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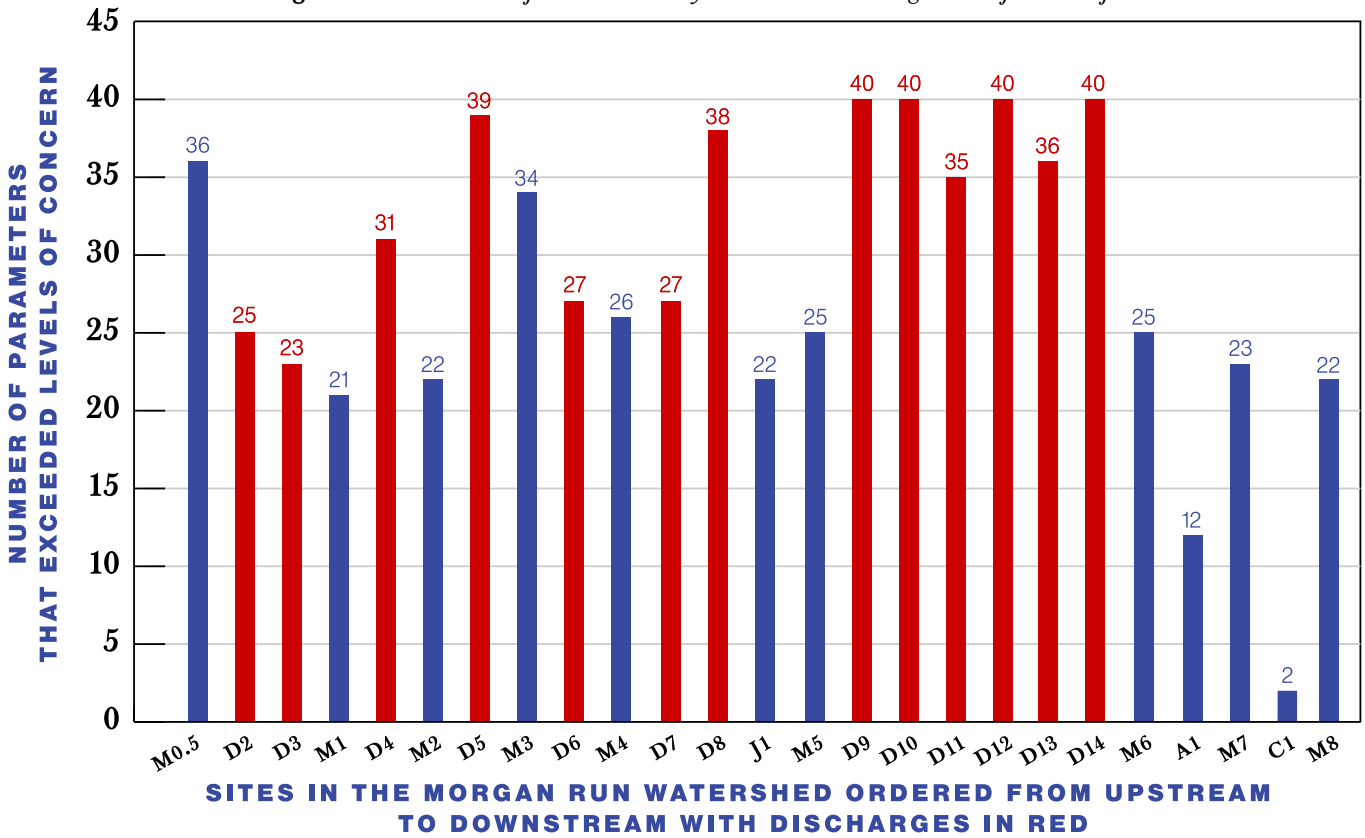
Figure 3. *Total Number of Water Chemistry Parameters Exceeding Levels of Concern for each Site*