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

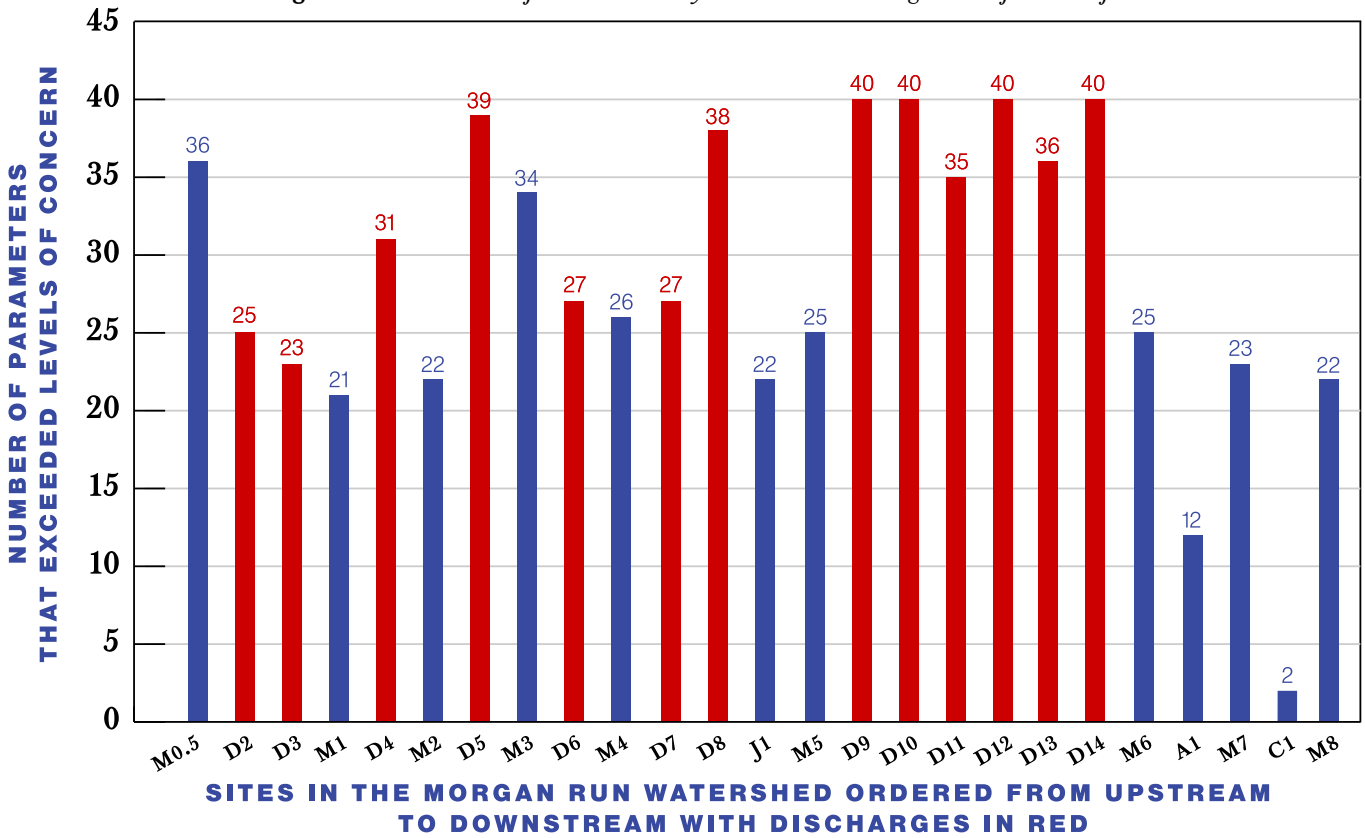
Water quality, macroinvertebrate, and habitat site conditions for each sampling site are depicted in Figure 2. Crooked Sewer Run (C1) served as the reference site for the Morgan Run Watershed since this site included the overall best conditions for water chemistry, biology, and habitat. All of the sites 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

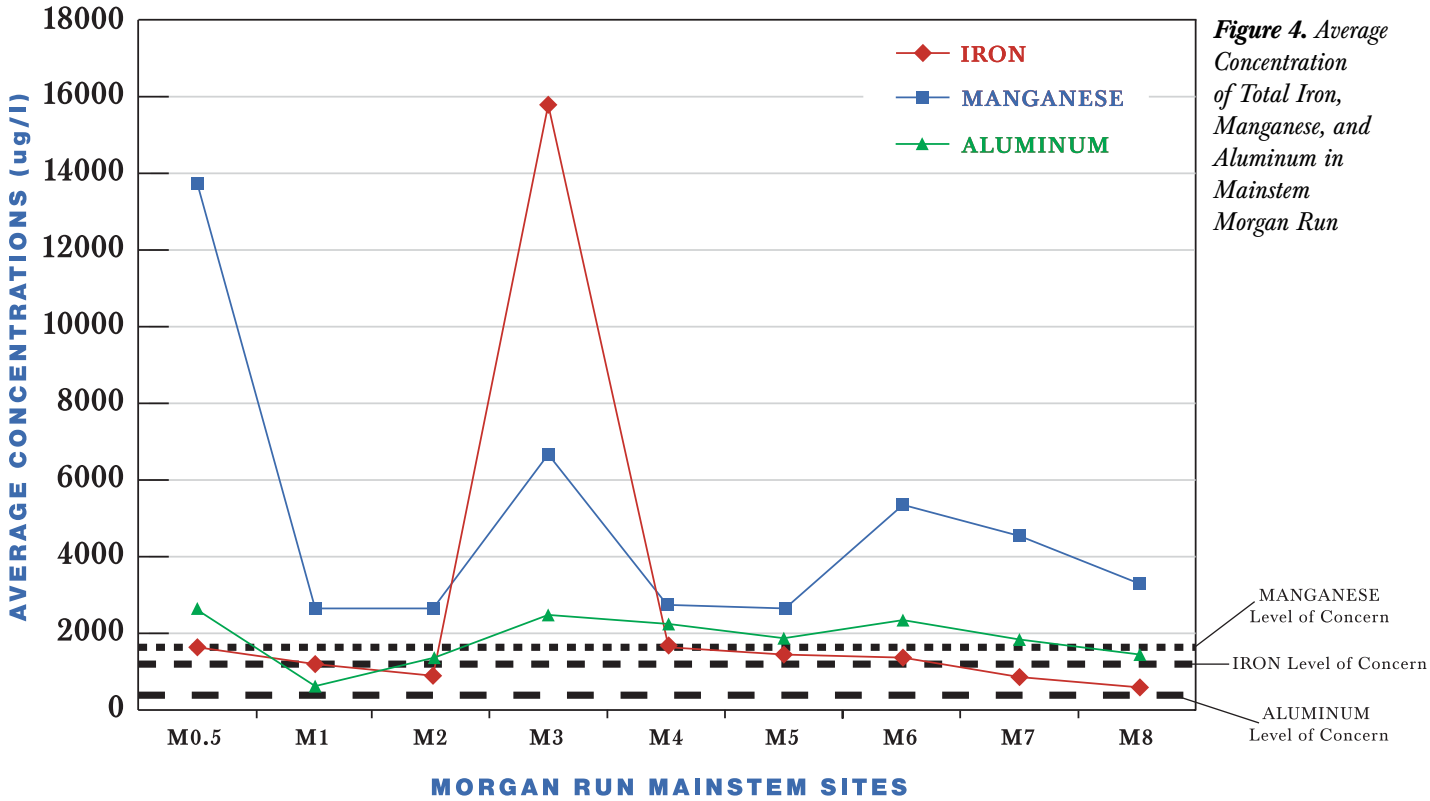


Figure 4. *Average Concentration of Total Iron, Manganese, and Aluminum in Mainstem Morgan Run*

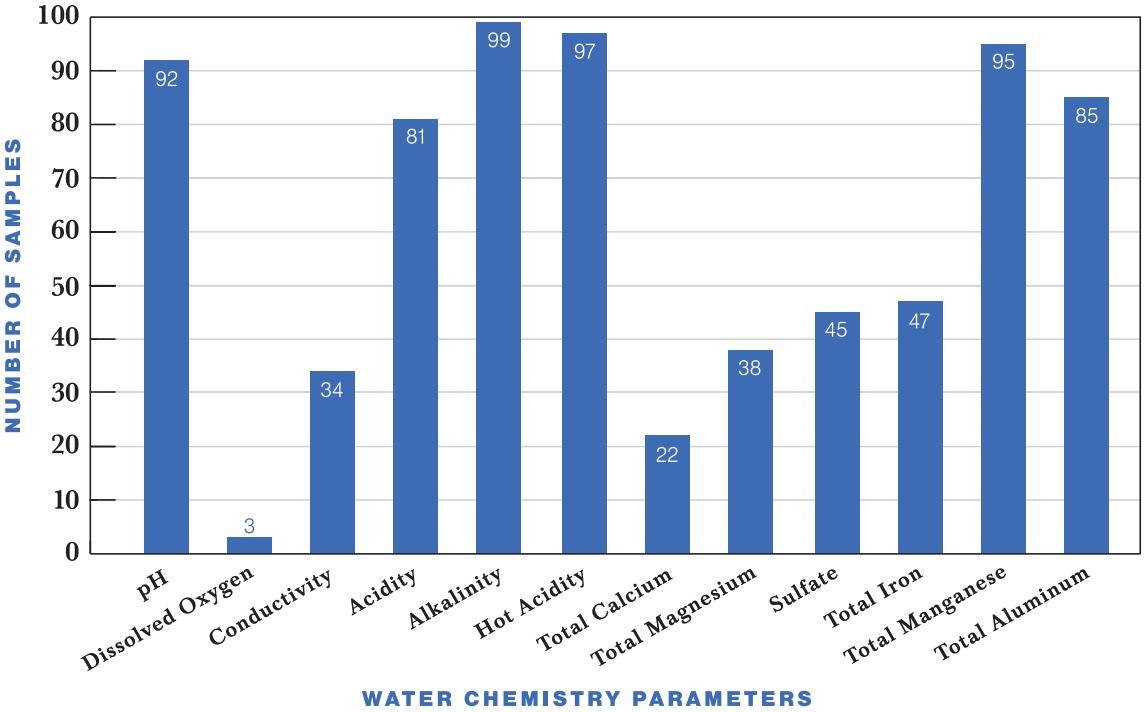


Figure 5. *Number of Water Chemistry Samples to Exceed Levels of Concern for each Parameter*

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.