club supports a small hatchery operation on Trout Run, a tributary not impaired by AMD. In areas of heavy deposition of metals onto the streambed (Quaker Run, North Branch Shamokin Creek, Carbon Run, Coal Run, and in parts of the mainstem), conditions are inhospitable for macroinvertebrate life. Large areas of the headwaters are assumed to support little, if any, macroinvertebrate life based on the coating of the bottom surfaces with metals.

State Game Land No. 165 is located primarily on the south side but extends onto the north side of Little Mountain a few miles west of Shamokin. The area on the north side of Little Mountain is located within the watershed, while the remainder lies in the Zerbe Run drainage area, part of the Mahanoy Creek Watershed. This 3,314-acre tract provides considerable hunting for both small and large game.

Abandoned mine drainage is the most obvious source of pollution in the upper section of the Shamokin Creek Watershed, producing biological impairment miles downstream from the source. There are other concerns in the watershed, however. The first of these concerns is sewage. It is common in areas of Pennsylvania where AMD has significantly impaired streams for problems from wildcat sewage and malfunctioning septic tanks to be masked. The USGS collected bacteriological data from select locations during their assessment of the watershed that may be useful in locating problem areas for sewage. The second concern is agricultural impairment. Most of the land use in the lower portion of the Shamokin Creek Watershed is for agriculture. The watershed has not yet been assessed using the Pa. DEP Unassessed Waters Protocol; however, it is anticipated that when the area is assessed, streams in the lower section of the watershed will show impairment due to nutrients, sediment, and low levels of dissolved oxygen. The final concern is water management after reclamation. Stream channels in some areas of the watershed, such as Shamokin Creek and Butternut Creek in Mount Carmel, have experienced little flow other than stormwater for many years due to extensive mining activities that have altered the natural hydrology of the area. One of the probable effects of remediation activities would be the return of normal hydrologic patterns to the watershed (water would flow in the stream channels rather than be intercepted and routed into underground mine pools). However, because of the current state of many of the channels, this increased flow could cause the likelihood of flooding of areas in the natural floodplain to increase. One project in Mount Carmel will widen and deepen the existing channel, reinforce man-made sections of the channel to withstand larger flows, and improve the existing stormwater delivery network. Many other similar projects may be necessary to handle the increased stream flow as reclamation is accomplished in the watershed.

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 acceptable 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, most of the TMDL's component makeup will be load allocations 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 daily concentrations are expected to meet water quality criteria (established by the Commonwealth of Pennsylvania in Title 25, Chapter 93) 99 percent of the time. Pennsylvania Title 25, Chapter 93.5(b) specifies that a minimum 99 percent level of protection is required. Most metals criteria evaluated in these TMDLs are specified as total recoverable. Pennsylvania does have a dissolved criterion for iron, which will be used to evaluate data from points with only dissolved iron data.

Table 2. Applicable Water Quality Criteria

Parameter	*Criterion Value (mg/l)*	*Duration*	*Total Recoverable/ Dissolved*
Iron (Fe)	1.50 0.3	1 day average Maximum	Total Recoverable Dissolved
Manganese (Mn)	1.00	Maximum	Total Recoverable
Aluminum (Al) *	0.1 of the 96 hour LC_{50} 0.75	Maximum One hour	Total Recoverable
pH **	6 – 9	At all times	NA

* This TMDL was developed using the value of 0.75 mg/l as the instream criterion for aluminum. This is the U.S. Environmental Protection Agency (USEPA) national acute fish and aquatic life criterion for aluminum. Pennsylvania's current aluminum criterion is 0.1 mg/l of the 96 hour LC-50 (the concentration of aluminum in test waters that is lethal to 50 percent of the test organisms during continuous exposure for 96 hours) and is contained in Pennsylvania Title 25, Chapter 93. The U.S. EPA national criteria were used because the Pa. DEP has recommended adopting the U.S. EPA criterion and is awaiting its final promulgation.

** According to research conducted by the Pa. DEP, at pH = 6.0 the net alkalinity (alkalinity-acidity) of a stream has been found to be zero (Attachment C). Therefore, the water quality criteria for pH will vary based on the instream alkalinity at that site with a minimum net alkalinity of zero being maintained. 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).

COMPUTATIONAL 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 point or nonpoint source discharges. For the purposes of these analyses, point source discharges are defined as discharges that are permitted or have a responsible party. Nonpoint sources are then any pollution sources that are not considered point sources.

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).

Analyses of available data for point SC6 for metals indicate there is no single critical flow condition for pollutant sources, and, further, there is no significant correlation between source flows and pollutant concentrations (Table 3). The available data for the other points in this TMDL did not have enough paired flow/parameter data to calculate correlations.

Table 3. Correlation Between Metals and Flow for Point SC6

Parameter	*R-Squared*
Iron	0.4266
Manganese	0.0666
Aluminum	0.2962

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 of 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 are lognormally distributed. Each pollutant source was evaluated separately using @Risk[1] by performing 5,000 iterations to determine any required percent reduction so that water quality criteria will be met instream at least 99 percent of the time. For each iteration, the required percent reductions are:

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

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

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

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

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:

$$LTA = Mean * (1 - PR_{99}) \quad \text{where,} \quad (2)$$

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. This 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 were the average flows. Where data were insufficient to determine a source flow frequency distribution, the average flow from unit-area hydrology was used.

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

Where a stream or stream segment is listed on the 303(d) list for pH impairment, the evaluation is the same as that discussed above. The pH method is fully explained in Attachment C. Information for the TMDL analyses performed using the methodology described above is presented in the TMDLs by segment section of this report. Unit-area hydrology calculations are presented in the hydrology section of this report. In addition, 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 D.

HYDROLOGY

Data for sites SC1, SC2, SC3, SC5, and SC7 did not include measurements of flow when they were taken. Flow determinations were made at these points using SC6 as the basis for computing flow in upper section of the watershed (SC6 is located near a USGS stream gage which monitored stream flow from 1939 to 1993). ArcView v.3.2 was used to delineate the watersheds and determine watershed areas upstream of these points and SC6. The flow at SC6 and the watershed areas upstream of these points and SC6 were used to compute the flow at the points using the following equation:

$$\frac{\text{Flow Point X}}{\text{Watershed Area Point X}} = \frac{\text{Flow SC6}}{\text{Watershed Area SC6}} \qquad (3)$$

Table 4. Flow Determination for Leading Points in the Shamokin Creek Watershed

Public Identification	*Average Flow (mgd)**	*Determination Method*	*Number of Samples*	*Date Range*
SC1	11.51	Unit-area Method		
SC2	26.80	Unit-area Method		
SC3	38.38	Unit-area Method		
SC4	40.06	Unit-area Method		
SC5	45.96	Unit-area Method		
SC6	55.32	Average of Available Flow Data	19,663	1938-1993
SC7	67.20	Unit-area Method		
SC8	82.87	Average of Available Flow Data	4	1998-2000
NB1	3.05	Average of Available Flow Data	12	1989-2000
LC1	0.295	Average of Available Flow Data	4	1998-2000
QR1	8.84	Average of Available Flow Data	6	1998-2000
CLR1	0.474	Average of Available Flow Data	3	1998-2000
CAR1	5.52	Average of Available Flow Data	5	1998-2000
Scott Ridge Mine Tunnel	3.91	Average of Available Flow Data	9	1989-2000
Colbert Mine Breach	0.987	Average of Available Flow Data	4	1975-2000
Maysville Mine Borehole	1.60	Average of Available Flow Data	5	1975-2000
Excelsior Strip Pit Overflow	6.15	Average of Available Flow Data	5	1975-2000
Big Mountain Slope	1.50	Average of Available Flow Data	5	1975-2000
Corbin Water Level	0.829	Average of Available Flow Data	5	1975-2000
Cameron Drift	1.43	Average of Available Flow Data	5	1975-2000
Cameron Air Shaft	2.06	Average of Available Flow Data	5	1975-2000
Royal Oak	0.0	Average of Available Flow Data	2	1975-2000
Mid Valley	2.76 (measured at discharge)	Average of Available Flow Data	5	1975-2000
Henry Clay Stirling Slope	4.63	Average of Available Flow Data	4	1975-2000

*mgd = million gallons per day

TMDLS BY SEGMENT

This TMDL document will address the eleven largest discharges in the Shamokin Creek Watershed (determined by either loads, flows, or concentration data) although over 55 discharge points have been identified through assessments conducted by Bucknell University and the USGS. These eleven discharges, historically, have accounted for over 90% of all pollutant loads in the watershed (Gannett Fleming Corddry and Carpenter 1972). Due to the large cost of remediation activities, it was the professional judgment of the authors to allocate to these eleven discharges only because they constitute such a large percentage of the pollutant loads in the watershed.

Mid Valley Discharge

The Mid Valley Discharge receives drainage from the Mid Valley Colliery. According to historical reports, 50 percent of the flow from the Mid Valley Discharge is lost by infiltration into a mine pool with a discharge in the neighboring Mahanoy Creek Watershed (Gannett Fleming Corddry and Carpenter 1972). In addition, flow is also lost by infiltration into another mine pool reappearing in the Scott Ridge Mine Tunnel Discharge in the Quaker Run subwatershed (Gannett Fleming Corddry and Carpenter 1972).

The TMDL for the Mid Valley Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Mid Valley Discharge (2.76 mgd).

Paired data were available for dissolved metals concentrations but not for total metals concentrations for the Mid Valley Discharge. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

An allowable long-term average instream concentration was determined at the Mid Valley Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 5 shows the load allocation for this stream segment.

Table 5. Reductions for the Mid Valley Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Mid Valley Discharge	**Instream monitoring point located at Mid Valley Discharge**					
	Fe	11.43	263.1	0.09	2.1	99.2
	Mn	2.19	50.4	0.94	21.6	57
	Al	4.21	96.9	0.59	13.6	86
	Acidity	113.25	2606.8	0	0	100
	Alkalinity	0	0			

The TMDL for the Mid Valley Discharge requires that a load allocation be made for the discharge for total iron, total manganese, total aluminum, and acidity.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

North Branch Shamokin Creek

The TMDL study area associated with this point begins at the mouth of the North Branch Shamokin Creek Subwatershed and extends upstream, covering the entire subwatershed except the Mid Valley Discharge. The entire area draining to this point is approximately 5.7 square miles and has been extensively affected by the Mid Valley Discharge. This watershed also receives overland flow from the Marion Heights Borough and the Village of Strong.

The TMDL for the North Branch Shamokin Creek consists of a load allocation to all of the watershed area above NB1, except the Mid Valley Discharge (Attachment A). Addressing the mining impacts for this segment addresses the impairment for the segment. An instream flow measurement was available for point NB1 (3.05 mgd).

An allowable long-term average instream concentration was determined at point NB1 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 6 shows the load allocations for this stream segment.

Table 6. Long-Term Average (LTA) Concentrations for North Branch Shamokin Creek Above NB1					
Station	*Parameter*	*Measured Sample Data*		*Allowable*	
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*
NB1	**Instream monitoring point located at NB1**				
	Fe	9.74	247.8	0.39	9.9
	Mn	2.72	69.2	0.65	16.5
	Al	5.66	144.0	0.11	2.8
	Acidity	81.88	2082.8	0.25	6.4
	Alkalinity	1.54	39.2		

The loading reductions for upstream points were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point NB1. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 7 shows a summary of loads that affect NB1. Table 8 illustrates the necessary reductions at NB1.

Table 7. Summary of All Loads the Affect NB1				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Mid Valley Discharge				
Existing Load	263.1	50.4	96.9	2606.8
Allowable Load	2.1	21.6	13.6	0
Load Reduction	261.0	28.8	83.3	2606.8

Table 8. Necessary Reductions at NB1				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at NB1	247.8	69.2	144.0	2082.8
Total Load Reduction (Mid Valley)	261.0	28.8	83.3	2606.8
Remaining Load	0	40.4	60.7	0
Allowable Load at NB1	9.9	16.5	2.8	6.4
Percent Reduction	0	59	96	0

The TMDL for point NB1 requires that a load allocation be made for all areas of North Branch Shamokin Creek above NB1 for total manganese and total aluminum.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between NB1 and SC1

The TMDL study area associated with this point begins above the confluence of Shamokin Creek and Locust Creek and extends upstream to the confluence of Shamokin Creek and the North Branch Shamokin Creek, excluding the watershed of the North Branch Shamokin Creek. The Borough of Mount Carmel lies in this reach of Shamokin Creek.

The Pa. DEP Bureau of Waterways Engineering is evaluating a $13.85 million dollar project in Mount Carmel Borough and Mount Carmel Township. The project will be designed to protect 270 buildings on Shamokin and Buttnernut Creeks in the flood plain of a 100-year flood event (Winey 1999). The project will be built assuming that all mined areas upstream of Mount Carmel on Shamokin Creek would be totally reclaimed. This reclamation would prevent water in Shamokin Creek presently from infiltrating into mine pools. Should the reclamation occur, the amount of water traveling in the channel would increase and floods of the 100-year magnitude could be experienced (Winey 1999). However, the project will widen and deepen the existing channels, replace worn bridges and box culverts, and engineer the channel to reduce the chance of flooding to the areas located in the floodplain and prevent flooding from occurring.

Sample data for point SC1 lack pH data. The 99th percentile acidity concentration determined by Monte Carlo analysis showed SC1 to be net acidic (21.69 mg/l acidity compared to 15.60 mg/l alkalinity). Therefore, reductions in acidity were taken at point SC1. The method and rationale for addressing pH is contained in Attachment C.

Fewer aluminum data than were necessary for Monte Carlo analysis were available for point SC1 (4); however, it is assumed that BMPs used to remove iron and manganese from discharge waters would also reduce the concentration of aluminum present.

The TMDL for point SC1 consists of a load allocation to all of the watershed area upstream of SC1, excluding the North Branch Shamokin Creek (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement was calculated using the unit-area method for point SC1 (11.51 mgd).

An allowable long-term average instream concentration was determined at point SC1 for iron, manganese, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 9 shows the load allocations for this stream segment.

Table 9. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC1 and NB1

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
SC1	**Instream monitoring point located at SC1**				
	Fe	1.32	126.7	0.42	40.3
	Mn	0.26	25.0	0.26	25.0
	Acidity	3.00	288.0	2.10	201.6
	Alkalinity	15.60	1497.5		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC1. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 10 shows a summary of loads that affect SC1. Table 11 illustrates the necessary reductions at SC1.

Table 10. Summary of All Loads the Affect SC1

	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
North Branch Shamokin Creek				
Existing Load	247.8	69.2	144.0	2082.8
Allowable Load	9.9	16.5	2.8	6.4
Load Reduction	237.9	52.7	141.2	2076.4

Table 11. Necessary Reductions at SC1				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC1	126.7	25.0	-	288.0
Total Load Reduction (North Branch)	237.9	52.7	141.2	2076.4
Remaining Load	0	0	-	0
Allowable Load at SC1	40.3	25.0	-	201.6
Percent Reduction	0	0	-	0

The TMDL for point SC1 does not require that load allocations be made for any parameters above SC1.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to derive loading values for the TMDL.

Locust Creek

The Locust Creek subwatershed joins with Shamokin Creek downstream of point SC1. Point LC1 is located at the mouth of Locust Creek. Locust Creek is an intermittent stream due to the effects mining activities have had on its hydrological regime. All surface water is lost into the mine pool, leaving a dry channel. Water is present and flowing in Locust Creek only when hydrologic conditions are favorable for water to be present in the channel (after a storm event, in the spring, etc.). Monte Carlo analysis was not conducted for point LC1 because there were fewer data points than necessary (4): however, loads for point SC2 will be allocated to all areas of mainstem of Shamokin Creek and the Locust Creek subwatershed.

Excelsior Mine Strip Pit Overflow Discharge

The Excelsior Mine Strip Pit Overflow Discharge receives drainage from the Reliance, Alaska, Enterprise and Excelsior-Corbin Collieries. It is one of the largest discharges in the Shamokin Creek Watershed in terms of volume, almost doubling the volume of Shamokin Creek at their confluence.

The TMDL for the Excelsior Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Excelsior Discharge (6.15 mgd).

An allowable long-term average instream concentration was determined at the Excelsior Mine Strip Pit Overflow Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 12 shows the load allocations for this stream segment.

Table 12. Reductions for Excelsior Discharge

Station	*Parameter*	*Measured Sample Data*		*Allowable*		*Reduction Identified*
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*	*Percent*
Excelsior Discharge	**Instream monitoring point located at Excelsior Discharge**					
	Fe	21.25	1089.9	0.21	10.8	99
	Mn	2.80	143.6	0.62	31.8	78
	Al	1.48	75.9	0.31	15.9	79
	Acidity	59.52	3052.8	1.78	91.3	97
	Alkalinity	18.17	932.0			

The TMDL for the Excelsior Discharge requires that a load allocation be made for the discharge for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Corbin Water Level Tunnel Discharge

The Corbin Water Level Discharge drains the Excelsior-Corbin Colliery. The original drainage path of the discharge was changed due to blockage of a culvert under State Route 901 by sludge material; however, the discharge no longer drains in this direction. It flows into Shamokin Creek upstream of its confluence with Quaker Run.

Paired data were available for dissolved metals concentrations but not for total metals concentrations for the Corbin Water Level Discharge. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

The TMDL for the Corbin Water Level Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Corbin Water Level Discharge (0.829 mgd).

An allowable long-term average instream concentration was determined at the Corbin Water Level Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 13 shows the load allocations for this discharge.

Table 13. Reductions for Corbin Water Level Tunnel Discharge						
Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Corbin Discharge	**Instream monitoring point located at Corbin Discharge**					
	Fe	40.8	282.1	0	0	100
	Mn	4.71	32.6	0.85	5.9	82
	Al	8.23	56.9	0.74	5.1	91
	Acidity	180.25	1246.2	0	0	100
	Alkalinity	0	0			

The TMDL for the Corbin Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Scott Ridge Mine Tunnel Discharge

The Scott Ridge Mine Tunnel Discharge receives drainage from the Morris Ridge, Sayre, Stuartsville, Sioux, Richards, Greenough, Pennsylvania, Scott and Natalie Collieries. It is located approximately 1.2 miles upstream of the mouth of Quaker Run and drains into a tributary locally known as Dark Run. The discharge comes to the surface through two different openings; however, it has been determined that both openings drain water from the same source.

Sample data for the Scott Ridge Mine Tunnel Discharge show pH to be between 5.30 and 6.50, with an average pH of 6.1. The 99th percentile acidity concentration determined by Monte Carlo analysis shows the Scott Ridge Mine Tunnel Discharge to be net acidic (153.68 mg/l acidity compared to 38.15 mg/l alkalinity). Therefore, reductions in acidity were taken for the Scott Ridge Mine Tunnel Discharge. The method and rationale for addressing pH is contained in Attachment C.

The TMDL for the Scott Ridge Mine Tunnel Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Scott Ridge Mine Tunnel Discharge (3.91 mgd).

An allowable long-term average instream concentration was determined at the Scott Ridge Mine Tunnel Discharge for iron, manganese, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 14 shows the load allocations for this stream segment.

Table 14. Reductions for the Scott Ridge Mine Tunnel Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Scott Ridge Discharge	**Instream monitoring point located at Scott Ridge Discharge**					
	Fe	25.88	843.9	0.52	17.0	98
	Mn	3.88	126.5	0.66	21.5	83
	Al	1.53	49.9	-	-	-
	Acidity	36.89	1203.0	8.49	276.9	77
	Alkalinity	38.15	1244.0			

The TMDL for the Scott Ridge Mine Tunnel Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Colbert Mine Breach Discharge

The Colbert Mine Breach Discharge receives drainage from the Morris Ridge, Sayre, Stuartsville, Sioux, Richards, Greenough, Pennsylvania, Scott and Natalie Collieries. It is located approximately 1.0 mile upstream of the mouth of Quaker Run and drains directly into Dark Run.

Paired data were available for dissolved metals concentrations but not for total metals concentrations for the Colbert Mine Breach Discharge. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

The TMDL for the Colbert Mine Breach Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Colbert Mine Breach Discharge (0.987 mgd).

An allowable long-term average instream concentration was determined at the Colbert Mine Breach Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 15 shows the load allocations for this stream segment.

Table 15. Reductions for the Colbert Mine Breach Discharge						
Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Colbert Discharge	**Instream monitoring point located at Colbert Discharge**					
	Fe	27.85	229.2	0.17	1.4	99.4
	Mn	3.70	30.5	0.92	7.6	75
	Al	0.12	1.0	0.12	1.0	0
	Acidity	100.5	827.3	7.04	58.0	93
	Alkalinity	31.0	255.2			

The TMDL for the Colbert Mine Breach Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, and acidity.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Maysville Mine Borehole Discharge

The Maysville Mine Borehole Discharge receives drainage from the Maysville Colliery and is located approximately 0.3 miles upstream of the mouth of Quaker Run. It emerges from a bank and enters directly into Quaker Run.

Sample data for the Maysville Mine Borehole Discharge show pH to range from 6.00 to 6.40 with an average pH of 6.20. Therefore, reductions in acidity were not taken for the Maysville

Mine Borehole Discharge because it is meeting the pH criteria of between 6.0 and 9.0. The method and rationale for addressing pH is contained in Attachment C.

The TMDL for the Maysville Mine Borehole Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Maysville Mine Borehole Discharge (1.60 mgd).

Paired data were available for dissolved metals concentrations but not for total metals concentrations for the Maysville Mine Borehole Discharge. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

An allowable long-term average instream concentration was determined at the Maysville Mine Borehole Discharge for iron, manganese, and aluminum. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 16 shows the load allocations for this segment.

Table 16. Reductions for the Maysville Mine Borehole Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Maysville Discharge	**Instream monitoring point located at Maysville Discharge**					
	Fe	21.45	286.2	0.17	2.3	99.2
	Mn	2.78	37.1	0.92	12.3	67
	Al	0.11	1.5	0.11	1.5	0
	Acidity	106.0	1414.5	NA	NA	NA
	Alkalinity	109.25	1457.8			

The TMDL for the Maysville Mine Borehole Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Quaker Run Above QR1

The TMDL study area associated with this point begins at the mouth of Quaker Run, extends upstream and covers the entire subwatershed. The entire area draining to this point is approximately 3.7 square miles and has been extensively affected by abandoned and active mining. Quaker Run is near the Boroughs of Kulpmont and Marion Heights, with the Kulpmont Wastewater Treatment Plant discharging into Quaker Run. A tributary locally called Dark Run is made primarily of discharge waters from the Scott Ridge Mine Tunnel Discharge and the Colbert Mine Breach Discharge (although Dark Run does flow upstream of the discharges). One other discharge, the Maysville Mine Borehole Discharge, drains into Quaker Run in its lower reaches. The majority of the water flowing in Quaker Run comes from these three discharges.

Sample data for point QR1 show pH ranging from 6.30 to 6.80 with an average pH of 6.61. Therefore, reductions in acidity were not taken for point QR1 because it is meeting the pH criteria of between 6.0 and 9.0. The method and rationale for addressing pH is contained in Attachment C.

Paired data were available for dissolved metals concentrations but not for total metals concentrations for QR1. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

The TMDL for point QR1 consists of a load allocation to all areas of Quaker Run upstream of QR1 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement was available for point QR1 (8.84 mgd).

An allowable long-term average instream concentration was determined at point QR1 for iron, manganese, and aluminum. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 17 shows the load allocations for this stream segment.

Table 17. Long-Term Average (LTA) Concentrations for Quaker Run Above QR1

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
QR1	**Instream monitoring point located at QR1**				
	Fe	16.05	1183.3	0.13	9.6
	Mn	3.13	230.8	0.72	53.1
	Al	0.14	10.4	0.14	10.3
	Acidity	11.50	847.8	NA	NA
	Alkalinity	22.37	1649.2		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point QR1. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 18 shows a summary of loads that affect QR1. Table 19 illustrates the necessary reductions at QR1.

Table 18. Summary of All Loads That Affect QR1			
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*
Scott Ridge Mine Tunnel			
Existing Load	843.9	126.5	49.9
Allowable Load	17.0	21.5	-
Load Reduction	826.9	105.0	-
Colbert Mine Breach			
Existing Load	229.2	30.5	1.0
Allowable Load	1.4	7.6	1.0
Load Reduction	227.8	22.9	0
Maysville Mine Borehole			
Existing Load	286.2	37.1	1.5
Allowable Load	2.3	12.3	1.5
Load Reduction	283.9	24.8	0

Table 19. Necessary Reductions at QR1			
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*
Existing Loads at QR1	1183.3	230.8	10.4
Total Load Reduction (Scott, Colbert, Maysville)	1338.6	152.7	0
Remaining Load	0	78.1	10.4
Allowable Load at QR1	9.6	53.1	10.3
Percent Reduction	0	32	1

The TMDL for point QR1 requires that a load allocation be made for all areas of Quaker Run upstream of QR1 for total manganese and total aluminum.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Big Mountain Discharge

The Big Mountain Discharge receives drainage from the Big Mountain, Burnside, and Enterprise Collieries. Along with a few small discharges, it makes up a tributary locally called Buck Run. As there are too few data for Buck Run and no significant pollutant sources other than the Big Mountain Discharge, the data for the discharge were used to calculate load reductions for the entire Buck Run Subwatershed.

The TMDL for the Big Mountain Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Big Mountain Discharge (1.50 mgd).

An allowable long-term average instream concentration was determined at the Big Mountain Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 20 shows the load allocations for this stream segment.

Table 20. Reductions for Big Mountain Discharge

Station	Parameter	Measured Sample Data		Allowable		Reduction Identified
		Conc. (mg/l)	Load (lb/day)	LTA Conc. (mg/l)	Load (lb/day)	Percent
Big Mountain Discharge	Instream monitoring point located at Big Mountain Discharge					
	Fe	20.73	259.3	0.41	5.1	98
	Mn	6.11	76.4	0.37	4.6	94
	Al	6.87	85.9	0.27	3.4	96
	Acidity	93.82	1173.7	1.88	23.5	98
	Alkalinity	8.18	102.3			

The TMDL for the Big Mountain Discharge requires that a load allocation be made for all areas of Buck Run for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC1 and SC2

The TMDL study area associated with this point begins downstream of the confluence with Buck Run, and extends up the mainstem of Shamokin Creek to SC1, including the Locust Creek Subwatershed. Many abandoned mine discharges drain directly into this reach of stream including the Excelsior Discharge, the Corbin Discharge, and the Big Mountain Discharge. One tributary, Quaker Run, comprised of the Colbert, Scott, and Maysville Discharges, flows into this reach upstream of SC2.

The TMDL for point SC2 consists of a load allocation to all areas of Shamokin Creek between SC1 and SC2 and the Locust Creek Subwatershed (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement was calculated using the unit-area method for point SC2 (26.80 mgd).

An allowable long-term average instream concentration was determined at point SC2 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 21 shows the load allocations for this stream segment.

Table 21. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC1 and SC2					
Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
SC2	**Instream monitoring point located at SC2**				
	Fe	17.90	4000.9	0.72	160.9
	Mn	3.62	809.1	0.51	114.0
	Al	2.51	561.0	0.15	33.5
	Acidity	46.50	10393.3	1.86	415.7
	Alkalinity	6.00	1341.1		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC2. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 22 shows a summary of loads that affect SC2. Table 23 illustrates the necessary reductions at SC2.

Table 22. Summary of All Loads that Affect SC2				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC1)				
Existing Load	126.7	25.0	-	288.0
Allowable Load	40.3	25.0	-	201.6
Load Reduction	86.4	0	-	86.4
Excelsior Discharge				
Existing Load	1089.9	143.6	75.9	3052.8
Allowable Load	10.8	31.8	15.9	91.3
Load Reduction	1079.1	111.8	60.0	2961.5
Corbin Discharge				
Existing Load	282.1	32.6	56.9	1246.2
Allowable Load	0	5.9	5.1	0
Load Reduction	282.1	26.7	51.8	1246.2
Quaker Run (QR1)				
Existing Load	1183.3	230.8	10.4	NA
Allowable Load	9.6	53.1	10.3	NA
Load Reduction	1173.7	177.7	0.1	NA
Big Mountain Discharge				
Existing Load	259.3	76.4	85.9	1173.7
Allowable Load	5.1	4.6	3.4	23.5
Load Reduction	254.2	71.8	82.5	1150.2

Table 23. Necessary Reductions at SC2				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC2	4000.9	809.1	561.0	10393.3
Total Load Reduction (SC1, Excelsior, Corbin, QR1, Big Mtn.)	2875.5	388.0	194.4	5444.3
Remaining Load	1125.4	421.1	366.6	4949.0
Allowable Load at SC2	160.9	114.0	33.5	415.7
Percent Reduction	86	73	91	92

The TMDL for point SC2 requires that a load allocation be made for all areas of Shamokin Creek between SC1 and SC2, including the Locust Creek Subwatershed, for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to derive loading values for the TMDL.

Royal Oak Discharge

The Royal Oak Discharge receives drainage from the Buck Ridge #1 and Luke Fidler Collieries and is located approximately 0.7 miles upstream of the mouth of Coal Run. The discharge has recently (in the past year) stopped flowing to the surface. However, because the reason that it stopped flowing is unknown and because there is a possibility that it may begin flowing again, loads will be calculated for the discharge should it begin to flow again with similar characteristics as those when the data were taken. Further study and data collection will be necessary.

The TMDL for the Royal Oak Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Royal Oak Discharge (0.027 mgd).

An allowable long-term average instream concentration was determined at the Royal Oak Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 24 shows the load allocations for this stream segment.

Table 24. Reductions for the Royal Oak Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
	Instream monitoring point located at the Royal Oak Discharge					
Royal Oak Discharge	Fe	5.49	1.2	0.11	0.02	98
	Mn	1.87	0.4	0.21	0.05	89
	Al	5.66	1.3	0.06	0.01	99
	Acidity	51.53	11.8	2.06	0.5	96
	Alkalinity	11.97	2.7			

The TMDL for the Royal Oak Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Henry Clay Stirling Slope Discharge

The Henry Clay Stirling Slope Discharge receives drainage from the Henry Clay, Stirling, Neilson, Bear Valley, Burnside, Royal Oak, and Buck Ridge Collieries. It is located approximately 1.5 miles upstream of the mouth of Carbon Run. It is the largest discharge in the Carbon Run Watershed and one of the largest in the Shamokin Creek Watershed. Water from the Stirling Slope Discharge flows from the mine pool through a slope opening.

Sample data for the Stirling Slope Discharge show pH to range between 5.60 and 6.10, with an average pH of 5.83. The 99th percentile acidity concentration determined by Monte Carlo analysis shows the Stirling Slope Discharge to be net acidic (172.94 mg/l acidity compared to 61.11 mg/l alkalinity). Therefore, reductions in acidity were taken for the Stirling Slope Discharge. The method and rationale for addressing pH is contained in Attachment C.

The TMDL for the Stirling Slope Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Stirling Slope Discharge (4.62 mgd).

An allowable long-term average instream concentration was determined at the Stirling Slope Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 25 shows the load allocations for this stream segment.

Table 25. Reductions for the Henry Clay Stirling Slope Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Stirling Discharge	**Instream monitoring point located at Stirling Discharge**					
	Fe	27.54	1061.1	0.28	10.8	99
	Mn	3.52	135.6	0.70	27.0	80
	Al	0.46	17.7	0.28	10.8	40
	Acidity	24.80	955.6	8.42	324.4	66
	Alkalinity	61.11	2354.6			

The TMDL for the Henry Clay Stirling Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Carbon Run Above CAR1

The TMDL study area associated with this point begins at the mouth of Carbon Run and extends upstream to cover the entire subwatershed. The entire area draining to this point is approximately 8.7 square miles and has been extensively affected by mining, the City of Shamokin, and the Stirling Slope Discharge. Much of the Carbon Run Watershed is fairly inaccessible because it flows through a heavily strip-mined area. Also, the stream is lost underground at various points and reemerges due to infiltration into the mine pools and reemergence in a discharge.

A passive treatment system was installed to treat a small discharge (SL-42) in the Carbon Run Watershed by the Pa. DEP's Bureau of Abandoned Mine Reclamation in cooperation with Bucknell University, the USGS, and the US Office of Surfacing Mining. Provisional data are available that show improvement in the water quality of Carbon Run downstream of the system (data available at http://www.facstaff.bucknell.ecu/kirby/42MonitorData.html). The Shamokin Creek Restoration Alliance has also installed a treatment system consisting of a series of settling ponds on another small discharge (SL-48) to Carbon Run. Although it was installed fairly recently, data show a 10-fold decrease in iron concentrations from the influent to the effluent ends of the system (Kirby, personal communication, 2001; data available at http://www.facstaff.bucknell.edu/kirby/Site48.html).

Sample data for point CAR1 show pH ranging from 6.44 to 6.90 with an average pH of 6.65. Therefore, reductions in acidity were not taken for point CAR1 because it is meeting the pH criteria of between 6.0 and 9.0. The method and rationale for addressing pH is contained in Attachment C.

Paired data were available for dissolved metals concentrations but not for total metals concentrations for CAR1. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

The TMDL for point CAR1 consists of a load allocation to all of the watershed area upstream of CAR1 except the Henry Clay Stirling Discharge (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement was available for point CAR1 (5.52 mgd).

An allowable long-term average instream concentration was determined at point CAR1 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 26 shows the load allocations for this stream segment.

Table 26. Long-Term Average (LTA) Concentrations for Carbon Run Above CAR1

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
CAR1	**Instream monitoring point located at CAR1**				
	Fe	14.57	670.8	0.12	5.5
	Mn	3.25	149.6	0.62	28.5
	Al	0.43	19.8	0.10	4.6
	Acidity	14.33	659.7	NA	NA
	Alkalinity	31.00	1427.1		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point CAR1. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 27 shows a summary of loads that affect CAR1. Table 28 illustrates the necessary reductions at CAR1.

Table 27. Summary of All Loads that Affect CAR1			
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*
Henry Clay Stirling Discharge			
Existing Load	1061.1	135.6	17.7
Allowable Load	10.8	27.0	10.8
Load Reduction	1050.3	108.6	6.9

Table 28. Necessary Reductions at CAR1			
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*
Existing Loads at CAR1	670.8	149.6	19.8
Total Load Reduction (Stirling)	1050.3	108.6	6.9
Remaining Load	0	41.0	12.9
Allowable Load at CAR1	5.5	28.5	4.6
Percent Reduction	0	31	64

The TMDL for point CAR1 requires that a load allocation be made for all areas of Carbon Run upstream of CAR1 for total manganese and total aluminum.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Coal Creek Above CLR1

The Coal Creek subwatershed joins with Shamokin Creek upstream of point SC3. Point CLR1 is located at the mouth of Coal Creek. Coal Creek is often an intermittent stream due to the effects mining activities have had on its hydrological regime. Some surface water is lost into mine pools, leaving a nearly dry channel in some areas. Monte Carlo analysis was not conducted for point CLR1 because there were fewer data points than necessary (4): however, loads for point SC3 will be allocated to all areas of mainstem of Shamokin Creek and the Coal Creek subwatershed.

Shamokin Creek Between SC2 and SC3

The TMDL study area associated with this point begins upstream of the Cameron Air Shaft Discharge and continues up the mainstem of Shamokin Creek to SC2, including the Coal Creek Subwatershed. Shamokin Creek receives drainage from Carbon Run and Coal Run in this reach but no abandoned mine discharges drain directly into Shamokin Creek in the reach. SC3 is located just downstream of the city of Shamokin.

The TMDL for point SC3 consists of a load allocation to all areas of Shamokin Creek between SC2 and SC3, including the Coal Creek Subwatershed (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement calculated using the unit-area method was available for point SC3 (38.38 mgd).

An allowable long-term average instream concentration was determined at point SC3 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 29 shows the load allocation for this stream segment.

Table 29. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC2 and SC3

Station	*Parameter*	*Measured Sample Data*		*Allowable*	
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*
SC3	**Instream monitoring point located at SC3**				
	Fe	18.50	5921.7	0.18	57.6
	Mn	3.09	989.1	0.40	128.0
	Al	1.16	371.3	0.38	121.6
	Acidity	24.91	7973.4	7.72	2471.1
	Alkalinity	22.95	7346.0		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC3. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 30 shows a summary of loads that affect SC3. Table 31 illustrates the necessary reductions at SC3.

Table 30. Summary of All Loads that Affect SC3

	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC2)				
Existing Load	4000.9	809.1	561.0	10393.3
Allowable Load	160.9	114.0	33.5	415.7
Load Reduction	3840.0	695.1	527.5	9977.6
Royal Oak Discharge				
Existing Load	1.2	0.4	1.3	11.6
Allowable Load	0.02	0.05	0.01	0.5
Load Reduction	1.18	0.35	1.29	11.1
Carbon Run (CAR1)				
Existing Load	670.8	149.6	19.8	NA
Allowable Load	5.5	28.5	4.6	NA
Load Reduction	665.3	121.1	15.2	NA

Table 31. Necessary Reductions at SC3

	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC3	5921.7	989.1	371.3	7973.4
Total Load Reduction (SC2, Royal Oak, CAR1)	4506.4	816.6	544.0	9989.2
Remaining Load	1415.3	172.5	0	0
Allowable Load at CAR1	57.6	128.0	121.6	2471.1
Percent Reduction	96	26	0	0

The TMDL for point SC3 requires that a load allocation be made for all areas of Shamokin Creek between SC2 and SC3, including the Coal Creek Subwatershed, for total iron and total manganese.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to calculate loading values for the TMDL.

Cameron Air Shaft Discharge

The Cameron Air Shaft Discharge is the first in a pair of discharges flowing from the Glen Burn Colliery Complex. This discharge receives drainage from the Hickory Ridge, Colbert, Hickory Swamp, Cameron, Glen Burn, Natalie, and Luke Fidler Collieries, and is located approximately 0.3 miles upstream of SC4.

The TMDL for the Cameron Air Shaft Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Cameron Air Shaft Discharge (2.06 mgd).

An allowable long-term average instream concentration was determined at the Cameron Air Shaft Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 32 shows the load allocations for this stream segment.

Table 32. Reductions for the Cameron Air Shaft Discharge

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
	Instream monitoring point located at Cameron Air Shaft Discharge					
Cameron Air Shaft Discharge	Fe	42.61	732.1	0.35	6.0	99.2
	Mn	4.94	84.9	0.44	7.6	91
	Al	1.96	33.7	0.14	2.4	93
	Acidity	128.91	2214.7	2.58	44.3	98
	Alkalinity	20.26	348.1			

The TMDL for the Cameron Air Shaft Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Cameron Drift Discharge

The Cameron Drift Discharge is the second in a pair of discharges flowing from the Glen Burn Colliery. This discharge, a drift opening, receives drainage from the Hickory Ridge, Colbert, Hickory Swamp, Cameron, Glen Burn, Natalie, and Luke Fidler Collieries.

The TMDL for the Cameron Drift Discharge consists of a load allocation to the discharge (Attachment A). Addressing the mining impacts for this discharge addresses the impairment. An instream flow measurement was available for the Cameron Drift Discharge (1.43 mgd).

An allowable long-term average instream concentration was determined at the Cameron Drift Discharge for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 33 shows the load allocations for this segment.

Table 33. Reductions for the Cameron Drift Discharge						
Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Cameron Drift Discharge	**Instream monitoring point located at Cameron Drift Discharge**					
	Fe	48.39	577.1	0.29	3.5	99.4
	Mn	4.99	59.5	0.45	5.4	91
	Al	0.56	6.7	0.25	3.0	55
	Acidity	136.82	1631.7	4.10	48.9	97
	Alkalinity	27.95	333.3			

The TMDL for the Cameron Drift Discharge requires that a load allocation be made for all areas of the discharge for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC3 and SC4

The TMDL study area associated with this point begins below the Cameron Drift Discharge and extends up the mainstem of Shamokin Creek to SC3. The reach receives water from the Cameron Air Shaft Discharge and the Cameron Drift Discharge, both located near the Glen Burn Colliery.

The TMDL for point SC4 consists of a load allocation to all areas of Shamokin Creek between SC3 and SC4 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement calculated using the unit-area method was available for point SC4 (40.06 mgd).

An allowable long-term average instream concentration was determined at point SC4 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 34 shows the load allocations for this stream segment.

Table 34. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC3 and SC4

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
SC4	**Instream monitoring point located at SC4**				
	Fe	18.58	6207.6	0.37	123.6
	Mn	3.28	1095.8	0.59	197.1
	Al	1.21	404.3	0.39	130.3
	Acidity	30.62	10230.2	3.37	1125.9
	Alkalinity	14.32	4784.3		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC4. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 35 shows a summary of loads that affect SC4. Table 36 illustrates the necessary reductions at SC4.

Table 35. Summary of All Loads that Affect SC4				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Cameron Air Shaft				
Existing Load	732.1	84.9	33.7	2214.7
Allowable Load	6.0	7.6	2.4	44.3
Load Reduction	726.1	77.3	31.3	2170.4
Cameron Drift				
Existing Load	577.1	59.5	6.7	1631.7
Allowable Load	3.5	5.4	3.0	48.9
Load Reduction	573.6	54.1	3.7	1582.8
Shamokin Creek (SC3)				
Existing Load	5921.7	989.1	371.3	7973.4
Allowable Load	57.6	128.0	121.6	2471.1
Load Reduction	5864.1	861.1	249.7	5502.3

Table 36. Necessary Reductions at SC4				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC4	6207.6	1095.8	404.3	10230.2
Total Load Reduction (Cameron Air Shaft, Cameron Drift, SC3)	7163.8	992.5	284.7	9255.5
Remaining Load	0	103.3	119.6	974.7
Allowable Load at SC4	123.6	197.1	130.3	1125.9
Percent Reduction	0	0	0	0

The TMDL for point SC4 requires that no load allocation be made for all areas of Shamokin Creek between SC3 and SC4.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC4 and SC5

The TMDL study area associated with this point begins upstream of the confluence of Bennys Run and Shamokin Creek and continues up the mainstem to SC4. Outside of the city of Shamokin, Shamokin Creek flows through gaps in the Big Mountain and the Little Mountain. Shamokin Creek begins to receive water of high quality in this reach, including the drainage of Trout Run and Eagle Run. Trout Run is a very inaccessible tributary surrounded by forested land. It is used as a water supply for the Coal Township State Prison Complex. A local sportsman's club maintains a small hatchery on Trout Run near its confluence with Shamokin Creek.

The TMDL for point SC5 consists of a load allocation to all areas of Shamokin Creek between SC4 and SC5 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement calculated using the unit-area method was available for point SC5 (45.96 mgd).

An allowable long-term average instream concentration was determined at point SC5 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 37 shows the load allocations for this stream segment.

Table 37. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC4 and SC5

Station	*Parameter*	*Measured Sample Data*		*Allowable*	
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*
SC5	**Instream monitoring point located at SC5**				
	Fe	19.55	7493.6	0.78	299.0
	Mn	3.62	1387.6	0.69	264.5
	Al	2.15	824.1	0.43	164.8
	Acidity	47.07	18042.2	0	0
	Alkalinity	35.20	13492.4		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC5. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 38 shows a summary of loads that affect SC5. Table 39 illustrates the necessary reductions at SC5.

Table 38. Summary of All Loads that Affect SC5				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC4)				
Existing Load	6207.6	1095.8	404.3	10230.2
Allowable Load	123.6	197.1	130.3	1125.9
Load Reduction	6084.0	898.7	274.0	9104.3

Table 39. Necessary Reductions at SC5				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC5	7493.6	1387.6	824.1	18042.2
Total Load Reduction (SC4)	6084.0	898.7	274.0	9104.3
Remaining Load	1409.6	488.9	550.1	8937.9
Allowable Load at SC5	299.0	264.5	164.8	0
Percent Reduction	79	46	70	100

The TMDL for point SC5 requires that a load allocation be made for all areas of Shamokin Creek between SC4 and SC5 for total iron, total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC5 and SC6

The TMDL study area associated with this point begins downstream of the USGS gage on Shamokin Creek located near the Wayside Inn and extends up the mainstem of Shamokin Creek to SC5. This reach of stream receives water of good quality from Bennys Run and Millers Run.

The TMDL for point SC6 consists of a load allocation to all areas of Shamokin Creek between SC5 and SC6 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement from a USGS gauge was available for point SC6 (55.32 mgd).

An allowable long-term average instream concentration was determined at point SC6 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 40 shows the load allocations for this stream segment.

Table 40. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC5 and SC6

Station	*Parameter*	*Measured Sample Data*		*Allowable*	
		Conc. (mg/l)	*Load (lb/day)*	*LTA Conc. (mg/l)*	*Load (lb/day)*
SC6	**Instream monitoring point located at SC6**				
	Fe	13.08	6034.7	0.78	359.9
	Mn	2.67	1231.9	0.56	258.4
	Al	1.41	650.5	0.34	156.9
	Acidity	21.60	9965.6	4.97	2293.0
	Alkalinity	11.88	5481.1		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC6. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 41 shows a summary of loads that affect SC6. Table 42 illustrates the necessary reductions at SC6.

Table 41. Summary of All Loads that Affect SC6				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC5)				
Existing Load	7493.6	1387.6	824.1	18042.2
Allowable Load	299.0	264.5	164.8	0
Load Reduction	7194.6	1123.1	659.3	18042.2

Table 42. Necessary Reductions at SC6				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC6	6034.7	1231.9	650.5	9965.6
Total Load Reduction (SC5)	7194.6	1123.1	659.3	18042.2
Remaining Load	0	108.8	0	0
Allowable Load at SC6	359.9	258.4	156.9	2293.0
Percent Reduction	0	0	0	0

The TMDL for point SC6 requires that no load allocations be made for all areas of Shamokin Creek between SC5 and SC6.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC6 and SC7

The TMDL study area associated with this point begins below the village of Snydertown and continues up the mainstem to SC6. Shamokin Creek receives water of good quality from various tributaries in this reach, including Lick Creek, Elysburg Creek, and other unnamed tributaries. The major land use in this part of the watershed switches from mining to agriculture, with forested areas present on the ridge tops.

The TMDL for point SC7 consists of a load allocation to all areas of Shamokin Creek between SC6 and SC7 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement calculated using the unit-area method was available for point SC7 (67.20 mgd).

An allowable long-term average instream concentration was determined at point SC7 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 43 shows the load allocations for this stream segment.

Table 43. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC6 and SC7

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
	Instream monitoring point located at SC7				
SC7	Fe	8.93	5004.8	0.27	151.3
	Mn	3.42	1916.7	0.79	442.8
	Al	1.35	756.6	0.28	156.9
	Acidity	34.83	19520.4	1.04	582.9
	Alkalinity	3.83	2146.5		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC7. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 44 shows a summary of loads that affect SC7. Table 45 illustrates the necessary reductions at SC7.

Table 44. Summary of All Loads that Affect SC7

	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC6)				
Existing Load	6034.7	1231.9	650.5	9965.6
Allowable Load	359.9	258.4	156.9	2293.0
Load Reduction	5674.8	973.5	493.6	7672.6

Table 45. Necessary Reductions at SC7				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC7	5004.8	1916.7	756.6	19520.4
Total Load Reduction (SC6)	5674.8	973.5	493.6	7672.6
Remaining Load	0	943.2	263.0	11847.8
Allowable Load at SC7	151.3	442.8	156.9	582.9
Percent Reduction	0	53	40	95

The TMDL for point SC7 requires that a load allocation be made for all areas of Shamokin Creek between SC6 and SC7 for total manganese, total aluminum, and acidity.

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.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The unit-area flow for this point was used to derive loading values for the TMDL.

Shamokin Creek Between SC7 and SC8

The TMDL study area associated with this point begins at the mouth of Shamokin Creek into the Susquehanna River near the city of Sunbury and extends up the mainstem to SC7. No mining activities are present in this part of the watershed, with agriculture being the primary land use. Shamokin Creek receives water from Little Shamokin Creek, Plum Creek, and other unnamed tributaries in this reach. Some of these tributaries have historically been impacted by agricultural activities and carry large loads of nutrients and sediment. These impairments will not be addressed in this TMDL document.

Paired data were available for dissolved metals concentrations but not for total metals concentrations for SC8. The dissolved metal values were compared to the water quality standards for total metals, with the exception of iron, to determine a percent reduction. Dissolved iron values were compared to the dissolved iron criteria given previously.

The TMDL for point SC8 consists of a load allocation to all areas of Shamokin Creek between SC7 and SC8 (Attachment A). Addressing the mining impacts for this segment addresses the impairment. An instream flow measurement was available for point SC8 (82.87 mgd).

An allowable long-term average instream concentration was determined at point SC8 for iron, manganese, aluminum, and acidity. The analysis is designed to produce an average daily value that, when met, will be protective of the water quality criterion for that parameter 99 percent 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 percent of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5,000 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 percent of the time. The mean value from this data set represents the long-term daily average concentration that needs to be met to achieve water quality standards. Table 46 shows the load allocations for this stream segment.

Table 46. Long-Term Average (LTA) Concentrations for Shamokin Creek Between SC7 and SC8

Station	***Parameter***	***Measured Sample Data***		***Allowable***	
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***
SC8	**Instream monitoring point located at SC8**				
	Fe	1.05	725.7	0.08	55.3
	Mn	2.01	1389.2	0.30	207.3
	Al	0.37	255.7	0.18	124.4
	Acidity	12.23	8452.6	1.10	760.2
	Alkalinity	5.77	3987.9		

The loading reductions for all points upstream were summed to show the total load that was removed from all upstream sources. This value, for each parameter, was subtracted from the existing load at point SC8. Reductions were necessary for any parameter that exceeded the allowable load at this point. Table 47 shows a summary of loads that affect SC8. Table 48 shows the necessary reductions at SC8.

Table 47. Summary of All Loads that Affect SC8

	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Shamokin Creek (SC7)				
Existing Load	5004.8	1916.7	756.6	19520.4
Allowable Load	151.3	442.8	156.9	582.9
Load Reduction	4853.5	1473.9	599.7	18937.5

Table 48. Necessary Reductions at SC8				
	Iron (lb/day)	*Manganese (lb/day)*	*Aluminum (lb/day)*	*Acidity (lb/day)*
Existing Loads at SC8	725.7	1389.2	255.7	8452.6
Total Load Reduction (SC7)	4853.5	1473.9	599.7	18937.5
Remaining Load	0	0	0	0
Allowable Load at SC8	55.3	207.3	124.4	760.2
Percent Reduction	0	0	0	0

The TMDL for point SC8 requires that no load allocations be made for all areas of Shamokin Creek between SC7 and SC8.

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:

- Comparing the dissolved value to the total criteria gives a conservative estimate of the percent reduction necessary for the parameter of interest because total metals concentrations would be at least as large, if not larger, than the dissolved metals concentrations.

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represent 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. The average flow for this point was used to derive loading values for the TMDL.

SUMMARY OF ALLOCATIONS

This TMDL will focus remediation efforts on the identified numerical reduction targets for each watershed. As changes occur in the watershed, the TMDL may be reevaluated to reflect current conditions. Table 49 presents the estimated reductions identified for all points in the watershed.

Table 49. Summary Table – Shamokin Creek Watershed

Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
Mid Valley	Fe	11.43	263.1	0.09	2.1	99.2
	Mn	2.19	50.4	0.94	21.6	57
	Al	4.21	96.9	0.59	13.6	86
	Acidity	113.25	2606.8	0	0	100
	Alkalinity	0	0			
NB1	Fe	9.74	247.8	0.39	9.9	0*
	Mn	2.72	69.2	0.65	16.5	59*
	Al	5.66	144.0	0.11	2.8	96*
	Acidity	81.88	2082.8	0.25	6.4	0*
	Alkalinity	1.54	39.2			
SC1	Fe	1.32	126.7	0.42	40.3	0*
	Mn	0.26	25.0	0.26	25.0	0*
	Acidity	3.00	288.0	2.10	201.6	0*
	Alkalinity	15.60	1497.5			
Excelsior	Fe	21.25	1089.9	0.21	10.8	99
	Mn	2.80	143.6	0.62	31.8	78
	Al	1.48	75.9	0.31	15.9	79
	Acidity	59.52	3052.8	1.78	91.3	97
	Alkalinity	18.17	932.0			
Corbin	Fe	40.80	282.1	0	0	100
	Mn	4.71	32.6	0.85	5.9	82
	Al	8.23	56.9	0.74	5.1	91
	Acidity	180.25	1246.2	0	0	100
	Alkalinity	0	0			
Scott	Fe	25.88	843.9	0.52	17.0	98
	Mn	3.88	126.5	0.66	21.5	83
	Al	1.53	49.9	-	-	-
	Acidity	36.89	1203.0	8.49	276.9	77
	Alkalinity	38.15	1244.0			
Colbert	Fe	27.85	229.2	0.17	1.4	99.4
	Mn	3.70	30.5	0.92	7.6	75
	Al	0.12	1.0	0.12	1.0	0
	Acidity	100.50	827.3	7.04	58.0	93
	Alkalinity	31.00	255.2			
Maysville	Fe	21.45	286.2	0.17	2.3	99.2
	Mn	2.78	37.1	0.92	12.3	67
	Al	0.11	1.5	0.11	1.5	0
	Acidity	106.00	1414.5	NA	NA	NA
	Alkalinity	109.25	1457.8			
QR1	Fe	16.05	1183.3	0.13	9.6	0*

Table 49. Summary Table – Shamokin Creek Watershed						
Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
	Mn	3.13	230.8	0.72	53.1	32*
	Al	0.14	10.4	0.14	10.3	1*
	Acidity	11.50	847.8	NA	NA	NA*
	Alkalinity	22.37	1649.2			
Big Mountain	Fe	20.73	259.3	0.41	5.1	98
	Mn	6.11	76.4	0.37	4.6	94
	Al	6.87	85.9	0.27	3.4	96
	Acidity	93.82	1173.7	1.88	23.5	98
	Alkalinity	8.18	102.3			
SC2	Fe	17.90	4000.9	0.72	160.9	86*
	Mn	3.62	809.1	0.51	114.0	73*
	Al	2.51	561.0	0.15	33.5	91*
	Acidity	46.50	10393.3	1.86	415.7	92*
	Alkalinity	6.00	1341.1			
Royal Oak	Fe	5.49	1.2	0.11	0.02	98
	Mn	1.87	0.4	0.21	0.05	89
	Al	5.66	1.3	0.06	0.01	99
	Acidity	51.53	11.6	2.06	0.5	96
	Alkalinity	11.97	2.7			
Stirling	Fe	27.54	1061.1	0.28	10.8	99
	Mn	3.52	135.6	0.70	27.0	80
	Al	0.46	17.7	0.28	10.8	40
	Acidity	24.80	955.6	8.42	324.4	66
	Alkalinity	61.11	2354.6			
CAR1	Fe	14.57	670.8	0.12	5.5	0*
	Mn	3.25	149.6	0.62	28.5	31*
	Al	0.43	19.8	0.10	4.6	64*
	Acidity	14.33	659.7	NA	NA	NA*
	Alkalinity	31.00	1427.1			
SC3	Fe	18.50	5921.7	0.18	57.6	96*
	Mn	3.09	989.1	0.40	128.0	26*
	Al	1.16	371.3	0.38	121.6	0*
	Acidity	24.91	7973.4	7.72	2471.1	0*
	Alkalinity	22.95	7346.0			
Cameron Air	Fe	42.61	732.1	0.35	6.0	99.2
	Mn	4.94	84.9	0.44	7.6	91
	Al	1.96	33.7	0.14	2.4	93
	Acidity	128.91	2214.7	2.58	44.3	98
	Alkalinity	20.26	348.1			
Cameron Drift	Fe	48.39	577.1	0.29	3.5	99.4
	Mn	4.99	59.5	0.45	5.4	91
	Al	0.56	6.7	0.25	3.0	55
	Acidity	136.82	1631.7	4.10	48.9	97
	Alkalinity	27.95	333.3			
SC4	Fe	18.58	6207.6	0.37	123.6	0*
	Mn	3.28	1095.8	0.59	197.1	0*
	Al	1.21	404.3	0.39	130.3	0*
	Acidity	30.62	10230.2	3.37	1125.9	0*

Table 49. Summary Table – Shamokin Creek Watershed						
Station	***Parameter***	***Measured Sample Data***		***Allowable***		***Reduction Identified***
		Conc. (mg/l)	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
	Alkalinity	14.32	4784.3			
SC5	Fe	19.55	7493.6	0.78	299.0	79*
	Mn	3.62	1387.6	0.69	264.5	46*
	Al	2.15	824.1	0.43	164.8	70*
	Acidity	47.07	18042.2	0	0	100*
	Alkalinity	5.20	13492.4			
SC6	Fe	13.08	6034.7	0.78	359.9	0*
	Mn	2.67	1231.9	0.56	258.4	0*
	Al	1.41	650.5	0.34	156.9	0*
	Acidity	21.60	9965.6	4.97	2293.0	0*
	Alkalinity	11.88	5481.1			
SC7	Fe	8.93	5004.8	0.27	151.3	0*
	Mn	3.42	1916.7	0.79	442.8	53*
	Al	1.35	756.6	0.28	156.9	40*
	Acidity	34.83	19520.4	1.04	582.9	95*
	Alkalinity	3.83	2146.5			
SC8	Fe	1.05	725.7	0.08	55.3	0*
	Mn	2.01	1389.2	0.30	207.3	0*
	Al	0.37	255.7	0.18	124.4	0*
	Acidity	12.23	8452.6	1.10	760.2	0*
	Alkalinity	5.77	3987.9			

*Summary data for percent reductions are found in the following tables: NB1 - Table 7; SC1 – Table 10; QR1 – Table 18; SC2 – Table 22; CAR1 – Table 27; SC3 – Table 30; SC4 – Table 35; SC5 – Table 38; SC6 – Table 41; SC7 – Table 44; SC8 – Table 47

RECOMMENDATIONS

There are many activities that could be undertaken to reduce or eliminate the amount and severity of the mine drainage occurring in the Shamokin Creek Watershed. Some of these activities could also reduce or eliminate public safety hazards in the watershed in addition to improving water quality.

The first recommendation would be to remove abandoned highwalls in conjunction with filling in abandoned pits. This would not only eliminate surface water accumulations which could become contaminated with AMD (through contact with exposed acid-producing strata or mixing with AMD seep), but would also greatly reduce the amount of surface runoff trapped and directed into the mine pool systems by promoting surface drainage. This could cause the benefit of a reduction in the flow from the numerous AMD discharges in the watershed. An ancillary benefit of highwall removal is the elimination of a safety hazard. This also would aid in restoring surface flow in stream channels that are often dry a large portion of the year.

The second recommendation would be the removal or reduction of abandoned coal refuse deposits in conjunction with re-grading and replanting of these areas (includes the above abandoned pit areas). This would reduce the amount of sediments and coal waste entering the streams in the watershed. The re-grading of all disturbed areas would provide a more natural flow pattern for runoff while preventing surface flows from entering the underground mine pool or percolating through abandoned refuse deposits and possible emerging as AMD. Replanting and adequate revegetation of disturbed areas is a necessary follow-up to re-grading as it aids in stabilizing the reclaimed spoil/refuse, and preventing silt and sediment transport to the receiving streams.

The third recommendation would be individual assessments for passive treatment for those identified discharges in the watershed. These assessments should consider all technical factors in determining whether passive treatment is practical and, if it is, which type is best suited for a specific discharge. Consideration should be given to water chemistry, discharge volume, topographical setting, and up-front and long-term costs, including maintenance. Active treatment alternatives and innovative technologies (including instream treatment if applicable) should also be investigated and pursued if passive treatment cannot be achieved.

Given the continually increasing cost of reclamation and the limited funds available to state agencies for reclaiming abandoned mine lands, an alternative means to state and federal programs for remedial efforts must be found. Cooperation between federal, state, and local governments, the mining industry, and local watershed groups is not only recommended, it is a prerequisite to making a measurable difference in water quality and biological communities throughout the watershed. Grants from programs such as Pennsylvania's Growing Greener, EPA Section 319, Appalachian Clean Streams Initiative, Chesapeake Bay Program, EPA Small Watershed Program, Eastern Pennsylvania Coalition for Abandoned Mine Reclamation, and various others should actively be pursued for clean-up monies. Substantial remining incentives, alternate bonding requirements, and simplified permitting requirements are actions that should be actively pursued in the watershed to make these areas more attractive to industry and thereby gain reclamation of affected areas at an accelerated rate.

The forth recommendation would be to plan, develop, and implement measures for controlling stormwater runoff, which will remain on the surface after reclamation and flow into or through existing drainage facilities that are likely not to be designed for such flows. Any such work should balance the interests of all parties. In order to make a real difference in the water quality without creating a potentially substantial flooding problem in other areas, a cooperative effort from all parties is essential. A joint effort in identifying these areas and providing guidelines to be followed should be made in order to accomplish the goals of government, industry, and local environmental/watershed organizations. One such project is the Shamokin/Butternut Creek project in the town of Mount Carmel.

Some of the aforementioned reclamation work has begun. Several private (non-industry) organizations, such as the Shamokin Creek Restoration Alliance, the Northumberland County Conservation District, and the Eastern Pennsylvania Coalition for Abandoned Mine Reclamation, have received or have applied for grants, such as Growing Greener, to install treatment systems and weirs, and remediate and/or reclaim numerous areas within the watershed. Bucknell University and the U.S. Geological Survey, in cooperation, conducted a comprehensive watershed assessment complete with GIS coverages, water quality, and flow data. These assessment data and this TMDL document will be useful in addressing the AMD problems in the watershed. However, a comprehensive watershed survey will be necessary to determine priorities not related to mining in other sections of the watershed. With the monies available through Growing Greener and numerous other sources, and the likely increase in public interest in protecting and enhancing the waters of Shamokin Creek and its tributaries, these programs and organizations will not only continue, but will most likely increase.

Two passive treatment systems, as mentioned previously, have been installed in the Shamokin Creek Watershed. Both of these systems are located in the Carbon Run Subwatershed. One system, installed by the Shamokin Creek Restoration Alliance, consists of a series of settling ponds. The system will provide enough retention time that precipitating metals, chiefly iron, will be able to settle out of the water and remain in the ponds. The second system, installed by the Pa. DEP Bureau of Abandoned Mine Reclamation, Bucknell University, USGS, and OSM, not only settles out metals, but also adds alkalinity to the receiving water and therefore, helps to raise the pH of the water in the receiving stream. Other passive treatment systems are planned for the future, as funds are available for their installation and landowner permission is obtained.

In cooperation with the above private efforts, the coal industry, through DEP-promoted remining efforts, can help to eliminate some sources of AMD and conduct some of the remediation identified in the above recommendations through the permitting, mining, and reclamation of abandoned and disturbed mine lands. Special consideration should be given to potential remining projects within these areas as the environmental benefit versus cost ratio is generally very high. Reclamation of these lands is also possible through the Department's Bureau of Abandoned Mine Reclamation that maintains responsibility for reclamation of safety hazards or other areas in which active mining is not feasible or profitable.

PUBLIC PARTICIPATION

Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* and the *Shamokin News Item* on December 16, 2000, to foster public comment on the allowable loads calculated. A public meeting was held on January 17, 2001, at the Mount Carmel Public Library in Mt. Carmel, Pa., to discuss the proposed TMDL.

REFERENCES

Ash, S.H., W.L. Eaton, Joseph C. Gilbert, H.M. James, Hayden E. Jenkins, D.O. Kennedy, H.D. Kynor, Howard B. Link, and W.M. Romischer. 1950. Data on Pumping at the Anthracite Mines of Pennsylvania. U.S. Department of the Interior, Bureau of Mines, Report of Investigations 4700.

Becher, Albert E. 1991. Groundwater Resources In and Near the Anthracite Basins of Schuylkill and Adjacent Counties, Pennsylvania. U.S. Geological Survey. Water Resource Report 64.

Gannett Fleming Corddry and Carpenter, Inc. 1972. Mine Drainage Abatement Measures for the Shamokin Creek Watershed. Commonwealth of Pennsylvania, Department of Environmental Resources, Operation Scarlift. Preliminary Engineering Report Project SL-113.

Growitz, Douglas J., Lloyd A. Reed, and Mark M. Beard. 1985. Reconnaissance of Mine Drainage in the Coal Fields of Eastern Pennsylvania. U.S. Geological Survey. Water-Resources Investigations Report 83-4272.

Kirby, Carl. January 11, 2001. Personal communication.

Northumberland County Conservation District, Shamokin Creek Restoration Alliance, U.S. Geological Survey, and Bucknell University. 1999. Assessment of Stream Quality in the Shamokin Creek Basin with Emphasis on Abandoned Mine Drainage, Northumberland and Columbia Counties, Pennsylvania. 1999 Section 319 Incremental Grant Proposal.

Pennsylvania Department of Environmental Protection. 2000. Watershed Restoration and Action Strategies for Subbasin 06B, Mahanoy Creek and Shamokin Creek Watersheds, (Susquehanna River), Northumberland and Schuylkill Counties.

Reed, Lloyd A., Mark M. Beard, and Douglas J. Growitz. 1987. Quality of Water in Mines in the Western Middle Coal Field, Anthracite Region, East-Central Pennsylvania. U.S. Geological Survey. Water-Resources Investigations Report 85-4038.

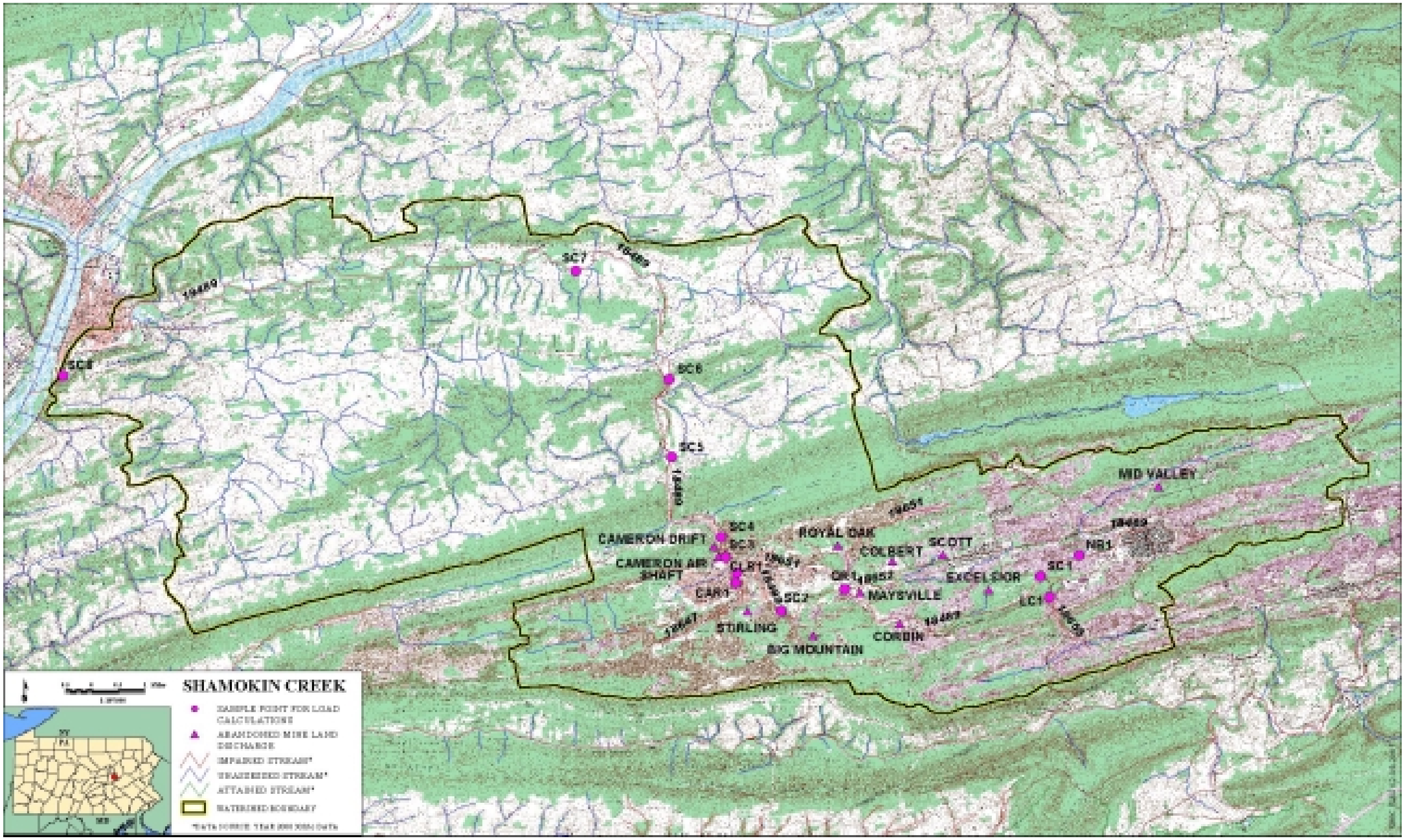
Shamokin Creek Restoration Alliance. 1999. Information Packet on Sites 19&20.

Winey, W. Larry. 1999. Flood Protection Study, Shamokin and Butternut Creeks, C49:3 Mount Carmel Borough and Mount Carmel Township, Northumberland County. Commonwealth of Pennsylvania, Department of Environmental Protection, Bureau of Waterways Engineering, Division of Project Evaluation.

Wood, Charles R. 1995. Water Quality of Large Discharges From Mines in the Anthracite Region of Eastern Pennsylvania. U.S. Geological Survey. Water-Resource Investigations Report 95-4243.

Attachment A

Shamokin Creek Watershed Map


SHAMOKIN CREEK
SAMPLE POINT FOR LOAD CALCULATIONS
ABANDONED MINE LAND DISCHARGE
IMPAIRED STREAM*
UNASSESSED STREAM*
ATTAINED STREAM*
WATERSHED BOUNDARY
SC8
SC7
SC6
SC5
SC4
SC3
SC2
SC1
CAMERON DRIFT
CAMERON AIR SHAFT
CLR1
CAR1
STIRLING
BIG MOUNTAIN
ROYAL OAK
COLBERT
SCOTT
QR1
MAYSVILLE
CORBIN
EXCELSIOR
LC1
NR1
MID VALLEY

Attachment B

List of Permits in the Shamokin Creek Watershed

Operation Name	Permit Number	Pottsville District Mining Office Number	Status
Blaschak (Burnside)	49783007	236	Active
Blaschak (Big Mountain)	49920101	237	Active
Reading (#10 Vein Refuse)	49850701	238	Active
Split Vein (Excelsior)	49910202	239	Active
Split Vein (Henry Clay)	49830202	240	Active
Rosini (Stirling)	49910201	242	Active
Rosini	49860201	243	Reclaimed
Mallard (Sayre)	49663009	250	Active
Savitski Brothers	49850101	251	Reclaimed
Susquehanna	49870201	256	Active
Susquehanna (Mt.Carmel)	49870202	257	Active
Savitski Brothers (Breaker)	49851602	258	Active
Split Vein	49851603	259	Active
Twin Creek (Swift Breaker)	49851605	260	Active
Bromley (Diebler Bank)	49820105	261	Stage 2
Mid Valley (Glen Burn)	49970203	274	Active
Gilberton	49950202	275	Active
Southern Anthracite	19860102	294	Reclaimed
N&L Morris Ridge	19950102	296	Active
Burnrite	19961301	298	Active
Eastern Industries	6175SM3	421	Active
Eagle Run Coal (#1 Drift)	49861307	120	Stage 1
F.K.Z. Coal (#1 Mine)	49971301	121	Active
K&L Coal (#0 Vein)	49851314	136	Active

Attachment C

The pH Method

Method for Addressing 303(d) listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published[1] by the PA Department of Environmental Protection demonstrates that by plotting net alkalinity vs. pH for 794 mine sample points, where net alkalinity is positive (greater or equal to zero), the pH range is most commonly 6 to 8, which is within the EPA's acceptable range of 6 to 9, and meets Pennsylvania water quality criteria in Chapter 93. The included graph (Figure 1) presents the nonlinear relationship between net alkalinity and pH. The nonlinear positive relation between net alkalinity and pH indicates that pH generally will decline as net alkalinity declines and vice versa; however, the extent of pH change will vary depending on the buffering capacity of solution. Solutions having near-neutral pH ($6 < pH < 8$) or acidic pH ($2 < pH < 4$) tend to be buffered to remain in their respective pH ranges.[2] Relatively large additions of acid or base will be required to change their pH compared to poorly buffered solutions characterized by intermediate pH ($4 < pH < 6$) where the correlation between net alkalinity and pH is practically zero.

The parameter of pH, a measurement of hydrogen ion acidity presented as a negative logarithm of effective hydrogen ion concentration, is not conducive to standard statistics. Additionally, pH does not measure latent acidity that can be produced from hydrolysis of metals. For these reasons the Pa. DEP is using the following approach to address the stream impairments noted on the 303(d) list due to pH. The concentration of acidity in a stream is partially dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values which would result from treatment of acid 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 able to measure the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable (>6.0). 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 to determine reductions 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) $CaCO_3$. The same statistical procedures that have been described for use in the evaluation of the metals at a point are 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 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(s) will be the average net alkalinity established from the stream's upper, pristine reaches. In other words, if the pH in an unaffected portion of a stream is found to be naturally occurring below 6, then the average net alkalinity for that 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% 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 meet a minimum net alkalinity of zero.

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[1] 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. Department of Environmental Protection, Harrisburg, PA.

[2] Stumm, Werner, and Morgan, J.J., 1996. Aquatic Chemistry--Chemical Equilibria and Rates in Natural Waters (3rd ed.), New York, Wiley-Interscience, 1022p.

Error may be introduced by the method of calculation shown above when waters have a pH > 6.0 and iron plus manganese concentrations greater than 10 mg/l. Measured acidity may significantly underestimate the actual acidity. This condition is most likely to be experienced in a mine discharge that has not undergone oxidation and would not be prevalent in a free flowing stream. Under these conditions the acidity should be both measured and calculated using the following formula:

$$\text{Calc. acidity, mg } CaCO_3/l = 50[(2Fe^{2+}/56) + (3Fe^{3+}/56) + (3Al/27) + 2Mn/55 + 1000(10^{-pH})]$$

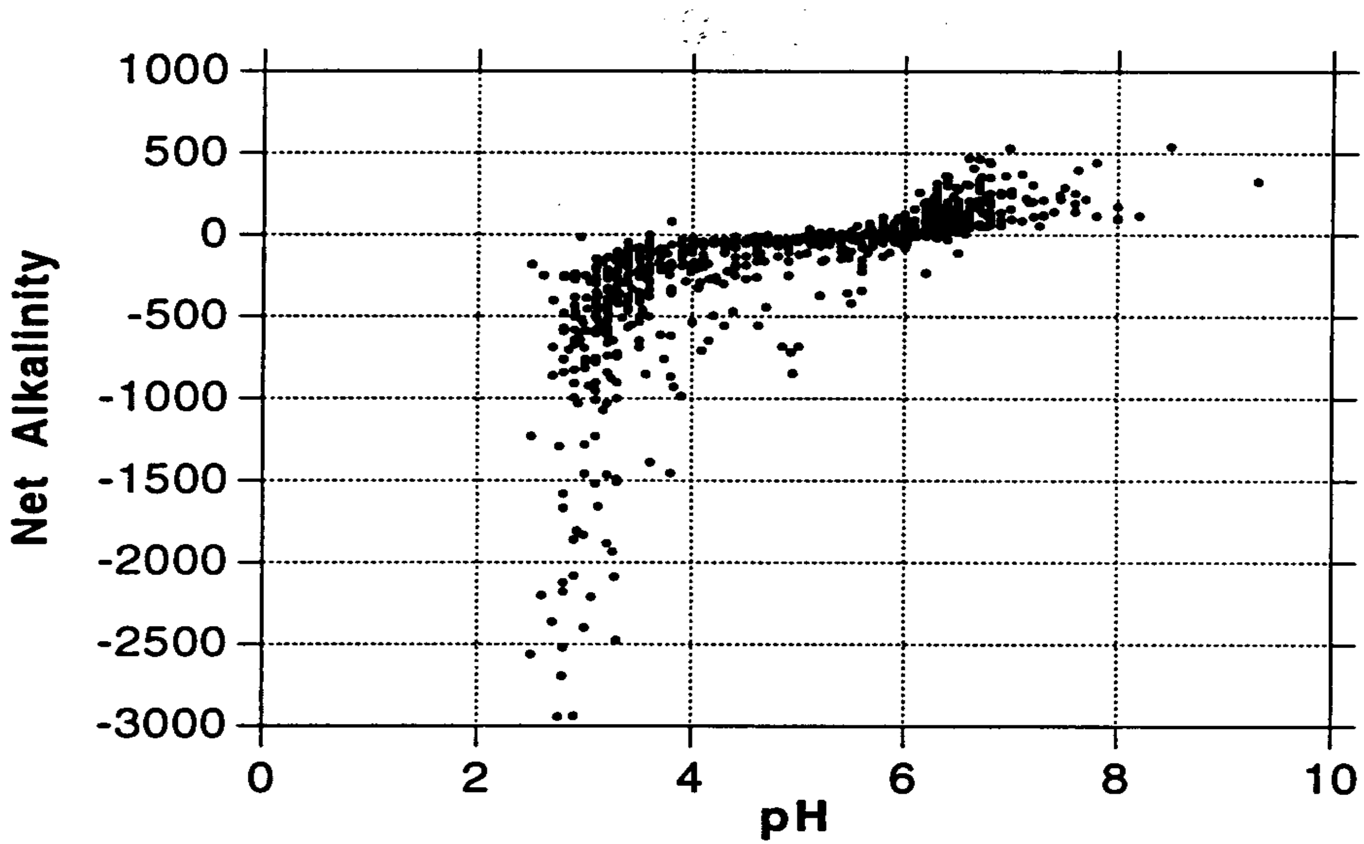

Figure 1. Net alkalinity vs. pH. Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania, Graph C, pp. 1-5.

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Attachment D

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.

Table 1. Equations Used for Rowe Tunnel Analysis (SWAT 04)

	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.

Table 2. Swat-04 Estimated Target Reductions			
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.

Table 3. Swat-04 Verification of Target Reductions			
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.

Table 4. Swat-11 Estimated Target Reductions			
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

Table 5. Swat-11 Verification of Target Reductions			
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.

Table 6. Variable Descriptions for Lorberry Creek Calculations	
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):

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

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).

$$Q_{swat11} = Q_{swat}04 \text{ x } 0.142 + 0.088 \qquad (2)$$

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

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

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.

Table 8. L-1 Adjusted BAT Concentrations

Parameter	**Measured Value**		**BAT adjusted Value**	
	Average Conc.	*Standard Deviation*	*Average Conc.*	*Standard Deviation*
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):

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

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.

Table 9. Verification of Meeting Water Quality Standards Below Point L-1			
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.

Table 10. Lorberry Creek Summary Table						
		Measured Sample Data		***Allowable***		***Reduction Identified***
Station	***Parameter***	***Conc. (mg/l)***	***Load (lb/day)***	***LTA Conc. (mg/l)***	***Load (lb/day)***	***Percent***
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 E

Data Used to Calculate The TMDLs

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
SC1	Savitski Bros.	49850101	#4 below operation	12/11/87		1.04	0.32		11.00	4.00				
	Savitski Bros.	49850101	Shamokin Creek below	11/12/87		0.77	0.36		4.00	8.00				
	Savitski Bros.	49850101	#4 Shamokin Creek below	10/16/87		2.73	0.40		0.00	36.00				
	Savitski Bros.	49850101	#4 Shamokin Creek below	9/18/87		0.56	0.12		0.00	17.00				
	Savitski Bros.	49850101	#4 Shamokin Creek below	8/14/87		1.50	0.12		0.00	13.00				
				Average=		1.32	0.26		3.00	15.60				
				StDev=		0.86	0.13		4.80	12.42				
SC2	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	4/6/94		15.90	2.61	2.66	42.00	5.00				
	Split Vein/Henry Clay Refuse	49830202	Stream	3/29/95		21.80	3.67	1.60	28.00	10.40				
	Split Vein/Henry Clay Refuse	49830202	Stream	12/13/94		17.90	3.36	1.86	60.00	13.20				
	Split Vein/Henry Clay Refuse	49830202	Stream	12/23/94		17.40	3.18	1.82	58.00	13.40				
	Split Vein/Henry Clay Refuse	49830202	Stream	10/4/94		10.80	6.37	8.60	96.00	0.00				
	Split Vein/Henry Clay Refuse	49830202	Stream	10/4/94		18.40	3.76	1.32	34.00	16.20				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	1/9/92		17.90	3.28	1.36	40.00	0.00				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	1/9/92		19.60	3.26	0.97	34.00	2.00				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	1/29/91		16.80	3.09	1.82	24.00	6.00				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	4/6/94		16.10	2.59	2.75	42.00	5.80				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	2/16/84		20.35	4.03	2.21	50.00	0.00				
	Split Vein/Henry Clay Refuse	49830202	Shamokin Creek	2/16/84		21.85	4.21	3.19	50.00	0.00				
				Average=		17.90	3.62	2.51	46.50	6.00				
				StDev=		3.00	1.00	2.02	19.15	5.96				
SC3	Eagle Run Coal	49861307	mp3 (#3 Glen Burn)	12/10/93		14.00	2.70			4.00				
	Eagle Run Coal	49861307	mp3 (#3 Glen Burn)	3/9/94		43.00	5.30			40.00				
	Eagle Run Coal	49861307	mp3 (#3 Glen Burn)	7/7/94		29.20	3.60			74.00				
	Eagle Run Coal	49861307	mp3 (#3 Glen Burn)	10/24/94		0.27	0.03			12.60				
	Eagle Run Coal	49861307	mp3 (stream)	10/21/96		15.90	3.53	1.24	26.00	12.60				
	Eagle Run Coal	49861307	mp3 (stream)	5/20/96		13.10	2.93	1.72	34.00	12.60				
	Eagle Run Coal	49861307	mp3 (stream)	3/10/97		13.50	2.79	1.31	22.00	16.00				
	Eagle Run Coal	49861307	mp3 (stream)	5/19/97		22.70	3.38	0.61	34.00	28.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Eagle Run Coal	49861307	mp3 (stream)	3/19/98		26.60	3.70	1.16	42.00	22.00				
	Eagle Run Coal	49861307	mp3 (stream)	6/10/98		12.10	2.81	1.12	10.80	14.60				
	Eagle Run Coal	49861307	mp3 (stream)	9/14/98		13.10	3.23	0.97	5.60	16.00				
				Average=		18.50	3.09	1.16	24.91	22.95				
				StDev=		11.32	1.25	0.34	13.16	19.42				
SC4	Eagle Run Coal	49861307	mp4 (#4 Glen Burn)	12/10/93		16.60	2.80			4.00				
	Eagle Run Coal	49861307	mp4 (#4 Glen Burn)	3/9/94		22.50	3.20			20.00				
	Eagle Run Coal	49861307	mp4 (#4 Glen Burn)	7/7/94		20.50	3.40			18.00				
	Eagle Run Coal	49861307	mp4 (#4 Glen Burn)	10/24/94		15.40	3.30			23.10				
	Eagle Run Coal	49861307	mp4 (stream)	10/21/96		16.10	3.60	1.24	26.00	12.60				
	Eagle Run Coal	49861307	mp4 (stream)	5/20/96		34.80	5.06	0.50	80.00	32.00				
	Eagle Run Coal	49861307	mp4 (stream)	3/10/97		13.30	2.77	1.32	24.00	16.60				
	Eagle Run Coal	49861307	mp4 (stream)	5/19/97		11.90	2.77	1.32	20.00	12.80				
	Eagle Run Coal	49861307	mp4 (stream)	3/19/98		25.40	3.55	1.10	44.00	22.00				
	Eagle Run Coal	49861307	mp4 (stream)	6/10/98		12.70	2.97	1.20	11.00	14.60				
	Eagle Run Coal	49861307	mp4 (stream)	9/14/98		13.60	3.42	1.03	3.60	15.80				
	USGS Ecological Survey		Shamokin Creek near Shamokin	10/6/99	26032									6.20
	Assessment (Carl Kirby)		Shamokin Creek near Shamokin	11/1/98	14584				37.20	6.30	17.37	3.59	0.32	6.22
	USGS Survey		(SC14)	3/14/00	38151	20.70	3.10	1.70	26.00	10.0	18.70	3.14	0.20	6.20
	USGS Survey		(SC14)	8/5/99	13465				41.00	0.00	15.00	3.80	0.05	5.90
	USGS Survey		Near Shamokin, Pa.	3/14/00	37702	18.00	2.67	1.51	24.00	7.00	14.50	2.67	0.20	6.30
	USGS Survey		Near Shamokin, Pa.	10/6/99	26032									6.20
				Average=	25994	18.58	3.28	1.21	30.62	14.32	16.39	3.30	0.19	6.17
				StDev=	10696	6.36	0.62	0.34	20.31	8.26	1.98	0.50	0.11	0.14
SC5	Split Vein	49851603	mp2 dnst Shamokin Creek	6/11/84	45000	22.50	4.30	2.80	96.00	375.00				
	Split Vein	49851603	mp2 dnst Shamokin Creek	9/20/95		18.60	3.82	1.31	42.00	13.00				
	Split Vein	49851603	Shamokin Creek below	8/17/93		17.80	3.89	2.16	34.00	26.00				
	Split Vein	49851603	Shamokin Creek below	9/23/92		17.80	3.56	1.56	32.00	17.00				
	Split Vein	49851603	Shamokin Creek below	3/16/92		21.20	3.17	2.32	34.00	12.00				
	Split Vein	49851603	Shamokin Creek below	11/13/91		18.20	3.75	1.64	54.00	9.00				
	Split Vein	49851603	Shamokin Creek below	9/4/91		18.10	3.80	1.93	44.00	11.00				
	Split Vein	49851603	Shamokin Creek below	5/8/91		16.90	2.84	1.83	34.00	9.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Split Vein	49851603	Shamokin Creek below	11/6/90		18.70	3.00	1.96	38.00	11.00				
	Split Vein	49851603	Shamokin Creek below	1/10/90		20.10	3.68	2.47	50.00	11.00				
	Split Vein	49851603	Shamokin Creek below	5/25/89		20.00	3.26	2.55	46.00	0.00				
	Split Vein	49851603	Shamokin Creek below	10/24/88		17.10	2.94	1.99	38.00	7.00				
	Split Vein	49851603	Shamokin Creek below	5/12/88		18.50	3.83	2.44	62.00	9.00				
	Split Vein	49851603	Shamokin Creek below	3/2/88		21.70	3.76	2.49	50.00	10.00				
	Split Vein	49851603	Shamokin Creek below	11/9/87		26.10	4.64	2.85	52.00	8.00				
				Average=	45000	19.55	3.62	2.15	47.07	35.20				
				StDev=		2.47	0.50	0.46	16.14	94.16				
SC6	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	3/10/00	50000	13.6	2.95		9.57	5.43				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	3/25/00	50000	12.6	2.22	1.52	12.6	19.8				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	12/9/99	50000	12.6	2.72	1.1	22	19.6				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	9/27/99	50000	11.1	2.68	1.28	19.2	11				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	5/25/99	50000	14.1	3.01	1.03	22	14				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	3/4/99	50000	14.2	3	1.35	20	13.6				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	10/22/98	50000	10.8	2.56	0.957	18.4	13.6				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	5/28/98	50000	13.7	3.04	1.76	22	14.4				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	11/24/97	50000	7.92	1.87	0.752	10.4	17.2				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	2/27/97	50000	12.8	2.67	1.57	30	17.4				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	8/18/95	20000	18.3	3.98	1.42	30	9.2				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	11/23/92	20000	14.1	1.2	2.89	13.8	8				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	8/6/92	20000	12.6	2.55	1.2	22	0				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	11/13/91	20000	13.7	3.1	1.49	40	6				
	Twin Creek/Swift Breaker	49851605	MP3 Shamokin Creek Above	5/9/91	35000	14.1	2.51	1.49	32	9				
				Average=	41000	13.08	2.67	1.41	21.60	11.88				
				StDev=	13654	2.22	0.62	0.50	8.53	5.65				
SC7	Bromley Coal	49820105	mp2 (Shamokin Creek)	3/25/83		2.00	3.00	0.22	67.00	0.00				
	Bromley Coal	49820105	Shamokin Creek below	6/27/91		8.07	3.37	1.48	26.00	0.00				
	Bromley Coal	49820105	Shamokin Creek below	8/26/93		5.41	3.84	1.84	30.00	0.00				
	Bromley Coal	49820105	Shamokin Creek below	10/2/91		5.32	3.67	1.19	28.00	0.00				
	Bromley Coal	49820105	Shamokin Creek below	2/11/92		15.90	3.29	1.59	32.00	11.00				
	Bromley Coal	49820105	Shamokin Creek below	2/23/93		16.90	3.35	1.75	26.00	12.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
				Average=		8.93	3.42	1.35	34.83	3.83				
				StDev=		6.10	0.30	0.60	15.93	5.95				
SC8	USGS Survey		NEAR SUNBURY PA	3/14/00	135098	2.46	0.56	0.44	0.00	11.00	1.34	0.54	0.20	6.50
	USGS Survey		NEAR SUNBURY PA	8/5/99	15260				18.00	0.00	0.23	3.30	0.67	4.00
	USGS Survey		NEAR SUNBURY PA	10/6/99	57450						1.70	1.60	0.03	6.60
	Assessment (Carl Kirby)		Shamokin Creek near Sunbury	11/1/98	22193				18.70	6.30	0.94	2.61	0.59	5.08
				Average=	57500	2.46	0.56	0.44	12.23	5.77	1.05	2.01	0.37	5.55
				StDev=	54931				10.60	5.52	0.63	1.21	0.31	1.24
NB1	Louis Coal	49900101	N.Branch Sham. Downstream	9/28/89	1150	2.10	3.40	15.20	239.00	0.50				3.50
	Louis Coal	49900101	N.Branch Sham. Downstream	10/16/89	1050	6.50	3.10	6.10	87.70	0.50				3.50
	Louis Coal	49900101	N.Branch Sham. Downstream	11/2/89	1100	14.30	2.80	3.30	65.40	1.90				5.00
	Louis Coal	49900101	N.Branch Sham. Downstream	12/1/89	1200	12.00	2.50	4.20	74.40	1.00				5.30
	Louis Coal	49900101	N.Branch Sham. Downstream	1/26/90	1150	5.70	2.14	5.20	60.80	1.00				3.50
	Louis Coal	49900101	N.Branch Sham. Downstream	2/2/90	1100	15.20	2.75	3.10	48.60	10.00				5.00
	USGS Ecological Survey		North Branch Shamokin Creek	10/5/99	3815									3.40
	Assessment (Carl Kirby)		North Branch Shamokin Creek	11/1/98	1539				75.00	0.00	3.30	2.69	5.62	3.03
	USGS Survey		(SC3D)	6/21/99	2244					0.00				4.10
	USGS Survey		(SC3D)	3/16/00	6284	12.40	2.38	2.50	32.00	2.00	10.60	2.24	1.51	5.20
	USGS Survey		(SC3D)	8/4/99	987				54.00	0.00	2.70	2.40	4.20	3.20
	USGS Survey		(SC3D)	10/6/99	3815					0.00	4.00	2.60	4.90	3.40
				Average=	2120	9.74	2.72	5.66	81.88	1.54	5.15	2.48	4.06	4.01
				StDev=	1670	4.97	0.43	4.39	61.15	2.90	3.67	0.20	1.79	0.86
LC1	USGS Survey		(LC4)	7/15/99	0									
	USGS Survey		(LC4)	3/15/00	808	0.46	0.88	3.79	34.00	0.00	0.43	0.88	3.79	3.90
	USGS Survey		(LC4)	8/4/99	0									
	Assessment (Carl Kirby)		Locust Creek at mouth	11/1/98	10				220.00	0.00	6.44	0.09	26.81	2.89
				Average=	205	0.46	0.88	3.79	127.00	0.00	3.44	0.48	15.30	3.40
				StDev=	402					0.00	4.25	0.56	16.28	0.71

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
QR1	USGS Survey		(QR8)	6/21/00	2244									6.60
	USGS Survey		(QR8)	3/14/00	9874	22.30	3.37	0.20			18.80	3.26	0.20	6.50
	USGS Survey		(QR8)	8/4/99	3366				23.00	12.00	17.00	3.40	0.07	6.30
	USGS Survey		(QR8)	10/5/00	8079						14.00	2.60	0.02	6.80
	Pa. DEP Aquatic Bio Study		Monitoring Point 3	10/27/86		20.40		0.39		12.00				6.70
	USGS Ecological Survey		QR8	10/5/99	7989									6.80
	Assessment (Carl Kirby)		Quaker Run at mouth	11/1/98	5231				0.00	43.10	14.40	3.27	0.27	6.60
				Average=	6131	21.35	3.37	0.30	11.50	22.37	16.05	3.13	0.14	6.61
				StDev=	2994	1.34		0.13	16.26	17.96	2.26	0.36	0.11	0.18
CLR1	USGS Survey		(COR11)	3/14/00	673	3.13	1.34	0.20	0.00	60.00	2.86	1.30	0.20	6.40
	USGS Survey		(COR11)	8/4/99	45				18.00	76.00	0.92	1.50	0.01	6.50
	Assessment (Carl Kirby)		Coal Run at mouth	11/1/98	269				0.00	80.90	1.23	1.39	0.29	6.70
				Average=	329	3.13	1.34	0.20	6.00	72.30	1.67	1.40	0.17	6.53
				StDev=	318				10.39	10.93	1.04	0.10	0.14	0.15
CAR1	USGS Survey		(CR12)	3/14/00	8079	17.10	2.59	1.38	0.00	32.00	14.70	2.50	1.38	6.60
	USGS Survey		(CR12)	8/4/99	1436				41.00	18.00	11.00	3.90	0.01	6.50
	USGS Survey		(CR12)	10/5/99	3636						17.00	3.50	0.02	6.80
	USGS Ecological Survey		(CR12)	10/5/99	3654									6.90
	Assessment (Carl Kirby)		Carbon Run at mouth	11/1/98	2378				2.00	43.00	15.58	3.09	0.31	6.44
				Average=	3837	17.10	2.59	1.38	14.33	31.00	14.57	3.25	0.43	6.65
				StDev=	2548				23.12	12.53	2.56	0.60	0.65	0.20
Scott Overflow	Susquehanna Coal	49870201	Scott overflow	10/27/99		23.30	3.12	<.5	10.60	54.00				
	Susquehanna Coal	49870201	Scott overflow	8/31/99		25.50	3.54	<.5	9.40	54.00				
	Susquehanna Coal	49870201	Scott overflow	5/26/99		25.10	3.58	<.5	17.40	50.00				
	Susquehanna Coal	49870201	Scott Overflow	3/3/99		25.70	3.63	<.500	11.60	50.00				
	Susquehanna Coal	49870201	Scott Overflow	9/9/98		22.20	3.40	<.500	9.60	50.00				
	Susquehanna Coal	49870201	Scott Overflow	1/28/98		23.60	3.26	<.500	36.00	48.00				
	Susquehanna Coal	49870201	Scott Overflow	10/30/97		22.70	3.37	<.500	44.00	52.00				
	Susquehanna Coal	49870201	Scott Overflow	7/28/97		25.10	3.84	<.500	60.00	48.00				
	Susquehanna Coal	49870201	Scott Overflow	4/15/97		22.00	3.58	<.500	18.40	44.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Susquehanna Coal	49870201	Scott Overflow	1/23/97		20.80	3.42	<.500	38.00	44.00				
	Susquehanna Coal	49870201	Scott Overflow	11/14/96		22.30	3.60	<.500	40.00	42.00				
	Susquehanna Coal	49870201	Scott Overflow	10/26/95		26.70	3.89	<.500	46.00	48.00				
	Susquehanna Coal	49870201	Scott Overflow	8/15/95		28.50	4.21	<.500	22.00	34.00				
	Susquehanna Coal	49870201	Scott Overflow	4/27/95		27.10	4.05	<.500	46.00	44.00				
	Louis Coal	49900101	Scott Overflow-Mine pool	10/16/89	310	31.20	4.60	<0.7	54.80	38.00				6.50
	Louis Coal	49900101	Scott Overflow-Mine pool	11/2/89	300	44.50	4.30	<0.7	49.50	23.50				6.50
	Louis Coal	49900101	Scott Overflow-Mine pool	12/1/89	310	37.50	4.30	<0.7	59.60	35.60				6.50
	Louis Coal	49900101	Scott Overflow-Mine pool	1/26/90	300	25.40	4.35	<0.7	38.40	30.60				6.40
	Louis Coal	49900101	Scott Overflow-Mine pool	2/2/90	300	26.50	4.30	<0.7	35.10	38.00				6.50
	Susquehanna Coal	49870201	Scott Overflow	7/22/94		25.10	4.09	<.500	46.00	40.00				
	Susquehanna Coal	49870201	Scott Overflow	4/29/94		26.60	4.18	<.500	54.00	10.80				
	Susquehanna Coal	49870201	Scott Overflow	5/28/93		25.30	4.18	<.500	32.00	38.00				
	Susquehanna Coal	49870201	Scott Overflow	2/20/98		24.00	3.60		17.30	57.50				
	Susquehanna Coal	49870201	Scott Overflow	4/16/98		21.40	3.70		22.10	48.30				
	Susquehanna Coal	49870201	Scott Overflow	7/28/98		25.20	3.50		15.60	46.20				
	Susquehanna Coal	49870201	Scott Overflow	12/11/98		23.40	3.70		19.30	27.80				
	Susquehanna Coal	49870201	Scott Overflow	12/15/98		23.40	3.70		19.30	57.80				
	Susquehanna Coal	49870201	Scott Overflow	6/30/98		21.40	3.70		22.10	48.30				
	Susquehanna Coal	49870201	Scott Overflow	2/23/98		24.00	3.60		17.30	57.50				
	Mallard Construction/Sayre	49663009	Scott overflow pt.1	2/15/00		23.50	3.10	<.500	13.00	52.00				
	Mallard Construction/Sayre	49663009	Scott overflow Kulpmont	4/3/98		22.90	3.40		18.80	49.50				
	Mallard Construction/Sayre	49663009	Scott overflow Kulpmont	10/1/97		24.80	3.60		11.30	51.70				
	Mallard Construction/Sayre	49663009	Scott overflow Kulpmont	4/23/97		20.30	3.40		15.00	38.00				
	Mallard Construction/Sayre	49663009	Scott overflow Kulpmont	6/29/92		0.40	5.80		<1	38.00				
	Empire Coal	49900102	Scott overflow	7/5/90		31.00	4.80	<.7	29.60	19.80				6.10
	Empire Coal	49900102	Scott overflow	8/2/90		30.10	4.35	<.7	59.20	49.50				
	Empire Coal	49900102	Scott overflow	10/2/90		23.50	3.80	<.7	30.40	32.30				
	Empire Coal	49900102	Scott overflow	10/12/90		31.00	4.20	<.7	30.80	32.80				
	Empire Coal	49900102	Scott overflow	11/5/90		31.00	4.20	<.7	16.00	31.90				
	N&L/Morris Ridge	19950102	Scott overflow	8/7/95		28.50	5.21	<.5	22.00	34.00				
	N&L/Morris Ridge	19950102	Scott overflow	10/19/95		26.70	3.89	<.5	46.00	48.00				
	N&L/Morris Ridge	19950102	Scott overflow	7/25/95		29.70	3.93	0.21	23.10	1.90				5.60
	N&L/Morris Ridge	19950102	Scott overflow	8/8/95		26.10	3.67	0.29	15.90	0.00				5.39
	Burnrite Coal	19930101	Scott Overflow	12/16/98		6.98	2.57	5.42	64.00	0.00				
	Burnrite Coal	19930101	Scott Overflow	7/11/97		29.60	4.36		35.00	38.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Burnrite Coal	19930101	Scott Overflow	8/15/97		27.40	4.20		37.00	31.00				
	Burnrite Coal	19930101	Scott Overflow	9/12/97		27.60	3.90		33.00	32.00				
	Burnrite Coal	19930101	Scott Overflow	4/10/97		26.78	4.02		40.00	29.00				
	Burnrite Coal	19930101	Scott Overflow	5/9/97		28.50	3.90		38.00	32.00				
	Burnrite Coal	19930101	Scott Overflow	6/13/97		25.41	4.10		33.00	34.00				
	Burnrite Coal	19930101	Scott Overflow	7/11/97		29.60	4.36		35.00	38.00				
	Burnrite Coal	19930101	Scott Overflow	7/29/97		19.30	2.61	<.500	44.00	42.00				
	USGS Survey		(SR19)	3/15/00	8528	30.60	3.64	0.20	24.00	42.00	30.40	3.72	0.20	5.80
	USGS Survey		(SR19)	8/5/99	4219				55.00	30.00	27.00	3.70	0.09	5.90
	USGS WRIR 85-4038		Scott Ridge Mine	4/17/75	7990	47.50			187.50	16.00				5.30
	USGS WRIR 95-4243		Scott Ridge Mine	11/1/91	2154	29.00	4.30		161.00	33.00				5.60
				Average=	2712	25.88	3.88	1.53	36.89	38.15	28.70	3.71	0.15	6.01
				StDev=	3414	6.71	0.55	2.59	30.93	13.71	2.40	0.01	0.07	0.47
Big Mt.	Blaschak/Big Mountain	49920101	mp4 Big Mountain #! Slope	3/10/00		27.30	7.93	7.80	98.28	<.4				3.93
Discharge	Blaschak/Big Mountain	49920101	dm4	2/5/00		27.10	7.82	8.02	108.00	0.00				
	Blaschak/Big Mountain	49920101	mp4 Big Mountain #! Slope	12/30/99		28.10	8.90	9.81	167.00	<.4				3.58
	Blaschak/Big Mountain	49920101	dm4	10/23/99		20.60	8.48	7.66	88.00	9.40				
	Blaschak/Big Mountain	49920101	mp4 Big Mountain #! Slope	9/22/99		30.90	8.61	5.85	177.10	<.4				4.54
	Blaschak/Big Mountain	49920101	dm4	7/29/99		25.40	7.25	7.52	106.00	0.00				
	Blaschak/Big Mountain	49920101	mp4 Big Mountain #! Slope	6/23/99		22.00	6.86	5.41	101.00	<.4				3.45
	Blaschak/Big Mountain	49920101	dm4	5/22/99		25.40	7.39	6.48	86.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	3/12/98		9.24	6.34	7.42	87.00	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	6/18/98		9.65	7.45	7.61	93.10	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	9/3/98		24.55	16.32	1.52	22.50	19.50				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	12/3/98		30.70	7.00	<.100	<.4	78.40				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	3/31/99		25.30	10.80	7.09	102.50	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	3/10/99		30.00	9.64	8.23	100.00	5.80				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	9/16/98		27.90	8.29	1.56	44.00	28.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	6/8/98		17.30	2.83	<.500	0.00	50.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	3/23/98		8.94	6.04	8.29	98.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	12/15/97		31.40	7.07	7.32	122.00	7.20				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	11/10/93		28.51	5.58	6.09	90.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	3/31/94		15.19	4.02	6.52	95.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	5/24/94		8.62	5.95	7.11	81.00	0.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	9/13/94		23.81	7.14	8.31	101.52	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	11/8/94		23.81	7.14	8.31	101.52	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	2/14/95		16.75	4.69	6.43	84.76	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	5/9/95		19.30	4.71	5.24	78.39	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	8/8/95		23.70	4.39	4.38	58.50	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	11/15/95		24.36	4.72	6.98	85.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	2/6/96		8.42	4.59	10.28	83.73	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	5/7/96		9.31	5.16	7.09	79.95	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	8/6/96		13.20	6.46	5.58	96.10	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	11/20/96		18.70	4.90	7.34	107.00	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	2/17/97		12.70	6.45	7.60	87.20	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	6/12/97		17.72	0.56	7.84	80.80	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. Slope #1	8/7/97		8.00	5.50	7.17	95.60	<.4				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	6/16/97		17.50	5.56	6.39	120.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	3/12/97		10.80	6.44	8.05	100.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	6/18/96		12.10	5.99	7.91	128.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	3/27/96		8.39	5.24	7.83	134.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	12/19/95		21.10	5.37	7.77	130.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	4/1/95		17.50	4.25	5.14	108.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	12/23/94		26.20	6.03	8.10	136.00	0.00				
	Blaschak/Big Mountain	49920101	Big Mtn. DM004	10/1/94		25.30	6.97	9.14	112.00	0.00				
	Blaschak/Big Mountain	49920101	Deep Mine	6/29/94		24.83	3.71	<.500	26.00	50.00				
	Blaschak/Big Mountain	49920101	Deep Mine	6/29/94		12.13	6.13	9.13	106.00	0.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303971)	2/2/93		30.60	4.15	<.500	26.00	68.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303972)	2/2/93		<.300	<.50	<.500	12.20	9.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303973)	2/2/93		23.40	4.25	6.14	88.00	0.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303974)	2/2/93		21.70	3.80	1.99	42.00	14.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303975)	2/2/93		20.80	3.17	2.46	50.00	12.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303976)	2/2/93		46.70	5.88	8.47	148.00	8.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9303977)	2/2/93		<.300	<.50	<.500	9.80	9.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9339088)	7/22/93		11.90	3.98	6.29	66.00	0.00				
	Blaschak/Big Mountain	49920101	Deep Mine (H9339089)	7/22/93		14.60	4.69	8.01	86.00	0.00				
	USGS Survey		(SR23)	3/14/00	1616	29.70	7.23	7.14	100.00	0.00	28.20	7.11	6.96	4.10
	USGS Survey		(SR23)	8/4/99	229				170.00	0.00	29.00	7.40	7.60	3.50
	USGS Survey		(SR23)	8/6/99	229				95.00		26.00	7.10	7.60	3.70
	USGS WRIR 85-4038		Big Mountain Mine #1 slope	4/16/75	898	20.00			160.00	0.00				3.40

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	USGS WRIR 95-4243		Big Mountain Mine #1 slope	10/31/91	2244	30.00	4.00		188.00	0.00				4.50
				Average=	1043	20.72	6.11	6.87	93.82	8.18	27.73	7.20	7.39	3.86
				StDev=	883	8.13	2.34	1.92	40.20	18.25	1.55	0.17	0.37	0.44
Buck	Susquehanna	49870202	discharge	5/10/00		<.3	0.53	1.19	7.80	8.00				
Ridge #1	Susquehanna	49870202	discharge	2/16/00		10.30	2.94	0.53	0.00	54.00				
Discharge	Susquehanna	49870202	discharge	8/31/99		1.49	0.45	3.23	0.00	42.00				
(Royal Oak	Susquehanna	49870202	discharge	5/26/99		0.35	0.80	3.05	24.00	9.00				
Discharge)	Susquehanna	49870202	discharge	12/17/98		5.48	5.67	9.34	84.00	0.00				
	Susquehanna	49870202	discharge	3/3/99		2.38	1.28	12.90	42.00	7.60				
	Susquehanna	49870202	discharge	10/30/97		0.78	1.29	4.45	48.00	0.00				
	Susquehanna	49870202	discharge	7/29/97		2.93	3.07	14.60	126.00	0.00				
	Susquehanna	49870202	discharge	4/15/97		1.15	1.58	6.58	56.00	0.00				
	USGS Survey		(SR36B)	7/15/99						0.00				4.30
	USGS Survey		(SR36B)	3/14/00	9	0.02	1.10	0.69		0.00	0.04	1.07	0.69	4.40
	USGS Survey		(SR36B)	8/5/99	4				44.00	0.00	13.00	1.10	0.04	5.40
	USGS WRIR 85-4038		Royal Oak Mine Seepage	4/16/75	45	30.00			135.00	35.00				5.30
				Average=	19	5.49	1.87	5.66	51.53	11.97	6.52	1.09	0.37	4.85
				StDev=	22	9.15	1.61	5.08	46.61	18.81	9.16	0.02	0.46	0.58
Henry Clay	Rosini/Sterling	49910201	Sterling Slope Discharge	5/2/00		16.30	2.60		<1	84.00				
Stirling	Rosini/Sterling	49910201	Sterling Slope Discharge	4/14/00		20.60	2.84	<.5	0.00	82.00				
Slope	Rosini/Sterling	49910201	Sterling Slope Discharge	3/1/00		24.70	3.60		<1	70.00				
Discharge	Rosini/Sterling	49910201	Sterling Slope Discharge	1/28/00		26.50	3.20		<1	73.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/15/00		28.20	3.48	<.5	0.00	66.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	-		30.60	3.69	0.61	6.40	52.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	-		27.70	3.38	0.57	6.20	60.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	-		23.40	3.13	<.5	0.00	64.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	9/15/98		27.30	3.49	<.500	7.60	58.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/11/98		22.30	2.89	<.500	0.00	78.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	12/16/97		129.60	3.51	<.500	74.00	70.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	6/16/97		21.10	2.92	<.500	44.00	64.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	3/13/97		23.10	3.31	<.500	14.00	64.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/11/97		22.60	3.30		2.30	58.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/8/97		17.80	3.00		<1	58.90				
	Rosini/Sterling	49910201	Sterling Slope Discharge	11/15/96		28.80	3.30		3.40	56.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/11/96		24.90	4.00		10.00	46.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	8/15/96		27.00	3.70		8.20	58.40				
	Rosini/Sterling	49910201	Sterling Slope Discharge	7/8/96		21.40	3.50		13.40	36.10				
	Rosini/Sterling	49910201	Sterling Slope Discharge	11/29/95		27.80	3.70		13.80	78.20				
	Rosini/Sterling	49910201	Sterling Slope Discharge	12/28/95		27.20	3.60		10.40	75.90				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/31/96		19.00	2.70		4.00	69.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/29/96		20.00	3.30		<1	64.10				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/30/96		22.70	3.10		<1	46.80				
	Rosini/Sterling	49910201	Sterling Slope Discharge	5/31/96		19.50	3.10		<1	47.70				
	Rosini/Sterling	49910201	Sterling Slope Discharge	6/18/96		22.10	3.34	<.500	74.00	52.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/28/95		26.00	3.30		17.70	65.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	5/31/95		26.80	3.70		27.30	63.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	6/30/95		22.00	3.60		20.20	55.80				
	Rosini/Sterling	49910201	Sterling Slope Discharge	7/28/95		21.00	3.70		9.70	54.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	8/31/95		32.90	3.10		7.40	64.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	9/29/95		38.60	3.30		165.00	73.50				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/31/95		31.00	3.90		18.00	63.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/31/95		25.60	3.20		<1	78.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/28/95		22.50	3.40		8.00	57.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/3/95		22.50	3.40		8.00	57.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/31/94		29.00	3.70		12.40	63.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	11/30/94		29.20	3.50		27.90	60.50				
	Rosini/Sterling	49910201	Sterling Slope Discharge	12/30/94		21.50	3.20		9.50	52.80				
	Rosini/Sterling	49910201	Sterling Slope Discharge	8/31/94		26.50	3.60		20.40	55.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	9/30/94		33.50	4.20		10.00	55.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	7/29/94		26.50	3.80		16.70	50.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/28/94		30.00	3.80		13.20	40.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/28/94		28.60	3.70		17.90	60.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	3/30/94		16.50	2.80		16.80	40.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/28/94		19.50	3.40		3.70	50.40				
	Rosini/Sterling	49910201	Sterling Slope Discharge	5/26/94		15.00	3.20		3.40	50.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	7/1/94		20.00	3.20		15.40	47.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	6/24/94		23.60	3.54	<.500	16.60	46.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/6/94		26.40	3.43	<.500	24.00	60.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/26/93		20.00	3.70		1.60	65.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	5/26/93		21.00	3.50		11.90	46.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	6/30/93		13.30	4.00		28.00	48.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	7/30/93		28.70	4.37		30.00	51.40				
	Rosini/Sterling	49910201	Sterling Slope Discharge	8/31/93		27.60	4.09		25.80	55.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/1/93		31.20	4.26		31.50	55.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/29/93		29.00	3.66		29.50	56.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	11/30/93		46.00	4.80		71.60	50.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	12/15/93		29.00	3.70		23.70	40.40				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/4/94		30.30	3.77	<.500	0.00	54.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	1/25/93		25.50	4.00		<1	72.50				
	Rosini/Sterling	49910201	Sterling Slope Discharge	2/23/93		27.00	3.60		5.20	75.60				
	Rosini/Sterling	49910201	Sterling Slope Discharge	3/30/93		26.30	3.10		<1	176.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	11/23/92		32.00	4.00		15.70	62.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	12/18/92		27.00	3.60		5.90	105.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	8/3/92		31.00	3.70		13.00	66.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	9/21/92		30.00	3.80		23.00	70.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	10/23/92		32.20	4.10		37.00	66.00				
	Rosini/Sterling	49910201	Sterling Slope Discharge	4/4/91		28.90	3.88	<.500	5.40	58.00				
	USGS Survey		(SR49)	3/14/00	5835	26.10	2.94	0.20	0.00	66.00	23.80	2.83	0.20	6.10
	USGS Survey		(SR49)	8/4/99	718				68.00	32.00	27.00	3.20	0.03	5.80
	USGS WRIR 85-4038		Henry Clay Stirling Mine Slope	4/16/75	4937	50.00			170.00	43.00				5.60
	USGS WRIR 95-4243		Henry Clay Stirling Mine Slope	10/31/91	1347	34.00	4.10		185.00	53.00				
				Average=	3209	27.54	3.52	0.46	24.80	61.11	25.40	3.02	0.12	5.83
				StDev=	2553	13.64	0.41	0.23	37.75	18.30	2.26	0.26	0.12	0.25

Cameron	Eagle Run Coal	49861307	mp1 (#1 Glen Burn)	12/10/93		60.00	6.10			22.00				
Mine Drift	Eagle Run Coal	49861307	mp1 (#1 Glen Burn)	3/9/94		14.80	3.00			7.00				
(Deep Mine)	Eagle Run Coal	49861307	mp1 (#1 Glen Burn)	7/7/94		13.50	2.90			14.00				
	Eagle Run Coal	49861307	mp1 (#1 Glen Burn)	10/24/94		14.00	3.20			21.00				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	10/21/96		71.10	7.15	0.50	142.00	36.00				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	5/20/96		64.60	7.48	0.50	198.00	28.00				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	3/10/97		62.10	6.47	0.50	152.00	36.00				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	5/19/97		11.80	2.74	1.27	22.00	12.20				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	3/19/98		55.00	5.69	0.50	106.00	52.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	6/10/98		36.90	4.70	0.50	28.00	54.00				
	Eagle Run Coal	49861307	mp1 (deep mine discharge)	9/14/98		54.50	5.65	0.50	84.00	42.00				
	USGS Survey		(SR51A)	6/28/99	1122									5.10
	USGS Survey		(SR51A)	3/14/00	1032	49.10	4.89	0.20	66.00	38.00	47.40	4.54	0.20	5.50
	USGS Survey		(SR51A)	8/4/99	539				164.00	32.00	51.00	5.30	0.07	5.30
	USGS WRIR 85-4038		Cameron Mine Drift	4/16/75	2110	150.00			474.00	0.00				4.10
	USGS WRIR 95-4243		Cameron Mine Drift	10/31/91	144	20.00	4.90		69.00	25.00				6.30
				Average=	989	48.39	4.99	0.56	136.82	27.95	49.20	4.92	0.13	5.26
				StDev=	740	36.49	1.63	0.31	125.22	15.71	2.55	0.54	0.09	0.79
Cameron	Eagle Run Coal	49861307	mp2 (#2 Glen Burn)	12/10/93		29.40	4.00			4.00				
Air Shaft	Eagle Run Coal	49861307	mp2 (#2 Glen Burn)	3/9/94		56.00	6.20			28.00				
	Eagle Run Coal	49861307	mp2 (#2 Glen Burn)	7/7/94		65.00	6.40			36.00				
	Eagle Run Coal	49861307	mp2 (#2 Glen Burn)	10/24/94		51.50	5.50			42.00				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	10/21/96		15.10	3.28	2.14	20.00	16.80				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	5/20/96		13.00	2.98	1.67	32.00	12.60				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	3/10/97		28.30	3.84	0.51	36.00	54.00				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	5/19/97		52.10	5.74	0.50	150.00	38.00				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	3/19/98		35.60	4.34	0.90	42.00	48.00				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	6/10/98		64.80	6.40	0.50	106.00	38.00				
	Eagle Run Coal	49861307	mp2 (deep mine discharge)	9/14/98		1.38	2.24	3.82	32.00	6.80				
	USGS Survey		(SR53)	6/28/99	673					0.00				4.10
	USGS Survey		(SR53)	3/14/00	2244	58.40	6.04	5.65	140.00	0.00	57.40	5.63	5.22	4.20
	USGS Survey		(SR53)	8/4/99	1032				186.00	0.00	54.00	6.10	5.20	4.00
	USGS WRIR 85-4038		Cameron Mine Air Shaft	4/16/75	1795	60.00			385.00	0.00				3.40
	USGS WRIR 95-4243		Cameron Mine Air Shaft	10/31/91	1391	66.00	7.30		289.00	0.00				4.10
				Average=	1427	42.61	4.94	1.96	128.91	20.26	55.70	5.87	5.21	3.96
				StDev=	618	21.84	1.58	1.88	119.33	19.81	2.40	0.33	0.01	0.32
Excelsior	Split Vein Excelsior	49910202	Excelsior DS002	3/3/99		15.00	2.45	1.15	22.00	17.60				
Mine Strip	Split Vein Excelsior	49910202	Excelsior DS002	9/14/98		16.60	2.62	1.11	15.20	16.80				
Pit Overflow	Split Vein Excelsior	49910202	Excelsior DS002	3/25/98		12.60	2.28	2.06	32.00	19.40				
	Split Vein Excelsior	49910202	Excelsior DS002	12/15/97		17.10	2.59	0.65	24.00	22.00				
	Split Vein Excelsior	49910202	Excelsior DS002	11/6/97		23.80	3.79		29.00	0.00				

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
	Split Vein Excelsior	49910202	Excelsior DS002	3/13/97		14.50	2.41	1.88	32.00	13.40				
	Split Vein Excelsior	49910202	Excelsior DS002	5/20/96		12.50	2.38	1.95	42.00	9.80				
	Split Vein Excelsior	49910202	Excelsior DS002	4/4/91		16.20	2.65	2.18	36.00	5.00				
	USGS Survey		(SR-12)	6/21/99	3142									5.70
	USGS Survey		(SR-12)	3/15/00	6284	30.40	3.21	0.84	38.00	30.00	30.40	3.21	0.20	5.70
	USGS Survey		(SR-12)	8/5/99	3232				95.00	48.00	28.00	2.90	0.06	5.80
	USGS WRIR 85-4038		Excelsior Strip Pool Overflow	4/18/75	5835	44.00			185.00	5.00	44.00	5.40	0.95	4.90
	USGS WRIR 95-4243		Excelsior Strip Pool Overflow	11/1/91	2828	31.00	3.60		164.00	31.00				5.50
				Average=	4264	21.25	2.80	1.48	59.52	18.17	34.13	3.84	0.40	5.52
				StDev=	1653	10.02	0.54	0.60	57.46	13.43	8.63	1.36	0.48	0.36
Mid Valley	USGS Survey		(SR5B)	6/21/00	1795					0.00				3.90
Mine Tunnel	USGS Survey		(SR5B)	3/15/00	2244	9.94	2.12	3.95	58.00	0.00	9.86	2.17	3.91	3.80
	USGS Survey		(SR5B)	8/5/99	1212				77.00	0.00	13.00	2.20	4.50	4.00
	USGS WRIR 85-4038		Mid Valley Mine - Tunnel	4/17/75	2648	15.00			155.00	0.00				3.30
	USGS WRIR 95-4243		Mid Valley Mine - Tunnel	11/1/91	1661	19.00	2.80		163.00	0.00				3.50
				Average=	1912	14.65	2.46	3.95	113.25	0.00	11.43	2.19	4.21	3.70
				StDev=	552	4.54	0.48		53.49	0.00	2.22	0.02	0.42	0.29
Corbin	USGS Survey		(SR15)	6/21/99	673					0.00				4.30
Water Level	USGS Survey		(SR15)	3/15/00	1122	44.90	4.98	8.47	130.00	0.00	45.60	4.82	8.26	4.40
Drift	USGS Survey		(SR15)	8/6/99	413				141.00	0.00	36.00	4.60	8.20	4.20
	USGS WRIR 85-4038		Corbin Water Level Drift	4/16/75	449	40.00			230.00	0.00				4.10
	USGS WRIR 95-4243		Corbin Water Level Drift	10/31/91	220	43.00	5.50		220.00	0.00				4.20
				Average=	575	42.63	5.24	8.47	180.25	0.00	40.80	4.71	8.23	4.24
				StDev=	345	2.47	0.37		52.03	0.00	6.79	0.16	0.04	0.11
Maysville	USGS Survey		(SR21)	6/28/99	898									6.00
Mine	USGS Survey		(SR21)	3/15/00	1930	23.40	2.69	0.20	0.00	116.00	22.90	2.75	0.20	6.40
Borehole	USGS Survey		(SR21)	8/4/99	251				59.00	82.00	20.00	2.80	0.01	6.00
	USGS WRIR 85-4038		Maysville Mine Borehole	4/16/75	1481	50.00			200.00	133.00				6.30
	USGS WRIR 95-4243		Maysville Mine Borehole	10/31/91	987	29.00	4.30		165.00	106.00				6.30

TMDL #	Company Name	Permit Number	Location Description	Date	Flow	T. Fe	T. Mn	T. Al	Acid	Alk	D. Fe	D. Mn	D. Al	pH
				Average=	1109	34.13	3.50	0.20	106.00	109.25	21.45	2.78	0.11	6.20
				StDev=	634	14.02	1.14		92.67	21.31	2.05	0.04	0.13	0.19
Colbert	USGS Survey		(SR20)	3/15/00	718	30.90	3.61	0.20	26.00	38.00	29.70	3.69	0.20	6.00
Mine Breach	USGS Survey		(SR20)	8/5/99	853				59.00	36.00	26.00	3.70	0.05	6.00
	USGS WRIR 85-4038		Colbert Mine Breach	4/17/75	404	40.00			138.00	13.00				5.30
	USGS WRIR 95-4243		Colbert Mine Breach	11/1/91	763	28.00	4.20		179.00	37.00				5.70
				Average=	685	32.97	3.91	0.20	100.50	31.00	27.85	3.70	0.12	5.75
				StDev=	195	6.26	0.42		70.33	12.03	2.62	0.01	0.11	0.33

Note: All flow values are shown in units of gallons per minute (gpm); all concentration values are shown in units of milligrams per liter (mg/l)
All pH measurements shown are pH taken in the field.

Attachment F

Comments and Responses

Comments/Reponses for the Shamokin Creek TMDL

EPA Region III Comments:

Comment:
Although the review was performed based on the assumption that Appendix E data tables are correct, the printed table does not agree with the worksheet labeled "Attachment E" of the provided spreadsheet. If the spreadsheet is correct, then existing flows and concentrations for SC4 through SC8 are wrong, i.e., Tables 4, 36, 41, 44, 47, 50, and 53.

Response:
Discrepancies between the provided spreadsheets and data contained in the listed tables have been corrected.

Comment:
If the historical reports indicate that 50 percent of the Mid Valley Discharge is lost to infiltration, explain why this is not reflected in Table 5.

Response:
The loss from the discharge to infiltration is downstream of the area where samples were taken. Therefore, the flows as shown in Table 5 for the Mid Valley Discharge are correct because they were taken at the discharge and the loss would occur downstream.

Comment:
Existing concentrations in Table 6, North Branch Shamokin Creek Above NB1, do not match the data table in Appendix E.

Response:
This has been corrected.

Comment:
Shamokin Creek above SC1: It is unclear if the stream flow at SC1 determined by the unit-area method included the North Branch area. The North Branch must be accounted for, please clarify. Existing loads for North Branch shown in Table 10 do not match existing loads for North Branch in Tables 6 and 8.

Response:
The flow determined by unit-area at point SC1 included the watershed area of the North Branch. Discrepancies between loads have been corrected.

Comment:
Table 13, Reductions for the Excelsior Discharge, the existing concentrations shown do not agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
Not all values in Table 15, Reductions for the Scott Ridge Mine Tunnel Discharge, agree with Appendix E data table.

Response:
This has been corrected.

Comment:
The acidity and alkalinity values in Table 21, Reductions for the Big Mountain Discharge, do not agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
Most of the existing load values in Table 22, Reductions for Shamokin Creek Between SC1 and SC2, appear to be wrong and the allowable loads seem to be slightly off. The errors are carried to Table 24 affecting the percentage reductions required.

Response:
This has been corrected.

Comment:
The existing concentration values in Table 25, Reductions for the Royal Oak Discharge, do not agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
Not all existing concentration values in Table 32, Reductions for the Henry Clay Stirling Discharge, agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
The existing concentration values in Table 39, Reductions for the Cameron Air Shaft Discharge, do not agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
Some of the existing concentration values in Table 40, Reductions for the Cameron Drift Discharge, do not agree with the Appendix E data table.

Response:
This has been corrected.

Comment:
In Table 49, Summary Table – Shamokin Creek Watershed, please identify the TMDL values, e.g., Shamokin Creek at points SC1, SC2, etc., and the allocations to principal "nonpoint" sources, e.g., Excelsior, Corbin, etc.

Response:
All TMDL values are shown in Table 49 for each point and discharge.

Comment:
No TMDL was developed from Locust Creek, a section 303(d) listed segment. Therefore, this report contains five, not six, TMDLs.

Response:
The TMDL for Locust Creek is included in the allocations to Shamokin Creek between SC1 and SC2 (Tables 21-23).

Carl Kirby, Associate Professor and Chair of Geology, Bucknell University Comments:

Comment:

The method used for evaluating acid mine drainage-affected streams where low pH is cited as the cause of the impairment is flawed. This flaw occurs in using values for net alkalinity ($\text{alkalinity}_{\text{measured}}$-$\text{acidity}_{\text{measured}}$). A net alkalinity of zero calculated using this method can significantly overestimate the alkalinity of mine water. The impact of using this flawed calculation as a proxy for pH in developing a total maximum daily load (TDML) may be relatively small, as I will explain below. The impact of using this method in designing a passive mine drainage treatment system, as the DEP is increasingly called upon to do, is likely much more significant. I will also explain below why I think treatment systems may prove inadequate if designed using a net alkalinity = zero as a primary design criteria.

Background

There are clear indications that the value of $\text{acidity}_{\text{measured}}$ (as determined by standard methods: APHA 2310, EPA 305.1, ASTM D1067-92 (1996)) underestimates the actual acidity of mine waters that also contain alkalinity. For example, when one submits to a lab a mine water which has 25 mg/L Fe (II), pH ≈ 6, and some alkalinity, the analysis will likely return an $\text{acidity}_{\text{measured}}$ of near zero. This method will consistently return such a result, but the sample obviously contains acidity due to the iron. According to Hedin *et al*. (1994), the acidity of this sample may be calculated using the equation

$$\text{Calc. acidity, mg } CaCO_3/L = 50[(2Fe^{2+}/56) + (3Fe^{3+}/56) + (3Al/27) + 2Mn/55 + 1000(10^{-pH})] \qquad (1)$$

where $^{Fe2+}$, Fe^{3+}, Al, and Mn are dissolved concentrations in mg/L. Hedin *et al*. (1994) only suggest applying this equation to waters with pH < 4.5, but my research suggests that this restriction if unnecessary. The water described above has a calculated acidity of 45 mg $CaCO_3$/L, which is more reflective of the actual acidity in the water than the $\text{acidity}_{\text{measured}}$. My research on this subject is briefly described in Kirby and Cerrone (2000). I plan to submit this work with greater detail to a peer-reviewed journal this spring.

Evidence that TMDL calculations are impacted

As an example from the Draft Shamokin Creek Watershed TMDL, see Table 15, which gives allowable LTA concentrations of 0.8 mg Fe/L, 0.7 mg Mn/L and 14.4 mg acidity/L. The calculated acidity for such a water would be between 2.7 and 3.4 (depending on the oxidation state of iron). Thus the target LTA for acidity should be much nearer 3 than the 14.4 suggested by the TMDL. Several TMDLs for other Shamokin creek sites showed the same trends. The site which showed this trend are all sites which have measurable alkalinity; sites with pH < 4.5 are not affected.

Impact on TMDLs

The overall impact on the implementation of TMDLs may be slight. My reasoning for this statement is that, if metal LTAs are achieved due to treatment, the actual in-stream acidity values will be lower than the LTAs for acidity.

What do I suggest for the use of acidity LTAs in TMDLs?

Because the impact on the implementation of TMDLs is likely small, I do not suggest recalculating the TMDLs for acidity. I suggest adding a note in the explanation of the pH method that explains this flaw in the calculation.

The impact on design of passive treatment systems

Table 1 shows averaged data from the Appendix of the Draft Shamokin Creek Watershed TMDL for the Henry Clay Stirling discharge. When net alkalinity is calculated using ($\text{alkalinity}_{\text{measured}}$ - $\text{acidity}_{\text{measured}}$), the value is 35.8 mg $CaCO_3$/L, suggesting that the discharge is clearly net alkaline. When net alkalinity is calculated using ($\text{alkalinity}_{\text{measured}}$ - $\text{acidity}_{\text{calculated, Eqn. 1}}$), the value is 5 mg $CaCO_3$/L, suggesting that the discharge is borderline net alkaline. The simple experiment of storing water from this discharge, open to the atmosphere, for one week shows that the pH usually drops to approximately 4.5, so clearly this water is not net alkaline.

Table 1. Data and calculated values for the Henry Clay Stirling discharge.

Concentration, mg/L		Concentration, mg $CaCO_3$/L				
Fe	Mn	$Acidity_{meas,}$	$Alk_{meas,}$	$Acidity_{calc}$	Net $alk_{meas,}$	Net alk_{calc}
27.5	3.5	25.2	61	56	35.8	5

If one were to use the formula net alkalinity = ($alkalinity_{measured}$ - $acidity_{measured}$) to determine whether additional alkalinity is required to treat this water, one would *incorrectly conclude that no limestone (for passive treatment) is needed*. In fact, additional alkalinity *is required to adequately treat this water*. Although the calculated net alkalinity is positive, the fact that the pH of this water drops to approximately 4.5 upon storage can be used to determine that this water would indeed require added alkalinity.

Suggestions for design of passive treatment systems

- Do not use net alkalinity = ($alkalinity_{measured}$ - $acidity_{measured}$).
- Use net alkalinity = ($alkalinity_{measured}$ - $acidity_{calculated,\ Eqn.\ 1}$) and determine final pH after one week of storage open to the atmosphere.

Many professionals who design passive treatment systems already follow the suggestions above. However, many do not, and this fact can result in inadequate mine water treatment.

Why the discrepancy between methods?

Many mine water samples contain both alkalinity and acidity, which are not mutually exclusive. Standard acidity titration methods (APHA 2310, EPA 305.1, ASTM D1067-92 (1996)) allow the HCO_3^- alkalinity already present in the water to react with acidity from H^+ or from the hydrolysis of metals. This fact causes the titration methods to underestimate the actual acidity present in water samples. In samples containing no alkalinity (pH < 4.5), the titration methods work fine, returning acidity concentrations very close to the acidity calculated using Equation 1.

Response:

We are not going to re-compute values for the TMDLs at this time. Following along with your suggestion, a note had been added to the explanation of the pH method that explains the flaw in the calculation.

This information will be passed along to the Pa. DEP staff that are involved in the design of passive treatment systems.

Shamokin Creek Restoration Alliance Comments:

Comment:
Phrases and terms in the report are not clear as to what is intended or recommended. As an example, terms such as ‘re-mining incentives’, ‘alternate bonding requirements’, and ‘simplified permitting requirements’ are not very specific. Without a clearer explanation as to what is meant by the phrases used in the recommendation portion of the report, the Alliance is unable to

determine what DEP is actually recommending, thus, we are unable to comment either for or against the general recommendations.

Response:
The terms referenced in your comment are defined below:
"Remining incentives" and "simplified permitting requirements" refer to the Commonwealth's "Reclaim PA" initiative. There is information available on the Department website at http://www.dep.state.pa.us and typing Reclaim PA in the direct link box.
"Alternative bonding requirements" refers to the current bonding process in use in the Commonwealth. We are in the process of changing to a conventional bonding system as defined by 30 CFR Subchapter J Section 800.11.

Comment:
There is one specific phrase in the recommendations that leads us to believe that DEP is suggesting that water quality be allowed to worsen is the watershed. This recommendation, even without further clarification, is totally unacceptable. We see no reason or justification to allow poorer water quality when we are attempting to improve the water quality throughout the watershed.

Response:

The specific phrase in question has been removed.

Comment:
We cannot understand why there are not other recommendations that could have been made that would help to address the impaired water quality of the watershed. The Alliance proposes that the following recommendations be included in the final report to the United States Environmental Protection Agency.

a. The United States Congress should release all of the funds collected from the tax on coal mined.
b. The United States Congress should pursue what was H. R. 4314 that would result in reclamation of 120,000 acres of abandoned mine lands over the next 30 years through $1.3 billion in tax credit bonds.
c. The Pennsylvania State Legislature should budget additional funds for abandoned mine reclamation.
d. DEP, US Army Corps of Engineers and EPA should simplify the grant application processes for watershed groups attempting to improve watersheds that are identified as impaired.
e. DEP, US Army Corps of Engineers and EPA to waive application fees for water improvement projects implemented by watershed groups.
f. Tax incentives for re-mining operations that include some level of improvement to acid mine water discharges located within the permitted area.
g. Tax incentives by federal and state governments to businesses and industry that convert to coal as a heat or power source so as to increase demand, thus increasing re-mining potential.

h. Cooperation/communication between agencies within DEP, such as between storm water groups and abandoned mine reclamation groups.

When the Shamokin Creek Restoration Alliance approached the agency within DEP that was responsible for the storm water project for the Mt. Carmel area to ask they consider looking into the acid mine water we were told it was not their problem, to contact the abandoned mine group. If the agencies with DEP cannot work together to address the overall water quality, it makes it more difficult for watershed groups to make progress.

i. Cooperation between state agencies.

When the Alliance contacted PennDOT and DEP about acid mine water at the site where a new bridge was to be built, PennDOT's response was that since they did not cause the problem, they were not responsible for fixing it. Similar to our comment above, this lack of cooperation within state government is not helpful to citizens who are trying to make a difference.

Response:
The recommendations you make are beyond the scope of the TMDL, which does not include such specific recommendations, and therefore are not included in the report. We have, however, passed the noted recommendations to the Mineral Resources Deputate for their consideration in future department activities, and to U.S. EPA. We look forward to working in partnership with your organization, and other groups and agencies in efforts to restore the watershed. We also suggest that you contact your legislators with these recommendations.

Comment:
This report and recommendations do not address all of the problems within the watershed. There is no mention of the fact that there are almost 100 DEP permitted discharges for sewage to enter the Shamokin Creek either in Mt. Carmel or Shamokin. Solving the acid mine water problem will not return this creek to a condition that will allow people to enter the water, as is stated as a goal of this process.

Response:
This TMDL was completed to address the impairments noted of the Departments 303(d) list. Future assessment work in the watershed will be needed to document any other water quality impairments. TMDLs will be developed, as necessary, to address any other impairments that are found.