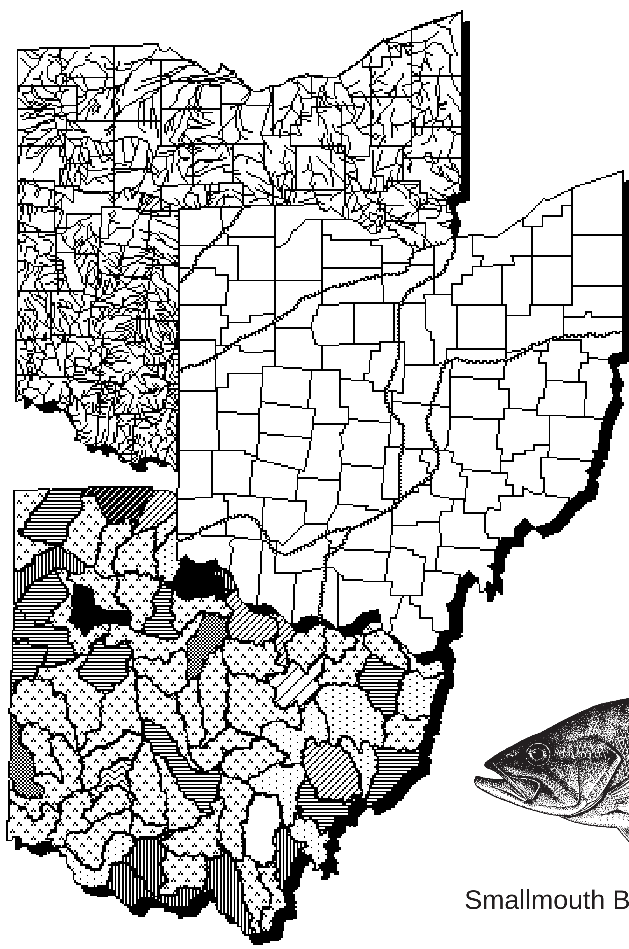
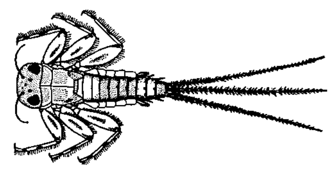
State of Ohio
Environmental Protection Agency

Ecological Assessment
Division of Surface Water

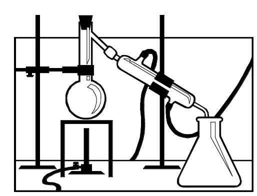
Biological and Water Quality Study of the Upper Hocking River and Selected Tributaries

Fairfield and Hocking Counties, Ohio

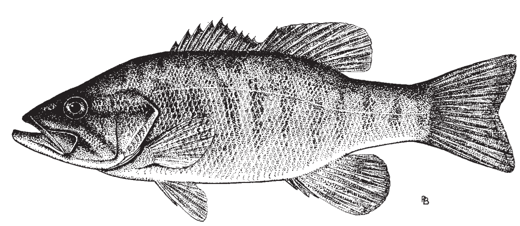




Mayfly *(Stenonema)*



Chemical Analysis



Smallmouth Bass *(Micropterus dolomieui)*

December 31, 1997

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-1049

Biological and Water Quality Study of the Upper Hocking River and Selected Tributaries

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prepared by

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Division of Surface Water
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TABLE OF CONTENTS

TABLE OF CONTENTS

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Study Area Description - Vince Mazieka
Pollutant Loadings - Paul Vandermeer
Ambient Chemical Water Quality - Paul Vandermeer
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TSD Coordinator - Charles Boucher
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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Qual. Plan. Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents new publications by Ohio EPA have become available. The following publications should also be consulted as they represent the latest information and analyses used by Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. *in* W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. *in* W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. *in* W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. *in* W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. *in* W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

These documents and this report can be obtained by writing to:

Ohio EPA, Division of Surface Water
Monitoring and Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228-3809
(614) 728-3377

FOREWORD

What is a Biological and Water Quality Survey?
A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful different study areas with an aggregate total of 250-300 sampling sites.

Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1]), and are eventually incorporated into Water Quality Permit Support Documents (WQPSDs), State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the Ohio Water Resource Inventory (305[b] report).

Hierarchy of Indicators
A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach is outlined in Figure 1 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6)

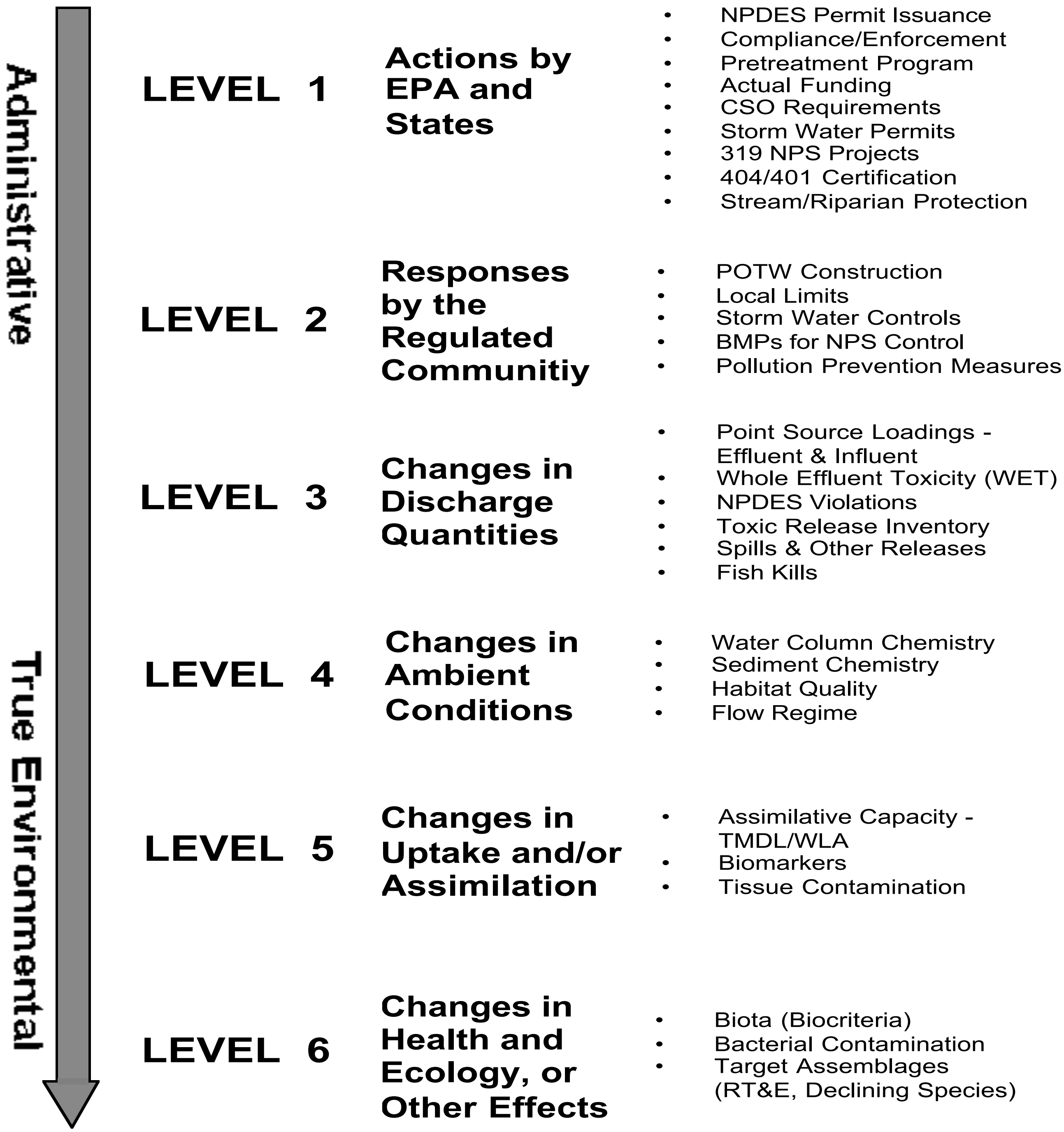

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995).

changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Ohio Water Resource Inventory (305[b] report), the Ohio NPS Assessment, and technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Uses

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the narrative goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently control the resulting protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS with the general intent of each with respect to the role of biological criteria are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.* Biological criteria are stratified across five ecoregions for the WWH use designation.

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.* Biological criteria for EWH apply uniformly across the state.

3) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall. No specific biological criteria have been developed for the CWH use although the WWH biocriteria are viewed as attainable for CWH designated streams.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned and permitted by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat. Biological criteria for MWH were derived from a separate set of habitat modified reference sites and are stratified across five ecoregions and three major modification types: channelization, run-of-river impoundments, and extensive sedimentation due to non-acidic mine drainage.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi.^{2} drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways. No formal biological criteria have been established for the LRW use designation.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to meet either criterion the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliforms, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health are detailed in other documents.

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Fairfield and Hocking Counties, Ohio

State of Ohio Environmental Protection Agency
Division of Surface Water
1800 Watermark Drive
Columbus Ohio, 43215-0166

INTRODUCTION

As part of the five-year basin approach for the NPDES (National Pollution Discharge Elimination System) permitting process, ambient biological, water column chemical and physical, and sediment sampling was conducted by the Ohio EPA within the upper Hocking River and selected tributaries. The 1995 study area included: the Hocking River mainstem from the headwaters (RM 100.2) to Logan (RM 68.3), Hunters Run, Baldwin-Ewing Run, Scott Creek, and the mainstem and principal tributaries of Clear Creek.

Specific objectives of this study were to:

1) Monitor and assess the overall chemical, physical, and biological integrity of the upper Hocking River study area,
2) Determine the attainment status of aquatic life and selected non-aquatic life use designations and recommend changes in use designations when appropriate,
3) Evaluate the influence of the Lancaster WWTP and combined sewer overflows (CSOs) on the Hocking River mainstem and Baldwin-Ewing Run,
4) Evaluate the influence of the Lancaster and Fairfield Co. landfills on Hunters Run (Hocking River tributary) and Cattail Creek (Clear Creek tributary), respectively,
5) Establish biological, chemical, and physical monitoring stations within the Clear Creek subbasin to evaluate implemented and pending basin-wide nonpoint source pollution abatement efforts and the recently constructed Amanda WWTP,
6) Evaluate the influence of the Southeast Ohio Correctional Facility WWTP on Arney Run (Clear Creek tributary), and
7) Summarize previous studies by Ohio EPA to evaluate environmental improvements to date and to expand Ohio EPA databases for trends analysis (e.g., 305[b]).

The findings of this study may factor into regulatory actions taken by Ohio EPA (e.g., NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1]), and eventually will be incorporated into the State Water Quality Management Plans, the Ohio Non-point Source Assessment, and the biennial Water Resource Inventory (305[b]) report.

SUMMARY

Hocking River (mainstem)

A total of 30.7 miles of the Hocking River mainstem was sampled and assessed as part of the 1995 survey. The effort included an aggregate total of 82 biological, chemical, and physical sampling stations, encompassing the mainstem from the headwaters (RM 100.2) to Logan (RM 69.5). Previous surveys of this segment were conducted by Ohio EPA in 1982 and 1990. The aquatic life use designation for the entire length of the upper Hocking River is currently WWH. Aquatic life attainment status (existing and recommended) for all water bodies evaluated within the study area is presented in Table 1.

The results of the 1995 survey found 17.6 miles (57.3%) in full attainment of the existing WWH aquatic life use designation. Partial attainment was indicated for 10.2 miles (33.2%), while non-attainment was observed in the remaining 2.9 miles (9.5%). Departures from the WWH biological criteria in 1995 were limited to two discrete river segments. The first impaired segment was located in the extreme headwaters, upstream from Lancaster. The second included the reach flowing through and downstream from Lancaster. Stream channelization and municipal pollutant loadings were the principal associated stressors.

Based on samples collected at RM 100.2/100.0 (Pickerington Rd.), impairment in the headwaters was limited to a 2.9 mile segment. This reach supported fish and benthic macroinvertebrate assemblages indicative of *fair* to *poor* conditions. This was directly related to poor macrohabitat quality, as this reach has been extensively channelized. The channel configuration of this segment was linear, shallow, and uniformly trapezoidal in cross section. The substrates consisted entirely of clay and silt deposits. Inferred mainly from the structure and composition of the benthic macroinvertebrate fauna, an additional stressor included nutrient enrichment from the surrounding agricultural uplands. Degraded habitat coupled with nutrient enrichment were the major associated causes of aquatic life use impairment within the headwaters.

Table 1. Attainment status for aquatic life use designations (existing and recommended) in the upper Hocking River study area based on data collected between 1978 and 1995.

River Mile Fish/Invert.	**IBI**	**Modified Iwb**	**ICI[a]**	**QHEI**	**Attainment Status[b]**	**Comment**
Hocking River (1995)						
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
100.2(H)/100.0	32*	N/A	10*	28.0	**NON**	Pickerington Rd.
95.2(W)/95.1	40	8.5	36	85.0	FULL	Hooker cemetery-ust. Lancaster
Erie Ontario Lake Plain - WWH/MWH Use Designation (Existing/Recommended)						
92.2(W)/92.1	33*	7.2*	44	38.5	PARTIAL/FULL	Pierce Ave, Lancaster-Channelized
90.8(W)/90.7	32*	7.4[ns]	42	41.5	PARTIAL/FULL	US 22, Lancaster-Channelized
89.4(W)/89.4	32*	7.6[ns]	40	63.0	PARTIAL/FULL	ust. Lancaster WWTP-Channelized
89.04(W,MZ)/89.04	*32*	*7.6*	*20*	*N/A*	*N/A*	*Lancaster WWTP-mixing Zone*
Erie Ontario Lake Plain - WWH Use Designation (Existing)						
89.0(W)/88.9	37[ns]	9.1	28*	65.0	PARTIAL	dst. Lancaster WWTP-Channelized
87.1(W)/87.2	33*	7.8[ns]	22*	70.5	PARTIAL	US 33
82.0(B)/82.0	44	8.4[ns]	36	82.5	FULL	ust. Rush Creek
Western Allegheny Plateau - WWH Use Designation (Existing)						
81.2(B)/81.4	52	9.2	44	70.5	FULL	dst. Rush Creek
77.2(B)/77.2	50	9.6	44	77.0	FULL	at Rockbridge
73.2(B)/73.6	51	9.6	VG	74.0	FULL	at Enterprise
69.5(B)/69.6	51	10.1	48	77.0	FULL	SR 664-ust. Logan
Hocking River (1990)						
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
95.2(W)/95.1	35*	8.2[ns]	50	66.0	PARTIAL	Hooker cemetery-ust. Lancaster
Erie Ontario Lake Plain - WWH Use Designation (Existing)						
92.2(W)/91.9	27*	6.5*	52	44.0	**NON**	Pierce Ave, Lancaster-Channelized
90.8(W)/90.7	28*	6.9*	46	37.0	PARTIAL	US 22, Lancaster-Channelized
89.4(W)/89.4	24*	5.9*	38	41.5	**NON**	ust. Lancaster WWTP-Channelized
89.04(MZ,W)/89.04	*25*	*4.7*	*26*	*N/A*	*N/A*	*Lancaster WWTP-mixing Zone*
89.0(W)/88.9	30*	6.5*	32[ns]	37.5	PARTIAL	dst. Lancaster WWTP-Channelized
87.1(W)/87.2	25*	4.9*	MG[ns]	58.5	**NON**	US 33

Table 1. continued.

River Mile Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Hocking River (1990)						
Western Allegheny Plateau - WWH Use Designation (Existing)						
82.0(B)/82.9	33*	6.5*	46	62.0	PARTIAL	ust. Rush Creek
81.2(B)/81.3	39^{ns}	8.1^{ns}	44	57.5	FULL	dst. Rush Creek
77.2(B)/77.1	34*	7.5*	G	63.5	PARTIAL	at Rockbridge
73.2(B)/73.4	43	8.1^{ns}	G	63.5	FULL	at Enterprise
69.5(B)/69.4	40	8.6	46	78.0	FULL	SR 664-ust. Logan WWTP
Hocking River (1982)						
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
95.2(W)/94.9	27*	6.1*	G	46.0	**NON**	Hooker cemetery-ust. Lancaster
Erie Ontario Lake Plain - WWH Use Designation (Existing)						
93.2(W)/ -	23*	5.5*	-	-	[**NON**]	Lancaster-Channelized
92.0(W)/92.0	17*	4.5*	44	48.0	**NON**	Lancaster-Channelized
- /91.2	-	-	8*	-	[**NON**]	Lancaster-Channelized
90.7(W)/89.3	17*	4.0*	2*	40.0	**NON**	US 22, Lancaster-Channelized
88.8(W)/88.5	12*	0.6*	0*	48.0	**NON**	dst. Lancaster WWTP
- /87.3	-	-	0*	-	[**NON**]	US 33
85.7(W)/85.4	12*	1.8*	0*	62.0	**NON**	
83.1(W)/82.9	20*	4.0*	0*	67.0	**NON**	ust. Rush Creek
Western Allegheny Plateau - WWH Use Designation (Existing)						
- /81.8	-	-	0*	-	[**NON**]	
81.4(B)/81.3	17*	2.4*	12*	84.0	**NON**	dst. Rush Creek
77.2(B)/77.3	29*	6.8*	22*	63.0	**NON**	at Rockbridge
73.3(B)/73.5	31*	7.3*	18*	66.0	**NON**	at Enterprise
Hunters Run (1995)						
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
3.5(H)/3.6	44	N/A	58	58.5	FULL	ust. Lancaster Landfill-Beck Rd.
2.5(H)/2.5	55	N/A	54	59.0	FULL	dst. Lancaster Landfill-Crumley Rd.
0.5(H)/0.6	46	N/A	MG^{ns}	55.5	FULL	SR 22-Lancaster

Table 1. continued.

River Mile Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Hunters Run ((1990)						
	Erie Ontario Lake Plain-WWH Use Designation (Existing)					
0.5(H)/0.5	39ns	N/A	38	50.0	FULL	SR 22-Lancaster
Hunters Run ((1982)						
	Erie Ontario Lake Plain-WWH Use Designation (Existing)					
0.6(H)/0.6	28*	N/A	P*	-	**NON**	SR 22 dst. Anchor Hocking
Baldwin-Ewing Run (1995)						
	Erie Ontario Lake Plain-WWH Use Designation (Existing)					
2.7(H)/2.7	44	N/A	54	75.0	FULL	ust. Lancaster
0.3(H)/0.2	42	N/A	F*	57.0	PARTIAL	Lancaster CSOs
- /0.1	-	-	P*	-	[**NON**]	dst. construction discharge
Baldwin-Ewing Run (1990)						
	Erie Ontario Lake Plain-WWH Use Designation (Existing)					
0.3(H)/0.2	31*	N/A	16*	50.5	**NON**	Lancaster CSOs
Baldwin-Ewing Run (1982)						
	Erie Ontario Lake Plain-WWH Use Designation (Existing)					
0.5(H)/0.2	27*	N/A	P*	-	**NON**	Lancaster CSOs
Scott Creek (1995)						
	Western Allegheny Plateau - WWH Use Designation (Existing)					
8.9(H)/9.0	34*	N/A	26/MG[c]	61.0	PARTIAL	adj. SR 93-Headwaters
5.6(H)/4.9	37*	N/A	44	68.0	PARTIAL	adj. SR 93-Mine Drainage
	Western Allegheny Plateau - EWH/WWH Use Designation (Existing/Recommended)					
0.1(W)/1.5	49ns	8.8*	34/G[c]*	76.0	**NON**/FULL	adj. SR 93-near mouth
Scott Creek (1978)						
	Western Allegheny Plateau - WWH Use Designation (Existing)					
8.9(H)/ -	56	N/A	-	-	[FULL]	adj. SR 93-Headwaters

Table 1. continued.

River Mile Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Scott Creek (1978)						
Western Allegheny Plateau - WWH Use Designation (Existing)						
8.1(H)/ -	48	N/A	-	-	[FULL]	adj. SR 93-Headwaters
8.0(H)/ -	<u>22</u>*	N/A	-	-	[**NON**]	adj. SR 93-Mine Drainage
7.2(H)/ -	28*	N/A	-	-	[**NON**]	adj. SR 93-Mine Drainage
5.6(H)/ -	36*	N/A	-	-	[**NON**]	adj. SR 93-Mine Drainage
Clear Creek (1995)						
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
21.8(H)/20.1	44	N/A	<u>P</u>*	62.0	**NON**	Amanda Northern Rd.-Headwaters
16.3(H)/ -	50	N/A	-	59.0	[FULL]	SR 22-ust. Amanda WWTP
14.2(W)/14.1	39[ns]	8.3	52	67.0	FULL	dst. Amanda WWTP
13.1(W)/13.2	42	9.5	44	58.0	FULL	SR 159
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
9.4(W)/9.5	51	10.0	54	68.0	FULL	Clearport Rd.
7.3(W)/7.3	51	9.8	54	78.0	FULL	dst. Revenge
Western Allegheny Plateau - WWH Use Designation (Existing)						
5.9(W)/5.8	49	9.7	52	73.0	FULL	adj. Lake Romona
1.9(W)/2.1	51	9.9	50	66.0	FULL	Camp Wyandot Bridge
Clear Creek(1982)						
Eastern Corn Belt Plain - WWH Use Designation (Existing)						
16.3(H)/16.1	30*	N/A	40	53.0	PARTIAL	SR 22-ust. Amanda
14.2(H)/14.2	<u>26</u>*	6.9*	34[ns]	49.0	**NON**	dst. Amanda
13.1(W)/13.1	<u>27</u>*	6.7*	40	57.0	**NON**	SR 159
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
9.4(W)/9.5	30*	7.5[ns]	32[ns]	71.0	PARTIAL	Clearport Rd.
7.3(W)/ -	31*	7.6[ns]	-	87.0	[PARTIAL]	dst. Revenge
Western Allegheny Plateau - WWH Use Designation (Existing)						
2.3(W)/2.0	35*	9.4	44	-	PARTIAL	Camp Wyandot Bridge

Table 1. continued.

River Mile Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Muddy Prairie Run (1995)						
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
0.7(H)/0.6	54	N/A	52	55.0	FULL	Amanda Clearport Rd.-NPS
Muddy Prairie Run(1982)						
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
0.7(H)/0.4	41	N/A	44	83.0	FULL	Amanda Clearport Rd.-NPS
Muddy Prairie Creek (1995)						
Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.1(H)/0.1	52	N/A	F*	42.0	PARTIAL	Amanda Northern Rd.-NPS
Sand Run (1995)						
Eastern Corn Belt Plain-Undesignated/WWH Use Designation (Existing/Recommended)						
0.1(H)/0.1	44	N/A	VG	46.0	FULL	Amanda Northern Rd.-NPS
Arney Run (1995)						
Erie Ontario Lake Plain-WWH Use Designation (Existing)						
4.3(H)/4.3	38[ns]	N/A	MG[ns]	37.0	FULL	ust. SE Ohio Correctional WWTP trib.
2.2(H)/3.7	43	N/A	F*	72.0	PARTIAL	dst. SE Ohio Correctional WWTP trib.
0.1(H)/0.1	53	N/A	G	81.0	FULL	near mouth-recovery
Dunkle Run (1995)						
Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.5(H)/0.5	44	N/A	E	62.0	FULL	Amanda Souther Rd.-NPS

Table 1. continued.

River Mile Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status[b]	Comment
Dunkle Run(1982)						
			Eastern Corn Belt Plain-WWH Use Designation (Existing)			
0.1(H)/ -	30*	N/A	-	66.0	[**NON**]	Near Mouth
Cattail Creek (1995)						
			Western Allegheny Plateau - Undesignated/WWH Use Designation (Existing/Recommended)			
2.8(H)/2.7	46	N/A	E	64.0	FULL	Drinkle Rd.-dst. Fairfield Landfill
Cattail Creek (1987)[d]						
- /2.7	-	-	E	-	[FULL]	Drinkle Rd.-dst. Fairfield Landfill

* - Significant departure from biocriteria (>4 IBI or ICI units, >0.5 MIwb units), poor/very poor results underlined.
ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, ≤0.5 MIwb units).
H - Headwater station (drainage area < 20 mile^2), the MIwb is not applicable.
W - Wading station.
B - Boat station.
a - Narrative evaluation based on qualitative sample (E-exceptional, VG-very good, G-good, MG-marginally good, F-fair,P- poor, and VP-very poor) is used in lieu of the ICI when quantitative data are not available.
b - Attainment status based on one organism group is parenthetically expressed.
c - The quantitative (artificial substrate) sample was affected by nondetectible current speed; marginally good (RM 9.0) and good (RM 1.5) narrative evaluations were substituted based primarily on qualitative sampling results.
d - In addition to the evaluations listed, qualitative benthic macroinvertebrate samples have been collected from Cattail Creek at RM 2.7 for the years 1993, 1992, 1990, and 1988. All evaluations indicated exceptional conditions.

Ecoregional Biological Criteria (OAC 3745-1-07, Table 7-14)

Eastern Corn Belt Plain (ECBP)

Index - Site Type	WWH	EWH	MWH[e]
IBI - Headwater/Wading	40	50	24
MIwb - Wading	8.3	9.4	6.2
ICI	36	46	22

Erie Ontario Lake Plain (EOLP)

Index - Site Type	WWH	EWH	MWH[e]
IBI - Headwater	40	50	24
IBI - Wading	38	50	24
IBI - Boat	40	48	24
MIwb - Wading	7.9	9.4	6.2
MIwb - Boat	8.7	9.6	5.8
ICI	34	46	22

e - Modified Warmwater Habitat (MWH) for channel modified areas.

Western Allegheny Plateau (WAP)

Index - Site Type	WWH	EWH	MWH[e]
IBI - Headwater	44	50	24
IBI - Wading	44	50	24
IBI - Boat	40	48	24
MIwb - Wading	8.4	9.4	6.2
MIwb - Boat	8.6	9.6	5.8
ICI	36	46	22

Macrohabitat quality was markedly improved downstream and represented natural conditions at RM 95.2 (Hooker Cemetery - downstream Lake Rockmill). The positive change not only provided the requisite physical features to support a healthy, diverse, and well-organized aquatic community (*e.g.,* mixed current velocities, coarse substrates, depth heterogeneity, wooded riparian corridor), but also resulted in amelioration of the upstream nutrient inputs through increased assimilation associated with high quality stream and riparian habitats. Additionally, the heavy silt load observed upstream was likely mitigated by the retention basin influence provided by Rockmill Lake, located upstream from Hooker. The downstream effects of nutrient inputs were also likely lessened through increased retention and biological processing/conversion within the impoundment. The buffering properties of Rockmill Lake and improved near and instream habitat were the most important factors associated with the biological recovery observed at RM 95.2. As a result, instream biological performance at this station was fully consistent with the WWH use. The results of water column sampling from these areas (upstream from Lancaster) revealed no exceedences of the Ohio WQS. Daytime and diel dissolved oxygen (D.O.) concentrations remained well above the average and minimum criteria and nutrient, demand, and other water quality parameters occurred at concentrations consistent with background conditions.

The remaining 10.2 miles of impairment (mostly partial attainment) extended through the greater Lancaster area to U.S. Rt. 33. As the Hocking River entered the urbanized area of Lancaster macrohabitat quality again declined. This reach has been extensively channelized and leveed resulting in the degradation of near and instream habitats. Although each sampling station showed varying degrees of recovery the habitat assessment indicated a predominance of moderate and high influence modified habitat attributes. Habitat quality, however, improved longitudinally within this segment. Highly modified conditions were evident at Pierce Ave. (RM 92.2) and U.S. Rt. 22 (RM 90.8) and recovering (better quality) habitat at Maple St. (RM 89.4) and RM 89.0 downstream from the Lancaster WWTP.

The Hocking River within Lancaster receives effluent from the Lancaster WWTP (RM 89.05) as well as pulsed or periodic discharges of untreated sewage from CSOs. Upstream from the WWTP modified habitat conditions were the most pronounced and biological community performance (fish and macroinvertebrates) exhibited a response signature typical of *habitat impairment*. Results from the comparatively habitat neutral quantitative macroinvertebrate samples were indicative of *good* and *very good* water quality. Despite modest CSO impacts evidenced by elevated fecal coliform bacteria counts and the occurrence of sewage solids and human hygiene materials instream, the effects of CSOs and urban runoff were not significant in 1995. The pollutant loadings contributed by the CSOs did not elicit a negative response from the macroinvertebrates. In contrast, the more habitat sensitive fish community yielded results no better than *fair*. The resulting partial attainment of the WWH use was driven by the failure of the fish community to perform at a WWH level. It has been Ohio EPA's experience that this community response - *good* to *very good* macroinvertebrates and *fair* performance of the fish community - is typically reflective of macrohabitat impacts and an absence of significant chemical water quality problems.

Immediately downstream from the Lancaster WWTP, habitat quality improved slightly, and by RM 87.1 (U.S. Rt. 33) appeared fully capable of supporting the WWH use. Despite the longitudinal improvement in habitat quality, biological impairment was observed downstream from the WWTP. This was particularly evident in the macroinvertebrates which declined from *good* quality immediately upstream from the WWTP (ICI = 40 at RM 89.4) to *fair* downstream (ICI = 28 at RM 88.9). The impairment extended from the 001 outfall to U.S. Rt. 33 (RM 87.1). Reduced biological performance associated with the WWTP was primarily indicative of organic enrichment as toxicity, avoidance, or chronic nutrient enrichment were not indicated at near or far field stations.

Water quality sampling within and downstream from Lancaster (between RM 91.93 and RM 87.32) revealed few exceedences of criteria for the protection of aquatic life. Fecal coliform counts in excess of the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) criteria were the only regularly observed excursions. The sources of the fecal contamination included periodic CSO discharges and the Lancaster WWTP 001 outfall. The frequency and magnitude of bacteriological contamination did not suggest pervasive or chronic CSO problems, rather it was more indicative of pulsed or intermittent events. Most of the fecal coliform exceedences occurred during periods of increased surface runoff and elevated river discharge following periods of rainfall in late July and early August. During periods of wet weather, diffuse urban and rural nonpoint sources and CSOs are typically the most active.

Mean concentrations of 5-day biochemical oxygen demand (BOD_5) and ammonia-nitrogen (NH_3-N) within the Lancaster segment were barely influenced by the Lancaster WWTP or CSOs. Nitrate+nitrite-nitrogen (NO_3+NO_2-N), total suspended solids (TSS), and total phosphorus (to a lesser degree), were elevated downstream from the WWTP. However, these constituents were safely assimilated as daytime and diel D.O. concentrations remained well above the WWH criterion.

Complete biological recovery was evident approximately seven miles downstream from the Lancaster WWTP at RM 82.0 (upstream from Rush Creek). Full attainment of the WWH use occurred throughout the remainder of the study area. Conditions continued to improve with increasing distance from the Lancaster WWTP and by RM 81.2/81.4 (downstream from Rush Creek), *very good* to *exceptional* communities were observed.

Water quality sampling within the lower reaches of the study area revealed exceedences of the PCR and SCR fecal coliform criteria downstream from the confluence of Rush Creek. The principal source of the bacterial contamination was likely the Sugar Grove WWTP which discharges to Rush Creek at the mouth. The exceedences lessened with increasing downstream distance. Daytime D.O. concentrations were well above the WWH criterion. However, diel D.O. sampling revealed nine excursions of the WWH minimum criterion and 17 excursions below the average criterion at Enterprise (RM 73.2). The cause of the D.O. excursions is not clear at this time, but may have been the result of increased algal production associated with nutrient inputs from Lancaster or the surrounding agricultural areas.

Trend Assessment

In comparison with the 1982 and 1990 Ohio EPA surveys further biological and water quality improvements were evident in 1995. These positive changes represent the full effect of the wastewater treatment system upgrades and the implementation of industrial pretreatment programs in Lancaster during the mid and late-1980s. The effect of these changes were initially detected by the 1990 survey results and fully reflected in the 1995 results. These actions were initiated to comply with water quality-based effluent limits required for compliance with the Ohio WQS and the National Municipal Policy. Historically, the upper Hocking River had been one of the most severely degraded river segments in the state (Ohio EPA 1985). Inadequate treatment of domestic wastewater (including bypassing) at the Lancaster WWTP, wet and dry weather CSOs, and a heavy contribution of industrial waste via the Lancaster sewer system resulted in gross enrichment, contamination by heavy metals, acute instream toxicity, and periodic fish kills (Ohio EPA 1991).

The quality of the Lancaster WWTP effluent has improved substantially over the past 20 years. Median annual loadings of NH_3-N, TSS, and BOD_5 through the period of record (1976-1995) were markedly reduced following the 1988 plant upgrade. As a result, substantial water quality improvements were realized in the Hocking River, within and downstream from Lancaster. In 1982, the zone of impact reflecting poor quality extended for a distance of approximately eight miles downstream from Lancaster (Ohio EPA 1985). These results exemplify a *classic* water quality profile downstream from inputs of poorly treated sewage. A distinct D.O. sag was evident with numerous excursions of the WWH D.O. criteria. With the exception of NO_3-N, total phosphorus, oxygen demanding, and other water quality parameters were markedly elevated downstream from the Lancaster WWTP. Total phosphorus concentrations regularly exceeded 1.0 mg/l and numerous exceedences of the NH_3-N criterion were recorded. The influence of industrial contributions was reflected in frequent detections of total cyanide (which included five exceedences of the WWH criterion) and elevated lead, zinc, copper, and nickel concentrations.

The results of the 1990 survey indicated fewer exceedences of WWH chemical criteria compared to the severely degraded conditions encountered in 1982. Exceedences were limited mainly to high fecal coliform levels. The D.O. deficiencies observed in 1982 were significantly reduced in

1990, as concentrations were typically well above the WWH criteria. Nutrient, oxygen demanding, and other conventional water quality parameters all declined to near background levels downstream from Lancaster. The one exception to this was NO_3-N which increased downstream from the WWTP. This was not unexpected as it is a by-product of nitrification in the wastewater treatment process. Instream concentrations of heavy metals (lead, zinc, and cadmium in particular) also occurred at lower levels within and downstream from Lancaster. These results were brought about by the improvements made in the improved collection and treatment of wastewater by Lancaster which including the implementation of an effective industrial pretreatment program.

The results of the 1995 survey indicated further improvements from those observed in 1990. All conventional water quality parameters (*e.g.,* D.O., nutrients, oxygen demand) and heavy metal parameters occurred at concentrations consistent with the WWH use. As was observed in 1990, exceedences of the WQS were typically limited to fecal coliform counts greater than either the PCR and SCR maximum criteria, the majority of which were associated with wet weather events. The only other exceedences in 1995 were instream D.O. excursions which were recorded at the lower boundary of the study area at Enterprise (RM 73.2). In contrast with daytime samples at this station, which indicated D.O. concentrations well above the WWH criteria, diel sampling found numerous violations of the 4.0 mg/l WWH minimum standard in mid-August. As stated earlier the cause of the D.O. depletion is not clear at this time.

The results of biological sampling conducted in the upper Hocking River between 1982 and 1995 reveal some of the most significant improvements of any river in the state. In 1982, the performance of the fish and benthic macroinvertebrate communities clearly reflected grossly polluted and acutely toxic conditions (Ohio EPA 1991). Both assemblages performed at *poor* to *very poor* levels within and downstream from Lancaster. The highly degraded assemblages encountered indicated severe impairment as none of the approximately 21.9 miles evaluated fully attained the WWH use (Table 1). Following upgrades to the Lancaster WWTP and improvements in industrial pretreatment, biological community performance was significantly improved in 1990. Full attainment was observed in 8.1 miles (31.4%) of the study segment, 11.6 miles (45.0%) exhibited partial attainment, and the remaining 6.1 miles (23.6%) exhibited non-attainment. The macroinvertebrate assemblage showed the greatest improvement, which followed the typical pattern due to shorter recovery times following pollution abatement. The fish community also showed substantial improvement, but not to the same degree shown by the macroinvertebrates. This was the result of several factors including lowered habitat quality due to channelization, residual chemical contamination in Lancaster, and an inadequate recovery time following improvement and stabilization of effluent quality from the Lancaster WWTP. By 1995, full and partial attainment increased to 16.6 miles (57.3%) and 10.2 miles (33.2%), respectively. The non-attaining miles observed in 1982 and 1990 were eliminated entirely being recovered to either full or partial status in 1995. Unfortunately, some of the biological improvements observed between 1982 and 1990 (Ohio EPA 1991) downstream from the Lancaster WWTP, have shown a declining trend in recent years. Annual sampling at RM 87.2 (approximately two miles downstream from the WWTP) revealed *marginally good* and *good* benthic macroinvertebrate communities in 1990 and 1992, but only *fair* quality in 1994 and 1995. Diminished biological performance recorded recently at this station was likely a result of treatment irregularities associated with the on-going construction activities in support of the WWTPs expansion. However, despite the recent decline, a consistent *net increase* in total river miles of full and partial attainment as well as a significant reduction in the *magnitude* of impairment has been consistently observed within the study area since 1982 (Figures 2 and 3).

Hocking River Tributaries

Hunters Run

A total of 3.7 miles of Hunters Run between RM 3.7 (Crumley Rd.) and RM 0.36 (U.S. Rt. 22). Previous sampling near the mouth was conducted in 1982 and 1990. The objectives of the 1995 survey were to expand the assessment upstream from Lancaster and to evaluate the influence of the Lancaster Landfill.

The entire length of Hunters Run is currently designated WWH and was found to be in full attainment. The fish and benthic macroinvertebrate communities at each station consistently performed at *very good* to *exceptional* levels. No biological impact was documented within the urbanized portion of Hunters Run or in the segment downstream from the tributary draining the Lancaster Landfill. Analysis of water column samples did not reveal any significant chemical water quality problems. Nutrient concentrations were generally low, with several parameters at or only slightly above the method detection limits. D.O. concentrations well above the minimum and average WWH criteria were measured at all sites. The chemical water quality of Hunters Run was unaffected by the Lancaster Landfill and the urbanized portion of the subbasin.

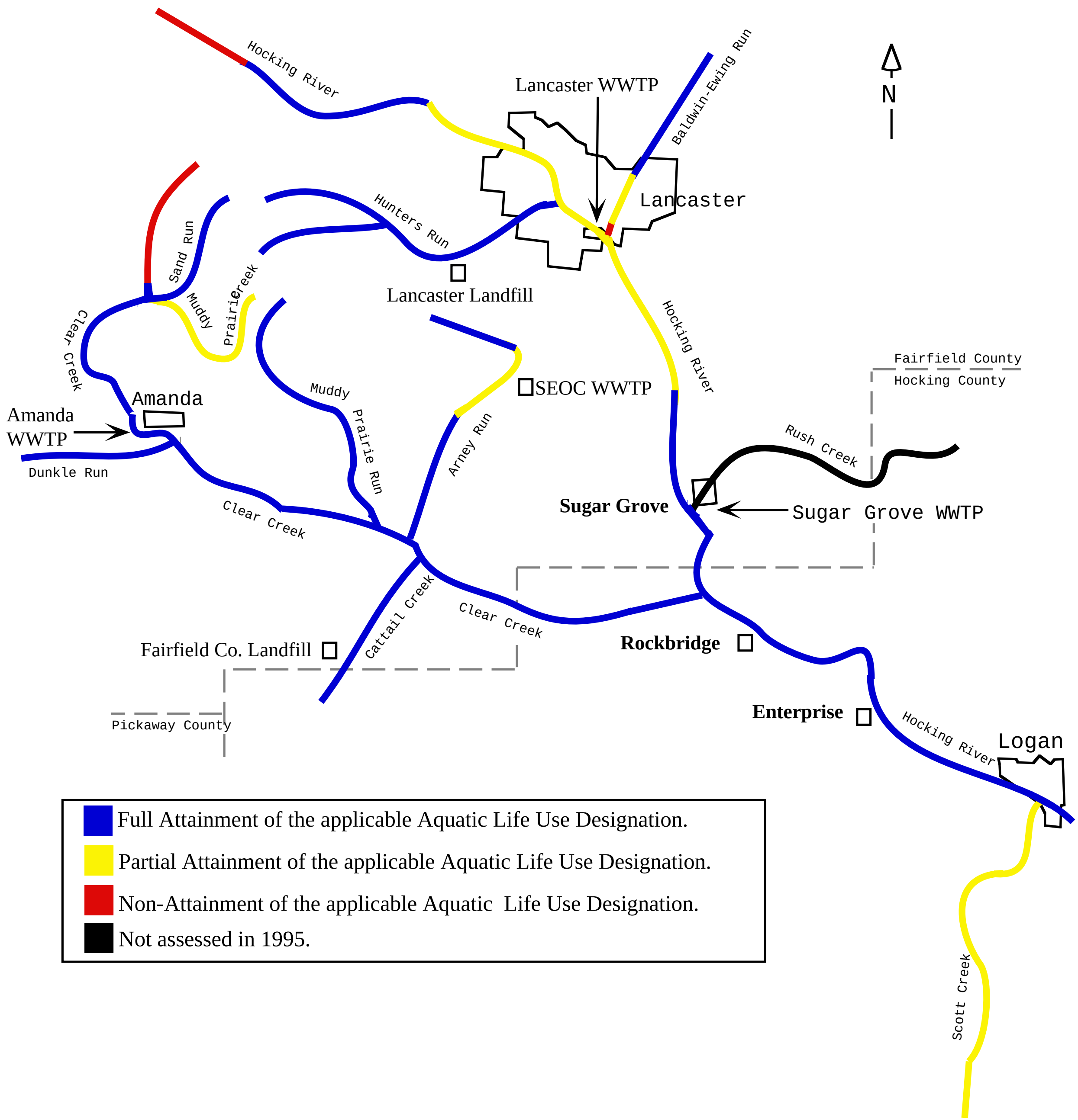


Figure 2. Attainment status of the applicable aquatic life use designations for the principal drainage network of the upper Hocking River study area, 1995.

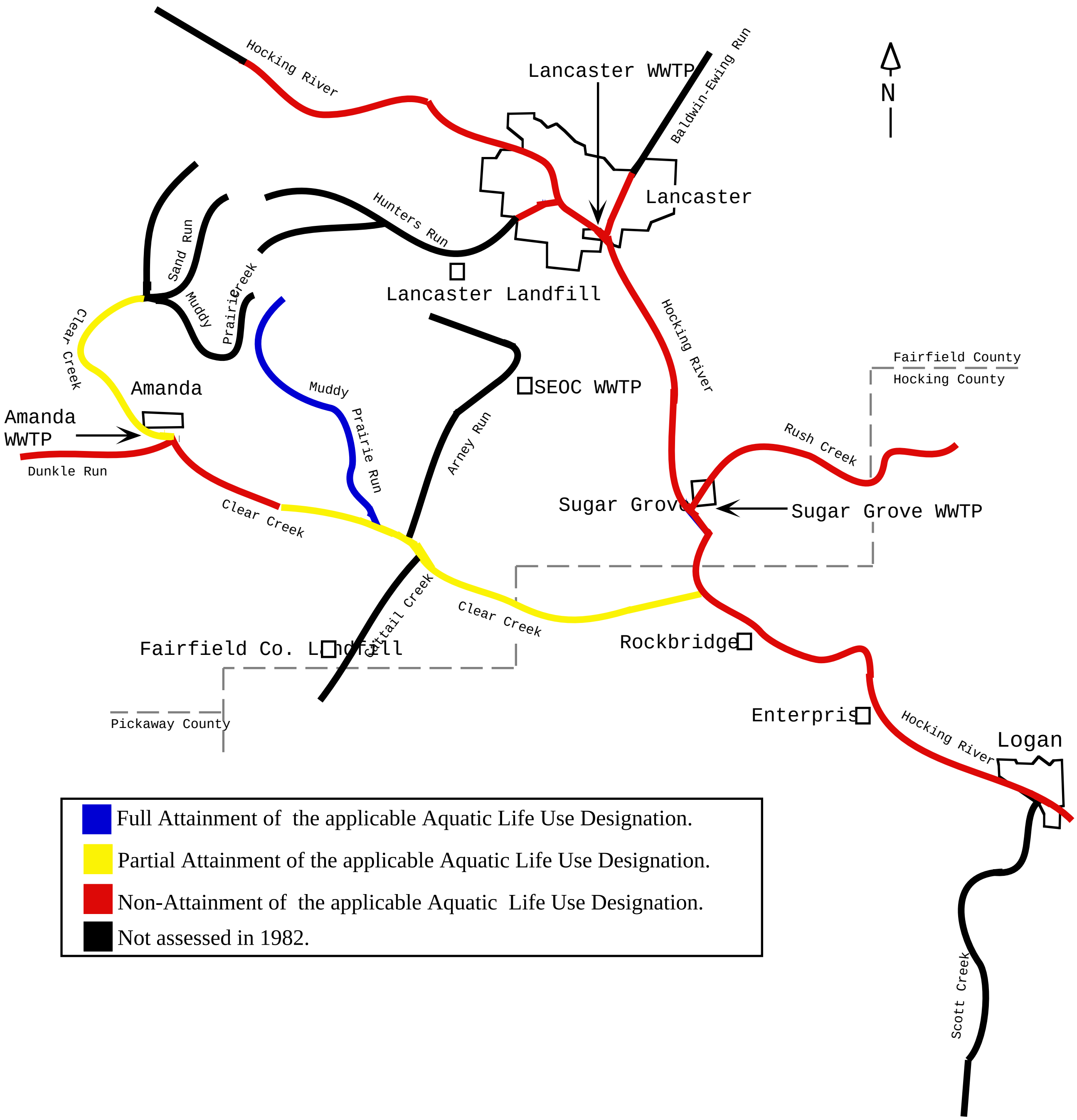


Figure 3. Attainment status of the applicable aquatic life use designations for the principal drainage network of the upper Hocking River study area, 1982.

Fecal coliform counts greater than the PCR and SCR criteria were the only exceedences of WQS. The highest counts were observed near the mouth, within the urbanized portion of the watershed. Given the absence of CSOs on Hunters Run the fecal contamination observed was likely associated with diffuse urban and rural nonpoint sources. Nearly one-half of the exceedences were recorded during periods of elevated runoff and stream discharge following heavy rainfall.

Baldwin-Ewing Run

A total of 2.7 miles of Baldwin-Ewing Run between RM 2.7 (Tiki Rd., upstream CSOs) and RM 0.1 (Lawrence Rd, downstream CSOs) was assessed in 1995. Previous sampling near the mouth was conducted by Ohio EPA in 1982 and 1990. The results showed 2.1 miles (77.8%) in full attainment of the WWH use. Partial attainment was indicated for 0.5 miles (18.5%), while non-attainment was observed for the remaining 0.1 mile (3.7%). Impairment of the lower 0.5 miles (partial and non-attainment) was driven solely by *fair* to *poor* benthic macroinvertebrate community performance, as all fish community samples yielded results consistent with the WWH biocriteria. The decline in the macroinvertebrate community at RM 0.2 was attributed to the discharge of untreated sewage from CSOs, while the discharge from a dewatering operation associated with construction activities at the Lancaster WWTP coupled with CSO inputs further impaired the community at RM 0.1. Evidence of CSO activity near the mouth included the common observance of sewage solids and human hygiene materials. The dewatering discharge markedly lowered temperature and covered the substrates with an iron precipitate. WQS exceedences were limited to fecal coliform counts greater than the PCR and SCR maximum criteria. The highest counts were observed near the mouth, within the urbanized portion of the subbasin downstream from the Lancaster CSOs. Two of the three exceedences were associated with periods of elevated runoff and stream discharge following heavy rainfall. During these wet weather periods nonpoint sources and CSOs are the most active.

Trend Assessment

The overall quality of Hunters Run at the mouth (RM 0.5/0.6) has demonstrated marked improvement since 1982. The biological conditions at that time were characterized as *fair* to *poor*, with both assemblages (fish and benthic macroinvertebrates) performing at a level far below the WWH biocriteria (non-attainment). Community performance improved to *marginally good* to *good* levels in 1990, meeting the WWH biocriteria (full attainment). In 1995, the fish community indicated additional improvements to *very good* and *exceptional* levels. The improved conditions within Hunters Run in 1990 and 1995 were associated with cessation of the Anchor Hocking discharge in 1978.

Ambient biological data were collected from Baldwin-Ewing Run in 1982, 1990, and 1995 at a station located near the confluence with the Hocking River, downstream from CSOs maintained by the city of Lancaster (RM 0.2/0.3). The results from the 1990 evaluation indicated improved conditions in comparison to 1982 as biological performance changed from *poor* to *fair*. While impairment existed in both sampling years (1982 and 1990) the magnitude of the impact was lessened in 1990. Departure from the WWH biocriteria during this period was attributed to chronic CSO releases (Ohio EPA 1991). By 1995, the CSO impact was diminished considerably, as the attainment status near the mouth improved to partial. Although evidence of CSO activity was apparent in 1995 (*e.g.,* observations of sewage solids and human hygiene devices) the frequency and duration, and resulting instream impacts, were reduced.

Scott Creek

A total of 8.9 miles of Scott Creek from RM 9.0 [adjacent SR 93, upstream mining influence(s)] to RM 0.1 (adjacent SR 93, near the mouth was assessed in 1995. Known stressors within this segment included active surface mines (Key Coal Co. and Empire Minerals Corp.) and livestock operations (Hocking Valley Horse Ranch). A previous survey was conducted within the headwaters of Scott Creek by Ohio EPA in 1978. The reach extending from the headwaters to the confluence of Dry Run (RM 3.9) is currently designated WWH. The downstream segment (RM 3.9 to the mouth) is designated EWH which has never been verified. The primary objectives in 1995 were to assess the current influence of the active strip mines, monitor overall environmental conditions through time, and determine the appropriateness of the existing EWH designation of the lower 3.9 miles.

The 1995 results found the entire segment impaired. The upper 5.1 miles of Scott Creek (56.7%) exhibited partial attainment of the WWH biocriteria. The remaining 3.9 miles (43.3%) failed to support the EWH use. The impairment of the headwaters was a result of several factors which included; intermittent flows, degraded habitat, and possibly mine drainage. Failure to achieve an exceptional level of biological performance within the lower segment was due to natural limiting factors. However, both the fish and benthic macroinvertebrate communities met the WWH biocriteria. As such, the existing EWH use designation seems inappropriate for the lower segment.

Analysis of water column chemistry samples did not reveal significant water quality problems in Scott Creek. Demand parameters and nutrient concentrations were generally low and longitudinally stable with several analytes at or only slightly above the method detection limits. D.O. concentrations were well above the minimum and average criteria within the WWH segment. Of the six chemical samples collected within the EWH segment at RM 0.1, two D.O. values were below the 5.0 mg/l minimum criterion. Two fecal coliform counts were in excess of the maximum PCR standard at RM 5.6 (downstream from the horse farm) and RM 0.1, respectively. These samples were collected in late-July under elevated surface runoff and stream flows. As such, the observed fecal contamination was likely a result of diffuse nonpoint source runoff. Both the D.O. and fecal coliform results represented the only water quality criteria exceedences.

Chronic mine drainage problems were not indicated in the water chemistry results at RM 5.6. This station is situated downstream from a small tributary network that drains the active surface mines. The common mine drainage parameters (manganese, aluminum, iron, sulfates, TDS, and pH) were at expected levels, except for sulfates which was elevated.

Trend Assessment
The 1978 fish survey revealed *very good* to *exceptional* communities (full WWH attainment - 0.9 miles) in the headwaters of Scott Creek, upstream from the influence of mine drainage (RM 8.9 and RM 8.1). Downstream from the tributary draining active mines (Key Coal Co., Allied Coal, and Empire Minerals), community performance was reduced to *fair* and *poor* levels (non-attainment of WWH - 2.4 miles). Departure from the WWH biological criteria at that time was attributed to the influence of spills and periodic discharges from Key Coal (Ohio EPA 1978). The results of the 1995 survey revealed reduced community performance within the headwaters at RM 9.0/8.9 in comparison with the 1978 results. The decline was attributed to intermittent stream flows. Whether the intermittency was anthropogenic in origin or represented a natural event was not clear. Community performance downstream from the mine impacted tributaries (RM 5.6) was comparable between 1978 and 1995, suggesting the possibility of continued mine drainage influences.

Clear Creek and Principal Tributaries

<u>Clear Creek</u> (mainstem)
A total of 21.8 miles of Clear Creek between RM 21.8 (SR 188, headwaters) and RM 1.9 (USGS gage, Camp Wyandot) was assessed in 1995. A similar survey was conducted by Ohio EPA in 1982 and scattered sampling occurred in 1983, 1988, and 1990. Full attainment of the existing WWH aquatic life use was indicated for 16.3 miles (74.8%) of Clear Creek in 1995. Impairment was limited to a 5.5 mile headwater segment (25.2%). Departure from the WWH biocriteria was driven solely by *poor* benthic macroinvertebrate community performance, as the fish community was found fully consistent with the WWH biocriteria. The structure and composition of the macroinvertebrate community appeared reflective of intermittent flows and unstable habitat conditions. Despite significant habitat, sediment bedload, and land use problems within the upper and middle reaches, the remaining 16.3 miles of Clear Creek consistently supported communities fully consistent with, and at times in excess of, the WWH biocriteria. No significant biological impact to Clear Creek was evident downstream from the Amanda WWTP (RM 14.5) or the SEOC WWTP via Arney Run (RM 8.0).

Fecal coliform counts in excess of the PCR criteria were the primary water quality exceedences in Clear Creek. The fecal contamination was limited to the upper reaches between RM 21.76 and RM 13.2 (SR 159). The likely source(s) of the elevated bacteria counts included; diffuse rural nonpoint sources, on-site septic systems, and possibly the Amanda WWTP. Excess bacteria counts were observed in only six of the 47 samples collected and did not appear to pose a serious threat to the PCR use designation. Other water quality exceedences included elevated lead and depressed D.O. concentrations. These parameters exceeded their respective criteria at RM 13.2 (downstream from Amanda) and RM 6.99 (downstream from Arney Run). The depressed D.O. observed at RM 13.2 may have resulted from the discharge of oxygen demanding wastes from the Amanda WWTP. The source of the lead exceedence at RM 6.99 is not clear at this time, but could have emanated from any one of several sources upstream from this point (Mid-West Fabricating Co., Amanda WWTP, or SEOC WWTP). The exceedences occurred in only one of the six samples collected at each station on the same date in early September. As such, they likely represent a temporal event, possibly related to the batch process and discharge from the Amanda WWTP. Regardless, these results did not represent a significant threat to the water quality of Clear Creek, as nutrient, demand, and other water quality parameters, including diel D.O. values, indicated *good* to *exceptional* water quality.

Trend Assessment

Ambient biological data were collected from Clear Creek at various locations in: 1982, 1983, 1988, 1990, and 1995. In 1982 collections were made at six stations, evaluating the stream reach between RM 16.3 (SR 22, upstream from Amanda) and RM 2.3 (Camp Wyandot bridge). The sampling efforts between 1983 and 1990 were scattered, evaluating discrete reaches of Clear Creek. The 1995 survey provided the same spatial coverage as that in 1982 in addition to the headwaters at RM 21.8 (SR 188). For the purposes of the trend assessment only the 1982 and 1995 survey data were deemed robust enough (*i.e.,* large enough number of samples and spatial coverage) to provide a meaningful evaluation of changes in the conditions of Clear Creek through time.

Community performance in 1982 indicated partial and non-attainment of the WWH use for 11.6 miles (71.2%) and 4.7 miles (28.8%), respectively. Full attainment was not observed at any station. The subpar assemblages that typified much of Clear Creek in 1982 were attributed to a combination of factors. Much of the upper and middle portions of Clear Creek have been channelized and the adjacent land use (intensive row crop agriculture) widely encroached on and occupied the riparian zone. The stream banks consistently lacked a wooded riparian corridor, as crops were cultivated to the edge of the stream bank. This situation promotes severe bank erosion and the rapid delivery of sediment laden runoff to the stream channel, embedding coarse substrates and contributing to the sediment bedload. Channelization and sediment deposition work in concert, degrading macrohabitat quality through physical simplification. The loss or simplification of habitat, in turn, directly affects the ability of the stream to support and maintain a diverse and well organized assemblage of aquatic organisms. These factors, and to a lesser extent, pollutant loadings from Amanda (unsewered at that time) were the major stressors to Clear Creek in 1982 (Ohio EPA 1985).

The results of the 1995 survey revealed complete biological recovery throughout the study area, as the 16.3 reassessed miles fully attained the WWH biocriteria. Impairment in 1995 was limited to a headwater segment that was not assessed in 1982. The dramatic improvements observed in 1995 were associated with the lessening of the stressors identified in 1982. First, following the widespread adoption of conservation tillage practices within the subbasin, average soil loss on cropland was reduced by more than 50%, from 10 tons per acre to less than 5 tons per acre between 1982 and 1994 (USDA 1995). The reduced sediment loading to Clear Creek from upland erosion contributed to improved stream habitat. Secondly, considerable recovery of the wetted channel, within the confines of the active channel, was observed in 1995. The reestablishment of some natural features of stream habitat over the intervening 13 years undoubtedly contributed to additional habitat improvement. Lastly, the Amanda WWTP recently came on line which alleviated most of the unsewered problems of the past.

Arney Run

A total of 4.3 miles of Arney Run between RM 4.3 (Christmas Rock Rd., upstream SEOC WWTP tributary) and RM 0.1 (near the mouth) was assessed in 1995. The aquatic life use designation for the entire length of Arney Run is WWH. The primary objective of the 1995 survey was to evaluate the influence of wastewater from the SEOC WWTP, via an unnamed tributary that joins Arney Run at RM 4.2.

In 1995, 1.3 miles (30.2%) of Arney Run was in full attainment of the WWH use. The remaining three miles (69.8%) exhibited partial attainment. Full attainment was observed within the extreme upper limits of the study area (RM 4.3) and further downstream near the mouth (RM 0.1). The intervening impaired segment extended three miles downstream from the SEOC WWTP tributary at RM 4.2. Complete biological recovery was indicated at RM 0.1. Departure from the WWH use was driven solely by a decline in the benthic macroinvertebrate community quality downstream from the WWTP. The fish assemblage consistently met the applicable biological criteria throughout the study area.

Fecal coliform counts regularly exceeded the PCR standard in Arney Run, with the most severe contamination (in terms of frequency and magnitude) downstream from the confluence of the SEOC WWTP tributary at RM 3.13. Additionally, one of five samples collected at this station had a total phosphorus concentration greater than the 1.0 mg/l WQS guideline. Elevated phosphorus and fecal coliform counts were a result of wastewater discharged by the SEOC WWTP, as most exceedences were not correlated with runoff events. Concentrations of other parameters during daytime (*i.e.,* demand and nutrients) were typically low and longitudinally stable. Ammonia-N was commonly observed at or near the method detection limit, and D.O. concentrations remained well above WWH criteria throughout the study area. In no case did the diel sampling indicate D.O. concentrations below the 4.0 mg/l WWH minimum criterion.

Selected Clear Creek Tributaries

The remaining Clear Creek tributaries evaluated in 1995 included; Muddy Prairie Run, Muddy Prairie Creek, Sand Run, Dunkle Run, and Cattail Creek. The sampling effort was limited to the collection of ambient biological data only. Samples were taken at one location on each stream, typically less than one mile upstream from the mouth. Similar sampling was conducted in 1982 on Muddy Prairie Run and Dunkle Run, and for five years (between 1987 and 1993) in Cattail Creek. All of these streams are currently designated WWH. The primary objectives of the 1995 sampling were to evaluate biological conditions through time where historical information exists, evaluate previously unassessed water bodies, and evaluate the potential biological impact from the Fairfield Co. Landfill on Cattail Creek.

With the exception of Muddy Prairie Creek, all fish and benthic macroinvertebrate community samples collected from these Clear Creek tributaries were found to be fully consistent with the WWH aquatic life use. Community performance from the attaining streams ranged between *very good* and *exceptional*. No ambient biological impact was evident in Cattail Creek downstream from the Fairfield County Landfill. The impairment of Muddy Prairie Creek was driven solely by the failure of the benthic macroinvertebrates to perform at the WWH level, as the fish community was in *exceptional* condition. Macroinvertebrate communities collected from natural substrates were considered *fair* based on the low EPT taxa richness and the QCTV score; both values reflected performance below ecoregional expectations. Enrichment derived from nonpoint source agricultural runoff and channelization were considered the primary negative influences.

Trend Assessment

Historical biological community data collected from the Clear Creek tributaries evaluated in 1995 were available for Muddy Prairie Run, Dunkle Run, and Cattail Creek. The results from both the 1982 and 1995 sampling indicated full attainment of the WWH use in Muddy Prairie Run. Improved conditions were indicated in 1995 in Dunkle Run when compared to the results from the 1982 sampling. The non-attainment observed in 1982 was replaced by full attainment in 1995. Numerous qualitative benthic macroinvertebrate samples have been collected from Cattail Creek downstream from the Fairfield County Landfill since 1987. Collections have consistently indicated *exceptional* conditions with high EPT taxa richness and QCTV scores. No significant changes in quality have been observed since sampling began in 1987.

CONCLUSIONS

Hocking River (mainstem)

- As a result of treatment process upgrades, improvements to the collection system, and the implementation of a successful industrial pretreatment program at Lancaster, significant improvements in the chemical water quality and biological quality of the upper Hocking River have occurred over the past 17 years. The 1995 survey documented reduced loadings of nutrients, oxygen demanding wastes, and metals from the Lancaster WWTP, with commensurate improvements in ambient water quality and biological community performance within and downstream from the Lancaster metropolitan area.

- Full attainment of the existing WWH aquatic life use occurred within the unmodified portions of the mainstem upstream from Lancaster (RM 95.2 to RM 92.2) and downstream from the immediate zone of influence of the Lancaster WWTP (RM 82.0 to RM 69.5). Conditions have so improved downstream from Lancaster that *very good* to *exceptional* community performance was observed throughout the lower 12 miles of the study area. These findings indicated a near complete recovery from the extremely degraded conditions (non and partial attainment) documented in 1982 and 1990.

- Impairment of the WWH aquatic life use in 1995 was limited to two segments. The first was located within the extreme headwaters and was associated primarily with channelization and nutrient enrichment (2.9 miles of non-attainment). The other segment of impairment included the 10.2 mile portion of the Hocking River flowing through and downstream from Lancaster. Departure from the WWH biocriteria upstream from the WWTP was attributed primarily to degraded habitat caused by past channelization. CSO discharges and resulting instream impacts documented in the past were greatly reduced in 1995. In recognition of the existing modified conditions, the lack of significant recovery through time, and the likelihood of future channel maintenance activities, this segment meets the criteria for redesignation to the MWH aquatic life use designation. The imposition of this use designation would bring the channel modified segment of the Hocking River (upstream from the influence of the WWTP) into full attainment (3.2 miles). A more detailed justification for this use change appears in the Recommendations, Status of Aquatic Life Uses, section of this report.

- The impairment downstream from the Lancaster WWTP in 1995 was primarily the result of organic enrichment, as toxicity, avoidance, or chronic nutrient enrichment were not evident. The zone of impairment extended approximately seven miles downstream from the Lancaster WWTP 001 discharge. However, a consistent net increase in total river miles of full and partial attainment of the WWH use, as well as a significant reduction in the magnitude and severity of impairment, has been consistently observed within the study area since the initial survey in 1982. While recovery of the existing WWH use was not complete, continued and steady progress towards this goal was clearly evident in the 1995 results. Following the completion of the WWTP expansion and adequate time for full recovery, the upper Hocking River should be reevaluated at the earliest opportunity.

Hocking River Tributaries

Hunters Run and Baldwin-Ewing Run

- Hunters Run was found to fully support the WWH aquatic life use designation throughout the reach evaluated in 1995. No instream impacts were evident downstream from the tributary network that drains the city of Lancaster landfill. Within the lower portion, Hunters Run was unaffected by the urban landscape and was fully recovered from the degraded conditions indicated in previous surveys in 1982 and 1990.

- Sampling in Baldwin-Ewing Run showed impairment of the WWH use within the urbanized portion of the subbasin, downstream from CSOs maintained by the city of Lancaster. Sewage solids, the common observance of human hygiene devices, and elevated fecal coliform counts all indicate regular CSO discharges. Full attainment of the WWH use was indicated upstream from the CSOs. Near the mouth a dewatering discharge further depressed the benthic macroinvertebrate community. As this discharge is temporary, servicing construction activities at the WWTP, the effects are likely temporary.

Scott Creek

- The entire length of Scott Creek was impaired to varying degrees (partial and non-attainment). The upper, WWH designated reach only partially supported the aquatic life use. Causes of the impairment included flow intermittency, degraded habitat, and possibly mine drainage impacts. Departures from the biological criteria in the lower, EWH designated segment was reflective of natural conditions. Biological performance within this segment was fully consistent with the WWH biocriteria. As such, the previously unverified EWH designation was deemed inappropriate, and this segment will be redesignated WWH. A more detailed justification for this use change is presented in the Recommendations, Status of Aquatic Life Uses, section of this report.

- In comparison with a previous survey, conditions throughout Scott Creek have not improved. The extreme headwaters, which fully attained in 1978, was impaired in 1995. The cause of the decline was a result of intermittent stream flows, possibly a natural phenomenon.

Clear Creek and Principal Tributaries

Clear Creek (mainstem)

- More than 70% of the Clear Creek mainstem was in full attainment of the WWH aquatic life use designation in 1995. Impairment was limited to the extreme headwaters. Departures from the WWH biocriteria were attributed to intermittent and unstable habitat conditions. No impairment was evident downstream from the recently constructed Amanda WWTP or Southeast Ohio Correctional Institution (SEOC) WWTP (via Arney Run).

- In comparison with a previous survey conducted in 1982, significant biological improvements were evident throughout the mainstem. The positive changes were the result of the following factors; 1) a significant reduction in the gross soil erosion rate through the widespread adoption of conservation tillage practices was evident throughout the watershed between 1982 and 1994, which reduced sedimentation and improved habitat quality; 2) natural physical recovery of habitat attributes lost to channelization has occurred over the intervening 13 years; and, 3) the impacts of pollutant loadings from Amanda were largely ameliorated following construction of the Amanda WWTP.

- Despite the improved biological conditions that now typify much of Clear Creek, the eroding and unstable uplands pose a serious threat to the maintenance of the existing quality. Sediment bedload exported downstream from the intensively cultivated uplands appeared to have significant downstream impacts within the lower portion of the mainstem. Although this segment still retains positive habitat characteristics, sediment export will significantly degrade near and instream habitat quality through persistent and gradual habitat simplification. Over time this process could result in impairment of the WWH use.

- Results of the 1995 water chemistry sampling showed no significant exceedences of water quality criteria. Nutrient and oxygen demanding wastes discharged from Amanda, SEOC, and other minor facilities had no negative effects and water quality throughout the mainstem.

Arney Run

- Three miles of Arney Run downstream from the SEOC WWTP tributary were impaired. Biological samples collected downstream from the treatment facility indicated enriched conditions. The remaining portions of Arney Run (upstream from the WWTP and further downstream, near the mouth) fully supported the WWH use.

- Elevated phosphorus and fecal coliform counts were found downstream from the SEOC WWTP tributary. These data indicate inconsistent wastewater treatment as most exceedences were not associated with wet weather events.

Selected Clear Creek Tributaries

- Full attainment of the WWH use was observed in Muddy Prairie Run, Sand Run, Dunkle Run, and Cattail Creek. Only Muddy Prairie Creek was found to partially support the WWH use. Departures from the WWH biocriteria were attributed to agricultural nonpoint source enrichment and modified habitat.

- In comparison with previous surveys of the Clear Creek tributaries, conditions have improved in Dunkle Run. Non-attainment of the WWH use indicated in 1982 has recovered to full attainment in 1995. Biological data from all other tributaries, where historical information exists, indicated stable communities.

RECOMMENDATIONS

Status of Aquatic Life Uses

Several of the streams and rivers evaluated as part of this survey were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of in-stream biological data or numerical biological criteria. This study represents a first use of this type of biological data to evaluate and establish aquatic life use designations. While some of the changes may appear to constitute "downgrades" (*i.e.*, EWH to WWH, WWH to MWH, etc.) or "upgrades" (*i.e.*, LWH to WWH, WWH to EWH etc.), any changes should not be construed as such because this constitutes the first use of an objective and robust use evaluation system and database. Ohio EPA is under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus some of the following aquatic life use recommendations constitute a fulfillment of that obligation. The beneficial use designation matrix for the upper Hocking River study area is presented in Table 2.

The following streams or stream segments evaluated in 1995 are recommended to be designated to or retain their current WWH aquatic life use designation. Maintenance of the use applies to the entire length of the river or stream unless otherwise noted.

Upper Hocking River (mainstem)

- Headwaters to Lithopolis Rd, RM 94.9 (WWH - existing)
- Baldwin-Ewing Run confluence, RM 89.02 to Logan, Scott Creek RM 69.0 (WWH - existing).

Hocking River Tributaries

- Hunter Run (WWH - existing)
- Baldwin-Ewing Run (WWH - existing)
- Scott Creek - headwaters to the confluence of Dry Run, RM 3.9 (WWH - existing)

Clear Creek and Selected Tributaries

- Clear Creek (WWH - existing)
- Arney Run (WWH - existing)
- Muddy Prairie Run (WWH - existing)
- Muddy Prairie Creek (WWH - existing)
- Sand Run (undesignated/WWH - recommended)
- Dunkle Run (WWH - existing)
- Cattail Creek (undesignated/WWH - recommended)

The existing WWH aquatic life use designation for the following streams or stream segments evaluated in 1995 are recommended for redesignation.

Hocking River (mainstem)

Hocking River in and around Lancaster has a long history of extensive hydromodification. These activities were primarily driven by the demand for flood protection, following severe flooding in 1907, 1913, and 1948. The segment through Lancaster and extending six miles upstream was initially channelized, straightened, and levied by Fairfield County in 1914. The same segment was once again dredged in 1937. A Soil Conservation Service (SCS) watershed project was completed in 1961 that included the installation of floodwater retarding structures (small impoundments) and several miles of channelization in the upper Hocking River mainstem and selected tributaries upstream from Lancaster. The net result of these projects provided protection from floods of a 25-year recurrence interval (Ohio DNR 1966). A plan was submitted in 1982 by several stakeholders in Fairfield County to further modify the Hocking River through Lancaster and enhance existing levees for improved flood protection (Hunters Run Conservancy District et al. 1982) However, no action in support of this project has occurred to date.

The details concerning a channel maintenance schedule and more recent channel work on the Hocking River mainstem in and around Lancaster were not available from the Fairfield County Engineer, city of Lancaster (engineer and safety director), or the U.S. Army Corps of Engineers. However, additional channel work (dredging, obstruction removal, or levee enhancement) has likely occurred since 1961, particularly in view of the rapid commercial development within the flood plain during the past ten years. Despite the apparent lack of a formalized channel maintenance schedule for the Hocking River (through Lancaster), it is likely that the current conditions will be maintained or further modified to provide improved flood protection. These activities would prevent the reestablishment of a natural channel and the associated positive habitat features. Unfortunately, the highly modified conditions that now typify this portion of the upper Hocking River will likely persist into the foreseeable future, precluding attainment of the WWH use because of continued habitat degradation.

Pollution abatement activities implemented within the city of Lancaster have been largely successful in rectifying the grossly polluted and toxic conditions documented in the past. Given the absence of significant water quality problems upstream from the Lancaster WWTP, the ambient biological effects of degraded habitat alone were documented in 1995. The results from this survey identified poor habitat quality (not water quality as in the past) as the major factor now limiting ambient biological performance within this segment. In light of these findings it appears that the Hocking River (through Lancaster) does not possess, nor will be allowed to naturally reestablish, the full compliment of near and in-stream habitat features required to support and maintain WWH communities. In recognition of both the existing conditions and the near certainty of future maintenance activities, the following segment of the Hocking River is recommended for redesignation to the MWH aquatic life use designation.

- Lithopolis Rd., RM 94.9 to the confluence of Baldwin-Ewing Run, RM 89.02 (WWH - existing/MWH - recommended).

The attainment status for the upper Hocking River mainstem based on the recommended use designation change is 20.8 miles (67.7%) full, 7.3 miles (22.8%) partial, and 2.9 (9.5%) non-attainment.

Hocking River Tributaries

The results of the 1995 biosurvey found that the lower portion of Scott Creek failed to support an EWH assemblage of fish and benthic macroinvertebrates. Failure to achieve the EWH use was attributed to natural habitat limitations, though the segment supported the WWH use. Therefore, the following segment of Scott Creek is recommended for redesignation to the more appropriate WWH aquatic life use designation.

Scott Creek

- From the confluence of Dry Run (RM 3.9) to the mouth (EWH - existing/WWH - recommended).

Attainment status for Scott Creek based on the recommended use designation change is 3.7 miles (41.1%) full and 5.3 miles (58.9%) partial.

Status of Non-Aquatic Life Uses

Based on the findings of this study, the Primary Contact Recreation (PCR) use designation should be retained for all of the stream and river segments evaluated in 1995. Despite reduced CSO discharges within Lancaster in 1995, the PCR use designation of the Hocking River continues to be threatened by wet weather overflow events, as numerous exceedences of the PCR average and maximum, and the less stringent SCR criterion were recorded within the greater Lancaster area. CSO control measures implemented by Lancaster appeared largely successful in remediating the chronic problems documented by previous investigations (Ohio EPA 1985, 1991). However, additional controls may be needed to retain the viability of the PCR use.

Table 2. Existing and recommended use designations for all of the rivers, streams, or stream segments contained within the 1995 upper Hocking River study area.

Stream Segment	Use Designations												
		Aquatic Life Habitat						Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Hocking River													
Headwaters to Lithopolis Rd. (RM 94.9)□		+							+	+		+	
Lithopolis Rd. (RM 94.9) to Baldwin-Ewing Run (RM 89.02)				▲					+	+		+	
Baldwin-Ewing Run (RM 89.02) to Rock-bridge		+							+	+		+	
Bordering Rockbridge Nature Preserve	o	+							*	*		+	
Rockbridge Nature Preserve to Scott Creek (RM 69.0)		+							*	*		*/+	
Baldwin-Ewing Run													
Entire length		+							+	+		*/+	
Hunters Run													
Entire length		+							+	+		*/+	
Scott Creek													
Headwaters to Dry Run (RM 3.9)		+							+	+		+	
Dry Run to Mouth		▲							*	*		*/+	

Stream Segment	Use Designations												
		Aquatic Life Habitat						Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Clear Creek													
Entire length		+							+	+		+	
Arney Run													
Boundaries of Christmas Rocks Preserve	o	*/+							*	*		*/+	
All other segments		*/+							*	*		*/+	
Muddy Prairie Run													
Entire length		+							+	+		*/+	
Dunkle Run													
Entire length		*/+							*	*		*/+	
Muddy Prairies Cr.													
Entire length		*/+							*	*		*/+	
Sand Run													
Entire length		▲							▲	▲		▲	
Cattail Creek													
Entire length		▲							▲	▲		▲	

* - Designated use based on the 1978 water quality standards (unverified).
+ - Designated use based on the results of an integrated ambient biological assessment performed by Ohio EPA (verified).
*/+ - Indicates verification of a previously unverified designation based on the results from the 1995 Upper Hocking River survey.
▲ - Recommended aquatic life use designation based on the results from the 1995 upper Hocking River survey.
o - Designated use based on justification other than the results of an integrated ambient biological assessment.

Future Monitoring Needs

A re-evaluation of the areas investigated in 1995 should be conducted in 2000 or 2005 as provided in the Five-Year Basin Monitoring Approach. Streams within the upper Hocking River basin which were not evaluated in 1995 should receive a higher priority for reassessment in 2000.

The Hocking River downstream from the Lancaster WWTP is sampled biennially for macroinvertebrates at RM 87.2. Future monitoring at this station should be adequate to establish trends and determine if the initial declines observed in 1994 and 1995 were temporary (related to treatment irregularities associated with construction activities at the WWTP) or long term (indicative of more systematic treatment problems).

Other Recommendations

Clear Creek basin

Sediment export from the unstable and eroding glaciated uplands of the Clear Creek basin was identified as a prominent threat to the maintenance of the existing WWH use within the lower, glaciated, segment of the mainstem. Although significant strides have been made in reducing overland erosion through the widespread adoption of conservation tillage practices since 1982, every effort should be made to further reduce the delivery of sediment to Clear Creek. The need exists within the agricultural uplands to reestablish riparian forest buffers and to enhance or maintain existing areas. The development of a persistent wooded riparian corridor will stabilize eroding stream banks, limit the delivery of sediment, and promote the development of a more natural low flow stream channel. Additionally, wooded corridors will enhance in-stream habitat complexity, attenuate sunlight, and will promote a more rapid assimilation of nutrient rich agricultural runoff. Strategies to achieve this goal are outlined in the Clear Creek Watershed Restoration and Management Plan (USDA 1995) and should be implemented as soon as possible.

If the unstable and eroding conditions identified within the uplands of the Clear Creek basin continue unabated, impairment of the lower unglaciated segment (over time) is highly probable. Although this segment still retains many high quality habitat features, sediment export from the uplands will significantly degrade near and in-stream macrohabitat quality through persistent and gradual habitat simplification.

STUDY AREA DESCRIPTION

Physiography and Land Use

The upper Hocking River subbasin drains 459 miles^2 of western Perry, southern Fairfield, and northern Hocking Counties. The headwaters originate in the glacial deposits of Fairfield County approximately 35 miles southeast of Columbus. The Hocking River flows in a general southeasterly direction through the cities of Lancaster and Logan. Downstream from the lower limits of the study area the river continues through Athens County where it joins the Ohio River near Coolville. The elevation of the Hocking River at its source is 997 feet and it flows for a total length of 101.6 miles, with an average gradient 5.7 ft./mile (Ohio DNR 1960). The principal tributaries to the Hocking River within the study area include Rush Creek, which joins the Hocking from the east near Sugar Grove, and Clear Creek which joins the Hocking from the west two miles downstream from Rush Creek. Rush and Clear Creek drain 235 and 92 miles ^{2}, respectively. A map showing principal streams and tributaries, population centers, pollution sources, and environmental monitoring stations of the 1995 upper Hocking River study area is presented in Figure 4. Specific sampling station locations are presented in Table 3.

Hocking River basin drains both glaciated and unglaciated physiographic areas, trisected by three distinct ecoregions, the Eastern Corn Belt Plains (ECBP), the Erie-Ontario Lake Plain (EOLP), and the Western Allegheny Plateau (WAP) (Omernik and Gallant 1988). The ECBP is a glaciated region, characterized by relatively flat terrain, typically with less than 50 ft. changes in elevation. Soils are derived from high lime glacial till materials. The predominant land use is agricultural (approximately 70%). Poor soil drainage has prompted extensive stream channelization to assist field tile systems. Streams or stream segments evaluated in 1995, contained within the ECBP included the headwaters of both the Hocking River and Clear Creek.

The EOLP region is a glacial plain characterized by outwash terraces, till plains, ridges, drumlins, and remnant beach ridges. These glacial features have a significant local relief with erratic changes from 100 to 300 feet occurring over short distances. This region is generally a transition zone between the flatter, till plains of the ECBP and the hilly, highly dissected terrain of the unglaciated WAP. Soils are derived from glacial till and lacustrine deposits. The dominant land use is agricultural, though not as pervasive as in the ECBP (Whittier et. al. 1987). The EOLP accounts for much of the upper Hocking River drainage from Lancaster to Rush Creek.

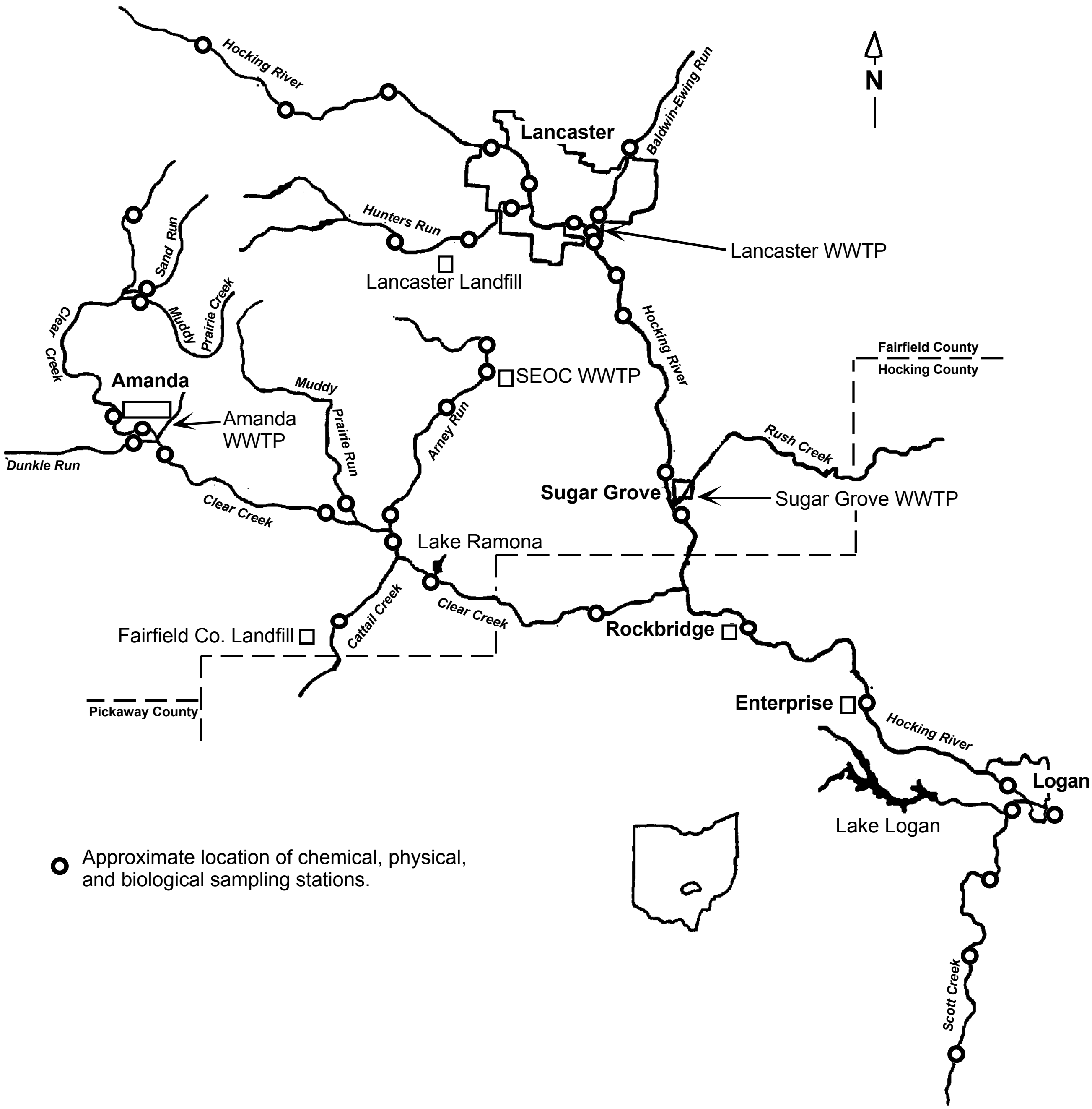


Figure 4 The upper Hocking River study area showing principal streams and tributaries, population centers, pollution sources, and environmental monitoring stations.

Table 3. Sampling locations (effluent sample - E, water chemistry - C, sediment chemistry - S, benthos - B, fish - F, and Datasonde - D) in the Hocking River basin study area, 1995.

Stream River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 minute Quadrangle Map
Hocking River				
100.2	F	39∞54'42"/80∞44'26"	Pickerington Rd.	Carroll
100.0	B	39∞45'36"/82∞44'17"	Pickerington Rd.	Carroll
98.39	C	39∞44'54"/82∞42'45:	at Rockmill	Carroll
95.2	F,S,D	39∞44'47"/82∞40'12"	Hooker Cemetery	Amanda
95.1	B	39∞44'50"/82∞40'10"	Hooker Cemetery	Amanda
94.9	C	39∞44'51"/82∞39'54"	Campground Rd - at Hooker	Amanda
93.15	D	39∞43'55"/82∞38'22"	Ely Rd.	Amanda
92.2	F	39∞43'14"/82∞37'36"	Pierce Ave. - Lancaster	Lancaster
92.1	B	39∞42'46"/82∞37'14"	Pierce Ave. - Lancaster	Lancaster
91.93	C	39∞43'41"/82∞37'05"	Pierce Ave. - Lancaster	Lancaster
90.8	F	39∞42'48"/82∞36'33"	US 22 - Lancaster	Lancaster
90.67	C	39∞42'16"/82∞36'34"	US 22 - Lancaster	Lancaster
90.7	B	39∞42'45"/82∞36'33"	US 22 - Lancaster	Lancaster
89.45	C	39∞42'22"/82∞35'37"	Maple St. -Lancaster	Lancaster
89.4	F,B,D	39∞42'23"/82∞35'37"	Maple St. - Lancaster	Lancaster
89.05	E	39∞42'24"/82∞35'12"	Lancaster WWTP	Lancaster
89.04	F,B,C	39∞42'23"/82∞35'11"	Lancaster WWTP **mix zone**	Lancaster
89.0	F	39∞42'17"/82∞35'04"	dst. Lancaster WWTP	Lancaster
88.99	B,C	39∞42'07"/82∞34'59"	dst. Lancaster WWTP	Lancaster
88.5	S	39∞41'56"/82∞37'28"	Deeds Rd. - dst. Lancaster WWTP	Lancaster
87.32	C	39∞41'09"/82∞34'24"	US 33 - dst. Lancaster WWTP	Lancaster
87.2	B	39∞41'04"/82∞34'28"	US 33 - dst. Lancaster WWTP	Lancaster
87.1	F,S,D	39∞41'02"/82∞34'27"	US 33 - dst. Lancaster WWTP	Lancaster
82.9	C	39∞38'11"/82∞33'14"	Sugar Grove Rd. - ust. Rush Creek	Lancaster
82.0	F,C,S,D	39∞37'27"/82∞33'09"	Sugar Grove Rd. - ust, Rush Creek	Lancaster
81.4	B	39∞37'11"/82∞32'42"	adj. Buckeye Rd. - Dst Rush Creek	Rockbridge
81.3	C	39∞37'08"/82∞32'43"	adj. Buckeye Rd .- Dst Rush Creek	Rockbridge
81.2	F,D	39∞36'53"/82∞32'36"	adj. Buckeye Rd. - Dst Rush Creek	Rockbridge
77.27	C	39∞34'55"/82∞31'00"	at Rockbridge	Rockbridge
77.2	F,B	39∞35'55"/82∞32'25"	at Rockbridge	Rockbridge
73.6	B	39∞33'57"/82∞28'30"	at Enterprise	Logan

Table 3. continued.

Stream River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 minute Quadrangle Map
Hocking River				
73.37	C	39∞34'54"/82∞28'30"	CR 31 - at Enterprise	Logan
73.2	F,D	39∞33'38"/82∞28'30"	at Enterprise	Logan
69.6	B	39∞32'30"/82∞25'22"	SR 664 - West Logan	Logan
69.5	F,D	39∞32'27"/82∞25'18"	SR 664 - West Logan	Logan
68.33	C	39∞32'27"/82∞24'28"	SR 93 - dst Scott Creek	Logan
Hunters Run				
3.7	B	39∞41'53"/82∞39'30"	Crumley Rd. - ust. Landfill	Amanda
3.5	F	39∞41'19"/82∞39'24"	Crumley Rd. - ust. Landfill	Amanda
2.5	F,B,C	39∞42'06"/82∞38'29"	Beck Rd. - dst. Landfill	Amanda
0.6	B	39∞42'48"/82∞37'06"	SR 22 -Lancaster	Lancaster
0.5	F	39∞42'46"/82∞37'02"	SR 22 - Lancaster	Lancaster
0.36	C	39∞42'40"/82∞36'49"	SR 22 - Lancaster	Lancaster
Baldwin-Ewing Run				
2.7	F,C	39∞44'15"/82∞33'59"	Tiki Rd. - ust. CSOs	Lancaster
2.0	B	39∞44'14"/82∞33'58"	Tiki Rd. - ust CSOs	Lancaster
0.3	F	39∞42'33"/82∞35'00"	Lawrence Rd. - dst. CSOs	Lancaster
0.2	B,C	39∞42'31"/82∞35'03"	Lawrence Rd. - dst. CSOs	Lancaster
0.1	B	39∞42'29"/82∞35'03"	Lawrence Rd. - dst. CSOs	Lancaster
Clear Creek				
21.8	F,D	39∞41'24"/82∞45'45"	SR 188	East Ringold
21.76	C	39∞42'25"/82∞45'46"	SR 188	East Ringold
20.1	B	39∞42'31"/82∞45'34"	SR 188	East Ringold
16.3	F	39∞39'12"/82∞46'12"	SR 22 - ust. Amanda WWTP	East Ringold
16.1	C	39∞39'09"/82∞46'23"	SR 22 - ust. Amanda WWTP	East Ringold
14.2	F,C	39∞38'20"/82∞44'55"	Amanda S. Rd. - dst. Amanda WWTP	Amanda
14.1	B	39∞38'29"/82∞44'56"	Amanda S. Rd. - dst. Amanda WWTP	Amanda
13.1	F,B,C	39∞37'52"/82∞44'12"	SR 159	Amanda
9.5	B,C	39∞37'05"/82∞40'50"	Clearport Rd	Clearport
9.4	F	39∞37'53"/82∞41'12"	Clearport Rd.	Clearport
7.3	F,B,D	39∞36'26"/82∞39'19"	Revenge Rd. - dst. Arney Run	Clearport
6.99	C	39∞36'49"/82∞39'05"	Revenge Rd. - dst. Arney Run	Clearport
5.9	F,C	39∞35'53"/82∞38'07"	adj Lake Romona	Clearport

Table 3. continued.

Stream River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 minute Quadrangle Map
Clear Creek				
5.8	B	39∞35'52"/82∞38'03"	adj. Lake Romona	Clearport
2.1	B,S,D	39∞35'18"/82∞34'42"	USGS gage - Camp Wyandot	Rockbridge
2.03	C	39∞35'18"/82∞34'42"	USGS gage - Camp Wyandot	Rockbridge
1.9	F	39∞35'19"/82∞34'34"	USGS gage - Camp Wyandot	Rockbridge
Muddy Prairie Run				
0.6	B	39∞37'14"/82∞40'31"	Amanda Clearport Rd.	Amanda
0.5	F,C	39∞37'11"/82∞40'26"	Amanda Clearport Rd.	Amanda
0.4	S	39∞37'09"/82∞40'26"	Amanda Clearport Rd.	Amanda
Muddy Prairie Creek				
0.1	F,B	39∞40'49"/82∞46'01"	Amanda Northern Rd.	East Ringold
Arney Run				
4.3	F,B,C,D	39∞39'35"/82∞37'30"	Christmas Rock Rd.	Amanda
3.7	B	39∞39'14"/82∞37'57"	dst. SEOC WWTP trib.	Amanda
3.1	C,	39∞38'55"/82∞32'28"	dst. SEOC WWTP trib.	Amanda
2.2	F,D	39∞41'53"/82∞39'30"	Mink Hollow Rd.-dst. SEOC WWTP	Amanda
0.1	F,B,C,D	39∞36'51"/82∞38'58"	near mouth	Clearport
Sand Run				
0.1	F,B	39∞40'51"/82∞45'52"	near mouth	East Ringold
Dunkle Run				
0.5	F,B	39∞38'01"/82∞45'07"	Amanda Southern Rd.	East Ringold
Cattail Creek				
2.7	B	39∞35'25"/82∞41'31"	dst. Fair.Co. Landfill	Clearport
Scott Creek				
9.0	B	39∞26'34"/82∞26'21"	adj. SR 93	New Plymouth
8.9	F,C	39∞26'43"/82∞26'24"	adj. SR 93	New Plymouth
5.6	F,C	39∞29'05"/82∞25'56"	dst. Mine drainage - adj. SR 93	New Plymouth
4.9	B	39∞29'30"/82∞25'45"	dst. Mine drainage - adj. SR 93	New Plymouth
1.5	B	39∞31'20"/82∞25'28"	"Wildwood" bridge	Logan
0.1	F,C	39∞32'00"/82∞25'09"	near mouth - adj. SR 93	Logan

The unglaciated WAP ecoregion constitutes the foothills to the Appalachian Mountains. Generally the relief is hilly and strongly dissected, with an average elevation of 1000 ft.. This region is heavily wooded, as less than one-fifth is used as pasture or cropland. Agricultural activities are limited mainly to narrow stream valleys. Residual soils on the uplands are derived from sedimentary shales, siltstones, and shales, with alluvial soils in the stream valleys (Omernik and Gallent 1988). The lower limits of both the upper Hocking River, from Rush Creek to Logan, and Clear Creek are contained within the WAP ecoregion.

The Rush Creek basin contains several unreclaimed surface and subsurface mines. Documented impacts within the basin from these abandoned sites included the acidification, mineralization and sedimentation of surface waters (USDA 1985). In 1987, Ohio DNR, Reclamation Division, began installation of major projects to reduce or eliminate acid drainage impacts in the Rush Creek system through reforestation and wetland installments. Additional abatement projects are slated to begin in 1998. (pers. comm. Kirk beech, Ohio DNR - Reclamation Division).

Clear Creek Metro Park (the largest dedicated nature preserve in the state) is contained within the unglaciated portion of the Clear Creek basin. Its 3,995 continuous acres straddle lower Clear Creek for seven linear miles east of Revenge. The park has been identified as a significant biological and recreational resource. Using a total ecosystem management approach, the stated intent of the Metropolitan Park District of Columbus and Franklin County is to maintain the park's semi-primitive character and a major emphasis shall be placed on minimizing the impact that development has on the preserved natural habitat (Metropolitan Park District of Columbus and Franklin County 1997).

The following agricultural statistics were generated by the Fairfield County ASCS (pers. comm.). Estimates of crop cover in the study area are: 40-50% corn, 20-40% beans, 5-10% wheat and 10-20% hay. The proportions vary annually due to price levels and weather conditions. Beef cattle are the predominant livestock in the study area. Pasture acres are declining as beef and dairy operations turn toward crop raising and or confined feeding arrangements. Total farm acreage is declining in response to development pressure, particularly in Fairfield County.

Fairfield County has traditionally been aggressive in adoption of conservation practices. It is estimated that some form of conservation tillage is practiced by 75% of the farming operations. (OSU Extension, pers. comm.). The federal Conservation Reserve Program (CRP) now emphasizes wildlife habitat and stream quality. Increased financial incentives are provided for operators that protect existing riparian corridors, or enhance these and other areas by planting trees, establishing grassed waterways, maintaining wetlands, and the implementation of other BMPs. Local agriculture agency staff expect that as public awareness of the new program increases so will adoption of riparian protective practices. Several operators in the Clear Creek basin have enrolled in this program in the spring of 1997.

Multiple influences operate to determine acres of wooded cover in the study area. The close proximity of a large paper producer in Circleville has created a demand for lower grade (pulp) timber. This demand may work against selective cutting and the management for more mature stands. This also facilitates timber sales for estate settlements, clearing for single home sites, and cuts along stream banks for drainage. The age of many secondary growth tree stands now make them increasingly more suitable for lumber and higher value uses as well. The revised CRP's emphasis riparian protection could, in time, result in an increase in forested stream corridors (NRCS-OEPA Liaison, pers. comm.).

Population Centers

The population of Fairfield county grew 10.89% between 1990 and 1994, from an estimated 103,472 to 114,741. During this period the greatest numerical increase within the study area occurred in Lancaster with an addition of 1,301 individuals. Amanda township, located within the Clear Creek subbasin, is the fastest growing area within Fairfield County as the population has increased 23.41%. Berne township, which includes the Hocking River valley south of Lancaster, ranks second with an increase of 14.76%. Clear Creek and Hocking townships reported 13.78% and 12.31% growth, respectively. Madison township provided strong contrast with a rate of only 1.56%. (Fairfield County Regional Planning Commission. 1994.). Population centers, pollution sources and stream characteristics of the study area are presented in Table 4.

In the last decade, land use change and development in the county has focused on the Hocking River basin along U.S. 33, north of Lancaster. Over the next ten years development activity will likely shift east of Lancaster in response to the proposed construction of a SR 33 bypass between Carroll and Horns Mill. The proposed U.S. 33 bypass will stimulate significant land use change, as virtually all the preferred alignment lies within the study area. Proposed interchanges at Coonpath Road, State Route 188 and U.S. 22 may focus development activity in these areas.

Table 3. Stream characteristics and identified pollution sources within the 1995 upper Hocking River study area.

Stream	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Non-point Source Pollution Categories	Point Sources
Hocking River					
	101.59	4.6	1197.0	Agriculture	Lancaster WWTP
				Channelization	Air Products & Chemicals Inc.
				CSOs	Rustic Ridge MHP
				Storm Sewers	Columbia Gas Systems Inc.
				On-site septic systems	Greenfield Twp WWTP
				In-place pollutants	Colonial Estates MPH
				Resource Extraction	Sugar Grove WWTP
				Urban runoff	Lakeside Estates WWTP
Hunters Run					
	7.5	33.4	10.44	Agriculture	
				Livestock pasture/feedlots	
				Urban runoff	
				Storm sewers	
				Sanitary landfills	
				Surface runoff	
				Channelization	
				On-site septic systems	
				In place pollutants	
Baldwin-Ewing Run					
	4.6	27.8	12.98	Livestock pasture/feedlots	
				Urban runoff	
				CSOs	
				Surface Runoff	
				Channelization	
				In place pollutants	
Scott Creek					
	9.5	15.0	39.58	Resource extraction	
				Agriculture	
				Livestock pasture/feedlots	
				In place pollutants	
Clear Creek					
	24	15.1	91.3	Pasture/feedlots	Amanda WWTP
				Silviculture	Mid-West Fabricating Co.
				Road construction/maintenance	
				Urban runoff	

Table 3. continued.

Stream	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Non-point Source Pollution Categories	Point Sources
Clear Creek (cont.)				Sanitary sewers Surface runoff Channelization Streambank modification Land disposal On-site septic systems In place pollutants	
Cattail Creek	5.2	31.8	5.7	Agriculture	Fairfield Co. Landfill
Muddy Prairie Run	7.2	36.3	11.22	Agriculture Livestock pasture/feedlots Silviculture Road construction/maintenance Sanitary sewers In place pollutants	
Arney Run	8.2	31.9	10.64	Agriculture Livestock pasture/feedlots Silviculture Road construction/maintenance Urban runoff Sanitary sewers Land disposal In place pollutants	SEOC WWTP
Muddy Prairie Creek	3.4	13.5	3.81	Channelization Agriculture Livestock pasture/feedlots Silviculture Road construction/maintenance Sanitary sewers Surface runoff In place pollutants	
Sand Run	2.5	5.7	1.7	Channelization Agriculture In place pollutants	

Table 3. continued.

Stream	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Non-point Source Pollution Categories	Point Sources
Dunkle Run					
	2.8	22.0	2.72	Agriculture Livestock pasture/feedlots Silviculture Road construction/maintenance Urban runoff Sanitary sewers Surface runoff	

METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment.

Determining Use Attainment Status

The attainment status of aquatic life uses (*i.e.,* FULL, PARTIAL, and **NON**) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-17). The biological community performance measures which are used include the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). The ICI was developed by Ohio EPA (1987b) and further described by DeShon (1994). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information from the Wabash River (Gammon 1976; Gammon *et al.* 1981).

Performance expectations for the principal aquatic life uses in the Ohio WQS (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes *et al.* 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of the aquatic life use is FULL if all three indices (or those available) meet the applicable biocriteria, PARTIAL if at least one of the indices does not attain and performance at least fair, and **NON**-attainment if all indices fail to attain or any index indicates *poor* or *very poor* performance. Partial and non-attainment indicate that the receiving water is impaired and does not meet the designated use criteria specified by the Ohio WQS.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1994). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of in-stream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively using multiple-plate, artificial substrate samplers (modified Hester/Dendy) in conjunction with a qualitative assessment of the available natural substrates.

Fish Community Assessment

Fish were sampled using wading or boat method pulsed DC electrofishing gear. The wading method was used at a frequency of one or two samples at each site. The boat method was used at a frequency of two samples at each site.

Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Rankin and Yoder 1991; Yoder and Rankin 1994) was calculated for the study area based on the longitudinal performance of the biological community indices. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, or ICI) departs from the applicable biocriterion or the upstream level of performance (Figure 5). The "magnitude" of impact refers to the vertical departure of each index below the biocriterion or the upstream level of performance. The total ADV is represented by the area beneath the biocriterion (or upstream level) when the results for each index are plotted against river mile. The results are also expressed as ADV/mile to normalize comparisons between segments and other streams and rivers.

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are the principal arbiter of aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria in the role of principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991a; Yoder 1994). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and the biological response signatures (Yoder and Rankin 1994) within the biological data itself. Thus the assignment of principal causes and sources of impairment in this report do not represent a true "cause and effect" analysis, but rather represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research which experimentally or statistically linked symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experience in interpreting symptoms (*i.e.,* multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and the well-being of the patient, the ultimate measure of success in water resource management is restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993) here we are referring to the process for identifying biological integrity and causes/sources associated with observed impairment, not whether human health and ecosystem health are analogous concepts.

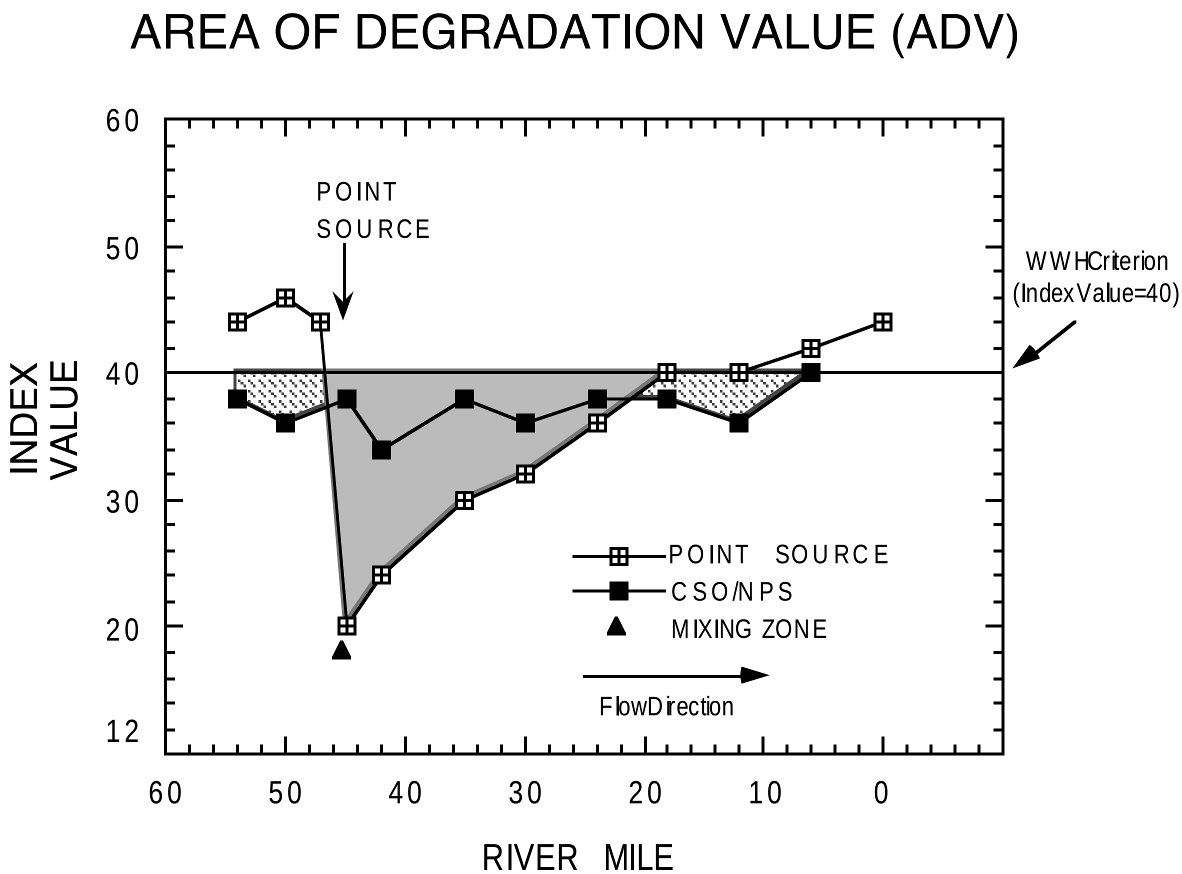


Figure 5 Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears as a solid triangle); the filled boxes and dashed shading (area of departure) represent a typical response to a nonpoint source or combined sewer overflow impact. The blended shading represents the overlapping impact of the point and nonpoint sources.

RESULTS AND DISCUSSION

Hocking River Mainstem

Pollutant Loadings

Monthly effluent loadings are reported to the Ohio EPA by all NPDES (National Pollutant Discharge Elimination System) permitted discharging entities. Third quarter (July - September) Monthly Operating Report (MOR) data described the quantity and character of pollutant loadings between 1976 - 1995 for each discharger evaluated within the 1995 Hocking River study area.

Pollutant loading trends were assessed using the 95th and 50th percentiles of the following sampling parameters: Ammonia - Nitrogen (NH_3 - N), Nitrate/Nitrite - Nitrogen (NO_3+NO_2 - N), Five - day Biochemical Oxygen Demand (BOD_5), Five - day Carbonaceous Biochemical Oxygen Demand ($cBOD_5$), Total Suspended Solids (TSS), and average flow in millions of gallons per day (MGD). Although there are MOR data available for most of the NPDES discharging entities in the area of study, analysis of this historical data, as a whole, suggests that the Lancaster WWTP is the only significant discharger within the past 10 years, and therefore the focus of historic analysis. Average daily loadings and flow data, for third-quarter 1995, are presented in Figure 6. This graphically depicts the relative loadings within the study area, by entity, at the time this survey was conducted.

MOR data were also used to record permit limit violations. This record, in turn, triggers OEPA's compliance and enforcement staff to send an official "Notice of Violation" to the discharger, as well as any other action deemed necessary to help remedy the situation. Third Quarter 1995 permit violations in the area of study are presented in Appendix A.

Air Products and Chemicals, Inc. (Permit# 4IF00007)

The Air Products and Chemicals, Inc. outfall is part of a groundwater remediation project in which groundwater is pumped to an equalization tank and then through three activated carbon columns. The project was designed to remove chlorinated solvents from the water (attributed to activities by Arcair - which no longer exists at this site). Designed flow through the treatment process is 0.086 MGD. Treated water flows to an unnamed tributary that confluences the Hocking River at RM 94.4. Historic data indicates insignificant loadings, while third quarter data does indicate a slight influence on $cBOD_5$ loadings.

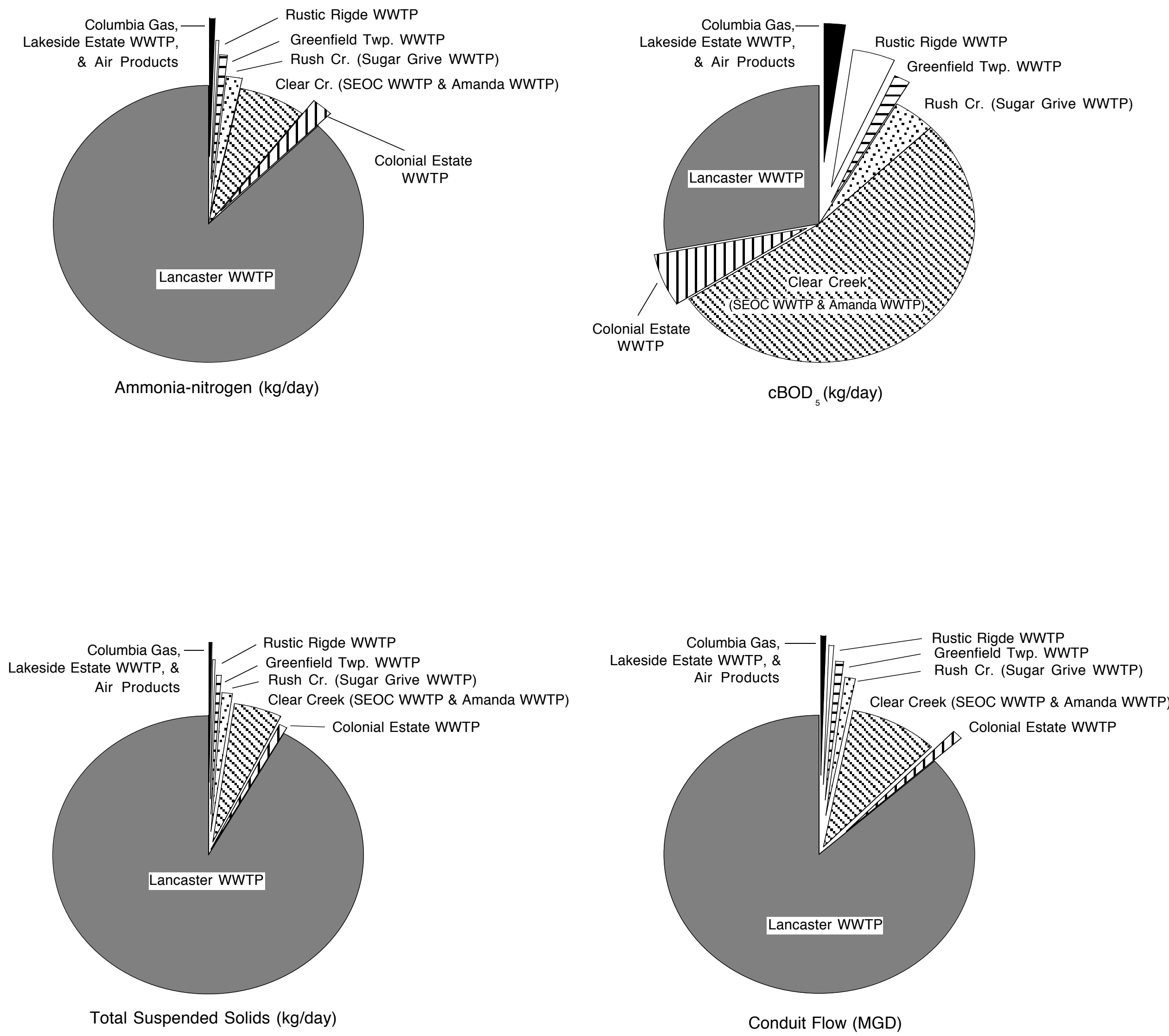


Figure 6 Relative contribution to average third-quarter loadings (kg/day) and conduit flow (MGD), by entity, to the Upper Hocking River, 1995. Conduit flow and pollutant loads from the Amanda WWTP (Clear Creek subbasin) are weighted averages based on six discharge events during July.

Lancaster WWTP (Permit# 4PD00001)
The Lancaster WWTP is an advanced treatment facility that discharges to the Hocking River at RM 89.05. A facility upgrade, completed in 1988, increased the designed flow to the present 8.33 MGD. Numerous improvements were made during this upgrade, and current treatment processes include: bar screening, grit removal, flow equalization, primary settling, trickling filters, aeration, final settling, and chlorination/dechlorination. Currently, the plant is being expanded to allow a designed flow of 10 MGD, with scheduled completion in 1997. Industries account for approximately 35% of the plant's flow and an EPA approved pretreatment program is in place. The Lancaster WWTP contributed 87.5% (13.6 kg/day) of the NH_3-N, 28.2% (4.62 kg/day) of cBOD, and 91.9% (219.2 kg/day) of TSS loads to the upper Hocking River (Figure 6).

Industrial pre-treatment regulations in Lancaster were approved by the OEPA in November of 1984, and implemented over the next several years. The locally managed program was designed to help eliminate significant problems that were occurring at the WWTP. Heavy metals loadings entering the plant caused several NPDES permit violations, as well as in-stream water quality standards violations. Industrial waste streams containing oil and grease were also a chronic problem. Even sewer system blockages had been attributed to industrial discharges of solids. This program was crucial in eliminating many violations of permit limits.

The Lancaster WWTP collection system contains close to 20% combined sewers, with 18 overflows discharging directly to the Hocking River, three discharging to Baldwin Run, and one discharging to Fetters Run. These overflows are in addition to a bypass at the WWTP (002 outfall into Hocking River). Although overflow events degrade the quality of the receiving stream through nutrient enrichment, solids deposition, and high D.O. demand, the discharges are permitted and monitoring requirements are minimal. During a storm event, five of the overflows (locations rotated) must be sampled within 30 minutes of the beginning of the discharge, and analyzed for $cBOD_5$ and suspended solids. The actual number of discharges, volume of each occurrence, and duration of the discharge are estimated. Overflow and bypasses for third quarter 1995 are summarized in Appendix A. When the Lancaster WWTP's NPDES permit is renewed, it will contain language requiring the city to submit a combined sewer overflow operation and maintenance plan.

The Lancaster WWTP effluent quality has improved substantially over the past 20 years (Figure 7). Between 1982 and 1995, the positive changes in effluent quality were indicative of greatly improved treatment of wastewater at the Lancaster WWTP and pretreatment of industrial wastes coming into that plant. Third quarter 95th and 50th percentile loadings data were used to characterize effluent quality and conventional pollutant loadings through time. Until the mid-1980s the Lancaster WWTP contributed very high levels of NH_3-N, TSS, and BOD_5/$cBOD_5$ to the Hocking River. By the early 1990s, NH_3-N was virtually eliminated, with TSS and $cBOD_5$

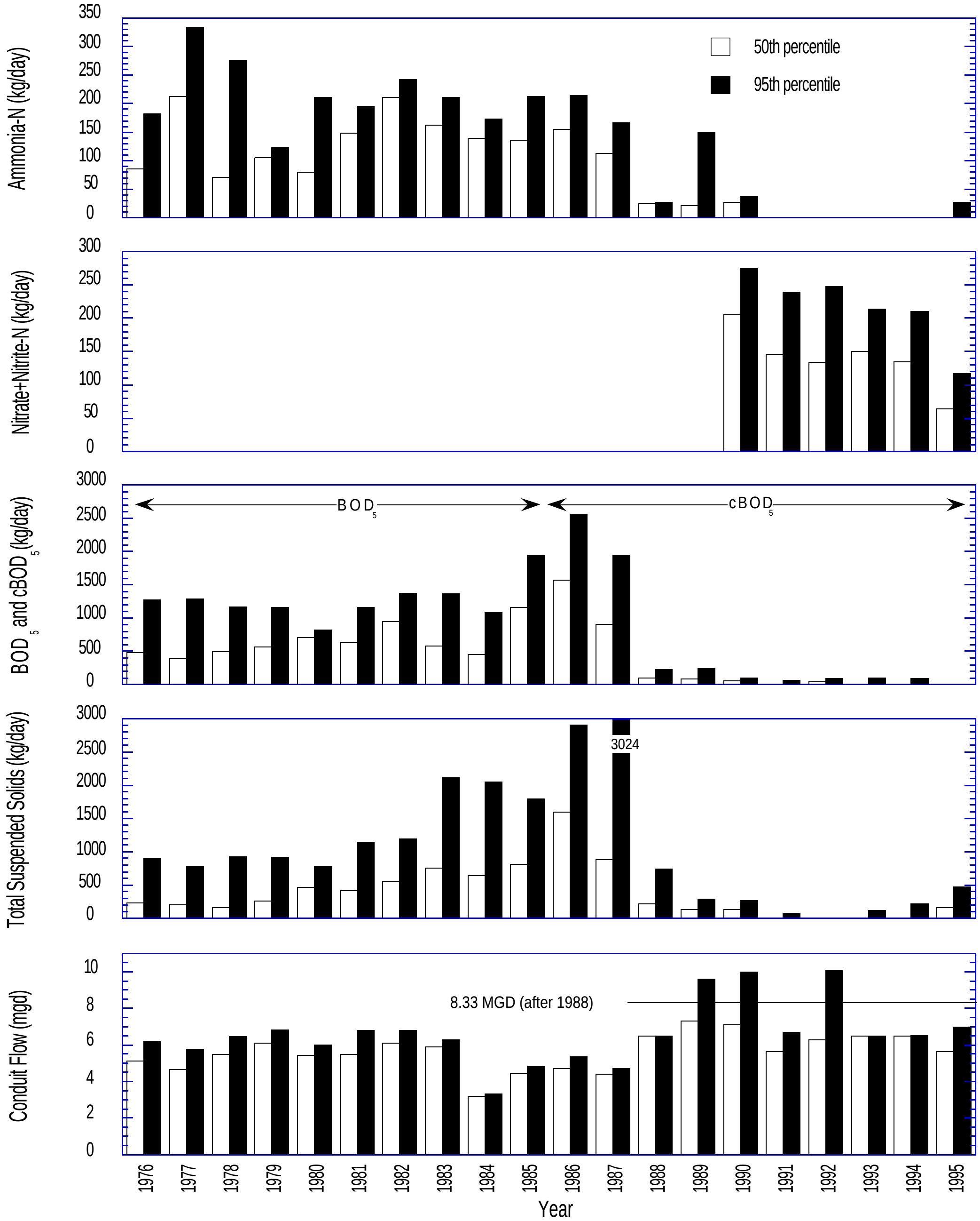


Figure 7 Third-quarter median and 95th percentile conduit flow (MGD) and pollutant loads (kg/day) of Ammonia-Nitrogen, Nitrate+Nitrite-Nitrogen, Biochemical Oxygen Demand (BOD), and Total Suspended Solids (TSS) from the Lancaster WWTP, 1976 through 1995.

showing similar trends. NO_3-N data was not available before 1990, but as the plant upgrade and pretreatment program became effective, NO_3-N levels should have risen, as this is the end product of improved nitrification. Permit violations between 1992 and 1995, were most pronounced in 1992. Seventeen violations of the maximum and 30 day average criteria for mercury were reported. The remaining violations included residual chlorine (six violations of the maximum), and cyanide (one violation of the maximum). The frequency of the mercury violations was suggestive of an industrial source. The problem appeared ameliorated the following year, as the number of permit violations were markedly reduced between 1993 and 1995. During this three year period only eight violations were reported. Moreover, these violations did not suggest poorly treated industrial influenced inflow, rather they comprised the typical constituents of treated domestic wastewater (e.g., NH_3-N, TSS, and residual chlorine).

Bioassays conducted by the city of Lancaster and the Ohio EPA between 1990 and 1995 did not indicate significant problems with effluent toxicity. Of the 12 acute and chronic tests performed during this period, effluent was found to be chronically toxic to *Ceriodaphnia dubia* in 1991 only. The observed toxicity (2.36 TU_c) was well above the AET_c (1.3 TU_c) derived from Lancaster's revised 1990 WLA. However, only one of three chronic tests conducted in 1991 indicated significant toxicity. All other bioassays failed to register a significant acute or chronic toxic response to Lancaster WWTP effluent.

Rustic Ridge MHP (Permit# 4PY00002)
The Rustic Ridge MHP WWTP has an advanced treatment plant with a design flow of 0.05 MGD. The outfall from the plant discharges to an unnamed tributary that enters the Hocking River at RM 84.38. Treatment processes include: communutor, extended aeration, clarification, sand filters and chlorination. This plant receives no industrial flow. While historical data reveals little impact on Hocking River loadings, third quarter 1995 data does indicate a small contribution to the overall loadings in the study area.

Columbia Gas Systems, Inc. (Permit# 4IM00005)
The Columbia Gas Systems, Inc. WWTP employs secondary treatment with extended aeration and chlorination. The plant was designed to treat 1500 gallons of water per day, all of which is sanitary flow. The system's outfall discharges to an unnamed tributary that intercepts the Hocking River at RM 82.52. Although this facility is scheduled to meet water quality-based chlorine limits by October, 1998, several chlorine exceedences were reported during this study. Both historical and third quarter 1995 data indicated minimal loadings placed on the study area.

Greenfield Township Water and Sewer District WWTP (Permit# 4PS00004)
The Greenfield Township WWTP is an advanced treatment facility with a design flow of 0.06 MGD. The plant outfall is located on an unnamed tributary that intersects Claypool Run at RM

0.1. Claypool Run confluences with the Ohio Canal at RM 1.72, which in turn empties into the Hocking River at RM 93.6. Plant treatment involves flow equalization, extended aeration, clarifiers, fixed media clarifiers, surface sand filters and chlorination. A large percentage of the flow to the plant is commercial and industrial. Depending on the outcome of negotiations with the City of Lancaster, this plant may either be abandoned or expanded and upgraded in the near future. The Greenfield Township Regional WWTP had a negligible affect on loadings historically, and current third quarter 1995 data reveals minimal loading impacts.

Colonial Estates MHP (Permit# 4PV00099)
The Colonial Estates MHP WWTP is an advanced treatment facility with a design flow of 0.084 MGD. The outfall discharges to an unnamed tributary to another unnamed tributary of the Ohio Canal. Advanced treatment is provided by extended aeration with screening and chlorination. Currently the facility will either tie into the Greenfield Township Water and Sewer District system by January 2, 1997, or install dechlorination by October 1, 1997. There is no industrial flow to the plant. Historical data indicates negligible loading impacts on the study area, while third quarter data from 1995 does show a slight impact.

Village of Sugar Grove (Permit# 4PA00001)
The Sugar Grove WWTP is a secondary wastewater treatment facility with a design flow of 70,000 gallons per day. Treatment processes include: bar screening, communuter, equalization tank, constant head tank, extended aeration, clarification and chlorination. Dechlorination was scheduled to be installed during the summer of 1995, but had not been installed by the conclusion of this study. The effluent discharges to Rush Creek 0.1 miles upstream of Rush Creek's confluence with the Hocking River at RM 81.66. There is no significant industrial flow to the plant.

Although MOR data does not indicate permit violations, the efficiency of the plant is questionable based on recent inspections. Spot checks of the plant revealed the periodic loss of solids into Rush Creek. Village representatives have agreed to address the problems uncovered during those inspections. Although no historical loadings impacts are noted, third quarter 1995 data does indicate a slight impact on total loadings (Figure 6).

Lakeside Estates (Permit# 4PG00028)
The Lakeside Estate WWTP provides advanced treatment through extended aeration, with clarification and chlorination. The design flow of 0.008 MGD discharges to an unnamed tributary to Pleasant Run at RM 7.15 before joining the Hocking River at RM 85.12. Currently the plant is under orders to evaluate and upgrade, if necessary, to consistently meet effluent limits. Lakeside Estates receives no industrial flow. Historical loading data indicates minimal impact on the watershed, while only slight impacts are detected in third quarter data.

Chemical Water Quality

Replicate water samples were collected for chemical analysis at 14 stations within the Hocking River mainstem during the summer of 1995. This effort included 12 ambient, one mixing zone, and one effluent station. Datasonde continuous monitoring units were deployed to record diel D.O. (Dissolved Oxygen), temperature, pH, and conductivity during August, at eight stations located between RM 69.5 and RM 95.2. Discharge of the upper Hocking River, monitored at the USGS gage station at Enterprise, indicated river flows well above the critical $Q_7 10$ throughout the third quarter (May - September) of 1995. Additionally, river discharge was typically above the 80% flow duration between May and August. Flows less than the 80% duration were observed in mid-July and throughout most of September. Peak discharge during the 1995 sampling effort (June - October) occurred in late-June, late-July, and early to mid-August, with flows reaching 1000 cfs (Figure 8).

Results from the 1995 chemical sampling effort did not reveal significant water quality problems. Results from daytime grab samples indicated D.O. concentrations well above the minimum and average WWH standards throughout the study area. NH_3-N concentrations and BOD appeared low and longitudinally stable. Nitrate+Nitrite-N concentrations were elevated downstream from the Lancaster WWTP, as it is the end product of nitrification. Although slightly elevated downstream from the Lancaster WWTP, mean total phosphorus concentrations remained below the WWH guideline of 1.0 mg/l at all stations sampled. Metallic analytes were found at concentrations below their applicable water quality criterion. The mean longitudinal concentration of D.O., nutrient, and demand parameters are presented in Figure 9.

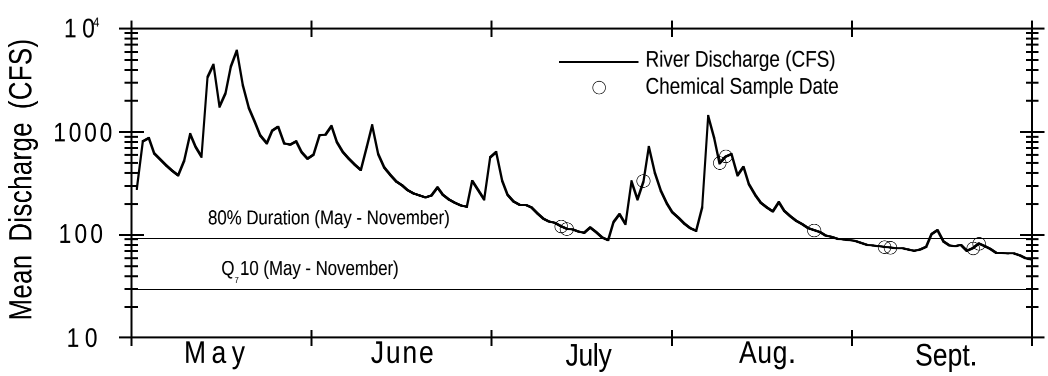


Figure 8 Flow hydrograph from the upper Hocking River at Enterprise, Ohio (RM 73.4), May through September, 1995.

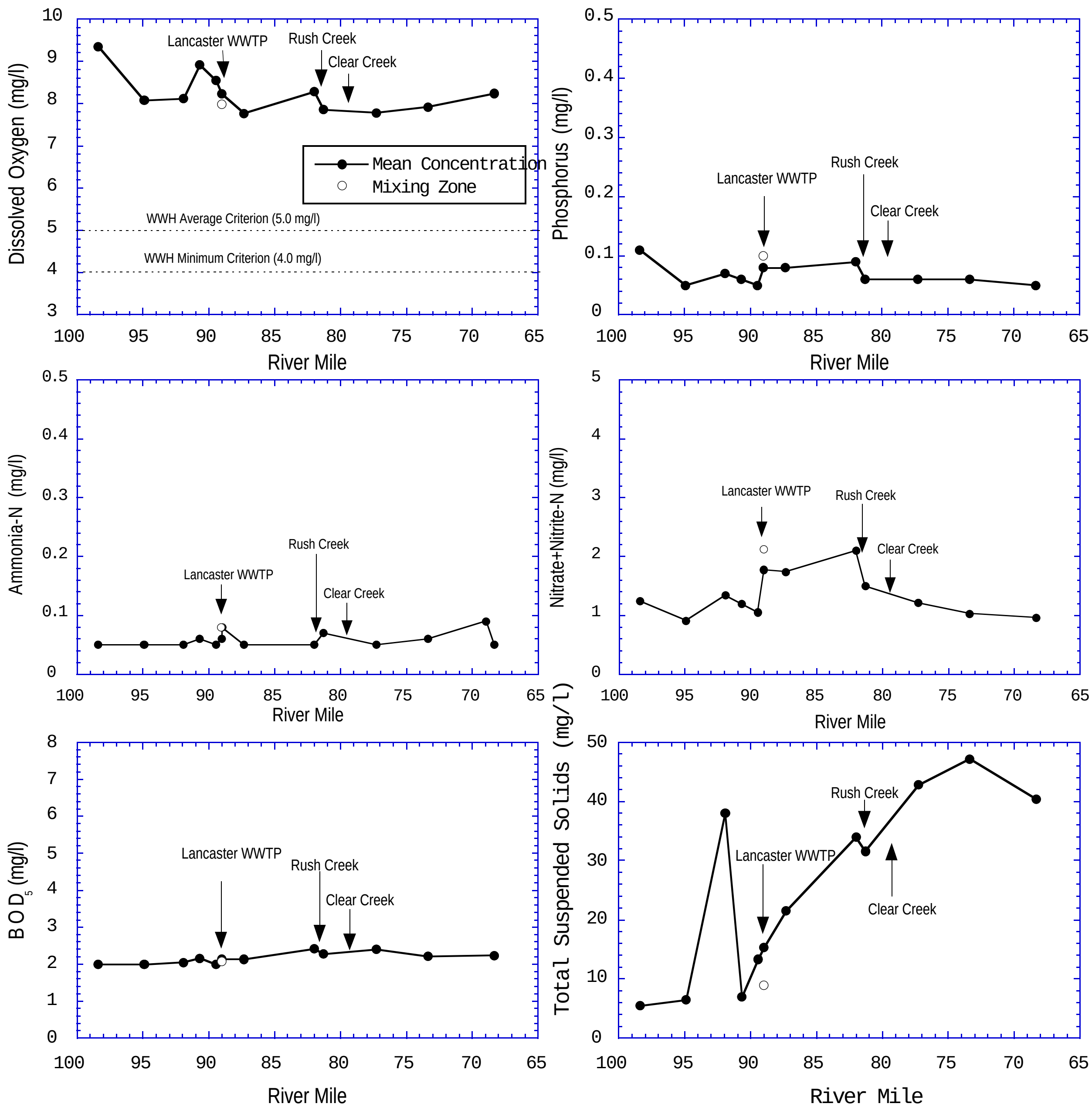


Figure 9 Longitudinal mean concentrations of dissolved oxygen, ammonia-nitrogen, nitrate+ nitrite-nitrogen, five-day biochemical oxygen demand (BOD_5), total phosphorus, and total suspended solids from the upper Hocking River mainstem, 1995.

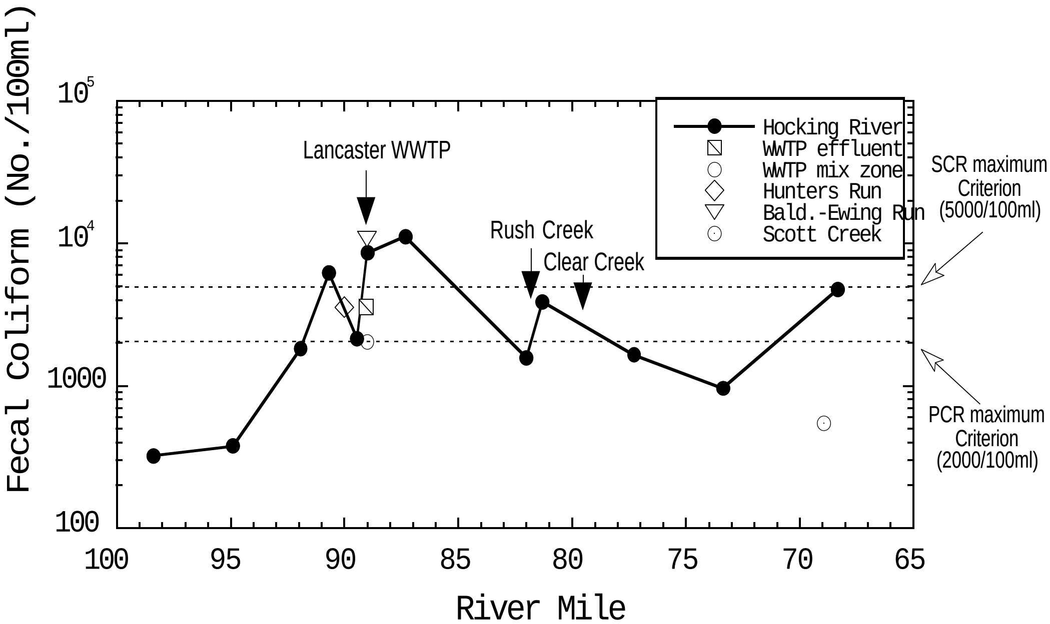


Figure 10 Longitudinal mean fecal coliform counts from the upper Hocking River mainstem, 1995.

Exceedences of the WQ standards were primarily limited to fecal coliform (Table 4; Figure 10). Most stations sampled on the Hocking River mainstem showed elevated fecal coliform counts, most on more than one occasion. Of the 78 replicated water column samples collected from the mainstem, 26.9% (21 samples) indicated fecal coliforms counts greater than the average PCR standard. Over 50% of these exceeded the less stringent (higher threshold) SCR maximum criterion. However, the frequency and magnitude of fecal coliform exceedences were the greatest within the segment of the Hocking River flowing through and downstream from the greater Lancaster area (RM 91.3, Pierce Ave. and RM 87.32, US 33 - downstream Lancaster). The source of the fecal contamination within this reach was likely a result of intermittent CSO discharges, as well as the Lancaster WWTP itself. Within urban areas, elevated fecal coliform counts have been found to be good indicators of CSO activity. The levels observed did not suggest pervasive and chronic CSO problems, rather it is likely indicative of pulsed or periodic events, as D.O. concentrations were maintained at or above the WWH level and other chemical indicators were not elevated (e.g., BOD, NH_3-N). Nearly 70% of the fecal exceedences occurred during periods of increased surface runoff and elevated river discharge following extended periods of rainfall in late-July and early-August. During these periods, diffuse urban and rural non-point sources, as well as CSOs are typically the most active. These factors as well as other minor WWTPs within the study area undoubtedly contributed to the elevated levels observed through Lancaster and other portions of the study area.

Table 5. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the Hocking River study area, 1995.

Stream	River Mile	Exceedence: Parameter (value)
Hocking River		
	91.93 (Maple St.-Lancaster)	Fecal Coliform (1390,1320)‡; (3900, 3500)‡‡
	90.67	Fecal Coliform (9450, 21000)‡‡‡
	89.45	Fecal Coliform (6450)‡‡‡, 4500)‡‡
	88.99 (dst. Lancaster WWTP)	Fecal Coliform (7090, 38000)‡‡‡, 4700)‡‡
	87.32	Fecal Coliform (33000, 31000)‡‡‡
	82.00	Fecal Coliform (5000)‡‡‡
	81.30 (dst. Rush Creek)	Fecal Coliform (9270, 5500)‡‡‡; (3450)‡‡
	77.27	Fecal Coliform (3800, 3900)‡‡
	73.37	Fecal Coliform (4200)‡‡
	73.20 (at Enterprise)	D.O.[a] (17 measurments)‡‡ (9 measurments)‡
	68.33	Fecal Coliform (21000)‡‡‡
Hunters Run		
	3.45	Fecal Coliform (2400, 2100, 2200)‡‡
	2.53	Fecal Coliform (2100)‡‡, (1270)‡
	0.36	Fecal Coliform (8540, 12100)‡‡‡; (2700)‡‡
Baldwin-Ewing Run		
	2.68	Fecal Coliform (3100)‡‡
	0.19 (dst. CSOs)	Fecal Coliform (>60000)‡‡‡; 2900)‡‡
Scott Creek		
	5.60	Fecal Coliform (3000)‡‡
	0.10	Dissolved Oxygen (4.5, 3.6‡‡‡); Fecal Coliform (2300)‡
Clear Creek		
	21.76	Fecal Coliform (1090)‡
	16.10(ust. Amanda WWTP)	Fecal Coliform (1010, 1050)‡; (2000)‡‡
	13.12(dst. Amanda WWTP)	Fecal Coliform (2100)‡‡; (1290)‡; Dissolved Oxygen (4.8)‡‡
	6.99(dst. Arney R./Cattail Cr.)	Lead (20*)

Table 5. continued.

Stream	River Mile	Exceedence: Parameter (value)
Arney Run		
	4.30	Fecal Coliform (2600)‡‡
	3.13(dst. SEOC WWTP)	Total Phosphorus (1.08)†; Fecal Coliform (2400, 3200)‡‡
	0.10	Fecal Coliform (3000, 3000)‡‡; (>60000, >60000)‡‡‡

a - Number of violations/exceedences from data collected with Datasonde continuous monitoring units.
* - exceedence of numerical criteria for prevention of chronic toxicity [Chronic Aquatic Chronic. (CAC)].
‡ - violation of the minimum warmwater habitat dissolved oxygen criterion (4.0 mg/l).
‡‡ - exceedence of the average warmwater habitat dissolved oxygen criterion (5.0 mg/l).
‡‡‡ - violation of the minimum exceptional warmwater habitat dissolved oxygen criterion (5.0 mg/l).
‡ - exceedence of the average Primary Contact Recreation criterion (fecal coliform 1000/100 ml).
‡‡ - exceedence of the maximum Primary Contact Recreation criterion (fecal coliform 2000/100 ml).
‡‡‡ - exceedence of the maximum Secondary Contact Recreation criterion (fecal coliform 5000/100 ml).
† - exceedence of the WWH phosphorus guideline (1 mg/l).

Note:Iron exceeded (1.0 mg/l (CAC) in 21 of 72 (29.2%) non-mixing zone samples in the upper Hocking River study area, 3 of 19 (15.8%) samples in Hunters Run, 6 of 16 (37.5%) samples in Scott Creek, 13 of 48 (27.1%) samples in Clear Creek.

The result from diel sampling found all stations exhibiting the typical oscillating pattern of dissolved oxygen (through time) commonly associated with algal photosynthesis and respiration (Figures 11 and 12). Data collected from most stations indicated D.O. concentration fully consistent with the WWH standards (average and minimum criteria). Only the sampling effort at RM 73.2 (downstream from Enterprise) showed a somewhat different pattern, as D.O. values gradually declined during the sampling interval. Dissolved oxygen concentrations below the 4.0 mg/l WWH minimum standard were observed in over half of the test cycle. In total the results from this station yielded nine violations of the 4.0 mg/l WWH D.O. minimum criterion and 17 concentrations below the minimum 5.0 mg/l WWH D.O. criterion.

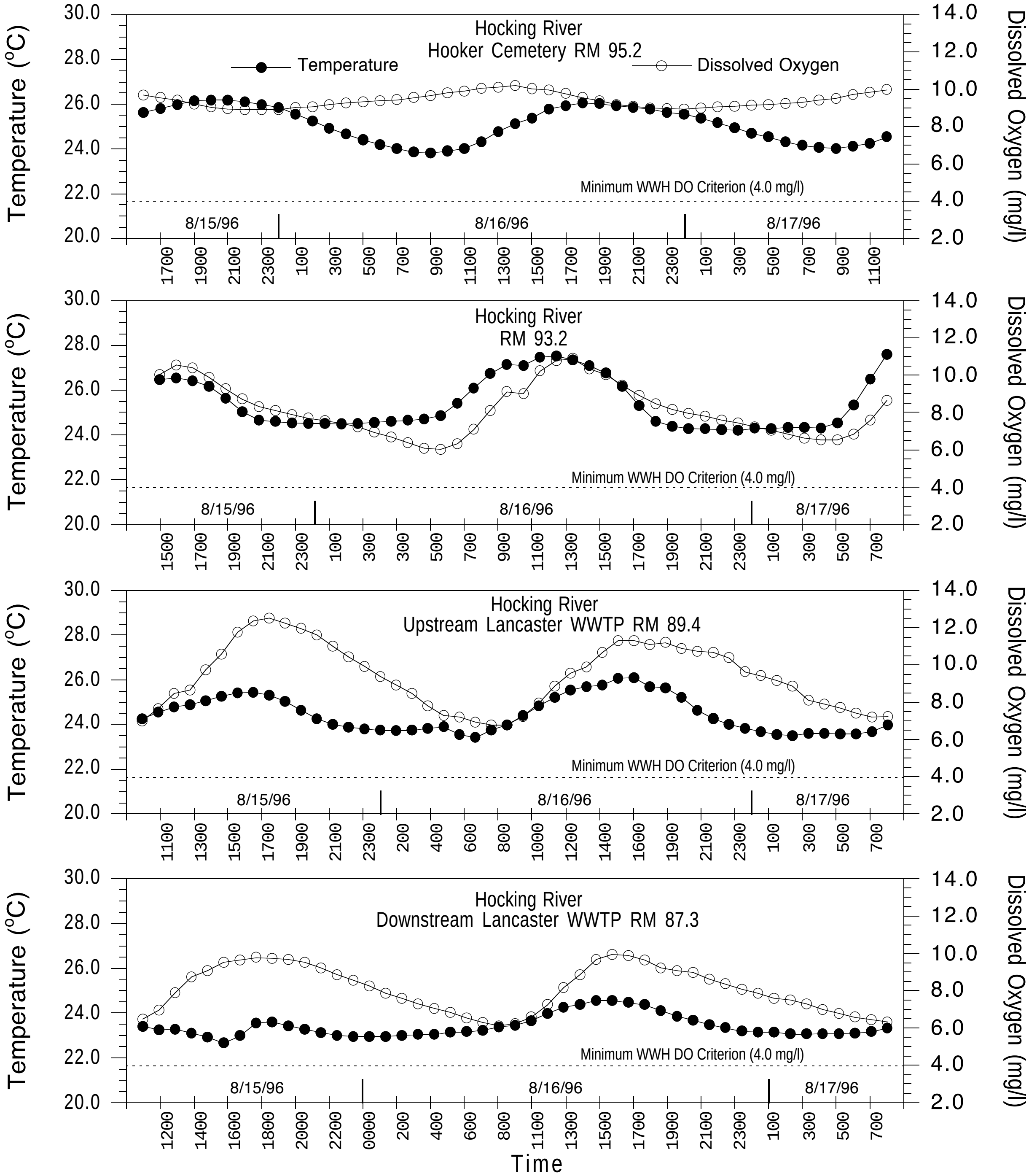


Figure 11 Diel temperature and dissolved oxygen data collected with continuous monitoring units from the upper Hocking River mainstem, August 1995.

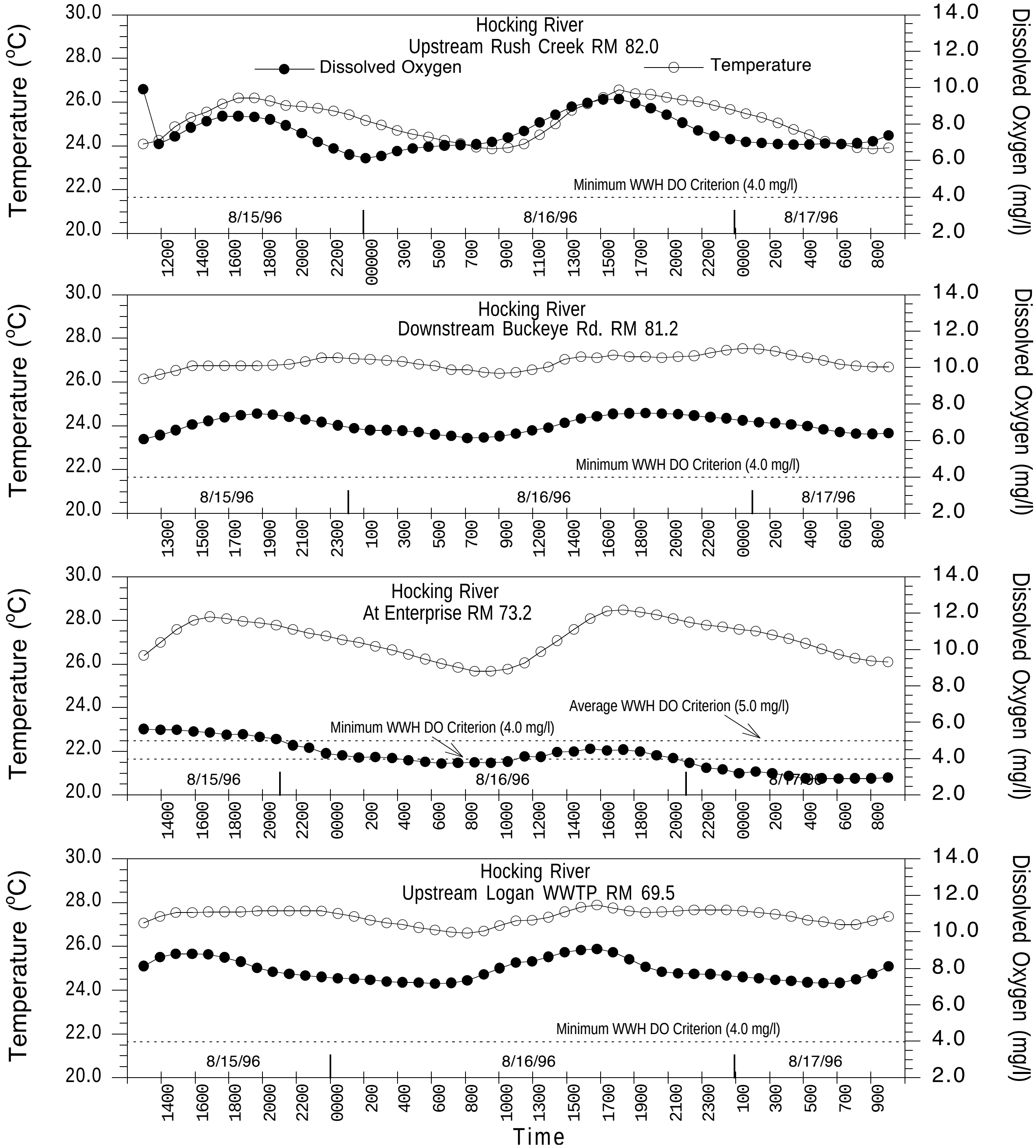


Figure 12 Diel temperature and dissolved oxygen data collected with continuous monitoring units from the upper Hocking River mainstem, August 1995.

Sediment Chemistry

Chemical pollutants present in sediments may create the potential for continuing environmental impacts, even where water column pollutant concentrations are not a concern. Many chemical pollutants found in sediments can have toxic impacts on aquatic life, and may pose a threat to human health due to biomagnification of contaminants through the aquatic food chain. Sediments in the Hocking River mainstem were collected for analysis from 5 sites. Chemical analysis of sediments included metals, semivolatile organic compounds, pesticides, PCBs, and volatile organic compounds. Selected parameters were ranked based on a sediment classification system described by Kelly and Hite (1984) and Persaud et al. (1993).

Sediment metals scans revealed the presence of arsenic (elevated to highly elevated), cadmium (not elevated to highly elevated), chromium (not detected to extremely elevated), copper (not elevated to elevated), iron (slightly elevated to highly elevated), lead (not detected to extremely elevated), and zinc (not elevated to extremely elevated). In the majority of cases, metals concentrations were highest in the areas downstream from the Lancaster WWTP discharge (Table 6). These elevated concentrations of metals in the sediments are probably artifacts of previous industrial discharges to the Lancaster WWTP from metal working operations in Lancaster. In addition, storm water inputs from factory grounds and city streets are continuing sources of metals contamination. For example, data complied in 1993 from storm water runoff around Lancaster Electroplating Inc. indicated contamination of storm water from arsenic, chromium, copper, and lead. Although this company is tied into the Lancaster sewer system, contaminated runoff does find its way into surface waters via CSOs during rain events.

Since metallic compounds and elements do not degrade (as organic compounds) their presence in the sediments may be perennial. Metals concentrations may decline slowly over time as contaminated sediments are washed away and replaced with noncontaminated sediments. Unfortunately, this process simply moves contaminants downstream. Many are still available for uptake by aquatic organisms.

Organic compounds were also detected in Hocking River sediments. Semivolatile organic compounds detected in sediments included several polynuclear aromatic hydrocarbons (PAHs). These were detected both up and downstream from Lancaster WWTP (Appendix C). Dieldrin was the only pesticide detected in the Hocking River sediments. No volatile organic compounds (VOCs) were detected in Hocking River sediments.

Table 6. Concentration (mg/kg) of metals in sediment for the Hocking River study area, 1995.

	Hocking River					**Clear Creek**	**Muddy Prairie Run**
River Mile	**95.2**	**89.4**	**88.5**	**87.1**	**82.0**	**2.1**	**0.4**
Arsenic	12.7[b]	12.8[b]	**36.1**[c]	**23.5**[c]	**18.8**[c]	13.3[b]	11.0[b]
Cadmium	0.33	1.01[b]	**3.01**[c]	1.86[b]	1.83[b]	0.28	0.18
Chromium	21.0[a]	24.1*	**65.3**[d]	36.2*	**46.4**[c]	21.4[a]	20.2*
Copper	15.3	25.0	79.6[b]	45.8[a]	27.3	12.6	8.76
Iron	18600[a]	18300[a]	**33400**[c]	27900[b]	26800[b]	17300	14300
Lead	19.1*	**103.7**[d]	**70.0**[c]	36.2[a]	37.4[a]	18.9*	20.2*
Nickel	25.4	32.1*	63.7	48.2*	44.7*	25.2*	27.0*
Zinc	75.0	100[b]	**300**[d]	**200**[c]	**170**[c]	70.5	49.9
TOC (%)	1.9	2.5	5.9	4.7	2.8	2.4	2.5

* indicates below method detection limit
Concentrations above Low Effect Level (LEL) are underlined (Persaud et al. 1993).
a Slightly Elevated (Kelly & Hite 1984).
b Elevated (Kelly & Hite 1984)
c **Highly Elevated** (Kelly & Hite 1984)
d **Extremely Elevated** (Kelly & Hite 1984)
Note: Nickle is not evaluated by Kelly & Hite (1984)

Physical Habitat for Aquatic Life

During the 1995 sampling effort the macrohabitats of the Hocking River were evaluated at 12 fish sampling stations. Qualitative Habitat Evaluation Index values ranged between 28 (RM 100.2, headwaters) and 82.5 (RM 82.0, Sugar Grove Rd.), with a mean reach value of 64.4. A mean reach value equal to or greater than 60 suggests that the aggregate habitat quality of the upper Hocking River should be sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989). However, habitat quality was not homogenous throughout the study area. The condition of physical habitat appeared to improve longitudinally. A matrix of habitat features and QHEI values for each sampling station within the study area is presented in Table 7.

To better evaluate the influence of macrohabitat quality on ambient biological performance the upper Hocking River mainstem was divided into four segments of relatively homogenous condition (Table 8). **Segment I** included the highly modified headwaters between RM 101.5 and RM 100.1. Macrohabitat quality of this segment was evaluated at one station located at RM 100.2 (Pickerington Rd.), achieving a QHEI value of 28.0. This segment has been extensively channelized in the past, with little physical recovery evident. The channel configuration was straight, shallow, and uniformly trapezoidal in cross section. The substrates consisted entirely of clay and silt deposits, at times reaching several feet in depth. A riparian corridor was present, but was narrow and consisted mainly of young successional herbaceous and woody vegetation.

The physically degraded habitat features of Segment I likely precluded the ability of this reach to support an assemblage of aquatic organisms consistent with the WWH aquatic life use designation.

Macrohabitat quality of **Segment II** was evaluated at RM 95.2 (adj. Hooker Cemetery - downstream Lake Rockmill). The results marked a considerable advance in habitat quality as this reach achieved a QHEI score of 85.0 (far in excess of the WWH threshold). The station was characterized by a predominance of high quality warmwater habitat attributes, with nearly every positive habitat feature present. Predominant substrates were coarse, glacial boulder, cobble, and gravel. The heavy silt load recorded within the headwaters was likely mitigated by simple retention in the basin provided by Rockmill Lake. Channel development was diverse and sinuous, possessing several riffle-run-pool complexes. Pool habitats were deep and were well-structured with woody debris and fallen timber. Adjacent land use contributed significantly to habitat quality, as a wooded riparian corridor appeared persistent throughout this segment. Excluding the Rockmill Lake basin, these positive habitat features appeared persistent from RM 100.1 to RM 95.0.

Table 7. Qualitative Habitat Evaluation Index (QHEI) matrix showing positive and negative habitat attributes for the upper Hocking River study area, 1995.

Table 7. continued.

Table 7. continued.

Table 8. Aggregate macrohabitat quality for four relatively homogenous segments of the Upper Hocking River based on qualitative habitat evaluations conducted in 1995.

Upstream Limit (River Mile)	Downstream Limit (River Mile)	Sampling Station (River Mile)	Station QHEI	Segment Average (QHEI)
Segment I				
Channelized headwaters				
101.5	100.1	100.2	28.0	28.0
Segment II				
Headwaters to Hooker Cemetery				
100.1	95.0	95.2	85.0	85.0
Segment III				
Hooker Cemetery to US 33				
95.0	87.3	95.2	38.5	52.0
		90.8	41.5	
		89.4	63.0	
		89.0	65.0	
Segment IV				
US 33 to Logan				
87.3	69.5	87.1	70.5	75.3
		82.0	82.5	
		81.2	70.5	
		77.2	77.0	
		73.2	74.0	
		69.5	77.0	

Segment III represents the channelized and levied portion of the Hocking River flowing though and downstream from Lancaster. The condition of physical habitat within this reach was evaluated at four stations located between RM 92.2 (Pierce Ave.) and RM 89.0 (downstream from the Lancaster WWTP), achieving a mean reach QHEI value of 52. Viewed in the aggregate, moderate and high influence modified habitat attributes were predominant. Although each station indicated varying degrees of physical recovery, channel configuration within this reach was generally trapezoidal. Habitat quality appeared to improve longitudinally, with greatly simplified conditions indicated at RM 92.2 and RM 90.8 and recovering (higher quality) habitats at RM 89.4 and RM 89.0. Though by no means as desolate as that encountered in the headwaters, the aggregate macrohabitat quality within this reach undoubtedly exerted a negative influence upon ambient biological performance.

The macrohabitat quality of **Segment IV** appeared unimpaired. Habitat conditions were evaluated at six stations between RM 87.1 and RM 69.5, achieving a mean reach QHEI value of 75.3. Warmwater habitat attributes were predominant at all stations. Channel development at most sites appeared natural and sinuous, possessing developed riffle-run-pool complexes. Substrates commonly consisted of glacial and native cobble and gravel and did not appear unduly burdened with embedding silts and clay. A wooded riparian corridor was present throughout the segment, comprised mainly of mature trees and a woody under story. Macrohabitat quality of Segment IV appeared fully capable of supporting a community of aquatic organisms consistent with the WWH aquatic life use.

Biological Assessment: Benthic Macroinvertebrate Community

Quantitative data were collected from 13 Hocking River mainstem stations from the headwaters at Pickerington Road (RM 100.0) to RM 69.6 in Logan (Table 9). Narrative evaluations ranged from *exceptional* (ICI=48) at the Logan site to *poor* (ICI=10) at Pickerington Road. In addition to the headwater site, ICI scores fell below the WWH biocriterion (fair range) for several miles downstream from the Lancaster WWTP (Figure 13). Outside of these areas, ICI scores ranged from *good* to *very good* throughout the remainder of the mainstem.

Benthic communities at RM 100.0 were upstream from all known point source discharges but reflected poor water quality and significant non-point source impacts. Samples were predominated by nutrient tolerant flatworms (Turbellaria) and sludge worms (Oligochaeta) while EPT (mayfly, caddisfly and stonefly) richness was limited to a single taxon, the mayfly *Baetis flavistriga*. The QCTV score of 32.3 (based on qualitative sampling) was also below ecoregional expectations, falling in the range typically associated with *fair* or *poor* quality communities.

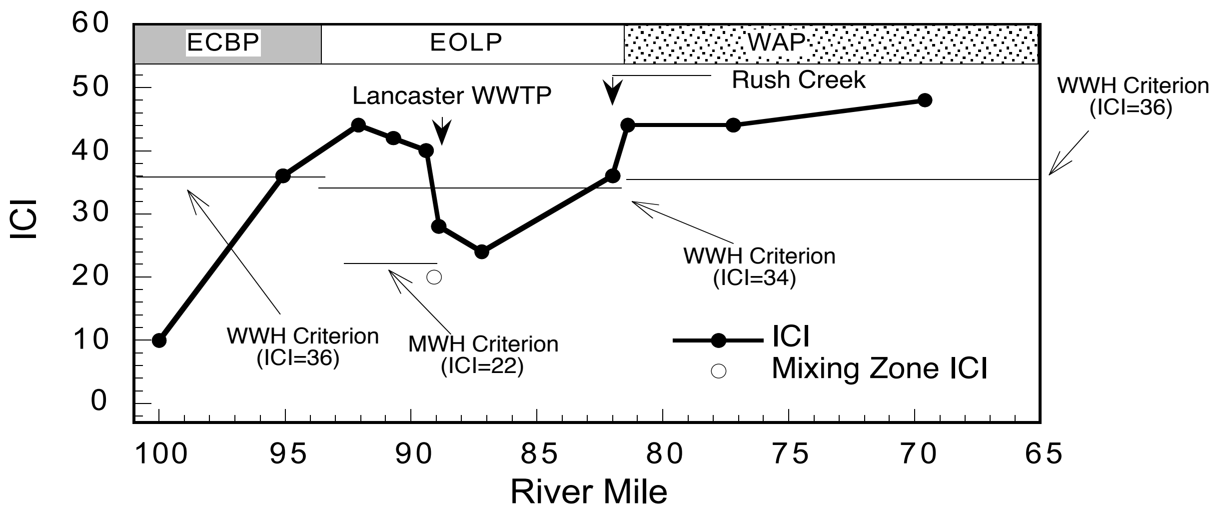


Figure 13 Longitudinal performance of the Invertebrate Community Index (ICI) from the upper Hocking River mainstem, 1995. The solid lines represent the criteria in support of the WWH and MWH aquatic life use designations for each ecoregion.

Communities improved to the *good* range immediately upstream from Lancaster and the *very good* range in the channelized urban area upstream from the Lancaster CSOs (ICIs = 36 and 44 at RM 95.1 and RM 92.1, respectively). Communities continued to exceed the WWH biocriterion through the Lancaster urban area and reflected minimal impacts prior to the Lancaster WWTP discharge (RM 90.7 to RM 89.4). QCTV scores also exceeded ecoregional expectations throughout the Lancaster urban area, falling in the range generally associated with *good* quality communities. Septic odors and trash were more prevalent at the US 22 site (RM 90.7) and sewage solids were observed immediately below a flap-gate discharge pipe upstream from the bridge. Field observations also noted an increase in the predominance of pollution tolerant leeches at RM 90.7, but the ICI and QCTV scores maintained *good* quality.

The Lancaster WWTP mixing zone sample was predominated by intermediate and tolerant midge taxa, lung breathing snails of the genus *Physella*, oligochaetes, and hydra. This assemblage, coupled with presence of eleven taxa total mayfly, caddisfly and tanytarsini midge taxa did not suggest acute toxicity, rather, the assemblage was more indicative of organic enrichment.

ICI scores dropped to the *fair* range (<30, >12) from the Lancaster WWTP mixing zone to U.S 33 (RM 89.1 to RM 87.2). The index scores ranged from 20 in the mixing zone to 28 immediately downstream from the WWTP and the confluence with Baldwin Run (RM 89.0). Communities throughout this stretch were characterized by a sharp decrease in mayfly diversity

Table 9. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative) and natural substrates (qualitative sampling) in the upper Hocking River basin study area, August to September, 1982-1994.

			Quantitative Evaluation						
Stream River Mile	Eco-region	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Hocking River 1995									
100.0	ECBP	852	29	20	38	1	32.3	10*	Poor
95.1	ECBP	225	37	34	54	12	39.7	36	Good
92.1	EOLP	423	66	46	83	12	38.2	44	Very Good
90.7	EOLP	292	47	38	62	10	37.2	42	Very Good
89.4	EOLP	209	47	52	70	13	39.2	40	Good
89.04 A mz	*EOLP*	*Qual. Only*	*NA*	*32*	*NA*	*4*	*31.3*	*NA*	*Poor*
89.04 B mz	*EOLP*	*Qual. Only*	*NA*	*24*	*NA*	*2*	*30.1*	*NA*	*Poor*
89.04 C mz	*EOLP*	*1033*	*35*	*25*	*45*	*3*	*29.6*	*20*	*Fair*
88.9	EOLP	940	43	43	62	6	34.2	28*	Fair
87.2	EOLP	2115	41	39	53	2	32.6	22*	Fair
82.0	EOLP	571	47	55	70	13	38.1	36	Good
81.4	WAP	1427	46	47	70	13	38.9	44	Very Good
77.2	WAP	403	40	46	61	9	40.4	44	Very Good
73.6	WAP	HDs Lost	NA	47	NA	13	39.3	NA	Very Good
69.6	WAP	1809	36	61	72	17	40.1	48	Exceptional
Hocking River 1994									
87.3	EOLP	646	44	43	61	3	32.9	22*	Fair
Hocking River 1992									
87.2	EOLP	747	50	48	66	11	34.8	36	Good
Hocking River 1990									
95.1	ECBP	1199	39	49	69	14	39.7	50	Exceptional
91.9	EOLP	855	47	56	71	16	37.7	52	Exceptional
90.7	EOLP	696	47	59	71	13	35.3	46	Exceptional
89.4	EOLP	943	49	44	67	7	34.7	38	Good
89.1mix zone	EOLP	*2788*	*41*	*23*	*48*	*3*	*37.2*	*26*	*Fair*
88.9	EOLP	1105	42	48	67	9	34.2	32[ns]	Marg. Good
87.2	EOLP	HDs Lost	NA	44	NA	9	37.2	NA	Marg. Good
82.9	EOLP	1292	46	53	68	13	38.2	46	Exceptional

Table 9. continued.

		Quantitative Evaluation							
Stream River Mile	Eco-region	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Hocking River 1990									
81.3	WAP	2348	32	44	56	15	39.7	44	Very Good
77.1	WAP	HDs Lost	NA	35	NA	11	40.5	NA	Good
73.4	WAP	HDs Lost	NA	43	NA	13	38.9	NA	Good
69.4	WAP	4057	28	47	55	12	39.7	46	Exceptional
Hocking River 1982									
94.9	ECBP	HDs Lost	NA	23	NA	10	38.5	NA	Good
92.0	EOLP	262	42	28	54	9	39.1	44	Very Good
91.2	EOLP	243	17	13	24	0	19.5	8*	Very Poor
89.3	EOLP	190	16	14	20	0	22.8	2*	Very Poor
88.5	EOLP	27,476	6	5	8	0	12.5**	0*	Very Poor
87.3	EOLP	2372	3	4	5	0	14.2**	0*	Very Poor
85.4	EOLP	785	11	8	14	0	15.4	0*	Very Poor
82.9	EOLP	452	12	13	19	0	17.7	0*	Very Poor
81.8	EOLP	735	10	11	16	0	19.2	0*	Very Poor
81.3	WAP	352	22	11	27	0	19.5	12*	Very Poor
78.3	WAP	321	31	22	39	6	31.1	22*	Fair
73.5	WAP	120	21	20	34	6	31.3	18*	Fair
Hunters Run 1995									
3.6	EOLP	436	51	41	67	10	39.2	58	Exceptional
2.5	EOLP	1345	45	44	70	10	38.2	54	Exceptional
0.6	EOLP	HDs Lost	NA	40	NA	6	37.2	NA	Marg. Good
Hunters Run 1990									
0.5	EOLP	655	44	41	59	7	34.2	38	Good
Hunters Run 1982									
0.4	EOLP	Qual. Only	NA	20	NA	2	25.5	NA	Poor
Baldwin Run 1995									
2.7	EOLP	245	46	44	67	12	38.2	54	Exceptional
0.2	EOLP	HDs Lost	NA	46	NA	7	32.6	NA	Fair
0.1	EOLP	Qual. Only	NA	19	NA	1	32.6	NA	Poor

Table 9. continued.

			Quantitative Evaluation						
Stream River Mile	Eco-region	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Baldwin Run 1990									
0.2	EOLP	243	39	28	48	3	32.6	16*	Fair
Baldwin Run 1990									
0.2	EOLP	243	39	28	48	3	32.6	16*	Fair
Baldwin Run 1982									
0.2	EOLP	Qual. Only	NA	10	NA	0	17.6	NA	Poor
Clear Creek 1995									
20.1	ECBP	HDs Lost	NA	19	NA	1	35.0	NA	Poor
14.1	ECBP	2399	47	67	88	15	35.3	52	Exceptional
13.1	ECBP	652	61	39	74	10	35.6	44	Very Good
9.5	EOLP	290	38	30	53	9	41.3	54	Exceptional
7.3	EOLP	596	51	39	63	13	41.3	54	Exceptional
5.8	EOLP	253	45	33	59	11	39.9	52	Exceptional
2.1	WAP	1373	43	42	64	12	40.3	50	Exceptional
Clear Creek 1990									
2.0	WAP	705	48	70	86	15	39.0	50	Exceptional
Clear Creek 1988									
16.1	ECBP	Qual. Only	NA	31	NA	5	36.8	NA	Marg. Good
14.1	ECBP	Qual. Only	NA	28	NA	1	30.3	NA	Poor
13.1	ECBP	Qual. Only	NA	43	NA	10	37.2	NA	Good
Clear Creek 1984									
2.1	WAP	1690	40	32	52	12	42.4	46	Exceptional
Clear Creek 1983									
2.1	WAP	507	38	37	53	14	42.4	50	Exceptional
Clear Creek 1982									
16.1	ECBP	320	43	30	53	5	38.2	40	Good
14.2	ECBP	901	42	28	47	8	39.1	34[ns]	Marg. Good
13.1	ECBP	376	37	41	55	10	37.8	40	Good
9.5	EOLP	215	40	36	54	10	38.9	32[ns]	Marg. Good
2.0	WAP	352	49	32	60	6	42.4	44	Very Good

Table 9. continued.

			Quantitative Evaluation						
Stream River Mile	Eco-region	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Muddy Prairie Run 1995									
0.6	EOLP	326	47	39	64	9	41.4	52	Exceptional
Muddy Prairie Run 1982									
0.4	EOLP	215	33	17	38	6	41.6	44	Very Good
Muddy Prairie Creek 1995									
0.1	ECBP	Qual. Only	NA	43	NA	5	31.3	NA	Fair
Sand Run 1995									
0.1	ECBP	Qual. Only	NA	33	NA	11	38.9	NA	Very Good
Arney Run 1995									
4.3	EOLP	Qual. Only	NA	46	NA	6	37.2	NA	Marg. Good
3.7	EOLP	Qual. Only	NA	32	NA	4	34.7	NA	Fair
0.1	EOLP	Qual. Only	NA	37	NA	8	38.9	NA	Good
Dunkle Run 1995									
0.5	ECBP	Qual. Only	NA	45	NA	15	39.2	NA	Exceptional
Cattail Creek 1995									
2.7A	WAP	Qual. Only	NA	39	NA	12	38.9	NA	Exceptional
2.7B	WAP	Qual. Only	NA	40	NA	17	40.9	NA	Exceptional
Cattail Creek 1993									
2.7	WAP	Qual. Only	NA	25	NA	11	41.5	NA	Exceptional
Cattail Creek 1992									
2.7	WAP	Qual. Only	NA	40	NA	13	40.0	NA	Exceptional
Cattail Creek 1990									
2.7	WAP	Qual. Only	NA	28	NA	11	40.0	NA	Exceptional
Cattail Creek 1988									
3.7	WAP	Qual. Only	NA	30	NA	14	40.9	NA	Exceptional
2.7	WAP	Qual. Only	NA	39	NA	12	38.9	NA	Exceptional

Table 9. continued.

			Quantitative Evaluation						
Stream River Mile	Eco-region	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Cattail Creek 1987									
2.7	WAP	Qual. Only	NA	41	NA	13	40.0	NA	Exceptional
Scott Creek1995									
9.0	WAP	25	23	23	37	9	39.1	26[d]	Marg. Good
4.9	WAP	101	31	25	50	7	38.9	44	Very Good
1.5[e]	WAP	510	33	38	59	7	38.2	34[d]	Good

Ecoregion Biocriteria:

Western Allegheney Plateau (WAP) and Eastern Corn Belt Plain (ECBP)

INDEX	WWH	EWH	MWH[f]
ICI	36	46	22

Erie Ontario Lake Plain (EOLP)

INDEX	WWH	EWH	MWH[f]
ICI	34	46	22

f - Modified Warmwater Habitat for channel modified areas.

a - A narrative evaluation based on the qualitative sample (G-good, MG-marginally good, F-fair, P-poor) is used in lieu of the ICI when artificial substrate data are not available.
b - EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).
c - Qualitative Community Tolerance Value (QCTV) is calculated as the median tolerance value of all taxa collected during qualitative (*i.e.,* natural substrate) sampling.
d - The quantitative (artificial substrate) sample was affected by nondetectable current speed; a marginally good (RM 9.0) and good (RM 1.5) narrative evaluations were substituted based primarily on qualitative sampling results.
e - Scott Creek is currently designated EWH from RM 3.9 to the mouth.
* - Significant departure from ecoregion biocriteria (>4 ICI units); poor and very poor results are underlined.
ns - Nonsignificant departure from biocriterion (<4 ICI units).
**- Taxa richness in the qualitative sample too low to calculate a valid QCTV score; in these instances, the average of tolerance values in the qualitative sample is reported.
NA - Not Available.

and predominance, sharp declines in EPT taxa from the natural substrates, and subsequent increases in the percentages of tolerant taxa and dipteran/non-insects (Appendix D). Further downstream at RM 87.2, oligochaetes accounted for over 60% of the artificial substrate community (5,795 individuals) and continued to indicate impacts from organic wastes. Qualitative sampling also reflected impacts throughout the approximate two mile stretch from the WWTP to US 33 (Figure 13). QCTV scores were below ecoregional expectations at both the mixing zone and US 33 sites while RM 89.0 fell between the high and low performance ranges. Prior to the WWTP discharge, all qualitative samples outside of RM 100.0 performed above ecoregional expectations.

The macroinvertebrate community recovered to the *good* range prior to the confluence with Rush Creek (ICI=36 at RM 82.0) and improved to the *very good* and *exceptional* ranges between Rush Creek and Logan (RM 81.4 to RM 69.6). The general recovery trends were characterized by increases in EPT taxa richness from the natural substrates, mayfly taxa richness, and percentages of mayflies, caddisflies and tanytarsini midges. In contrast, percentages of tolerant and diptera/non-insect taxa showed a general declining trend through the same stretch. QCTV scores also reflected the improving trend with all scores from RM 82.0 to RM 69.6 above ecoregional expectations. Like previous surveys, the introduction of waters from Rush Creek appeared to benefit Hocking River communities downstream from the confluence.

Biological Assessment: Fish Community

A total of 15,001 fish comprising 50 species and three hybrids were collected from the upper Hocking River mainstem between July 12 and August 14, 1995. The sampling effort included 13 stations located between RM 100.2 (Pickerington Rd.) and RM 69.5 (SR 664), providing an assessment coverage of 30.7 miles.

Numerically predominant species were: creek chub (18.6%), white sucker (10.7%), northern hog sucker (10.7%), striped shiner (8.1%), bluntnose minnow (5.6%), central stoneroller (5.5%), and greenside darter (5.3%). Species that predominated in terms of biomass included: common carp (42.2%), northern hog sucker (13.6%), silver redhorse (9.5%), golden redhorse (8.3%), creek chub (3.6%), and smallmouth bass (2.4%).

In terms of numerical abundance, species classified as tolerant of both habitat and water quality degradation were dominant (e.g., creek chub, white sucker, bluntnose minnow). Nevertheless, the environmentally sensitive northern hog sucker and striped shiner were well represented within the assemblage. In terms of biomass, the exotic and highly tolerant common carp comprised a considerable proportion of total (42.2%). The common carp's position within the community appeared fairly typical in comparison with other medium sized river systems within Ohio. This highly adaptable species is well distributed (Trautman 1981) and commonly occupies a prominent position within the fish assemblages of some of the state's high quality waterways.

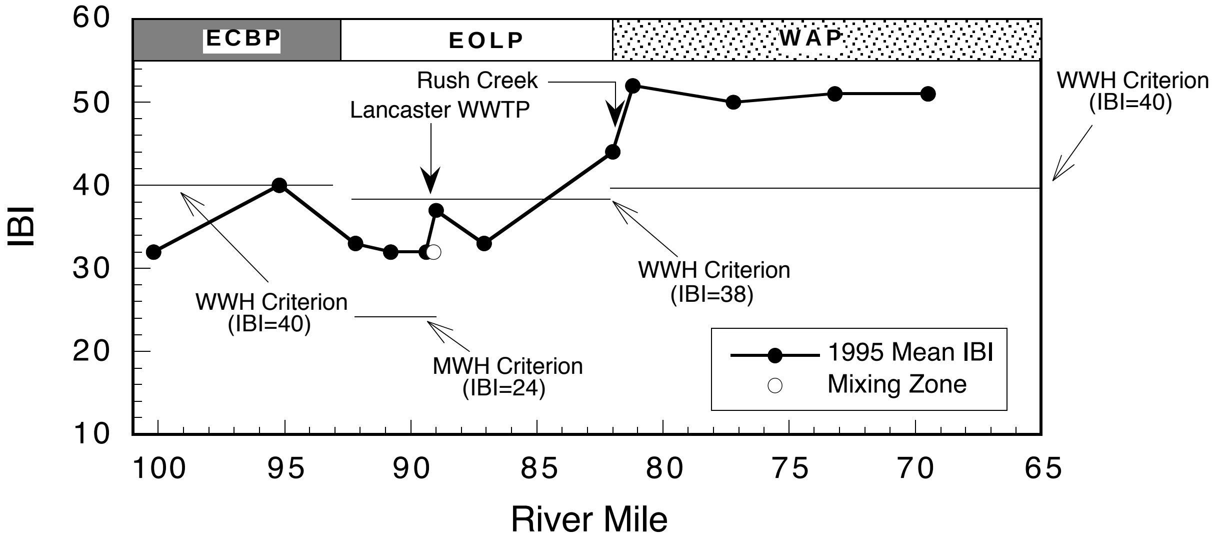
Excluding creek chub, the remaining biomass (33.8%) was concentrated in environmentally sensitive centrachid (sunfish) and catastomid (sucker) species.

Fish community sampling between RM 100.2 (Pickerington Rd.) and RM 87.1 (US 33) employed standard wading methodologies. The remaining segment, extending from RM 82.0 (Sugar Grove Rd) to RM 69.5 (SR 664), was sampled with standard boat methodologies. Due to the undesirable effects of drainage area on the MIwb, related primarily to attributes of headwater fish assemblages, community performance within headwater streams is evaluated with the IBI only. The station at RM 100.2 represented the only headwater station evaluated on the upper Hocking River mainstem. Community samples collected with wading (non-headwater) and boat methodologies employed both the MIwb and IBI to evaluate fish community condition (Ohio EPA 1987[b]). Community performance and accompanying narrative evaluations ranged between *fair* (IBI=32) at RM 100.2 and *exceptional* at RM(s) 77.2, 73.2, and 69.5 (IBI≥50 and MIwb≥9.6) (Table 10). As a whole, the fish community of the upper Hocking River was characterized as *marginally good* to *good*. Longitudinal performance of the IBI and MIwb are presented in Figure 14.

Community condition, as measured by the IBI, within the headwaters of the upper Hocking River (RM 100.2) was considered *fair* (IBI=32). The station was characterized by low species richness, low relative abundance, and a predominance of environmentally tolerant species - mainly young-of-year. The depauperate assemblage appeared directly reflective of greatly simplified macrohabitats, as this reach has been extensively channelized. Substrates consisted entirely of accumulated clays and silts, in places deposits reaching several feet in depth. The channelized headwaters of the Hocking River extended for 1.4 miles, between RM 101.5 and 100.1. The data gathered at RM 100.2 was likely indicative of the assemblages supported within this segment as a whole. Community performance was below the WWH standard, but appeared fully consistent with the limited potential of this reach.

Macrohabitat quality was much improved further downstream at RM 95.2 (adj Hooker Cemetery-upstream of Lancaster), as the stream appeared in a fairly natural state. Performance of the fish community at this station appeared commensurate with macrohabitat quality. The condition of the assemblage, as measured by both the IBI and MIwb, was in full agreement with the WWH biological criteria achieving 40 and 8.5, respectively. In comparison with the headwaters, all basic community statistics were significantly improved (e.g., species richness, relative abundance, biomass) above that which would be expected with increasing drainage area.

As the Hocking River entered the urbanized area of Lancaster, macrohabitat quality again declined. The river segment flowing through and downstream from the city of Lancaster has been extensively channelized and levied for a distance of approximately 8.1 miles. This segment receives effluent from the Lancaster WWTP as well as pulsed or periodic discharges of untreated



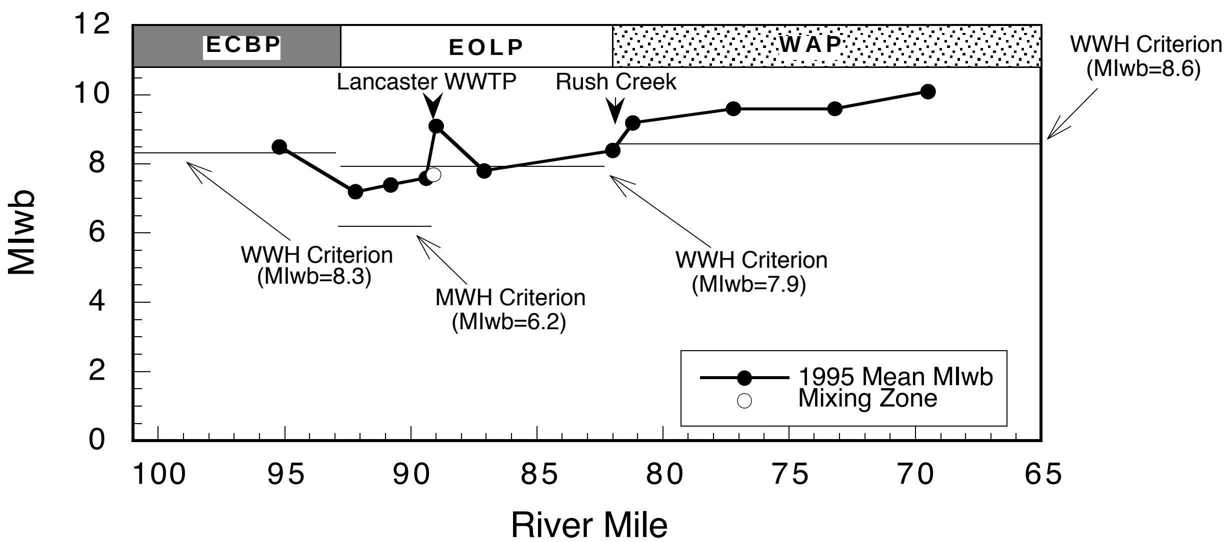


Figure 14 Longitudinal performance of the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) for the upper Hocking River mainstem, 1995. The solid lines represent numerical biological criteria in support of the WWH and MWH aquatic life use designation for each ecoregion.

Table 10. Fish community indices and descriptive statistics based on samples collected by Ohio EPA from the upper Hocking River study area, 1978-1995.

Mean Stream **River Mile**	Number Species	Mean Cumulative Species	Mean Rel. No. (No./km)	Rel. Wt. (Wt./km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Hocking River (1995)								
Eastern Corn Belt Plain - WWH Use Designation (Existing)								
100.2(H)	7	5.0	160.7	0.7	28.0	32*	N/A	Fair
95.2(W)	22	20.0	1791.8	16.5	85.0	40	8.5	Good
Erie Ontario Lake Plain - WWH Use Designation (Existing)								
92.2(W)	23	18.0	908.3	59.3	38.5	33*	7.2*	Fair
90.8(W)	20	17.5	967.5	31.6	41.5	32*	7.4ns	Fair-M. Good
89.4(W)	21	18.5	1209.0	40.0	63.0	32*	7.6ns	Fair-M. Good
89.04(W,MZ)	*16*	*13.0*	*1332.0*	*33.0*	*N/A*	*32*	*7.6*	*Fair-M. Good*
89.0(W)	22	20.0	2145.8	69.2	65.0	37ns	9.1	M Good-V. Good
87.1(W)	21	18.5	1168.5	74.8	70.5	33*	7.8ns	Fair-M. Good
82.0(B)	24	21.5	720.0	103.1	82.5	44	8.4ns	V. Good-M. Good
Western Allegheny Plateau - WWH Use Designation (Existing)								
81.2(B)	30	26.0	506.0	79.6	70.5	52	9.2	Except.-V. Good
77.2(B)	30	24.5	689.0	137.6	77.0	50	9.6	Exceptional
73.2(B)	30	25.0	582.0	75.2	74.0	51	9.6	Exceptional
69.5(B)	33	28.0	954.0	121.5	77.0	51	10.1	Exceptional
(1990)								
Eastern Corn Belt Plain - WWH Use Designation (Existing)								
95.2(W)	19	16.3	1046.0	15.9	66.0	35*	8.2ns	Fair-M. Good
Erie Ontario Lake Plain - WWH Use Designation (Existing)								
92.2(W)	20	14.3	499.0	121.5	44.0	27*	6.5*	Poor-Fair
90.8(W)	21	16.7	332.5	6.7	37.0	28*	6.9*	Fair
89.4(W)	24	15.3	369.5	21.9	41.5	24*	5.9*	Poor-Fair
89.04(MZ,W)	*12*	*6.7*	*268.0*	*22.2*	*N/A*	*25*	*4.7*	*Poor*
89.0(W)	16	13.0	304.0	29.6	37.5	30*	6.5*	Fair
87.1(W)	17	11.3	149.0	41.9	58.5	25*	4.9*	Poor
82.0(B)	20	16.0	159.6	18.9	62.0	33*	6.5*	Fair
Western Allegheny Plateau - WWH Use Designation (Existing)								
81.2(B)	21	16.3	265.3	65.5	57.5	39ns	8.1ns	M. Good
77.2(B)	26	19.3	277.3	137.2	63.5	34*	7.5*	Fair

Table 10. continued.

Mean Stream **River Mile**	Number Species	Mean Cumulative Species	Mean Rel. No. (No./km)	Rel. Wt. (Wt./km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Hocking Rive (1990)								
Western Allegheny Plateau - WWH Use Designation (Existing)								
73.2(B)	25	18.7	245.3	53.3	63.5	43	8.1[ns]	Good-M. Good
69.5(B)	22	17.7	262.0	65.4	78.0	40	8.6	Good
Hocking River (1982)								
Eastern Corn Belt Plain - WWH Use Designation (Existing)								
95.2(W)	12	10.7	513.3	256.6	46.0	<u>27</u>*	6.1*	Poor-Fair
Erie Ontario Lake Plain - WWH Use Designation (Existing)								
93.2(W)	15	20.0	295.5	74.0	-	<u>23</u>*	<u>5.5</u>*	Poor
92.0(W)	15	17.3	283.3	72.9	48.0	<u>17</u>*	<u>4.5</u>*	V. Poor-Poor
90.7(W)	14	20.0	292.0	105.1	40.0	<u>17</u>*	<u>4.0</u>*	V. Poor
88.8(W)	4	16.0	363.3	84.7	48.0	<u>12</u>*	<u>0.6</u>*	V. Poor
85.7(W)	8	15.0	308.0	74.8	62.0	<u>12</u>*	<u>1.8</u>*	V. Poor
83.1(W)	14	12.3	76.0	20.2	67.0	<u>20</u>*	<u>4.0</u>*	Poor-V. Poor
Western Allegheny Plateau - WWH Use Designation (Existing)								
81.4(B)	10	13.7	131.3	26.1	84.0	<u>17</u>*	<u>2.4</u>*	Poor
77.2(B)	21	13.0	142.0	28.0	63.0	29*	6.8*	Fair
73.3(B)	23	24.3	396.0	150.9	66.0	31*	7.3*	Fair
Hunters Run (1995)								
Erie Ontario Lake Plain-WWH Use Designation (Existing)								
3.5(H)	18	16.0	2220.0	10.31	58.5	44	N/A	Good
2.5(H)	17	16.5	2710.5	13.1	59.0	55	N/A	Exceptional
0.5(H)	17	15.5	1866.0	7.96	55.5	46	N/A	V. Good
(1990)								
Erie Ontario Lake Plain-WWH Use Designation (Existing)								
0.5(H)	17	15.3	744.5	9.4	50.0	39[ns]	N/A	M. Good
(1982)								
Erie Ontario Lake Plain-WWH Use Designation (Existing)								
0.6(H)	16	11.3	928.8	13.0	-	28*	N/A	Fair
Baldwin-Ewing Run (1995)								
Erie Ontario Lake Plain-WWH Use Designation (Existing)								
2.7(H)	15	13.0	2097.0	13.5	75.0	44	N/A	Good
0.3(H)	15	17.0	4620.8	25.7	57.0	42	N/A	Good

Table 10. continued.

Stream River Mile	Number Species	Mean Cumulative Species	Mean Rel. No. (No./km)	Mean Rel. Wt. (Wt./km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Baldwin-Ewing Run(1990)								
	Erie Ontario Lake Plain-WWH Use Designation (Existing)							
0.3(H)	20	12.7	1941.7	18.4	50.5	31*	N/A	Fair
(1982)								
	Erie Ontario Lake Plain-WWH Use Designation (Existing)							
0.5(H)	12	8.0	1483.2	13.5	-	27*	N/A	Poor
Scott Creek (1995)								
	Western Allegheny Plateau - WWH Use Designation (Existing)							
8.9(H)	6	4.5	221.0	0.5	61.0	34*	N/A	Fair
5.6(H)	19	16.0	857.3	10.2	68.0	37*	N/A	Fair
	Western Allegheny Plateau - EWH/WWHUse Designation (Existing/Recommended)							
0.1(W)	37	29.0	651.8	11.4	76.0	49^{ns}	8.8*	V. Good-Good
(1978)								
	Western Allegheny Plateau - WWH Use Designation (Existing)							
8.9(H)	7	7.0	3020	3.6	76.0	56	N/A	Exceptional
8.1(H)	11	11.0	1200	-	70.0	48	N/A	V. Good
8.0(H)	3	3.0	120	-	-	22*	N/A	Poor
7.2(H)	8	8.0	680	-	-	28*	N/A	Fair
5.6(H)	13	13.0	610.0	15.5	-	36*	N/A	Fair
Clear Creek (1995)								
	Eastern Corn Belt Plain - WWH Use Designation (Existing)							
21.8(H)	10	9.5	2362.9	6.8	62.0	44	N/A	Good
16.3(H)	28	24.5	2305.5	34.7	59.0	50	N/A	Exceptional
14.2(W)	25	23.0	1475.3	45.7	67.0	39^{ns}	8.3	M. Good-Good
13.1(W)	24	21.5	2994.0	52.5	58.0	42	9.5	Good-Exceptional
	Erie Ontario Lake Plain-WWH Use Designation (Existing)							
9.4(W)	27	26.0	2139.0	50.7	68.0	51	10.0	Exceptional
7.3(W)	29	26.0	1598.3	51.6	78.0	51	9.8	Exceptional
5.9(W)	29	28.0	1601.3	46.8	73.0	49	9.7	V.Good-Except.
	Western Allegheny Plateau - WWH Use Designation (Existing)							
1.9(W)	30	28.0	1176.8	39.5	66.0	51	9.9	Exceptional

Table 10. continued.

Mean Stream **River Mile**	Number Species	Mean Cumulative Species	Mean Rel. No. (No./km)	Rel. Wt. (Wt./km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Clear Creek (1982)								
		Eastern Corn Belt Plain - WWH Use Designation (Existing)						
16.3(H)	18	15.7	1484.3	71.6	53.0	30*	N/A	Fair
14.2(H)	17	14.3	1256.6	101.4	49.0	26*	6.9*	Poor-Fair
13.1(W)	16	13.0	1416.5	34.3	57.0	27*	6.7*	Poor-Fair
		Erie Ontario Lake Plain-WWH Use Designation (Existing)						
9.4(W)	21	17.3	954.3	50.2	71.0	30*	7.5^{ns}	Fair-M.Good
7.3(W)	25	18.7	780.4	2.1	87.0	31*	7.6^{ns}	M.Good
		Western Allegheny Plateau - WWH Use Designation (Existing)						
2.3(W)	23	20.5	1550.7	151.9	-	35*	9.4	Fair-Exceptional
Muddy Prairie Run (1995)								
		Erie Ontario Lake Plain-WWH Use Designation (Existing)						
0.4(H)	18	18.0	2113.8	11.7	55.0	54	N/A	Exceptional
(1982)								
		Erie Ontario Lake Plain-WWH Use Designation (Existing)						
0.7(H)	13	12.9	2778.6	52.8	83.0	41	N/A	Good
Muddy Prairie Creek (1995)								
		Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.1(H)		19.0	2064.0	33.4	42.0	52	N/A	Exceptional
Sand Run (1995)								
		Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.1(H)	14	14.0	1428.0	10.5	46.0	44	N/A	Good
Arney Run (1995)								
		Erie Ontario Lake Plain-WWH Use Designation (Existing)						
4.3(H)	13	11.0	807.8	2.6	37.0	38^{ns}	N/A	M.Good
2.2(H)	16	14.5	891.8	10.6	72.0	43	N/A	Good
0.1(H)	24	22.0	3221.3	23.8	81.0	53	N/A	Exceptional
Dunkle Run (1995)								
		Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.5(H)	15	15.0	2386.0	13.4	62.0	44	N/A	Good
(1982)								
		Eastern Corn Belt Plain-WWH Use Designation (Existing)						
0.1(H)	8	8.0	620.0	-	66.0	30*	N/A	Fair

Table 10. continued.

Stream River Mile	Number Species	Mean Cumulative Species	Mean Rel. No. (No./km)	Mean Rel. Wt. (Wt./km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Cattail Creek (1995)								
	Western Allegheny Plateau - WWH Use Designation (Existing)							
2.8(H)	12	12.0	1306.0	3.1	64.0	46	N/A	V. Good

* - Significant departure from applicable criteria (>4 IBI or ICI units, >0.5 MIwb units), poor or very poor results are underlined.

ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, ≤0.5 MIwb units).

H - Headwater station (drainage area < 20 mile^2), the MIwb is not applicable.

W - Wading station.

B - Boat station.

Ecoregional Biological Criteria:

Eastern Corn Belt Plain (ECBP)

Index - Site Type	WWH	EWH	MWH[d]
IBI - Headwater/Wading	40	50	24
IBI - Boat	42	48	24
MIwb - Wading	8.3	9.4	6.2
MIwb - Boat	8.5	9.6	5.8
ICI	36	46	22

Erie Ontario Lake Plain (EOLP)

Index - Site Type	WWH	EWH	MWH[d]
IBI - Headwater	40	50	24
IBI - Wading	38	50	24
IBI - Boat	40	48	24
MIwb - Wading	7.9	9.4	6.2
MIwb - Boat	8.7	9.6	5.8
ICI	34	46	22

Western Allegheny Plateau (WAP)

Index - Site Type	WWH	EWH	MWH[d]
IBI - Headwater	44	50	24
IBI - Wading	44	50	24
IBI - Boat	40	48	24
MIwb - Wading	8.4	9.4	6.2
MIwb - Boat	8.6	9.6	5.8
ICI	36	46	22

d - Modified Warmwater Habitat (MWH) for channel modified areas.

sewage from numerous CSOs maintained by the city of Lancaster. Stations within this reach, particularly upstream from the Lancaster WWTP, supported *fair* to *marginally good* assemblages. Although CSO activity was evidenced by limited deposits of sewage solids, mild septic stream odor, and the common observance of personal hygiene material in-stream; the structure and composition of the community, as well as the condition of individual fish (i.e., the incidence of disease and gross external anomalies) was not indicative of severe enrichment or chronic septic conditions. Rather, nominal departure from the WWH criteria observed within this segment was attributed to overall poor macrohabitat quality.

Though still retaining much evidence of past modification, aquatic habitats of the Hocking River immediately downstream from the Lancaster WWTP were improved (recovered). The fish community at RM 89.0 was characterized as *marginally good* to *very good* (IBI=37 and MIwb=9.1), fully consistent with the WWH biological criteria. By RM 87.1 (US 33) habitat conditions were further advanced and appeared fully capable of supporting a WWH community of aquatic organisms. High quality macrohabitats were prevalent within the remaining downstream portion of the study area. Despite the longitudinal improvement of stream habitat quality, nominal departure of the IBI from the WWH criterion was indicated at RM 87.1 (US 33), approximately two miles downstream from the Lancaster WWTP. In comparison with the upstream results (RM 89.0), the decline observed in the IBI was a result of the loss of two darter species (rainbow darter and log perch). All other IBI metrics were basically correspondent between stations (RM 89.0 and RM 87.1). Departure from the WWH criteria was driven solely by the IBI at RM 87.1, as the MIwb remained within nonsignificant departure from the WWH standard.

The community response at RM 87.1 was likely a result of moderate organic enrichment. The negative effects of oxygen demanding wastes discharged by WWTPs are typically pronounced some distance downstream from the discharge. The effects mediated by effluent constituents, existing pollutant load, and stream discharge characteristics. Impact associated with the Lancaster WWTP observed at RM 87.1 appeared moderate, as near-field (mixing zone) and far-field (RM 89.0) samples were not indicative of effluent toxicity or gross nutrient enrichment.

Complete biological recovery was indicated approximately seven miles downstream from the Lancaster WWTP at RM 82.0 (upstream of Rush Creek) and extended through the remaining portion of the study area. Community performance was markedly improved and fully consistent with the WWH biological criteria. Within the last 11.7 mile of the study area additional improvement was evident as community indices indicated *very good* to *exceptional* conditions.

Hocking River Tributaries

Hunters Run and Baldwin-Ewing Run

Chemical Water Quality

There sampling stations were situated on Hunters Run to evaluate the influence of an unnamed tributary draining the Lancaster Landfill which enters Hunters Run at RM 2.69, and to monitor environmental condition of this Hocking River tributary within Lancaster. Analysis of water column samples did not reveal any significant chemical water quality problems within Hunters Run. Nutrient concentrations were generally low, with several parameters near or at the method detection limits. Dissolved oxygen concentrations well above the minimum and average WWH criteria were measured at all sites, averaging 9.1 mg/l. With the exception of iron, analyses for heavy metals in the water column did not indicate any elevated concentrations. Elevated iron concentrations were recorded at all three sampling stations on July 27 (during a period of high stream flow). No longitudinal pattern was evident relative to the confluence of the landfill tributary. The chemical water quality of Hunters Run appeared unaffected by the Lancaster Landfill and the urbanized portion of the catchment contained within the greater Lancaster area.

Exceedences of the water quality standards were limited to fecal coliform (Table 5). Eight of the 19 replicate samples collected from Hunters Run yielded fecal coliform counts greater than the PCR average criterion. The highest counts were observed near the mouth, within the urbanized portion of the watershed. Given the absence of CSOs on Hunters Run the fecal contamination observed was likely associated with diffuse urban and rural non-point sources. Nearly half of the exceedences appeared associated with periods of elevated runoff and stream discharge following heavy rainfall. During these wet weather periods non-point sources are typically the most active.

Two chemical sampling stations were placed on Baldwin-Ewing Run at RM 0.19 (downstream Lancaster CSOs) and RM 2.68 (upstream Lancaster). This placement provided an opportunity to monitor and assess longitudinal water quality upstream of and within the city of Lancaster. Analysis of water column samples did not reveal any significant chemical water quality problems within Baldwin-Ewing Run. Nutrient concentrations were typically low, with several parameters near or at the method detection limits. Dissolved oxygen (D.O.) concentrations well above the minimum and average WWH criteria were measured at all sites.

As observed in Hunters Run, exceedences of the water quality standards within Baldwin-Ewing Run were limited to fecal coliform (Table 5). Three of the 12 replicate samples collected yielded fecal coliform counts greater than the PCR average criterion. The highest counts were observed near the mouth, within the urbanized portion of the catchment downstream from CSOs maintained by the city of Lancaster. Two of the three exceedences appeared associated with periods of elevated runoff and stream discharge following heavy rainfall. During these wet weather periods non-point sources and CSOs are typically the most active. CSO activity did not appear chronic as releases to Baldwin-Ewing Run seemed associated with wet weather events.

Physical Habitat for Aquatic Life

During the 1995 sampling effort the macrohabitats of Hunters Run were evaluated at three fish sampling stations. Qualitative Habitat Evaluation Index (QHEI) values ranged between 55.5 (RM 0.5, SR 22-Lancaster) and 59.0 (RM 2.5, Crumley Rd.-downstream Fairfield Co. Landfill), with a mean reach value of 57.7. A mean reach value equal to or greater than 60 typically indicates aggregate macrohabitat quality sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989). The mean reach value observed in Hunters Run was near the WWH threshold, suggesting sub-optimal habitat quality but not necessarily habitat impairment.

The channel and riparian conditions at all stations indicated significant modification in the past. The active channel appeared trenched and remained trapezoidal in cross section throughout the study area. However, considerable recovery was observed within the confines of the active channel, as the wetted channel has reestablished, to some extent, a natural course. Although high and moderate influence habitat attributes were predominant, minimum WWH features appeared present. Positive components observed at most stations included: abundant coarse glacial and native substrates, developed pools (typically greater than 40 cm in depth), modestly developed riffles, and well-maintained stream discharge. Despite pervasive evidence of past riparian and channel modifications, aggregate macrohabitat quality within Hunters Run appeared sufficient to support and maintain a community of aquatic organisms consistent with the existing WWH aquatic life use designation.

The macrohabitats of Baldwin-Ewing Run were evaluated at two fish sampling stations. QHEI values ranged between 74.5 (RM 2.7, upstream Lancaster) and 57.6 (RM 0.3, Lawrence Rd.-Lancaster), with a mean reach value of 66.0. A mean reach value equal to or greater than 60 typically indicates aggregate macrohabitat quality sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989).

Despite the proximity of Baldwin-Ewing Run (at RM 2.7) to suburban development, macrohabitat quality appeared unimpaired. The channel was well-developed, maintaining a natural and sinuous course. The substrates consisted primarily of gravel, with a low level of embeddedness. Plunge pools were generally deep (greater than 40 cm), and well-structured with woody debris and other cover types. This station clearly possessed a full compliment of WWH attributes.

The remaining station (RM 0.3), within Lancaster, retained much evidence of past channel modifications, containing a predominance of high and moderate influence modified warmwater habitat attributes (Table 7). Substrates were a mix of coarse and fine material, although considerable embeddedness was observed. Positive habitat components encountered at this station included moderate quantities of in-stream cover and good to fair pool development. Despite the modified characteristics, recovering macrohabitats were present and the station appeared to contain a minimum compliment of positive WWH features.

Biological Assessment: Benthic Macroinvertebrate communities

Artificial substrate samplers were collected from Hunters Run upstream and downstream from the Lancaster Landfill tributary at RM 3.6 and RM 2.5, respectively (Table 9). Sampling at RM 0.6 near US 22 in Lancaster was limited to qualitative sampling due to loss of the artificial substrates.

Macroinvertebrate communities were clearly in the *exceptional* range at the two sites bracketing the Landfill Tributary (ICIs =58 and 56 at RM 3.6 and RM 2.5, respectively). Outside of a possible increase in nutrient enrichment at the downstream site, both sites were quite diverse and predominated by more pollution sensitive mayflies and caddisflies.

At RM 0.6 the narrative evaluation changed from *exceptional* to the *good* range, primarily due to a drop in the number of EPT taxa collected from the natural substrates (from 10 to 6). This stretch of stream had been previously channelized, silt and muck deposition appeared heavier and land use was predominantly urban. However, many of the pollution sensitive taxa found at the upstream sites were also represented at RM 0.6, indicating the changes from upstream to downstream were not severe.

Artificial substrates were collected upstream from the Lancaster urban area in Baldwin-Ewing Run at RM 2.7 but were lost at RM 0.2. An additional qualitative sample was collected at RM 0.1 immediately prior to the confluence with the Hocking River. The site was downstream from a large discharge of groundwater from the Lancaster WWTP property, apparently associated with plant construction.

Macroinvertebrates at RM 2.7 were clearly in the *exceptional* range (ICI=54) and reflected no significant water quality problems. The QCTV OF 38.2 fell in the high performance range for streams in the EOLP and the number of EPT taxa from the natural substrates (12) was at a level typically associated with *exceptional* quality. Community health declined sharply at RM 0.2; the QCTV score (32.6) dropped into the low performance range and was predominated were tolerant and intermediate midge populations including *Cricotopus spp.*, *Polypedilum (P) illinoense*, and the genus *Conchepelopia* (Appendix D). EPT taxa richness also dropped compared to RM 2.7 (from 12 to 7) but still maintained a level associated with WWH attainment.

A large amount of slimy brown solids were observed at the site which may have been dead or decaying algae. Overall, community performance was considered slightly below WWH standards and received a fair evaluation.

Downstream from the groundwater discharge at the WWTP, the stream was much colder and a pervasive layer of bright orange iron precipitate was deposited on all substrates. Only 19 taxa (including one mayfly individual) were collected at RM 0.1 and the bodies of most specimens were covered with the orange solids. Collections were considered of *poor* quality that probably resulted from the deposition of fine particulate matter, the radical alteration of in-stream temperature or low dissolved oxygen levels associated with the groundwater discharge. The impacts were most likely temporal and recovery would be expected when the discharge is removed.

Biological Assessment: Fish Community

A total of 9,063 fish, comprised of 21 species and two hybrids were collected from Hunters Run between July 11 and September 19, 1995. The effort included three sampling stations located between RM 3.9 (Beck Rd., upstream the Lancaster Landfill) and RM 0.5 (SR 22, Lancaster). The entire Hunters Run study area is classified as headwaters (drainage area £20.0 miles^2). Thus, only the IBI was applicable to evaluate the condition of the fish community.

Mean community index values and accompanying narrative evaluations ranged between *good* (IBI=44), at RM 3.5 and *exceptional* (IBI=55) at RM 2.5. Performance of the fish community indicated full agreement with the WWH biological criteria at all stations (Table 10). The fish assemblage encountered at each location was diverse and well structured with sensitive species represented. No adverse impact was observed either downstream from the Lancaster Landfill or within the urbanized lower reach through the city of Lancaster.

A total of 8,957 fish, comprised of 20 species and one hybrid were collected from Ewing-Baldwin Run between July 7 and September 15, 1995. The effort included two sampling stations located at RM 2.7 (upstream Lancaster) and RM 0.3 (Lawrence Rd.-Lancaster CSOs). The entire Ewing-Baldwin Run study area is classified as headwaters (drainage area £ 20.0 miles^2). Thus, only the IBI was applicable to evaluate the condition of the fish community.

Mean community index values and accompanying narrative evaluations were *good*, IBI=44 and 42, at RM 2.7 and RM 0.3, respectively. Performance of the fish community indicated full agreement with the WWH biological criteria at both stations (Table 10). Despite evidence of CSO activity near the mouth (RM 0.3) - primarily in the form of sewage solids blanketing the natural substrates and the occurrence of personal hygiene material in-stream - the discharge(s) must not have been chronic or severe as the community was not indicative of enriched (nutrient or organic) or toxic conditions.

Scott Creek

Chemical Water Quality

Replicate water samples were collected for chemical analysis at three stations from Scott Creek during the summer of 1995. The stations were situated to assess the water quality from the extreme headwaters (RM 8.9) to the mouth (RM 0.1). Environmental stressors within this segment included active surface mining and animal husbandry.

Analysis of water column samples did not reveal any significant chemical water quality problems within Scott Creek. Demand parameters and nutrient concentrations were generally low and longitudinally stable, with several analytes near or at the method detection limits. Dissolved oxygen concentrations well above the minimum and average WWH criteria were measured within the headwaters. Of the six samples collected at RM 0.1 (EWH segment), two D.O. values were below the 5.0 mg/l minimum EWH criterion (Table 5). Two fecal coliform counts in excess of the maximum PCR standard were recorded at RM 5.6 (downstream from Hocking Valley Horse Ranch) and RM 0.1, respectively. These samples were collected in late-July, at a time when surface runoff and stream flows were elevated following an extended period of rainfall. As such, the observed fecal contamination was likely a result of diffuse non-point source runoff. Both the D.O. and fecal coliform results were the only water quality exceedences recorded.

Chronic acidified conditions were not indicated at RM 5.6. This station is situated downstream from a small tributary network that drains several active surface mines. Typical acid mine parameters (pH, aluminum, iron, and sulfates) were analyzed and found to be at expected levels, except for sulfate which was noticeably elevated downstream from the mined areas.

Physical Habitat for Aquatic Life

During the 1995 sampling effort the macrohabitats of Scott Creek were evaluated at three fish sampling stations. Qualitative Habitat Evaluation Index (QHEI) values ranged between 61.0 (RM 8.9, adjacent SR 93) and 75.5 (RM 0.1, near mouth), with a mean reach value of 68.0. A mean reach value equal to or greater than 60 typically indicates aggregate macrohabitat quality sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989).

Macrohabitat quality of the extreme headwaters of Scott Creek was evaluated at RM 8.9. This station achieved a QHEI value of 61.0, suggesting the conservation of minimum WWH features. As a consequence of the small drainage area of this station (0.3 $miles^2$), the stream was very narrow and shallow, as channel widths and pool depths were typically less than one meter and 40 cm, respectively. However, these and other habitat characteristics appeared reflective of natural conditions, as the station represented typical headwater habitat encountered in unglaciated Ohio. The greatest limiting factor of the headwaters of Scott Creek appeared to be intermittent stream discharge. During the second sampling effort in September, 1995, terrestrial vegetation was observed growing within the wetted channel at RM 8.9. This observation suggested that the stream had run dry sometime between July and September. The lack of residual pools during the critical summer months would undoubtedly limit the maintenance of a permanent assemblage of WWH aquatic organisms.

Although still classified as a headwater stream (i.e., drainage area £ 20 miles^2), the physical conditions encountered at RM 5.6 were considerably different than that observed upstream. The channel was much larger with a greater diversity of habitat features, achieving a QHEI value of 67.5. Despite macrohabitat quality, as measured by the QHEI, consistent with the WWH use conditions appeared significantly diminished at this station. The substrates were primarily shifting and unstable sand and fine gravel. This reach appeared to receive a considerable sediment load from the surrounding uplands. The abundance of fine sediment reduced pool depth, embedded coarse substrates, and often reduced the functionality of in-stream cover. Upstream sources of sediment loading may include: tributaries draining several strip-mined areas (Key Coal Co., Empire Minerals Corp.), animal husbandry activities at the Hocking Valley Horse Ranch, and other land use practices adjacent to and upstream of this station. Stream discharge and water level appeared reduced during the second sampling effort in September, as much of the reach sampled was reduced to a series of near-stagnant pools connected only by small rivulets. The conditions observed, particularly during the second sampling effort, would likely have a negative influence on the ambient biological potential of this station.

Macrohabitat quality was much improved near the mouth at RM 0.1 (adjacent SR 93). The predominance of positive habitat features resulted in a QHEI value of 75.5, far in excess of the WWH threshold. High quality habitat attributes commonly encountered at this station included: sinuous and well-developed channel, numerous riffle-run-pool complexes, deep pools, extensive to moderate in-stream cover, well-maintained stream flow, and an abundance of coarse substrates. This station clearly contained a full compliment of positive WWH features.

The longitudinal improvements of macrohabitat quality observed within Scott Creek appeared reflective of stream size and habitat features associated with increasing drainage area. Reduced or eliminated stream discharge within the headwaters would likely negatively affect the ambient biological potential of this reach. The remaining station appeared intact, maintaining strong perennial flow as well as a diverse compliment of high quality habitat features.

Biological Assessment: Benthic Macroinvertebtrate Communities

Scott Creek was sampled at three locations to monitor potential residual influences from an acid water spill from the Keyes Mine approximately 15 years earlier. The spill had resulted in a massive fish kill throughout the lower approximate eight miles of the stream.

The most upstream site at RM 9.0 was very small, intermittent, and artificial substrates were set and retrieved from an area with no detectable current. The ICI of 26 was in the fair range but EPT taxa richness (9) and the QCTV (39.1) reflected *good* performance (Table 9). Since the ICI was negatively influenced by a lack of flow dependent taxa (primarily hydropsychid caddisflies), the community was considered of higher quality than the ICI score would indicate. Therefore, the macroinvertebrate community was evaluated as *marginally good* and attaining the designated WWH aquatic life use designation.

Additional sites downstream at RM 4.9 and RM 1.5 were also collected from areas of non-detectable current but the stream was free-flowing. ICI scores ranged from *very good* (44) at RM 4.9 to *marginally good* (34) at RM 1.5. QCTV scores and EPT taxa richness reflected *good* performance and both sites included some pollution sensitive and cold water taxa. Both sites met WWH criteria and ICI scores probably underestimated the quality of the macroinvertebrates due to the lack of current over the artificial substrates. Mine drainage associated with the Keyes Mine had no detectable influence on the communities.

Biological Assessment: Fish Community

A total 2,233 fish, comprised of 41 species and two hybrids were collected from Scott Creek between July 7 and September 5, 1995. The effort included 3 sampling stations located between RM 8.9 (adjacent SR 93, headwaters) and RM 0.1 (adjacent SR 93, near mouth), providing an assessment coverage of 8.9 river miles.

In the aggregate (all collections) numerically predominant fish species were: creek chub (26.5%), bluegill sunfish (13.7%), green sunfish (12.7%), white sucker (8.3%), and striped shiner (5.2%). Species that predominated in terms of biomass included: white sucker (21.4%), creek chub (17.5%), bluegill sunfish (15.7%), green sunfish (9.0%), northern hog sucker (4.3%). In terms of both relative abundance and biomass the fish assemblage was comprised mainly of species classified as tolerant of physically and/or chemically disturbed environments (e.g., white sucker, creek chub, and green sunfish). The remaining predominant taxa are commonly associated with pooled, low gradient streams or stream segments (e.g., bluegill sunfish and striped shiner). Only one environmentally sensitive species, the northern hog sucker, was represented in these predominant groups.

All community sampling within Scott Creek employed standard wading methodologies (Ohio EPA 1987b). Within the headwaters of the study area (RM 8.9 and RM 5.6), the condition of the fish community was evaluated with the IBI only. At the remaining downstream station (RM 0.1) both the IBI and MIwb were applicable. Community index values and their accompanying narrative evaluations ranged between *fair* (IBI=34) at RM 8.9 and *very good* to *good* (IBI=49 and MIwb=8.8) at RM 0.1 (Table 10). As a whole, the fish community of Scott Creek was considered in *good* condition.

Community performance, as measured by the IBI, indicated *fair* conditions at both headwater stations. The site marking the upper limits of the study area (RM 8.9) was found to contain only 6 species (half of which are classified as highly tolerant), with a mean relative abundance of 221.0/0.3 km. The mean IBI at this site was 34, below the WWH headwater criterion. Community statistics were advanced at the remaining headwater station (RM 5.6). Species richness increased to 19 and included the addition of two environmentally sensitive taxa (e.g., golden redhorse and longear sunfish). Mean relative abundance was also increased, reaching 857.3/0.3 km. Though much improved in comparison with the upstream station, community performance still remained below WWH expectations.

The longitudinal improvements observed within the headwaters of Scott Creek appeared reflective of stream size and habitat features associated with increasing drainage area. The most upstream stations represented the extreme headwater of the study area. The stream at this site is very small, with channel widths typically less than one meter. However, habitat characteristics appeared intact and represented natural headwater conditions typical of unglaciated Ohio. Unfortunately, the stream flow was likely intermittent, as terrestrial vegetation was observed growing in the wetted channel during the second sampling effort in September. Failure of the fish community to perform at a WWH level at this station was attributed to the ephemeral nature of this reach, as no visible chemical or physical impacts (acid mine or sediment load) were evident. Whether the intermittency was a natural phenomenon or anthropogenic in origin is not clear at this time.

Although still classified as a headwater stream (i.e., drainage area < 20 $miles^2$), the physical conditions encountered at RM 5.6 were considerably different than that observed upstream. The stream was much larger, with a greater diversity of habitat features. The general improvement of basic community statistics appeared directly related to increasing drainage area. However, macrohabitat quality was diminished at RM 5.6. The substrates were primarily shifting and unstable sand and fine gravel. This reach appeared to receive a considerable sediment load from the surrounding uplands. Upstream sources of these sediment deposits may include: tributaries draining several stripped mined areas (Key Coal Co. and Empire Minerals Corp.), animal husbandry activities at the Hocking Valley Horse Ranch, and other land use practices adjacent to and upstream of this station. Stream discharge and depth appeared reduced during the second sampling effort in September, as much of the reach sampled was reduced to a series of stagnant pools connected only by small rivulets. An additional stressor, above the habitat constraints, may have included pulsed runoff from the tributaries draining adjacent strip mine areas. These factors, collectively or individually, appeared directly related to departure from the WWH biological criterion observed.

Community performance was markedly improved at RM 0.1 (near the confluence with the Hocking River). Both the IBI and MIwb indicated complete agreement with the WWH biological criteria, achieving mean values of 49 and 8.8, respectively. Positive community attributes observed at this station included an increase in species richness to 37 (including 10 environmentally sensitive species) and a significant reduction in the percentage of tolerant and omnivorous species. Community performance was advanced at RM 0.1 and appeared reflective of improvements in macrohabitat and water quality. Additionally, the close proximity of this station to the Hocking River undoubtedly influenced species composition. The movement of fish between the two water bodies, particularly catostomids entering Scott Creek from the Hocking mainstem, likely resulted in seasonal or periodic recruitment to the resident fish assemblage.

Clear Creek and Principal Tributaries

Clear Creek (mainstem)

Pollutant Loading

Village of Amanda (Permit# 4PB00021)

The Village of Amanda WWTP is a secondary treatment facility with a design capacity of 0.063 MGD. Treatment of waste water is provided by a three cell lagoon system with bar screen and comminutor. The plant discharges to Clear Creek at RM 14.5. Flow from the WWTP is limited to not more than 90 gallons per minute for each cubic foot per second (CFS) of stream flow measured upstream of the outfall. No discharge is allowed when stream flow is less than one CFS. Discharge is not continuous, with slugs of approximately 0.48 MGD occurring over a six to seven day period every other month. The Amanda facility receives primarily sanitary flow. Although historically the facility has had minimal effects on loading in the watershed, third quarter 1995 data shows that the Amanda WWTP contributed 0.1% (0.01 kg/day) of the NH_3-N, 2.3% (0.35 kg/day) of cBOD, and 0.6% (1.42 kg/day) of TSS loads to the upper Hocking River, via Clear Creek (Figure 6).

Mid-West Fabricating Co. (Permit# 4IS00000)

The Mid-West Fabricating Co. treatment process consists of: storage, equalization, reduction, coagulation, neutralization, clarification, sand filtration, carbon filter towers, sludge thickening, sludge filter press, and a final pH adjustment. Design flow is 16,000 gallons per day. The facility discharges to a railroad ditch that flows to an unnamed tributary and then joins Clear Creek at RM 14.22. Only process water is treated at the plant, while sanitary flow is tied into the Amanda WWTP. At best there are only minimal affects on both historical and third quarter 1995 loadings.

Chemical Water Quality

Five to six replicate water samples were collected for chemical analysis at eight stations within Clear Creek during the summer of 1995. The stations were situated between RM 21.76 (SR 188) and RM 2.03 (Camp Wyandot bridge). Datasonde continuous monitoring units were deployed in August at three stations located at RM(s) 21.8, 7.3, and 2.12, to monitor diel D.O, temperature, pH, and conductivity. Longitudinal mean concentrations of basic water quality parameters are presented in Figure 15.

Fecal coliform counts in excess of the average and maximum PCR criteria were the main water quality exceedences discovered in Clear Creek in 1995 (Table 5). The fecal contamination appeared limited to the upper reaches between RM 21.76 and RM 13.2 (SR 159, downstream from Amanda WWTP). The source(s) of the elevated fecal levels likely included: diffuse rural non-point source, on-site septic systems, and the Amanda WWTP. Regardless, these levels were only observed in six of the 47 samples collected and did not appear to pose a serious threat to the PCR use designation.

The remaining water quality exceedences observed in 1995 included lead and D.O.. These parameters were found in exceedence of their respective criteria at RM 13.2 and RM 6.99. The depressed D.O. observed at RM 13.2 likely resulted from the discharge of oxygen demanding wastes from the Amanda WWTP. The source of the lead exceedence at RM 6.99 is not clear at this time, but could have emanated from the any of the facilities upstream from this point (Mid-West Fabricating Co. and Amanda WWTP). These exceedences were found in only one of the six samples collected at each station on the same date in early September. As such, they likely represent a temporal event and did not appear to pose a significant threat to the water quality of Clear Creek

The results from diel sampling found all stations in Clear Creek to exhibit the typical oscillating D.O. pattern commonly associated with algal photosynthisis and respiration over a 24 hour cycle (Figure 16). No extraordinary diurnal changes were noted. In no case during the diel sampling efforts did Clear Creek exhibit D.O. concentrations below the 4.0 mg/l minimum or the 5.0 mg/l average criteria.

Sediment Chemistry

Sediments in Clear Creek were collected for analysis from one site located at RM 2.1 (Camp Wyandot Bridge). Chemical analysis of sediments included selected metals, semivolatile organic compounds, pesticides, PCBs, and VOCs. Parameters were ranked based on a sediment classification system described by Kelly and Hite (1984) and Persaud et al. (1993). Metals analysis found elevated concentrations of arsenic and slightly elevated concentrations of chromium (Table 6). Cadmium, copper, iron, and zinc concentrations were not elevated. Both VOCs and semivolatile organic compounds were undetected in Clear Creek sediments. The gamma isomer of benzene hexachloride (the pesticide lindane) was the only pesticide detected in the sample (Appendix C).

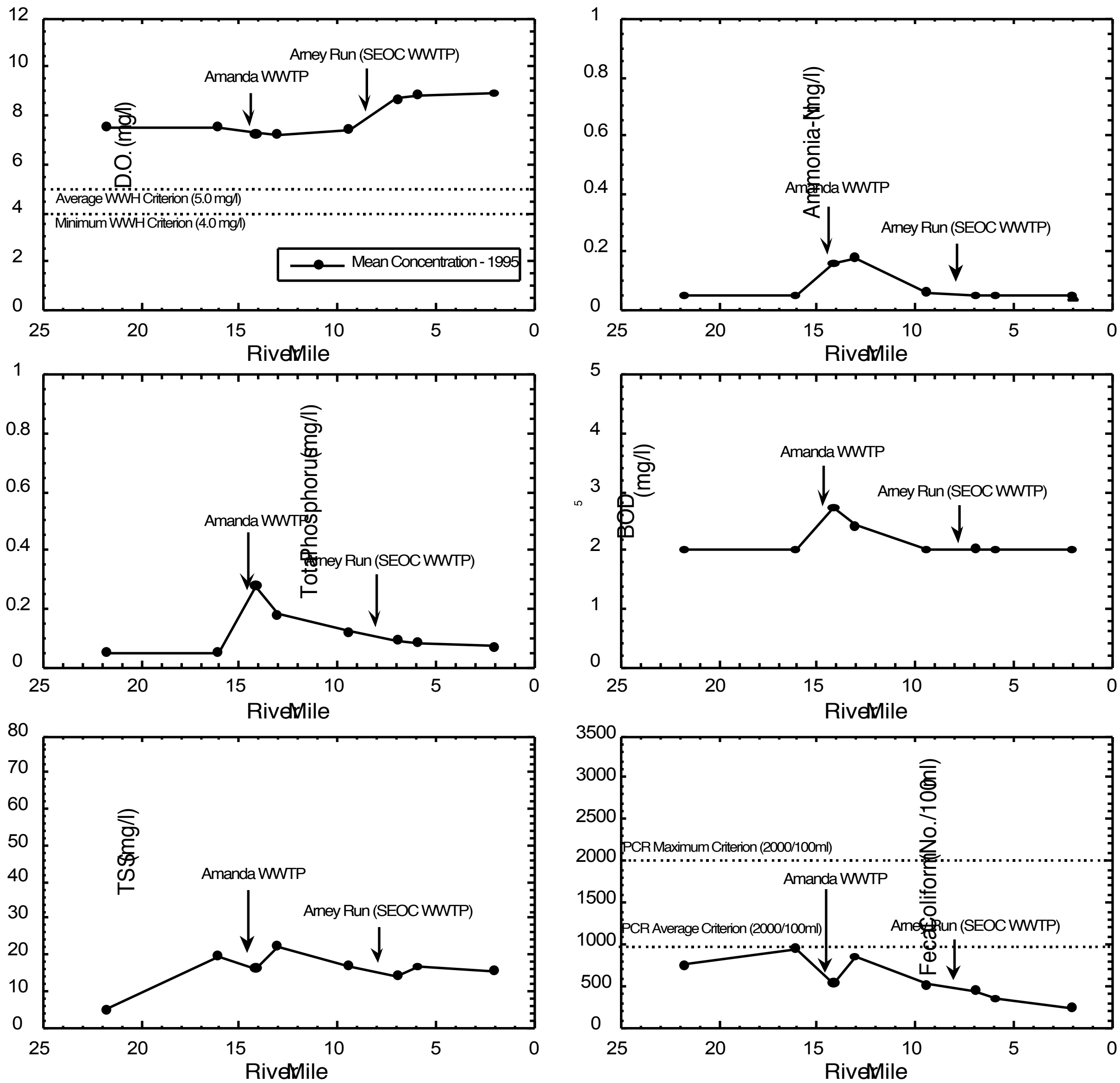


Figure 15 Longitudinal mean concentrations of dissolved oxygen, ammonia-nitrogen, fecal coliform, five-day biochemical oxygen demand, total phosphorus, and total suspended solids from Clear Creek, 1995.

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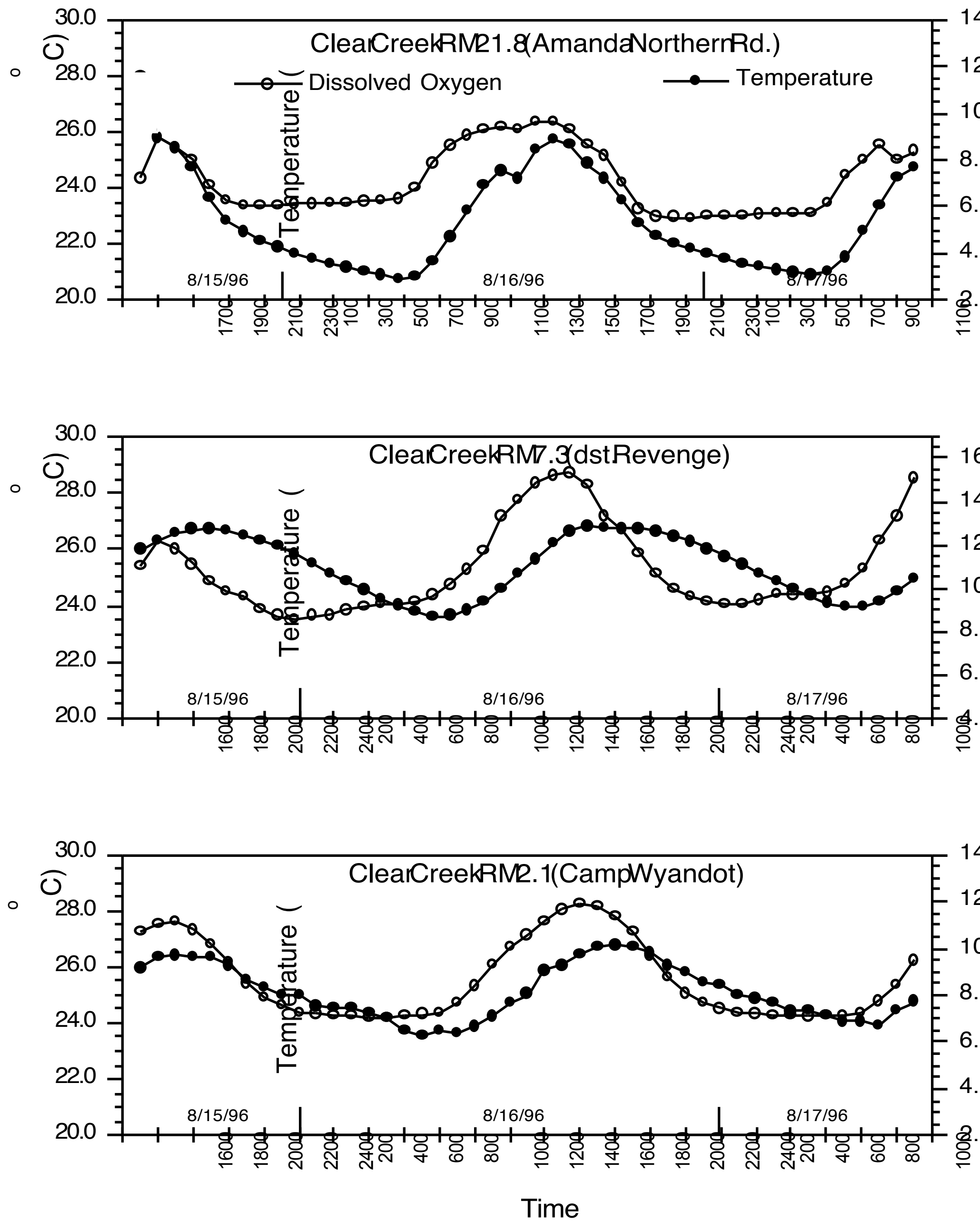


Figure 16 Diel temperature and dissolved oxygen data collected with continuous monitoring units from Clear Creek, August 1995.

Physical Habitat for Aquatic Life

During the 1995 sampling effort the macrohabitats of Clear Creek were evaluated at eight fish sampling stations. Qualitative Habitat Evaluation Index (QHEI) values ranged between 57.5 (RM 13.1, SR 159) and 78.0 (RM 7.3, Revenge Rd.), with a mean reach value of 66.2. A mean reach value equal to or greater than 60 typically indicates aggregate macrohabitat quality sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989).

Habitat quality within the upper limits of the study area was evaluated at RM 21.8 (SR 188). The stream appeared in a natural state, possessing the typical compliment of habitat features associated with till plains headwaters. These conditions appeared sufficient to support an headwater assemblage of aquatic organisms consistent with the WWH aquatic life use designation.

Habitat evaluations conducted between RM 16.3 (US 22) and RM 13.1 (SR 159) revealed highly modified conditions, with QHEI values ranging from 58.5 and 66.5. This segment has been channelized in the past and stripped of much of its original riparian vegetation. Moderate to severe bank erosion, resulting from denuded stream banks, was commonly observed. The active channel remained trapezoidal throughout, though the wetted channel at each site demonstrated varying degrees of recovery. At times a moderately sinuous course, with limited riffle-run-pool development, was reestablished within the confines of the active channel. Despite the modified and well drained conditions that typified this segment, stream flows were well maintained throughout the summer months. The stream discharge appeared augmented by strong groundwater inputs. Though by no means optimal, this modified reach has reestablished minimum habitat features typically associated with warmwater assemblages of aquatic organisms.

Macrohabitat quality was improved at the remaining downstream stations between RM 9.4 (Clearport Rd.) and RM 1.9 (Camp Wyandot Bridge), with QHEI values ranging from 66.0 to 78.0. The channel configuration within this segment was generally in an unaltered state or appeared recovered from previous modification. Positive habitat features encountered at most stations included: moderate sinuosity, coarse substrates (native and glacial), and well-developed riffle-run-pool complexes. Deficient habitat appeared associated with sediment bedload exported from the unstable and eroding glaciated uplands. Coarse gravels and cobbles were often embedded with sand. Though sufficient pool development was evident within this reach, the creeping sand bedload appeared to diminish depth heterogeneity, often producing segments of monotonous sand glide. However, the predominance of positive habitat attributes within this portion of Clear Creek yielded QHEI values equal to or greater than that necessary to support an assemblage of aquatic organisms consistent with the WWH use.

Despite the presence of sufficient warmwater macrohabitats, as measured by the QHEI, the fundamental fluvial processes of the Clear Creek basin responsible for the formation and maintenance of habitat features appeared in transition. These changes are systemic, primarily driven by land use and stream management practices within the upper portion of the basin, and represent the most significant threat to the maintenance of the existing habitat quality of the unglaciated portion of Clear Creek.

Clear Creek drains a diverse topography, flowing through both glaciated and unglaciated physiographic regions of south-east central Ohio. The land use in each area, dictated by natural topography, has had a significant influence on the quality of near and in-stream habitats throughout the Clear Creek study area. The upper and middle reaches are situated in the agriculturally dominated Eastern Corn Belt Plains and Erie Ontario Lake Plains regions. The desire to improve drainage within these areas has resulted in extensive channelization of the mainstem and several tributaries. These activities have diminished stream macrohabitats by simplifying or eliminating physical habitat features and altering discharge characteristics. Additional detrimental activities commonly associated with intensive agriculture include the removal of the wooded riparian corridor. Lacking permanent woody riparian vegetation, banks throughout much of the upper and middle course appeared unstable. Severe bank erosion and slippage were evident at most stations within the glaciated portion of the mainstem. In the absence of a sufficient riparian buffer, sediments derived from overland erosion are rapidly delivered to the stream, compromising substrate quality and contributing to existing sediment load. Both overland and bank erosion appeared active within the glaciated portion of Clear Creek.

The remaining downstream segment of Clear Creek drains the unglaciated Allegheny Plateau, flowing through Clear Creek valley before joining the Hocking River. The stream channel and riparian characteristics of the mainstem and small tributaries within this segment generally appeared unmodified. Agricultural activity along this stretch of Clear Creek is much less intensive than that encountered in the uplands, restricted to a few areas within the valley's narrow floodplain. Land use within this segment is further restricted, as much of the valley is contained within land holdings administered by the Franklin County Metroparks system.

The sediment bedload exported from the unstable and eroding glacial uplands of the Clear Creek basin appeared to have significant downstream impacts to the lower unmodified portion of the mainstem. The negative effects of this sediment load appeared two-fold. First, sediment export and subsequent deposition appeared sufficient to reduce pool volume and embed substrates, at times producing a wide and shallow stream course. Second, as the channel capacity is diminished, through sediment aggradation, existing stream discharge is forced laterally, destabilizing and eroding even well-vegetated banks. These processes (bedload facilitated bank erosion, channel homogeny, and shifting and unstable substrates) appeared active at several downstream locations.

If the unstable and eroding conditions within the uplands of the Clear Creek basin continue unabated the processes described above will eventually result in impairment of the resource. Although this segment still retains many high quality habitat features, sediment export from the uplands will significantly degrade near and in-stream macrohabitat quality through persistent and gradual habitat simplification.

Biological Assessment: Benthic Macroinvertebrate Community

Artificial substrate samples were collected from six stations beginning downstream from the Amanda WWTP and extending to near the confluence with the Hocking River (RM 14.1 to 2.1). Sampling upstream from Amanda was limited to a qualitative sample (artificial substrates were lost) in the headwaters at RM 20.1. Longitudinal performance of the ICI is presented in Figure 17.ICI scores in Clear Creek were consistently in the *exceptional* range (50-54) except for RM 13.1 where the ICI of 44 was *very good* (Table 9). The decline at RM 13.1 was probably related to NPS loadings from livestock and agriculture; dried cow manure was observed along stream banks and floating on the stream surface. Most of the stream near Amanda (ECBP and EOLP ecoregions) is heavily farmed and channelized. However, the relatively high gradient, coarse substrates and possibly elevated stream flows during the summer of 1995 appeared to minimize point and non-point source influences in this stretch.

Station RM 20.1 was upstream from all known point source discharges and significant non-point sources. Unlike the middle reaches of Clear Creek near Amanda, the stream had not been channelized. However, substrates were primarily loose, shifting sand and recent heavy rains had resulted in significant bank erosion and bedload movement. Artificial substrates were lost or buried in the loose sand on two occasions during the summer following heavy rains. Despite the wet conditions during the summer, stream flow was nearly intermittent when samples were collected on September 5. The macroinvertebrate community was very low in density and taxa richness (19) and EPT taxa were limited to a single net-spinning caddisfly of the species group *Hydropsyche morosa*. The QCTV reflected somewhat better conditions with the value of 35.0 falling in the range between high and low performance. Overall, the community was considered *poor*. Unstable habitat conditions and stream intermittency were considered primary reasons for the low performance.

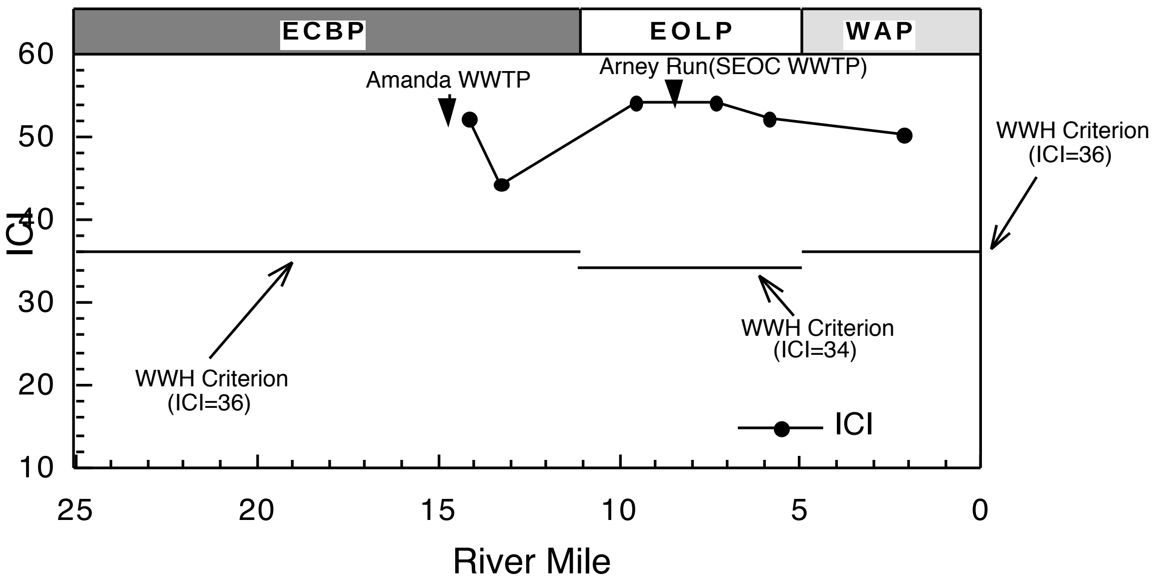


Figure 17 Longitudinal performance of the Invertebrate Community Index (ICI) from Clear Creek, 1995. The solid lines represent the WWH aquatic life use designation criteria for each ecoregion.

Biological Assessment: Fish Community

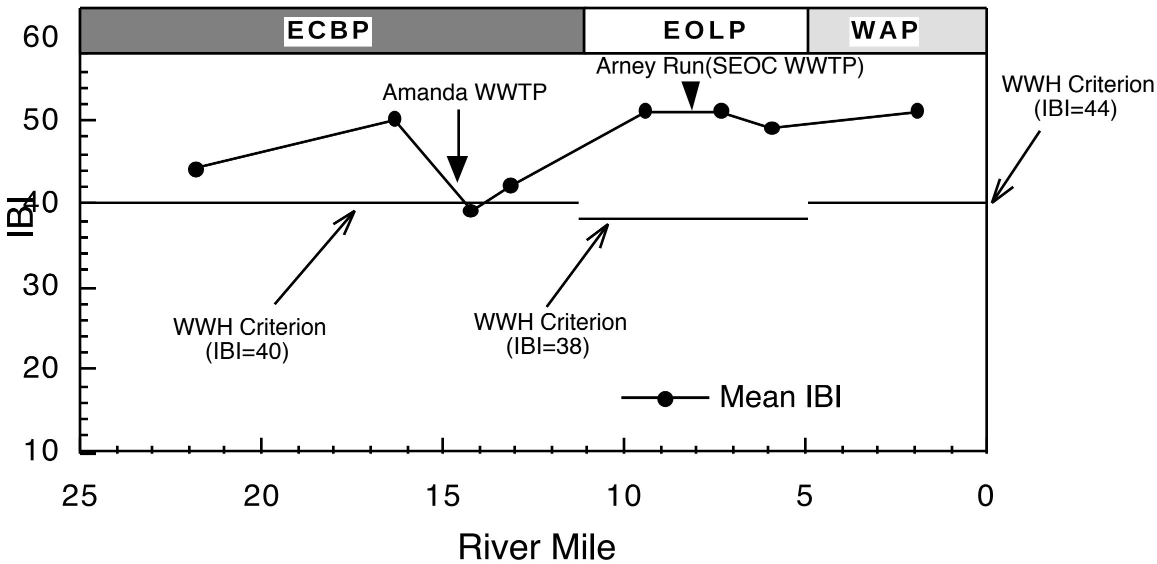
A total of 20,261 fish comprised of 37 species and two hybrids were collected from the mainstem of Clear Creek, between July 19 and October 22, 1995. The sampling effort included eight stations located between RM 21.8 (SR 188) and RM 1.9 (Camp Wyandot Bridge), providing an assessment coverage of 19.9 miles.

Numerically predominant fish species were: central stoneroller (13.4%), bluntnose minnow (11.6%), sand shiner (10.7%), striped shiner (9.4%), creek chub (8.7%), and northern hog sucker (7.1%). Species that were predominant in terms of biomass included: white sucker (28.9%), northern hog sucker (19.1%), common carp (12.3%), golden redhorse (9.4%), central stone roller (7.1%), and yellow bullhead (4.1%).

In terms of both relative abundance and biomass, environmentally tolerant species (bluntnose minnow, creek chub, common carp, and yellow bullhead) were well represented. However, environmentally sensitive species (sand shiner, hog sucker, and golden redhorse) were maintained within the predominant groups. Nearly 10% of total biomass was concentrated in the central stone roller. This herbivorous species is commonly associated with nutrient enriched systems possessing limited riparian vegetation - conditions that typified the upper and middle reaches of Clear Creek.

All community samples were collected with standard wading methods (Ohio EPA 1987[b]). In the headwaters of Clear Creek, RM 21.8 and RM 16.3, only the IBI is employed to evaluate the condition of the fish assemblages, due to the undesirable effects of drainage area on the MIwb. Both the MIwb and IBI were applicable within the remaining downstream stream stations. Community performance and accompanying narrative evaluations ranged between *marginally good* to *good* (IBI=39 and MIwb=8.3) at RM 14.2 and *exceptional* at RM(s) 9.4, 7.3, 5.9, and 1.9 (IBI ≥ 49 and MIwb ≥ 9.7) (Table 10). As a whole, the fish community of Clear Creek was characterized as *very good* to *exceptional*. Longitudinal performance of both the IBI and MIwb are presented in Figure 18.

Community samples collected at every station within the study area consistently meet or exceeded the existing WWH biological criteria. Community performance as measured by the IBI and MIwb (where applicable) indicated a general pattern of longitudinal improvement from *good* conditions in the headwaters to *exceptional* assemblages in the lower nine miles. The negative effects of the modified habitats that characterized the upper and middle segments of Clear Creek appeared mitigated by both the reestablishment of some positive physical stream features and groundwater augmented stream flow. High quality community attributes commonly encountered within the study area included: high species richness (including many sensitive species), an abundance of lithophilic and insectivorous species (indicators of unimpaired substrates), and a low incidence of disease and other external anomalies. No significant impact was attributed to wastes discharged by the Amanda WWTP or the SEOC WWTP.



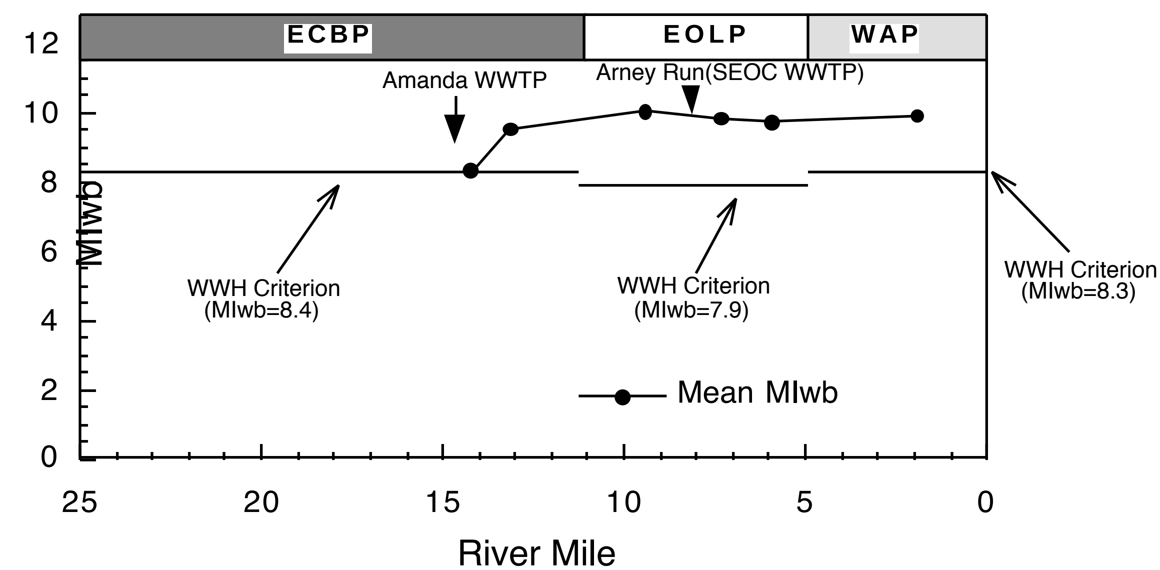


Figure 18 Longitudinal performance of the Index of Biotic Integrity (IBI) and Modified Index of Well-being (MIwb) for Clear Creek, 1995. The solid lines represent numerical biological criteria in support of the WWH aquatic life use designation for each ecoregion.

Arney Run

Pollutant Loading

Southeastern Ohio Correctional Institution (Permit# 4PP00011)

Southeastern Ohio Correctional Institute (SEOC) WWTP is an advanced treatment facility with a design flow of 0.4 MGD. The plant discharges to an unnamed tributary to Arney run at approximately RM 0.97. The WWTP tributary confluences with Arney Run at RM 4.2, Arney Run then joins Clear Creek at RM 7.98. The treatment process involves mechanical screening, a track trap, communutor, pre-aeration, primary settling, trickling filters, final settling, sand filters and chlorination. Dechlorination is currently being designed to meet water quality based limits. Flow to the plant is primarily domestic, with about 2000 gallons per week coming from an institute-run soap factory.

Plant inspections indicate both hydraulic and organic overloading. MOR data reveals fecal coliform permit exceedences throughout the first month of this study. The plant managers have been advised that remedial action is necessary to prevent discharge permit excursions. Plans to correct plant deficiencies are being implemented. While historical data shows little impact from facility loadings on recieving streams in the study area, third quarter 1995 data indicates the SEOC WWTP contributed 6.8% (1.05 kg/day) of the NH_3-N, 50.8% (7.68 kg/day) of cBOD, and 4.4% (10.4 kg/day) of TSS loads to the upper Hocking River, via Clear Creek (Figure 6).

Chemical Water Quality

Five to six replicate water samples were collected for chemical analysis at three stations on Arney Run during the summer of 1995. The stations were situated to evaluate the influence of the SEOC WWTP, assessing the stream segment between RM 4.3 (Christmas Rock Rd.) and RM 0.1 (near the mouth). Datasonde continuous monitoring units were deployed in August at three stations located at RM(s) 4.3, 2.3, and 0.1, to monitor diel D.O, temperature, pH, and conductivity.

Fecal coliform counts regularly exceeded the primary contact recreational standard for Arney Run (Table 5). At each of the three sampling locations [RM(s) 4.3, 3.13, and 0.10] at least one fecal coliform exceedence was observed. The most severe fecal coliform contamination (frequency and magnitude) in Arney Run occurred downstream from the confluence of the tributary carrying treated wastewater from the SEOC WWTP (RM 3.13 and RM 0.1). Additionally, one of five samples collected at RM 3.13 found the concentration of total phosphorus greater than 1.0 mg/l WWH recommendation. Elevated phosphorus and fecal coliform appeared a result of wastewater discharged by the SEOC WWTP, as most exceedences were not associated with periods of high runoff and stream discharge associated extended periods of rainfall.

Concentrations of the remaining parameters from daytime sampling (e.g., demand and nutrients) were typically low and longitudinally stable. Ammonia-N was commonly found at or near the method detection limit, and D.O. concentrations well above the WWH minimum and average criteria were observed throughout the study area.No extraordinary diurnal changes were noted in diel data. Diurnal D.O. fluctuations appeared normal if somewhat flattened or heightened. In no case did the continuous monitoring units indicate D.O. concentrations below the 4.0 mg/l WWH minimum criterion (Figure 19).

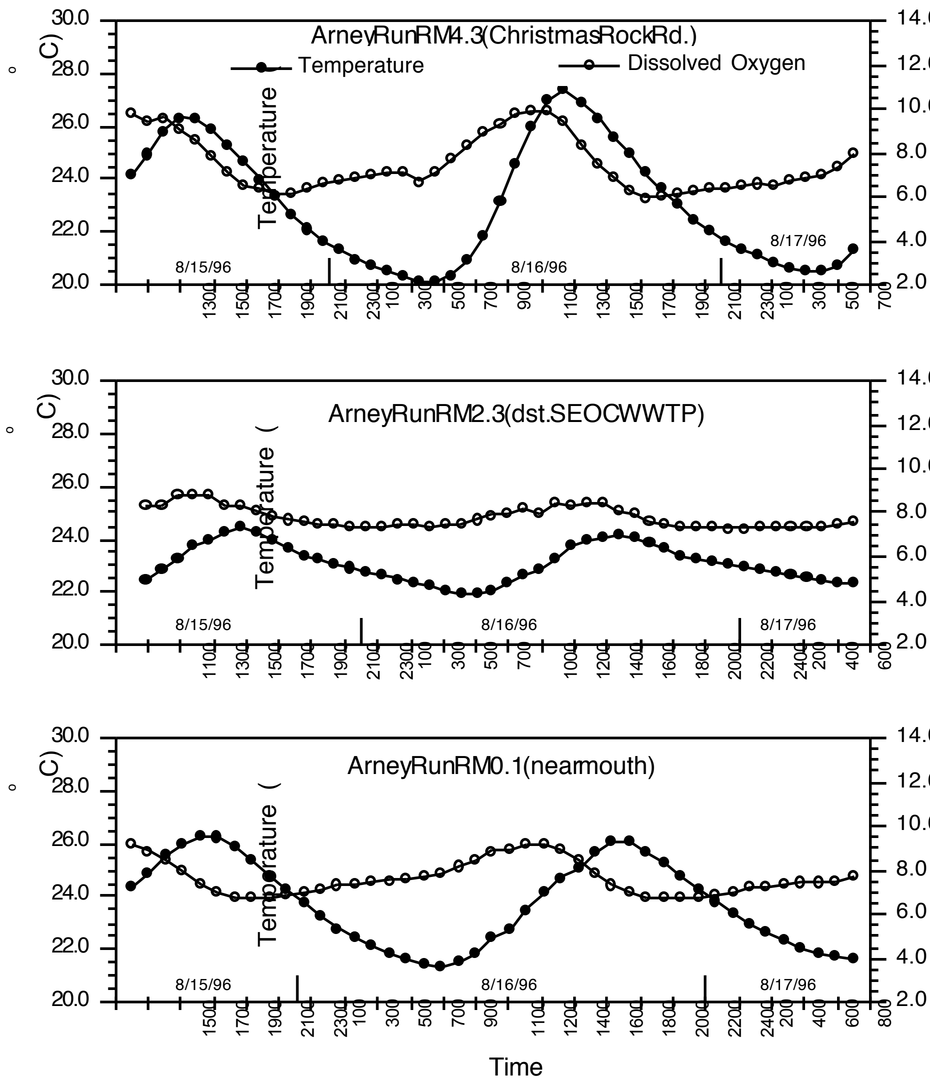


Figure 19 Diel temperature and dissolved oxygen data collected with continous monitoring units from Arney Run, 1995.

Physical Habitat for Aquatic Life

Macrohabitat quality of Arney Run was evaluated at three fish sampling stations. Qualitative Habitat Evaluation Index (QHEI) values ranged between 36.5 (RM 4.3, upstream SEOC WWTP) and 81.0 (RM 0.1, near mouth), with a mean reach value of 63.2. A mean reach value equal to or greater than 60 typically indicates aggregate macrohabitat quality sufficient to support a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989).

The condition of near and in-stream macrohabitats of Arney Run varied longitudinally. The upper portion of the study area appeared in a highly modified state, while the lower reach represented natural unmodified conditions. The channelized headwaters were evaluated at RM 4.3. This station contained a predominance of high and moderate influence modified habitat attributes which included: low sinuosity, sparse cover, poor pool development, and moderate embeddedness.

Habitat quality was markedly improved at the remaining downstream stations(RM 2.2 and 0.1). The stream course within this segment was natural and sinuous, with well developed riffle-run-pool complexes. Substrates were predominantly coarse native gravel and cobble, although moderate embeddedness was observed. Based upon the evaluations conducted at these stations the middle and lower portion of Arney Run appeared to contain a full compliment of positive habitat features.

Biological Assessment: Benthic Macroinvertebrate Community

Qualitative macroinvertebrate collections were made at three locations, upstream and downstream from the Southeast Ohio Correctional Facility WWTP tributary (RM 4.3 and RM 3.7, respectively) and near its confluence with Clear Creek (RM 0.1).

Collections at RM 4.3 indicated *marginally good* conditions prior to the WWTP discharge. The site was predominated by net-spinning caddisflies and riffle beetles but yielded a relatively low number of EPT taxa (6). The QCTV of 37.2 was performing above ecoregional expectations and taxa richness (46) was fairly diverse. Substrate embeddedness and fine sediment deposition was heavy in the previously modified stream channel.

Sampling downstream from the WWTP revealed sharp increases in caddisfly and midge densities, a further reduction in EPT taxa richness (4) and a QCTV score which fell between the high and low performance ranges for streams in the EOLP ecoregion. The dipteran (midge) community also exhibited a general shift to more pollution tolerant and intermediate populations. The macroinvertebrate community were considered *fair* and highly enriched downstream from the WWTP discharge.

Communities were in the *good* range at RM 0.1, prior to entering Clear Creek. Improvements were characterized by an increase in the QCTV (38.9), EPT taxa richness (8), and improved community composition. Mayflies and caddisflies increased in predominance while more pollution tolerant taxa observed at RM 3.7 were either reduced in predominance or absent.

Biological Assessment: Fish Community

A total of 6,561 fish comprised of 25 species and one hybrid were collected from Arney Run, between August 18 and September 18, 1995. The sampling effort included three stations located between RM 4.3 (upstream SEOC WWTP) and RM 0.1 (near mouth). The entire Arney Run study area is classified as headwaters (drainage area ≤20.0 miles^2). Thus, only the IBI was applicable to evaluate the condition of the fish community.

Mean community index values and accompanying narrative evaluations ranged between *marginally good* (IBI=38), at RM 4.3 and *exceptional* (IBI=53) at RM 0.1 (Table 10). Performance of the fish community indicated full agreement with the WWH biological criteria at all stations. No adverse impact was observed downstream from the SEOC WWTP.

Selected Clear Creek Tributaries

Pollutant Loading

Fairfield Sanitary Landfill (Permit# 4IN00066)

The Fairfield Sanitary Landfill does not have a treatment facility, and is permitted for stormwater runoff only. The design flow is 1000 gallons per day. Stormwater is collected in sedimentation ponds and then discharged to Cattail Creek which confluences with Clear Creek at RM 9.52. The current permit includes Stormwater Pollution Prevention language and requirements which reduce silt and other pollutants associated with stormwater run off. Both historical and third quarter data indicate negligible loadings contributions.

Physical Habitat for Aquatic Life

The condition of near and in-stream macrohabitats of selected Clear Creek tributaries were evaluated as part of the sampling effort 1995 in the following streams: Muddy Prairie Run, Muddy Prairie Creek, Sand Run, Dunkle Run, and Cattail Creek.

As measured by the QHEI, macrohabitat quality at or near the WWH threshold (QHEI=60) was observed in Muddy Prairie Run, Dunkle Run, and Cattail Creek. Qualitative Habitat Evaluation Index values ranged between 55 and 62. Although many of these streams appeared to have been channel modified in the past, the recovery of minimum WWH attributes has occurred.

Simplified habitats were observed within the remaining Clear Creek tributaries. Muddy Prairie Creek and Sand Run achieved QHEI scores of 42 and 46, respectively. These values were reflective of the predominance of high and moderate influence modified habitat attributes.

Negative habitat features common to both stream included: monotonous channel development (i.e., channelized in the past), a predominance of fine substrates (e.g., silt, sand, and pea gravel), riparian encroachment, and sparse in-stream cover. These data suggest potential habitat impairment. However, a cautionary note is warranted as to inference drawn from the habitat evaluations provided. The results are based on one sampling station within the lower segments of these Clear Creek tributaries. Habitat evaluations are typically based upon aggregate conditions determined by the results from several sampling stations placed throughout a given stream reach. Given the limited stream coverage, an aggregate assessment was not possible. Thus, the evaluations were site specific, and the true habitat potential of these streams may not have been determined.

Biological Assessment: Benthic Macroinvertebrate Community

In Muddy Prairie Run communities from RM 0.6 were clearly in the *exceptional* range (ICI=52) and the QCTV score (41.4) was also well above ecoregional expectations. In addition, sampling revealed a number of highly sensitive taxa, three cold water taxa and several additional taxa associated with cool, headwater streams. A minimum of four coldwater taxa has been adopted by the Ecological Assessment Unit as indicative of coldwater potential. The assemblage suggests EWH potential and at least marginal CWH potential in Muddy Prairie Run.

Lower quality communities were found at the mouth of Muddy Prairie Creek (RM 0.1) compared to Muddy Prairie Run. The natural substrate community (artificial substrates were lost) was considered *fair* at based on the low EPT taxa richness (5) and the QCTV score (31.3); both values reflected performance below ecoregional expectations. Unlike Muddy Prairie Run, Muddy Prairie Creek was channelized, with an open canopy and fine substrates of silt, sand and fine gravel. Sedimentation and channelization were considered the primary negative influences.

Qualitative samples collected from Sand Run, Dunkle Run, and Cattail Creek revealed QCTV scores in the high performance range (Table 9) and EPT taxa richness consistent with *exceptional* quality communities. All streams were considered *exceptional*. In Cattail Creek, the Fairfield County Landfill appeared to have no detectable impact on communities immediately downstream at RM 2.7.

Biological Assessment: Fish Community

The fish community samples were collected at one station, near the mouth, from each of the Clear Creek tributaries evaluated. The study area included: Muddy Prairie Run, Muddy Prairie Creek, Sand Run, Dunkle Run, and Cattail Creek. All of these stream are classified as headwaters (drainage area $\leq$20 mile^2). As such, the condition of the fish assemblage was evaluated with the IBI only.

Community performance ranged between *good* and *exceptional*. Sand Run and Dunkle Run met the minimum WWH standard, both achieving an IBI score of 44. The remaining streams, Muddy Prairie Run, Muddy Prairie Creek, and Cattail Creek, supported *very good* to *exceptional* communities. Despite apparent habitat limitations of some streams or stream segments, community performance at all stations indicate full agreement with the WWH biological criterion (Table 10).

TREND ASSESSMENT

Hocking River (mainstem)

Chemical Water Quality: 1982-1995

Historical water column chemistry data from the Hocking River mainstem was used to perform long-term water quality trend assessment. Data from the summers of 1982 and 1990 were used to supplement the latest (1995) survey work. The 1982 survey included data from the stream reach between RM 94.9 and RM 73.37. Data from the 1990 survey was collected between RM 94.9 and RM 66.36. Additional water quality information was included from third quarter fixed station (e.g. Ambient) monitoring data gathered between 1982 and 1995 from RM 87.32 (downstream Lancaster). This locale served to characterize water quality at one location through time, downstream from the Lancaster WWTP.

During 1982, BOD_5 and NH_3-N displayed marked increases downstream from the Lancaster WWTP. Dissolved oxygen concentrations downstream from Lancaster WWTP demonstrated a noticeable sag well below the minimum WWH standard of 4 mg/l (Figure 20). Fecal contamination was also apparent. Additionally, concentrations of phosphorus and several metals (namely cadmium, lead, zinc, copper, and manganese) were noticeably elevated (Figures 20, 21 and 22). Improved treatment at the Lancaster WWTP due to plant upgrades and pretreatment of industrial wastes greatly improved environmental conditions in 1990 and further improvements were noted in 1995. BOD and NH_3-N removal were markedly improved with a corresponding increase in the concentration of nitrates in-stream and an increase in the amount of dissolved oxygen. Phosphorus concentrations remained relatively stable from 1982 to 1990, however, 1995 data indicated a considerable reduction in phosphorus concentrations downstream from Lancaster. Nitrate+nitrite-N concentrations have also declined somewhat in this area indicating denitrification. Downstream from Lancaster WWTP, metals concentrations generally declined between 1982 and 1995

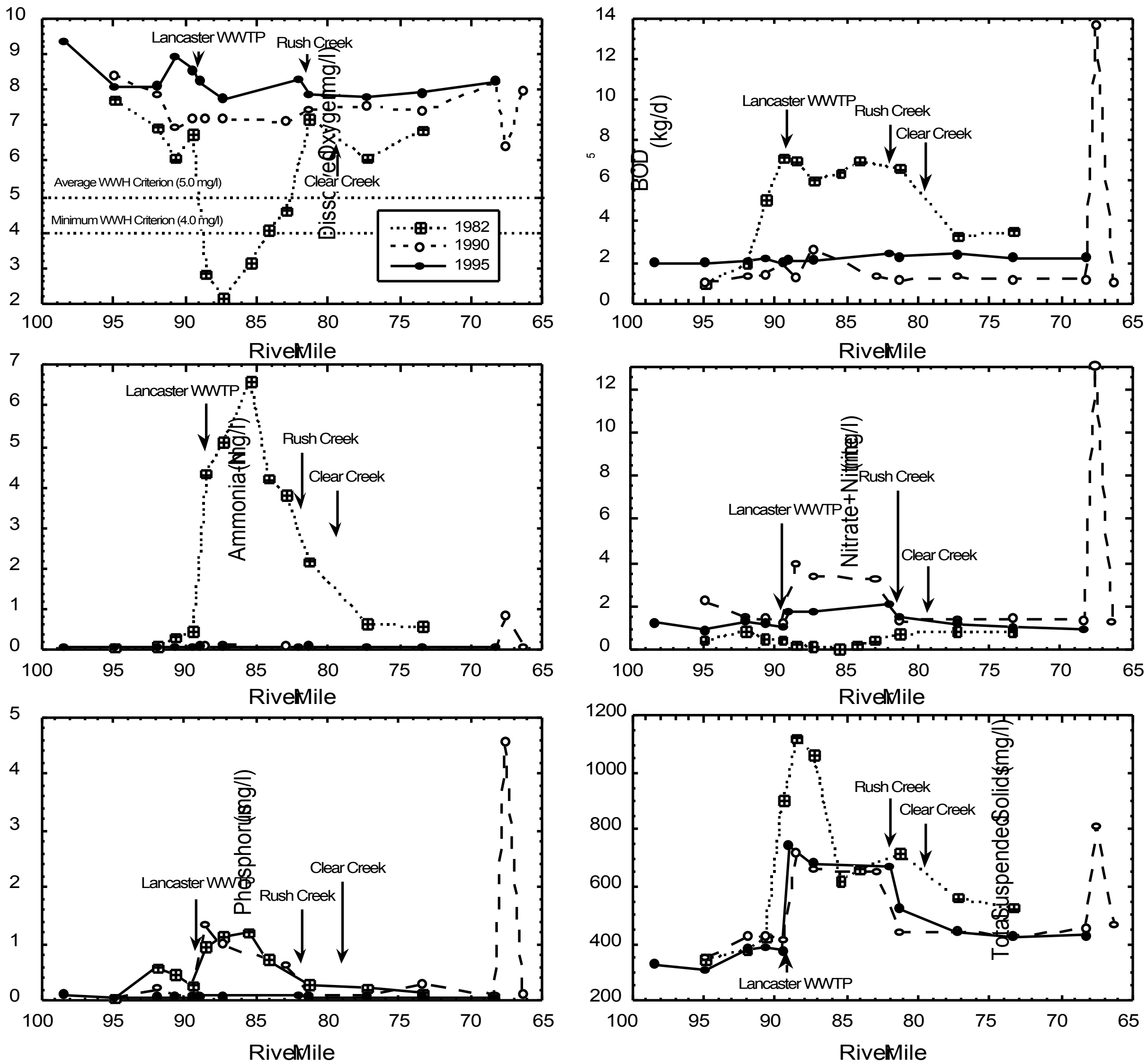


Figure 20 Longitudinal mean concentrations of dissolved oxygen, ammonia-nitrogen, nitrate+ nitrite-nitrogen, five-day biochemical oxygen demand (BOD_5), total phosphorus, and total suspended solids from the upper Hocking River mainstem, 1982 - 1995.

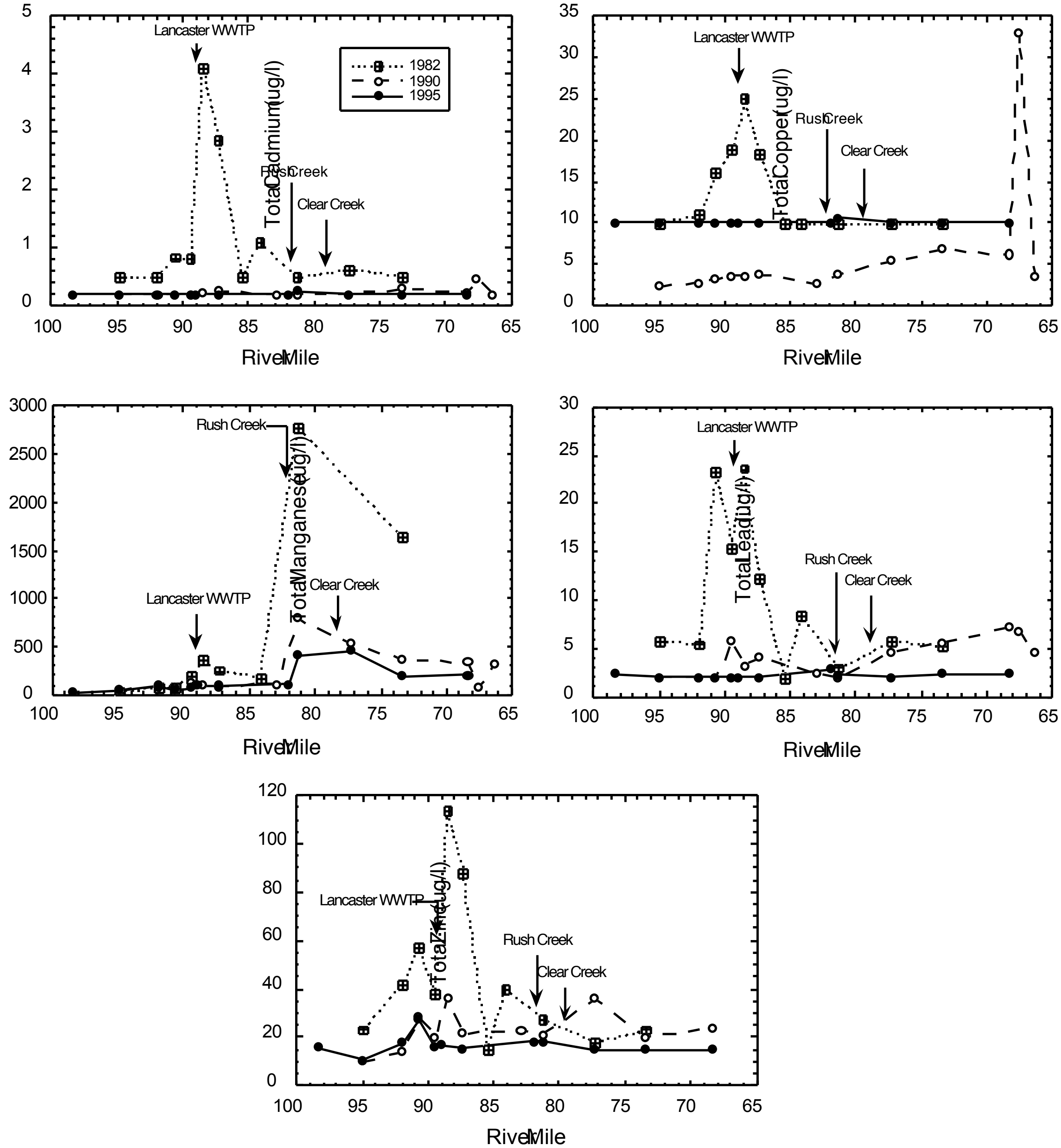


Figure 21 Longitudinal mean concentrations of cadmium, copper, zinc, manganese, and lead from the upper Hocking River, 1982 - 1995.

Fixed station monitoring was performed and used to analyze long term trends in third quarter, ambient water quality between 1982 and 1995 at RM 87.32 (adjacent US 33, downstream from Lancaster). In most every case, this data shows the effect of upgrading the Lancaster WWTP and instituting pretreatment of industrial wastes prior to discharge to the POTW. Mean ammonia concentrations decreased substantially from 1987 to 1988 downstream from the plant and remain very low after 1988 (Figure 23). Phosphorus concentrations also exhibit a downward trend after 1987. Both mean BOD and mean COD also show a similar trend. Mean levels of fecal coliform also showed noticeable reductions following 1987. Metals (cadmium, lead, nickel, and zinc) concentrations, which fluctuated greatly prior to plant upgrade, also dropped to near detection limits after 1987 (Figure 24). Mean NO_3+NO_2-N concentrations showed a corresponding increase (improved nitrification) downstream from Lancaster WWTP. Mean concentrations of dissolved oxygen changed from 2-3 mg/l prior to 1988 to 7-8 mg/l after 1988.

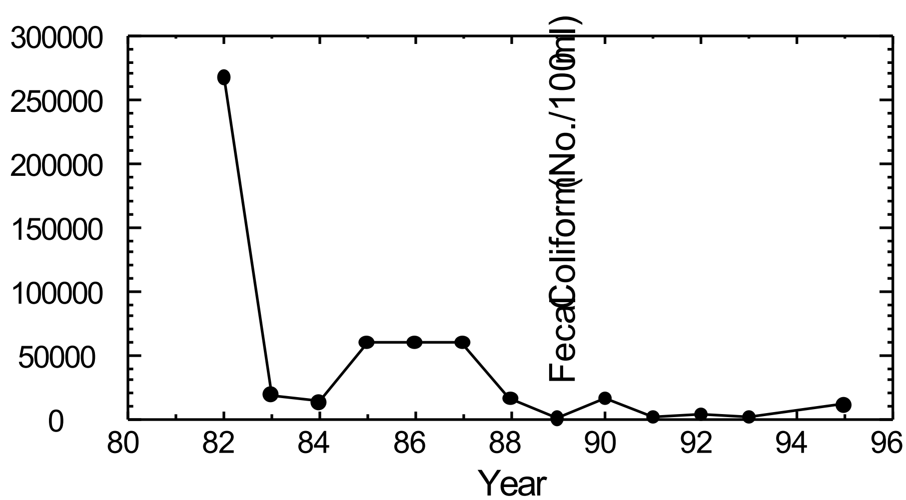


Figure 22 Mean fecal coliform counts (No./100ml) from third-quarter fixed station water quality monitoring at RM 87.32 (US 33, downstream from the Lancaster WWTP) on the Hocking River, 1982 - 1995.

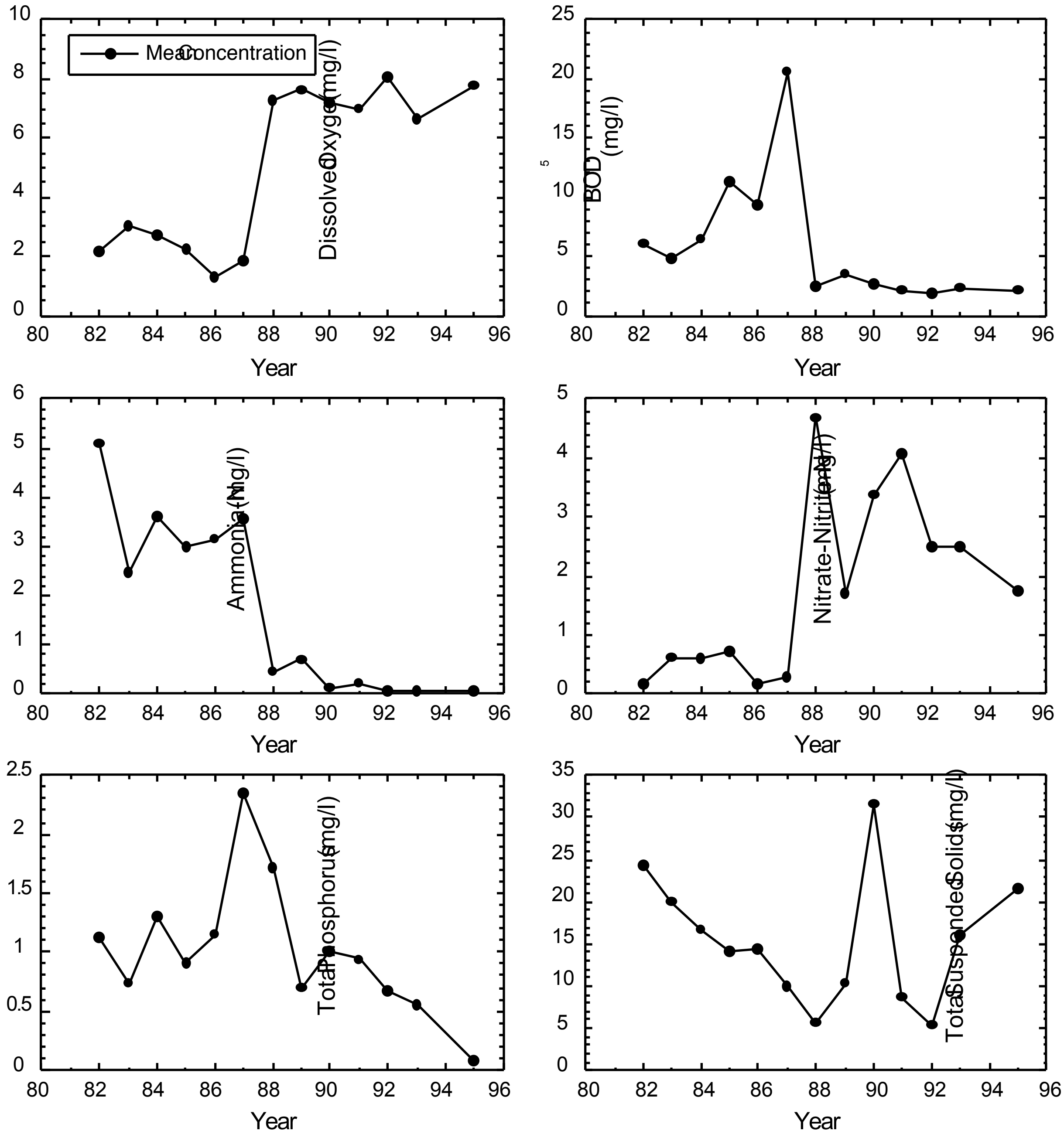


Figure 23 Results from third-quarter fixed station water quality monitoring at RM 87.32 (US 33, downstream from the Lancaster WWTP) on the Hocking River, 1982 - 1995.

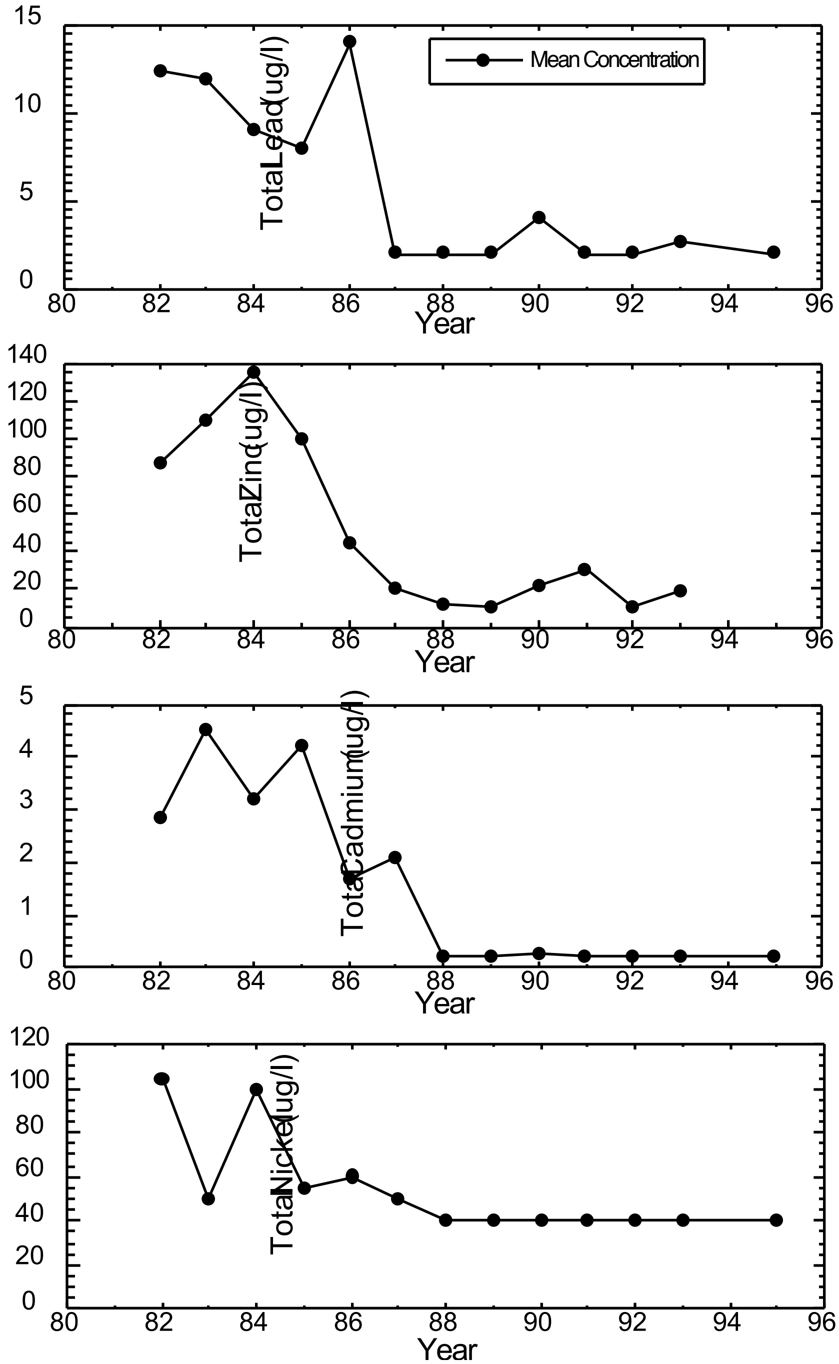


Figure 24 Results from third-quarter fixed station monitoring for selected metals at RM 87.32 (US 33, downstream from the Lancaster WWTP) from the Hocking River, 1982 - 1995.

Benthic Macroinvertebrates 1982-1995

Previous sampling in the upper Hocking River mainstem was conducted in 1982 and 1990 between Hooker, upstream from the Lancaster urban area, and Logan (RM 95.1 through RM 69.6). In 1982 the survey ended at Enterprise (RM 73.5) and sampling at Hooker was limited to natural substrate collections due to the loss of artificial substrates. In addition to the intensive surveys, fixed station monitoring was conducted downstream from the Lancaster WWTP at RM 87.2 in 1992 and 1994.

The 1990 survey reflected dramatic improvement in Hocking River communities in the Lancaster urban area and downstream from the Lancaster WWTP since 1982 (see Ohio EPA, 1991). In 1995, communities in Lancaster continued to exceed WWH criteria. However, in contrast to 1990 results, ICI scores dropped into the fair range downstream from the Lancaster WWTP and declined from *exceptional* to *good* upstream from Rush Creek (Figure 25). The 1995 results suggest an increase in organic waste loadings and subsequent declines in community health in this approximate eight mile stretch.

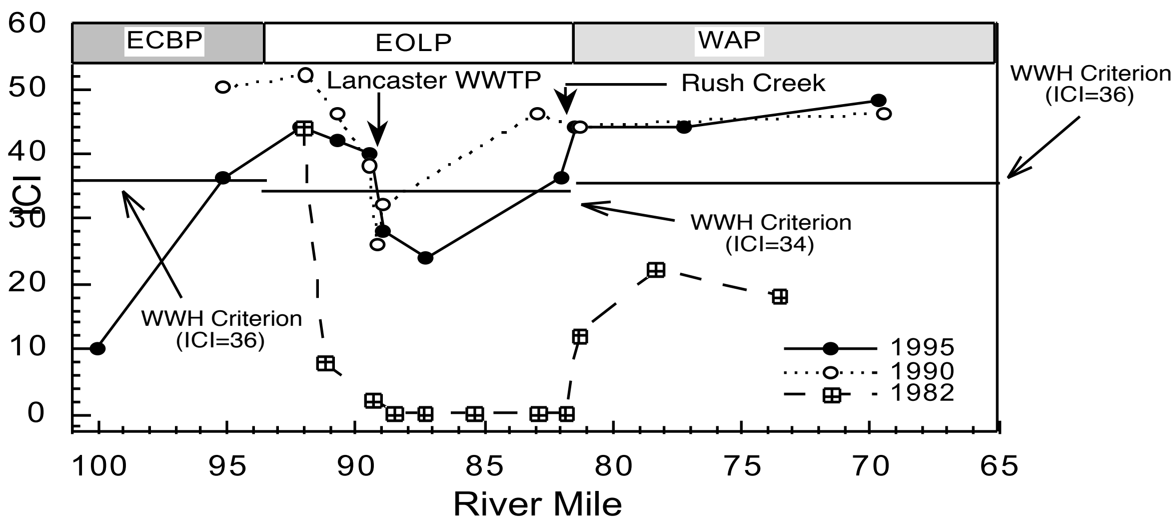


Figure 25 Longitudinal performance of the Invertebrate Community Index (ICI) from the upper Hocking River mainstem, 1982 - 1995. The solid lines represent the WWH aquatic life use designation criteria for each ecoregion.

A review of data at RM 82.7 from 1982 through 1995 shows dramatic improvement downstream from the Lancaster WWTP. The 1982 communities were in the *very poor* range (ICI=0) and reflected grossly polluted and toxic conditions. All aspects of the communities improved in 1990-92 and reflected *good* to *marginally good* quality. However, beginning in 1994 the ICI dropped to the fair range (ICI=22) and remained fair in 1995 (ICI=24). Declines between 1990-92 and 1994-95 were characterized by sharp declines in mayfly predominance and EPT taxa richness from the natural substrates. QCTV scores also reveal a declining trend since 1990 and dropped into the low performance range for streams in the EOLP by 1995 (Figure 26).

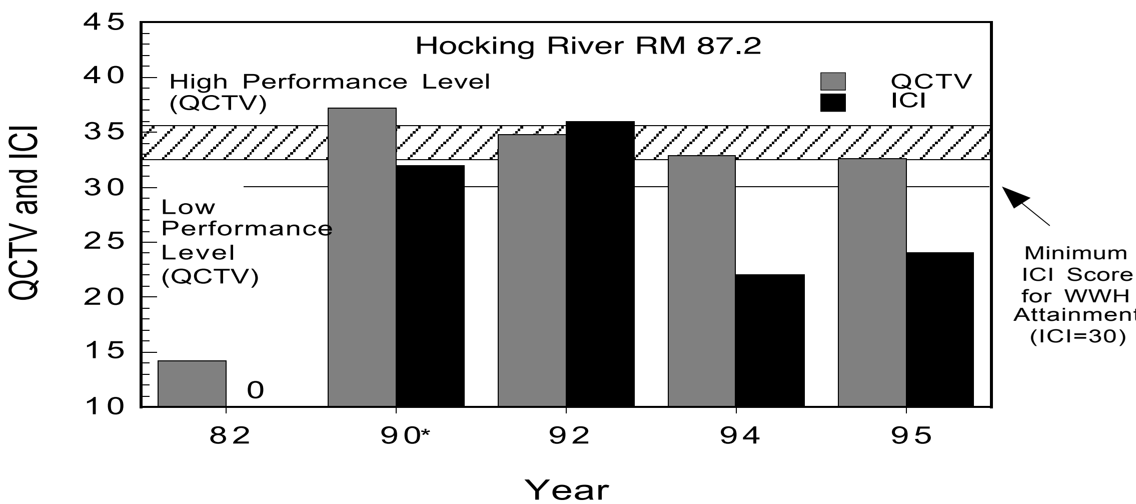


Figure 26 Invertebrate Community Index (ICI) and Qualitative Community Tolerance Value (QCTV) scores from the upper Hocking River at RM 87.2 in 1982, 1990, 1992, 1994 and 1995. Qualitative taxa richness in 1982 was too low to determine a median tolerance value; an average of tolerance values was substituted for this site. *Note: Artificial substrates were lost in 1990. Based on the *marginally good* evaluation from the qualitative sample, an analogous ICI score (32) was substituted.

Another site that experienced a significant decline in 1995 was at Hooker (RM 95.1), upstream from the Lancaster urban area. The ICI experienced a 14 point decline (from *exceptional* to *good*) between surveys. However, QCTV scores were nearly identical during all sampling years and did not reflect significant changes in water quality. During the 1995 survey a large cold water discharge was observed immediately upstream from RM 95.1 and may have resulted in compositional changes on the artificial substrates without severely degrading overall water quality conditions. The conflicting results tend to minimize concerns about a significant declining trend immediately upstream from Lancaster.

Fish Community 1982-1995

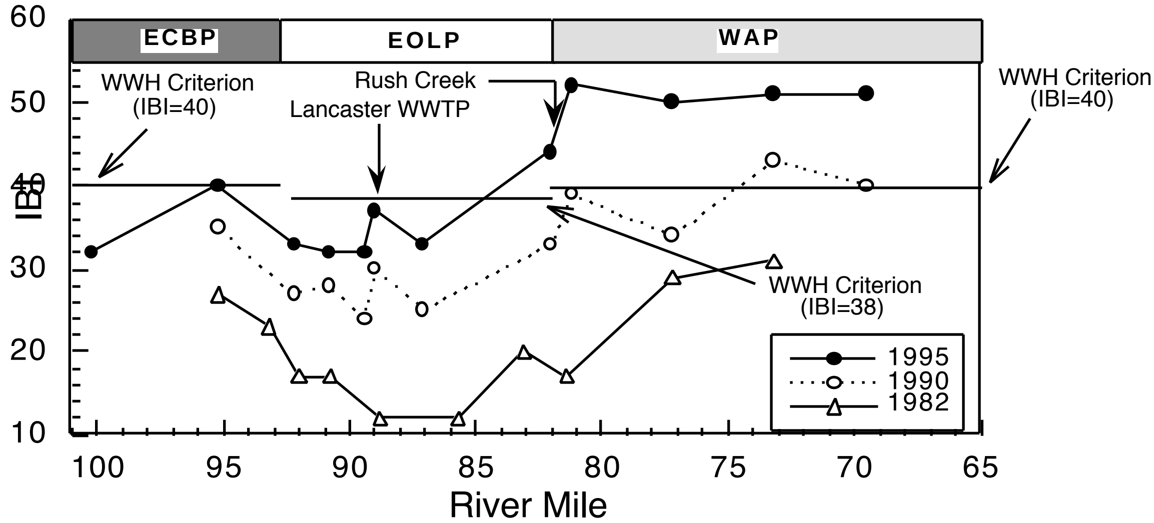
Fish community data were collected from the upper Hocking River mainstem in 1982, 1990, and 1995. The 1982 survey included 10 stations, assessing the river reach between RM 95.2 (Hooker Cemetery, upstream Lancaster) and RM 73.3 (at Enterprise). The 1990 effort included 12 stations covering a similar reach demarcated by RM 95.2 and RM 69.5 (SR 664, at Logan). The 1995 survey assessed a nearly identical area as that from 1990, except for an additional coverage provided by a station placed at RM 100.2 (Pickerington Rd.) within the headwaters. Longitudinal performance of the IBI and MIwb through time is presented in Figure 27.

Performance of the fish community in 1995 demonstrated striking improvements in comparison with the results from both the 1982 and 1990 surveys. In 1982, the depauperate fish assemblage of the upper Hocking River was clearly reflective of the grossly polluted and acutely toxic conditions present within and downstream from the greater Lancaster area - a result of poorly treated effluent from the Lancaster WWTP as well as chronic CSO discharges (Ohio EPA 1985). Community performance was uniformly *poor* to *very poor* throughout this area. Typically, the fish assemblage supported at each sampling station was greatly simplified, consisting of a few highly pollution tolerant species. The trophic structure was strongly skewed in favor of omnivorous and generalists feeders, as specialist insectivores and top carnivores were present levels well below ecoregional expectations. Environmentally intolerant species were absent and both overall abundance and biomass were diminished (Figure 28). The initial stages of biological recovery were indicated approximately 12 miles downstream from the Lancaster WWTP at RM 77.2 (at Rockbridge). Additional community stressors within the area of partial recovery included mine drainage and wastewater from the Sugar Grove WWTP (both emanating from Rush Creek). Although still well below the WWH standard, community performance was improved to a *fair* level within the lower limits of the study area.

Following large scale upgrades to the Lancaster WWTP and its collection system, ambient biological performance was significantly advanced in 1990. Although incomplete, considerable recovery was indicated within and downstream from the greater Lancaster area (Ohio EPA 1991). Community indices and accompanying narrative evaluations were improved at every station in comparison with the 1982 results. The more positive environmental conditions in 1990 resulted in increased species richness, relative abundance, biomass, and overall community organization throughout the mainstem.

By 1995, near complete recovery was indicated within the upper Hocking River mainstem. The condition of the fish assemblage within the greater Lancaster area ranged between *fair* to *marginally good* - very near the WWH threshold. Longitudinal community performance in 1995 still delineated a zone of WWH departure through Lancaster; however, the magnitude and length were significantly reduced in comparison with previous evaluations. As the Lancaster WWTP's effluent quality has improved and CSO releases have decreased, the grossly polluted conditions observed in the past appeared ameliorated to a large extent. As such, the nominal departure of the fish community in 1995 appeared related primarily to marginal habitat quality of the channelized portion of the Hocking River flowing through and downstream from Lancaster. Given the absence of significant water quality problems, fish community performance in 1995 appeared commensurate with the simplified macrohabitats that typified this reach.

Complete ambient biological recovery was indicated approximately seven miles downstream from the Lancaster WWTP at RM 82.0 (upstream Rush Creek), and extended through the remaining portion of the study area. The prominent influence of the Lancaster WWTP, and lesser influences of mine drainage and wastewater from the Sugar Grove WWTP documented in the past appeared largely eliminated. This reach has exhibited the most dramatic improvement in comparison with previous investigations (Ohio EPA 1985 and 1991). The fish assemblages within the lower segment consistently performed at *very good* to *exceptional* levels in 1995 - much improved in comparison with the *fair* levels observed in 1982 - indicating full biological realization of ecoregional and habitat potential of this reach.



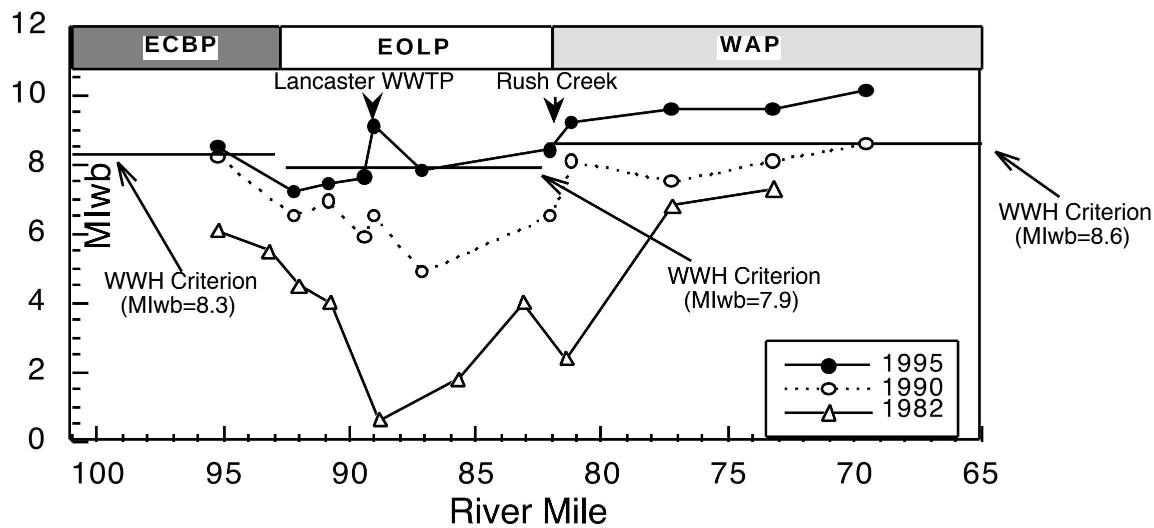


Figure 27 Longitudinal performance of the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) for the upper Hocking River mainstem, 1982 - 1995. The solid lines represent numerical biological criteria in support of the WWH aquatic life use designation for each ecoregion.

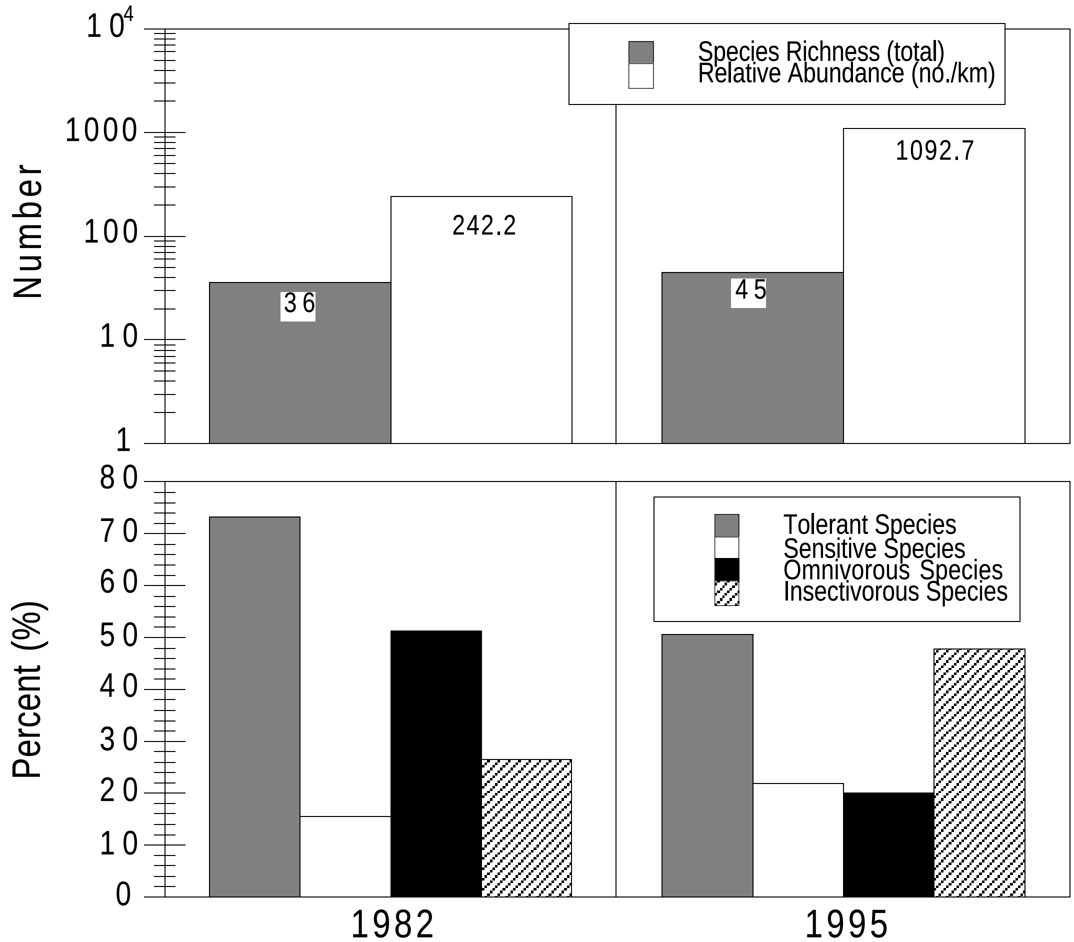


Figure 28 Aggregate compositional and structural features of the fish community of the upper Hocking River mainstem between 1982 and 1995.

Hocking River Tributaries

Hunters Run and Ewing Baldwin Run

Benthic Macroinvertebrates 1982-1995

Sampling near the mouth of Hunters Run has revealed significant improvement (from *poor* to *good*) between 1982 and 1990. The elimination of the Anchor Hocking discharge in 1978 was considered the major reason for improvement. More recently, 1995 results from natural substrate sampling indicate similar quality to 1990 collections and no significant declines over the past five years.

Sampling near the mouth of Baldwin-Ewing Run has also indicated an improving trend from 1982 to 1990 when evaluations shifted from *poor* to *fair*. In 1982 conditions were grossly polluted due to combined sewer overflows. No EPT taxa were collected, the QCTV score of 17.6 was extremely low, and the stream bed was completely covered by sewage fungus. The 1995 results indicated further improvements with an increase in EPT taxa richness (from 3 to 7) and total taxa richness (from 28 to 46) between 1990 and 1995. The stream has improved from *very poor* to *marginally good* since 1982.

Fish Community 1982-1995

Fish community data were collected from Hunters Run in 1982, 1990, and 1995. Both the 1982 and 1990 efforts included one station located near the confluence with the Hocking River, downstream a former Anchor Hocking discharge (RM 0.5/0.6, SR 22). The 1995 effort included three stations: one located near the mouth, duplicating the 1982 and 1990 site, and two additional stations upstream of Lancaster (RM 2.5, Crumley Rd. and RM 3.5, Beck Rd.).

In Lancaster, the community in Hunters Run (RM 0.5/0.6) has demonstrated marked improvement since 1982. Samples collected at that time yielded results no better than *fair* (IBI=28), failing to achieve the WWH biological criterion. Community performance improved to *marginal good* (IBI=39) in 1990 and was further advance to a *very good* (IBI=46) level in 1995. The results from both the 1990 and 1995 surveys indicated full agreement with the WWH standard. These improvements appeared to represent continued recovery following the cessation of an Anchor Hocking discharge in 1978.

Fish community data were collected from Baldwin-Ewing Run in 1982, 1990, and 1995. Both the 1982 and 1990 efforts included one station located near the confluence with the Hocking River, downstream from CSOs maintained by the city of Lancaster (RM 0.2). The 1995 effort included two stations: one located near the mouth, duplicating the 1982 and 1990 site, and an additional station upstream of Lancaster at RM 2.5.

The results from both the 1982 and 1990 evaluations indicated *poor* to *fair* conditions, respectively. Departure from the WWH criterion during this time was attributed to chronic CSO releases (Ohio EPA 1991). By 1995, the CSO impact appeared to have lessened, as the fish community near the mouth was found to be fully consistent with the WWH standard. Though evidence of CSO activity was apparent in 1995 (e.g., sewage solids, personal hygiene devices in-stream) the frequency and duration, and subsequent impact, appeared reduced.

Scott Creek

Fish Community 1978-1995

Fish community data were collected from Scott Creek in 1978 and 1995. The 1978 sampling effort included five stations placed between RM 8.9 (upstream mine drainage tributaries, adjacent SR 93) and RM 5.6 (downstream mine drainage tributaries, adjacent SR 93). The objective of the 1978 survey was to evaluate the influence of tributaries that drain several active surface mines. The 1995 survey included three stations located at RM(s) 8.9, 5.6, and 0.1. The objectives of the 1995 effort were to reevaluate selected mine drainage influenced stations and to determine ambient biological conditions of lower Scott Creek - an area that has never been evaluated.

The results from 1978 found *very good* to *exceptional* communities in the headwaters of Scott Creek (RM 8.9 and RM 8.1), upstream of all mining activity. At the remaining stations downstream from several waterways draining active mines (Key Coal Co., Allied Coal, and Empire Minerals), community performance was marked reduced to *fair* to *poor* levels. Departure from the WWH biological criterion was attributed to the influence of actively mined areas (Ohio EPA 1978).

The results from the 1995 survey revealed reduced community performance within the headwaters at RM 8.9 in comparison with the 1979 data. The decline was attributed to intermittent stream flow observed during the summer of 1995. Whether or not the intermittency was anthropogenic in origin or represented a natural event is not clear at this time. Community performance downstream from the mine tributaries (RM 5.6) remained comparable between 1978 and 1995, suggesting a continued mining influence. Additionally, poor habitat quality was identified as a major stresor in 1995.

Clear Creek and Principal Tributaries

Clear Creek Mainstem

Chemical Water Quality 1982-1995

Historical water column chemistry data from Clear Creek was used to perform water quality assessment. A single collection site at RM 2.03, sampled in 1982 and 1990, was used to supplement data the latest (1995) survey work. Water quality data from 1995 indicates minor, negligible impacts from the Amanda WWTP. Ammonia, BOD_5, phosphorus, and chloride all showed small spikes downstream from the Amanda WWTP in 1995. Other parameters showed little correlation with the discharge point of the Amanda WWTP, however, data from 1990 show some *relatively* high values for aluminum, iron, manganese, arsenic, COD, and suspended solids at RM 2.03. These result were found associated with high stream flows (Ohio EPA 1991). There were no direct indications as to a discrete source of these values, especially since the 1995 values are found to be much lower in comparison.

Benthic Macroinvertebrate Community 1982-95

Historical trends from Clear Creek in the Amanda area suggest significant improvement in macroinvertebrate communities since previous surveys in 1982 and 1988 (qualitative sampling only). Station RM 14.1 was located downstream from the unsewered village of Amanda drainage in 1982 and 1988, and downstream from the recently built Amanda WWTP in 1995. Previous evaluations at the site ranged from *marginally good* in 1982 to *poor* in 1988 but improved to *exceptional* by 1995. Results indicate improvements in the vicinity of Amanda as a result of improved wastewaster treatment in Amanda.

The lower five miles of Clear Creek are unglaciated and within the WAP ecoregion. Sampling near the mouth of Clear Creek at RM 2.1 has been conducted on six occasions between 1982 and 1995 (Table). ICI scores have consistently fallen in the *exceptional* range since 1983 (46-50) and were in the *very good* range in 1982 (44). QCTV scores have also been consistently high throughout the sampling periods but EPT taxa richness has only reached levels associated with *exceptional* quality (*i.e.,* a Qual. EPT metric score of "6") during one sampling year (1990). The data suggest excellent water quality conditions but consistently lower performance based on the numbers of EPT taxa. The trend may indicate slight but chronic negative influences from sedimentation associated with channelization and agricultural runoff in the middle and upper reaches of the basin. Longitudinal performance of the ICI through time is presented in Figure 29.

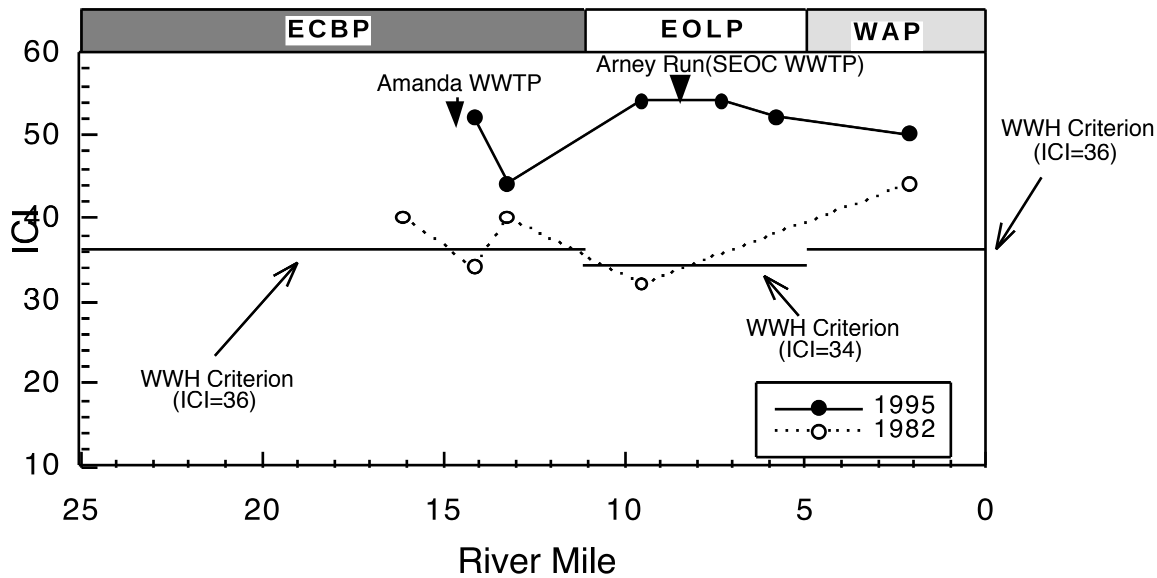


Figure 29 Longitudinal performance of the Invertebrate Community Index (ICI) from Clear Creek, 1982 - 1995. The solid lines represent the WWH aquatic life use designation criteria for each ecoregion.

Fish Community 1982-1995

Fish community data were collected from Clear Creek at various locations in: 1982, 1983, 1988, 1990, and 1995. In 1982 collections were made at six stations, evaluating the stream reach between RM 16.3 (SR 22, upstream of Amanda) and RM 2.3 (Camp Wyandot bridge). The 1983 and 1988 sampling efforts were relatively small and consisted of only one to three stations, evaluating fairly discrete reaches of Clear Creek. The 1990 effort was similar to the 1983 and 1988 surveys, as only a small segment was evaluated. The 1995 survey provided identical coverage as that provided by the 1982 survey, plus additional information was collected within the headwaters at RM 21.8 (SR 188). For the purposes of a trend assessment only the 1982 and 1995 survey were deemed robust enough (i.e., large number of samples and broad coverage) to provide a meaningful evaluation of ambient biological conditions of Clear Creek through time. Thus, the following trend assessment is based exclusively upon these data. Longitudinal performance of the IBI and MIwb in 1982 and 1995 is presented in Figure 30.

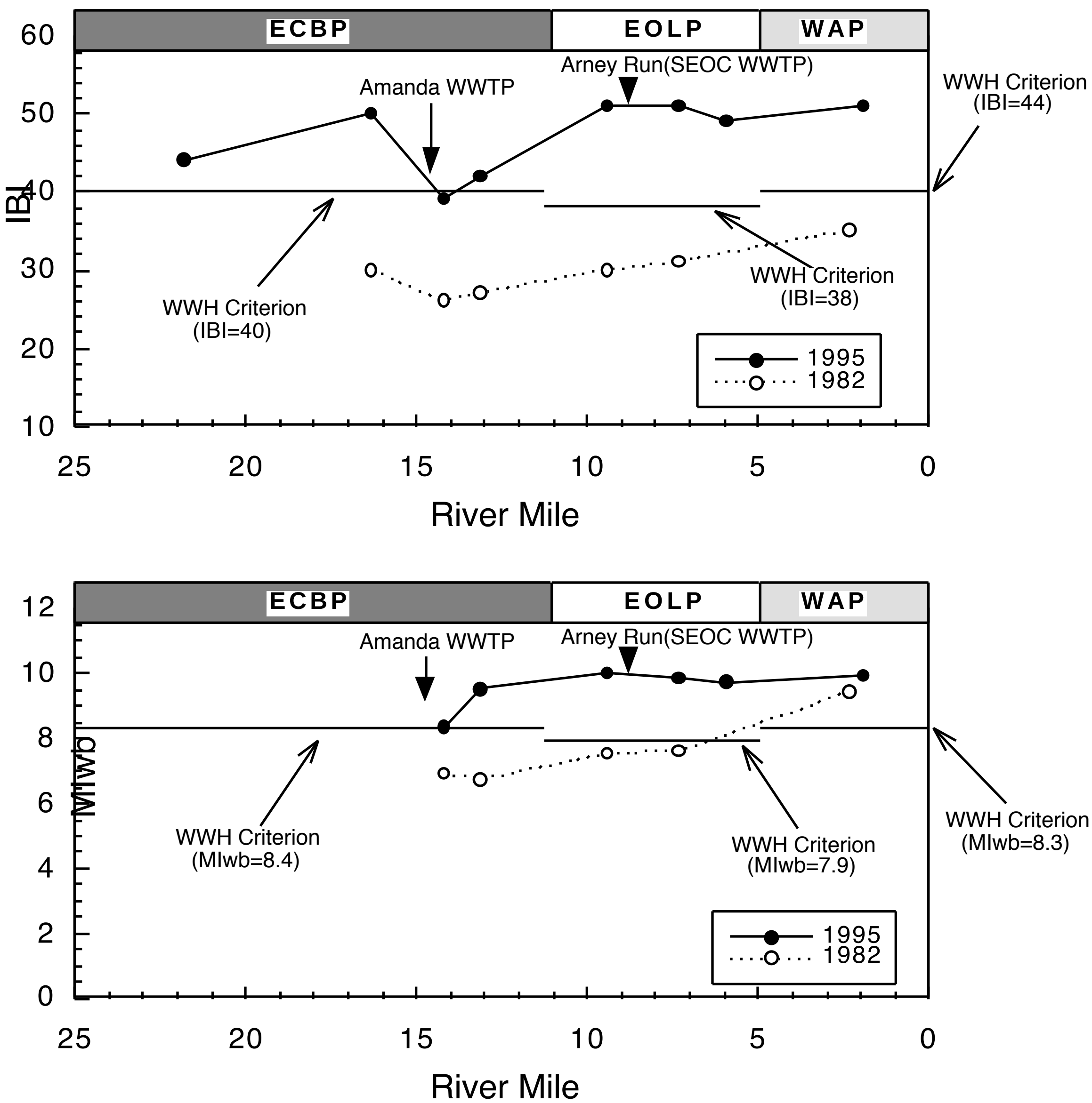


Figure 30 Longitudinal performance of the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) for Clear Creek, 1982 - 1995. The solid lines represent numerical biological criteria in support of the WWH aquatic life use designation for each ecoregion.

Community performance in 1982 ranged between *poor-fair* within the channelized uplands and *exceptional* near the mouth. At that time only two stations (RM 7.3 and RM 2.3) supported fish communities fully consistent with the WWH criteria. The depauperate fish assemblages that typified much of Clear Creek were attributed a combination of factors. Much of the upper and middle portions of Clear Creek have been channelized and adjacent land use is typically intensive row crop agriculture. The stream banks were found to lack a persistent wooded riparian corridor, as farm fields were often cultivated to channel margins. This situation is conducive to bank erosion and promotes the rapid delivery of sediment laden runoff to the stream, embedding coarse substrate and contributing to the existing sediment load. Channelization and sediment deposition work in concert, diminishing macrohabitat quality through substrate and channel simplification. The loss or simplification of habitat, in turn, directly affects the ability of the modified stream or stream segment to support and maintain a diverse and well organized assemblage of fishes. These factors, and to a lesser extent, moderate pollutant loads from Amanda (unsewered at that time) appeared the major stressors to Clear Creek in 1982 (Ohio EPA 1985).

The results from the 1995 survey revealed considerable improvement throughout the study area. Community performance was found to range between *good* and *exceptional*. Conditions have so improved that much of the study area supported *very good* to *exceptional* communities. Every station sampled in 1995 contained a community of fish fully consistent with the WWH biological criteria. Species richness, relative abundance, and community organization were advanced in comparison with the 1982 results. The dramatic improvements observed in 1995 appeared a result of the remediation of stressors identified in the past. First, the results of USDA, Soil Conservation Service study of gross erosion rates and tillage practices within the basin found that between 1982 and 1994 estimated average soil loss on cropland has been reduced by over 50%, from 10 tons per acre (in 1982) to less than 5 tons per acre (in 1994) (USDA 1995). The reduction was attributed to the large scale adoption of conservation tillage throughout the watershed. While gross erosion still persists on many areas, these finding suggest that great strides have been made in controlling overland erosion in agricultural areas. This positive trend undoubtedly lessened the sediment load to Clear Creek and likely resulted in improved stream habitats. Secondly, considerable recovery of the wetted channel, within the confines of the trapezoidal active channel, was observed in 1995. The reestablishment of some natural features of the stream course over the intervening 13 years undoubtedly contribute to an increase in habitat complexity. Last, the Amanda WWTP recently came on line. This development rectified the unsewered conditions of the past.

Selected Clear Creek Tributaries

Benthic Macroinvertebrate Community 1982-95

Historical macroinvertebrate sampling data from Clear Creek tributaries evaluated in 1995 was limited to Cattail Creek and Muddy Prairie. Numerous qualitative samples have been collected from Cattail Creek downstream from the Fairfield County Landfill since 1987. Collections have consistently indicated *exceptional* conditions with high EPT taxa richness and QCTV scores. No significant changes in quality have been observed since 1987. Community heath in Muddy Prairie Run improved from *good* (ICI=44) at RM 0.4 in 1982 to *exceptional* (ICI=52) at RM 0.6 in 1995. While specific reasons for the trend are not known, it follows the general pattern of improvement observed in the upper Clear Creek basin in 1995.

Fish Community 1982-1995

Historical fish community data collected from the Clear Creek tributaries evaluated in 1995 were available for Muddy Prairie Run and Dunkle Run only. Both of these streams were sampled at one station near their confluence with Clear Creek in 1982. A comparable sampling effort was repeated in 1995.

The results from both the 1982 and 1995 sampling indicated full agreement with the WWH biological criterion in Muddy Prairie Run (Table 10). Community performance as measured by the IBI indicated *good* to *exceptional* communities. Improved conditions were indicated in 1995 in Dunkle Run when compared to the results form the 1982 sampling. Species richness, relative abundance, and community organization were all advance. Given the lack of a significant known stressor on Dunkle Run the discrepancy observed between the 1995 and 1982 data may have been a result of site specific variation, as station location varied by 0.4 miles between efforts. Regardless, the condition of the community in 1995 indicated full agreement with the WWH-biological criterion.

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