BIOLOGICAL ASSESSMENT OF THE MAHONING RIVER LAWRENCE COUNTY, PENNSYLVANIA

RIVER MILE 0 THROUGH RIVER MILE 12

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FEBRUARY, 2000

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EXECUTIVE SUMMARY

The study area for this biological assessment is the lower 12 miles of the Mahoning River as it flows from the Ohio border through Lawrence County, Pennsylvania to its confluence with the Shenango River and the formation of the Beaver River at New Castle. The data presented in this report were gathered between mid-October of 1999 and early November of 1999. The assessment procedures focused on three primary, and two lesser, Ohio Environmental Protection Agency developed biotic indices.

- The Qualitative Habitat Evaluation Index (QHEI) criterion exceeded the Ohio Warm Water Habitat (WWH) criterion throughout the study area. Habitat concerns remained; however, with the lack of instream physical structure and a "cementitious" type substrate.

- The Invertebrate Community Index (ICI) criterion did not meet the minimum Ohio WWH value at any of the sampling locations. Low total taxa numbers, including low diversity within the mayfly and dipteran groups, were a primary cause of the decreased total ICI scores. While the study section of the Mahoning River does support a viable macroinvertebrate population, this population is not consistent with the defined WWH community.

- The Index of Biotic Integrity (IBI) criterion did not meet the minimum Ohio WWH value at any of the sampling locations, but an unexpectedly large number of taxa and individuals were found throughout the study area. Overall, the lack of intolerant species, percent abundance of tolerant species, and the lack of darter and sucker species collected at the selected sampling stations, contributed most heavily to the calculated IBI values. It was noted during the fish sampling that anytime structure was encountered, particularly logs and woody debris, that there was an increase in species numbers and diversity.

  - The Modified Index of Well Being (MIwb) values followed a similar trend to the IBI as a result of the percentage of pollution tolerant species in the samples.

  - An evaluation of fish "Deformities, Eroded Fins, Lesions, or Tumors (DELT);

however, exceeded the values of the reference reach of river and met the Ohio WWH criterion. Very few individuals exhibited physical anomalies, suggesting that the species present were of good overall health. This finding is in direct contrast with the Ohio reach of river between miles 12 and 39.

The results of this study potentially reflect a recovering ecosystem. While the fishery is degraded, it has improved from a worsened historical state and is showing a healthy condition for the level of the present recovery. Overall, it appears as though the lower 12 miles of the Mahoning River, while degraded as compared to (unimpacted) reference streams within the ecoregion, does indeed support a viable biotic community that can be further enhanced through restoration activities.

INTRODUCTION

The study area for this assessment is the lower 12 miles of the Mahoning River as it flows from the Ohio border through Lawrence County, Pennsylvania tc its confluence with the Shenango River and the formation of the Beaver River at New Castle. The data presented in this report were gathered between mid-October of 1999 and early November of 1999.

The Mahoning River was one of the nation's most severely degraded rivers for most of the 20th century because of heavy industrialization in the river valley. Today, most of the point sources of pollution to the Mahoning have either ceased to exist, or have come under regulation and control, and the quality of the river is improving. It is generally acknowledged; however, that the river's substrate in particular remains contaminated, and the biotic integrity of the Mahoning River remains depressed. The degree of degradation of the Ohio portion of the River was determined in a previous study (OEPA, 1996).

The purpose of this biological assessment was to determine the extent of impact in Pennsylvania with an ultimate goal of developing a benthic habitat restoration strategy along the overall length of the impacted reaches of the Mahoning River.

APPROACH

Aquatic biotic community health depends upon a complex and integrated set of biological, chemical, and physical factors. In their natural state, biotic communities are expected to display relatively stable and typically diverse compositions and functions. Human activities can stress, and therefore change, the makeup of these same aquatic communities to various degrees.

Aquatic macroinvertebrates and fishes are sensitive to the conditions of their immediate habitat. In that these organisms are in effect "continuous quality monitors", even short lived stresses can have long-term effects on the makeup of the community. Year classes of fish may be absent, pollution sensitive insects may be missing, diversity may be lacking, and organisms typical of stressed conditions may be abundant.

These ecological conditions can be readily measured in comparison with relatively unimpacted rivers in the same general ecoregion. The Ohio Environmental Protection Agency (OEPA) has been in the forefront of developing measures of aquatic biotic integrity, and their methods have been adopted for this evaluation.

The assessment of the lower Mahoning relied on three primary (and in this case two lesser) OEPA biotic indices of the structure and function of the aquatic biotic community. The Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989), the Invertebrate Community Index (ICI) (OEPA, 1987a), and the Index of Biotic Integrity (IBI) (OEPA, 1987a) were the three primary measures. The Modified Index of Well Being (MIwb) and an evaluation of fish "Deformities, Eroded Fins, Lesions, or Tumors" (DELT) were the two complementary evaluations (OEPA, 1987a).

The QHEI assesses the physical attributes of a river, and in essence defines an upper limit to biotic composition. The ICI and IBI are measures of the overall health of the macroinvertebrate and fish communities; respectively. The MIwb is essentially a measure of the abundance and weight of the fish population, excluding pollution tolerant species. The DELT score is actually a component of the IBI, but is also evaluated independently as a measure of the frequency of occurrence of abnormalities as described by the acronym. Each index is further discussed in the individual sections of the report.

Collectively, these measures of biotic integrity provide a target, or goal, that healthy aquatic communities should demonstrate when compared to relatively natural or undisturbed streams of similar setting. Biotic integrity infers the ability of an aquatic ecosystem to support and maintain a balanced and functional community. This integrity reflects the capacity of the system to maintain an optimum condition when stressed, either physically or chemically, and suffers when the ability of the community to withstand or recover from external stresses is exceeded. The referenced biotic indices can be used as tools to identify the source or sources of degradation responsible for the measured values.

Table 1. provides a description of each of the eight sampling locations used throughout the rest of this report. The corresponding United States Army Corps of Engineers (USACE) river mile designations are given for each location.

Table 1. Sampling Location Descriptions

The study area covers the lower 12 Pennsylvania miles of the Mahoning River before its juncture with the Shenango River to form the Beaver River. This section was divided into eight sampling stations, from the approximate mouth of the river to the Pennsylvania and Ohio border.

- Location No. 1 corresponds to approximate (USACE) River Mile 10.9, immediately downstream of a tributary entering the river from the southern shore.

- Location No. 2 corresponds to approximate (USACE) River Mile 10.0, immediately upstream of the SR 4003 bridge, north of Hillsville.

- Location No. 3 corresponds to approximate (USACE) River Mile 8.5, immediately upstream of two major pipeline crossings of the river.

- Location No. 4 corresponds to approximate (USACE) River Mile 7.1, downstream of the US Route 224 bridge at North Edinburg, and upstream of a breached low head dam.

- Location No. 5 corresponds to approximate (USACE) River Mile 6.9, downstream of the Location No. 4 breached low head dam.

- Location No. 6 corresponds to approximate (USACE) River Mile 4.4, downstream of the SR 4007 bridge crossing at Coverts.

- Location No. 7 corresponds to approximate (USACE) River Mile 1.6, upstream of the SR 108 bridge, and downstream of the (railroad) bridge.

- Location No. 8 corresponds to approximate (USACE) River Mile 0.2, downstream of what appears to be the "old" SR 18 bridge.

INVERTEBRATE COMMUNITY INDEX (ICI)

Introduction

The Ohio Environmental Protection Agency (OEPA) uses the Invertebrate Community Index (ICI) as its principal measure of overall macroinvertebrate community condition. ICI standards were derived from a comprehensive data set gathered from relatively undisturbed reference locations throughout Ohio. The ICI approach generates a single number used to evaluate biological condition.

The ICI consists of ten structural and functional community metrics, with each metric assigned a scoring category of 0, 2, 4, or 6 points (The 10 metrics are defined in Table 5., page 14.). The four scoring values correspond to the rankings of "poor, fair, good, and exceptional"; respectively, and essentially compare a given sample against the database generated from the reference sites. The ICI is therefore a standardized measure of the ecological impairment of a given river, as compared against relatively non-impacted rivers in the same ecoregion of Ohio.

A value of 0 metric points is the lowest possible ICI score, indicating that the sample for a specific metric strongly deviates from the expected range of the reference value of an "exceptional" site. Conversely, a value of 6 metric points is the highest possible score, indicating that the sample for that metric is comparable to an exceptional site. The maximum attainable ICI score is 60 points (10 metrics times a maximum of 6 points per metric). The point assignments take into consideration the effects of drainage area.

The Mahoning River is located in the Erie Ontario Lake Plain (EOLP) ecoregion, and has an OEPA and Pennsylvania Department of Environmental Protection (PADEP) use designation of a Warm Water Habitat (WWH). The minimum OEPA ICI score necessary to achieve the WWH designation in this region is a value of 34 (OEPA, 1987b). The WWH designation is mutually dependent on other biotic indices and minimum associated point values.

Background

The OEPA uses the ICI approach as a quantitative sampling technique based on macroinvertebrate colonization of an artificial substrate. A considered principal benefit of artificial substrates is that they offer a standardized approach to evaluation, limiting biases of other collection techniques. The ICI technique involves placing a composite of five substrate samplers instream at a given sampling location for a period of six weeks. The accuracy of the method relies in part on a consistent placement of the artificial substrates both temporally and spatially. (A qualitative sample is also taken at each location as part of the evaluation.)

The seasonal timing and defined length of the current study did not allow for strict adherence to the ICI methodology in terms of using the artificial samplers. While the samplers are a key aspect of the ICI, the ICI methodology was modified rather than abandoned in an effort to provide relative consistency with other studies. The chosen approach followed the ICI format of placing more emphasis on quantifying taxonomic groupings, than of quantifying total numbers of individuals.

In essence, the only change in approach was that the macroinvertebrate population used in this study was actively, rather than passively collected. It is recognized that some taxa may be over or under represented by this methodology as compared to the artificial sampling technique, but an overall representative assessment of the macroinvertebrate community should be gained through this approach.

Methodology

The United States Environmental Protection Agency (USEPA) has developed a "Rapid Bioassessment Protocol" (RBP) for benthic macroinvertebrates that in a general way complements the ICI approach. The RBP is intended to integrate habitat quality and biological condition as a means of identifying sources of impairment for a given region. The most rigorous assessment is the Level III protocol (RBP III), which was borrowed for this effort (EPA, 1989).

Macroinvertebrates were collected from all representative physical habitat types utilizing a kick screen, and were then composited as one sample for each sampling location. Attempts were made to sample rock and gravel substrate riffle areas with both "fast and slow" current velocities, runs with larger submerged logs and boulders, and still water areas rich in sediment and detritus. Approximately one meter square areas were disturbed with each sampling effort.

Collected organisms were picked from the kick screen and placed in a white enamel tray marked off with roughly one inch square grids. Grids were then randomly selected, with all organisms within those grids removed and preserved until a sample of 100 organisms was collected. The ICI methodology as referenced was used to complete the analysis.

Findings

The Mahoning River is 108 miles long and drains 1,132 square miles of northeastern Ohio and west central Pennsylvania. The Mahoning River flows through only 12 miles of Pennsylvania before joining with the Shenango River to form the Beaver River. Roughly 96%, or 1,087 square miles, of the drainage basin is in Ohio. As noted in the introduction, the ICI takes into consideration the effects of drainage area. Therefore, all of the data were compared against a watershed area of greater than 1,000 square miles.

There is a varying degree of identification to taxonomic levels generally associated with the ICI approach that varies as widely as from class to species. We attempted to identify all collected organisms to the appropriate level, but placed the greatest emphasis on accurate identifications. In some cases, an organism may have been classified only to genus rather than species (as example) if a more detailed identification was not certain.

Table 2. on the following page provides the raw numbers which were used to develop the ICI metric values for the eight individual sampling locations for this study. Table 3. on page 8 provides the individual and sum total metric values for each of the eight study locations. Table 4. on page 9 offers a list of the actual taxa collected at each of these same locations.

Table 2. Macroinvertebrate community metrics and empirical data gathered from eight Mahoning River study sites (Lawrence County, Pennsylvania); for calculating the Invertebrate Community Index* (ICI). Sampling Station No.'s 1, 2, 3, and 4 were sampled on 19 October, 1999; Station No.'s 5, 6, 7, and 8, were sampled on 20 October, 1999.

	(VALUE)							
SAMPLING STATION NO.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
(River Mile)	**10.9**	**10.0**	**8.5**	**7.1**	**6.9**	**4.4**	**1.6**	**0.2**
1. Total Number of Taxa	13	13	13	16	14	13	17	11
2. Total Number of Mayfly Taxa	1	2	2	2	2	1	3	2
3. Total Number of Caddisfly Taxa	3	3	2	3	3	3	2	2
4. Total Number of Dipteran Taxa	1	1	2	1	1	1	2	2
5. Percent Mayfly Composition	31	2	11	15	26	12	20	24
6. Percent Caddisfly Composition	45	65	42	31	27	60	32	54
7. Percent Tribe Tanytarsini	0	0	0	0	0	0	0	0
8. Percent Other Dipteran and Non-Insect Composition	13	28	44	48	36	23	35	19
9. Percent Tolerant Organisms	3	3	5	13	6	4	1	1
10. Total Number of Qualitative EPT Taxa	4	5	4	5	5	4	5	4

*modified as discussed in text

Table 3. Macroinvertebrate community metrics and Invertebrate Community Index* (ICI) scores derived from eight Mahoning River study sites (Lawrence County, Pennsylvania). Sampling Station No.'s 1, 2, 3, and 4 were sampled on 19 October, 1999; Station No.'s 5, 6, 7, and 8, were sampled on 20 October, 1999.

					(SCORE)			
SAMPLING STATION NO.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
(River Mile)	**10.9**	**10.0**	**8.5**	**7.1**	**6.9**	**4.4**	**1.6**	**0.2**
1. Total Number of Taxa	0	0	0	0	0	0	0	0
2. Total Number of Mayfly Taxa	0	0	0	0	0	0	2	0
3. Total Number of Caddisfly Taxa	4	4	2	4	4	4	2	2
4. Total Number of Dipteran Taxa	0	0	0	0	0	0	0	0
5. Percent Mayfly Composition	6	2	4	4	6	4	4	4
6. Percent Caddisfly Composition	6	6	6	6	4	6	6	6
7. Percent Tribe Tanytarsini	0	0	0	0	0	0	0	0
8. Percent Other Dipteran and Non-Insect Composition	6	2	0	0	2	4	2	4
9. Percent Tolerant Organisms	2	2	0	0	0	0	6	6
10. Total Number of Qualitative EPT Taxa	2	2	2	2	2	2	2	2
TOTAL SCORE	**26**	**18**	**14**	**16**	**18**	**20**	**24**	**24**

*modified as discussed in text

Table 4. Macroinvertebrate taxa lists (100 Count Samples) gathered from eight Mahoning River study sites (Lawrence County, Pennsylvania); Sampling Station No.'s 1, 2, 3, and 4 were sampled on 19 October, 1999; Sampling Station No.'s 5, 6, 7, and 8, were sampled on 20 October, 1999.

SAMPLING STATION NO. (River Mile)	1 10.9	2 10.0	3 8.5	4 7.1	5 6.9	6 4.4	7 1.6	8 0.2	
TAXA									**Total**
Ephemeroptera									
Heptageniidae									
Stenonema	---	---	---	---	5	---	9	10	**24**
Stenacron	31	1	4	14	21	12	7	14	**104**
Baetidae									
Baetis	---	1	7	1	---	---	4	---	**13**
Trichoptera									
Hydropsychidae									
Hydropsyche	41	50	37	26	23	55	32	50	**314**
Cheumatopsyche	3	14	5	4	3	3	1	4	**37**
Macronema	---	---	---	---	1	1	---	---	**2**
Glossosomatidae*	1	1	---	1	---	---	---	---	**3**
Odonata									
(Zygoptera)									
Coenagriidae									
Argia	5	---	---	3	2	---	4	2	**16**
(Anisoptera)									
Gomphidae									
Gomphus	---	---	---	3	---	2	1	---	**6**
Megaloptera									
Corydalidae									
Corydalus cornutus	4	2	---	---	4	3	6	1	**20**
Coleoptera									
Psephenidae									
Psephenus herricki	---	---	---	---	3	1	---	---	**4**
Elmidae									
Stenelmis	---	---	3	---	2	---	1	---	**6**
Diptera									
(Nematocera)									
Chironomidae	2	3	9	14	24	2	7	6	**67**
(Brachycera)									
Athericidae									
Atherix	---	---	---	1	---	---	1	3	**5**

*case only

Discussion

None of the eight sampling locations generated the prerequisite ICI score of 34 necessary for a WWH designation. The mean ICI value for this study was 20. The ICI values ranged between 14 and 26 and are graphically presented in Figure 1. on page 13. The EPT score was 2 at all eight locations.

Low total taxa numbers, including low diversity within the mayfly and dipteran groups, were a primary cause of the decreased total ICI scores. A relatively large percentage of non-insect sample composition, and a contribution of pollution tolerant organisms, also contributed to the generated ICI values. While the study section of the Mahoning River does support a viable macroinvertebrate population, this population is not consistent with the defined WWH community.

In that the ICI is based on the function and composition of benthic organisms, the evaluation is sensitive to the chemical quality of both water and substrate, and to the physical makeup of benthic habitat. Current investigations are considering the benefits of benthic habitat restoration only; any existing sources of pollution will remain as an influence on the river even with the implementation of a habitat restoration effort. Therefore, with all else assumed equal, the quality of the biotic community upstream of the area of sediment contamination has been chosen as a reference area to evaluate the potential benefits of substrate restoration proposals. This reference area is described as follows.

A 1998 study (Benthic Habitat Restoration of the Lower Mahoning River, Ecological Implication) was prepared by AWK Consulting Engineers and Dr. Lauren Schroeder as part of the Reconnaissance Phase of the United States Army Corps of Engineers' (USACE) restoration project for the lower Mahoning River in northeastern Ohio (Schroeder, 1998). This study evaluated OEPA data collected in the summer of 1994. The proposed reference zone, or relatively non-impacted reach of river, began upstream of USACE River Mile 39. The sediment contaminated study reach extended to the Pennsylvania border at River Mile 12.

The mean ICI value for the 1998 report for the free flowing section of the reference zone of river was 34, with a mean EPT value of 6.5. The mean ICI value for the 1998 report for

free flowing reaches of the sediment contaminated section of river was 9.7, with a mean EPT value of 1.9. These values indicate poor river quality and severe degradation as compared to the reference zone. A maximum ICI score of 16 was recorded at RM 20.4.

The current study shows consistent EPT values when compared to the 1998 study, although the Pennsylvania reach of river shows overall higher ICI values. This finding potentially exists because the Pennsylvania reach is relatively free flowing and is not as directly influenced by low head dams as is the Ohio study area. Additionally (because of the dams), it is assumed that greater concentrations of contaminated sediments, and commensurably less suitable physical habitat for benthic organisms, exists in the Ohio study area than in the Pennsylvania section of river. It should also be noted that as a rule, the total number of taxa tend to decrease in larger rivers, or in the same river as it becomes larger flowing downstream.

It was noted above that the WWH designation is mutually dependent on several biotic indices. The Qualitative Habitat Evaluation Index (QHEI) is one of these measures that evaluates the physical quality of the stream. The maximum QHEI score is 100, with a minimum value of 60 necessary for a WWH designation. The assumption, pertaining to the ICI, is that if the QHEI value meets the minimum WWH score, physical habitat is not a limiting factor with the ICI. The mean QHEI score for the eight sample locations on the lower 12 miles of the Mahoning River exceeded the minimum value of 60, equaling 74.9, with a range of 61 to 81.5.

Summary

The data indicates that environmental stress exists along the lower 12 miles of the Mahoning River that is depressing the potential diversity of the aquatic macroinvertebrate populations. In the absence of any known significant source or sources of water quality pollution that could cause this affect as compared to the reference area of the river, it is assumed that limiting toxic conditions exist within the substrate. The lack of mayfly and caddisfly taxa, overall pollution sensitive taxa, support this assumption.

Figure 1. ICI values for the Mahoning River. Data gathered October 19 & 20, 1999 for the eight sample locations. Reference value generated from 1994 OEPA study.

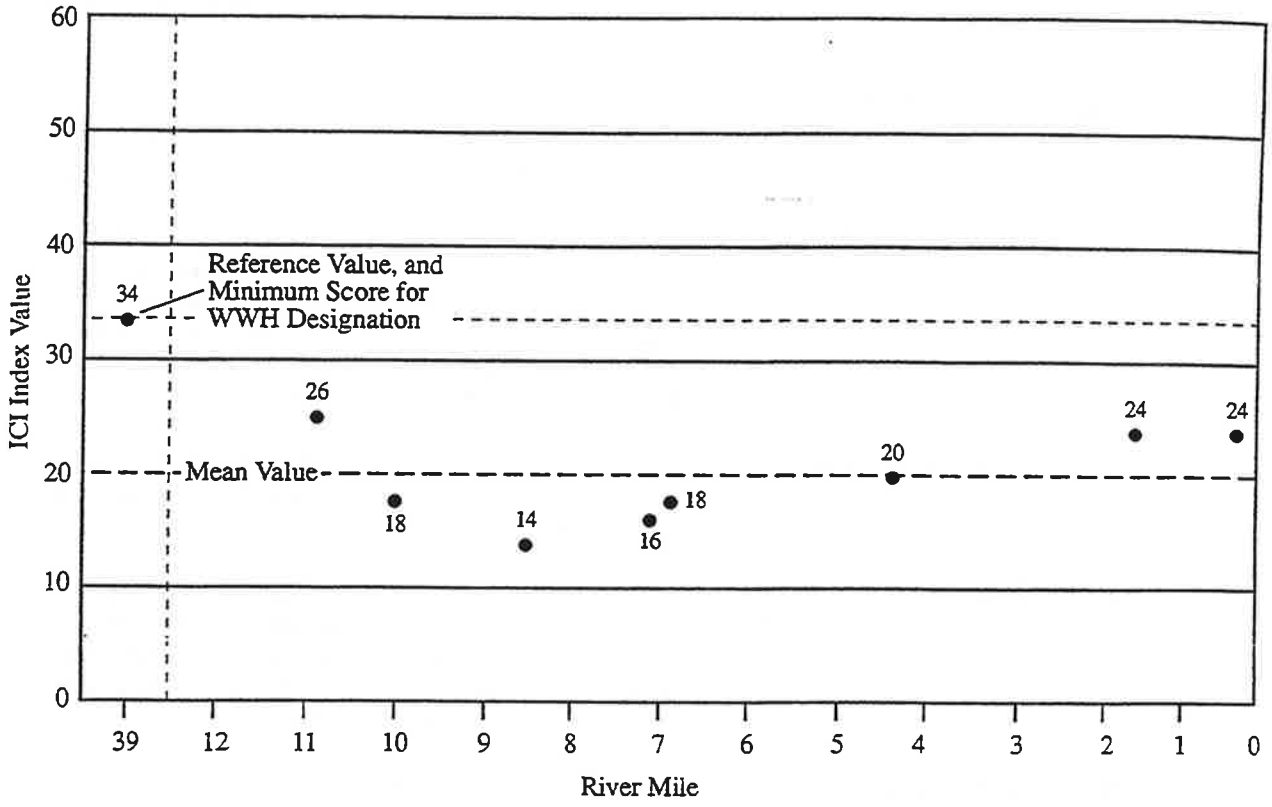


Table 5. Invertebrate Community Index (ICI) Metric Explanations

1.	Total Number of Taxa:	The greater this number, the more stable and diverse the biotic community, and the greater the metric value.
2.	Total Number of Mayfly Taxa:	Mayflies are typically pollution sensitive and a good indicator of stream health; therefore the greater the taxa number, the higher the metric score.
3.	Total Number of Caddisfly Taxa:	Caddisflies are somewhat more pollution tolerant than mayflies, but overall the assessment is similar to the mayfly metric.
4.	Total Number of Dipteran Taxa:	Dipterans have the greatest diversity and range of pollution tolerance of all the major aquatic invertebrate groups. The fewer the number of Dipteran taxa, the more likely that they are present in greater numbers, and the more likely that pollution is affecting the biota. This is reflected in the metric scores.
5.	Percent Mayfly Composition:	Even slight amounts of pollution can lower total mayfly numbers. Stream size does not impact this metric value.
6.	Percent Caddisfly Composition:	Caddisflies often make up a large portion of the macroinvertebrate population, and numbers are strongly related to stream size. Their intermediate pollution tolerance suggests that at least minimal numbers exist to score greater than 0 for this metric.
7.	Percent Tribe Tanytarsini:	This tribe of the chironomid subfamily can rapidly disappear under even minor pollutional stresses. Drainage area does not impact this metric.
8.	Percent Other Dipteran and Non-Insect Composition:	This is a "negative" metric, in that typically the greater the number of "non-insect" taxa, the greater the likely pollution load of the stream.
9.	Percent Tolerant Organisms:	These organisms tend to predominate the biota under extreme pollutional circumstances. This is also a negative metric.
10.	Total Number of Qualitative EPT Taxa:	This is a qualitative ICI metric that reflects habitat type and quality more than the other 9 metrics.

INDEX OF BIOLOGICAL INTEGRITY (IBI)

Introduction & Methods

The Index of Biological Integrity (IBI) uses an approach to examine different, quantifiable, metrics. As originally proposed by Karr (1981) and later modified by Faush *et al.* (1984), the IBI incorporates 12 community (fish) metrics. The value of each metric is compared to the value expected at a reference site located in a similar geographical region (in this case Ohio) where human influence has been minimal. Ratings of 5, 3, or 1 are assigned to each metric according to whether its value approximates (5), deviates somewhat (3), or strongly deviates (1) from the value expected at a reference site. The maximum IBI score possible is 60 and the minimum is 12.

The individual IBI metrics assess fish community attributes that are presumed to correlate (either positively or negatively) with biotic integrity. Although no one metric alone can indicate this consistently, all of the IBI metrics combined include the redundancy that is needed to accomplish a consistent and sensitive measure of biotic integrity (Karr *et al.*, 1986). The IBI relies on multi-parameters, a requirement when the system being evaluated is complex (Karr *et al.*, 1986). It incorporates elements of professional judgment, but also provides the basis for quantitative criteria for determining what is exceptional, good, fair, poor and very poor.

The IBI, as developed for Ohio surface waters and Ohio sampling methods, was incorporated into this evaluation. Because of the wide variety of stream and river sizes containing differing fish assemblages, different sampling methods are required. Therefore, it is necessary to modify the IBI according to stream/river size and sampling gear. In this study, wading electrofishing gear was utilized (300 m of river were sampled per station) as the vast majority of the Mahoning River was accessible with this type of gear. Only Station 3 in this study required the use of a boat (a 0.5 kilometer station) to evaluate the fish assemblage (the IBI for this station was modified accordingly).

The individual IBI values for each metric score; i.e., 5, 3, or 1, were determined by comparing the site drainage area (in this case all stations were greater than 1,000 square

miles), and metric value with standard figures constructed from a reference site data base developed by the Ohio EPA (1987b) for the EOLP ecoregion. Table 6. on the following page provides the raw numbers which were used to develop the IBI metric values for the eight individual sampling locations for this study. Table 7. on page 18 provides the individual and sum total metric values for each of the eight study locations. Table 8., beginning on page 19 offers a list of the actual taxa collected at each of these same locations. The following section describes each of the twelve metrics that was utilized for the eight stations sampled on the lower Mahoning River in Pennsylvania.

IBI Metrics

Karr proposed 12 community metrics within three broad categorical groupings; i.e., species richness and composition, trophic composition, and fish abundance and condition, for calculating the IBI. Some of the metrics respond to increasing environmental quality ("positive metrics") whereas others respond to increasing degradation ("negative metrics"). Some respond across the entire range of perturbation, whereas others respond strongly to a portion of the range. The intolerance criteria used in Metrics 2, 3, 4, and 5 were developed by the OEPA based on Ohio river conditions, but can be considered applicable to the lower Pennsylvania reach of the Mahoning River.

Metric 1 - Total Number of Indigenous Fish Species (all methods)

This metric is used with all three versions of the IBI. Exotic species are not included. This metric is based on the well-documented observation that the number of indigenous fish species in a given size stream or river will decline with increasing environmental disturbance (Karr, 1981; Karr *et al.*, 1986). Thus the number of the fish species metric is expected to give an indication of environmental quality throughout the range from exceptional to poor. Exotic; i.e., introduced species, present in a system through stocking or inadvertent releases do not provide an accurate assessment of overall integrity, and their abundance may even indicate a loss of integrity (Karr *et al.*, 1986).

Table 6. Evaluation of the fish community at eight Mahoning River study sites (Lawrence County, Pennsylvania); for calculating the Index of Biotic Integrity (IBI) as modified for application to Ohio waters (wading sites). Sampling Station No.'s 1, 2, 3, and 4 were sampled on 26 October, 1999; Station No.'s 5, 6, 7, and 8, were sampled on 27 October, 1999.

		(VALUE)								
SAMPLING STATION NO.		1	2	3*	4	5	6	7	8	
(River Mile)		10.9	10.0	8.5	7.1	6.9	4.4	1.6	0.2	total
No.	IBI Metric									
	Numbers of:									
1.	Total Species	8	12	5	9	14	14	9	8	
10.	Total Individuals	243	358	220	284	436	431	351	277	(2,600)
2.	Darter Species	1	2	1	0	2	2	2	2	
3.	Sunfish Species	1	3	1	2	3	2	2	1	
4.	Sucker Species	0	0	1	1	1	2	1	1	
5.	Intolerant Species	1	2	0	0	2	1	2	2	
	Proportion of Individuals (%):									
6.	Tolerant Species	87	85	100	100	86	93	77	75	
7.	Omnivores	38	17	60	44	21	29	11	12	
8.	Insectivores	62	67	40	44	64	57	77	88	
9.	Top Carnivores	0	8	0	0	14	14	0	0	
11.	Simple Lithophils	25	17	20	11	21	29	33	38	
12.	DELT Anomalies	0.02	0.01	0.06	0.03	0.01	0.02	0.01	0.01	

* Station 3 utilized boat sampling method metrics for the IBI evaluation.

Table 7. Evaluation of the fish community at eight Mahoning River study sites (Lawrence County, Pennsylvania); for calculating the Index of Biotic Integrity (IBI) as modified for application to Ohio waters (wading sites). Sampling Station No.'s 1, 2, 3, and 4 were sampled on 26 October, 1999; Station No.'s 5, 6, 7, and 8, were sampled on 27 October, 1999.

				(SCORE)				
SAMPLING STATION NO.	1	2	3*	4	5	6	7	8
(River Mile)	10.9	10.0	8.5	7.1	6.9	4.4	1.6	0.2
No. IBI Metric								
Numbers of:								
1. Total Species	1	3	1	1	3	3	1	1
10. Total Individuals	3	3	3	3	3	3	3	3
2. Darter Species	1	1	1	1	1	1	1	1
3. Sunfish Species	1	3	1	3	3	3	3	1
4. Sucker Species	1	1	11	1	1	1	1	1
5. Intolerant Species	1	3	1	1	3	1	3	3
Proportion of Individuals (%):								
6. Tolerant Species	1	1	1	1	1	1	1	1
7. Omnivores	1	5	1	1	3	3	5	5
8. Insectivores	5	5	3	3	5	5	5	5
9. Top Carnivores	1	5	1	1	5	5	1	1
11. Simple Lithophils	3	1	3	1	3	3	3	5
12. DELT Anomalies	5	5	5	5	5	5	5	5
IBI Index Value	**24**	**36**	**22**	**22**	**36**	**34**	**32**	**32**
Approximate Drainage Area (miles)	1,087	1,097	1,100	1,105	1,105	1,109	1,128	1,132

* Station 3 utilized boat sampling method metrics for the IBI evaluation.

Table 8. Fish community data from eight Mahoning River study sites (Lawrence County, Pennsylvania); collected through wading techniques at all sampling locations except Station 3 (which was a boat station) through electro-fishing of 300 m stretches of river. Sampling Station No.'s 1, 2, 3, and 4 were sampled on 26 October, 1999; Sampling Station No.'s 5, 6, 7, and 8, were sampled on 27 October, 1999.

Sampling Station 1.
River Mile 10.9

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	4	12.1 [3]	13.4 [3]
Percina caprodes	Log Perch	1	9.8	12.1
Etheostoma zonale	Banded Darter	2	4.9 [3]	1.2 [3]
Cyprinus carpio	Carp[1]	10	7.8 [3]	8.6 [3]
Pimephales notatus	Bluntnose Minnow[1]	74	5.3 [3]	0.6 [3]
Campostoma anomalum	Central Stoneroller[1]	38	8.8 [3]	2.6 [3]
Notropis cornutus	Common Shiner	62	5.2 [3]	1.5 [3]
Notropis hudsonius	Spottail Shiner	52	4.6 [3]	1.1 [3]
		243		

Sampling Station 2.
River Mile 10.0

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	5	11.6 [3]	12.2 [3]
Lepomis gibbosus	Pumpkinseed	7	9.0 - 12.3 [3]	4.9 - 11.0 [3]
Ambloplites rupestris	Rock Bass	3	10.5 [3]	8.6 [3]
Etheostoma zonale	Banded Darter	12	4.9 [3]	1.2 [3]
Etheostoma blennioides	Greenside Darter	17	5.1 [3]	1.3 [3]
Cyprinus carpio	Carp[1]	8	7.5 - 56 [2]	8.5 - 2,043 [2]
Carassius auratus	Goldfish[1]	4	25 [3]	470 [3]
Campostoma anomalum	Central Stoneroller[1]	39	8.8 [3]	2.6 [3]
Notropis cornutus	Common Shiner	127	5.4 [3]	1.9 [3]
Notropis hudsonius	Spottail Shiner	107	4.6 [3]	1.0 [3]
Semotilus atromaculatus	Creek Chub[1]	18	5.5 [3]	2.1 [3]
Nocomis micropogon	River Chub	8	13.5 [3]	4.8 [3]
Ictalurus natalis	Yellow Bullhead[1]	3	26 - 30 [2]	304 - 326 [2]
		358		

Table 8. (continued)

Sampling Station 3.
River Mile 8.5

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	12	11.2 - 12.3 [2]	11.7 - 13.7 [2]
Cyprinus carpio	Carp[1]	17	7.0 - 58 [2]	7.1 - 2,110 [2]
Pimephales notatus	Bluntnose Minnow[1]	182	5.3 [3]	0.6 [3]
Ictalurus natalis	Yellow Bullhead[1]	5	24 - 29 [2]	298 - 310 [2]
Catostomus commersoni	White Sucker[1]	4	19.4 [3]	107 [3]
		220		

Sampling Station 4.
River Mile 7.1

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	8	12.0 [3]	13.2 [3]
Lepomis macrochirus	Bluegill	7	8.9 [3]	4.9 [3]
Cyprinus carpio	Carp[1]	10	9.2 [3]	10.1 [3]
Pimephales notatus	Bluntnose Minnow[1]	79	5.3 [3]	0.6 [3]
Campostoma anomalum	Central Stoneroller[1]	16	9.0 [3]	2.9 [3]
Notropis cornutus	Common Shiner	102	5.3 [3]	1.7 [3]
Notropis spilopterus	Spotfin Shiner	46	4.4 [3]	0.9 [3]
Catostomus commersoni	White Sucker[1]	3	18.1 - 27.3 [2]	99 - 388 [2]
Semotilus atromaculatus	Creek Chub[1]	13	5.7 [3]	2.4 [3]
		284		

Sampling Station 5.
River Mile 6.9

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	10	11.0 - 12.4 [2]	10.9 - 14.0 [2]
Lepomis gibbosus	Pumpkinseed	3	10.2 [3]	6.7 [3]
Ambloplites rupestris	Rock Bass	4	9.9 [3]	8.1 [3]
Micropterus dolomieui	Smallmouth Bass	2	18.4 - 31.8 [2]	260 - 320 [2]
Etheostoma zonale	Banded Darter	21	4.9 [3]	1.3 [3]
Etheostoma blennioides	Greenside Darter	32	5.0 [3]	1.3 [3]

Table 8. (continued)

Sampling Station 5. (continued)
River Mile 6.9

Species	Common Name	Count	Length (cm)	Weight (gm)
Cyprinus carpio	Carp[1]	9	8.2 - 58 [2]	9.1 - 2,250 [2]
Carassius auratus	Goldfish[1]	1	22.5	426
Pimephales notatus	Bluntnose Minnow[1]	162	5.3 [3]	0.6 [3]
Notropis hudsonius	Spottail Shiner	97	4.5 [3]	1.1 [3]
Notropis spilopterus	Spotfin Shiner	78	4.4 [3]	0.8 [3]
Hypentelium nigricans	Northern Hog Sucker	11	16.5 [3]	14.3 [3]
Nocomis micropogon	River Chub	5	17.4 [3]	8.7 [3]
Ictalurus natalis	Yellow Bullhead[1]	1	27	310
		436		

Sampling Station 6.
River Mile 4.4

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis gibbosus	Pumpkinseed	17	8.7 - 11.4 [2]	4.3 - 10.2 [2]
Ambloplites rupestris	Rock Bass	8	9.2 [3]	8.1 [3]
Micropterus dolomieui	Smallmouth Bass	1	12.0	11.6
Etheostoma zonale	Banded Darter	25	4.8 [3]	1.0 [3]
Etheostoma blennioides	Greenside Darter	38	5.1 [3]	1.4 [3]
Cyprinus carpio	Carp[1]	12	8.6 - 44 [2]	14.0 - 1,305 [2]
Pimephales notatus	Bluntnose Minnow[1]	108	5.4 [3]	0.6 [3]
Campostoma anomalum	Central Stoneroller[1]	25	8.9 [3]	2.8 [3]
Notropis cornutus	Common Shiner	42	5.0 [3]	1.3 [3]
Notropis hudsonius	Spottail Shiner	51	4.3 [3]	0.8 [3]
Notropis spilopterus	Spotfin Shiner	82	4.5 [3]	0.9 [3]
Catostomus commersoni	White Sucker[1]	5	24.2 [3]	235 [3]
Hypentelium nigricans	Northern Hog Sucker	13	9.1 [3]	12.9 [3]
Ictalurus natalis	Yellow Bullhead[1]	4	27.1 [3]	306 [3]
		431		

Table 8. (continued)

Sampling Station 7.
River Mile 1.6

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis cyanellus	Green Sunfish[1]	8	11.0 - 12.0 [2]	9.8 - 13.1 [2]
Lepomis gibbosus	Pumpkinseed	4	9.1 [3]	4.9 [3]
Etheostoma zonale	Banded Darter	28	5.1 [3]	1.4 [3]
Etheostoma blennioides	Greenside Darter	20	5.3 [3]	1.7 [3]
Pimephales notatus	Bluntnose Minnow[1]	139	5.2 [3]	0.7 [3]
Notropis spilopterus	Spotfin Shiner	102	4.3 [3]	0.7 [3]
Hypentelium nigricans	Northern Hog Sucker	6	15.3 [3]	18.7 [3]
Semotilus atromaculatus	Creek Chub[1]	29	5.4 [3]	2.1 [3]
Nocomis micropogon	River Chub	15	13.5 - 15.2 [2]	4.8 - 8.0 [2]
		351		

Sampling Station 8.
River Mile 0.2

Species	Common Name	Count	Length (cm)	Weight (gm)
Lepomis macrochirus	Bluegill	6	11.1 [3]	6.5 [3]
Etheostoma zonale	Banded Darter	27	4.9 [3]	1.1 [3]
Etheostoma blennioides	Greenside Darter	13	5.2 [3]	1.4 [3]
Pimephales notatus	Bluntnose Minnow[1]	92	5.4 [3]	0.6 [3]
Notropis hudsonius	Spottail Shiner	49	4.2 [3]	0.7 [3]
Notropis spilopterus	Spotfin Shiner	65	4.4 [3]	0.9 [3]
Hypentelium nigricans	Northern Hog Sucker	11	14.6 - 26.0 [2]	12.8 - 29.4 [2]
Nocomis micropogon	River Chub	14	12.2 - 15.4 [2]	4.4 - 12.2 [2]
		277		

[1] "highly" pollution tolerant, hybrids, or exotic species; [2] *range* of lengths, or weights; respectively;
[3] *average* length, or weight; respectively

Table 8. (continued)

TOTAL SPECIES COUNTS PER ALL 8 STATIONS

Species	Common Name	Count
Lepomis cyanellus	Green Sunfish	47
Lepomis macrochirus	Bluegill	13
Lepomis gibbosus	Pumpkinseed	31
Ambloplites rupestris	Rock Bass	15
Micropterus dolomieui	Smallmouth Bass	3
Percina caprodes	Log Perch	1
Etheostoma zonale	Banded Darter	115
Etheostoma blennioides	Greenside Darter	120
Cyprinus carpio	Carp	66
Carassius auratus	Goldfish	5
Pimephales notatus	Bluntnose Minnow	836
Campostoma anomalum	Central Stoneroller	118
Notropis cornutus	Common Shiner	333
Notropis hudsonius	Spottail Shiner	458
Notropis spilopterus	Spotfin Shiner	271
Semotilus atromaculatus	Creek Chub	60
Nocomis micropogon	River Chub	42
Ictalurus natalis	Yellow Bullhead	13
Catostomus commersoni	White Sucker	12
Hypentelium nigricans	Northern Hog Sucker	41
		2,600

Metric 2 - Number of Darter Species (wading & headwaters methods);
Proportion of Round-bodied Catostomidae (boat method)

The darter species metric is reflective of good water quality conditions (Karr *et al.*, 1986). None of the species in this group have been found to thrive in degraded stream conditions. Eleven of the twenty-two Ohio species have been found to be highly intolerant of degraded conditions based on Ohio EPA intolerance criteria. Life history data on this group show the darters to be insectivorous, habitat specialists, and sensitive to physical and chemical environmental disturbances. These factors make darter species reliable indicators of good water quality. The darter metric is used for wading site sampling methods.

The proportion of "round-bodied" suckers is substituted for the number of darter species metric for the boat site. This is done primarily because darter species are not sampled consistently or effectively with typical boat sampling methods. Round-bodied suckers include species of the genera *Hypentelium*, *Moxostoma*, *Minytrema*, and *Erimyzon*. These species are sampled effectively with the boat electro-fishing methods and they comprise a sensitive component of larger stream and river fish faunas, much as darters do in the wadable streams.

Metric 3 - Number of Sunfish Species (wading & boat methods)

This metric follows Karr (1981) and Karr *et al.* (1986) by including the number of sunfish species (Centrachidae) collected at a site, excluding the black basses (*Micropterus* spp.). The Redear Sunfish (*Lepomis microlophus*) is not included in Ohio; it is an introduced species and only locally distributed. Hybrid sunfish are also excluded from this metric.

This metric is included as a monitor of ecosystem degradation. Specifically, it is a measure of the degradation of their preferred habitats and foods items. Differing from suckers and darters, preferred habitats are generally located in quiet pools where sunfish spend much of their time near some form of instream cover. As such, they are sensitive to the degradation of pool habitats. Preferred food items include mid-water and surface invertebrates, in addition to benthic forms.

Metric 4 - Number of Sucker Species (wading & boat methods)

All species in the family Catostomidae are included in this metric. Suckers represent a major component in the Ohio fish fauna, with their total biomass in many samples surpassing that of all other species combined. The general intolerance of most sucker species to habitat and water quality degradation (Karr, 1981) results in a metric with a sensitivity at the high end of environmental quality. In addition, the relatively long life spans of many sucker species (10-20 years) provides a long-term assessment of past and prevailing environmental conditions.

Metric 5 - Number of Intolerant Species (wading & boat methods)

The number of intolerant species metric is designed to distinguish streams of the highest quality. As a result, the sensitivity of this metric is at the highest end of biotic integrity. The criteria used for determining intolerance are based on numerical and graphical analysis of Ohio EPA's statewide data base from 1979 through 1985. Intolerant species are those that decline with decreasing environmental quality, and disappear as viable populations when the aquatic environment is degraded to the fair category (Karr *et al.*, 1986). The intolerant species list was divided into three categories, all of which are included in scoring this metric as follows:

1) Common intolerant species or species that are intolerant, but are still widely distributed in the best streams in Ohio.

2) Uncommon or geographically restricted species - species that are infrequently captured or that have restricted ranges; and,

3) Species that are rare or possibly extirpated - species that are rarely captured or for which we have little recent data.

Metric 6 - Percent Abundance of Tolerant Species (all methods)

This metric is a modification of one of Karr's original IBI metrics (Karr, 1981), the

percentage of the fish community comprised by Green Sunfish (*Lepomis cyanellus*). In the modification, Karr *et al.* (1986) suggested that other species could be substituted for the Green Sunfish if they responded in a similar manner; i.e., they increased as a proportion of the community in degraded environments. Several species meeting this criterion were included to give this metric an improved sensitivity for the range of streams and river sizes encountered in Ohio. Since individual species have habitat requirements that are keyed to stream size, composition of the tolerant species metric shifts with drainage area and this metric remains useful among small, medium, and large streams and rivers.

Metric 7 - Number of Omnivorous Species (all methods)

The Ohio EPA definition of the omnivorous species follows Karr (1981) and Karr *et al.* (1986) with two important distinctions added. Specialized filter-feeding species which technically are omnivorous are not included. Specialist filter feeders are represented by the Paddlefish (*Polyodon spathula*) and brook lamprey ammocoetes. These species are generally sensitive to environmental degradation. Since the omnivore metric is designed to measure increasing levels of environmental degradation due to a disruption of the food base, it is not appropriate to include these sensitive, filter-feeding species. This metric was further restricted to those species that did not show feeding specialization and were reported primarily as omnivores in all studies reviewed. This eliminates species such as the Channel Catfish (*Ictalurus punctatus*), which may or may not feed as an omnivore under different environmental conditions.

Metric 8 - Proportion as Insectivores (all methods)

This metric is designed to be sensitive over the middle range of biotic integrity. A low abundance of insectivorous species can reflect a degradation to the insect food base of a stream (Karr *et al.*, 1986). As a disturbance increases, the diversity of benthic insects decreases, production becomes more variable, and the community often becomes predominated by a few taxa. Thus, specialist feeders such as specialist insectivores will decrease and be replaced by generalist feeders such as omnivores.

Metric 9 - Top Carnivores (wading & boat methods)

Karr (1981) developed the top carnivore metric to measure community integrity in the upper functional levels of the fish community. In designating a species as a top carnivore, the guidelines outlined by Karr (1981) and Karr *et al.* (1986) were followed. Species which feed primarily on other vertebrates, or crayfish are included in this metric. As with the omnivore metric, species which display feeding plasticity are excluded; e.g., Channel Catfish.

Metric 10 - Number of Individuals in a Sample (all methods)

This metric assesses population abundance as the number of individuals per unit of sampling effort. This metric is most sensitive at the low to middle end of biotic integrity when polluted sites yield fewer individuals (Karr *et al.*, 1986). In such cases, the normal relationships are disturbed enough to have severe effects on fish production, or directly reduce fish abundance through toxic effects. As integrity increases, total abundance increases, and becomes more variable with natural factors such as ionic concentration, temperature, and amount of energy reaching the stream surface.

Metric 11 - Proportion of Individuals as Simple Lithophilic Spawners

Spawning guilds can be affected by habitat quality and have been suggested as an alternative IBI metric (Karr *et al.*, 1986). Fish that exhibit simple spawning behavior and require clean gravel and/or cobble for successful reproduction; i.e., "lithophilous", appear to be the most environmentally sensitive of the spawning guilds. These simple lithophilic species broadcast their eggs which come into contact with the bottom substrates. Eggs then develop in the interstitial spaces between the sand, gravel, and cobble sized substrate particles. Karr *et al.* (1986) found a significant negative correlation between simple lithophilic spawners and the percentage of silt in riffles.

Metric 12 - Proportion of Individuals with Deformities, Eroded Fins, Lesions and Tumors - DELT (all methods)

This metric keys in on the health of individual fish within a community using the percent occurrence of external anomalies, and corresponds to the percentage of diseased fish in Karr's (1981) original IBI. Studies of wild fish populations have revealed that these and other anomalies are either absent, or occur at very low rates at reference sites, but reach higher percentages at impacted sites (Baumann, 1989). Common causes of DELT anomalies can include the effects of bacterial, viral, fungal, parasitic infections, neoplastic diseases, and chemicals.

An increase in the frequency of occurrence of these anomalies is generally an indication of stress and environmental degradation; which may be caused by chemical pollutants, overcrowding, improper diet, excessive siltation, and other disturbances. This metric can show marked responses between an increasing incidence of anomalies and increasing stream degradation.

Discussion

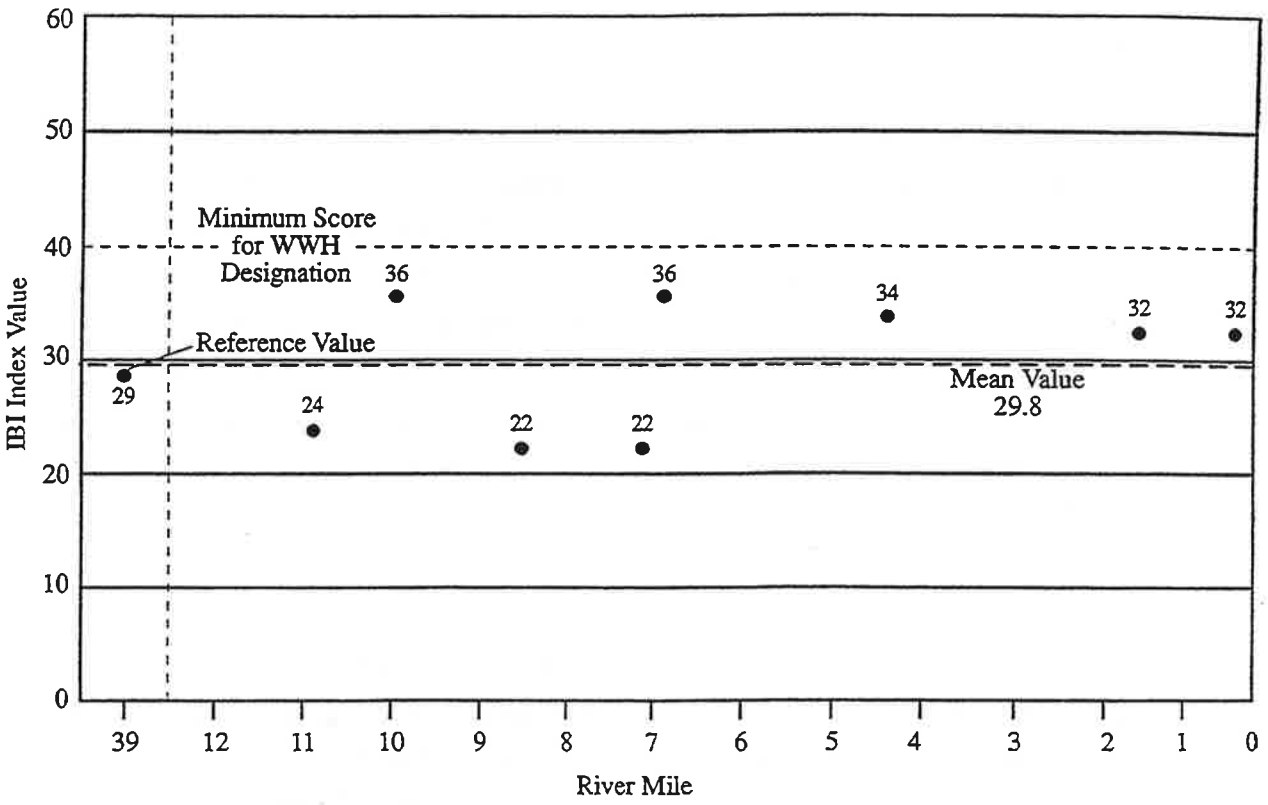
None of the eight sampling locations generated the prerequisite IBI score of 40 necessary for a WWH classification. The reference zone in Ohio had and IBI value of 29 and the polluted study zone had a value of 22. The mean IBI value of this study, on the Mahoning River, was 29.8 and the IBI values ranged between 22 and 36 (see Figure 2, page 29).

The values obtained for the IBI on this section of the Mahoning River are best reflected in several of the metrics utilized to calculate the IBI. The IBI values for each station reflect the fact that each metric examined was lower than that expected for a river of this magnitude. The following observations were noted for each metric associated with the respective IBI values for the selected sampling stations.

Metric 1

The total number of species for the eight stations ranged from five (5) at Sampling Station

Figure 2. IBI values for the Mahoning River. Data gathered October 26 & 27, 1999 for the eight sample locations. Reference value generated from 1994 OEPA study.



3, to fourteen (14) each at Sampling Stations 5 and 6. Overall, the number of (indigenous) fish species observed is associated with environmental disturbances. For a reference site in this ecoregion, one would expect greater than twenty (20) indigenous fish species; therefore, the Mahoning River in this section does deviate somewhat from reference sites.

Metric 2

The number of darter species (round-bodied suckers at Sampling Station 3) is reflective of good quality water as none of the species in this group are known to thrive in degraded waters. For a river of this size, one would expect greater than six (6) species of darters in a reference site for a quality waterway. The stations sampled in this study never exceeded two (2) species of darters, and suggests that the Mahoning River deviates strongly from reference sites in this region. The proportion of round-bodied suckers at Sampling Station 3 was similar to the number of darter species, and also deviated strongly from reference sites in this ecoregion.

Metric 3

The number of sunfish species is similar to Metric 2, except that it measures the degradation of water quality in pool habitats. One would expect greater than four (4) species in a relatively unimpacted river of this size in this region. In this study, the range of sunfish species collected per station ranged from one (1) to three (3) species; suggesting that the Mahoning river in this section deviates somewhat at Sampling Stations 2, 4, 5, 6, & 7, to strongly at Sampling Stations 1, 3, & 8, from reference sites in this region.

Metric 4

The number of sucker species (all species in the family Catostomidae) is used primarily because they represent a major component (biomass) of the fish fauna in this ecoregion. For a river of this size one would expect greater than six (6) species of suckers in a reference site for a quality waterway. The stations sampled in this study never exceeded two (2) species of suckers, suggesting that the Mahoning River deviates strongly from reference sites in this region.

Metric 5

The number of intolerant species is a very sensitive metric as related to this measurement of biotic integrity. This is due primarily to the fact that intolerant species are reflective of good quality water as none of the species in this category are known to thrive in degraded waters. For a river of this size, one would expect greater than six (6) intolerant species in a reference site for a quality waterway. The stations sampled in this study never exceeded two (2) intolerant species, suggesting that the Mahoning River deviates strongly at Sampling Stations 1, 3, 4 & 6, and somewhat at Sampling Stations 2, 5, 7 & 8, from reference sites in this region.

Metric 6

The proportion of tolerant species increases as a proportion of the community in degraded environments. Thus, the greater the proportion of tolerant species in a sampling area, generally the greater the degradation and the lower the IBI score. For a river of this size, one would expect less than 35% of the total number of species collected to be tolerant species in a reference site for a quality waterway. The stations sampled in this study never contained less than 75% tolerant species. This suggests that the Mahoning River deviates strongly at all sampling stations from reference sites in this region.

Metric 7

The proportion of omnivorous species at sampling locations in various waterways are generally sensitive to environmental degradation as an indicator of disruption in the food base. Thus, the lower the proportion of omnivorous species in a sampling area, generally the lower the degradation and the greater the IBI score. For a river of this size, one would expect less than 20% of the total number of species collected to be omnivorous species in a reference site for a quality waterway. The stations sampled in this study contained from 11% to 60% omnivorous species. This indicates, that based on the metric values obtained, that the Mahoning River deviates strongly at Sampling Stations 1, 3, & 4, somewhat at Sampling Stations 5 & 6, and little at Sampling Stations 2, 7 & 8, from reference sites in this region.

Metric 8

The proportion of insectivorous species at sampling locations in various waterways are generally sensitive to environmental degradation. A low abundance of insectivorous species can reflect a degradation to the insect food base in a waterway . For a river of this size, one would expect greater than 53% of the total number of species collected to be insectivorous species in a reference site for a quality waterway. The stations sampled in this study contained from 40% to 88% insectivorous species. This indicates, that based on the metric values obtained, that the Mahoning River deviates little at Sampling Stations 1, 2, 5, 6, 7, & 8, and somewhat at Sampling Stations 3 & 4, from reference sites in this region.

Metric 9

The proportion of carnivorous species is a measurement of community integrity in the upper functional level of the fish community. Higher proportions of carnivorous species in a sampling area correspond to a higher IBI scores. For a river of this size, one would expect greater than 5% of the total number of species collected to be carnivorous species in a reference site for a quality waterway. The stations sampled in this study contained from 0% to 14% carnivorous species. This indicates, that based on the metric values obtained, that the Mahoning River deviates little at Sampling Stations 2, 5 & 6, and strongly at Sampling Stations 1, 3, 4, 7 & 8, from reference sites in this region.

Metric 10

The number of individuals at sampling locations in various waterways generally indicate affects on trophic relationships within a fish community. Generally, the lower the total number of individuals in a sampling area, the higher the environmental disturbance in the fish community and the lower the IBI score. For a river of this size, one would expect greater than 450 total individuals collected to be classified as a quality waterway. The stations sampled in this study contained from 220 to 436 individuals collected per station, with mostly minnows (Cyprinidae) collected. This indicates, that based on the metric values obtained, that the Mahoning River deviates somewhat at all Sampling Stations from reference sites in this region.

Metric 11

The proportion of individuals as simple lithophilic spawners at sampling locations in various waterways are generally indicators of habitat quality. Simple lithophils require clean substrate (gravel and or cobble) to successfully reproduce. Thus, the higher the proportion of simple lithophilic spawners species in a sampling area, generally the lower the degradation and the greater the IBI score. For a river of this size, one would expect greater than 36% of the total number of species collected to be simple lithophilic species in a reference site for a quality waterway. The stations sampled in this study contained from 11% to 38% omnivorous species. This indicates, that based on metric values obtained, that the Mahoning River deviates strongly at Sampling Stations 2 & 4, somewhat at Sampling Stations 1, 3, 5, 6, & 7, and little at Sampling Station 8, from reference sites in this region.

Metric 12

The proportion of individuals with deformities (DELT) at sampling locations in various waterways is also a metric that is sensitive to environmental degradation as an indicator of direct disease and/or pollution. Thus, the higher the proportion of affected species in a sampling area, generally the greater the degradation and the lower the IBI score. For a river of this size, one would expect less than 0.1% of the total number of species collected to have deformities, lesions, eroded fins, and/or tumors in a reference site for a quality waterway. The stations sampled in this study all contained less than 0.1% of the individuals with any identifiable problems. This indicates, that based on metric values obtained, that the Mahoning River deviates little at all sampling stations from reference sites in this region.

Summary

Overall, the lack of intolerant species (Metric 5), percent abundance of tolerant species (Metric 6), lack of darter species (Metric 2), and sucker species (Metric 4) collected at the selected sampling stations contributed most heavily to the IBI values calculated. Similar to the ICI, the study section of the Mahoning River does support a viable fisheries with a mean

IBI of 29.8 as compared to the reference zone value of 29. This is validated by the number of individuals with DELT anomalies (Metric 12), insectivores (Metric 8), total number of individuals (Metric 10), and somewhat by the proportion of simple lithophils (Metric 11), all of which contribute positively to increasing the IBI value.

It was further noted during the fish sampling, that anytime structure was encountered, particularly logs and woody debris, that there was an increase in species numbers and diversity. This was best reflected at Sampling Stations 2, 5, and 6 where structure existed that apparently supplied habitat to fish species not encountered at the sampling stations where similar structure was not present.

MODIFIED INDEX OF WELL BEING (MIwb)

Introduction

The Modified Index of Well Being (MIwb) combines fish species numbers, their biomass, and diversity to generate a value used as an indicator of water quality. The combination of these measures presumably provides better information than scores generated by the individual values. The MIwb factors out pollution tolerant species to prevent false high readings on streams which may have large populations of pollution tolerant species.

Methodology

The MIwb is measured utilizing the weight and species composition of the fish community as well as the abundance of the various species. The biomass component of the MIwb excludes species that are "highly" pollution tolerant, that are hybrids, or that are exotic species. The index is calculated as follows:

$$MIwb = 0.5 \ln N + 0.5 \ln B + H \text{ (number)} + H \text{ (weight)}$$

where:

N = the relative of all species (excluding the "highly" pollution tolerant species)
B = the relative weights of all species (excluding the "highly" pollution tolerant species)
H (number) = Shannon Diversity Index (SDI) based on numbers
H (weight) = Shannon Diversity Index (SDI) based on weight

The SDI is calculated for number or weight; respectively, as H' as follows:

$$H' = -\sum p_i \ln p_i$$

where:

p_i refers to the frequency of the i^{th} species where i = 1, 2, 3, ...n

Findings

The species list used to generate this metric was provided in Table 8. Table 9. provides the metric values for the individual sampling stations.

Table 9. Modified Index of Well Being (MIwb) values generated from eight Mahoning River study sites (Lawrence County, Pennsylvania) sampled on 26 & 27 October, 1999.

				(Score)				
SAMPLING STATION NO.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
(River Mile)	**10.9**	**10.0**	**8.5**	**7.1**	**6.9**	**4.4**	**1.6**	**0.2**
Modified Index of Well Being	5.0	7.1	0	4.9	7.7	8.2	6.8	7.4

Discussion

The MIwb has no upper limit, although scores seldom exceed 10 (OEPA, 1987a). The Mahoning River is located in the EOLP ecoregion, and has an OEPA use designation of a Warm Water Habitat (WWH). The minimum MIwb score necessary to achieve the WWH designation in this region is a value of 8.7. None of the eight sampling locations generated the prerequisite WWH MIwb score of 8.7. The mean value for the eight stations was 5.9, with a range of 0 at Sampling Station 3 to 8.2 at Sampling Station 6.

The reference zone (River Mile 39) MIwb value is 7.9, suggesting that less than optimum river conditions exist outside of the area of assumed sediment contamination. Sampling Station 6 actually exceeded the reference value and Sampling Station 5 approached this value. The mean MIwb value for the study was less than that of the reference zone as noted.

The score of 0 at Sampling Station 3 corresponded to the fact that all of the captured species were pollution tolerant, and were excluded from the calculations. The higher scores at Sampling Stations 5 and 6 could be attributed to the higher species count as compared to the other stations, taking into account pollution tolerant and exotic species.

Summary

While the MIwb values were below the (Ohio) WWH criteria, the data suggests that values consistent with the quality of the reference zone are achievable through the lower 12 miles of the Mahoning River.

QUALITATIVE HABITAT EVALUATION INDEX (QHEI)

Introduction

The biotic health of a river is as directly related to the physical structure of the river as it is to the quality of the river's water and sediments. Biotic diversity and health are functions of habitat type and availability as they relate to inherent quality considerations. In essence, the quality of the habitat controls the composition of the biotic community in the absence of any other limiting factors.

The Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989) was developed to assess riverine habitat quality as an empirical, quantified evaluation. The index is based on six habitat metrics, with the general headings of: 1) substrate; 2) instream cover; 3) channel morphology; 4) riparian zone and bank erosion; 5) pool/glide and riffle/run quality; and 6) gradient. A maximum QHEI score is 100.

The QHEI is a visual method of measuring habitat quality, and as such, there are subjectivity considerations with scoring. However, the QHEI process offers a useful predictive tool that can be correlated with biotic integrity, and that can aid in assessing the causes of degrading impacts.

The Mahoning River is located in the EOLP ecoregion, and has an OEPA and PADEP use designation of a Warm Water Habitat (WWH). The minimum QHEI score necessary to achieve the WWH designation in this region is a value of 60. The WWH designation is mutually dependent on other biotic indices and minimum associated point values.

Assessment

Each of the six metrics has a maximum achievable score, which are summed for a total score. Higher total scores generally indicate higher quality physical habitat and the potential for greater biotic integrity. The six metrics are briefly described as follows.

1. Substrate: The substrate metric defines the type, origin, and quality of the stream's physical substrate. The primary score is derived from the two dominant types of substrate, with potential negative metrics included for the quality of the substrate in terms of siltation. The maximum score of this metric is 20.

2. Instream Cover: This metric quantifies the types of cover that can support aquatic organisms. The cover metric sums all existing habitat types, and then provides a score for the amount of total cover present. The maximum score of this metric is 20.

3. Channel Morphology: The morphology metric emphasizes the quality of the stream channel as it relates to the availability and stability of habitat. Higher scores are attributed to stable, non-developed reaches of water that exhibit the greatest sinuosity. The maximum score for this metric is also 20.

4. Riparian Zone and Bank Erosion: This metric provides a physical measure of the width of the riparian zone, with higher scores associated with wider zones. The metric also includes a quality assessment of the flood plain past the 100 m riparian zone, and further evaluates bank erosion. This metric is developed for both banks and averaged. The maximum score is 10.

5. Pool/Glide and Riffle/Run Quality: This metric is developed for both pool/glide and riffle/run habitat as implied. The pool/glide metric compiles depth, morphology, and velocity data for a maximum potential score of 12. Greater water depths offer greater diversity potential and score higher than shallow water. The riffle/run metric is fairly similar, with a maximum score of 8.

6. Gradient: Stream gradients are measured from available topographic mapping and compared against drainage area to develop a metric score, with a maximum potential value of 10.

Findings

Individual QHEI data forms for the eight study locations are included as Appendix A in this section. Table 10. on the next page provides the individual and sum total metric scores for these same locations. This information is graphically depicted in Figure 3., page 42.

The minimum QHEI score for a WWH designation in this ecoregion is 60. All eight QHEI values exceeded 60, with an average score of 74.9. The reference site score at mile 39 also exceeded the minimum value with a score of 66.

Discussion

It can be inferred from this data that physical habitat is not necessarily the factor limiting the biotic integrity of the lower 12 miles of the Mahoning River. The structure and make-up of the river appears consistent with a WWH designation. Substrate and instream cover metrics scored consistently high, except for Sampling Station 4.

Sampling Station 4, at river mile 7.1, displayed the lowest QHEI value with a score of 61. This value is related to the location being upstream of a partially breached low head dam. The highest score, 81.5, was generated at the uppermost sampling station at river mile 10.9. The stream at this location had a high aesthetic rating and was typical of a free flowing river in a sylvan setting.

Summary

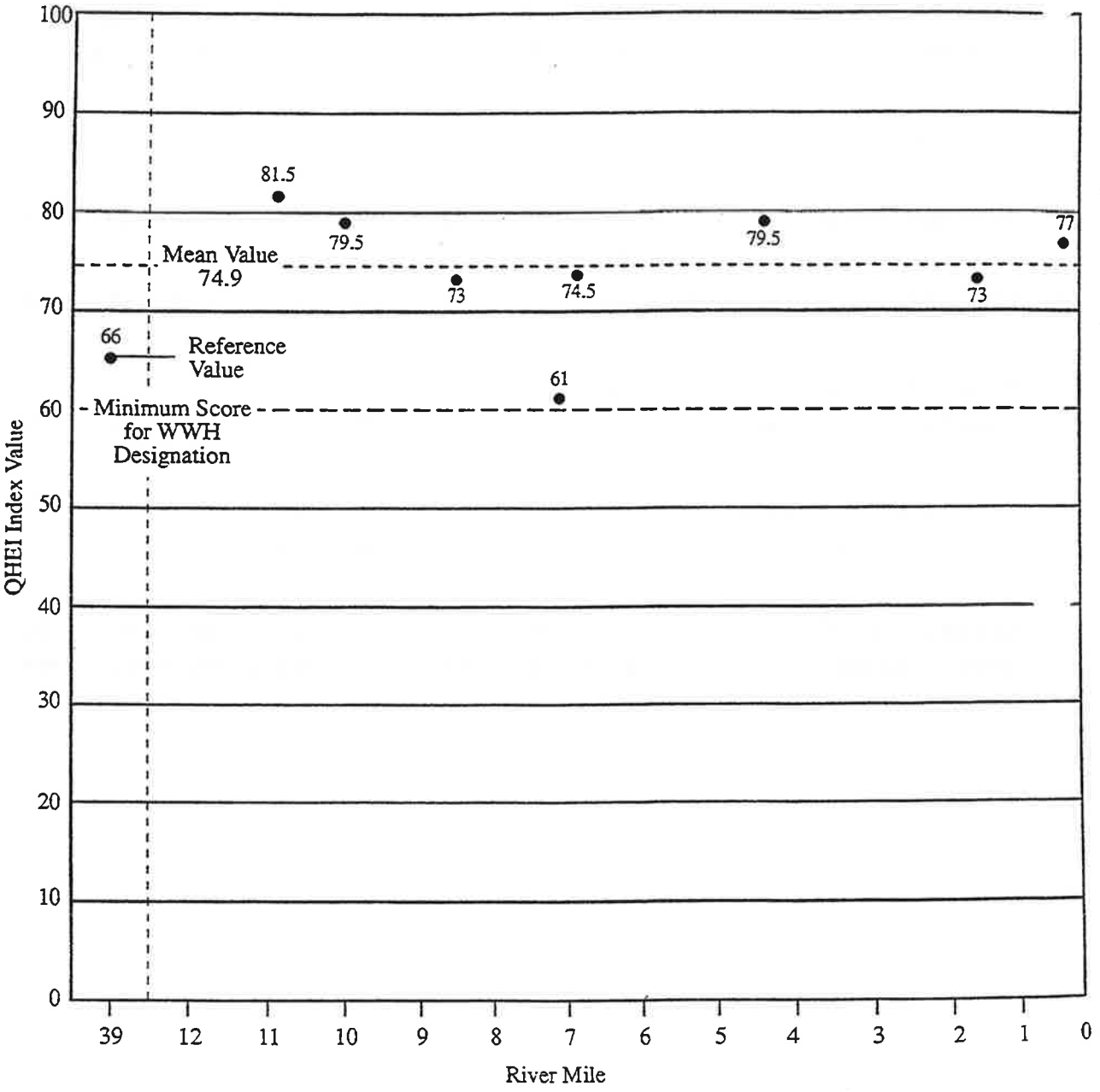
The generated data indicates that the physical habitat of the lower Mahoning River is not the limiting factor concerning the biotic integrity of the river. The QHEI suggests that there is adequate substrate and cover, the depths of the pools and riffles offer suitable habitat, and the river is fairly stable. Urban encroachments are perhaps the most limiting aspect of the QHEI scores.

The QHEI rating does not assess the chemical quality of the substrate in terms of suitability or toxicity to organisms. This is a consideration evaluated in the ICI and IBI indices.

Table 10. Qualitative Habitat Evaluation Index (QHEI) metrics and scores derived from eight Mahoning River study sites (Lawrence County, Pennsylvania). Evaluated 03 November 1999.

	(SCORE)							
SAMPLING STATION NO.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
(River Mile)	**10.9**	**10.0**	**8.5**	**7.1**	**6.9**	**4.4**	**1.6**	**0.2**
1. Substrate (max. 20)	16	17	16	8	14	18	16	17
2. Instream Cover (max. 20)	16	16	11	9	12	13	10	13
3. Channel Morphology (max. 20)	16	12	15	13	12	13.5	14	14
4. Riparian Zone and Bank Erosion (max. 10)	7.5	7.5	7	7.5	9.5	8	7	8
5. Pool/Glide (max. 12) and	10	11	9	9	10	10	10	9
Riffle/Run (max. 8)	6	6	5	4.5	7	7	6	6
6. Gradient (max. 10)	10	10	10	10	10	10	10	10
TOTAL SCORE	**81.5**	**79.5**	**73**	**61**	**74.5**	**79.5**	**73**	**77**

Figure 3. QHEI values for the Mahoning River. Data gathered November 03, 1999 for the eight sample locations. Reference value generated from 1994 OEPA study.



Appendix A

Qualitative Habitat Evaluation Index (QHEI)
Data Forms

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

QHEI SCORE: 79.5

DATE: 10/27/99 STREAM: Mahoning River River Mile: 10
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 2

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)	____	____
☐ ☐ BOULDER (9)	____	____
☐ ■ COBBLE (8)	____	65
☐ ■ GRAVEL (7)	____	25
☐ ☐ SAND (6)	____	____
☐ ☐ BEDROCK (5)	____	____
☐ ☐ HARDPAN (4)	____	____
☐ ☐ DETRITUS (3)	____	____
☐ ☐ MUCK (2)	____	____
☐ ☐ SILT (2)	____	____
☐ ☐ ARTIFICIAL (0)	____	____

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average)
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
■ 5 or More (2)
☐ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average)
SILT:
☐ SILT HEAVY (-2)
■ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
■ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS: _____

SUBSTRATE: 17 Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
■ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
■ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
■ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
■ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
■ MODERATE 25-75% (7)
☐ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS: _____

COVER: 16 Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
☐ MODERATE (3)
■ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
☐ RECOVERED (4)
■ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
☐ ONESIDE CHANNEL MODIFICATIONS
☐ IMPOUNDS
■ ISLANDS
☐ LEVEED
☐ BANK SHAPING

STABILITY
☐ HIGH (3) ■ MODERATE (2) ☐ LOW (1)

COMMENTS: _____

CHANNEL: 12 Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH
L R (Per Bank)
■ ☐ WIDE >50m (4)
☐ ■ MODERATE 10-50m (3)
☐ ☐ NARROW 5-10m (2)
☐ ☐ VERY NARROW <5m (1)
☐ ☐ NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN)
L R (Most Predominant Per Bank)
☐ ■ FOREST, SWAMP (3)
☐ ☐ SHRUB OR OLD FIELD (2)
☐ ☐ RESIDENTIAL, PARK, NEW FIELD (1)
☐ ☐ FENCED PASTURE (1)

L R
☐ ☐ CONSERVATION TILLAGE (1)
☐ ☐ URBAN OR INDUSTRIAL (0)
■ ☐ OPEN PASTURE, ROW CROP (0)
☐ ☐ MINING/CONSTRUCTION (0)

BANK EROSION
L R (Per Bank) L R (Per Bank) L R (Per Bank)
☐ ■ NONE/LITTLE (3) ■ ☐ MODERATE (2) ☐ ☐ HEAVY/SEVERE (1)

COMMENTS: _____

RIPARIAN: 7.5 Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
■ POOL WIDTH > RIFFLE WIDTH (2)
☐ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
■ EDDIES (1)
■ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS: _____

POOL/CURRENT: 11 Max. 12

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

DATE: 10/27/99 STREAM: Mahoning River River Mile: 8.5 **QHEI SCORE: 73**
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 3

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)		
☐ ☐ BOULDER (9)		
☐ ■ COBBLE (8)		65
☐ ■ GRAVEL (7)		25
☐ ☐ SAND (6)		
☐ ☐ BEDROCK (5)		
☐ ☐ HARDPAN (4)		
☐ ☐ DETRITUS (3)		
☐ ☐ MUCK (2)		
☐ ☐ SILT (2)		
☐ ☐ ARTIFICIAL (0)		

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average))
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
☐ 5 or More (2)
■ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average))
SILT:
☐ SILT HEAVY (-2)
☐ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
☐ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS:

SUBSTRATE: 16 Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
☐ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
☐ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
■ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
■ MODERATE 25-75% (7)
■ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS:

COVER: 11 Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
☐ MODERATE (3)
☐ LOW (2)
■ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
■ NONE (6)
☐ RECOVERED (4)
☐ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
■ CANOPY REMOVAL
☐ DREDGING
☐ ONESIDE CHANNEL MODIFICATIONS
☐ IMPOUNDS
☐ ISLANDS
☐ LEVEED
■ BANK SHAPING

STABILITY
■ HIGH (3) ☐ MODERATE (2) ☐ LOW (1)

COMMENTS:

CHANNEL: 15 Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH (L R (Per Bank))
☐ ☐ WIDE >50m (4)
■ ■ MODERATE 10-50m (3)
☐ ☐ NARROW 5-10m (2)
☐ ☐ VERY NARROW <5m (1)
☐ ☐ NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN) (L R (Most Predominant Per Bank))
☐ ☐ FOREST, SWAMP (3)
☐ ■ SHRUB OR OLD FIELD (2)
☐ ☐ RESIDENTIAL, PARK, NEW FIELD (1)
☐ ☐ FENCED PASTURE (1)

L R
☐ ☐ CONSERVATION TILLAGE (1)
☐ ☐ URBAN OR INDUSTRIAL (0)
■ ☐ OPEN PASTURE, ROW CROP (0)
☐ ☐ MINING/CONSTRUCTION (0)

BANK EROSION L R (Per Bank) L R (Per Bank) L R (Per Bank)
■ ■ NONE/LITTLE (3) ☐ ☐ MODERATE (2) ☐ ☐ HEAVY/SEVERE (1)

COMMENTS:

RIPARIAN: 7 Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 0.7-1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
☐ EDDIES (1)
☐ FAST (1)
■ MODERATE (1)
■ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS:

POOL/ CURRENT: 9 Max. 12

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

QHEI SCORE: 61

DATE: 10/27/99 STREAM: Mahoning River River Mile: 7.1
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 4

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)		
☐ ☐ BOULDER (9)		
☐ ☐ COBBLE (8)		
☐ ■ GRAVEL (7)		10
☐ ■ SAND (6)		60
☐ ☐ BEDROCK (5)		
☐ ☐ HARDPAN (4)		
☐ ☐ DETRITUS (3)		
☐ ☐ MUCK (2)		
☐ ☐ SILT (2)		
☐ ☐ ARTIFICIAL (0)		

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average))
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
☐ 5 or More (2)
■ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average))
SILT:
☐ SILT HEAVY (-2)
■ SILT MODERATE (-1)
☐ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
☐ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS: some silt along banks in eddies

SUBSTRA: 8 Max. 2(

2. INSTREAM COVER:

TYPE (Check All That Apply)
☐ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
■ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
☐ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
☐ MODERATE 25-75% (7)
■ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS:

COVER: 9 Max. 2(

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
☐ MODERATE (3)
■ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
☐ RECOVERED (4)
■ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
☐ ONESIDE CHANNEL MODIFICATIONS
■ IMPOUNDS
☐ ISLANDS
☐ LEVEED
☐ BANK SHAPING

STABILITY
■ HIGH (3) ☐ MODERATE (2) ☐ LOW (1)

COMMENTS: upstream of a partially breached dam

CHANNE: 13 Max. 2(

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH (L R (Per Bank))
☐ ☐ WIDE >50m (4)
■ ■ MODERATE 10-50m (3)
☐ ☐ NARROW 5-10m (2)
☐ ☐ VERY NARROW <5m (1)
☐ ☐ NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN) (L R (Most Predominant Per Bank))
☐ ■ FOREST, SWAMP (3)
☐ ☐ SHRUB OR OLD FIELD (2)
☐ ☐ RESIDENTIAL, PARK, NEW FIELD (1)
☐ ☐ FENCED PASTURE (1)

L R
☐ ☐ CONSERVATION TILLAGE (1)
■ ☐ URBAN OR INDUSTRIAL (0)
☐ ☐ OPEN PASTURE, ROW CROP (0)
☐ ☐ MINING/CONSTRUCTION (0)

BANK EROSION L R (Per Bank) L R (Per Bank) L R (Per Bank)
■ ■ NONE/LITTLE (3) ☐ ☐ MODERATE (2) ☐ ☐ HEAVY/SEVERE (1)

COMMENTS: stream bordered by railroad and bike path

RIPARIA: 7.5 Max. 1(

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 0.7-1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
☐ EDDIES (1)
■ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS:

POOL/ CURREN: 9 Max. 1

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

DATE: 10/27/99 STREAM: Mahoning River River Mile: 6.9 **QHEI SCORE: 74.5**
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 5

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)	____	____
☐ ☐ BOULDER (9)	____	____
☐ ■ COBBLE (8)	____	85
☐ ☐ GRAVEL (7)	____	____
☐ ■ SAND (6)	____	10
☐ ☐ BEDROCK (5)	____	____
☐ ☐ HARDPAN (4)	____	____
☐ ☐ DETRITUS (3)	____	____
☐ ☐ MUCK (2)	____	____
☐ ☐ SILT (2)	____	____
☐ ☐ ARTIFICIAL (0)	____	____

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average)
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
☐ 5 or More (2)
■ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average)
SILT:
☐ SILT HEAVY (-2)
■ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
■ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS: some silt along banks in eddies

SUBSTRATE: 14 Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
☐ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
■ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
■ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
■ MODERATE 25-75% (7)
■ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS: ____

COVER: 12 Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
☐ MODERATE (3)
■ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
☐ RECOVERED (4)
■ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
■ IMPOUNDS
■ ISLANDS
☐ LEVEED
☐ BANK SHAPING
☐ ONESIDE CHANNEL MODIFICATIONS

STABILITY
☐ HIGH (3) ■ MODERATE (2) ☐ LOW (1)

COMMENTS: breached low head dam

CHANNEL: 12 Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH (L R (Per Bank))
☐ ■ WIDE >50m (4)
■ ☐ MODERATE 10-50m (3)
☐ ☐ NARROW 5-10m (2)
☐ ☐ VERY NARROW <5m (1)
☐ ☐ NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN) (L R (Most Predominant Per Bank))
■ ■ FOREST, SWAMP (3)
☐ ☐ SHRUB OR OLD FIELD (2)
☐ ☐ RESIDENTIAL, PARK, NEW FIELD (1)
☐ ☐ FENCED PASTURE (1)

L R
☐ ☐ CONSERVATION TILLAGE (1)
☐ ☐ URBAN OR INDUSTRIAL (0)
☐ ☐ OPEN PASTURE, ROW CROP (0)
☐ ☐ MINING/CONSTRUCTION (0)

BANK EROSION L R (Per Bank) L R (Per Bank) L R (Per Bank)
■ ■ NONE/LITTLE (3) ☐ ☐ MODERATE (2) ☐ ☐ HEAVY/SEVERE (1)

COMMENTS: stream bordered by railroad and bike path

RIPARIAN: 9.5 Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 0.7-1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
■ EDDIES (1)
■ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS: ____

POOL/CURRENT: 10 Max. 12

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

DATE: 10/27/99 STREAM: Mahoning River River Mile: 4.4 **QHEI SCORE: 79.5**
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 6

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)		
☐ ☐ BOULDER (9)		
☐ ■ COBBLE (8)		80
☐ ■ GRAVEL (7)		10
☐ ☐ SAND (6)		
☐ ☐ BEDROCK (5)		
☐ ☐ HARDPAN (4)		
☐ ☐ DETRITUS (3)		
☐ ☐ MUCK (2)		
☐ ☐ SILT (2)		
☐ ☐ ARTIFICIAL (0)		

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average))
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
■ 5 or More (2)
☐ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average))
SILT:
☐ SILT HEAVY (-2)
☐ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
☐ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS: some silt along banks in eddies

SUBSTRATE: 18 Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
■ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
■ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
■ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
■ MODERATE 25-75% (7)
■ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS:

COVER: 13 Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
☐ MODERATE (3)
■ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
■ RECOVERED (4)
☐ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
☐ ONESIDE CHANNEL MODIFICATIONS
☐ IMPOUNDS
■ ISLANDS
☐ LEVEED
☐ BANK SHAPING

STABILITY
■ HIGH (3) ■ MODERATE (2) ☐ LOW (1)

COMMENTS: channelization from bridge construction

CHANNEL: 13.5 Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH (L R Per Bank)
■ ☐ WIDE >50m (4)
☐ ■ MODERATE 10-50m (3)
☐ ☐ NARROW 5-10m (2)
☐ ☐ VERY NARROW <5m (1)
☐ ☐ NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN) (L R Most Predominant Per Bank)
■ ☐ FOREST, SWAMP (3)
☐ ☐ SHRUB OR OLD FIELD (2)
☐ ☐ RESIDENTIAL, PARK, NEW FIELD (1)
☐ ☐ FENCED PASTURE (1)

L R
☐ ☐ CONSERVATION TILLAGE (1)
☐ ■ URBAN OR INDUSTRIAL (0)
☐ ☐ OPEN PASTURE, ROW CROP (0)
☐ ☐ MINING/CONSTRUCTION (0)

BANK EROSION L R (Per Bank) L R (Per Bank) L R (Per Bank)
■ ■ NONE/LITTLE (3) ☐ ☐ MODERATE (2) ☐ ☐ HEAVY/SEVERE (1)

COMMENTS: a relatively narrow corridor of undisturbed land remains in this area

RIPARIAN: 8 Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 1m (4)
☐ 0.7-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
■ EDDIES (1)
■ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS:

POOL/CURRENT: 10 Max. 12

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

DATE: 10/27/99 STREAM: Mahoning River River Mile: 1.6 **QHEI SCORE: 73**
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 7

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)		
☐ ☐ BOULDER (9)		
☐ ■ COBBLE (8)		80
☐ ☐ GRAVEL (7)		
☐ ■ SAND (6)		10
☐ ☐ BEDROCK (5)		
☐ ☐ HARDPAN (4)		
☐ ☐ DETRITUS (3)		
☐ ☐ MUCK (2)		
☐ ☐ SILT (2)		
☐ ☐ ARTIFICIAL (0)		

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average))
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
■ 5 or More (2)
☐ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average))
SILT:
☐ SILT HEAVY (-2)
■ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
■ MODERATE (-1)
■ NORMAL (0)
☐ NONE (1)

COMMENTS: silt in low flow areas

SUBSTRATE **16** Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
☐ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
■ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
■ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
☐ MODERATE 25-75% (7)
■ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS:

COVER **10** Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
■ MODERATE (3)
☐ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
■ RECOVERED (4)
☐ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
☐ ONESIDE CHANNEL MODIFICATIONS
☐ IMPOUNDS
■ ISLANDS
☐ LEVEED
☐ BANK SHAPING

STABILITY
☐ HIGH (3) ■ MODERATE (2) ☐ LOW (1)

COMMENTS:

CHANNEL **14** Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH (Per Bank)

L	R	
☐	■	WIDE >50m (4)
☐	☐	MODERATE 10-50m (3)
■	☐	NARROW 5-10m (2)
☐	☐	VERY NARROW <5m (1)
☐	☐	NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN)

L	R	(Most Predominant Per Bank)
☐	■	FOREST, SWAMP (3)
☐	☐	SHRUB OR OLD FIELD (2)
☐	☐	RESIDENTIAL, PARK, NEW FIELD (1)
☐	☐	FENCED PASTURE (1)

L	R	
☐	☐	CONSERVATION TILLAGE (1)
■	☐	URBAN OR INDUSTRIAL (0)
☐	☐	OPEN PASTURE, ROW CROP (0)
☐	☐	MINING/CONSTRUCTION (0)

BANK EROSION

L	R	(Per Bank)	L	R	(Per Bank)	L	R	(Per Bank)
☐	■	NONE/LITTLE (3)	■	☐	MODERATE (2)	☐	☐	HEAVY/SEVERE (1)

COMMENTS: a relatively narrow corridor of undisturbed land remains in this area

RIPARIAN **7** Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
■ >1m (6)
☐ 0.7-1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
■ EDDIES (1)
■ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS: the pools gently break into shallow riffles

POOL/ CURRENT **10** Max. 12

(continued)

QUALITATIVE HABITAT EVALUATION INDEX FIELD SHEET

DATE: 10/27/99 STREAM: Mahoning River River Mile: 0.2 **QHEI SCORE: 77**
State: Pennsylvania County: Lawrence Scorer's Initials: ECM & DAK
Comments: Sample Location No. 8

1. SUBSTRATE:

Check Only 2 Substrate TYPE Boxes; Estimate % Present)

TYPE	Pool	Riffle
☐ ☐ BLDR/SLBS (10)		
☐ ☐ BOULDER (9)		
☐ ■ COBBLE (8)		70
☐ ■ GRAVEL (7)		15
☐ ☐ SAND (6)		
☐ ☐ BEDROCK (5)		
☐ ☐ HARDPAN (4)		
☐ ☐ DETRITUS (3)		
☐ ☐ MUCK (2)		
☐ ☐ SILT (2)		
☐ ☐ ARTIFICIAL (0)		

NOTE (Ignore sludges originating from point sources; score on natural substrates)

ORIGIN (Check 1 (Or 2 and Average))
☐ LIMESTONE (1)
■ TILLS (1)
☐ WETLANDS (0)
☐ HARDPAN (0)
☐ SANDSTONE (0)
☐ RIP/RAP (0)
☐ LACUSTRINE (0)
☐ SHALE (1)
☐ COAL FINES (2)

NUMBER OF SUBSTRATE TYPES
■ 5 or More (2)
☐ 4 or Less (0)

QUALITY (Check 1 (Or 2 and Average))
SILT:
☐ SILT HEAVY (-2)
☐ SILT MODERATE (-1)
■ SILT NORMAL (0)
☐ SILT FREE (1)

EMBEDDEDNESS:
☐ EXTENSIVE (-2)
■ MODERATE (-1)
☐ NORMAL (0)
☐ NONE (1)

COMMENTS: some silt present along shores

SUBSTRAT: 17 Max. 20

2. INSTREAM COVER:

TYPE (Check All That Apply)
■ UNDERCUT BANKS (1)
■ OVERHANGING VEGETATION (1)
■ SHALLOWS (IN SLOW WATER) (1)
☐ ROOTMATS (1)
■ POOLS >70 cm (2)
☐ ROOTWADS (1)
☐ BOULDERS (1)
☐ OXBOWS, BACKWATERS (1)
☐ AQUATIC MACROPHYTES (1)
■ LOGS OR WOODY DEBRIS (1)

AMOUNT (Check Only 1 or Check 2 and Average)
☐ EXTENSIVE >75% (11)
■ MODERATE 25-75% (7)
☐ SPARSE 5-25% (3)
☐ NEARLY ABSENT <5% (1)

COMMENTS: most streamside vegetation is mature forest

COVER: 13 Max. 20

3. CHANNEL MORPHOLOGY: (Check Only 1 Per Category or Check 2 and Average)

SINUOSITY
☐ HIGH (4)
■ MODERATE (3)
☐ LOW (2)
☐ NONE (1)

DEVELOPMENT
☐ EXCELLENT (7)
■ GOOD (5)
☐ FAIR (3)
☐ POOR (1)

CHANNELIZATION
☐ NONE (6)
☐ RECOVERED (4)
■ RECOVERING (3)
☐ RECENT OR NO RECOVERY (1)

MODIFICATIONS/OTHER
☐ SNAGGING
☐ RELOCATION
☐ CANOPY REMOVAL
☐ DREDGING
☐ IMPOUNDS
☐ ISLANDS
☐ LEVEED
☐ BANK SHAPING
☐ ONESIDE CHANNEL MODIFICATIONS

STABILITY
■ HIGH (3) ☐ MODERATE (2) ☐ LOW (1)

COMMENTS: this location is essentially the mouth of the river

CHANNEL: 14 Max. 20

4. RIPARIAN ZONE AND BANK EROSION (Check 1 box per bank or check 2 and average per bank)

• River Right Looking Downstream •

RIPARIAN WIDTH

L	R	(Per Bank)
■	☐	WIDE >50m (4)
☐	■	MODERATE 10-50m (3)
☐	☐	NARROW 5-10m (2)
☐	☐	VERY NARROW <5m (1)
☐	☐	NONE (0)

FLOOD PLAIN QUALITY (PAST 100 M RIPARIAN)

L	R	(Most Predominant Per Bank)
■	☐	FOREST, SWAMP (3)
☐	☐	SHRUB OR OLD FIELD (2)
☐	☐	RESIDENTIAL, PARK, NEW FIELD (1)
☐	☐	FENCED PASTURE (1)

L	R	
☐	☐	CONSERVATION TILLAGE (1)
☐	■	URBAN OR INDUSTRIAL (0)
☐	☐	OPEN PASTURE, ROW CROP (0)
☐	☐	MINING/CONSTRUCTION (0)

BANK EROSION

L	R	(Per Bank)	L	R	(Per Bank)	L	R	(Per Bank)
■	■	NONE/LITTLE (3)	☐	☐	MODERATE (2)	☐	☐	HEAVY/SEVERE (1)

COMMENTS: a relatively narrow corridor of undisturbed land remains in this area

RIPARIAN: 8 Max. 10

5. POOL/GLIDE and RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 Only)
☐ >1m (6)
☐ 0.7-1m (4)
☐ 0.4-0.7m (2)
☐ 0.2-0.4m (1)
☐ <0.2m (POOL=0)

MORPHOLOGY (Check 1 or 2 & Average)
☐ POOL WIDTH > RIFFLE WIDTH (2)
■ POOL WIDTH = RIFFLE WIDTH (1)
☐ POOL WIDTH < RIFFLE WIDTH (0)

CURRENT VELOCITY (POOLS & RIFFLES) (Check All That Apply)
■ EDDIES (1)
☐ FAST (1)
■ MODERATE (1)
☐ SLOW (1)
☐ TORRENTIAL (-1)
☐ INTERSTITIAL (-1)
☐ INTERMITTENT (-2)

COMMENTS: the pools gently break into shallow riffles

POOL/ CURRENT: 9 Max. 12

(continued)

SUMMARY

The results of the current study have been summarized in Table 11. Values are listed for each measured biotic index, providing the associated (Ohio) WWH criterion, the reference zone values, each of the eight sampling station scores, and the mean values and standard deviations for these eight locations. Some of the variation seen between sampling stations in any of the metrics is most likely due to the differences in habitat between the stations. There were no outstanding cause and effect features that we noted during our evaluations that would suggest major variation between any of the sampling locations.

Table 11. Biocriteria minimum Ohio WWH values, reference values*, and individual and mean values gathered from eight Mahoning River study sites (Lawrence County, PA); Data collected between mid-October 1999 and early November 1999.

SAMPLING STATION NO. (River Mile)			1 10.9	2 10.0	3 8.5	4 7.1	5 6.9	6 4.4	7 1.6	8 0.2		
Biocriteria	WWH	Reference									Mean	Standard Deviation
QHEI	(60)	66	81.5	79.5	73	61	74.5	79.5	73	77	74.9	6.4
ICI	(34)	34	26	18	14	16	18	20	24	24	20	4.3
(EPT)	---	6.5	2	2	2	2	2	2	2	2	2	0
IBI	(40)	29	24	36	22	22	36	34	32	32	29.8	6.1
MIwb	(8.7)	7.9	5.0	7.1	0	4.9	7.7	8.2	6.8	7.4	5.9	2.6
(DELT %)	<3	5.7	<1	<1	<1	<1	<1	<1	<1	<1	<1	0

* River Mile 39 (free flowing)

The mean QHEI value exceeded the Ohio WWH criterion and the reference zone value, indicating that from a structural standpoint (utilizing this methodology), the lower Mahoning River provides suitable biotic habitat. As previously noted; however, quality physical habitat seemed limited at the eight sampling locations. It is possible, that even though the QHEI scores throughout both the study area and the reference zone exceeded the Ohio WWH criterion, that critical instream structure is lacking for certain species. When structure such as downed trees and other woody debris was encountered, an increase in both numbers and diversity of fish species was noted. This was particularly true for the game fish species, and is not an unusual finding. Restoration of this portion of the river, in

terms of increasing the numbers and diversity of game fish species in particular, could be enhanced with the introduction of suitable habitat.

The ICI score for this study did not meet the Ohio WWH criterion, while the reference zone ICI value equaled the minimum value of 34. Additionally, while there is no Ohio WWH value for the EPT Index, the mean study value was well below the reference zone value for this measure of river health. It is assumed, and a logical presumption, that contaminated sediments are the principle cause of these depressed values.

It was noted on the QHEI forms that the larger stones in the study areas were essentially "cemented" into the substrate. Visually, the substrate appeared to consist of a "normal" make-up of the described substrate types. Physically, the substrate was held together in a truly cementitious fashion that made it difficult to dislodge even small rocks, and was not characterized by a silt that would flush downstream once the stones were dislodged. Macroinvertebrates were conspicuously absent from the undersides of such "cemented in" rocks.

This condition appeared to be the most limiting macroinvertebrate habitat feature in the study portion of the Mahoning. The lack of suitable available surface area for the invertebrates likely has an overall negative impact on species diversity and biomass. The cause of this condition was not determined in this portion of the study, but is presumed to be linked to past industrial uses of the river. This effect on the invertebrate populations, in combination with the lack of suitable shelter and structure for non-game fish species, and a decrease in available spawning sites in general, is arguably correlated with the lack of a more diverse fishery. Toxic effects within the substrate, if present, would exacerbate the physical limitations.

The fish metrics, as represented by the IBI, MIwb, and DELT scores, indicate that a viable, but less than "optimum" fishery exists in this section of the Mahoning River. Interestingly, the mean IBI value essentially equals the reference zone value, but both values are well below the Ohio WWH criterion. However, both the number and diversity of the fish species encountered in this study exceeded *a priori* expectations in light of the referenced 1998 Schroeder report.

The MIwb values followed a similar trend with the IBI as a result of the percentage of pollution tolerant species in the samples. Sampling Stations 2, 5, and 6 approached or exceeded the reference zone value, although the mean value was less than that of the reference zone. The Sampling Station 3 value was zero (0) which further depressed the mean score. Sampling Station 3 was the only station where a boat was necessary for electro-fishing, and in this respect somewhat limited our ability to sample as effectively as with the other seven locations.

The DELT values; however, were found to be much better than the reference reach of river, and actually met the Ohio WWH criterion. Very few individuals exhibited physical anomalies, suggesting that the species present were of good overall health. While the established Ohio WWH criterion are for unimpacted waters, the study reach of the Mahoning can hardly be considered an "unimpacted" water. With the historical industrial impacts that have been documented on the Mahoning River, the results of this study potentially reflect a recovering ecosystem, rather than a degrading one. That is, while the fishery is degraded, it is potentially improving over a worsened state and is showing a healthy condition for the level of the present recovery. The DELT values support this potential.

It is possible, pending the toxicity of the sediments, that physically disturbing the Mahoning River's substrate might offer a restoration option. This action, coupled with structural habitat enhancements could help this river realize its present day potential as a fishery. Restoration then would only be limited to the types and availability of species able to migrate into the study area. This factor is dependent on the integrity and make-up of the tributaries associated with the Mahoning River.

Overall, it appears as though the lower 12 miles of the Mahoning River, while degraded as compared to (unimpacted) reference streams within the ecoregion, does indeed support a viable biotic community. The diversity of the community as an overall measure of system health is less than optimum, but certainly within a range where relatively minor restoration activities would be of benefit.

REFERENCES

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