Assessment of Benthic Macroinvertebrate Communities in Streams of the Pennsylvania Lake Erie Watershed

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Erie County Conservation District
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By

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INTRODUCTION

This purpose of this report is to describe the results of stream assessment work completed by the Biology Department of Mercyhurst College as part of a Growing Greener Grant from the Pennsylvania Department of Protection (PADEP) to the Pennsylvania Lake Erie Watershed Association (PLEWA) and administered by the Erie County Conservation District. One of the main goals of the project was to conduct detailed characterizations of selected streams (Sixteenmile, Sevenmile, Sixmile Creeks, McDannels Run, Elk Creek and Crooked Creek) to determine whether they are affected by non point source pollution (NPSP), and to prioritize needs for remediating problems in those watersheds. The overall assessment effort included three major elements: 1) an analysis of the physical habitat and water quality (by Gannon University Department of Environmental Science & Engineering), 2) fish community assessment (by the Biology Department of Gannon University), and benthic macroinvertebrate community analysis (Mercyhurst's task).

The Mercyhurst assessment work added to a database for benthic macroinvertebrate communities previously acquired as part of a similar study (funded by Growing Greener) of streams in the Presque Isle Bay watershed (Campbell 2002), that had included "control" sites on several of the streams selected for study in the current project. The current study obtained samples from several additional non-target streams in the Pennsylvania Lake Erie watershed besides the principle ones. The main benefit of collecting macroinvertebrate data (with a consistent sampling/analysis protocol) from a large number of (both stressed and unstressed) streams is that it allowed development of objective "yardsticks" for judging the condition of sites on the principle streams, based

upon local/regional criteria. The collective dataset will now provide "benchmarks" for future stream assessment work, so that progress in stream and watershed restoration can be measured. The streams of the PA Lake Erie watershed were independently assessed by the Commonwealth of Pennsylvania during the same time period that our studies were carried out (PADEP 2004), and a few streams included in our study (McDannels Run and parts of Sixteenmile Creek) were found to be not meeting their designated aquatic life uses. The degraded segments and several others, including the streams of the Presque Isle Bay watershed, are now on PA's 303(d) list of "non-attainment" waters scheduled for development of TMDL's (Total Maximum Daily Loads). It is intended that the findings and recommendations of this assessment will contribute to remediation activities by PLEWA to complement PADEP's actions to improve water quality in the affected streams.

METHODS

Sampling Sites for Benthic Macroinvertebrates

Benthic macroinvertebrate community sampling was conducted in the target and non-target "control" streams mostly during the spring and late fall of 2003 (Tables 1-3). Some additional sampling of non-target streams was carried out in the fall of 2004 (Conneaut Creek) and late winter of 2005 (Duck Run) as part of separate research projects involving Dr. Mike Campbell and Mercyhurst students. Tables 1-3 include also the sampling locations and dates for streams and sites assessed during the previous watershed assessment project (Campbell 2002). Results for a total of 146 samples are included in this report, representing 63 sites on 15 different streams in the Pennsylvania

Lake Erie watershed. Data is reported only for sampling sites on second-order and larger streams. The results of macroinvertebrate studies of first-order stream sites in the Pennsylvania Lake Erie watershed are found in the Presque Isle Bay watershed study (Campbell 2002), recent published reports (Welte & Campbell 2004, Weber & Campbell 2005) and a manuscript in preparation (Campbell 2006).

For the principle streams assessed in the current study, a total of 5, 4, and 3 sites were sampled on Sixteenmile, Sevenmile, and Sixmile Creeks, respectively. Two sites were sampled on McDannels Run. Ten and three sites were sampled on Elk and Crooked Creeks, respectively. For comparative purposes, sites were also sampled on Twentymile, Twelvemile, Fourmile, Mill, Cascade, Walnut, Raccoon, and Conneaut Creeks, and Duck Run. The basis for selecting sampling site locations included accessibility from major roads and representation of key locations within the watersheds (i.e. above and below suspected major sources of NPSP). Site selection was coordinated between Mercyhurst and Gannon researchers so that key locations on the streams could be characterized by all three kinds of assessment parameters (i.e. physical-chemical, fish, and benthic macroinvertebrates).

Sampling and Analysis Protocols

Sampling for benthic macroinvertebrates was carried out using the methodology of Plafkin et al.'s (1999) Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (2^{nd} ed.) -- "Multihabitat Approach: D-Frame Net" (Section 7.2). For each site, a 100-m reach representative of the characteristics of the stream was selected, upstream from road crossings, and the relative abundance of various habitats (riffle, run, pool) was

estimated. Then multiple kick samples were taken and combined into a single sample while moving from the downstream to upstream end of the reach, using a D-Frame net with a mesh size of 500 microns.

Approximately 1 square meter of substrate on the stream bottom upstream from the mouth of the net was dislodged for each kick. In most situations, ten kick samples were taken per site, with kicks distributed among habitats in proportion to habitat abundance (e.g. if the reach contained 50% riffles, 30% runs, and 20% pools, then 5,3, and 2 kick samples were taken from each respective habitat). Large stones, leaves and pieces of woody debris were rinsed-off in the mouth of the net, and the sample was transferred to jars and preserved with a 5% formalin rose-bengal solution. Rose-bengal is a bright pink stain that facilitates distinguishing organisms (especially small midge larvae and worms) from mineral matter and plant debris during sample sorting. In the laboratory, each sample was transferred to large shallow, white pans marked with grid lines, and organisms were picked-out with the aid of moveable table-mounted lights and magnifiers or diopters.

Invertebrate animals in the samples were identified to the lowest practicable taxonomic level (to genus in the case of most aquatic insects) and counted, with the aid of a dissecting microscope. The primary taxonomic reference used was Peckarsky et al. (1990). Comprehensive lists of all taxa identified at sampling sites on the principle streams are found in Tables 4-9. Tables 10-16 contain taxa lists for sites on non-target

streams. Comprehensive taxa lists for streams in the Presque Isle Bay watershed are found in Campbell (2002).

Sample count data was analyzed using the "Multimetric Approach" (Section 9.1.1) of Plafkin et al. (1999). The first step in this analysis was to determine values for six different metrics for each sample – total number of taxa, number of EPT taxa (Ephemeroptera, Plecoptera, Trichoptera), number of intolerant taxa (taxa with PA modified Hilsenhoff Biotic Index Scores less than 6), percentage EPT, percentage intolerant, and Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987, 1988; Klemm et al. 1990). Sample metrics for all sites and dates are found in Tables 17-19.

The second step in the analysis was the standardization of each metric so that the values could be scored on a range of values from 1 to 10. Metric data standardization involved compiling the metric values in separate data sets according to stream order for all sample sites, including the reference sites (locations thought to be minimally impacted by NPSP). A statistical analysis (using Microsoft Excel) was carried out for each metric and stream size-category to determine the 95 percentile value (5 percentile value in the case of the Hilsenhoff Biotic Index), which was then divided by 10 to determine the increment of metric scores for each standardized value from 1 to 10. The metric values for each sample were then reassigned a score from 1 to 10, with higher scores representing greater diversity/water quality. Ranges of metric values for standardized scores determined for third-order (or larger) and second-order sites are found in Tables 20 and 21, respectively.

The standardized scores for the six metrics per sample were summed to determine the Composite Index score, which could range from 6, for samples in which all metric scores were 1 (a condition classified as “minimal biotic diversity”), to 60, for samples that received the top score (10) for all six metrics (classified as “optimum condition”). Composite Index scores determined for all sampled sites and dates are found in the last column of Tables 17-19.

The final step in the analysis was to determine the threshold composite index value for classifying the biological condition of the sites. This was done by a statistical analysis of the composite index scores of sites designated as “reference” sites for each stream size category. Reference sites were defined as stream reaches having: 1) mostly intact riparian corridors within 1-km upstream, 2) no known significant point-sources of pollution within 1 km upstream, and 3) location upstream of urbanized/developed areas and major roads. Sites receiving the “reference” designation are indicated in Tables 1-3 and 17-19. The 25 percentile value for reference site Composite Index scores was determined and set as the score that separated “good” sites from “fair” sites for each stream-size category. The remaining range of possible Composite Index scores above the 25 percentile were then divided into two equal increments (“good” and “very good”), and index scores below the 25 percentile were divided into four equal increments (“fair,” “slightly degraded,” “poor,” and “very poor”). The final ranges of Composite Index score values for the various rating categories are summarized in Table 22. Ratings were assigned to each site in the final analysis based upon the average of Composite Index values for sites that were sampled on two or more dates (summarized in Table 23).

RESULTS AND DISCUSSION

Taxonomic Analysis

Tables 4-16 indicate abundance of invertebrates per site for all of the sampled streams outside of the Presque Isle Bay watershed, using summary descriptors based upon the actual counts in samples. A taxon was indicated as abundant (a) at a site if 100 or more individuals were counted in one or more samples from that site (on all dates). If the maximum count per sample for all dates sampled was between 10 and 100, the taxon was listed as common (c) for that site. Uncommon (u) was indicated for taxa whose maximum count was between 3 and 10 on all dates, and a descriptor of rare (r) was assigned if there were never more than 1 or 2 individuals counted in any of the samples for a site.

Representatives of six different phyla of invertebrate animals were widespread among the sampled streams (Tables 4-16). Free-living planarian flatworms (Platyhelminthes: Planariidae) and nematode worms (phylum Nematoda) were found in all streams. A single representative of the phylum Cnidaria, the freshwater *Hydra,* was found at one site on Conneaut Creek. The phylum Annelida was represented in most streams by both earthworms and small oligochaete worms; leeches were also found at a few sites on some of the streams. Most of the abovementioned taxa are generally considered pollution-tolerant (Hilsenhoff 1987, 1988; Klemm et al. 1990). Pollution-tolerant taxa (especially planarians and oligochaetes) were numerically important in samples from McDannels Run and Sixmile Creek (Tables 6 and 7), and contributed to low Composite Index scores and ratings for these streams (Tables 17 and 23).

Phylum Mollusca was represented by snails in 11 streams, limpets (Ancylidae) in 8 streams, and/or fingernail clams (e.g. *Pisidium*) in 9 streams. Although data is not reported here for unionid clams, this important family (also known as freshwater mussels) was found only in Conneaut Creek. Crustaceans were common representatives of the arthropod phylum in PA Lake Erie watershed streams. Among the crustacean groups, decapods (crayfish) were observed in 8 streams, amphipods were found in 7 streams, isopods were collected in 8 streams, cyclopoid copepods were found in 5 streams, and cladocerans were found in one. Water mites (Hydracarina) were found in samples from two streams. Most of the taxa mentioned above are considered pollution-tolerant (Hilsenhoff 1987, 1988; Klemm et al. 1990).

Ten different orders and 60 different families of insects were represented in the streams. Insect taxa in the three orders traditionally considered intolerant of water pollution in streams: mayflies (Ephemeroptera – E), stoneflies (Plecoptera – P), and caddisflies (Trichoptera – T) encompassed more than half of the many insect taxa found at most of the sites on Sixteenmile Creek (Table 4), and all of the sites on Sevenmile Creek (Table 5), Elk Creek (Table 8), and Crooked Creek (Table 9). Relatively few aquatic insects (and EPT taxa) were found at the Baker Creek site on Sixteenmile Creek and two of the three sampling sites on Sixmile Creek (Table 6), and even fewer were found at McDannels Run (Table 7). No mayflies or stoneflies were found at any of the sites on McDannels Run. Reduced representation of EPT taxa contributed to low Composite Index scores and “poor” to “very poor” final ratings for sites on Baker Creek, Sixmile Creek and McDannels Run (Tables 17 and 23).

The most abundant insects found in samples from McDannels Run were larvae of true flies (Diptera), an order generally considered tolerant of pollution (Hilsenhoff 1987, 1988; Klemm et al. 1990). Among the dipterans, immature, pollution-tolerant Chironomidae (midges) were the most widespread and abundant type among all sampled streams. They were the most abundant insect taxon at the Baker Creek, Sixmile Creek and McDannels Run sites. The midge family may have been represented by more than one species at the poor sites, and dozens of different species in the more biologically diverse streams/sites.

Substrate Conditions and Macroinvertebrates

A general decline in benthic macroinvertebrate community metrics and Composite Index scores was evident from upstream reaches to sites closer to the mouths of Sixteenmile, Sevenmile, Fourmile, and Elk Creeks. The Composite Index scores for sites near the mouths of these streams resulted in ratings of "slightly degraded" (16M1, 7M1, Elk1) or "poor" (4M1). The site near the lower end of Elliotts Run (east branch of Sevenmile Creek) also was rated as "slightly degraded." It is suspected that invertebrate community decline evident in all of these situations was mostly due to poor substrate quality – i.e. the absence of cobble/boulder material and predominance of scoured bedrock. A negative effect of scoured substrate on macroinvertebrate communities has been observed in a small urban stream on Erie's lower east side (Weber and Campbell 2005). Moderate Composite Index scores resulting in only "fair" ratings for the Hall's Run site (and Elk Creek tributary) and the lowest site on Crooked Creek (CrC1) also seemed to be related to scoured bedrock substrate. It is unknown whether the prevalence of bare bedrock

substrate was the original (presettlement) condition of these reaches, a characteristic that developed as a consequence of historical deforestation, or a feature related to hydrological disturbances in the modern era. Most of the scoured bedrock sites occur in stream segments within or below areas of steep gradient, and are likely the result of erosion from high energy flows that occur during major runoff events.

Substrate is a fundamental physical factor that limits the occurrence of aquatic insects in streams (review in Merritt and Cummins 1996) and that mediates effects of pollutants on stream invertebrates (Blasius and Merritt 2002). Besides scoured bedrock, other substrate problems observed at sites with degraded benthic macroinvertebrate communities included excessive filamentous algae accumulation (observed at 6M3 on Sixmile Creek), and deposition of silt or sand within the interstitial spaces of the streambed. Excessive deposition of sand and/or silt probably affected the benthic macroinvertebrate communities in Baker Creek, Sixmile Creek (site 6M2) and McDannels Run. It was also evident in association with poor macroinvertebrate communities at the Millcreek Mall and Old French Road sites on Walnut Creek (Wal2 & Wal3) and a site on Conneaut Creek along Rt. 6N west of Albion (Con4). All of the sites with excessive fine particles in their substrate are in low-gradient stream segments and areas with obvious “sources” of NPSP, including major roads or urban areas.

General Observations Regarding Small Streams

Sampling was conducted on first-order streams during the current study, in addition to the small streams included in Campbell (2002). Comparative data is available (but not

included in this report) on the biological conditions of the headwaters of Sixteenmile Creek, Sevenmile Creek, Mill Creek, Cascade Creek, Elk Creek, and Duck Run, as well as several first-order streams that enter Lake Erie directly, such as Cemetery Run and Scott Run. Some of this data is already published (Welte and Campbell 2003, Weber and Campbell 2005), and a manuscript focusing on first-order streams is forthcoming (Campbell 2006, in preparation). Some general points about headwaters streams will be made here, to communicate the need for taking protective measures.

The author of this report asserts that insufficient protection of headwaters (first order) streams results in degradation of the larger streams to which they connect. Developers and government agencies may fail to recognize the presence of some first-order streams because they are not always indicated on topographic maps. There is also sometimes uncertainty about whether a small stream is permanent or intermittent, and this status affects the perception of their importance. The general public, regulatory community, and (until recently) scientists have not fully appreciate the *functional* significance of small streams, as it has only recently been discovered that these ecosystems have important roles in maintaining biodiversity and water quality (discussed in more detail below). In many states, environmental regulations let small streams "fall through the cracks." For instance, in Pennsylvania, it is relatively easy for a developer to obtain permission to enclose a small stream in a culvert and build over it, if the stream has a watershed smaller than 100 acres. Wetlands are vigorously protected under state and federal laws irregardless of their size and drainage area. In our own watershed, developers designing storm water management systems will carefully avoid impacts on

wetlands, but end-up negatively affecting small streams, since they are not given equal protection. In essence, small streams are harmed in the process of protecting wetlands during land development activities.

Local evidence of the importance of small streams that Campbell (2006, in preparation) has gathered includes the following facts: 1) small tributaries may collectively hold greater ecosystem diversity than the larger channel systems that they "feed;" 2) small tributaries produce biologically diverse invertebrate communities that rival large streams; and 3) small streams contain some unique species of invertebrates not found in larger channels. It has been determined that headwaters streams are critical "primary functional units" of the larger systems they connect to; and small streams are now recognized as having major roles in organic matter (food) processing (Merritt and Cummins 1996, Vannote et al. 1980) and nutrient cycling. A recent nationwide study published in Science magazine reported that small streams are more effective than larger ones in removing excess nitrogen (originating in fertilizer runoff and auto emissions) from receiving waters (Peterson et al. 2001).

Headwaters are important in maintaining genetic diversity of aquatic insect populations, since adult insects have been found to fly between headwaters of different streams (Briers et al. 2004), facilitating gene flow between otherwise isolated populations. It has been found that first-order streams often harbor populations of some of the same aquatic insect species that occur in second- and third-order streams (Campbell 2006, in preparation). As long as headwaters tributaries are not degraded by NPSP or altered by urbanization,

they may serve as refuges for insect populations that cannot survive in degraded downstream reaches. If and when degraded stream segments are restored, the headwaters would likely provide organisms to restore populations downstream via drift of immature stages or dispersal flights of adult insects. Adult aquatic insects have been found to disperse distances greater than 1 km (Briers et al. 2004, Macneale et al. 2005); and it is reasonable to expect that insects in the headwaters of a healthy watershed would probably be able migrate to stream segments in an adjoining unhealthy watershed undergoing restoration. In these ways, small streams may play an important role in restoring the benthic macroinvertebrate diversity of degraded streams.

Recommendations

It must first be emphasized that macroinvertebrate communities indicated good to very good conditions at nearly all sites in *less developed* areas of the Pennsylvania Lake Erie watershed. Although Sixteenmile, Sevenmile, and Fourmile Creeks had slightly degraded or poor conditions in their lower reaches, the benthic macroinvertebrate communities in their upper reaches indicated good conditions and little or no NPSP problems. Healthy stream conditions were also found at sampling sites in less developed areas of the upper reaches of Mill, Walnut, and Elk Creeks. In general, degraded invertebrate communities were found at sites in the middle and lower reaches of the streams in the PA Lake Erie watershed, especially in areas affected by urban/suburban development. The most degraded sites were found in high density population and commercial centers with large amounts of impervious surfaces (parking lots, roads, buildings, etc.) and tributary streams enclosed within storm sewers.

A high priority for watershed groups that want to maintain the good health of their streams should be to work with their local developers and government leaders to minimize future disturbance of small headwaters streams (tributaries with watersheds smaller than 100 acres), which are currently under-protected by state regulations, and to seek ways to prevent additional conversion of "green space" to high density development.

Remediation of degraded streams affected by NPSP and urbanization should emphasize restoration of riparian buffers, and retrofitting storm water retention/detention systems (Best Management Practices or BMP's) in locations having large amounts of impervious surfaces. It may not be possible to remediate the degradation of substrate (scoured bedrock) in the lower reaches of streams like Sevenmile, Sixteenmile, Fourmile and Elk Creeks, unless the underlying causes are eliminated – excessive flows associated with major runoff events. Many areas of the PA Lake Erie watershed have experienced natural reforestation during the last century, associated with the decline of active agricultural land use. Forest vegetation helps absorb precipitation and increases the likelihood that rainfall and snowmelt will enter groundwater and reach our streams gradually. If reforestation were to continue, hydrological changes may occur in the future that could reduce the erosion that occurs in streams during/following storm events. Therefore, encouraging the (ongoing) natural conversion of abandoned farmland to forest would serve to promote the natural restoration of our water cycle. Increased public and landowner education regarding the hydrological benefits of forest land over open fields could help ensure that the PA Lake Erie watershed continues to regain forests.

Historical records suggest that coniferous trees, especially white pine and hemlock, were more prominent elements of the presettlement forest of the Pennsylvania Lake Erie watershed than in the second-growth forests that have developed during the past century. The dominant species that now occupy the "forest niche" formerly occupied by conifers include almost entirely deciduous species such as red maple, tulip, and northern red oak. Deciduous trees are less beneficial than conifers during reforestation, from a hydrological perspective, because of their seasonal foliage and lower storage/interception capacity for precipitation. Therefore it is recommended that steps be taken to increase the representation of native conifers in our watershed's forests. Increasing conifer cover would be expected to provide hydrological benefits for streams (e.g. Mackay & Band 1997, Tate 1995, Swank 1968, Yue & Michio 2005). Pines (including white pine) are important elements of forest restoration initiatives in other regions of the Great Lakes, including Ontario (Wildlands League 2001) and Wisconsin (He et al. 1998, Bollinger et al. 2004).

If positive steps are taken to reduce the underlying cause of substrate degradation in our streams (erosion from excess runoff), then it might be possible to restore boulder and cobble substrates in scoured areas, through natural accretion or substrate augmentation. Reintroduction of boulders and woody debris has been shown to be beneficial to fish and benthic macroinvertebrate communities in stream restoration projects elsewhere (Muotka et al. 2002, Negishi and Richardson 2003, review in Roni et al. 2005). Federal and state guidance on these types of restoration initiatives are available (USDA 1998, Ohio DNR,

2004). Planting conifers and organizing/funding substrate enhancement projects could be excellent activities that watershed organizations might undertake.

The views expressed herein are those of the author, Dr. J. Michael Campbell, and do not necessarily reflect the views of the Erie County Conservation District or the PA Department of Environmental Protection.

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Table 1. Sites, locations, and sampling dates for streams included in 2005 analysis, east of City of Erie. Sites classified as "Reference" meet criteria defined in text, and were used to develop objective ratings of final Composite Index scores.

Watershed	Stream	Site	Address	Size/order	Status	Date
Twentymile	Twentymile	20M	North of I-90	3rd+	Reference	11/27/2001
Twentymile	Twentymile	20M	North of I-90	3rd+	Reference	6/6/2003
Sixteenmile	Sixteenmile	16M1	South of Route 5	3rd		11/27/2001
Sixteenmile	Sixteenmile	16M1	South of Route 5	3rd		6/2/2003
Sixteenmile	Sixteenmile	16M1	South of Route 5	3rd		12/4/2003
Sixteenmile	Sixteenmile	16M2	South of Wellington St.	3rd	Reference	11/27/2001
Sixteenmile	Sixteenmile	16M2	South of Wellington St.	3rd	Reference	6/2/2003
Sixteenmile	Sixteenmile	16M2	South of Wellington St.	3rd	Reference	12/4/2003
Sixteenmile	Sixteenmile	16M3	West side Oxbow Rd.	3rd	Reference	12/20/2001
Sixteenmile	Baker Creek	16M4	West of Vine St	2nd		6/2/2003
Sixteenmile	Baker Creek	16M4	West of Vine St	2nd		12/4/2003
Sixteenmile	Sixteenmile	16M5	South of Cole Rd.	2nd	Reference	12/20/2001
Sixteenmile	Sixteenmile	16M5	South of Cole Rd.	2nd	Reference	6/2/2003
Sixteenmile	Sixteenmile	16M5	South of Cole Rd.	2nd	Reference	12/4/2003
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	5/11/2001
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	7/18/2001
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	10/2/2001
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	12/20/2001
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	6/4/2003
Twelvemile	Twelvemile	12M1	South of Rt. 5	3rd	Reference	12/4/2003
Twelvemile	Twelvemile	12M2	South of Sandhill Rd.	2nd	Reference	12/20/2001
Twelvemile	Twelvemile	12M2	South of Sandhill Rd.	2nd	Reference	6/4/2003
Sevenmile	Sevenmile	7M1	North of Rt. 5	3rd		5/1/2001
Sevenmile	Sevenmile	7M1	North of Rt. 5	3rd		7/18/2001
Sevenmile	Sevenmile	7M1	North of Rt. 5	3rd		10/2/2001
Sevenmile	Sevenmile	7M1	North of Rt. 5	3rd		5/26/2003
Sevenmile	Sevenmile	7M1	North of Rt. 5	3rd		12/4/2003
Sevenmile	Sevenmile	7M2	East of Depot Rd.	2nd	Reference	5/11/2001
Sevenmile	Sevenmile	7M2	East of Depot Rd.	2nd	Reference	7/18/2001
Sevenmile	Sevenmile	7M2	East of Depot Rd.	2nd	Reference	10/3/2001
Sevenmile	Sevenmile	7M2	East of Depot Rd.	2nd	Reference	5/28/2003
Sevenmile	Sevenmile	7M2	East of Depot Rd.	2nd	Reference	12/9/2003
Sevenmile	Sevenmile	7M3	South of I-90, Prindle Rd.	2nd	Reference	5/28/2003
Sevenmile	Sevenmile	7M3	South of I-90, Prindle Rd.	2nd	Reference	12/9/2003
Sevenmile	Elliott's Run	7M4	South of Rt.20	2nd		6/3/2003
Sevenmile	Elliott's Run	7M4	South of Rt.20	2nd		12/9/2003
Sixmile	Sixmile	6M1	North of Rt. 5	3rd		12/16/2003
Sixmile	Sixmile	6M2	North of Iroquois Rd.	3rd		5/26/2003
Sixmile	Sixmile	6M2	North of Iroquois Rd.	3rd		12/11/2003
Sixmile	Sixmile	6M3	West of Depot Rd.	3rd		5/26/2003
Sixmile	Sixmile	6M3	West of Depot Rd.	3rd		12/11/2003
Fourmile	Fourmile	4M1	North of Rt. 5	3rd		5/26/2003
Fourmile	Fourmile	4M1	North of Rt. 5	3rd		12/4/2003
Fourmile	Fourmile	4M2	South of Copper Rd.	3rd	Reference	7/7/2003
Fourmile	Fourmile	4M3	South of Hartman Rd.	2nd	Reference	11/29/2001
McDannel's Run	McDannel's Run	McD1	North of Rt. 5	2nd		5/27/2003
McDannel's Run	McDannel's Run	McD1	North of Rt. 5	2nd		12/4/2003
McDannel's Run	McDannel's Run	McD2	West of Franklin Ave.	2nd		5/11/2001
McDannel's Run	McDannel's Run	McD2	West of Franklin Ave.	2nd		8/1/2001
McDannel's Run	McDannel's Run	McD2	West of Franklin Ave.	2nd		10/3/2001
McDannel's Run	McDannel's Run	McD2	West Franklin Ave.	2nd		12/16/2003

Table 2. Sites, locations, and sampling dates for streams included in 2005 analysis, in and near City of Erie. Site Classified as "Reference" met criteria defined in text, and data were used to develop objective ratings of Final Composite Index scores.

Watershed	Stream	Site	Address	Size/order	Status	Date
Mill Creek	Mill Creek	MC1	34th St.	3rd		10/10/2000
Mill Creek	Mill Creek	MC1	34th St.	3rd		3/27/2001
Mill Creek	Mill Creek	MC1	34th St.	3rd		6/21/2001
Mill Creek	Mill Creek	MC1	34th St.	3rd		9/11/2001
Mill Creek	Mill Creek	MC1	34th St.	3rd		12/11/2003
Mill Creek	Mill Creek	MC1A	38th St	3rd		10/16/2001
Mill Creek	Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd		10/10/2000
Mill Creek	Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd		11/18/2000
Mill Creek	Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd		4/10/2001
Mill Creek	Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd		6/21/2001
Mill Creek	Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd		9/12/2001
Mill Creek	West Branch	MC3	Glenridge Rd.	2nd		11/18/2000
Mill Creek	West Branch	MC3	Glenridge Rd.	2nd		6/26/2001
Mill Creek	Mill Creek	MC3	Glenridge Rd.	2nd		9/12/2001
Mill Creek	Mill Creek	MC5	East of Rt.97	2nd	Reference	10/17/2000
Mill Creek	Mill Creek	MC5	East of Rt.97	2nd	Reference	4/26/2001
Mill Creek	Mill Creek	MC5	East of Rt.97	2nd	Reference	7/17/2001
Mill Creek	Mill Creek	MC5	East of Rt.97	2nd	Reference	9/12/2001
Mill Creek	Mill Creek	MC6	Belle Valley, Norcrooss Rd	2nd		10/3/2000
Mill Creek	Mill Creek	MC6	Belle Valley, Norcrooss Rd	2nd		3/22/2001
Mill Creek	Mill Creek	MC6	Belle Valley, Norcrooss Rd	2nd		6/21/2001
Mill Creek	Mill Creek	MC6	Belle Valley, Norcrooss Rd	2nd		9/20/2001
Mill Creek	Mill Creek	MC8	Headwaters Park	2nd		10/3/2000
Mill Creek	Mill Creek	MC8	Headwaters Park	2nd		3/22/2001
Mill Creek	Mill Creek	MC8	Headwaters Park	2nd		6/14/2001
Mill Creek	Mill Creek	MC8	Headwaters Park	2nd		9/21/2001
Mill Creek	Mill Creek	MC8	Headwaters Park	2nd		6/4/2003
Mill Creek	Garrison Run	GR	North of 5th St.	2nd		12/14/2000
Mill Creek	Garrison Run	GR	North of 5th St.	2nd		5/11/2001
Mill Creek	Garrison Run	GR	North of 5th St.	2nd		8/1/2001
Mill Creek	Garrison Run	GR	North of 5th St.	2nd		9/28/2001
Cascade Creek	Cascade Creek	CC1	Above mouth near bay	2nd		12/7/2000
Cascade Creek	Cascade Creek	CC1	Above mouth near bay	2nd		5/9/2001
Cascade Creek	Cascade Creek	CC1	Above mouth near bay	2nd		7/20/2001
Cascade Creek	Cascade Creek	CC1	Above mouth near bay	2nd		9/25/2001
Cascade Creek	Cascade Creek	CC1	Above mouth near bay	2nd		12/16/2003
Cascade Creek	Cascade Creek	CC2	Fronteir Park	2nd		12/7/2000
Cascade Creek	Cascade Creek	CC2	Fronteir Park	2nd		5/9/2001
Cascade Creek	Cascade Creek	CC2	Fronteir Park	2nd		7/24/2001
Cascade Creek	Cascade Creek	CC2	Fronteir Park	2nd		9/25/2001
Cascade Creek	Cascade Creek	CC3	East of Greengarden	2nd		7/27/2001
Cascade Creek	Cascade Creek	CC3	East of Greengarden	2nd		10/4/2001

Table 3. Sites, locations, and dates sampled for streams included in 2005 analysis, west of the City of Erie. Sites Classified as "Reference" meet criteria defined in text, and were used to develop objective ratings of Final Composite Index scores.

Watershed	Stream	Site	Address	Size/order	Status	Date
Walnut Creek	Walnut Creek	Wal 1	Old Sterrettania Rd.	3rd+	Reference	12/3/2001
Walnut Creek	Walnut Creek	Wal 1	Old Sterrettania Rd.	3rd+	Reference	6/16/2003
Walnut Creek	Walnut Creek	Wal 2	Millcreek Mall	3rd		1/6/2004
Walnut Creek	Walnut Creek	Wal 3	Old French	2nd		6/16/2003
Walnut Creek	Walnut Creek	Wal 4	Rt. 97 above landfill	2nd	Reference	12/3/2001
Walnut Creek	Walnut Creek	Wal 4	Rt. 97 above landfill	2nd	Reference	6/27/2003
Walnut Creek	Walnut Creek	Wal5	West of Thomas Rd.	2nd	Reference	12/3/2001
Elk Creek	Elk Creek	ElkM	North of Rt. 5	3rd+		9/27/2004
Elk Creek	Elk Creek	Elk1	Elk Park Rd.	3rd+		6/30/2003
Elk Creek	Elk Creek	Elk1	Elk Park Rd.	3rd+		12/22/2003
Elk Creek	Elk Creek	Elk2	South of Rt. 20	3rd+	Reference	6/16/2003
Elk Creek	Elk Creek	Elk2	South of Rt. 20	3rd+	Reference	12/22/2003
Elk Creek	Elk Creek	Elk3	West of Rt. 98	3rd+	Reference	7/7/2003
Elk Creek	Elk Creek	Elk3	West of Rt. 98	3rd+	Reference	12/23/2003
Elk Creek	Elk Creek	Elk4	East of I-79	3rd	Reference	12/3/2001
Elk Creek	Elk Creek	Elk4	East of I-79	3rd	Reference	6/16/2003
Elk Creek	Elk Creek	Elk4	East of I-79	3rd	Reference	12/25/2003
Elk Creek	Elk Creek	Elk5	Hamot Rd.	2nd	Reference	12/3/2001
Elk Creek	Little Elk Creek	Elk6	Franklin Center Rd.	3rd	Reference	12/10/2001
Elk Creek	Little Elk Creek	Elk6	Franklin Center Rd.	3rd	Reference	6/30/2003
Elk Creek	Little Elk Creek	Elk6	Franklin Center Rd.	3rd	Reference	12/22/2003
Elk Creek	Little Elk trib.	Elk7	Franklin Center Rd.	2nd	Reference	12/10/2001
Elk Creek	Little Elk trib.	Elk7	Franklin Center Rd.	2nd	Reference	12/23/2003
Elk Creek	Hall's Run	Elk8	Colespring Rd.	2nd	Reference	12/10/2001
Elk Creek	Hall's Run	Elk8	Colespring Rd.	2nd	Reference	6/30/2003
Elk Creek	Hall's Run	Elk8	Colespring Rd.	2nd	Reference	12/23/2003
Elk Creek	Falk Run	Elk9	Falls Rd.	2nd	Reference	12/10/2001
Duck Run	Duck Run	DR1	N. Penn Central line	2nd		3/4/2005
Duck Run	Duck Run	DR1	N. Penn Central line	2nd		3/4/2005
Duck Run	Duck Run	DR1	N. Penn Central line	2nd		3/4/2005
Duck Run	Duck Run	DR2	North of Rt. 5	2nd		2/12/2004
Duck Run	Duck Run	DR2	North of Rt. 5	2nd		3/4/2005
Crooked Creek	Crooked Creek	Cr1	South of Albes Rd.	3rd	Reference	7/2/2003
Crooked Creek	Crooked Creek	Cr1	South of Albes Rd.	3rd	Reference	12/23/2003
Crooked Creek	Crooked Creek	Cr2	West side Happy Valley Rd.	3rd	Reference	7/2/2003
Crooked Creek	Crooked Creek	Cr2	West side Happy Valley Rd.	3rd	Reference	12/23/2003
Crooked Creek	Crooked Creek	Cr3	East side Lexington Rd.	2nd	Reference	6/28/2003
Crooked Creek	Crooked Creek	Cr3	East side Lexington Rd.	2nd	Reference	12/23/2003
Raccoon Creek	Raccoon Creek	Rac1	South side Old Lake Rd.	2nd	Reference	7/7/2003
Raccoon Creek	Raccoon Creek	Rac1	South side Old Lake Rd.	2nd	Reference	12/23/2003
Raccoon Creek	Raccoon Creek	Rac2	South side Elmwood Rd.	2nd	Reference	7/7/2003
Raccoon Creek	Raccoon Creek	Rac2	South side Elmwood Rd.	2nd	Reference	12/23/2003
Conneaut Creek	Conneaut Creek	Con1	South of Conneaut Oh	3rd+	Reference	9/28/2004
Conneaut Creek	Conneaut Creek	Con2	Akerly rd.	3rd+	Reference	9/28/2004
Conneaut Creek	Conneaut Creek	Con3	McKee Rd.	3rd+	Reference	9/30/2004
Conneaut Creek	Conneaut Creek	Con4	South of Rt. 6N	3rd+	Reference	10/12/2004
Conneaut Creek	Conneaut Creek	Con5	South side of Carter Rd.	3rd+	Reference	11/9/2004
Conneaut Creek	Conneaut Creek	Con6	Springboro	3rd	Reference	10/12/2004
Conneaut Creek	Conneaut Creek	Con7	South of Rt. 6N	2nd	Reference	7/7/2003
Conneaut Creek	Conneaut Creek	Con7	South of Rt. 6N	2nd	Reference	11/9/2004
Conneaut Creek	Conneaut Creek	Con8	North of Rt. 6N	2nd	Reference	11/9/2004
Conneaut Creek	Conneaut Creek	Con9	East side Barney Rd.	2nd	Reference	11/9/2004
Conneaut Creek	Conneaut Creek	Con10	Gameland 101	2nd	Reference	11/16/2004

Table 4. Benthic macroinvertebrate abundance at sampling sites on Sixteenmile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	16M1 (3)	16M2 (3)	16M3 (1)	16M4 (2)	16M5 (3)
Platyhelminthes					
Planariidae	a	u	r	a	r
Nematoda	u			r	
Annelida					
Oligochaeta	a	a	c	a	a
Lumbricidae	c	u	u	c	c
Hirudinea		r	r		
Mollusca					
Ancylidae	u				
Gastropoda Lymnaeidae			r		
Physidae		r			
Bivalvia Pisidium	r			r	r
Planorbidae Arminger Crista				r	
Arthropoda - Crustacea					
Decapoda Cambaridae	r		r	r	c
Isopoda Lirceus					u
Terrestrial isopod					
Amphipoda Crangonyx					u
Cyclopoid					r
Hyallela					u
Arthropoda – Insecta					
Hemiptera					
Corixidae					r
Hebridae Merragata				r	
Odonata					
Aeshnidae Aeshna				r	
Collembola Isotomidae			r		r
Isotomurus					r
Ephemeroptera					
Baetidae					
Centroptilum	c	a	c		c
Unidentified	r	c			c
Caenidae Caenis	u	c	u	r	
Ephemerellidae Ephemerella	r	u			
Eurylophella		u	u	r	r
Ephemeridae Ephemera		r	u		
Heptageniidae					
Epeorus	c	c	a		c
Leucrocuta	r	c			u
Stenonema	c	u	r	u	c
Stenacron		c	u		u
Leptophlebiidae					
Habrophlebiodes	r	a			a
Lepthophlebia	r	u	c		
Paraleptophlebia	u	a	c		
Siphlonuridae Ameletus	c	a	a		a

Table 4. continued

Taxon	16M1 (3)	16M2 (3)	16M3 (1)	16M4 (2)	16M5 (3)
Plecoptera					
Capniidae Allocapnia	a	c	c	u	u
Paracapnia		c	c		c
Chloroperlidae Sweltsa		r	c		a
Leuctridae Leuctra	r	u	u		r
Zealeuctra					r
Nemouridae Amphinemoura		c			r
Prostoia		u			
Perlidae Acroneuria	r	u	u		
Agnetina	r	c			
Beloneuria		r			
Neoperla		r			
Paragnetina		r			
Perlodidae Chimarra		c			
Clioperla		r			
Diploperla		u	u		c
Unidentified		u			
Trichoptera					
Hydropsychidae					
Cheumatopsyche	c	c	u	c	r
Diplectrona	r	r	c		u
Hydropsyche	c	c		u	
Hydroptilidae Hydroptila	r			u	
Limnephilidae					
Pycnopsyche			r		
Lepidostomatidae Lepidostoma		r			r
Philopotamidae Chimarra	u	u			
Dolophilodes	r	c			c
Wormaldia		u	c		r
Polycentropodidae					
Polycentropus	u	c	c	r	c
Rhyacophilidae Rhyacophila	r	r	u		
Uenoidae Neophylax		r	c		r
Megaloptera					
Corydalidae Nigronia	u	r	r		r
Sialidae Sialis	u				
Lepidoptera Pyralidae Unid.	r				
Coleoptera					
Dytiscidae Agabus					r
Copelatus	r				
Hydroporus				u	
Elmidae Dubiraphia	r			r	
Oulimnius	u	u		u	
Stenelmis	u	u		c	
Hydrophilidae Unid.			r		r
Psephenidae Psephenus	c	c	r	a	u
Diptera					
Ceratopogonidae Ceratopogon					r
Stilobezzia		r			
Chaoboridae Chaoborus	c				

Table 4. continued

Taxon	16M1 (3)	16M2 (3)	16M3 (1)	16M4 (2)	16M5 (3)
Diptera - continued					
Chironomidae	c	c	c	a	c
Empididae Hemerodromia	u				
Psychodidae Pericoma	r				
Psychoda	r	r			
Simuliidae Simulium	u	r			u
Prosimulium			c	r	r
Tabanidae Chrysops					r
Tipulidae Antocha	u				
Dicranota	u	c	c		
Hexatoma	r	c	c		c
Limnophila	r	r			
Molophilus		r			r
Pseudolimnophila					r
Tipula	u	u	u	u	u
Unidentified					r
Total taxa	49	57	38	25	49
Total insect taxa	42	52	32	18	40
Total EPT taxa	23	39	23	8	23

Table 5. Benthic macroinvertebrate abundance at sampling sites on Sevenmile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	7M1 (5)	7M2 (5)	7M3 (2)	7M4 (2)
Platyhelminthes				
Planariidae	c	c		u
Nematoda	r	u		
Annelida				
Oligochaeta	a	a	a	a
Lumbricidae	u	c	r	c
Mollusca				
Ancylidae	u			
Lymnaeidae		r		
Physidae	c	c		
Bivalvia Pisidium		c		
Arthropoda - Crustacea				
Decapoda Cambaridae	u	u	u	
Isopoda Lirceus	u	r		
Terrestrial isopod	r			
Amphipoda				
Copepoda Cyclopoid	u	r		
Arthropoda – Insecta				
Hemiptera				
Gerridae Gerris		r		
Trepobates	r			
Mesovelidae Mesovelia	u	r		
Veliidae Rhagovelia	u			
Odonata				
Aeshnidae Boyeria		u		
Calopterygidae Calopteryx		r		
Gomphidae Unid.		r		
Collembola				
Isotomidae Agrenia	r	r		
Ephemeroptera				
Baetidae Baetis	r	a	u	u
Centroptilum	c	a	a	u
Ephemerellidae Drunella		c		
Ephemerella		u	u	
Eurylophella	c	a	u	c
Ephemeridae Ephemera	r	c		
Heptageniidae Cinygmula		r		
Epeorus	u	c	a	u
Leucrocuta		r	r	c
Stenonema	r		r	
Stenacron		r	u	
Leptophlebiidae				
Leptophlebia	r			r
Habrophlebiodes	u	c		c
Paraleptophlebia	u	c	c	c
Siphlonuridae Ameletus	r	u	c	c
Tricorythidae Tricorythodes	r			
Plecoptera				
Capniidae Allocapnia	c		c	u

Table 5. continued

Taxon	7M1 (5)	7M2 (5)	7M3 (2)	7M4 (2)
Plecoptera Capniidae continued				
Paracapnia			c	
Utacapnia		u		
Chloroperlidae Haploperla		u		
Suwallia		c		
Sweltsa	r	u	c	r
Utaperla	r	c		
Leuctridae Leuctra	r	r		
Paraleuctra			r	
Nemouridae Amphinemoura	r	u	a	
Prostoia			c	
Peltoperlidae Peltoperla				
Perlidae Acroneuria	r	u	u	
Agnetina	u	c	r	
Beloneuria	r	r		
Neoperla				
Paragnetina				
Perlodidae Diploperla	r	r	u	c
Diura				
Clioperla	r			
Isoperla			u	u
Taeniopterygidae Taeniopteryx			r	
Trichoptera				
Hydropsychidae				
Cheumatopsyche	c	c	r	u
Diplectrona		a	c	u
Hydropsyche	u	c	r	u
Limnephilidae Apatania		r		
Asynarchus	r			
Philopotamidae Chimarra	c			r
Dolophilodes	u	a	u	
Wormaldia			u	
Polycentropodidae Neureclipsis		r		
Polycentropus	r	c	u	
Rhyacophilidae Rhyacophila	r	c	u	
Uenoidae Neophylax			r	r
Unidentified		r		
Megaloptera				
Corydalidae Nigronia	r	c	r	
Sialidae Sialis	r	r		r
Coleoptera				
Dytiscidae Hydroporus				r
Unidentified	r			
Elmidae Dubiraphia		c		
Optioservus		u		
Oulimnius	c	c		u
Stenelmis	u	c		
Psephenidae Psephenus	c	a	c	
Ptilodactylidae Anchytarsus	r			

Table 5. continued

Taxon	7M1 (5)	7M2 (5)	7M3 (2)	7M4 (2)
Diptera				
Ceratopogonidae Probezzia		c		
Stilobezzia		r		
Unid.				u
Chironomidae	a	a	a	a
Dixidae Dixa		r		
Empididae Chelifera		r		
Clinocera		u		
Hemerodromia	c	c		
Simuliidae Simulium	c	c	r	c
Prosimulium			r	
Tabanidae Chrysops				
Tipulidae Antocha	r	r		
Dicranota	c	c	r	
Hexatoma	r	c	u	
Limnophila	r			
Molophilus		r	r	
Pseudolimnophila		r	u	u
Tipula	c	a	u	c
Total taxa	57	70	43	30
Total insect taxa	47	60	40	27
Total EPT taxa	28	33	30	18

Table 6. Benthic macroinvertebrate abundance at sampling sites on Sixmile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	6M1 (1)	6M2 (2)	6M3 (2)
Platyhelminthes			
Planariidae	u	r	
Nematoda		r	u
Annelida			
Oligochaeta	a	c	a
Lumbricidae	u	u	u
Collembola			
Isotomidae		r	r
Ephemeroptera			
Baetidae Baetis		r	
Centroptilum	u	r	r
Caenidae Caenis		r	
Heptageniidae Stenonema	r	u	
Epeorus			r
Leptophlebiidae			
Habrophlebiodes		r	r
Paraleptophlebia		u	r
Siphlonuridae Ameletus		r	r
Plecoptera			
Capniidae Unid.		r	
Chloroperlidae Sweltsa		r	r
Utaperla		r	
Perlidae Paragnetina	r	r	
Perlodidae Diploperla	r		
Taeniopterygidae Taeniopteryx		r	
Trichoptera			
Leptoceridae Oecetis		r	
Hydropsychidae			
Cheumatopsyche	c	c	u
Hydropsyche	r	r	
Hydroptilidae Unid.		r	
Polycentropodidae			
Polycentropus	r	c	u
Lepidoptera Pyralidae			r
Coleoptera			
Hydrophilidae Helophorus		r	
Psephenidae Psephenus	r	r	
Diptera			
Chaoboridae Chaoborus		r	
Chironomidae	c	a	c
Simuliidae Simulium		r	
Prosimulium		u	
Tipulidae Antocha	u		
Dicranota	r		r
Hexatoma		r	
Tipula	u		r
Total taxa	15	29	16
Total insect taxa	12	25	13
Total EPT taxa	7	17	8

Table 7. Benthic macroinvertebrate abundance at sampling sites on McDannels Run. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled. Site McD3 was a first-order stream north of Buffalo Rd., not included in comparative analyses in this report.

Taxon	McD1 (1)	McD2 (5)	McD3 (3)
Platyhelminthes			
Planariidae	a	a	a
Nematoda		r	r
Annelida			
Oligochaeta	c	a	a
Lumbricidae	c	c	u
Hirudinea	r		
Mollusca			
Physidae		u	c
Arthropoda - Crustacea			
Isopoda Lirceus		r	
Amphipoda Crangonyx	a	c	r
Collembola			
Isotomidae		r	
Trichoptera			
Hydropsychidae			
Cheumatopsyche	r	r	
Coleoptera			
Hydrophilidae Helochares		r	
Diptera			
Chironomidae	c	c	c
Muscidae Limnophora			u
Syrphidae		r	
Empididae Hemerodromia		u	
Stratiomyidae Odontomyia		r	
Simuliidae		r	
Simulium			r
Tipulidae Limonia		r	
Tipula	u	u	u
Total taxa	8	17	10
Total insect taxa	3	10	4
Total EPT taxa	1	1	0

Table 8. Benthic macroinvertebrate abundance at sampling sites on Elk Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	Elk1 (2)	Elk2 (2)	Elk3 (2)	Elk4 (3)	Elk5 (1)	Elk6 (3)	Elk7 (2)	Elk8 (3)	Elk9 (1)
Platyhelminthes									
Planariidae	u	r	c	c	c	c	c	u	r
Nematoda			u	r	c	u	r	r	
Annelida									
Oligochaeta	c	a	a	c	c	c	a	c	c
Lumbricidae - earthworm	r	u	u	r	u	r	u		u
Hirudinea cylindrical				r					r
oval									r
Hydrachnidia									r
Mollusca									
Gastropoda Ancylidae				r	r	r		u	
Hydrobiidae						r	r	u	
Physidae			r		r	u	r	c	u
Bivalvia Corbicula					r				
Pisidium			r			r			
Arthropoda - Crustacea									
Decapoda Cambaridae				r	r			r	r
Orconectes propinquus			r	r					
Isopoda Lirceus	r		u	u			r		
Cladocera Simocephalus			u	u					
Copepoda Cyclopoid	u								
Amphipoda Crangonyx	u	r	r				r		r
Arthropoda - Insecta									
Collembola									
Isotomidae Agrenia					r			r	
Hemiptera									
Corixidae Cymatia								r	
Unid. insect larva					r				
Odonata									
Aeshnidae Boyeria						r			
Coenagrionidae Amphiagrion				u					
Argia		r	r	r					
Gomphidae Lanthus					r				
Stylogomphus					r				
Ephemeroptera									
Baetidae Baetis	u	u	u	c				u	
Callibaetis									r
Centroptilum	c	c	a	c	c	c	a	c	r
Caenidae Caenis	r	u	c	c	c	c		r	r
Ephemerellidae Ephemerella	r	r							
Eurylophella	r				r	a	c	u	
Ephemeridae Ephemera					r	r		c	
Heptageniidae Epeorus		r	c	u	r	a	c		
Leucrocuta	c	c	c	c					
Nixe		u							
Stenonema	r	u	c	c	c	c	c	c	c
Stenacron	u	u	r	u	c	u	r		
Leptophlebiidae									
Habrophlebiodes		u	r	c		c	u	u	

Table 8. continued

Taxon	Elk1 (2)	Elk2 (2)	Elk3 (2)	Elk4 (3)	Elk5 (1)	Elk6 (3)	Elk7 (2)	Elk8 (3)	Elk9 (1)
Ephemeroptera – Leptophlebiidae cont.									
Leptophlebia				r					
Paraleptophlebia		r		u	c	c			r
Unid.		r							
Oligoneuridae Isonychia	r	r	c	c	c	u		u	
Siphlonuridae Ameletus		u	c	r	u	a	a	u	u
Tricorythidae Tricorythodes	r		c						
Plecoptera									
Capniidae Allocapnia	c	a	a	a	u	a	a	c	a
Capnia		r	u			c			
Paracapnia					u	c	c		
Chloroperlidae Sweltsa				r	u		c	u	
Utaperla						c			
Unidentified						r			
Leuctridae Leuctra				r	u				
Paraleuctra				u					
Nemouridae Amphinemoura				r		r			
Peltoperlidae Peltoperla					r				
Perlidae Acroneuria						u	r		
Agnetina					r				
Beloneuria				r					
Neoperla		u	u						
Perlodidae Clioperla						r	u	r	r
Diploperla				r	u	a	a	u	c
Isoperla					u	u	c		
Unid.							u		
Taeniopteryaidae Taeniopteryx			u	c	r	u		u	
Trichoptera									
Glossosomatidae Glossosoma				r					
Hydropsychidae									
Cheumatopsyche	r	c	a	c	c	c	u	c	u
Diplectrona					r	r	u		
Hydropsyche	u	u	a	c	c	c	u	u	
Hydroptilidae									
Pycnopsyche					u				
Unidentified									
Limnephilidae Unid.						r			
Philopotamidae Chimarra	r	r	a	c		c	c	c	u
Dolophilodes	r				r	u	r		
Wormaldia					r		r		
Polycentropodidae									
Polycentropus		r	a			u	u	r	
Rhyacophilidae Rhyacophila						r	r		c
Uenoidae Neophylax						u	c		c
Lepidoptera									
Pyralidae Petrophila				r					
Unidentified				r					
Megaloptera									
Corydalidae Nigronia				r	r				
Sialidae Sialis				r					c

Table 8. continued

Taxon	Elk1 (2)	Elk2 (2)	Elk3 (2)	Elk4 (3)	Elk5 (1)	Elk6 (3)	Elk7 (2)	Elk8 (3)	Elk9 (1)
Coleoptera									
Dytiscidae Copelatus		r							
Hydroporus						r			
Elmidae Microcylloepus	r								
Oulimnius	r	u		u	u			u	u
Stenelmis		u	a	c	r	u		u	r
Gyrinidae Dineutus			r						
Hydrophilidae Berosus						u			
Psephenidae Psephenus	r	r	a	a	u	u		u	r
Unid. Larva		r							
Diptera									
Anthericidae Antherix		r	u	r	u				
Ceratopogonidae Dasyhelea	r								
Probezzia		r	r					r	
Stilobezzia								r	
Unid.	r					r			
Chaoboridae Chaoborus			r						
Chironomidae	c	c	a	a	a	a	a	a	c
Dolichopodidae unid.									r
Empididae Hemerodromia		r		r				r	r
Simuliidae Simulium		c	c	a		a		c	
Prosimulium			r	r		c	c	r	a
Tabanidae Chrysops								r	
Unidentified			u						
Tipulidae Antocha		r		u		u		r	
Dicranota		r		r		u	c	c	
Hexatoma				r		u	r		r
Pseudolimnophila			r				r		c
Tipula		r	r	r	r	c	c	c	c
Unidentified						r			
Total taxa	27	39	42	52	44	53	38	40	33
Total insect taxa	21	35	32	42	36	45	30	33	24
Total EPT taxa	15	21	19	24	25	31	24	18	13

Table 9. Benthic macroinvertebrate abundance at sampling sites on Crooked Creek. Criteria for abundance Categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	Cr1 (2)	Cr2 (2)	Cr3 (2)
Platyhelminthes			
Planariidae	r	r	u
Nematoda	r	u	
Annelida			
Oligochaeta	c	a	a
Lumbricidae	r	r	
Mollusca			
Ancylidae	r		
Bivalvia Pisidium			r
Gastropoda Lymnaeidae Unid.	r		
Arthropoda - Crustacea			
Decapoda Cambaridae			
Oronectes obscurus		r	r
Collembola			
Isotomidae			r
Ephemeroptera			
Baetidae Baetis	c	u	u
Centroptilum	c	c	c
Caenidae Caenis		r	
Ephemeridae Ephemera			r
Heptageniidae Leucrocuta	c	u	r
Stenonema	u		r
Stenacron		r	r
Leptophlebiidae			
Habrophlebiodes		r	
Paraleptophlebia			u
Oligoneuridae Isonychia	u	u	
Siphlonuridae Ameletus	r		
Plecoptera			
Capniidae Allocapnia	a	c	a
Perlidae Agnetina	r		r
Beloneuria		u	c
Perlodidae Diploperla			r
Taeniopterygidae Taeniopteryx	c	r	c
Trichoptera			
Hydropsychidae			
Cheumatopsyche	c	c	c
Diplectrona	r	r	
Hydropsyche	c	c	c
Hydroptilidae Unid.		r	
Philopotamidae Dolophilodes		u	
Rhyacophilidae Rhyacophila			r
Uenoidae Neophylax	r		
Lepidoptera Pyralidae Unid.	r		
Coleoptera			
Dytiscidae Hydroporus			r
Elmidae Oulimnius	c	c	c
Stenelmis	u	c	c
Psephenidae Psephenus	u	u	r

Table 9. continued

Taxon	Cr1 (2)	Cr2 (2)	Cr3 (2)
Diptera			
Ceratopogonidae Unid.			r
Chironomidae	a	a	a
Empididae Hemerodromia		r	r
Psychodidae Unid.	r		
Simuliidae Simulium	c	c	c
Prosimulium			u
Tabanidae Chrysops	r		r
Tipulidae Antocha	u	c	u
Brachypremna		r	
Dicranota			u
Total taxa	28	28	32
Total insect taxa	22	23	28
Total EPT taxa	13	15	15

Table 10. Benthic macroinvertebrate abundance at sampling site on Twentymile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Number in parentheses indicates number of dates site was sampled.

Taxon	20M (2)
Platyhelminthes	
Planariidae	u
Nematoda	u
Annelida	
Oligochaeta	c
Lumbricidae	r
Mollusca	
Lymnaeidae	u
Arthropoda - Insecta	
Ephemeroptera	
Caenidae Caenis	u
Ephemerellidae Ephemerella	c
Eurylophella	r
Heptageniidae	
Epeorus	c
Leucrocuta	c
Stenonema	c
Stenacron	u
Leptophlebiidae	
Habrophlebiodes	r
Leptophlebia	u
Paraleptophlebia	c
Siphlonuridae Ameletus	c
Plecoptera	
Capniidae Allocapnia	c
Leuctridae Leuctra	r
Nemouridae Amphinemoura	r
Perlidae Agnetina	r
Neoperla	u
Paragnetina	r
Perlodidae Unidentified	u
Trichoptera	
Helicopsychidae Helicopsyche	r
Hydropsychidae Cheumatopsyche	c
Diplectrona	u
Hydropsyche	c
Philopotamidae Chimarra	c
Dolophilodes	u
Polycentropodidae	
Polycentropus	u
Psychomyiidae Lype	r
Rhyacophilidae Rhyacophila	r
Megaloptera	
Corydalidae Nigronia	u
Coleoptera	
Elmidae Oulimnius	c
Stenelmis	r
Psephenidae Psephenus	c

Table 10. continued

Taxon	20M (2)
Diptera	
Athericidae	
Atherix	u
Chironomidae	c
Simuliidae Prosimulium	u
Tabanidae Chrysaps	r
Tipulidae Antocha	u
Hexatoma	u
Pseudolimnophila	r
Tipula	r
Total taxa	44
Total insect taxa	39
Total EPT taxa	27

Table 11. Benthic macroinvertebrate abundance at sampling sites on Twelvemile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	12M1 (6)	12M2 (2)
Platyhelminthes Planariidae	c	r
Nematoda	r	r
Annelida		
Oligochaeta	a	c
Lumbricidae	u	c
Mollusca		
Ancylidae	u	
Lymnaeidae	u	
Physidae	u	
Bivalvia Pisidium	r	
Arthropoda - Crustacea		
Amphipoda Crangonyx		r
Cambaridae	r	r
Arthropoda – Insecta		
Hemiptera		
Gerridae Gerris	r	
Ephemeroptera		
Baetidae Baetis	c	u
Centroptilum	c	c
Caenidae Caenis	c	
Ephemerellidae Ephemerella	c	c
Eurylophella	c	c
Ephemeridae Ephemera	c	
Heptageniidae Cinygmula	c	
Epeorus	c	a
Leucrocuta	c	c
Stenonema	c	r
Stenacron	c	c
Leptophlebiidae		
Habrophlebiodes	a	a
Leptophlebia	u	u
Paraleptophlebia	a	u
Oligoneuridae Isonychia	u	
Siphlonuridae Ameletus	c	a
Plecoptera		
Capniidae Allocapnia	a	a
Paracapnia	r	
Utacapnia	u	
Chloroperlidae Sweltsa	c	c
Utaperla	u	
Leuctridae Leuctra	u	
Nemouridae Amphinemoura	c	c
Prostoia	u	
Perlidae Agnetina	r	
Neoperla	r	
Paragnetina	r	r
Perlodidae Diploperla	u	c
Diura	u	
Taeniopterygidae Taeniopteryx	u	

Table 11. continued

Taxon	12M1 (6)	12M2 (2)
Trichoptera		
Glossosomatidae Glossosoma	r	
Helicopsychidae Helicopsyche	u	
Lepidostomatidae Lepidostoma		r
Hydropsychidae		
Cheumatopsyche	a	r
Diplectrona	r	u
Hydropsyche	a	u
Hydroptilidae Hydroptila	u	
Philopotamidae Chimarra	c	r
Dolophilodes	a	r
Polycentropodidae		
Polycentropus	c	u
Psychomyiidae Psychomyia	r	
Rhyacophilidae Rhyacophila	c	
Uenoidae Neophylax	u	r
Megaloptera		
Corydalidae Nigronia	u	
Coleoptera		
Dytiscidae Hydroporus	u	
Elmidae Dubiraphia	r	
Optioservus	c	
Oulimnius	c	
Stenelmis	c	r
Psephenidae Psephenus	a	u
Diptera		
Chironomidae	a	c
Empididae Clinocera	u	
Hemerodromia	c	
Simuliidae Simulium	c	
Tipulidae Antocha	u	
Dicranota	c	u
Hexatoma	c	
Limnophila	u	
Molophilus		c
Pseudolimnophila	r	
Tipula	c	u
Unidentified		u
Terr. Millipede	r	
Total taxa	69	38
Total insect taxa	60	32
Total EPT taxa	42	25

Table 12. Benthic macroinvertebrate abundance at sampling sites on Fourmile Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	4M1 (2)	4M2 (1)	4M3 (1)
Platyhelminthes Planariidae	c	u	c
Nematoda	u		r
Annelida			
Oligochaeta fw	a	c	a
Lumbricidae	c	r	u
Mollusca			
Lymnaeidae		r	
Physidae		c	c
Bivalvia Pisidium	r		
Arthropoda - Crustacea			
Isopoda Lirceus	r	u	
Copepoda Cyclopoid	r		
Amphipoda Crangonyx	u		
Hyalella		r	
Arthropoda – Insecta			
Hemiptera Gerridae Gerris		u	
Odonata			
Aeshnidae Boyeria		r	
Ephemeroptera			
Baetidae Centroptilum	u	a	r
Unid.	r		
Caenidae Caenis	u	u	
Ephemerellidae Eurylophella	r		u
Heptageniidae Leucrocuta		u	
Stenacron	r	r	
Leptophlebiidae			
Habrophlebiodes		c	
Leptophlebia			r
Oligoneuridae Isonychia		r	
Siphlonuridae Ameletus	r	u	c
Tricorythidae Tricorythodes		c	
Plecoptera			
Capniidae Allocapnia	u		u
Capnia		c	
Chloroperlidae Sweltsa	r	r	c
Unid.			u
Leuctridae Paraleuctra			r
Nemouridae Soyedina			u
Perlidae Agnetina			u
Neoperla		u	
Perlodidae Diploperla			r
Isoperla			c
Unid.	r		
Trichoptera			
Helicopsychidae Helicopsyche		r	
Hydropsychidae			
Cheumatopsyche	u	r	u
Diplectrona		u	u
Hydropsyche	r	c	u

Table 12. continued

Taxon	4M1 (2)	4M2 (1)	4M3 (1)
Trichoptera cont.			
Lepidostomatidae Lepidostoma		r	
Philopotamidae Chimarra		r	
Dolophilodes			c
Wormaldia			r
Polycentropodidae			
Polycentropus	r	u	r
Rhyacophilidae Rhyacophila			r
Megaloptera			
Corydalidae Nigronia		r	
Sialidae Sialis	r		r
Coleoptera			
Elmidae Oulimnius			r
Stenelmis	r		
Psephenidae Psephenus	u	u	
Diptera			
Ceratopogonidae Stilobezzia			c
Chironomidae	a	a	c
Muscidae Limnophora			r
Simuliidae Simulium	u	a	
Tabanidae Unidentified		r	
Tipulidae Dicranota		r	c
Hexatoma		r	r
Limonia			r
Molophilus	u	r	r
Pseudolimnophila		r	
Tipula	u	u	u
Total taxa	27	37	34
Total insect taxa	19	30	29
Total EPT taxa	12	18	19

Table 13. Benthic macroinvertebrate abundance at sampling sites on Walnut Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	Wal1 (2)	Wal2 (1)	Wal3 (1)	Wal4 (2)	Wal5 (1)
Platyhelminthes Planariidae	c	u		r	u
Nematoda	r		r	u	r
Annelida					
Oligochaeta	a	c	a	a	a
Hirudinea				r	
Lumbricidae	u	u			r
Mollusca					
Ancylidae	r			u	u
Physidae	r			r	u
Hydracarina		r			r
Arthropoda - Crustacea					
Decapoda Cambaridae Cambarus					
Orconectes				r	
Unid.		r		u	
Isopoda Lirceus	c	r			
Amphipoda Crangonyx	u	r		r	
Odonata					
Aeshnidae Boyeria	u				r
Gomphidae Stylogomphus				r	
Ephemeroptera					
Baetidae Baetis	u				
Centroptilum	a	c	r	u	c
Caenidae Caenis	c	u	u	a	u
Ephemerellidae Ephemerella		r			a
Eurylophella				a	c
Ephemeridae Ephemera	u			c	r
Heptageniidae Leucrocuta	c		u	c	
Stenonema	c	r		a	
Stenacron	c	r			
Leptophlebiidae					
Habrophlebiodes	u		u	c	
Paraleptophlebia					u
Oligoneuridae Isonychia	u			u	
Siphlonuridae Ameletus		r		r	u
Plecoptera					
Capniidae Allocapnia	c	c		c	a
Paracapnia		r			
Chloroperlidae Sweltsa				r	
Leuctridae Paraleuctra	r			c	
Peltoperlidae Peltoperla					u
Perlidae Agnetina					c
Beloneuria				a	
Perlodidae Diploperla	u	r		r	u
Isoperla	c				c
Unid.,			r		

Table 13. continued

Taxon	Wal1 (2)	Wal2 (1)	Wal3 (1)	Wal4 (2)	Wal5 (1)
Plecoptera cont.					
Taeniopterygidae Taeniopteryx					a
Trichoptera					
Glossosomatidae Glossosoma					u
Hydropsychidae					
Cheumatopsyche	a	c		c	
Diplectrona					u
Hydropsyche	a	u		r	c
Hydroptilidae				u	
Limnephilidae Pycnopsyche				u	
Unid.	u			r	
Philopotamidae Chimarra	a	r		c	
Dolophilodes	u				c
Rhyacophilidae Rhyacophila	u			u	c
Uenoidae Neophylax				r	r
Megaloptera					
Corydalidae Nigronia	u				u
Sialidae Sialis		r		c	u
Hemiptera Unid.			r		
Coleoptera					
Dytiscidae Hydroporus	r		r	c	
Elmidae Dubiraphia				u	
Oulimnius	c			c	u
Stenelmis	u		c	c	
Psephenidae Psephenus	c			a	u
Diptera					
Athericidae Atherix	c				
Chironomidae	a	c	c	a	a
Simuliidae Simulium	u				c
Tabanidae Chrysops	r			r	r
Ceratopogonidae unid.			r		
Tipulidae Antocha	u				c
Dicranota	u			u	u
Hexatoma	u	r		u	c
Pseudolimnophila	r				
Tipula	r	r		u	u
Unidentified					r
Total taxa	42	23	12	43	39
Total insect taxa	34	16	10	34	32
Total EPT taxa	19	12	6	22	19

Table 14. Benthic macroinvertebrate abundance at sampling areas on Duck Run. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates or replicate sites each area was sampled.

Taxon	DR1 (3)	DR2 (2)
Platyhelminthes		
Planariidae	r	r
Nematoda	r	r
Annelida		
Hirudinea		
Oligochaeta	u	c
Mollusca		
Bivalvia Pisidium		r
Ephemeroptera		
Baetidae Centroptilum	c	c
Heptageniidae Stenonema	r	
Leptophlebiidae		
Habrophlebiodes		r
Paraleptophlebia	u	r
Siphlonuridae Ameletus	r	u
Plecoptera		
Capniidae Allocapnia	u	c
Paracapnia	r	
Chloroperlidae Sweltsa	c	r
Perlodidae Isoperla	r	
Trichoptera		
Hydropsychidae		
Cheumatopsyche	r	u
Diplectrona	u	c
Coleoptera		
Elmidae Oulimnius	r	r
Stenelmis	r	r
Diptera		
Ceratopogonidae Unid.	r	r
Chironomidae	c	a
Empididae Hemerodromia	r	r
Simuliidae Prosimulium	a	a
Diptera		
Tipulidae Dicranota	u	r
Hexatoma	r	r
Molophilus	r	
Tipula	r	u
Total taxa	23	21
Total insect taxa	20	17
Total EPT taxa	10	8

Table 15. Benthic macroinvertebrate abundance at sampling sites on Raccoon Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	Rac1 (2)	Rac2 (2)
Platyhelminthes		
Planariidae	r	u
Nematoda		u
Annelida		
Oligochaeta	u	c
Mollusca		
Ancylidae	r	u
Physidae		r
Bivalvia Pisidium		r
Sphaerium		r
Arthropoda - Crustacea		
Decapoda Cambaridae Cambarus	r	
Isopoda Lirceus	r	c
Copepoda Cyclopoid		r
Amphipoda Crangonyx	r	u
Arthropoda - Insecta		
Ephemeroptera		
Baetidae Baetis	c	u
Centroptilum	a	u
Caenidae Caenis	c	
Ephemeridae Ephemera	u	
Heptageniidae Epeorus	c	
Leucrocuta	u	
Stenonema	c	c
Stenacron	c	c
Leptophlebiidae		
Habrophlebiodes	a	u
Plecoptera		
Capniidae Allocapnia	a	a
Chloroperlidae Sweltsa	r	
Leuctridae Leuctra	c	
Nemouridae Amphinemura		u
Perlidae Agnetina	u	
Beloneuria		c
Taeniopterygidae Taeniopteryx	c	c
Trichoptera		
Helicopsychidae Helicopsyche		r
Hydropsychidae		
Cheumatopsyche	c	c
Hydropsyche	c	c
Hydroptilidae Pupa		r
Limnephilidae Unid.	r	
Philopotamidae Chimarra	c	c
Dolophilodes	r	c
Rhyacophilidae Rhyacophila	u	c
Uenoidae Neophylax	r	

Table 15. continued

Taxon	Rac1 (2)	Rac2 (2)
Megaloptera		
Corydalidae Nigronia	u	u
Sialidae Sialis	r	
Coleoptera		
Elmidae Oulimnius	c	c
Stenelmis	u	u
Psephenidae Psephenus	c	
Diptera		
Athericidae Atherix	c	r
Chironomidae	c	c
Empididae Hemerodromia	r	
Simuliidae Simulium	c	c
Prosimulium	u	a
Tabanidae Chrysops		r
Tipulidae Antocha	r	u
Dicranota	u	c
Hexatoma	r	u
Tipula	u	u
Total taxa	41	38
Total insect taxa	35	28
Total EPT taxa	21	16

Table 16. Benthic macroinvertebrate abundance at sampling sites on Conneaut Creek. Criteria for abundance categories defined in text: a = abundant; c = common; u = uncommon; r = rare. Numbers in parentheses indicate number of dates each site was sampled.

Taxon	Con1	Con2	Con3	Con4	Con5	Con6	Con7	Con8	Con9	Con10
Cnidaria										
Hydra					r					
Platyhelminthes										
Planariidae	r	r			u	a	u	r		
Nematoda			r	u		u				
Annelida – earthworm					r				r	
Oligochaeta	u	c	c	c	a	a	u	c	c	c
Hirudinea					r					r
Mollusca										
Gastropoda										
Ancyclidae			r	r						
Cymnaxaediae										
Physidae										
Lymnaeidae		r								
Planorbidae		r								
Bivalvia										
Corbicula										
Pisidium		r	u		r				r	u
Sphaeriidae										
Sphaerium		u	r							
Arthropoda										
Crustacea										
Decapoda										
Oronectes		r			r		r			u
Cambarus						u	u			
Isopoda										
Lirceus			r							
Caecidota	r				r					
Amphipoda										
Hyalalella			r							
Crangonyx		r		u						
Arachnida Hydracarina				r					r	
Insecta										
Hemiptera										
Corixidae Cymatia					u					

Table 16. continued

Taxon	Con1	Con2	Con3	Con4	Con5	Con6	Con7	Con8	Con9	Con10
Odonata										
Aeshnidae Aeshna	r									
Gomphidae Lanthus							r			
Ephemeroptera										
Baetidae										
Baetis		r				u	c			
Centroptilum			u		u	u	c	c	c	
Caenidae										
Caenis	u	r	u	r	r		u		u	
Ephemeridae										
Ephemera		r	r		r					
Ephemerellidae										
Eurylophella								u		
Unidentified						c				
Drunella							u			
Ephemerella	r	u	u		r					
Heptageniidae										
Leucrocuta							a	u		
Stenonema	a	c	a	c	c	c	c		c	a
Stenacron	c	c	u		u	r	c		c	u
Leptophlebiidae										
Habrophleboides	u	c	c	c	u	c	a			
Leptophelebia					u				c	c
Paraleptophlebia						r	c	c		
Habrophlebia		r			r					
Oligoneuridae										
Isonycha	c	c	c		c	c	c		c	
Siphlonuridae										
Ameletus	u	c			r		c			
Tricorythidae										
Tricorythodes							r			
Plecoptera										
Capniidae										
Allocapnia		r	u		a	c	c		a	c
Capnia									r	
Paracapnia				c	u	u				

Table 16. continued

Taxon	Con1	Con2	Con3	Con4	Con5	Con6	Con7	Con8	Con9	Con10
Plecoptera cont.										
Chloroperlidae										
Sweltsa						u	r	c		
Utaperla					u					
Leuctridae										
Luctra							c			
Perlidae										
Acroneuria	r		u				r	u	c	r
Agnetina	c	u	r				u			
Beloneuria							u			
Neoperla	u	c	u							
Perlodidae										
Diploperla			r	u					u	u
Isoperla					u		a	c		r
Unidentified						u				
Taeniopteryaidae										
Taeniopteryx			c		c	c	c	r	c	
Tricoptera										
Hydropsychidae										
Cheumatopsyche	u	c	a	r	a	c	c	u	c	c
Hydropsyche	c	c	c		u	c	c	u		
Macrostemum					r					
Heliopsychidae										
Helicopsyche		r								
Limnephilidae										
Pycnopsyche									r	
Philopotamidae										
Chimarra	c	c	c		c	c	a		c	
Dolophilodes							a			
Polycentropodidae										
Polycentropus				r			u		r	
Rhyacophilidae										
Rhyacophila							u	u		u
Uenoidae										
Neophylax			r							r

Table 16. continued

Taxon	Con1	Con2	Con3	Con4	Con5	Con6	Con7	Con8	Con9	Con10
Megaloptera										
Corydalidae										
Nigronia						r	r			
Corydalus		r								
Sialidae Sialis			r		r	r	r		r	
Coleoptera										
Elmidae										
Stenelmis	c	a	c	c	c	c	c		r	c
Oulimnuus	u	c	c	u	c	c	c		u	c
Dubiraphia		u		u	u					
Oulimnius				u						
Stenelmis				c						
Hydrophilidae Helophorus					r					
Psephenidae Psephenus	u	c	c		r	c	c			
Diptera										
Athericidae Atherix					u	r	u			
Ceratopogonidae unid.				r						
Probezzia					r			r		
Stilobezzia							c			
Chironomidae	u	u	c	c	a	a	a	a	c	c
Empididae Hemerodromia							u			r
Simuliidae										
Simulium	r	c	a		u	c	a		u	
Prosimulium					r		c	u		
Tabanidae unid.		c								
Chrysops					r					r
Tipulidae Antocha					u	r	c			
Hexatoma	r	u	r	u	r	r	c	c		
Pseudolimnophila	r						u			r
Tipula					r		u	r		r
Dicranota								u		u
Total taxa	24	34	32	18	44	30	46	20	24	22
Total insect taxa	21	26	25	13	36	26	42	18	20	18
Total EPT taxa	13	17	18	7	20	16	26	12	15	10

Table 17. Summary of metric values for individual samples from sites east of the City of Erie.

Site	Order	Status	Date	Total taxa	EPT taxa	Intol. Taxa	%EPT	%Intol.	HBI	Composite Index
20M	3rd+	Reference	11/27/2001	27	14	18	71	64	5	46
20M	3rd+	Reference	6/6/2003	31	22	24	75	71	2.66	56
16M1	3rd		11/27/2001	26	7	12	10	13	8.83	22
16M1	3rd		6/2/2003	18	11	9	12	10	8.56	20
16M1	3rd		12/4/2003	32	17	22	66	56	4.94	48
16M2	3rd	Reference	11/27/2001	33	23	26	56	57	5.1	50
16M2	3rd	Reference	6/2/2003	25	17	17	90	66	2.48	50
16M2	3rd	Reference	12/4/2003	38	25	25	94	92	1.9	60
16M3	3rd	Reference	12/20/2001	38	23	27	83	89	1.62	60
16M4	2nd		6/2/2003	21	6	9	2	32	6.61	23
16M4	2nd		12/4/2003	13	3	7	8	11	7.27	16
16M5	2nd	Reference	12/20/2001	24	12	16	74	77	2.21	47
16M5	2nd	Reference	6/2/2003	19	12	12	96	17	5.17	35
16M5	2nd	Reference	12/4/2003	29	13	16	90	87	1.31	52
12M1	3rd	Reference	5/11/2001	28	18	22	23	24	4.94	38
12M1	3rd	Reference	7/18/2001	33	16	22	42	53	5.05	43
12M1	3rd	Reference	10/2/2001	32	20	21	59	66	4.48	50
12M1	3rd	Reference	12/20/2001	37	17	23	56	68	4.41	50
12M1	3rd	Reference	6/4/2003	28	18	20	81	28	5.05	45
12M1	3rd	Reference	12/4/2003	30	17	19	64	69	3.82	49
12M2	2nd	Reference	12/20/2001	24	16	18	93	94	1.78	52
12M2	2nd	Reference	6/4/2003	26	17	17	97	84	1.37	53
7M1	3rd		5/1/2001	20	12	13	11	10	6.19	27
7M1	3rd		7/18/2001	32	12	18	25	45	5.85	37
7M1	3rd		10/2/2001	19	5	10	14	52	6.47	25
7M1	3rd		5/26/2003	13	5	5	1	1	8.99	13
7M1	3rd		12/4/2003	22	11	15	34	37	5.81	32
7M2	2nd	Reference	5/11/2001	42	25	27	29	21	5.71	43
7M2	2nd	Reference	7/18/2001	33	12	19	11	21	6.45	33
7M2	2nd	Reference	10/3/2001	33	15	17	59	74	3.78	50
7M2	2nd	Reference	5/28/2003	36	20	24	34	40	5.46	45
7M2	2nd	Reference	12/9/2003	13	3	5	5	7	6.59	15
7M3	2nd	Reference	5/28/2003	31	21	24	72	74	3.15	55
7M3	2nd	Reference	12/9/2003	32	22	26	77	77	2.39	57
7M4	2nd		6/3/2003	15	7	8	22	20	6.88	22
7M4	2nd		12/9/2003	24	14	16	16	18	6.97	29
6M1	3rd		12/16/2003	15	7	9	13	7	7.72	19
6M2	3rd		5/26/2003	24	14	12	14	7	7.28	26
6M2	3rd		12/11/2003	10	4	3	12	7	7.66	14
6M3	3rd		5/26/2003	10	5	4	7	2	8.6	12
6M3	3rd		12/11/2003	11	5	4	10	6	8.28	14
4M1	3rd		5/26/2003	16	6	6	3	3	7.69	17
4M1	3rd		12/4/2003	21	9	10	12	11	7.73	22
4M2	3rd	Reference	7/7/2003	37	18	22	29	28	5.01	42
4M3	2nd	Reference	11/29/2001	34	19	22	31	36	6.38	41
McD1	2nd		5/27/2003	7	0	0	0	0	7.63	10
McD1	2nd		12/4/2003	8	1	1	1	2	8.05	10
McD2	2nd		5/11/2001	6	0	2	0	4	7.49	10
McD2	2nd		8/1/2001	7	0	1	0	3	6.43	11
McD2	2nd		10/3/2001	8	0	1	0	3	6.94	11
McD2	2nd		12/16/2003	9	1	1	1	1	9.08	9

Table 18. Summary of metric values for individual samples from sites in and near the City of Erie.

Site	Order	Status	Date	Total taxa	EPT taxa	Intol. Taxa	%EPT	%Intol.	HBI	Composite Index
MC1	3rd		10/10/2000	17	6	8	19	27	6.31	24
MC1	3rd		3/27/2001	14	6	7	23	20	6.64	21
MC1	3rd		6/21/2001	26	8	13	7	9	6.17	24
MC1	3rd		9/11/2001	15	4	6	11	11	6.39	18
MC1	3rd		12/11/2003	19	7	8	33	27	6.31	26
MC1A	3rd		10/16/2001	9	3	9	19	9	8.67	15
MC2	3rd		10/10/2000	16	4	8	22	53	5.81	26
MC2	3rd		11/18/2000	21	7	9	38	44	5.95	30
MC2	3rd		4/10/2001	13	6	7	17	21	7.5	19
MC2	3rd		6/21/2001	28	10	16	21	21	5.5	33
MC2	3rd		9/12/2001	18	9	12	55	39	5.8	32
MC3	2nd		11/18/2000	20	10	12	50	50	4.05	36
MC3	2nd		6/26/2001	15	5	5	8	4	7.21	15
MC3	2nd		9/12/2001	15	5	8	7	8	8.96	15
MC5	2nd	Reference	10/17/2000	25	13	14	44	72	5.91	39
MC5	2nd	Reference	4/26/2001	18	9	11	17	10	7	23
MC5	2nd	Reference	7/17/2001	38	16	19	46	46	6.45	41
MC5	2nd	Reference	9/12/2001	30	14	15	57	57	5.19	42
MC6	2nd		10/3/2000	13	5	9	15	21	8.51	18
MC6	2nd		3/22/2001	15	6	10	3	2	9.78	14
MC6	2nd		6/21/2001	29	11	18	9	12	7.88	27
MC6	2nd		9/20/2001	28	11	17	24	40	7.15	33
MC8	2nd		10/3/2000	15	8	8	37	57	6.2	28
MC8	2nd		3/22/2001	17	6	9	15	22	5.78	23
MC8	2nd		6/14/2001	22	8	11	11	16	5.78	25
MC8	2nd		9/21/2001	31	12	16	28	31	5.62	35
MC8	2nd		6/4/2003	28	8	16	16	22	5.67	30
GR	2nd		12/14/2000	3	0	1	0	2	9.82	6
GR	2nd		5/11/2001	3	0	0	0	0	10	6
GR	2nd		8/1/2001	3	0	0	0	0	9.57	6
GR	2nd		9/28/2001	3	0	0	0	0	9.99	6
CC1	2nd		12/7/2000	10	0	3	0	4	8.31	11
CC1	2nd		5/9/2001	7	0	0	0	0	6.19	11
CC1	2nd		7/20/2001	13	2	2	1	1	6.86	13
CC1	2nd		9/25/2001	9	1	2	0.6	1	8.06	10
CC1	2nd		12/16/2003	8	0	0	0	0	9.35	8
CC2	2nd		12/7/2000	6	1	2	1	2	6.96	10
CC2	2nd		5/9/2001	8	0	1	0	0.5	6.63	12
CC2	2nd		7/24/2001	12	0	2	0	1	6.91	12
CC2	2nd		9/25/2001	14	1	2	0.8	1.4	8.81	10
CC3	2nd		7/27/2001	7	0	2	0	4	6.81	11
CC3	2nd		10/4/2001	10	0	1	0	0.4	8.73	9

Table 19. Summary of metric values for individual samples from sites west of the City of Erie.

Site	Order	Status	Date	Total taxa	EPT taxa	Intol. Taxa	%EPT	%Intol.	HBI	Composite Index
Wal 1	3rd+	Reference	12/3/2001	30	13	21	69	38	5.75	43
Wal 1	3rd+	Reference	6/16/2003	31	13	16	27	27	5.48	36
Wal 2	3rd		1/6/2004	23	12	12	29	17	7.27	28
Wal 3	2nd		6/16/2003	12	5	5	2	2	9.65	12
Wal 4	2nd	Reference	12/3/2001	35	16	20	51	41	5.99	43
Wal 4	2nd	Reference	6/27/2003	29	13	16	38	38	6.52	37
Wal5	2nd	Reference	12/3/2001	39	19	26	74	79	3.28	56
ElkM	3rd+		9/27/2004	16	8	11	34	39	5.18	30
Elk1	3rd+		6/30/2003	13	8	9	36	36	6.4	27
Elk1	3rd+		12/22/2003	19	9	8	69	68	4.05	39
Elk2	3rd+	Reference	6/16/2003	31	16	15	37	32	6.68	36
Elk2	3rd+	Reference	12/22/2003	25	15	16	83	83	3.65	50
Elk3	3rd+	Reference	7/7/2003	33	15	16	52	55	4.88	44
Elk3	3rd+	Reference	12/23/2003	21	11	12	79	75	3.37	45
Elk4	3rd	Reference	12/3/2001	33	16	21	66	55	4.84	48
Elk4	3rd	Reference	6/16/2003	28	14	15	32	31	5.44	36
Elk4	3rd	Reference	12/25/2003	24	12	16	65	67	4.24	44
Elk5	2nd	Reference	12/3/2001	43	25	32	54	54	4.64	49
Elk6	3rd	Reference	12/10/2001	39	24	29	86	87	2.68	60
Elk6	3rd	Reference	6/30/2003	23	13	14	10	4	6.08	28
Elk6	3rd	Reference	12/22/2003	25	18	18	94	94	3	52
Elk7	2nd	Reference	12/10/2001	32	21	23	89	91	3.08	57
Elk7	2nd	Reference	12/23/2003	27	17	18	94	95	2.84	54
Elk8	2nd	Reference	12/10/2001	32	16	19	58	66	4.42	48
Elk8	2nd	Reference	6/30/2003	19	8	8	18	17	5.55	23
Elk8	2nd	Reference	12/23/2003	11	3	8	46	60	5	28
Elk9	2nd	Reference	12/10/2001	34	14	18	61	81	3.44	48
DR1	2nd		3/4/2005	8	4	5	28	83	2.74	30
DR1	2nd		3/4/2005	12	6	8	6	98	2.07	32
DR1	2nd		3/4/2005	19	9	15	14	85	2.75	38
DR2	2nd		2/12/2004	15	5	8	10	17	6.32	20
DR2	2nd		3/4/2005	17	7	10	12	90	2.43	35
Cr1	3rd	Reference	7/2/2003	23	10	14	30	34	5.43	33
Cr1	3rd	Reference	12/23/2003	17	8	10	78	81	3.89	42
Cr2	3rd	Reference	7/2/2003	25	13	14	27	39	6.53	33
Cr2	3rd	Reference	12/23/2003	13	6	8	74	83	4.13	38
Cr3	2nd	Reference	6/28/2003	19	7	9	16	18	7.79	20
Cr3	2nd	Reference	12/23/2003	25	12	17	70	72	4.63	43
Rac1	2nd	Reference	7/7/2003	18	11	10	95	12	5.53	33
Rac1	2nd	Reference	12/23/2003	28	11	20	88	95	3.26	51
Rac2	2nd	Reference	7/7/2003	20	8	8	30	23	6.58	26
Rac2	2nd	Reference	12/23/2003	31	12	19	70	76	3.38	49
Con1	3rd+	Reference	9/28/2004	24	13	16	74	89	3.81	48
Con2	3rd+	Reference	9/28/2004	34	17	19	70	81	4.45	52
Con3	3rd+	Reference	9/30/2004	31	18	20	59	55	5.03	46
Con4	3rd+	Reference	10/12/2004	18	7	6	36	40	6.03	28
Con5	3rd+	Reference	11/9/2004	46	20	26	52	47	6.65	47
Con6	3rd	Reference	10/12/2004	30	16	20	56	55	4.89	44
Con7	2nd	Reference	7/7/2003	28	16	16	29	27	5.2	37
Con7	2nd	Reference	11/9/2004	39	21	28	74	76	3.55	56
Con8	2nd	Reference	11/9/2004	20	12	15	37	41	4.43	35
Con9	2nd	Reference	11/9/2004	22	10	14	60	70	4.54	40
Con10	2nd	Reference	11/16/2004	24	15	14	90	78	3.78	48

Table 20. Ranges of metric values for third-order streams and larger for conversion to standardized metric scores of 1 to 10, used to determine Composite Index scores for each site and date sampled for benthic macroinvertebrates. Ranges determined by percentile analysis of unstandardized metrics from 65 samples and 11 streams in the Pennsylvania Lake Erie watershed.

	Unstandardized Metric Values					
Standardized Score	Total Taxa	EPT Taxa	Intol. Taxa	% EPT	% Intol.	Hilsenhoff Biotic Index
1	0-3	0-2	0-2	0-9	0-9	9.27-10
2	4-7	3-4	3-5	10-17	10-18	8.53-9.26
3	8-11	5-6	6-7	18-26	19-27	7.80-8.52
4	12-15	7-9	8-10	27-34	28-35	7.06-7.79
5	16-19	10-11	11-13	35-43	36-44	6.33-7.05
6	20-22	12-13	14-15	44-51	45-53	5.60-6.32
7	23-26	14-16	16-18	52-60	54-62	4.86-5.59
8	27-30	17-18	19-20	61-68	63-71	4.13-4.85
9	31-34	19-20	21-23	69-77	72-80	3.39-4.12
10	$\geq$35	$\geq$21	$\geq$24	$\geq$77	$\geq$81	$\leq$3.38

Table 21. Ranges of metric values for second-order streams for conversion to standardized metric scores of 1 to 10, used to determine Composite Index scores for each site and date sampled for benthic macroinvertebrates. Ranges determined by percentile analysis of unstandardized metrics from 81 samples and 14 streams in the Pennsylvania Lake Erie watershed.

	Unstandardized Metric Values					
Standardized Score	Total Taxa	EPT Taxa	Intol. Taxa	% EPT	% Intol.	Hilsenhoff Biotic Index
1	0-3	0-2	0-2	0-9	0-9	9.21-10
2	4-7	3-4	3-5	10-19	10-18	8.44-9.20
3	8-11	5-6	6-7	20-28	19-27	7.66-8.43
4	12-15	7-8	8-10	29-37	28-36	6.88-7.65
5	16-19	9-10	11-13	38-47	37-46	6.11-6.87
6	20-22	11-12	14-15	48-56	47-55	5.33-6.10
7	23-26	13-14	16-18	57-65	56-64	4.55-5.32
8	27-30	15-16	19-20	66-74	65-73	3.77-4.54
9	31-34	17-18	21-23	75-84	74-82	2.99-3.76
10	$\geq$35	$\geq$19	$\geq$24	$\geq$85	$\geq$83	$\leq$2.98

Table 22. Final ratings of stream condition and the corresponding ranges of Composite Index values for the two different stream-size categories in the Pennsylvania Lake Erie watershed.

Site Condition Rating	**Second Order Sites**	**Third Order+ Sites**
Optimum Condition	60	60
Very Good	47.5-59.9	50.0-59.9
Good	35.5-47.4	40.0-49.9
Fair	28.1-35.4	31.5-39.9
Slightly Degraded	20.8-28.0	23.0-31.4
Poor	13.4-20.7	14.5-22.9
Very Poor	6.1-13.3	6.1-14.4
Minimum Biotic Diversity	6	6

Table 23. Average Composite Index for sites on streams of the Pennsylvania Lake Erie watershed and site condition rating.

Stream Name	Site	Address	Order	Avg. Comp. Index	Condition
Twentymile Creek	20M	North of I-90	3rd+	51	very good
Sixteenmile Creek	16M1	South of Route 5	3rd	30	slightly degraded
Sixteenmile Creek	16M2	South of Wellington St.	3rd	53.3	very good
Sixteenmile Creek	16M3	West side Oxbow Rd.	3rd	60	optimum condition
Baker Creek	16M4	West of Vine St.	2nd	19.5	poor
Smith Res. Branch	16M5	South of Cole Rd.	2nd	44.7	good
Twelvemile Creek	12M1	South of Rt. 5	3rd	45.8	good
East Branch	12M2	South of Sandhill Rd.	2nd	52.5	very good
Sevenmile Creek	7M1	North of Rt. 5	3rd	26.8	slightly degraded
Sevenmile Creek	7M2	East of Depot Rd.	2nd	37.2	good
Sevenmile Creek	7M3	South of I-90, Prindle Rd.	2nd	56	very good
Elliotts Run	7M4	South of Rt. 20	2nd	25.5	slightly degraded
Sixmile Creek	6M1	North of Rt. 5	3rd	19	poor
Sixmile Creek	6M2	North of Iroquois Ave.	3rd	20	poor
Sixmile Creek	6M3	West of Depot Rd.	3rd	13	very poor
Fourmile Creek	4M1	North of Rt. 5	3rd	19.5	poor
Fourmile Creek	4M2	South of Cooper Rd.	3rd	42	good
Fourmile Creek	4M3	South of Hartman Rd.	2nd	41	good
McDannels Run	McD1	North of Rt. 5	2nd	10	poor
McDannels Run	McD2	West of Franklin Ave.	2nd	10	poor
Mill Creek	MC1	34th St.	3rd	25.6	slightly degraded
Mill Creek	MC1A	38th St.	3rd	15	poor
Mill Creek	MC2	Above Zoo, S. of 41st St.	3rd	28	slightly degraded
West Branch	MC3	Glenridge St.	2nd	22	slightly degraded
Mill Creek	MC5	East of Rt. 97	2nd	36.25	good
Mill Creek	MC6	Belle Valley, Norcross Rd	2nd	23	slightly degraded
Mill Creek	MC8	Headwaters Park	2nd	28.2	fair
Garrison Run	GR	North of 5th St.	2nd	6	min. biotic diversity
Cascade Creek	CC1	Above mouth near Bay	2nd	10.6	very poor
Cascade Creek	CC2	Frontier Park	2nd	11	very poor
East Branch	CC3	East of Greengarden	2nd	10	very poor
Walnut Creek	Wal1	Old Sterrettania Rd.	3rd+	39.5	fair
Walnut Creek	Wal2	Millcreek Mall	3rd	28	slightly degraded
Walnut Creek	Wal3	Old French	2nd	12	very poor
Walnut Creek	Wal4	Rt. 97 above landfill	2nd	40	good
Thomas Run	Wal5	West of Thomas Rd.	2nd	56	very good
Elk Creek	ElkM	North of Rt. 5	3rd+	30	slightly degraded
Elk Creek	Elk1	Elk Park Rd.	3rd+	33	fair
Elk Creek	Elk2	South of Rt. 20	3rd+	43	good
Elk Creek	Elk3	West of Rt. 98	3rd+	44.5	good
Elk Creek	Elk4	East of I-79	3rd	42.7	good
Elk Creek	Elk5	Hamot Rd.	2nd	49	very good
Little Elk Creek	Elk6	Franklin Center Rd.	3rd	46.7	good
Little Elk Cr. Trib.	Elk7	Franklin Center Rd.	2nd	55.5	very good
Hall's Run	Elk8	Colespring Rd.	2nd	33	fair
Falk Run	Elk9	Falls Rd.	2nd	48	very good
Duck Run	DR1	N. Penn Central line	2nd	33.3	fair
Duck Run	DR2	North of Rt. 5	2nd	27.5	slightly degraded
Crooked Creek	Cr1	South of Ables Rd.	3rd	37.5	fair
Crooked Creek	Cr2	West side Happy Valley Rd.	3rd	35.5	fair
Crooked Creek	Cr3	East side Lexington Rd.	2nd	31.5	fair
Raccoon Creek	Rac1	South side Old Lake Rd.	2nd	42	good
Raccoon Creek	Rac2	South side Elmwood Rd.	2nd	37.5	good
Conneaut Creek	Con1	South of Conneaut OH	3rd+	48	very good
Conneaut Creek	Con2	Akerly Rd.	3rd+	52	very good
Conneaut Creek	Con3	McKee Rd.	3rd+	46	good
Conneaut Creek	Con4	South of Rt. 6N	3rd+	28	slightly degraded
Conneaut Creek	Con5	South side Carter Rd.	3rd+	47	good
Conneaut Creek	Con6	Springboro	3rd	44	good
Temple Creek	Con7	South of Rt. 6N	2nd	46.5	good
Temple Creek trib.	Con8	North of Rt. 6N	2nd	35	fair
West Branch	Con9	East side Barney Rd.	2nd	40	good
E. Br.of W. Branch	Con10	Gameland 101	2nd	48	very good