DATA ANALYSIS

Water quality at stream sites was assessed by examining field and laboratory parameters, including major ions and nutrients. The data were compared to water chemistry values at a level of concern based on current state and federal regulations or references for reported tolerances of aquatic life (Table 2). When both laboratory and field values existed for the same parameter, the laboratory value was used in the analysis. The difference between the yearly average value for each parameter and the level of concern for that parameter was calculated for each site. If the value did exceed the level of concern, the difference was listed; if not, then the site was given a score of zero. For each site, the sum of all the exceeded values was calculated and averaged by the number of parameters.

Sites with a water quality score between 0-0.40 were classified as "higher" quality. Sites between 0.41-0.70 were classified as "middle" quality. Water quality scores between 0.71-1.0 were given the ranking of "lower" quality. Any site with a value more than 1.0 was classified as "poor" quality. Although there are aquatic life standards for magnesium and total hardness, these two parameters were not included in the water quality analysis due to the naturally high hardness of the streams, resulting from the underlying geology of Morrison Cove. For the water quality calculations, an average of the seasonal values for each parameter at each location was used.

Benthic macroinvertebrate samples were analyzed using six metrics mainly derived from RBP III (Plafkin and others, 1989; Barbour and others, 1999): (1) taxonomic richness; (2) modified Hilsenhoff Biotic Index; (3) percent Ephemeroptera; (4) number of Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa; (5) percent Chironomidae; and (6) Shannon-Wiener Diversity Index. Four reference categories were developed for the macroinvertebrate data analysis based on drainage size and origin. Two of the sites had drainage areas less than 1-square-mile and were separated from the others not only for size, but also because they originated on forested ridges while the other sites were in the valley area. Eight of the sites had a drainage area less than 10 square miles, seven of the sites had a drainage area from 10 to 20 square miles, and five sites had a drainage area greater than 20 square miles.

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

PARAMETER	LIMIT	REFERENCE CODE
Temperature	> 25 °C	a,e
Dissolved Oxygen	< 4 mg/l	a,g
Conductivity	> 800 µmhos/cm	c
pH	< 5.0	b,e
Alkalinity	< 20 mg/l	a,f
Total Nitrate	> 1.0 mg/l	d
Total Hardness	> 300 mg/l	d
Total Magnesium	> 35 mg/l	g
Total Sodium	> 20 mg/l	g
Total Chloride	> 150 mg/l	a
Total Sulfate	> 250 mg/l	a
Total Potassium	None	
Total Calcium	None	
Total Silica	None	

REFERENCE CODE & REFERENCES

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.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm
e http://www.hach.com/h2ou/h2wtrqual.htm
f http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
g http://www.dec.state.ny.us/website/regs/part703.html

Reference sites were determined for each reference category, primarily based on the results of the macroinvertebrate metrics and secondarily based on habitat and water quality scores, to represent the best combination of conditions. The reference sites were T2 (tributary to Halter Creek) for the forested ridge tributaries, Y1 (Hickory Bottom Creek) for less than a 10-square-mile drainage, Y3 (Potter Creek) for 10 to 20 square miles, and C1 (Clover Creek) for greater than 20 square miles.

The metric scores for each site were compared to the reference scores, and a biological condition category was assigned based on RBP III methods (Plafkin and others, 1989; Barbour and others, 1999). The same reference sites were used in the analysis for the habitat scores. The ratings for each habitat parameter were totaled, and a percentage of the reference site was calculated. The percentages were used to assign a habitat condition category to each stream site (Plafkin and others, 1989; Barbour and others, 1999).

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 the number of Ephemeroptera (mayflies) 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 Tricoptera (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 taxonomic diversity of the community. Index value decreases with increasing stress.

Water quality at the spring sites was evaluated by comparing the data to state drinking water standards or Maximum Contaminant Loads (MCLs) (Table 3). (Not all drinking water parameters were analyzed in this study, but of those that were analyzed the only one that exceeded the standards in any of the springs was nitrate). Spring sites were ranked in order of their average concentrations of nitrate. Water quality data from springs also were used for water typing analysis.

Water typing was performed using a variety of methods to determine the origination of water for each of these springs. Sites were ranked based on calcium/magnesium (Ca^{+2}/Mg^{+2}) ratios, as well as concentrations of major ions, in order to group stream sites and springs by their water chemistry signatures. Additionally, a ternary plot was used to group sites with similar concentrations of major ions together. By using this information and comparing the data to previous studies done on the characteristics of groundwater in carbonate aquifers, some conclusions were made as to which streams and springs have water from a similar origin.

Table 3. *Pennsylvania Drinking Water Standards*

PARAMETERS	LIMITS	REFERENCE CODE
Nitrate	10 mg/L	a
Chloride	250 mg/L	a
Sulfate	250 mg/L	a
pH	6.5 - 8.5	a

REFERENCE CODE & REFERENCE

a www.depweb.state.pa.us/watersupply/lib/watersupply/pa-mcls_05.pdf

Results and Discussion

Water quality, macroinvertebrate, and habitat conditions for each stream sampling site in the Morrison Cove region are depicted in Figure 4. Two sites demonstrated the best overall conditions in each category with "higher" water quality, non-impaired macroinvertebrates and excellent habitat. Four sites did not exceed water quality levels of concern and were considered as "higher" water quality sites. Thirteen sites slightly exceeded levels of concern and received a "middle" water quality designation, while four sites considerably exceeded levels of concern and were given a "lower" water quality designation. The remaining two sites were classified as "poor" water quality, as they were considerably worse than the "lower" designation. Habitat conditions throughout Morrison Cove were rated highly overall. Fifteen sites were rated as excellent (68 percent), supporting habitat was found at five sites (23 percent), one site (4.5 percent) was rated as partially supporting, and one site (4.5 percent) was non-supporting. Of all the individual samples that were collected, 80 percent of the values exceeding water quality levels of concern were of nitrate. Another 12 percent of the exceedances were of sodium, while conductivity, alkalinity, and chloride accounted for the remaining few exceeding values (Figure 5).

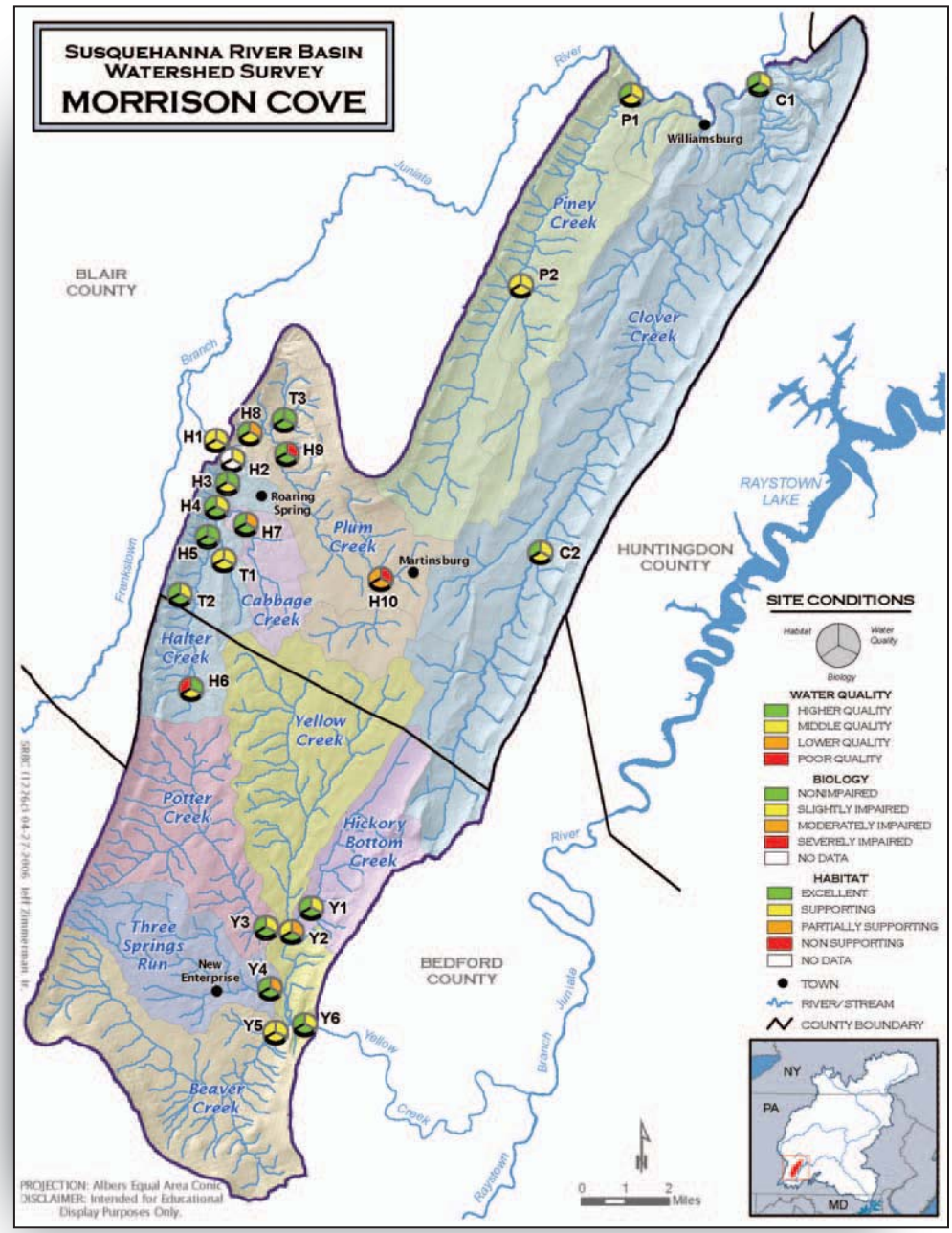

Figure 4. *Subwatersheds and Site Conditions at Each Sampling Site in Morrison Cove*