Aquatic Survey of Selected Reaches of the Mahoning River Trumbull, and Mahoning Counties, Ohio.

Final Report

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EXECUTIVE SUMMARY

EnviroScience, Inc. completed a water quality assessment of six sampling stations in the Mahoning River between August 21st and October 9th, 2003 for the U.S. Army Corps of Engineers (Corps), Pittsburgh District. The purpose of the study was to survey the aquatic communities, evaluate the use attainment of the Mahoning River and provide support to a feasibility study for the proposed environmental dredging on the Mahoning River.

The study area was located between river mile RM 45.5 and 12.0, and includes the area between Warren, Ohio and the Ohio, Pennsylvania state line. The Mahoning River study stations had drainage areas ranging between 575 and 1,074 mi² with varying land uses representative of the EOLP ecoregion.

The aquatic community assessment included the sampling of resident fish and benthic macroinvertebrate communities, as well as the evaluation of habitat and water chemistry parameters. All methods performed were in accordance with protocols of the Ohio Environmental Protection Agency (OEPA 1988) and Rankin (1989). All of the sampling sites were previously sampled by the Ohio EPA in 1994(Ohio EPA, 1996), and allowed for comparison with the current study to evaluate consistencies, improvements, and/or degradations.

Fish and benthic macroinvertebrate data generated in this study indicate that two (RM 44.3 and RM 33.2) of the six sampling stations are in PARTIAL Attainment of WWH criteria. The four remaining sampling stations (RM 45.5, RM 28.5, RM 19.4, RM 12.0) were all considered to be in NON Attainment of WWH criteria. Sampling stations in the lower reaches of the Mahoning River exhibited general declines from the upstream reference reach in all biological indices calculated despite habitat (QHEI) scores which indicate the river should be able to support a WWH community.

IBI and MIwb scores declined from reference conditions at RM 33.2 and continued at Stations RM 28.5 and RM 19.4. The fish community indicated signs of improvement at RM 12.0 with scores increasing slightly. The current study also noted a general decrease in habitat (QHEI) scores in the reaches that had depressed fish populations. Generally, QHEI scores were much lower in the impounded sections of the Mahoning River compared to the free flowing areas such as RM 12.0. The quality of the sediments in the impounded reaches may be contributing to the overall degradation of the biological communities.

Further evidence of very poor sediment quality was found in the ICI scores at stations RM 28.5, RM 19.4 and RM 12.0, which decreased into the *poor* narrative range. It must also be noted that flow conditions during the 2003-sampling season were abnormally high. Although it is believed that the increased flows affected the overall biological scores, the longitudinal trend of increasingly degraded biological communities are consistent with past studies on the Mahoning River (Ohio EPA, 1996).

The results of the current study are comparable to, but somewhat improved from, the 1994 Ohio EPA study of the Mahoning River. The Ohio EPA study found PARTIAL Attainment at RM 45.5 and FULL (based on fish only) Attainment at RM 44.3 before decreasing to NON-Attainment downstream to the state border (RM 12.0). IBI and MIwb scores in the present study indicate the same general trend of environmental degradation in downstream areas with a slight increase in quality at RM 12.0. Overall, MIwb scores showed the same longitudinal trend but were somewhat higher than in the 2003 study. Additionally, ICI scores follow a similar trend between studies with narrative ranges decreasing significantly at RM 33.2 in 1994 and RM 28.5 in 2003.

Overall, the results of the 2003 study of the Mahoning River reveal significant degradation of the biological communities within the Proposed environmental dredging area. The biological communities have shown limited improvement since Ohio EPA's 1994 study and should be monitored for future progress, especially in a normal flow year. Additionally, further benthic macroinvertebrate monitoring could indicate the degree of potential contamination of river sediments and help serve as a basis for prioritizing remedial activities.

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1.0 INTRODUCTION

EnviroScience, Inc. completed a water quality assessment of six sampling stations in the Mahoning River between August 21st and October 9th, 2003 for the U.S. Army Corps of Engineers (Corps), Pittsburgh District. The purpose of the study was to survey the aquatic communities, evaluate the use attainment of the Mahoning River and provide support to a feasibility study for the proposed environmental dredging on the Mahoning River. Six sampling stations were selected in the location of sites previously investigated by the Ohio EPA (1996). These sampling stations exist upstream, within, and downstream of the proposed environmental dredging area.

The study area is located between river mile RM 45.5 and 12.0, and includes the area between Warren, Ohio and the Ohio, Pennsylvania state lines. The Mahoning River study stations have drainage areas ranging between 575 and 1,074 mi^2 with varying land uses. The watershed lies within the Erie Ontario Lake Plain (EOLP), and the land use in this area includes; 50% forested 39% agricultural, 6% water and wetlands, and 5% urban (Sanders, 2001). Potential sources of pollution include industrial and municipal outfalls, septic, combined sewer overflows, and various non-point sources such as row-crop agriculture. This 33-mile reach of the Mahoning River has historically been recognized as one of the most polluted in Ohio (OEPA, 1996).

The aquatic community assessment included the sampling of resident fish and benthic macroinvertebrate communities, as well as the evaluation of habitat and water chemistry parameters. All methods performed were in accordance with protocols of the Ohio Environmental Protection Agency (OEPA 1988) and Rankin (1989). Field chemistry analysis was performed following the American Public Health Association (APHA) et al. (1992). All of the sampling sites were previously sampled by the Ohio EPA and allowed for comparison with the current study to evaluate consistencies, improvements, and/or degradations.

1.1 Use-Attainment

Ohio's water quality standards were developed to protect and restore surface waters within the state for a variety of uses, including the protection of aquatic life (OEPA 1987). These standards define the six aquatic life use designations that can be applied to streams within the state. They include Exceptional Warmwater Habitat (EWH), Warmwater Habitat (WWH), Modified Warmwater Habitat (MWH), Cold Water Habitat (CWH), Seasonal Salmonid Habitat (SSH), and Limited Resource Waters (LRW). The Ohio EPA has set an overall goal requiring all state surface waters be in full attainment of WWH water quality standards to support Clean Water Act objectives, including restoration of chemical, physical and biological integrity of the nations surface water.

Ohio EPA assigns use designations to surface waters of Ohio using biological and chemical data, as well as in-stream habitat. The use designation is based primarily on the attainment status of the biological communities, but chemical and habitat data is used as supporting evidence. Currently the Ohio EPA utilizes a five-year rotating basin approach to evaluate use designations in each major watershed in the state.

The attainment status of a stream is a measure of the current biological community compared to expectations for its assigned use designation. The attainment status of a stream is based on indices that evaluate the fish communities Index of Biotic Integrity (IBI) and Modified Index of Well-being (MIwb) and the benthic macroinvertebrate Invertebrate Community Index (ICI). The numerical value calculated for each of these indices are assigned a narrative score of *exceptional*, *very good*, *good*, *marginally good*, *fair*, *poor*, or *very poor* (Table 1-1.).

Table 1-1. Narrative ranges for the Erie Ontario Lake Plain (OEPA, 1987).

Narrative Range	IBI - Boat Sites	MIwb - Boat Sites	ICI - All Sites
Exceptional	48-60	>9.5	46-60
Very Good	44-47	9.1-9.5	42-44
Good	40-43	8.7-9.0	34-40
Marginally Good	36-39	8.2-8.6	30-32
Fair	26-35	6.4-8.1	14-28
Poor	16-25	5.0-6.3	2-12
Very Poor	12-15	0.0-4.9	0

To be in full attainment of WWH, each numerical index must meet or exceed standardized criteria set by the Ohio Administrative (Table 1-2). Full attainment of WWH correlates to the *good* narrative range of scoring. If one index does not meet the criteria and is not below a *fair* rating, but the others meet the criteria, the site is considered in partial attainment of WWH. If all index values are below the criteria, or if one index is considered *poor* or *very poor*, even if the other indices are above the criteria, the site is considered in non-attainment. Even though habitat is not directly involved in determining use-attainment, the results of the habitat analysis are used as supporting evidence and to identify potential sources of impairment.

Table 1-2. Use Attainment Criteria for the Erie Ontario Lake Plain (OEPA, 1987).

Biological Index	WWH Attainment
Index of Biotic Integrity (IBI)	40
Modified Index of Well Being (MIwb)	8.7
Invertebrate Community Index (ICI)	34

*nonsignificant departure from biocriterion (≤ 4 IBI or ICI units; ≤ 0.5 MIwb units)

The current use designations for the Mahoning River in this project were assigned according to the Ohio Water Quality Standards set forth by the Ohio Administrative Code 3745-1 (effective May 1990). According to the most recent biological and water quality studies by the Ohio EPA, the Mahoning River has a use designation of WWH (OEPA 1994, 1999).

2.0 METHODS

The existing fish and macroinvertebrate communities were quantitatively and qualitatively sampled to evaluate the biological integrity at each sample station. Pulsed direct current (DC); from a Smith-Root 5.0 GPP electrofisher was utilized to collect representative samples of the fish population. Based on drainage area, all of the sampling stations were surveyed using boat methods, which necessitate two electrofishing passes six weeks apart (Ohio EPA, 1987) Hester-Dendy multiple-plate artificial substrate samplers and qualitative "kick" samples collected benthic macroinvertebrates. One macroinvertebrate sampling event was completed at all sampling locations. In stream and riparian habitat was evaluated using the Ohio EPA Qualitative Habitat Evaluation Index (QHEI). At each sample station, water chemistry parameters of dissolved oxygen, conductivity, pH, and temperature were colleted using a Hydrolab® Quanta mulitprobe.

2.1 Site Selection

In order to provide the best possible scenario for comparison, EnviroScience utilized sampling stations previously used by the Ohio EPA (1994) within the proposed environmental dredging area. The Mahoning River watershed within the state of Ohio can be seen in Figure 1 (Appendix A) along with the study area overview, which is presented in Figure 2 (Appendix A). Station RM 45.5 is the furthest upstream sampling station and is located within what is considered the model reach of the Mahoning River. Station RM 12.0 is the furthest downstream location and represents the biological integrity of the Mahoning River as it exits Ohio into Pennsylvania. The four remaining sampling stations (RM 44.3, RM 33.2, RM 28.5, and RM 19.4) were located between the model reach and the state line. Representative photographs as are provided for each station in Appendix B. A brief description of each sampling station and their location within Appendix A is provided below in Table 2-1.

Table 2-1. Sampling Station Descriptions

RM 45.5

Location:	Downstream of Leavittsburg Dam
Coordinates:	(-80.88043, 41.23968)
Land Use:	Urban /suburban residential with narrow riparian corridor
Site Map:	Figure 3, Appendix A

RM 44.3

Location:	Upstream US 422, downstream of 2nd Leavittsburg Road dam
Coordinates:	(-80.86423, 41.24355)
Land Use:	Suburban residential with narrow to wide riparian corridor
Site Map:	Figure 4, Appendix A

RM 33.2

Location:	Downstream West Park Rd.
Coordinates:	(-80.78985, 41.17964)
Land Use:	Rural / Forested with wide riparian corridor
Site Map:	Figure 5, Appendix A

RM 28.5

Location:	Downstream Niles WWTP, upstream of Mc Donald Steel
Coordinates:	(-80.73571, 41.17197)
Land Use:	Industrial / Scrub-shrub with wide riparian corridor
Site Map:	Figure 6, Appendix A

RM 19.4

Location:	Youngstown WWTP mixing zone
Coordinates:	(-80.63763, 41.09250)
Land Use:	Urban/industrial with moderate to narrow riparian corridors
Site Map:	Figure 7, Appendix A

RM 12.0

Location:	OH/PA line, downstream of Lowellville WWTP
Coordinates:	(-80.53159, 41.03325)
Land Use:	Rural and light industry with wide to moderate riparian corridors
Site Map:	Figure 8, Appendix A

2.2 Fish

The first sampling event was conducted on August 21st, 22nd, 25th, and 26th, followed by a second event on October 7th, 8th, and 9th, 2003. Effort was made to sample the fish community when stream flows were normal to provide the best opportunity to sample the population when the fish community was most stable and sedentary, stream and river flows were relatively normal, and pollution stresses were potentially the greatest

2.2.1 Collection Methods

Boat electrofishing methods are used in moderate to large sized streams and rivers with drainage areas greater than 100 mi ^{2}, where wading methods are impractical and inefficient. The Smith-Root electrofisher provides an available peak current from range up to 1,000 volts and 5,000 watts. The output of the unit was adjusted according to the conductivity of the Mahoning River. The lower the conductivity of the water, the higher the voltage needed to effectively sample the area. The current flowing through the water is directly related to the voltage applied; the higher the voltage, the greater the current.

Fish are usually oriented into the current and must either swim into the electric field or turn sideways to escape downstream. This sideways movement creates an increased voltage gradient making the fish more susceptible to the electric current. The degree to which fish are affected by electric current is a function of their surface area. Generally, larger fish are more sensitive to the electric currents. The power output was therefore adjusted to representatively sample smaller individuals while minimizing adverse effects on larger individuals.

Each of the 500 meter sampling zones were electrofished from upstream to downstream.
The boat was carefully maneuvered by directing the boat's bow as close as possible to the shore and/or submerged objects while shocking the near shore area. Sampling was performed carefully and adjusted for different habitats, particularly at sites where there was extensive woody debris or a moderately fast to swift current. In zones with extensive woody debris, it was necessary to maneuver the boat in and out of the macrohabitats formed by the debris.

Captured fish were immediately placed in one of three on-board livewells. When sampling was completed the fish were transported to the field station where they were processed and released unharmed.

2.2.2 Sample Processing

All captured fish placed in the livewell were processed when sampling was completed. In order to maintain dissolved oxygen levels and minimize mortality, aerators were placed in the livewell and water replaced as needed. During processing, fish were identified to species, examined for external anomalies, weighed and measured. Fish were released immediately after this process and every effort was made to minimize handling and holding times.

Most captured fish were identified in the field with the aid of various taxonomic keys. The senior field biologist verified questionable species, however, some species required laboratory identification. When laboratory identification was necessary, fish were preserved in borax buffered 10% formalin in the field, labeled by date, and site designation.

With smaller species (e.g. most minnows and darters), mass weighing in aggregate was necessary. If more than 50 individuals of one species were collected, a random subsample of at least 50 fish was weighed and the remainder counted. If there was a noticeable variation in sizes between individual fish of a species, individual weights were taken. If extremely high numbers were collected, the number of individuals was determined by mass weighing all fish collected and extrapolating the numbers from a counted and weighed subsample. All results were recorded on fish data sheets modeled after the OEPA (1987).

Individual fish weighing less than 2000 g were weighed to the nearest 1 g on a portable top loader scale (2000 g capacity x 0.1 g intervals). Fish weighing more than 2000 g were weighed with a Berkley7 Fish Scale in pounds and these weights were converted to grams. All scales were calibrated with National Bureau of Standards Class F check weights (up to 2000 g in 1 g increments) and adjusted as necessary.

The occurrence of gross external DELT (Deformities, Erosions, Lesions, Tumors) anomalies was noted when the fish were captured, identified, sorted, weighed, and counted. Gross external anomalies were defined as externally visible skin or subcutaneous disorders. Precise counts of anomalies present (i.e. the number of tumors, lesions, etc. per fish) were not made, although light and heavy infestations were noted when present. Anomalies were expressed as a percent of affected fish among the sample population.

Collection techniques are not consistently effective with fish less than 2.54 cm in length. Therefore, young of the year fish were not included in catch totals or index calculations as they could have produced bias in the measure of aquatic ecosystem health (Angermier and Karr, 1986; Angermier and Schlosser, 1988).

2.2.3 Data Analysis

Fish population data were evaluated using IBI and MIwb, and calibrated by Ohio EPA for the EOLP Ecoregion. The IBI is a multi-metric index patterned after the original described by Karr (1981) and Fausch et al. (1984) and varies with drainage area. Each metric receives a score of one, three, or five, with the maximum possible score of 60. The sum of the metrics becomes the IBI score with a higher score being considered more favorable. The overall IBI score is compared to narrative ranges developed by the Ohio EPA for the ecoregion. The twelve IBI metrics are presented in Table 2-2.

Table 2-2. Index of Biotic Integrity Metrics.

IBI Metric	Description
One	Total Number of Indigenous Fish Species
Two	Proportion of Round-bodied Catostomidae
Three	Number of Sunfish Species
Four	Number of Sucker Species
Five	Number of Intolerant Species
Six	Percent Abundance of Tolerant Species
Seven	Percent Abundance of Omnivores
Eight	Percent Abundance of Insectivores
Nine	Percent Abundance of Top Carnivores
Ten	Number of Individuals
Eleven	Percent Abundance of Simple Lithophilic Spawners
Twelve	Percent Abundance with DELT Anomalies

The IBI and the MIwb were calculated on data from each site and each sampling event. Relative fish data are expressed in terms of both numbers (number of individuals per 0.5 km) and weight (kg per 0.5 km). The evaluation of use-attainment is based on the average IBI and MIwb scores for each site for both rounds.

2.2.4 Modified Index of Well-being

The MIwb incorporates four measures of fish communities that have traditionally been used separately: numbers of individuals, fish biomass, and the Shannon Diversity Index based on numbers and weights (OEPA, 1987). The MIwb scores range between 1 and >9.5 with 1 being *very poor* and >9.5 being *exceptional* quality.

The MIwb is calculated as follows:

$$MIwb = 0.5 \ln N + 0.5 \ln B + H (no.) + H (wt.)$$

where:

N = relative numbers of all species excluding species designated “highly tolerant”

B = relative weights of all species excluding species designated “highly tolerant”

H (no.) = Shannon Diversity Index based on numbers

H (wt.) = Shannon Diversity Index based on weight

The Shannon Diversity Index is calculated as follows:

$$H = -\Sigma\ (n_i)\ N \log_e (n_i) N$$

where:

n_i = relative numbers or weight of the i^{th} fish species

N = total number or weight of the sample

2.3 Benthic Macroinvertebrates

The benthic macroinvertebrate community of the Mahoning River study area was sampled between August 21st and October 9th, 2003 using a combination of quantitative and qualitative methods to collect data on benthic diversity, relative abundance and distribution. An extended sampling period was necessary due to high flow conditions throughout the sampling period.

2.3.1 Quantitative and Qualitative Sampling Methods

Quantitative benthic macroinvertebrate samples were obtained using Hester-Dendy multi-plate artificial substrate samplers (Figure 16, Appendix J). Each sampler is constructed of 1/8 inch tempered hardboard cut into eight three-inch square plates, separated by twelve one-half inch diameter spacers.

The plates and spacers are placed on a 1/4-inch eyebolt with three single spaces, three double spaces, and one triple space between the plates. The total surface area of the sampler, excluding the eyebolt, is 145.6 inches^2. Samplers were placed on eight-inch cement blocks and anchored to the substrate to avoid loss during floods. One set of samplers consisted of five Hester-Dendys attached to a block, and two sets of samplers are installed at each sampling station. One set serves as a backup in the event one set was lost due to flood, vandalism, excess siltation, or exposure due to low flow. To obtain maximum abundance and diversity of macroinvertebrates, samplers were positioned in the euphotic zone one to two feet below the water surface. Where present, samplers were placed at the head of a recovery pool immediately below riffle habitat. Care was taken to place the samplers at an adequate depth so they remained submerged during periods of low flow, and to avoid contact with the stream bottom to minimize siltation and the potential loss of sample. Every effort was made to place samplers in similar habitat among sites. After a colonization period of approximately six weeks, one set of samplers was collected from each station for processing. When retrieving the samplers, the potential loss of macroinvertebrates was minimized by approaching from downstream and placing a sieve under the samplers before lifting them from the stream. The samplers were quickly removed from the block and placed in polyethylene containers containing 10-15% formalin. Organisms, which came from the Hester-Dendys, were picked from the sieve and placed in the containers with the samplers.

Streams are naturally heterogeneous in their composition of substrates. Because quantitative samplers only sample one specific type of habitat (i.e., woody debris and rocks in flowing water), Ohio EPA protocols require use of qualitative samples to supplement the quantitative data. This additional effort provides a more complete assessment of macroinvertebrate species within each study reach. This data is incorporated into metric ten of the ICI, which assesses the diversity of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa. During Hester-Dendy collection, qualitative samples were collected at each sampling station. Kick samples were performed in all types of habitat (i.e., pool, riffle, and run) and substrates which included boulders, cobble, gravel, sand, woody debris, leaf packs, undercut banks, aquatic vegetation, and root mats if present. However due to the deep average depth and lack of wadable areas, kick samples were generally preformed near shore either from a boat or close to the bank.

Qualitative samples were obtained using a D-frame kick net fitted with a U.S. No. 30 mesh. When sampling cobble, gravel and sand substrates, the kick net was positioned securely on the substrate, parallel to the flow of water, with the net pointing downstream. Once the kick net was in position on the stream bottom, an area directly upstream of the net opening was vigorously kicked to loosen the natural substrates and dislodge any invertebrates attached to the substrate. The stream current carried the loosened substrate, debris and invertebrates into the mouth of the net. Heavier mussels and snails not carried into the net were hand picked. When sampling all other substrates, the kick net was used to sweep the substrate surface to dislodge any invertebrates into the net. Collections were made for a minimum of thirty minutes and continued until no new taxa were evident in gross examination.

The sample was removed by inverting the net into a previously rinsed bucket containing ambient stream water. The bucket was poured and rinsed into a sieve, which was partially submerged in water and agitated until all fine materials passed through.

All organisms and debris were rinsed or removed with forceps and placed into a polyethylene container containing 10-15% formalin. Collection information was placed on each sample container and on a label placed inside the container with the location, type of sample, date, and samplers initials. Labels were made on water-resistant paper using a lead based soft pencil or indelible ink to protect against bleeding or discoloration due to the sample preservative.

2.3.2 Sample Sorting and Processing

After returning to the laboratory, each sample was assigned a unique sequential identification (ID) number. This number identifies the sample in a permanent ledger where pertinent collection information on sample date, client, location, and sample type is recorded. The sample ID number was placed prominently on each sample vial, microscope slides and other items connected with the sample before storing.

The Hester-Dendy plates from each site were composited and placed into a sample tray of water. The individual tiles were scrubbed with a soft brush and carefully rinsed into the tray. Tiles were visually inspected for clinging organisms, and the water in the tray washed through a No. 30 sieve placed on top of a No. 40 sieve. Organisms and debris obtained from the kick net samples were removed from the polyethylene container and placed in a sorting tray containing. All organisms were picked from the screen or tray with forceps and placed into sample vials containing 90% ethanol. The remaining debris from the multi-plate samples in the sieve were inspected under a dissection microscope for additional minute organisms.

Sub-sampling techniques were used when the number of individuals from a specific group (Order) exceeded a minimum standard recommended by the Ohio EPA. At least 70 Mayfly, 70 Caddisfly, and 100 Chironomid larvae must be collected before subsampling techniques are performed. Subsampling was performed by placing all organisms into a gridded pan and randomly extracting organisms from the sample until adequate numbers were counted. The remaining organisms were extrapolated among the species identified and recorded to obtain a relative number for each sample.

2.3.3 Identification

Larger organisms were identified in petri dishes under a dissecting microscope. Identification was taken to the lowest practical taxonomic level (generally genus/species). Experienced taxonomists identified each organism and placed each taxon into vials with an identification label. The identification labels display the sample identification number, taxa, location, site, date of collection, and initials of the taxonomist in indelible ink. The identified taxa and number of individuals for each taxon were recorded on aquatic invertebrate bench sheets. A separate set of bench sheets was used for each sample.

Members of the Dipteran family Chironomidae (midges) were cleared by being permanently mounted on a microscope slide in CMC-9[7] (Masters Company, Inc.) and allowed to dry with clear cement. Questionable or unusual taxa were verified on a consensus basis between experienced EnviroScience taxonomists. A final check for correct identification was made against EnviroScience's permanent reference collection for confirmation. The reference collection consists of organisms that have been verified by an outside authority in macroinvertebrate identification.

2.3.4 Data Analysis

The Invertebrate Community Index (ICI) is a measurement too developed by Ohio EPA (1987) to evaluate the community structure in a similar manner to the IBI. The ICI consists of ten structural community metrics, which are assigned scores of zero, two, four, or six, for a total possible score of 60 (Table 2-3.).

Table 2-3. Invertebrate Community Index Metrics (OEPA, 1987).

ICI Metric	Description
One	Total Number of Taxa
Two	Total Number of Mayfly Taxa
Three	Total Number of Caddisfly Taxa
Four	Total Number of Dipteran Taxa
Five	Percent Mayfly Composition
Six	Percent Caddisfly Composition
Seven	Percent Tribe *tanytarsini* Midge Composition
Eight	Percent Other Dipteran and Non-insect Composition
Nine	Percent Tolerant Organisms
Ten	Total Number of Qualitative EPT Taxa

Metrics one through nine are based on quantitative (Hester-Dendy) data while metric ten uses only qualitative data. The point system associated with each metric is based on drainage area and allows a sample to be evaluated against a database of 247 relatively undisturbed reference sites throughout Ohio. Six points are given if a metric has a value comparable to those of exceptional stream communities, 4 points for those metric values characteristic of good communities, 2 points for metric values slightly deviating from the expected range of good values, and 0 points for metric values strongly deviating from the expected range of good values. The sum of the individual metric scores is the overall ICI score that was compared to Ohio EPA criteria (1987).

2.4 Habitat

The Qualitative Habitat Evaluation Index (QHEI; Rankin 1989) was used to evaluate habitat at each site. The QHEI is a physical habitat index, which provides a numerical evaluation of the lotic macrohabitat and riparian zone characteristics important to the fish community. The index is calculated by assigning scores for each of six metrics (Table 2-4.). The sum of these metric scores yields a total score that numerically rates the habitat of a particular stream reach, based on a scale of 100 possible points. Sites having QHEI scores greater than 60 are expected to sustain fish and macroinvertebrate populations indicative of WWH. Sites with scores <45 are considered MWH.

For sites with scores between 45 and 60, the best professional judgment of the evaluator is used to determine the appropriate use designation.

Table 2-4. Qualitative Habitat Evaluation Index Metrics (Rankin, 1989).

QHEI Metric	Description
One	Type of Substrate
Two	Type of In-stream Cover
Three	Channel Morphology
Four	Riparian Zone and Bank Erosion
Five	Pool/Glide and Riffle/Run Quality
Six	Stream Gradient

2.5 Field Chemistry

At the time of electrofishing, field chemistry was performed with a Hydrolab®7 Quanta, which measured dissolved oxygen, pH, conductivity, and water temperature. These parameters are critical in determining suitability for aquatic organisms because they can cause direct mortality or a shift in species composition. Field testing was performed in accordance with *Standard Methods For The Examination of Water and Wastewater* (APHA et al, 1992).

Field samples were taken by placing the multiprobe directly into the stream. The probe was placed into moving water, preferably below a riffle, to ensure a constant flow of water over the membrane. Once the reading stabilized, the value was read directly from the display unit and recorded on a fish data sheet. The multiprobe was calibrated at the start of each workday.

3.0 RESULTS

The following sections describe the results of the fish and benthic macroinvertebrate assessments and the habitat analysis at each Mahoning River Sampling Station.

3.1 Fish

The overall IBI and MIwb scores used to evaluate fish data are based on the mean scores calculated from the combined rounds of data collection. A total of 45 species were collected from all sites. Fish Data Sheets are presented in Appendix C, and IBI scoring sheets in Appendix D. A species list with MIwb scores for each site is presented in Appendix E.

3.1.1 IBI Scores

Mean IBI scores for all sampling stations ranged from 24 to 36 (Table 3-1.), which correlates to narrative scores (Table 3-2.) of *poor* to *marginally good* in the EOLP ecoregion. A mean IBI score of 32 was observed at RM 45.5, which is located downstream of the second Leavittsburg dam. The highest mean IBI score of 36 was observed at RM 44.3, which is further downstream of the 2nd Leavittsburg dam. The mean IBI score decreased to 29 at RM 33.2, which is located downstream of West Park Road, near the Warren city limits. The lowest mean score of 24 was observed at both RM 28.5 and RM 19.4. RM 28.5 is located downstream of the Niles WWTP and upstream of McDonald Steel, and RM 19.4 is located within the mixing zone of the Youngstown WWTP. The furthest downstream sampling station is located at RM 12.0, downstream of the Lowellville WWTP and had a mean IBI score of 27. IBI scores for both rounds with the calculated mean are also presented in Figure 9 (Appendix I).

Table 3-1. IBI Metric Scores for Round 1 (R1) and Round 2 (R2) sampling (2003).

Metric	RM 45.5 R1, R2	RM 44.3 R1, R2	RM 33.2 R1, R2	RM 28.5 R1, R2	RM 19.4 R1, R2	RM 12.0 R1, R2
1. Total Number of Indigenous Fish Species	3 , 3	5 , 3	3 , 3	1 , 3	3 , 3	3 , 3
2. Percent Round-bodied Catostomidae	3 , 1	1 , 1	1 , 1	1 , 1	1 , 1	1 , 1
3. Number of Sunfish Species	5 , 5	5 , 5	5 , 5	5 , 3	5 , 5	5 , 3
4. Number of Sucker Species	3 , 3	3 , 3	1 , 1	1 , 3	1 , 1	3 , 3
5. Number of Intolerant Species	1 , 1	5 , 1	1 , 1	1 , 1	1 , 1	1 , 3
6. Percent Abundance of Tolerant Species	3 , 3	3 , 3	1 , 3	1 , 3	3 , 1	1 , 3
7. Percent Omnivores	3 , 3	3 , 3	3 , 3	3 , 3	3 , 3	3 , 5
8. Percent Insectivores	3 , 3	3 , 3	3 , 3	5 , 5	5 , 3	3 , 1
9. Percent Top Carnivores	5 , 5	5 , 5	5 , 5	1 , 1	1 , 1	1 , 5
10. No. of Individuals	1 , 3	1 , 1	1 , 1	1 , 1	1 , 1	1 , 1
11. Percent Simple Lithophilic Spawners	1 , 1	3 , 1	1 , 1	1 , 1	1 , 1	1 , 1
12. Percent DELT Anomalies	1 , 1	1 , 5	1 , 5	1 , 1	1 , 1	1 , 1
Round 1 IBI Score	32	38	26	22	26	24
Round 2 IBI Score	32	34	32	26	22	30
Mean IBI Score	**32**	**36**	**29**	**24**	**24**	**27**

Table 3-2. Mean Metric Scores and Narrative Water Quality Ranges for the IBI Scores.

Sampling Station	IBI Score	Narrative Range
RM 45.5	32	Fair
RM 44.3	36	Marg. Good
RM 33.2	29	Fair
RM 28.5	24	Poor
RM 19.4	24	Poor
RM 12.0	27	Fair

Variation Between Sampling Rounds and Within Metrics

Four stations (RM 33.2, RM 28.5, RM 19.4, RM 12.0) showed an increase in IBI scores between first and second round sampling, while Station RM 44.3 showed a slight decrease. IBI scores at RM 45.5 were the most consistent between rounds with scores of 32 for both sampling rounds, though individual metric scores did not maintain a similar result. All IBI metrics lacked consistency between all sites and sampling periods. However, three metrics, including metrics seven (percent omnivores), ten (number of individuals), and eleven (percent simple lithophilic spawners), were the most consistent between sampling sites and rounds with only a single deviation of scoring (±2) between rounds for each metric. The number of fish species varied from scores of 3 to 5, except a single occurrence at RM 28.5 during the first round of sampling, scoring a 1. The number of fish species was highly variable, ranging from eight to 22 species between both sites and sampling events. Although scoring variation between sampling rounds was relatively minor, more significant differences were noted at RM 44.3, RM 33.2, RM 19.4, and RM 12.0 for specific metrics.

Metric five evaluates the number of intolerant species that were present at a sampling station. Intolerant species observed during the survey included, the black redhorse (*Moxostoma duquesnei*), eastern sand darter (*Ammocrypta pellucida*), banded darted (*Etheostoma zonale*), silver shiner (*Notropis photogenis*), and river chub (*Nocomis Mircropogon*). Scores for this metric were usually 1, due to a low number of intolerant species present at most sampling stations. However, a score of 5 was calculated at RM 44.3 in the first round of sampling and a score of 3 was calculated at RM 12.0 during the second round of sampling.

Metric twelve evaluates the percent of the population that have DELT anomalies, which are considered indicators of environmental degradation. More specifically, contaminated sediments tend to result in DELT anomalies in bottom dwelling species. Four of the six sampling stations had the lowest possible score of 1 for this metric. The more common DELTs were deformities and tumors (Figure 17, Appendix I). However, stations RM 44.3 and RM 33.2 had a decrease in DELT observations, which resulted in a metric score of 5 during the second round of sampling.

A notable difference between sampling rounds for metric nine (% carnivores) was observed at RM 12.0. This is primarily due to the increase in diversity in species captured and the greater number of rock bass (*Ambloplites rupestris*) observed during the second round of sampling.

RM 45.5

At RM 45.5, lower proportions of round-bodied Catostomidaes (metric two) were observed during the second round, which resulted in a metric score of 1, compared to a 3 in the first sampling round. An increase in the total number of individuals sampled between rounds one and two caused a difference in the scoring for metric ten. The metric score of 1 for the first round was due to an overall low number of fish surveyed which contained tolerant species that are excluded from the final calculation. The second round of sampling produced approximately three times the number of individuals resulting in the metric score of 3.

RM 44.3

The highest individual IBI score of 38 was observed at RM 44.3 during the first round of sampling. Second round scores at this site yielded the second highest score of 34, and the mean of the two scores yielded the highest overall IBI score of the study (36). The higher first round score was due to results in three metrics; metric one (total number of indigenous fish species), metric six (total number of tolerant species), and metric eleven (percent simple lithophilic spawners). The high score (5) for metric one was the result of the highest number of total indigenous species (22) at any site in the survey. This site had the most number of tolerant species (4) surveyed at any one site, and therefore received the highest individual score. Finally, first round electrofishing yielded a relatively large assemblage (25%) of simple lithophilic spawners, which produced a metric score of 3 at this station.

RM 33.2

RM 33.2 exhibited differences in scoring between rounds in metrics six (abundance of tolerant species) and twelve (percent DELT anomalies). The score of 1 for metric six in round one increased to 3 in round 2 due to a 10% increase in the abundance tolerant individuals. The tolerant species, which affected this metric, also varied between rounds. The first round samples were mainly comprised of white sucker (*Catostomus commersoni*) and carp (*Cyprinus carpio*) compared to the second round, which primarily consisted of bluntnose minnows (*Pimephales notatus*).

RM 28.5

The lowest individual IBI round (22) and overall mean score (24) was observed at RM 28.5 and RM 19.4. Four differences in scoring between rounds occurred at station RM 28.5 and included metrics one (total number indigenous fish species), three (number of sunfish species), four (number of sucker species), and six (percent abundance of tolerant species). The difference in metric one, although only resulting in a two point increase in the second round, is a notable one. The total number of fish species sampled increased from 8 to 19 in the second round. This increase in species directly affected the increase to a metric score of 3 due to the presence of spotted sucker (*Minytrema melanops*), silver redhorse (*Moxostoma anisurum*), golden redhorse (*Moxostoma erythurm*), and white sucker (*Catostomus commersoni*), each of which were not observed during the first round. A decrease from a 5 to a 3 in the second round for the number of sunfish metric (three) was due to a difference of one sunfish species. Another influence of the higher abundance in the second round of electrofishing was noted in the percent abundance of tolerant species (metric six). The score increased from 1 in the first round of sampling to 3 in the second round.

RM 19.4

Collections at station RM 19.4 revealed two differences in IBI metric scores between rounds. The percent abundance of tolerant species (metric six) increased during the second round of electrofishing, resulting in a score of 1 compared to 3 in the first round. This decrease in score is mainly due to the number of carp collected in the second round of electrofishing. The other decrease in metric scores between rounds was noted in the proportion of insectivores (metric eight), which scored a 5 and 3 in the first and second round of collections, respectively.

RM 12.0

RM 12.0 had one of the more significant variances in IBI score between sampling rounds with a 24 in round one compared to a 30 in round two. This was due to variations for metric three and metrics five through nine. Five of these metrics varied only by two points, while metric nine varied by four points and increased from a 1 to a 5 in the second round of sampling. The presence of two more sunfish species, pumpkinseed (*Lepomis gibbosus*) and black crappie (*Pomoxis nigromaculatus*) in round one, resulted in a metric score of 5 compared to the 3 scored for the second round of sampling. Differences in scoring between rounds for metrics six through nine are primarily due to the absence or presence of a single species in large proportions; for example spotfin shiner (*Notropis spilopterus*) seen in round two compared to round one for metric eight.

Longitudinal Trends

Stations RM 45.5 and RM 44.3, are located on the edge of the urbanized reach of the Mahoning River as it flows through the City of Warren. Moving downstream away from the second Leavittsburg dam, IBI scores improve from the initial score of 32 (*fair*) at RM 45.5 to 36 (*marginally Good*) at RM 44.3. This increase is primarily due to two metrics, which evaluated the number of intolerant species (five) and DELT anomalies (twelve). During the first round of sampling, collections at RM 44.3 included four intolerant species, which resulted in a metric score of 5 compared to a 1 at RM 45.5. Second round collections at RM 44.3 also showed a decrease in the number of DELT anomalies resulting in a metric score of 5 compared to 1 at RM45.5.

The Mahoning River flows into a relatively rural watershed at RM 33.2. Although the watershed is less urbanized, the IBI scores decreased from upstream reaches that were *marginally good* to a score of 29 (*fair)*. The number of sucker species (metric four) sampled at upstream locations included approximately three species, compared to fewer than two species at RM 33.2, which resulted in a metric score of 1. Additionally, the absence of intolerant fish species (metric five) lowered the IBI score at RM 33.2. Conversely, the number of tolerant species begins to increase at RM 33.2 with tolerant species contributing 30% or more to the fish community. The increase of tolerant fish and decrease of intolerants and sucker species indicates that environmental degradation is notable in this reach of the Mahoning River.

The Mahoning River flows into an urbanized reach at RM 28.5 and IBI scores decrease further. Low metric scores noted at RM 33.2 persist while three additional decreases in metric scores are apparent. Decreases in the metric score for the number of indigenous fish species (metric one) can be attributed to the lowest observation of indigenous fish species (8) throughout the survey at RM 28.5. Low diversity also affected metric three; with the lowest number of sunfish species (3) observed occurring at RM 28.5. The most significant decrease was in the percent of top carnivores (metric nine) at RM 33.2, which was a major contribution to the decline in mean IBI score of 29 (*fair)* to 24 (*poor)*. Although the overall score decreased, a notable improvement in the percentage of insectivores increased scores for metric eight. This increase is mainly due to a dominance of sunfish species and a lack of shiner species in the fish community.

Suppressed scores noted at RM 33.2 and RM 28.5 continues at RM 19.4. Minor increases and decreases in scores occurred, but the overall IBI score remained *poor* (24).

As the Mahoning River flows toward the border of Pennsylvania (RM 12.0), IBI scores improve slightly from the 24 (*poor)* at RM 19.4 to 27 (*fair)*. However, these scores are still significantly lower than those in the reference reaches of the Mahoning River project area. The slight improvement in mean IBI score at RM 12.0 can be attributed to several metrics. An increase in the number of sucker species (metric four) to reference reach conditions (three species) contributed to the increase. The number of intolerant species (metric five) and the number of top carnivores also increased contributing to the overall increase. Conversely, a decrease in the percent of insectivores (metric eight) in round two scoring was observed and resulted in the lowest metric score for this metric compared to all other sampling stations. This was due to the dominance of the spotfin shiner (*Notropis spilopterus*), which affects low end scoring for this metric.

3.1.2 MIwb Scores

Modified index of well being (MIwb) scores ranged from 5.33 to 8.69 and are considered to be within the *poor* and *marginally good* narrative range (Table 3-3. and Figure 10 Appendix I). The lowest individual score of 5.33 at RM 28.5 occurred during the first round and can be attributed to the low species diversity and high abundance of tolerant species. At this sampling station, the common carp contributed 25% of the relative number of individuals and comprised 87.5% of the population in relative weight. The highest individual score of 8.34 at RM 33.2 during the second round was attributed to a high species diversity and low abundance of tolerant species. At this sampling station, the bluegill sunfish contributed 21% of the relative number of individuals, while the common carp contributed 28% of the population in relative weight. The remaining sites scored in the *fair* to *marginally good* ranges for both rounds of sampling.

Table 3-3. MIwb Scores for Round 1 (R1) and Round 2 (R2) at all sample sites (2003).

Sampling Station	R1, R2	Mean	Narrative Range
RM 45.5	7.2, 8.2	**7.7**	Fair
RM 44.3	8.2, 8.3	**8.25**	Marginally Good
RM 33.2	6.8, 8.7	**7.75**	Fair
RM 28.5	5.3, 7.4	**6.35**	Poor
RM 19.4	7.6, 6.9	**7.25**	Fair
RM 12.0	8.2, 8.1	**8.15**	Fair

Overall, the second round of sampling resulted in higher MIwb scores with collections at RM 19.4 and RM 12.0 being the exception. Mean scores were very similar in trend to IBI scores. The upstream sampling stations (RM 45.5 and RM 44.3) scored higher than the middle three sampling sites (RM 33.2, RM 28.5, RM 19.4), which revealed the lowest scores. The mean MIwb score did increase to the *fair* rating at the furthest downstream station (RM 12.0).

3.2 Benthic Macroinvertebrates

The results of the ICI scores calculated from the macroinvertebrate data range from 8 - 32. ICI scoring sheets are presented in Appendix F. The highest score 32, which relates to a *marginally good* narrative range score, occurred at RM 33.2. The lowest ICI score of 8 occurred at both RM 28.5 and RM 12.0. These scores are considered to be in the *poor* narrative range (Table 3-4 and Figure 11 Appendix I). Scores for the individual metrics for each site are presented in Table 3-5.

Table 3-4. Metric Scores and Narrative Water Quality Ranges for the ICI Scores.

Sampling Station	ICI Score	Narrative Range
RM 45.5	26	Fair
RM 44.3	26	Fair
RM 33.2	32	Marginally Good
RM 28.5	8	Poor
RM 19.4	10	Poor
RM 12.0	8	Poor

Table 3-5. ICI Metric Scores for Mahoning River (October 2003).

Metric	RM 45.5	RM 44.3	RM 33.2	RM 28.5	RM 19.4	RM 12.0
1. Total Number of Taxa	4	4	4	2	2	2
2. Number of Mayfly Taxa	0	0	2	0	0	0
3. Number of Caddisfly Taxa	4	6	4	2	2	2
4. Number of Dipteran Taxa	6	4	4	2	4	2
5. Percent Mayflies	2	2	6	2	2	2
6. Percent Caddisflies	2	6	2	0	0	0
7. Percent Tanytarsini Midges	2	2	2	0	0	0
8. Percent Other Diptera and Non-Insects	0	2	2	0	0	0
9. Percent Tolerant Organisms	4	0	6	0	0	0
10. Qualitative EPT Taxa	2	0	0	0	0	0
Total ICI Score	**26**	**26**	**32**	**8**	**10**	**8**

None of the ten ICI metric scores were consistent among the six sites sampled. Only three metrics (2, 5, 10) had consistent scores at five of the six sites. Metric two (the number of mayfly taxa) scored 0 at all sites with the exception of RM 33.2, which scored a 2. Metric five (the percent abundance of mayfly taxa), which has a strong relationship with metric two, scored a 2 at all sites with the exception of RM 33.2 (score of 6). The low numbers of mayfly taxa also affected metric ten (qualitative EPT taxa). All sampling stations scored a 0 for this metric with the exception of the reference location (RM 45.5), which had a metric score of 2. The remaining six metrics scored differently perhaps due to fluctuations in habitat and/or water quality.

Macroinvertebrate collections at RM 45.5 were similar to RM 44.3 with regard to number of taxa, percent mayfly, percent tanytarsini midges, and overall ICI scoring (26). Comparatively, RM 44.3 had approximately three times the total abundance of organisms collected. Also scoring similarly to RM 45.5 and RM 44.3 was RM 33.2, obtaining the highest ICI score of 32 (*marginally good*). Overall, macroinvertebrate abundance at RM 33.2 was almost identical to the community at RM 45.5. Three metrics, (two, five and nine) scored comparatively higher contributing to the increase in score at this station. The higher metric two score (2) at RM 33.2 was due to the presence of three mayfly taxa, the most seen at any sampling station. This metric is also closely related to the percent of mayfly taxa metric (metric five). The mayfly composition at RM 33.2 resulted in a metric score of 6 compared to metric scores of 2 at all other sampling locations.

ICI scores decreased significantly at RM 28.5, RM 19.4, and RM 12.0 with scores in the *poor* range (8, 10, and 8, respectively). A principle differences between these sampling stations and upstream locations is the low abundance of mayfly taxa. This affected all mayfly metrics including metrics two, five, and ten. The low abundance of Caddisfly taxa also affected several metric scores including three, six, and ten. Overall, all three of these sampling stations had metric scores of 0 for metrics two (number of mayfly taxa), six (percent caddisflies), seven (percent tanytarsini midges), eight (percent other diptera and non-insects), nine (percent tolerant organisms), and ten (qualitative EPT taxa).

Overall, ICI scores were relatively low at all Mahoning River sampling stations. However, there may be several explanations, including impacted sediments, which may in part explain some of the poor community structure. The EnviroScience study was initiated late in the season due to contract arrangements. Hester-Dendy samplers were not deployed into the Mahoning River until late August (21 through 26th). The macroinvertebrate colonization period was followed by heavy rain events over several months, affecting much of the Midwest United States. The flow conditions as a result of this rain put additional stress on biological communities, which could have affected invertebrate movements, drift and/or colonization of other available habitats (i.e. Hester-Dendy). After the Hester-Dendy samplers were deployed, several heavy rain events flooded the Mahoning River. The Hester-Dendy samplers were not retrieved until October 7th through the 9th, when flows conditions receded and were more amenable for collection and qualitative sampling. Many of the areas appeared to have been scoured from the high flows and kick sampling proved very unproductive. Much of the substrates and/or woody debris sampled were most likely heavily disturbed or not even present during some of the sampling season. Although the data suggest direct correlations with IBI and MIwb scores, scores may be somewhat lower due to weather conditions during the 2003 sampling season.

3.3 Habitat

Overall, the QHEI scores for ranged from 48.5 to 85.25 (Table 3-6. and Figures 9 and 10, Appendix I) depending on the location of the sampling station. QHEI scoring sheets are presented in Appendix G and station photos in Appendix B. QHEI scores lower than 60 were recorded at sampling stations that were impounded or heavily influenced by urbanization. These areas included RM 45.5, RM 28.5 and RM 19.4 with scores of 56, 48.5 and 59.25, respectively. The highest QHEI score of 85.25 was recorded at RM 12.0. This score was significantly higher than all other scores due to the presence of riffle and pool complexes. RM 44.3 and RM 33.2 had in-stream habitat that was relatively similar with QHEI scores of 61.25 and 66.5, respectively. Overall, QHEI scores were relatively low but can be expected to sustain fish and macroinvertebrate populations indicative of WWH.

Table 3-6. QHEI Individual Metric Scores of the Mahoning River (Oct, 2003).

Metric	Max Points	RM 45.5	RM 44.3	RM 33.2	RM 28.5	RM 19.4	RM 12.0
1. Substrate	20	7	12	9	4.5	9	20
2. Instream Cover	20	14	15	14	12	14	15
3. Channel Morphology	20	12	10	16	10.5	12	13.5
4. Riparian Zone and Bank Erosion	10	5	6.25	9.5	7.5	5.25	7.75
5. Pool/Glide and Riffle/Run Quality	20	10	10	10	8	9	19
6. Gradient	10	8	8	8	6	10	10
Total Score	**100**	**56**	**61.25**	**66.5**	**48.5**	**59.25**	**85.25**

Most sampling stations scored very low for metric one (Substrate) due to the dominance of a hardpan and silt substrate. Hardpan substrates are very stable but offer little in-stream cover due to scour. The smooth surface of hardpan decreases shear stress thereby increasing water velocities making high flow events very swift and efficient at sediment transport. The only sampling station that was not impacted by hardpan substrates was RM 12.0, which had the highest possible score (20) for this metric. Additionally, silt was noted from areas of bank erosion, especially at stations located in urban areas. Cobble or boulder substrates were present at all the sampling sites but their abundances fluctuated, and they were usually too low in comparison to the hardpan or silt to be considered a dominant substrate. The cobble and boulders were not free of embeddedness due to the lack of riffle / run qualities and the impounded nature of the majority of the Mahoning River.

There was a moderate amount of in-stream cover (metric 2) at all sampling stations included in the study. In-stream cover was dominated by overhanging vegetation, rootwads, woody debris, rootmats, and shallows. RM 28.5 received the lowest metric score (12) due to sparse cover and the impounded nature of the sampling station.

Channel morphology (metric three) was similar at all the sampling sites. Channel development at RM 33.2 was rated highest among the sites; specifically due to the *excellent* score received for the of channel development metric. Most commonly occurring characteristics associated with these metric scores were fair channel development, moderate channel stability, and recovering channelization.

Riparian zones were present at all sampling sites with varying widths. The least impacted riparian zone was at RM 33.2 due to its relative rural location. This produced a metric score of 9.5. The most heavily impacted riparian zone was at RM 45.5, having a score of 5.0. The narrow to wide riparian zone consisted of a mix of residential and commercial land uses along both stream banks. The second most impacted riparian zone was at RM 19.4, due to its proximity to a highly urban and industrialized area, resulting metric score of 5.25. Some areas of erosion resulting from the reduction in floodplain quality and riparian vegetation were observed on the right descending bank of this sampling station. Located in a heavily industrialized area, RM 28.5 contained wide riparian zones, but still had moderate erosion on both banks resulting in a metric score of 7.5. In comparison, moderate to wide riparian zones of heavy forest and swamp were noted at RM 12.0 resulting in a metric score of 7.75.

All sampling sites had similar riffle/run and pool/glide scores but varying characteristics, mostly that of impounded river stretches resulting in the lack of riffles. Maximum pool depths were greater than 1 meter (3.28 ft.). Pool width was wider than riffle width only at RM 12.0, this being the only site containing a riffle/pool association. Two flow regimes consisting of fast and moderate were present at all sites, resulting in metric scores between 8 and 10. RM 19.4 was the only stretch of river surveyed without functional eddies.

Riffle and run quality was marginal at all sites, with the exception of RM 12.0, which was the only site satisfying riffle/run criterion. Riffle quality was absent at all sites except RM 12.0, with only moderate to minimal amounts of cover and substrate. The impounded nature of the Mahoning River results in the lack of quality areas. Impoundment reduces current velocity, thereby reducing the sediment loads carried by the river. A decrease in sediment load capacity, coupled with inundation deep pools, reduces quality substrates needed for riffle development. The impounded nature of the Mahoning River also affects the stream gradient metric of the QHEI. Metric scores varied from 6 at RM 28.5 to 10 at stations RM 19.4 and RM 12.0.

3.4 Field Chemistry

Field chemistry was measured at each site during both rounds of fish sampling (Tables 3-7 and 3-8). All values recorded meet the statewide water quality criteria for the protection of aquatic life (OEPA 1999). However, dissolved oxygen concentrations were at the levels, which would be considered low at RM 33.2, RM 28.5 and RM 19.4 during the first round of sampling and at all sampling stations during the second round of sampling.

Table 3-7. Field Chemistry for First Round of Electrofishing

Sampling Station	RM 45.5	RM 44.3	RM 33.2	RM 28.5	RM 19.4	RM 12.0
Temperature (C°)	22.78	22.8	25.62	32.45	26.32	26.92
Dissolved Oxygen (mg/L)	7.22	7.2	6.2	6	6.25	7.78
PH (pH Units)	7.66	7.67	7.95	8.04	7.69	7.89
Conductivity (*u*mhos)	327	351	388	423	453	515

Table 3-8. Field Chemistry for Second Round of Electrofishing

Sampling Station	RM 45.5	RM 44.3	RM 33.2	RM 28.5	RM 19.4	RM 12.0
Temperature (C°)	13.28	13.78	13.42	13.7	14.8	13.85
Dissolved Oxygen (mg/L)	6.05	6.05	6.31	6.4	6.32	6.32
PH (pH Units)	7.58	7.66	7.84	7.8	7.85	7.85
Conductivity (*u*mhos)	317	325	345	341	360	392

3.5 Climate Data

The 2003 sampling season was one of the wettest in recorded history for the Mahoning River Watershed (Table 3-9). Precipitation was below average until May when rainfall increased and resulted in 8.50 inches of precipitation compared to the average of 3.45 inches. July, August, September, and October were all well above average with rainfall amounts of 11.30, 4.80, 6.50 and 4.20 inches. The total rainfall for 2003 was 52.9 inches compared to the average of 38.02 inches resulting in 14.88 inches of precipitation above the average from 1971 to 2000 (NCDC ClimVis, 2004). The above average rainfall made biological sampling very difficult and most likely affected resultant data.

Table 3-9. Precipitation Data for Station 339406 Youngstown

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1971-2000 Average	2.34	2.03	3.05	3.33	3.45	3.91	4.1	3.43	3.89	2.46	3.07	2.96	38.02
2003 Actual	1.7	2.3	2.5	2.4	8.5	4.1	11.3	4.8	6.5	4.2	3.4	1.2	52.9
Delta	-0.64	0.27	-0.55	-0.93	5.05	0.19	7.2	1.37	2.61	1.74	0.33	-1.76	14.88

3.6 Flow Data

As a direct result of the above average rainfall encountered throughout the sampling months of 2003, stream flow was also at significantly higher than normal throughout the summer of 2003. Stream flow gauging stations are located at four of the six stations sampled in the study and include RM 45.5, RM 28.5, RM 19.4, and RM 12.0. Flow values recorded by the United States Geological Survey on dates that biological sampling occurred is presented in Table 3-10. Flow conditions at RM 44.3 are similar to those recorded at the gauging station located at RM 45.5 due to their proximity. Especially high stream flow conditions were present during the second round of sampling. The original intent was to sample the fish and macroinvertebrate populations during base flow at the Leavittsburg Dam gauging station. After many delays in the second round of sampling due to poor weather conditions, the USACE Pittsburgh District, Ohio EPA and EnviroScience jointly decided to sample despite higher flow conditions. High flow conditions are believed to have affected the results for the macroinvertebrate community results more than the fish populations. Scour and general loss of habitat and increased drift associated with these high flows most likely effected all sampling stations equally.

Table 3-10. USGS Stream Gauge Flow Data at EnviroScience Mahoning River Sites

Sampling Station	RM 45.5		RM 28.5		RM 19.4		RM 12.0	
Date	8/21/2003	10/7/2003	8/22/2003	10/8/2003	8/25/2003	10/9/2003	8/25/2003	10/8/2003
Mean flow* (cfs)	322	351	455	492	507	657	635	658
Actual flow (cfs)	400	984	445	1409	533	1350	520	1530
Delta (cfs)	78	633	-10	917	26	693	-115	872

*mean flow based on 62 year period of stream gauge data

3.7 Use-Attainment

The result of biological sampling indicates that RM 45.5, RM 28.5,RM 19.4, and RM 12.0 are in non-attainment status of WWH (Table 3-11). RM 44.3 and RM 33.2 are the only stations in partial attainment. This partial attainment status designation is due to the nonsignificant departure from WWH attainment scoring levels and the relative narrative range of the other biocriterion scores (Ohio EPA, 1987).

Table 3-11. EnviroScience (2003) Water Quality Use Attainment Scores for IBI, MIwb and ICI Scores.

Sampling Station	IBI Score	MIwb Score	ICI Score	Attainment Status
RM 45.5	32=Fair	7.66=Fair	26=Fair	NON
RM 44.3	36*=Marginally Good	8.29*=Marginally Good	26=Fair	PARTIAL
RM 33.2	29=Fair	7.75=Fair	32=Marginally Good*	PARTIAL
RM 28.5	24=Poor	6.36=Poor	8=Poor	NON
RM 19.4	24=Poor	7.26=Fair	10=Poor	NON
RM 12.0	27=Fair	8.15=Marginally Good	8=Poor	NON

*nonsignificant departure from biocriterion (≤ 4 IBI or ICI units; ≤0.5 MIwb units).

3.8 Ohio EPA Results

The Ohio EPA has previously collected biological and habitat data from the same locations as the sites sampled in the 2003 study (Ohio EPA, 1996). Data from the Ohio EPA's 1994 study allows limited comparison with the data generated from the current study. A summary of biocriteria data from the Ohio EPA's report and associated QHEI sheets are presented in Appendix H. The data collected in the current study indicates a general trend of overall improvements in water quality when compared to the Ohio EPA findings of 1994. Ohio EPA and EnviroScience data is compared graphically in Figures 12 through 15, Appendix I. The greatest improvements were observed in the IBI and the MIwb, where scores improved at five of the six sampling sites. When comparing IBI and ICI scores, it should be noted that scores within four points of each other are considered within the standard margin of error and therefore are insignificant. Given this, 2003 IBI scores were higher at three sampling locations (RM 45.5, RM 19.4, and RM 12.0) and substantially equal at the remaining sampling stations. Similarly, 2003 ICI scores were higher at one (RM 33.2) of the five stations sampled, substantially equal at three (RM 28.5, RM 19.4 and RM 12.0) of the stations and lower at station RM 45.5.

One of the only departures from a general improving trend since the 1994 study was noted at RM 44.3, where slight decreases in IBI, MIwb, and QHEI data were observed. ICI scores could not be compared due to the absence of data for this station in 1994. The decrease in IBI score was insignificant being that the separation was only one point and subsequently discounted. The more notable decrease at RM 44.3

occurred within the MIwb. This decrease in MIwb scoring from 9.2 (1994) to 8.2 (2003), changed the narrative range at this location from *very good* to *marginally good*.

A departure from the trend of improvement since 1994 was also seen in the macroinvertebrate community at RM 45.5. The Ohio EPA 1994 study reported an ICI score of 38 at RM 44.4 compared to 26 reported by EnviroScience in 2003. Although insignificant, a slight decrease in ICI score at RM 12.0 from 10 (1994) to 8 (2003) was also noted.

QHEI scores were relatively similar between the Ohio EPA 1994 study and the 2003 study. However, significant decreases in QHEI scores were noted at RM 19.4 from one study to the next. The Ohio EPA calculated a QHEI score of 79 compared to a score of 59.25 in 2003. The difference in scores is due to the presence of a riffle at this location in the 1994, and the absence of a riffle in 2003. . There are two possible explanations for this scoring difference. Either the sampling sites were not exactly located in the same 500-meter sampling zone or flooding and high flows changed the morphological characteristics in this stream reach.

Individual scores for habitat and biological data improved at the remaining sites between the 1994 and 2003 study. For example, large increases in ICI scores were observed at RM 33.2 from 1994 (10), to 2003 (32). Other increases in metric scores, which had a noted effect on narrative ranges, occurred at RM 12.0, where large increases in IBI, QHEI, and MIwb scoring were observed in the current study. Six point improvements in IBI scores between studies occurred at three of the sites (RM 45.5, RM 33.2, RM 12.0), also improving narrative ranges for IBI scores at each of the three stations.

Table 3-12. Water Quality Use Attainment Comparison.

Sampling Station	EnviroScience Attainment Status, 2003	Ohio EPA Attainment Status, 1994
RM 45.5	NON	PARTIAL
RM 44.3	PARTIAL	FULL - Based on Fish Only
RM 33.2	PARTIAL	NON
RM 28.5	NON	NON
RM 19.4	NON	NON
RM 12.0	NON	NON

Table 3-13. Comparison of OEPA (1994) results to results collected by EnviroScience (ES) (2003).

Sampling Station	ES IBI	Ohio EPA IBI	ES MIwb	Ohio EPA MIwb	ES ICI	Ohio EPA ICI	ES QHEI	Ohio EPA QHEI
RM 45.5	32	26	7.66	6.9	26	38	56	47
RM 44.3	36	37	8.29	9.2	26	NA	61.25	65.5
RM 33.2	29	25	7.75	6	32	10	66.5	56
RM 28.5	24	21	6.36	4.9	8	6	48.5	42.5
RM 19.4	24	19	7.26	4.9	10	10	59.25	79
RM 12.0	27	21	8.15	6.2	8	10	85.25	78.5

4.0 CONCLUSIONS

Fish and benthic macroinvertebrate data generated in this study indicate that two of the six sampling stations are in PARTIAL Attainment of WWH criteria for the EOLP ecoregion. These sampling stations include RM 44.3 and RM 33.2. The four remaining sampling stations (RM 45.5, RM 28.5, RM 19.4, RM 12.0) were all considered to be in NON Attainment of WWH criteria. Sampling stations in the lower reaches of the Mahoning River exhibited general declines from the upstream reference reach in all biological indices calculated despite habitat (QHEI) scores which indicate the river should be able to support a WWH community.

IBI and MIwb scores declined from reference conditions at RM 33.2 and continued at Stations RM 28.5 and RM 19.4. Tolerant species became more dominant at these stations as suckers and intolerant species began to decline in numbers and diversity. The fish community indicated signs of improvement at RM 12.0 with scores increasing slightly. The longitudinal trends noted in the fish community can be attributed to several factors. The current study also noted a general decrease in habitat (QHEI) scores in the reaches that had depressed fish populations. The Mahoning River is an impounded waterway and varies in flow and morphological characteristics along its length. QHEI scores were generally much lower in the impounded sections of the Mahoning River compared to the free flowing areas such as RM 12.0. These impounded stream reaches are also the areas that most likely have the highest rate of sedimentation. The quality of these sediments may be contributing to the overall degradation of the biological communities. The decrease in the number of sucker species and increase in tolerant species in these areas support this contention.

Further evidence of very poor sediment quality was found in the ICI scores at stations RM 28.5, RM 19.4 and RM 12.0, when they decreased into the *poor* narrative range. The decrease in quality of the macroinvertebrate community in these reaches is likely due to sediments that have been contaminated from both point and non-point sources. It must also be noted that flow conditions during the 2003 sampling season were abnormally high which may have affected macroinvertebrate populations and collection techniques. Overall, the Mahoning watershed received nearly 15 inches of precipitation above normal during 2003. Much of this rainfall was concentrated into major storms during the summer season. Subsequently, river flows increased and were recorded at record highs during 2003. Because of high flows, a significant amount of scouring and habitat disturbance occurred during the sampling season. Although it is believed that the increased flows affected the overall biological scores, the longitudinal trend of increasingly degraded biological communities are consistent with past studies on the Mahoning River (Ohio EPA, 1996).

The results of the current study are comparable to, but somewhat improved from, the 1994 Ohio EPA study of the Mahoning River. The Ohio EPA study found PARTIAL Attainment at RM 45.5 and FULL (based on fish only) Attainment at RM 44.3 before decreasing to NON-Attainment downstream to the state border (RM 12.0). IBI and MIwb scores in the present study indicate the same general trend of environmental degradation in downstream areas with a slight increase in quality at RM 12.0. Overall, MIwb scores showed the same longitudinal trend but were somewhat higher than in the 2003 study. This is another indication that the fish community has improved in the Mahoning River since 1994. However, scores are still suppressed in the same stream reaches as identified by the Ohio EPA in 1994. Additionally, ICI scores were similar between studies with narrative ranges decreasing significantly at RM 33.2 in 1994 and RM 28.5 in 2003.

Overall, the results of the 2003 study of the Mahoning River reveal significant degradation of the biological communities within the Proposed environmental dredging area. Although flows were above normal, data are very comparable to the Ohio EPA 1994 study. The biological communities have shown limited improvement since Ohio EPA's 1994 study and should be monitored for future progress, especially in a normal flow year. Additionally, further benthic macroinvertebrate monitoring could indicate the degree of potential contamination of river sediments and help serve as a basis for prioritizing remedial activities. Future studies should be conducted at the same stations used in past studies. Consideration should be given to additional sampling stations at other locations sampled by the Ohio EPA that were not sampled in the current study.

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