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West Branch Susquehanna River Subbasin Small Watershed Study: Morgan Run Watershed

A Water Quality and Biological Assessment, November 2003 - September 2004

The Susquehanna River Basin Commission (SRBC) conducted a survey in the Morgan Run Watershed from November 2003 to September 2004 as part of the Year-2 small watershed study in the West Branch Susquehanna River Subbasin (Figure 1). The Year-1 survey was conducted in the West Branch Susquehanna Subbasin from July to November 2002 (LeFevre, 2003). Through this Year-1 survey, SRBC determined that the largest source of impairment in the West Branch Subbasin was abandoned mine drainage (AMD), and a large portion of the abandoned mine lands (AML) were concentrated in the western part of the subbasin. Based on these findings from the Year-1 survey and input from state and local government officials and watershed organizations, SRBC decided to conduct its Year-2 study in the Morgan Run Watershed, which is heavily impacted by AMD. The goal of this Year-2 study was to provide chemical, biological, and habitat information to the state and local government officials, watershed organizations, local citizens, and other interested parties. The ultimate goal is to have a Total Maximum Daily Load (TMDL) and restoration plan developed and implemented for the Morgan Run Watershed.

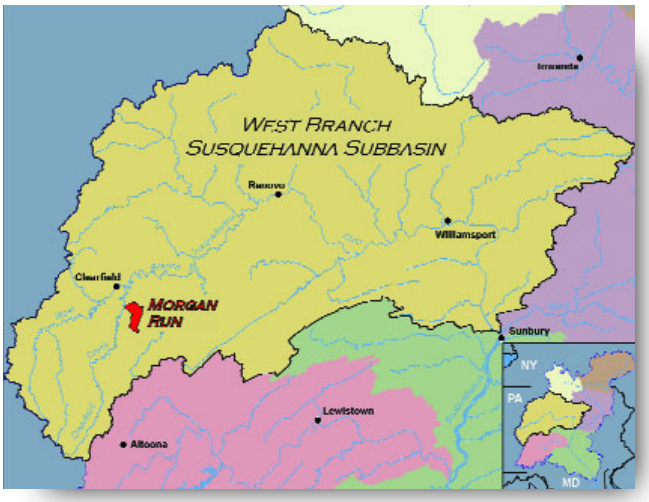


Figure 1. *Morgan Run Watershed Located in the West Branch Susquehanna Subbasin*

The Year-2 survey included quarterly water chemistry samples and flow measurements, and spring and summer sampling and assessment of macroinvertebrates, fish, and habitat. For more information on the Subbasin Survey Program at SRBC, see reports by Diehl and Sitlinger (2001), LeFevre (2002), LeFevre (2003), and LeFevre (2004). These reports are posted on SRBC's web site at http://www.srbc.net/techreports.htm.

S. LeFevre

Morgan Run downstream of Crooked Sewer Run

Description of the Morgan Run Watershed

Morgan Run, a Cold Water Fishes (CWF) stream, is a tributary to Clearfield Creek and is located southeast of Clearfield, Pa., in Clearfield County. The watershed drains approximately 14.55 square miles (9,315 acres) starting near Ashland, Pa., and flowing to south of Dimeling, Pa., which includes Boggs, Decatur, and a small portion of Woodward Townships.

The study area lies within Ecoregion 67 – Central Appalachian Ridges and Valleys, which is characterized by ridges and valleys of varying widths and heights formed by folding and faulting events. The predominant geologic materials consist of sandstone, shale, limestone, dolomite, siltstone, chert, mudstone, and marble; springs and caves are common in this ecoregion (Omernik, 1987).

The Morgan Run Watershed is mostly forested and sparsely populated (Figure 2). A large portion of the watershed is covered by State Game Lands (SGL) #98. A small percentage of the watershed is crop agriculture. Occasional logging activities occur in the watershed, but no significant operations were present at the time of the survey. There are small residential areas in Newtown, Jeffries, Burly, and New Castle. Some of the residences in the watershed appear to be seasonal cabins. A closed landfill exists north of Jeffries, and another landfill is proposed for the neighboring watershed of Camp Hope Run.

Morgan Run is protected with naturally vegetated areas surrounding the riparian zone of the stream. The headwaters area of Morgan Run is low gradient and slow-moving. A section of stream between Jeffries and SGL #98 is affected by beaver dams. Further disturbances to the hydrology and geomorphology of the stream may be attributed to the previous land disturbance that resulted from mining activities in this area.

Mining in Morgan Run Watershed began in the early 1900s with clay and coal mining. This early mining was very destructive, since there were no regulations

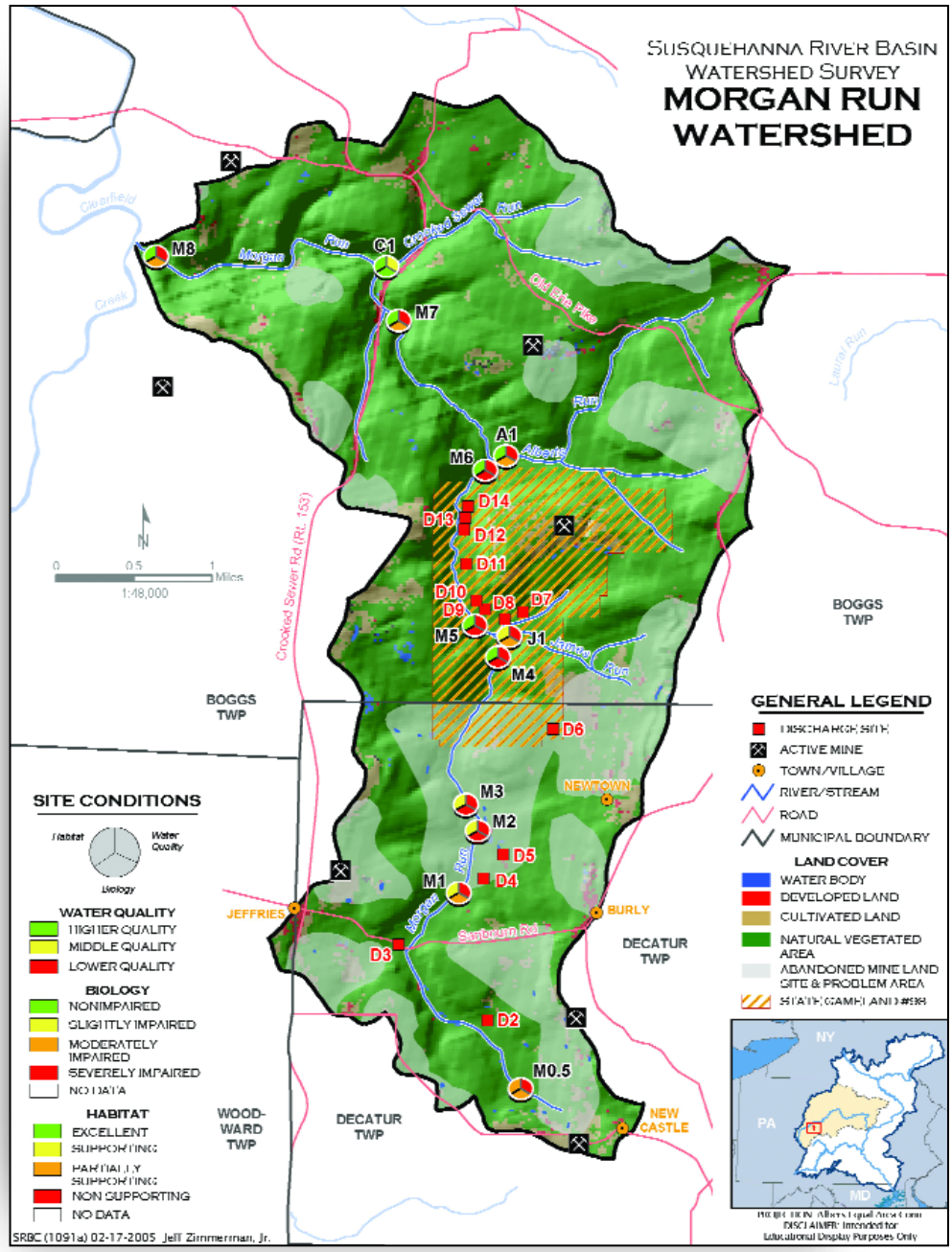


Figure 2. *Land Use, Township Boundaries, and Site Conditions in the Morgan Run Watershed*

at the time legally requiring land or water reclamation. A fish survey on Morgan Run was completed in 1931 that found the stream to be badly polluted with no fish species present (Commonwealth of Pennsylvania Board of Fish Commissioners, 1931). In 1945, legislators passed the Pennsylvania Bituminous Coal Open Pit Mining Conservation Act that required coal miners to register their mines, post a bond, at least partially backfill, and revegetate if possible (Pennsylvania Department of Environmental Protection, 2005). Also, in 1945, the Clean Streams Law was amended to require miners to submit a discharge plan for mine drainage (Pennsylvania Department of Environmental Protection, 2005). In the late 1960s, the Land and Water Conservation and Reclamation Act strengthened laws and regulations governing coal mining in Pennsylvania. This Act required reclamation of AML and abatement of the drainage from those lands (Pennsylvania Department of Environmental Protection, 2005).

AMD is often characterized by acidic waters and high metals and sulfates produced by water and oxygen contacting pyritic material and other soil and rock layers exposed through the

process of mining. The soil and rock layers, termed overburden, determine the characteristics of the AMD such as levels of acidity or alkalinity and levels of different metals and sulfates. The impacts to streams vary, but AMD often results in orange or gray colored metal precipitate that coats the streambed. These poor water quality and habitat conditions caused by AMD are detrimental to aquatic life.

Morgan Run Watershed, located in State Water Plan 08C, was impaired for AMD by SRBC biologists in 1999 and 2003 as part of the Pennsylvania Department of Environmental Protection (PADEP) Unassessed Waters Program. Approximately 10 miles of the mainstem of Morgan Run was listed on the 2002 and 2004 Pennsylvania Section 303(d) impairment lists for high metals and low pH. The tributaries, Crooked Sewer Run and Alberts Run, were assessed as attaining, and James Run was not assessed since it was determined to have intermittent flow.

On March 20, 2003, concerned citizens established the Morgan Run Watershed Group with a mission to:

- *Restore Morgan Run by improving water quality and protecting the surrounding land through cooperation of the landowners;*
- *Restore aquatic life and a native fish population; and*
- *Educate the public and local communities on ecological benefits for future generations (Carnahan, 2005).*

Prior to the formation of the Morgan Run Watershed Group, Clearfield County Conservation District (CCCD) conducted a study of the Morgan Run Watershed in 2002 and 2003 with water sampling and family-level macroinvertebrate investigations. Water sampling was conducted at 15 discharges, and inspections for macroinvertebrate life were conducted in springs, small tributaries, and sections of the mainstem to determine sources of recolonization for Morgan Run. CCCD concluded that Morgan Run was impacted by AMD; however, if this stream were reclaimed, it would have sources for recolonization and would have excellent habitat for trout in beaver dam pools and in deep pools that exist in the lower two-thirds of the watershed.

Methods
DATA COLLECTION

During November 2003 to September 2004, SRBC collected water chemistry samples and measured flow quarterly at three tributary sites, nine instream sites, and 13 discharge sites. Macroinvertebrate collections and habitat assessments were completed at the nine instream sites and three tributary sites from May 24 - 27, 2004. Electrofishing surveys were completed at three instream sites and four tributary sites from June 28 - July 1, 2004. Appendix A contains a list of station names, sampling location descriptions, and latitude and longitude coordinates. Abandoned mine discharge sites are listed in red.

Water chemistry samples were collected quarterly in November 2003, March 2004, May 2004, and September 2004 for field and laboratory parameters (Table 1), according to the standard protocol for AMD TMDL analysis. Samples were split into a 250-ml bottle acidified with nitric acid for metals analysis, and a 500-ml bottle for all additional parameters. Hot acidity is measured in AMD streams since it takes into account metal oxidation and provides information on the excess alkalinity needed to neutralize the sample (Cravotta III and Kirby, 2004). Abandoned mine discharges were directed through a weir or pipe, and flow was measured according to the Clay Pipe Manual (National Clay Pipe Institute, 1974) at weirs, and as volume per time at pipes. The weirs were either 1-foot rectangular or 90° V-notch weirs where height of water was measured. The smaller discharges were measured at a pipe with a container of known volume and a stopwatch. Flow at instream and tributary sites was measured using a Scientific Instruments pygmy meter according to the United States Geological Survey methods (Buchanan and Somers, 1969). If a weir was not functioning correctly at the time of sampling, flow was measured with the pygmy meter, where applicable.

Macroinvertebrate samples, fish surveys, and habitat assessments were completed according to a modified version of the United States Environmental Protection Agency's (USEPA's) Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (RBP III) (Plafkin and others, 1989; Barbour and others, 1999). Electrofishing surveys included a one-time pass through 100-meter stretches of streams using a Coffelt electrofishing backpack unit that delivers a direct current. Fish captured were identified, measured for length, and released. A field sample of water chemistry was collected, and five measurements of stream width were gathered for an average width. An additional site was added in the headwaters of Alberts Run for the electrofishing survey due to anecdotal accounts of fish presence. All other water quality, macroinvertebrate collection, and habitat assessment methods follow the methods listed in LeFevre (2003).

Table 1. *Water Quality Parameters Sampled in the Morgan Run Watershed*

FIELD PARAMETERS	
Flow, instantaneous cfs[a]	Conductivity, µmhos/cm[c]
Temperature, °C	Alkalinity, mg/l
pH	Acidity, mg/l
Dissolved Oxygen, mg/l[b]	
LABORATORY ANALYSIS	
pH-3.9	Sulfate, mg/l
Alkalinity-3.9, mg/l	Total Iron, µg/l[d]
Total Suspended Solids, mg/l	Total Manganese, µg/l
Total Calcium, mg/l	Total Aluminum, µg/l
Total Magnesium, mg/l	Hot Acidity, mg/l

[a] cfs = cubic feet per second
[b] mg/l = milligram per liter
[c] µmhos/cm = micromhos per centimeter
[d] µg/l = micrograms per liter

DATA ANALYSIS

Water quality was assessed by examining the field and laboratory parameters (Table 1) for AMD conditions. Water quality levels of concern were established for each parameter based on state and federal regulations or references for approximate tolerances of aquatic life (Table 2). The difference between each value and the level of concern value from Table 2 was calculated for each site, and if the value did not exceed the level of concern value, the site was given a score of zero. If the level of concern value was exceeded, the difference was listed, and an average of all the parameters for each site was calculated. The four quarterly sample averages were combined for one cumulative average for each site. The sites were grouped by stream sites (instream and tributary) and discharges, and a percentage of the highest cumulative average value (representing the worst water quality) was taken for each group in order to account for differences between stream sites and discharges. All sites that received a zero (no parameters exceeded the limits) were classified as "higher" quality. Sites that had a percentage value between zero and one were classified as "middle" quality, and sites with a percentage value greater than one were classified as "lower" quality.

Benthic macroinvertebrate samples were analyzed using seven metrics mainly derived from USEPA's RBP manual (Plafkin and others, 1989; Barbour and others, 1999): (1) taxonomic richness; (2) modified Hilsenhoff Biotic Index; (3) percent Ephemeroptera; (4) percent contribution of dominant taxon; (5) number of Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa; (6) percent Chironomidae; and (7) Shannon-Wiener Diversity Index. A reference site (C1) was established based on the best results of macroinvertebrate, water chemistry, fish, and habitat conditions. The macroinvertebrate metric scores were compared to the reference site scores, and a biological condition category was assigned based on USEPA's RBP methods (Plafkin and others, 1989; Barbour and others, 1999).

The same reference site was used in the analysis of the habitat scores. The ratings for each habitat condition were totaled, and a percentage of the reference site was calculated. The percentages were used to assign a habitat condition category to each site (Plafkin and others, 1989; Barbour and others, 1999).

Fish data were simply tallied and applied to metrics to display results. Metrics recommended in the USEPA RBP manual (Barbour and others, 1999) for the Central Appalachian Region include: (1) total number of species; (2) number of darter species; (3) percentage of creek chubs; (4) percentage of generalist feeders; (5) percentage of specialized insectivores; (6) number of individuals; and (7) percentage of diseased individuals. The metrics were not compared to a reference site or assigned a biological condition category, since only two sections of stream were found to have fish.

Loading values were calculated for all the sites in the Morgan Run Watershed for acidity, alkalinity, iron, manganese, aluminum, and hot acidity.

Table 2. *Water Quality Levels of Concern and References*

PARAMETERS	LIMITS	REFERENCE CODES
Temperature	>25 °C	a,d
Dissolved Oxygen	<4 mg/l	a,e
Conductivity	>800 µmhos/cm	c
pH	<5	b,d
Acidity	>20 mg/l	i
Alkalinity	<20 mg/l	a,e
Total Suspended Solids	>25 mg/l	f
Calcium	>100 mg/l	i
Magnesium	>35 mg/l	g
Sulfate	>250 mg/l	a
Iron	>1,500 µg/l	a
Manganese	>1,000 µg/l	a
Aluminum	*>200 µg/l	b
Hot Acidity	>0 mg/l	h

** Aluminum detection level in the lab water analysis was 500 µg/l*

REFERENCE CODES/REFERENCE

a	http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b	Gagen and Sharpe (1987) and Baker and Schofield (1982)
c	http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
d	http://www.hach.com/h2ou/h2wtrqual.htm
e	http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
f	http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf
g	http://www.dec.state.ny.us/website/regs/part703.html
h	Cravotta and Kirby (2004)
i	Based on archived data at SRBC

Taxonomic Richness: Total number of taxa in the sample. Number decreases with increasing stress.

Hilsenhoff Biotic Index: A measure of organic pollution tolerance. Index value increases with increasing stress.

Percent Ephemeroptera: Percentage of number of Ephemeroptera in the sample divided by the total number of macroinvertebrates in the sample. Percentage decreases with increasing stress.

Percent Contribution of Dominant Taxa: Percentage of the taxon with the largest number of individuals out of the total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

EPT Index: Total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa present in a sample. Number decreases with increasing stress.

Percent Chironomidae: Percentage of number of Chironomidae individuals out of total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

Shannon-Wiener Diversity Index: A measure of the taxonomic diversity of the community. Index value decreases with increasing stress.

The loadings for each parameter were expressed in pounds per year (lbs/yr) after converting flow from cubic feet per second (cfs) to million gallons per day (MGD) and then using the formula:

lbs/yr = concentration mg/l *
[(8.345 lb/MG)/(mg/l)] *
flow MGD * 365 days/year.

An average loading value was calculated from the four quarterly samples.

Information on the mining activities in Morgan Run Watershed was gathered by reviewing the permit files at the PADEP Moshannon District Mining Office in Phillipsburg, Pa. The files were reviewed in February 2005.

Results/Discussion

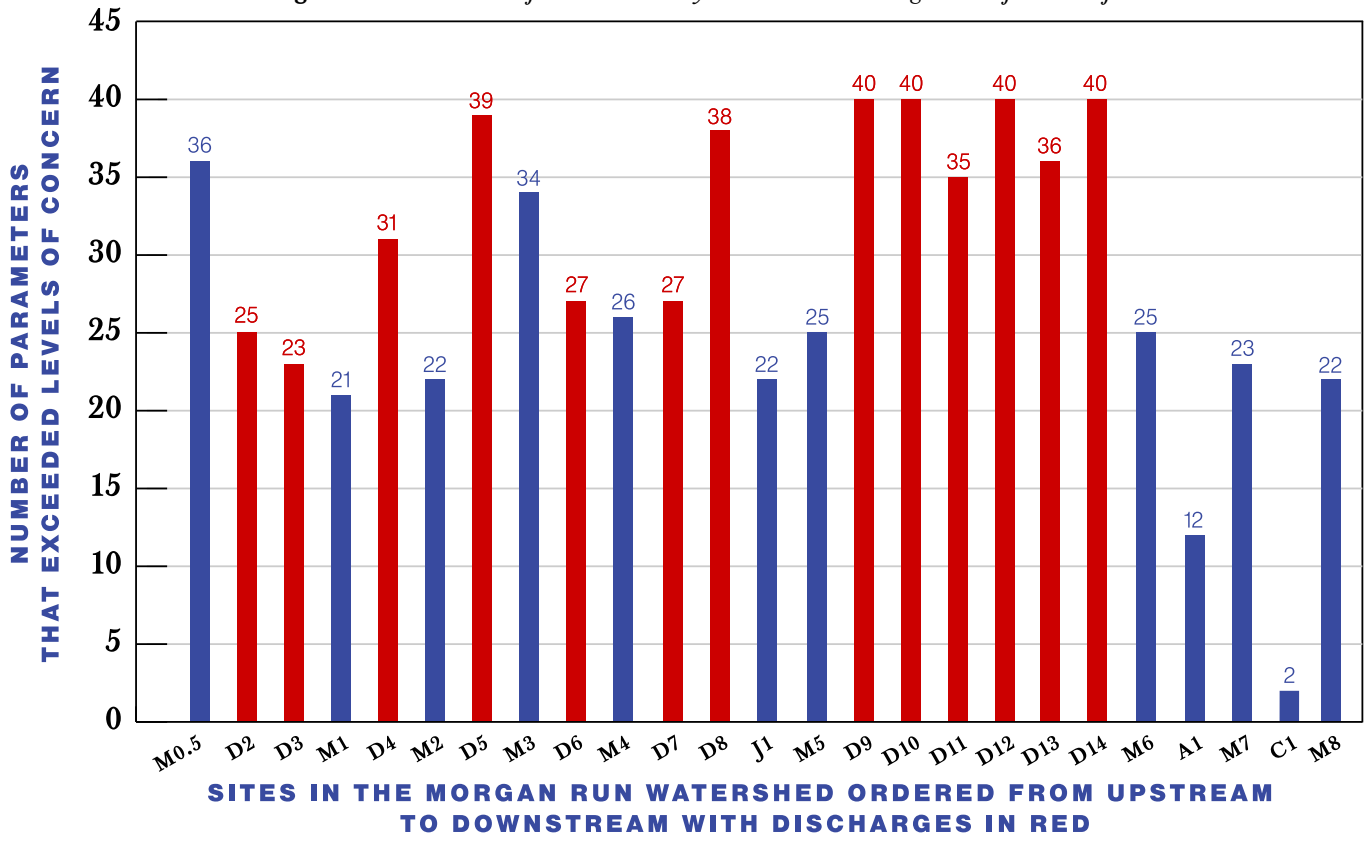
Water quality, macroinvertebrate, and habitat site conditions for each sampling site are depicted in Figure 2. Crooked Sewer Run (C1) served as the reference site for the Morgan Run Watershed since this site included the overall best conditions for water chemistry, biology, and habitat. All of the sites received a "lower" water quality rating except C1, which received a "middle" rating. C1 did not receive a "higher" quality rating due to a few alkalinity and hot acidity values that slightly exceeded levels of concern. M3 and M0.5 had the worst water quality scores of the instream sites. The mine discharge with the worst water quality score was D14. M0.5 was the instream site with the highest number of parameters (36) that exceeded levels of concern, and D9, D10, D12, D14 were the discharge sites with the highest number of parameters (40) that exceeded levels of concern (Figure 3).

The highest level of metal from the quarterly samples on Morgan Run was 92,691 µg/l of manganese at D11 in September 2004. D14 exhibited the highest average level of manganese (80,687 µg/l), indicating that manganese was consistently high during sampling at this site. D5 produced the highest single sample level of iron (66,000 µg/l), and D14 had the highest single sample level of aluminum (32,900 µg/l) of all the sites in the watershed. The highest hot acidity discrete value was found at D11 (449 mg/l); however, D13 had the highest average hot acidity (344.08 mg/l).

Average concentrations of iron, manganese, and aluminum in Morgan Run mainstem sites, in order from the headwaters to the mouth, are depicted in Figure 4. Average manganese concentrations were highest at M0.5, M3, and M6. Manganese maintained the highest levels of these three metals at all sites except M3, where there was a spike of iron. Iron had the lowest average concentrations, except for at M3, and at times was below the level of concern. Average aluminum concentrations were higher than average iron concentrations from M4 to M8, and were above the level of concern at all sites.

Figure 5 provides the number of water chemistry samples to have values exceeding levels of concern for each parameter. Alkalinity was the parameter to exceed levels of concern in the highest number of samples (99 out of 100 possible samples). Hot acidity and pH exceeded levels of concern in a high number of samples also (97 and 92, respectively). The metal that exceeded levels of concern in the highest number of samples (95) was manganese; however, the standard for manganese used in this analysis was for potable water supply and not aquatic life tolerance (Commonwealth of Pennsylvania, 2002). Aquatic tolerance can be determined using corresponding levels of hardness (Reimer, 1999); however, hardness was not measured during this study.

Figure 3. *Total Number of Water Chemistry Parameters Exceeding Levels of Concern for each Site*



Hardness was approximated by taking a regression of measured calcium and magnesium values with data from other subbasin surveys. This analysis indicated that aquatic life tolerance levels of concern for manganese were exceeded at D7, D8, D9, D10, D11, D12, D13, and D14 rather consistently in each quarter of sampling. This suggests that a priority area for manganese pollution remediation should be the discharges in SGL #98.

Macroinvertebrate samples also depicted the severity of the AMD impacts on Morgan Run. Only one site, C1, was found to be nonimpaired; the rest of the sites were either moderately or severely impaired. Severely impaired conditions existed at M2, M3, M4, M5, and M6 (Figure 2). These sites cover the middle area of the watershed from near Newtown to just upstream of Alberts Run at the northern edge of SGL # 98.

A review of the functional feeding groups of the macroinvertebrate population revealed that the feeding group "scrapers" was absent from all the sites except C1, where scrapers comprised the largest percentage of functional feeding groups (41.5 percent). Filterers/collectors were low in numbers on the mainstem Morgan Run and completely absent from M0.5, M2, and M4.

S. LeFevre

AMD Discharge to Morgan Run at Sanbourn Road

"Only one site, C1, was found to be nonimpaired; the rest of the sites were either moderately or severely impaired."

Scrapers were absent and filterers/collectors were reduced most likely due to the AMD precipitate on the substrate and the filterers' nets, interfering with the method of feeding and the food source. Shredders were relatively more abundant

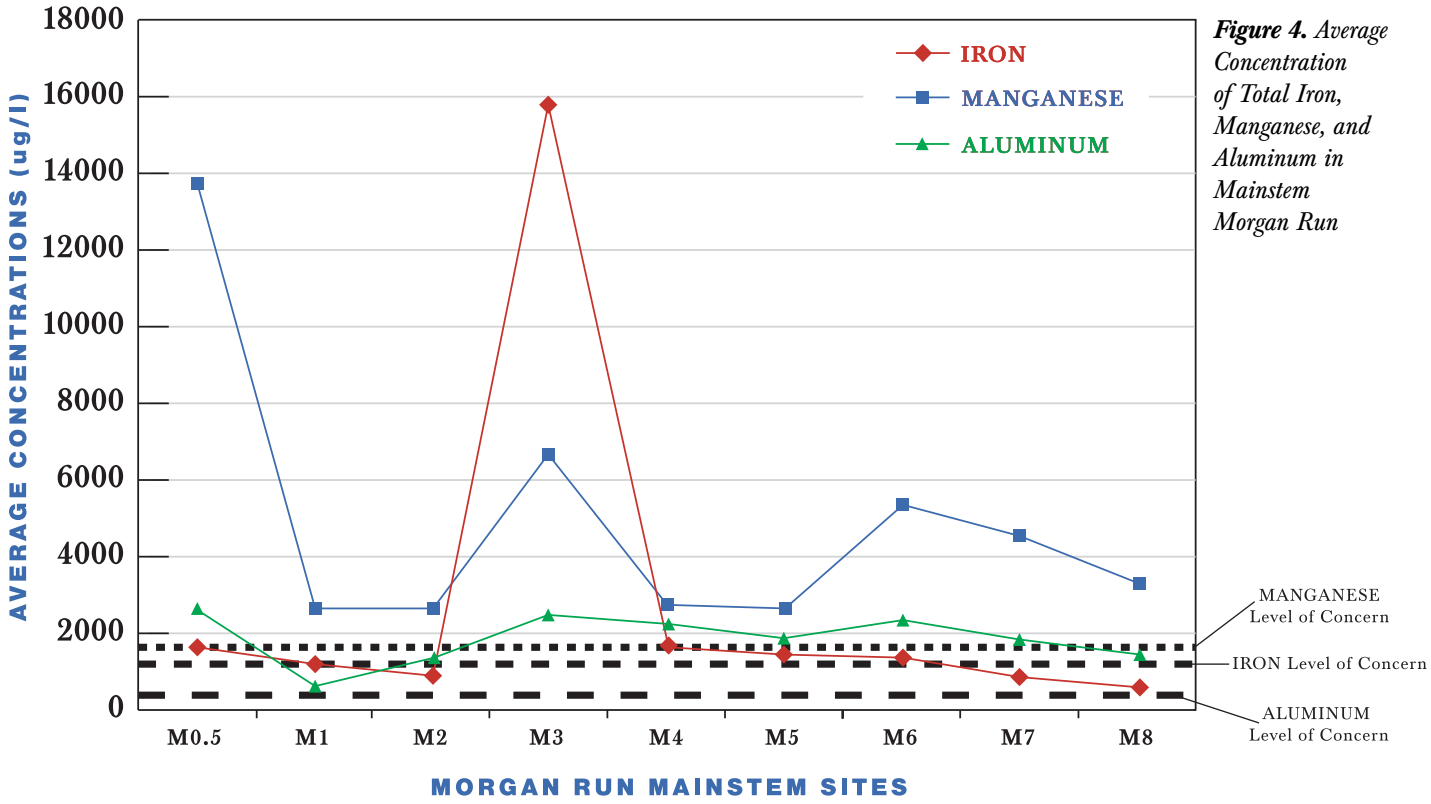


Figure 4. *Average Concentration of Total Iron, Manganese, and Aluminum in Mainstem Morgan Run*

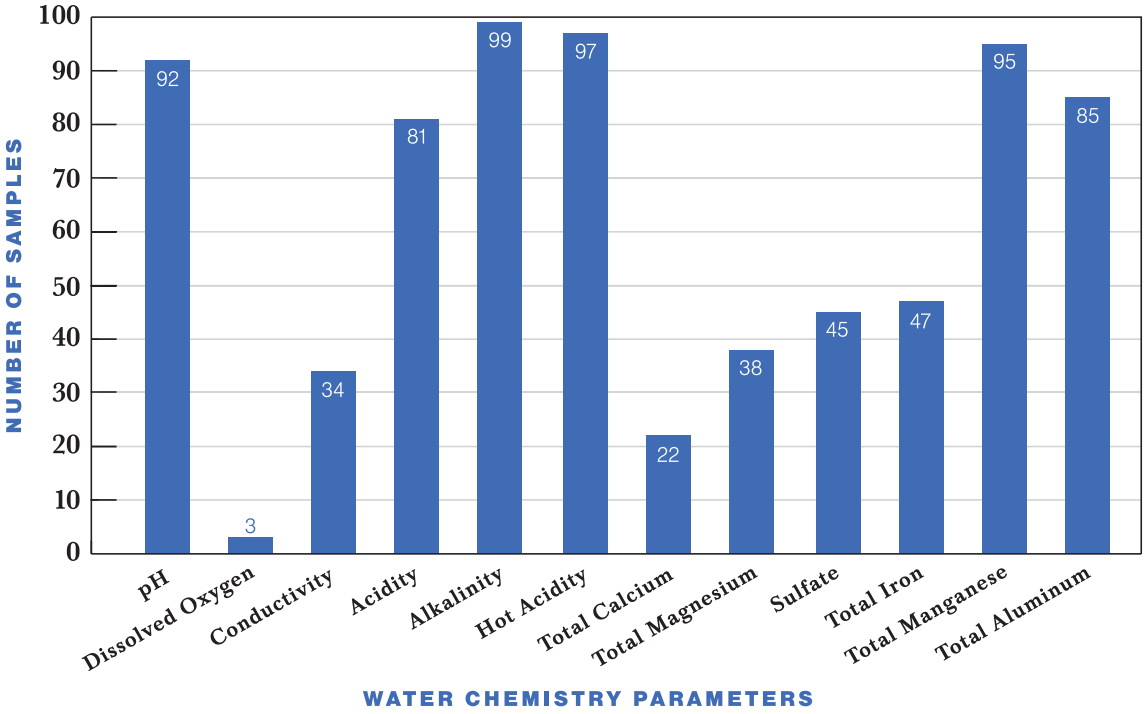


Figure 5. *Number of Water Chemistry Samples to Exceed Levels of Concern for each Parameter*

in the headwaters, near the mouth, and in the tributaries, and had lower percentages throughout the middle section of the watershed. Predators and collectors/gatherers were the most common functional feeding groups throughout the mainstem Morgan Run and in the most impaired sites.

Only two of the electrofishing sites maintained a fish population (Figure 6 and Table 3). Crooked Sewer Run maintained brook trout (*Salvelinus fontinalis*) and white suckers (*Catostomus commersoni*), and the headwaters of Alberts Run (ALBT Hdw.) had brook trout (*Salvelinus fontinalis*), white suckers (*Catostomus commersoni*), blacknose dace (*Rhinichthys atratulus*), and spottail shiners (*Notropis hudsonius*). These populations appeared to be reproducing due to the presence of different size fish and parr markings on small trout. The fish at C1 ranged in size from 5.9 - 17.7 cm, and the fish at ALBT Hdw. ranged from 4.2 - 18.6 cm. Even though ALBT Hdw. had a wider range of sizes, there was a higher frequency of small fish at ALBT Hdw. The mean length for brook trout at C1 was 13.25 cm, compared to the mean length at ALBT Hdw. of 7.42 cm. Computation of the metrics indicated that total number, density, and taxonomic richness were higher at ALBT Hdw. than C1. Diversity was also higher (0.772) compared to 0.245 at Crooked Sewer Run.

Habitat conditions were mostly excellent and supporting with only one site (M0.5) rated as partially supporting. The lower ratings for habitat were in the upper third of the watershed where the stream meandered through a series of wetland type areas.

Loading calculations take into account the amount of flow and concentration of measured parameters at a particular site. Calculations of average loading values for Morgan Run indicate that M3 had the highest loads in lbs/yr of acidity (2,138,588 lbs/yr) and iron (449,695 lbs/yr); M7 had the highest loads of manganese (195,147 lbs/yr) and aluminum (83,272 lbs/yr); and M8 had the highest amount of hot acidity (3,817,180 lbs/yr) (Table 4). Numerous sites had zero lbs/yr of alkalinity. The sites near the mouth of Morgan Run exhibited higher loading values because the flow was largest there, representing a cumulative impact. Loading analysis is pertinent for assessment of discharges and tributaries, since it takes into account the flow or amount of pollutant that these sites are contributing to Morgan Run instead of the concentration. D5 had the highest average loading values for acidity, iron, manganese, aluminum, and hot acidity of the discharge and tributary sites. This explains the high iron and acidity loads for M3, since it was the site located downstream of D5. The tributary sites, A1 and J1, mostly contribute manganese and hot acidity to Morgan Run; however, they also contribute alkalinity.

The discharge water chemistry results from this survey were similar to the discharge results obtained by CCCD. The only site that showed a major difference was D9 in aluminum levels. The aluminum values that CCCD recorded at D9 were much higher than those recorded by SRBC; however, it appeared that aluminum levels at this site were decreasing over the course of the CCCD study.

S. LeFevre

Electrofishing on Crooked Sewer Run.

MORGAN RUN (M0.5)

M0.5 was the most upstream site in the watershed during this survey. This site characterizes the headwaters of Morgan Run, which are impacted immediately by AMD. Permit files on mining operations in the area upstream of M0.5 referenced surface mining in the 1980s for Upper Kittanning, Middle Kittanning, Lower Kittanning, Clarion, Mercer, and Lower Freeport Coals and Mercer Clay. The mining permit files also contained a history of mining that indicated this area had at least four mining operations prior to the 1980s of both deep and surface mines for clay and coal. One more recent mining operation was a government-financed reclamation that used the money earned by remining coal to finance the reclamation of the land. This operation occurred from approximately 2000 to 2001 and was used to reclaim a 3.4-acre area of land subsidence. This operation was considered an active mine in 2005 and was located near New Castle, Pa. (Figure 2).

The sampling results at M0.5 indicated AMD pollution including low pH and alkalinity and high metals. This site had the lowest pH and the highest conductivity, calcium, magnesium, sulfate, manganese, and aluminum levels of all instream sites. The level of concern for iron was exceeded during one sampling quarter in this survey, whereas the levels of concern for acidity, pH, alkalinity,

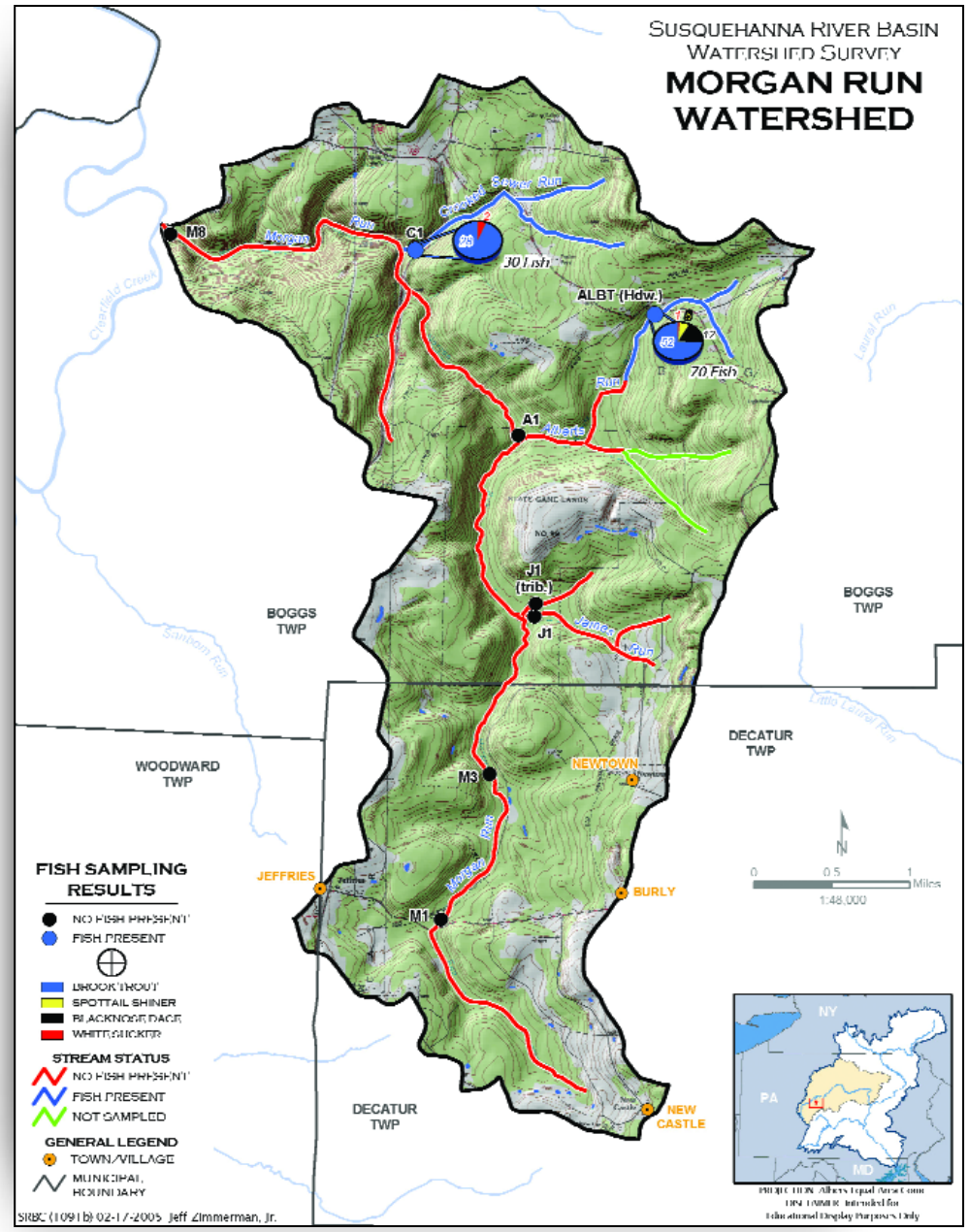


Figure 6. *Fish Sampling Results and Topographic Map of Morgan Run Watershed*

Table 3. *Electrofishing Survey - Morgan Run June 28 - July 1, 2004*

SITE	DATE	TIME	DURATION (shock time on coffelt unit)	Mean Area (ft.2)	HABITAT	FISH	pH	Cond. (µhmos/cm)	Temp. Celsius	D. O.	Alk.	Acidity
M3 (Trial Run)	20040628	1415	361 secs.	2132.65	Mostly pools; a lot of log jams	NONE	N/A	N/A	N/A	N/A	N/A	N/A
A1	20040629	800	514 secs.	4278.42	Riffles 45%; Pools 30%; Runs 20%; Snags 5%	NONE	5.35	244	13.3	8.07	2	14
C1	20040629	1015	680 secs.	2546.06	Riffles 50%; Pools 50%	28 Brook Trout; 2 White Sucker	7.5	176	14.6	8.1	28	2
M1	20040630	910	425 secs.	3773.15	Pools 70%; Runs 5%; Snags 25%	NONE	3.8	573	15.9	NA	0	26
J1	20040630	1045	517 secs.	2801.97	Riffles 40%; Pools 25%; Runs 30%; Snags 5%	NONE	4.8	203	13.3	8.14	2	8
J1 (tributary)	20040630	1115	176 secs.	2119.53	Riffles 25%; Pools 50%; Runs 10%; Snags 15%	NONE	4.35	168	13.1	NA	0	18
M8	20040630	1430	603 secs.	7769.41	Riffles 50%; Pools 45%; Runs 5%	NONE	4.1	410	19.6	7.54	0	24
ALBT Hdw.	20040701	800	683 secs.	1778.30	Riffles 50%; Pools 25%; Runs 15%; Snags 10%	52 Brook Trout; 12 Blacknose Dace; 5 Spottail Shiner; 1 White Sucker	6.7	168	15.1	7.99	14	4

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Measuring length of Brook Trout from Crooked Sewer Run.

magnesium, sulfate, manganese, aluminum, and hot acidity were exceeded every quarter. The macroinvertebrate community at this site was rated moderately impaired and was dominated by large numbers of the stonefly *Leuctra*, which is tolerant of some AMD conditions. M0.5 had a partially supporting habitat rating with high levels of sediment and embeddedness. The stream was slow-moving and surrounded by wetland areas.

DISCHARGES (D2 & D3)

D2 and D3 were discharges in the headwaters between M0.5 and M1. There was one active mine file for the area between M0.5 and D2 and D3. The operations for this permit were surface mining and fly ash disposal in the Lower and Middle Kittanning coal seams. This mine permit was issued in the mid-1980s and was considered active in 2005 (Figure 2), since it was abandoned recently and the bonds on the site were forfeited. Information on historical mining in this headwaters area south of Sanbourn Road (SR2012) includes at least seven surface and deep mines used for coal and clay in the Kittanning and Mercer seams. Many of these older operations were abandoned and not reclaimed. At the time of the survey, mine spoil piles still existed in this general area. Some of the mines, particularly the deep clay mines, probably were mined prior to the 1930s. D2 and D3 most likely originated from either the deep clay or coal mines or from surface coal mine operations conducted prior to the 1970s in this area. A hydrologic study completed in the mid-1980s, required for a coal mining application, reported AMD pollution of the local groundwater in the area around Jeffries near D3 from previous mining activities.

Both discharges were characterized by low pH, low alkalinity, and high manganese. Levels of iron were relatively low at D2, and levels of aluminum were relatively low at D3. D2 and D3 had the lowest number of parameters to exceed levels of concern for the discharges (Figure 3) and did not exceed levels of concern for conductivity, magnesium, and sulfate. D2 only exceeded the level of concern for iron during September 2004, and D3 never exceeded the aluminum detection limit during this survey. D3 produced the largest flow of all the discharges, indicating a larger influence on Morgan Run. Average loading values for iron, manganese, hot acidity, and sulfate were second highest for D3 compared to the other discharges; however, D3 also had the highest average loading level of alkalinity, which may help in reclamation efforts.

Table 4. *TMDL Average Values from 2003 - 2004 in the Morgan Run Watershed*

	ACIDITY lbs/yr	ALKALINITY-3.9 lbs/yr	IRON lbs/yr	MANGANESE lbs/yr	ALUMINUM lbs/yr	HOT ACIDITY lbs/yr
A1	58,762	81,114	3,137	13,622	5,119	246,775
C1	22,275	125,300	1,542	257	2,625	-10,077
J1	79,853	28,480	1,357	11,181	4,740	201,337
D2	34,529	0	358	2,013	2,711	35,899
D3	63,525	20,370	10,561	10,247	1,490	110,193
D4	75,135	0	1,254	5,932	6,524	68,880
D5	323,421	0	53,901	14,758	8,349	222,361
D6	44,993	488	1,821	6,194	1,841	81,301
D7	12,504	506	56	2,314	1,046	14,132
D8	11,307	0	209	3,345	475	12,041
D9	17,178	0	460	6,199	1,134	22,362
D10	26,727	0	956	7,050	1,411	24,633
D11	8,810	0	444	1,454	177	7,106
D12	11,352	0	688	2,401	541	10,811
D13	8,177	0	192	884	257	6,578
D14	45,211	0	1,423	8,955	3,069	37,692
M0.5	31,944	157	1,106	7,424	1,172	31,944
M1	169,925	72,389	9,299	27,028	6,991	597,986
M2	228,350	56,123	7,249	27,239	12,341	616,030
M3	2,138,588	0	449,695	163,649	55,680	1,967,574
M4	731,418	32,152	32,512	50,636	41,970	930,109
M5	809,650	72,317	36,897	64,378	47,450	1,269,541
M6	1,232,711	53,768	35,847	150,130	73,222	1,398,987
M7	1,400,320	180,684	34,015	195,147	83,272	2,664,272
M8	1,232,481	417,710	31,245	180,833	81,655	3,817,180

MORGAN RUN (M1)

M1 was located between two beaver dams, and consequently exhibited higher total suspended solids (TSS). Other problems associated with this site include low alkalinity and high manganese and aluminum, although overall, M1 was one of the least impaired water quality sites in the mainstem. M1 had the lowest average values of all the mainstem sites for aluminum, acidity, and manganese. This site also had the lowest number of parameters (21) to exceed levels of concern (Figure 3) with pH, alkalinity, manganese, and hot acidity exceeding limits in every sample, aluminum and acidity during two samples, and iron during one sample. A possible reason for the lower levels of metals at M1 may be due to the beaver dams and ponds in this area slowing down the flow and allowing metal precipitate to drop out of solution.

The macroinvertebrate population at M1 was similar to M0.5. The community was rated moderately impaired and included similar taxa, although there were fewer *Leuctra* at M1 than were found at M0.5. The habitat was impacted by beaver dams and rated supporting. The section was noticeably impacted by AMD with heavy metal precipitate covering the substrate, and the stream was slow and deep due to the beaver dams. Morgan Run was electrofished upstream of the beaver dams near this site, and no fish were found (Figure 6 and Table 3).

Mining in the area between M0.5 and M1 included numerous operations throughout the twentieth century. Mining occurred around Jeffries for Middle and Lower Kittanning coal in the 1990s, and prior to that at least three surface mines and one deep mine operated in the Lower Kittanning coal seam. The active mining operation near Jeffries (Figure 2) originated in the 1990s and was recently abandoned leaving polluted discharges that enter Morgan Run north of Sanbourn Road (SR 2012). A Successive Alkalinity Producing System or Anoxic Limestone Drain is being considered to treat these discharges using bond money the mining company set aside prior to mining the site (Carrello, 2005). The area north of Sanbourn Road between Morgan Run and Burly, Pa., was mined in the 1970s and 1980s for Mercer clay and coal and prior to that was surface mined for Mercer clay. There also was a Middle Kittanning coal mining operation south of Sanbourn Road near Burly, Pa., in the mid-1980s to mid-1990s. The mining operations between Morgan Run and Burly, Pa., and the operation south of Sanbourn Road near Burly, Pa., were completed and the land was reclaimed to current environmental standards in the early to mid-1990s. Historical records indicate that three surface mines from the 1950s for Middle and Lower Kittanning Coal existed in the area south of Burly, Pa. The area south of Sanbourn Road and to the east of Morgan Run around D2 was mined extensively, as mentioned previously in the D2 and D3 section.

DISCHARGE (D4)

The discharge at D4 was characterized by low pH and alkalinity, and high sulfate, iron, manganese, and aluminum. Levels of concern were exceeded quarterly for pH, acidity, alkalinity, sulfate, manganese, aluminum, and hot acidity. Iron and magnesium levels of concern also were exceeded. The average loading value of aluminum was the second highest value of the discharges, and acidity also was relatively high. D4 produced one of the larger flows of the discharges and probably originated from an old, abandoned, deep clay mine developed by a firebrick company in the early 1900s.

MORGAN RUN (M2)

The main problems at M2 appeared to be low alkalinity, high manganese, and high aluminum. Increased aluminum from D4 appears to impact Morgan Run at M2. Otherwise, the water quality at M1 and M2 was similar. Values for pH, alkalinity, manganese, aluminum, and hot acidity exceeded levels of concern in every sample, and acidity exceeded levels of concern in two of the samples.

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Morgan Run at Rt. 153 bridge

Iron levels appeared to decrease slightly in some of the samples from M1 to M2, possibly due to iron precipitate settling out in the beaver dam ponds. The macroinvertebrate sample from M2 was rated severely impaired with the lowest number of macroinvertebrates (20). The number of taxa decreased by three, and the number of macroinvertebrate individuals decreased by 30. This additional biological impairment could be due to the change in habitat and to difficulty in sampling. M2 was located in a marshy area with slow, deep flow and aquatic grasses. There was poor shade for the stream due to the low vegetation. The habitat at this site was rated supporting and was located approximately 25 yards upstream of a beaver dam.

The two abandoned mining operations northeast of Jeffries that impacted M1 also may have affected the water quality at M2. The recently abandoned Middle and Lower Kittanning coal strip mining operation used to maintain a treated discharge that entered Morgan Run in the swampy area near M2. An older strip mining operation farther north that had been in operation since the 1960s was abandoned in 1995. Degradation of two tributaries to Morgan Run on the south of this operation was reported in 1983. Furthermore, there were historical reports of abandoned clay strip mining operations in this area.

DISCHARGE (D5)

The discharge at D5 originates in an abandoned deep clay mine most likely developed prior to the 1930s and enters Morgan Run between sites M2 and M3. This site was one of the worst discharges in Morgan Run. Problems at D5 include low pH and alkalinity, and high acidity, conductivity, calcium, magnesium, sulfate, iron, manganese, aluminum, and hot acidity. This site exceeded all of these parameters at least once during sampling. Conductivity, acidity, pH, alkalinity, sulfate, iron, manganese, aluminum, and hot acidity were exceeded during every sampling quarter. This site generated the highest recorded iron levels (66,000 µg/l). D5 also had the highest loading values of all the discharges (Table 4) for all the parameters listed.

MORGAN RUN (M3)

Morgan Run at M3 was impacted by the discharge at D5. The pH and alkalinity decreased, and all other parameters increased significantly compared to M2. A large increase in iron was noted at this site (Figure 4). M3 exhibited the highest recorded values for iron (33,300 µg/l), acidity (134 mg/l), and hot acidity (122 mg/l) of all the instream mainstem sites, and the second highest number of parameters to exceed levels of concern (Figure 3). The loading values for acidity and iron were the highest of all the Morgan Run sites, and it was the only instream site to have an alkalinity of zero (Table 4). The macroinvertebrate community at M3 was severely impaired with the lowest number of taxa (5) present. Sampling was difficult at this site due to deep, slow moving water with thick AMD precipitate on the substrate. An increase in iron precipitate was noted here compared to M2. The habitat was rated supporting, and ratings for sediment deposition were low. A trial run of electrofishing was conducted at this site, and no fish were found.

DISCHARGE (D6)

D6 was impacted by deep mining prior to the 1930s and strip mining in the 1950s and 1960s of Lower Mercer Clay northwest of Newtown. D6 also was strongly impacted by deep and strip mining of coal on the hill northeast of Newtown during the 1940s and 1950s. Manganese, aluminum, and iron values appeared to be the most significant problems at D6, along with the low pH and alkalinity that was a problem throughout the watershed. The average loading values for iron and hot acidity were high at D6; however, there was an average loading value of 488 lbs/yr of alkalinity (Table 4), which may assist in the reclamation of the site.

MORGAN RUN (M4)

Extensive mining around the area of Newtown may have impacted the quality of M4. Mining permits indicate that previous surface and deep mining in the area around Newtown left open pits and disturbed and poorly vegetated land. There have been deep mines for Middle and Lower Kittanning coal and at least five surface mines for clay and coal in Lower, Middle, and Upper Kittanning, Lower Freeport, Clarion, and Mercer coal seams. Mining completed in the 1980s to early 1990s was reclaimed and approved by PADEP; however, the area reclaimed was only approximately 10 percent of the previously unreclaimed mining areas from past mining use.

M4 exceeded levels of concern 26 times (Figure 3), mostly for pH, acidity, alkalinity, manganese, aluminum, and hot acidity. This site also exceeded iron levels of concern during two of the sampling events. The water quality appears to have improved slightly from M3 with a lower number of parameters exceeding levels of concern (Figure 3), the presence of some measured alkalinity, and a reduction of average loading values (Table 4). Although the severely impacted macroinvertebrate community did not show any signs of recovery, the habitat rating also improved to excellent at M4 as the stream channel improved due to a lack of influence from the beaver dams found at M3. Also, less AMD precipitate was noted at M4, and the substrate was mostly cobble and somewhat less embedded.

DISCHARGES (D7 & D8)

At least 100 to possibly 300 acres in the SGL #98 area was extensively strip mined from mid-1980 to late-1990 with surface and auger mining in the Lower Kittanning and Lower Kittanning Rider seams. Previous mining of at least six abandoned coal and clay mining operations existed in the area prior to this operation. An abandoned deep clay mine and deep and surface coal mines were near the areas of the D7 and D8 discharges. D7 was one of the less severe discharges in the watershed; the lowest flow and the lowest average level of iron were recorded at this discharge. D7 exceeded levels of concern 27 times, and D8 exceeded levels 38 times (Figure 3). Both discharges exceeded levels for pH, acidity, alkalinity, sulfate, manganese, aluminum, and hot acidity; however, D8 also exceeded levels for conductivity, magnesium, and iron.

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Swampy area of Morgan Run near Sanbourn Road

JAMES RUN (J1)

J1 was located on James Run, a small tributary to Morgan Run that

drained AML north of Newtown (Figure 2). Pollution on James Run was from deep and surface clay and coal mining. In particular, there was record that the deep mining and stripping of coal during the 1940s and 1950s on the hill northeast of Newtown impacted a spring in the headwaters of James Run. When James Run was monitored in the mid-1990s, manganese and iron were high (2,000 µg/l) in the headwaters. J1 was the most severely impacted tributary site and was characterized by low pH, low alkalinity, high manganese, high aluminum, and high hot acidity. Twenty-two parameter values were exceeded at J1 during this survey (Figure 3).

The macroinvertebrate community was moderately impaired and contained similar acid-tolerant taxa as Morgan Run with the addition of more stonefly and caddisfly taxa, such as *Amphinemura* (the dominant taxa), *Diplectrona*, and *Rhyacophila*. The habitat was rated supporting and consisted of primarily gravel substrate. Fish sampling was conducted on the mainstem (J1) and the small tributary to the stream (J1 (tributary)) at the mouth of James Run (Figure 6). No fish were found at either site.

MORGAN RUN (M5)

M5 was located downstream of the confluence of James Run and Morgan Run. The parameters exceeding levels of concern at this site included pH, acidity, alkalinity, manganese, aluminum, hot acidity, and, on one occasion, iron. A very slight improvement in water quality was noted from M4 to M5 except for sulfate, hot acidity, and manganese in some samples. A slight biological improvement was noted also with the presence of some of the taxa that were present in James Run, although the rating still fell in the severely impaired range. The habitat was similar to M4 and was rated excellent.

STATE GAME LAND #98 DISCHARGES (D9, D10, D11, D12, D13, D14)

The six discharges in SGL #98 between M5 and M6 may be attributable to historical mining and mining from mid-1980 to late-1990. Monitoring data from PADEP hydrogeologists in the mid-1990s identified degradation at small streams and groundwater discharge points (seeps). One groundwater seep that was documented with good water quality in 1982 and degraded in 1984 was in the general location of D11.

> *The highest number of parameters exceeded during the survey (40) was attained in four of these six discharges.*

The discharges that drained the mined areas in SGL #98 had small flows but were severely impacted by acidity and metals concentrations. D14 had the worst water quality rating followed by D12, D10, and D13. D14 also had the highest loading values of these discharges (Table 4), indicating that it had the strongest impact on Morgan Run when considering the combination of flow amount and chemistry. The highest number of parameters exceeded during the survey (40) was attained in four of these six discharges (D9, D10, D12, and D14) (Figure 3). D11 yielded the lowest pH (2.6), and the highest recorded conductivity (3,850 µmhos/cm), acidity (710 mg/l), calcium (346.12 mg/l), magnesium (255.02 mg/l), manganese (92,691 µg/l), and hot acidity (449 mg/l) of all the Morgan Run sampling sites. D13 had the highest recorded sulfate value (1,907 mg/l), and D14 had the highest level of aluminum (32,900 µg/l). Due to the small flows, the amount of pollution these discharges individually contributed to the stream was minor according to the average loading values (Table 4); however, the cumulative impact was considerable.

MORGAN RUN (M6)

M6 was located downstream of the SGL #98 discharges and upstream of Alberts Run. Acidity, alkalinity, pH, manganese, aluminum, and hot acidity exceeded levels of concern in every sample, and iron only exceeded levels during one sampling quarter. The concentration levels remained similar to M5, although sulfate, manganese, and aluminum were a bit higher overall at M6. When accounting for flow differences between the sites, acidity, manganese, aluminum, and hot acidity loading values increased, while alkalinity and iron loading values decreased at M6 (Table 4).

The macroinvertebrate community at M6 was severely impaired, although the number of *Leuctra* increased compared to upstream sites. The habitat was rated excellent; this portion of Morgan Run was scenic, despite traces of AMD precipitate in the stream.

ALBERTS RUN (A1)

Alberts Run was impacted downstream of the fork on the southern tributary to Alberts Run by the mining in SGL #98. Documentation beginning in 1987 indicated groundwater discharge degradation, particularly in specific conductance and sulfate. North of Alberts Run, in approximately the middle of the watershed, was a 200-acre strip mining operation of Clarion #1 and #2 coal in the mid-to late-1980s. Documentation indicated problems with discharges at this site, which has since been abandoned. Other mining operations in this area included: three surface operations mining Clarion #1 and #2 and Lower Kittanning coal seams that were all completed in the mid-1970s; one abandoned surface operation mining Clarion #2 coal; and one surface operation of Clarion #1 and #2 coal. Anecdotal records of a deep mining operation for Lower Kittanning

coal north of this area were dated to 1906. Currently a small shale operation also exists in the headwaters of Alberts Run.

The AMD problems at A1 included low alkalinity, and high manganese and hot acidity. Levels of concern for these parameters were exceeded slightly during every sampling quarter. Moderately impaired biological conditions existed at A1. Habitat at Alberts Run was rated excellent, with fast-flowing water and small waterfalls; however, the substrate was slightly embedded.

A fish survey was conducted at A1, and no fish were present, although crayfish were occasionally observed (Figure 6). Anecdotal reports of fish in the headwaters of Alberts Run were confirmed with a survey of the section downstream of Old Erie Pike (SR 2024). Brook trout (*Salvelinus fontinalis*), white suckers (*Catostomus commersoni*), blacknose dace (*Rhinichthys atratulus*), and spottail shiners (*Notropis hudsonius*) were found in the headwaters of Alberts Run (Figure 6 and Table 3). The habitat was rated excellent at this site also; although the flow was less, and the pools were not as deep as at A1. The field chemistry at this site indicated good quality water with a pH of 6.7 and conductivity of 168 µmhos/cm (Table 3). Alberts Run had the highest potential for reclamation, since the pollution at the mouth was not very severe; the headwaters had good field chemistry and maintained fish; the macroinvertebrate population at the mouth was only moderately impaired with recolonization potential from upstream sections; and the habitat was excellent. This stream had small waterfalls and riffles to aerate the water and had excellent pools and instream cover for fish.

MORGAN RUN (M7)

M7 was impacted by the mining that was located north of Alberts Run. In 2000, a discharge was documented that flowed from an abandoned mine area where a treatment pond had been removed. This discharge ran parallel to the pipeline down the eastern bank to Morgan Run in the area downstream of the Alberts Run confluence and upstream of M7. Another mining operation existed on the west side of Morgan Run near Crooked Sewer Road. This operation covered a surface area of approximately 200 acres where Lower and Middle Kittanning coal was mined from 1972 to 1973. The mining was completed in compliance in 1975.

> *"Anecdotal reports of fish in the headwaters of Alberts Run were confirmed..."*

Water chemistry at M7 was characterized by low pH and alkalinity, and high acidity, hot acidity, manganese, and aluminum. Average iron values decreased from M6 and did not exceed levels of concern (Figure 4). Water chemistry concentrations from M6 to M7 seemed to improve slightly except for hot acidity. The macroinvertebrate community also improved to moderately impaired. The habitat was rated excellent and was characterized by numerous boulders creating substantial riffles and by ample stream canopy and woody debris. Some AMD precipitate was noted at the site.

CROOKED SEWER RUN (C1)

C1 served as the reference site for the instream and tributary sites in the Morgan Run Watershed. The water quality was rated middle quality since alkalinity and hot acidity slightly exceeded levels of concern. Given that these parameters were only slightly exceeded and overall water quality appeared to be fine, it was speculated that the stream might be naturally less alkaline due to the local geology or have very minor impacts due to AMD. AML were in the headwaters of Crooked Sewer Run (Figure 2) where three surface mine operations for Lower and Middle Kittanning coal were operated by two different companies in the 1950s. A coal mining operation during the 1990s on the edge of the watershed boundary was completed in compliance in 2000; all treated discharges flowed into the neighboring watershed of Longs Run.

This site had the highest pH (7.4) and alkalinity (35.8 mg/l), and the lowest conductivity (121 µmhos/cm), acidity (2 mg/l), sulfate (35.2 mg/l), iron (<300 µg/l), manganese (<50 µg/l), aluminum (<500 µg/l), and hot acidity (-19 mg/l) values of all the sites in the watershed. The macroinvertebrate population at C1 was rated nonimpaired and was the only site that contained mayflies, which are generally sensitive to AMD pollution. Six different genera of mayflies were present, comprising almost 60 percent of the population sample. Overall, there were 25 different taxa. The fish population appeared to be reproducing and was dominated by brook trout (Figure 6 and Table 3). Habitat was rated excellent with a steep gradient due to large boulders generating small waterfalls and pool areas. The watershed area around C1 was a mixed coniferous forest providing a dense canopy and ample woody and leafy debris.

MORGAN RUN (M8)

M8 was located near the mouth of Morgan Run. The upland area to the south of Morgan Run near the mouth was historically mined by three companies for Lower Kittanning and Mercer coal. Two of these operations were abandoned, and one was reclaimed. A polluted discharge to Morgan Run was reported due to this previous mining activity. From 1997 to 2002, a surface mining operation for Lower Kittanning #2 and #3 coal of approximately 458 acres polluted six springs along the ridge south of Morgan Run. The company abandoned the mine site and forfeited the bond. A passive treatment system is currently under construction

for these six polluted springs using bond money the mining company was required to set aside prior to mining (Carrello, 2005). North of Morgan Run near Dimeling were a number of historical surface mining operations for Upper and Middle Kittanning, Clarion #1, #2 and #3, and Mercer coals that were possibly a cause for moderately polluted areas along Morgan Run in the middle to late 1980s. There was a 56.9 acre permit for a small active mining operation in 2005 that was considered to be in Stage 2 of reclamation, meaning that the topsoil had been replaced and vegetation was growing on the site (Pennsylvania Department of Environmental Protection, 1996).

In general, pollution levels decreased from M7 to M8. The pH increased, while conductivity, sulfate, iron, manganese, and aluminum decreased. Alkalinity, pH, manganese, aluminum, and hot acidity still exceeded levels of concern in all four samples, and acidity exceeded levels in two samples. Iron values remained low. The macroinvertebrate community continued to be moderately impaired, and although the number of macroinvertebrates decreased, diversity increased. Of particular notice at M8 were a dragonfly (*Lanthus*), a Perlidae stonefly (*Acroneuria*), and a caddisfly (*Lepidostoma*), all of which also were found in Crooked Sewer Run. Only one individual of each taxon was found, indicating that these taxa may have drifted from Crooked Sewer Run during rain events the night before sampling and may not be residents of Morgan Run. Electrofishing results indicated no fish were present at M8 (Figure 6 and Table 3). The habitat was rated excellent with large boulders lining the streambed in a mixed forest area with good stream canopy and cover. Some wetland areas existed in the riparian area, and AMD precipitate was evident on the rocks.

Conclusions/Recommendations

Morgan Run has been severely impacted by AMD from past mining practices in the watershed. Mining practices prior to mining regulations in the late 1960s left abandoned mine areas, open pits, and spoil piles that have allowed the pollution of surface and groundwater in this watershed. The most prevalent and extensive mining was conducted in the upper portion of the watershed (Figure 2). The entire length of Morgan Run was polluted and exhibited low pH and alkalinity, and high metals and acidity. In addition, the metal precipitate on the streambed adversely impacted the instream habitat by coating substrate and filling niches. The worst section of Morgan Run was the section of the watershed from M2 to M6. This section had severely impaired macroinvertebrate populations and some of the most severe water quality impacts. The habitat was degraded from the headwaters to M3, mostly due to the disruption of streamflow by beaver dams and, consequently, larger amounts of sediment and AMD precipitate. Overall habitat ratings were high due to the forested and remote nature of the watershed. AMD metal precipitate degraded the habitat; however, the other aspects of the habitat were sufficient for support of aquatic life, indicating the stream has potential for remediation.

Morgan Run has been severely impacted by AMD from past mining practices in the watershed. Mining practices prior to mining regulations in the late 1960s left abandoned mine areas, open pits, and spoil piles that have allowed the pollution of surface and groundwater in this watershed.

Two of the three major tributaries to Morgan Run were polluted by AMD. James Run was the most severely polluted tributary, with pollution concerns being acidity, manganese, and aluminum. It was impacted by the AML north of Newtown and in SGL #98. Alberts Run had good field chemistry and supported a fish population in the headwaters; however, it became polluted downstream by the abandoned mining in SGL #98 and possibly the abandoned mining operations north of the stream. This stream has excellent potential for remediation, since it supports a fish population in the headwaters. Remediation efforts could concentrate on increasing the alkalinity and decreasing manganese levels on this stream. Crooked Sewer Run was a good quality stream, and efforts should be made to protect it.

The 13 discharges sampled on Morgan Run exude extreme AMD pollution in the form of high acidity and high metal concentrations. The most severe discharges were D5, D3, D6, D4, and D14, in addition to the cumulative impact of the SGL discharges. Some of the most severe discharges likely originate in abandoned deep clay mines.

Figures 4 and 5 indicate that elevated manganese levels were a problem throughout the watershed. High aluminum concentrations also were fairly widespread and, considering the higher toxicity to

aquatic life, are as much, if not more, of a concern as manganese. Discharges highest in aluminum were SGL #98 discharges, in particular D14 and D13. Iron was not as widespread of a pollutant (Figure 5); however, it is a large problem at D5 and has a huge impact at M3 (Figure 4).

Morgan Run did not support healthy populations of macroinvertebrates, and the mainstem did not support any fish populations. Recolonization potential exists through fish and macroinvertebrate populations in Crooked Sewer and the headwaters of Alberts Run. Habitat was sufficient to support a healthy, reproducing fishery, if AMD in this watershed were to be remediated.

Technology for AMD remediation varies depending on the site specific characteristics such as metal concentrations and space available for remediation systems. Site specific recommendations for the Morgan Run discharges will be made in the restoration plan. Remediation of AMD may be costly and difficult; therefore, it is important that mining companies follow current regulations and use best management practices in order to minimize or avoid any detrimental impact. For more information on mining and AMD treatment, see the following web sites and contact information:

D. Carnahan

Mouth of Morgan Run

Information on Mining - "Inspect a Surface Coal Mine" (Pennsylvania Department of Environmental Protection) http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Table_of_Contents.htm

Information on Mining - Bureau of Deep Mine Safety (Pennsylvania Department of Environmental Protection) http://www.dep.state.pa.us/dep/deputate/minres/dms/dms.htm

AMD Passive Treatment - "Overview of Passive Systems for Treating Acid Mine Drainage" (West Virginia University Extension Service) http://www.wvu.edu/~agexten/landrec/passtrt/passtrt.htm

Active Treatment - "Overview of Acid Mine Drainage Treatment with Chemicals" (West Virginia University Extension Service) http://www.wvu.edu/~agexten/landrec/chemtrt.htm

AMD Treatment - Abandoned Mine Reclamation Clearinghouse (Pennsylvania Department of Environmental Protection and Western Pennsylvania Coalition for Abandoned Mine Reclamation) http://www.amrclearinghouse.org/index.html and http://www.amrclearinghouse.org/Sub/AMDtreatment/

AMD Information - Office of Surface Mining (U.S Department of the Interior) http://amd.osmre.gov/amdtreat.asp

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Moshannon District Mining Office, Pennsylvania Department of Environmental Protection

Address: 186 Enterprise Drive, Philipsburg, PA 16866

Phone: (814) 342-8200

Susquehanna River Basin Commission

(Beth Dillon, *Water Quality Chemist*)

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APPENDIX A

Station	Location Description	Latitude	Longitude
A1	Mouth of Alberts Run, located north of State Game Lands No. 98	40.939992442	-78.359183274
ALBT Hdw.*	Headwaters of Alberts Run, downstream of Old Erie Pike (SR 2024)	40.951800000	-78.343100000
C1	Mouth of Crooked Sewer Run, located alongside Rt. 153	40.957403199	-78.373567680
J1	Mouth of James Run located south of State Game Lands No. 98, near Newtown, Pa.	40.924338717	-78.359534448
D2	Discharge located north of new development off of Meases Road (T659)	40.887674184	-78.359296211
D3	Discharge upstream of SR 2012	40.894592837	-78.370270758
D4	Discharge located downstream of SR 2012 along old railroad bed, downstream of MORG01	40.901203031	-78.361344317
D5	Discharge located above beaver dam and abandoned building along old railroad bed near Newtown, Pa.	40.903076041	-78.357655721
D6	Discharge located on Ross Creek along old railroad bed across from log gate near Newtown, Pa.	40.914850078	-78.351808516
D7	Upstream discharge located on James Run	40.924818694	-78.357990413
D8	Downstream discharge located on James Run	40.924495951	-78.359156565
D9	Discharge located in State Game Lands No. 98 downstream of James Run and Morgan Run confluence	40.924945542	-78.360354092
D10	Discharge located in State Game Lands No. 98 downstream of MORD09	40.925843152	-78.361886448
D11	Discharge located in State Game Lands No. 98 downstream of MORD10	40.930305556	-78.364166667
D12	Discharge located in State Game Lands No. 98 downstream of MORD11	40.934222222	-78.363833333
D13	Discharge located in State Game Lands No. 98 downstream of MORD12	40.934327147	-78.362976630
D14	Discharge located in State Game Lands No. 98 downstream of MORD13	40.934837145	-78.362802774
M0.5	Most upstream site on Morgan Run behind new development off Meases Road (T659)	40.881403417	-78.354651499
M1	Morgan Run downstream of SR 2012 along abandoned railroad bed at large boulders and ford	40.899588011	-78.363087464
M2	Morgan Run downstream of MORD04 and upstream of where MORD05 discharge enters Morgan Run	40.905116810	-78.360653380
M3	Morgan Run downstream of where MORD05 enters Morgan Run	40.907716758	-78.361818759
M4	Morgan Run upstream of James Run	40.924149594	-78.359699156
M5	Morgan Run downstream of James Run and upstream of State Game Land No. 98 discharges	40.924658413	-78.360170993
M6	Morgan Run downstream of State Game Lands No. 98 discharges and upstream of Alberts Run	40.939861036	-78.359975418
M7	Morgan Run downstream of Alberts Run and upstream of Rt. 153 bridge	40.953854265	-78.373875598
M8	Morgan Run at mouth	40.958096465	-78.401036368

** Only electrofishing, field chemistry sampling, and habitat assessment were conducted at this site.*
Abandoned mine discharge sites are listed in red.

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Discharge (D6) located on Ross Creek

FOR MORE INFORMATION

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Beaver dam pool on Morgan Run

SUSQUEHANNA RIVER BASIN COMMISSION

In 1971, the Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact among the states of Maryland, New York, and the Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of the basin's water resources among the public and private sectors.

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