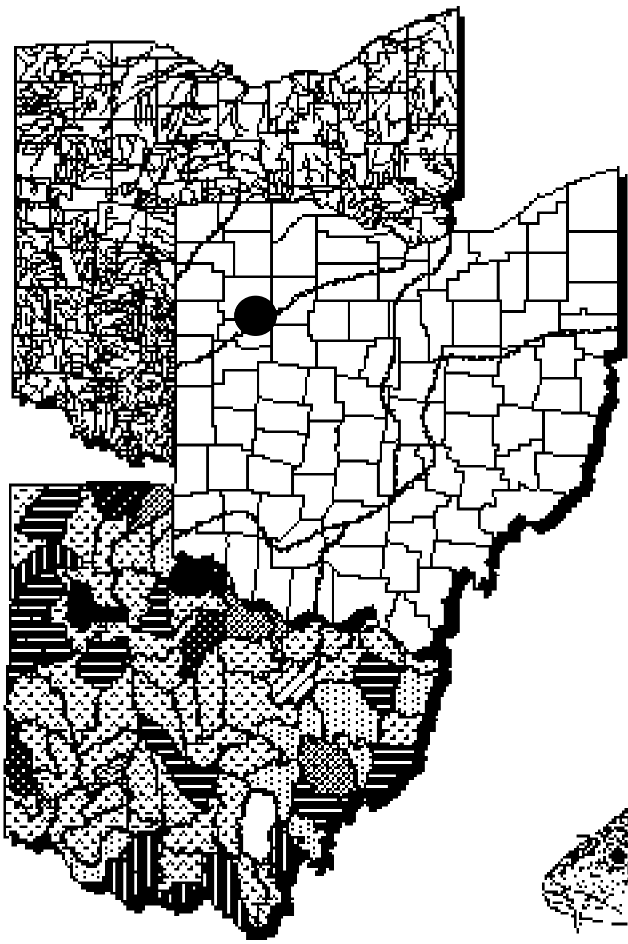
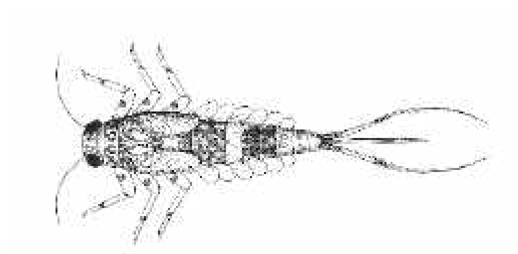
State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of The Ottawa River Basin (1996)

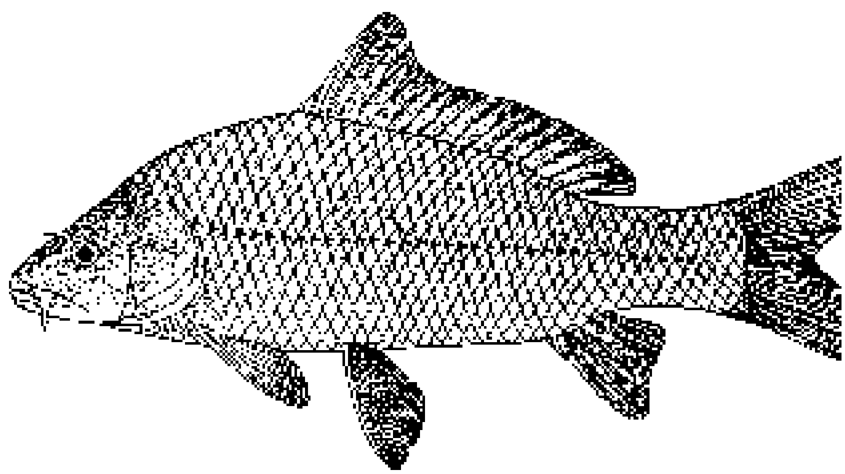
Allen and Putnam Counties, Ohio





Mayfly

(*Baetis intercalaris*)



Common Carp

(*Caprodes carpio*)

December 31, 1998

Robert A. Taft
Governor, State of Ohio
Christopher Jones
Director, Ohio Environmental Protection Agency
P.O. Box 1049, Lazarus Government Center, 122 S. Front St., Columbus, Ohio 43216-1049

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Allen and Putnam Counties
Ohio

December 31, 1998

OEPA Technical Report
Number MAS/1997-12-6

Division of Surface Water
P.O. Box 1049
Lazarus Government Center
122 S. Front St.
Columbus, Ohio 43216-1049

TABLE OF CONTENTS

Acknowledgments

Dave Altfater - Biomarker collections.
Bernie Counts - Biomarker collections.
Jack Freda - Macroinvertebrate field collections.
Erin Gaskill - Chemical water quality/sediment trends (from the Indicator Project Report)
Dan Glomski - Instream and sediment chemistry collection, pollutant loadings, facility descriptions, chemical trends, and sediment chemistry.
Martin Knapp - Macroinvertebrate community assessments and field collections, biomarker analyses, chemical trends and sediment chemistry analyses, study area maps, and TSD editor.
Robert Miltner - Fish community assessments.
Katie McKibben - Study area description.
Eric Nygaard - Pollutant loading trends (from the Indicator Project Report)
Randy Sanders - Fish field collections.

Jeff DeShon, Marc Smith and Chris Yoder - Reviewers.

Water chemistry and organic/metal sediment analyses were provided by the Ohio EPA Division of Environmental Services. Numerous college interns and District Office staff assisted in the collection of field samples. Landowners who granted permission for site access are duly appreciated.

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., Ecological Assessment Section, 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 Quality 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 of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 10-15 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 ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are 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) changes in health,

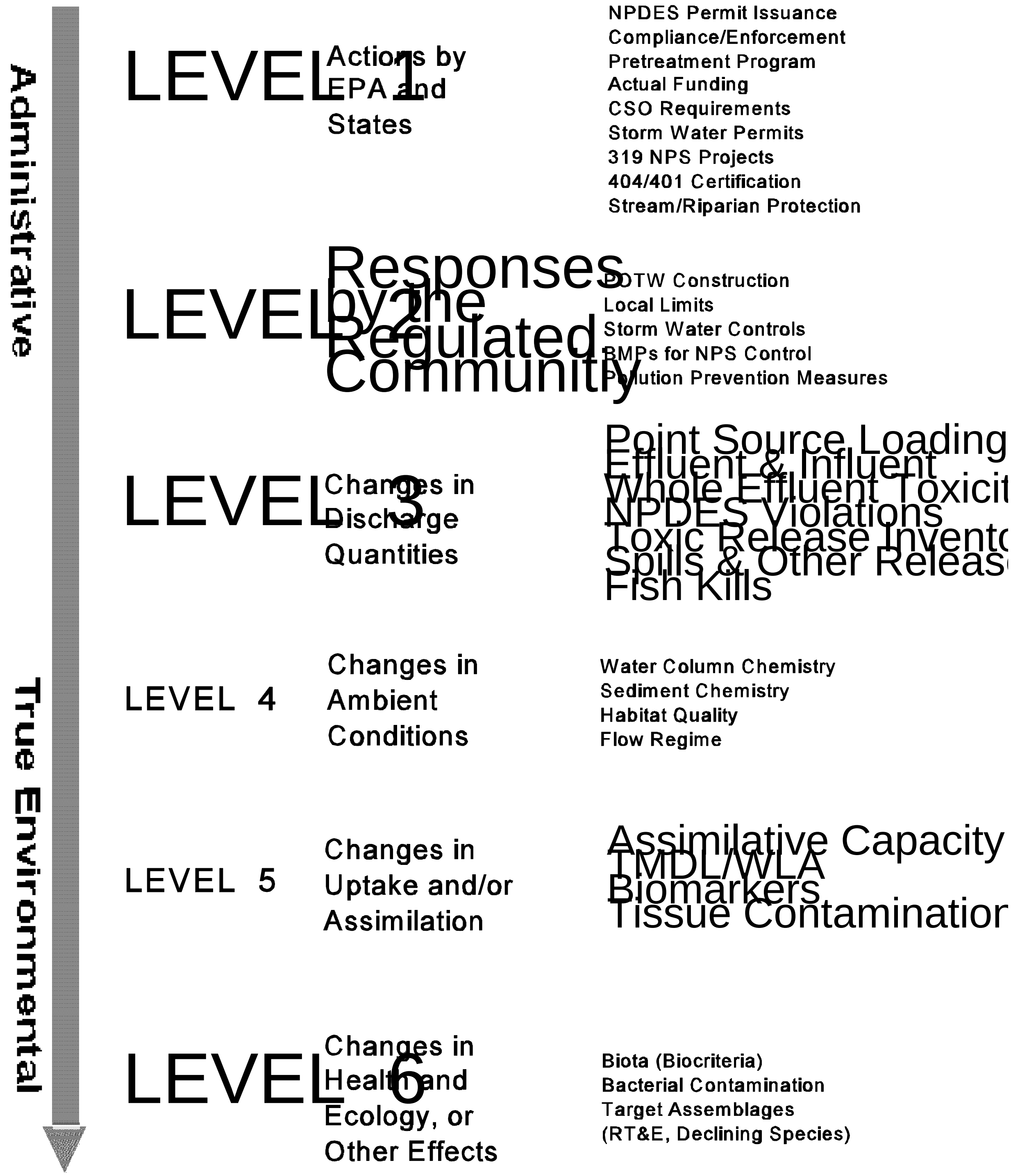

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995).

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 Nonpoint Source Assessment, and other 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 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 Ohio’s rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses.

The five different aquatic life uses currently defined in the Ohio WQS 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.*

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.*

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.

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.

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.

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.

Biological and Water Quality Study of the Ottawa River Basin (1996)

(Allen and Putnam Counties Ohio)

INTRODUCTION

The 1996 Ottawa River study area consisted of the Ottawa River mainstem from Thayer Road (RM 46.1) to near the mouth (RM 1.0). Subbasins sampled within the study area included Pike Run and Plum Creek. Two other tributaries within the Ottawa River study area were sampled - Zurmehley Creek and the Little Ottawa River. See Table 4 and Figures 2-4 for a complete list of sampling locations.

Specific objectives of this study were to:

1) evaluate the physical habitat, surface water and sediment quality, and the biological integrity of the Ottawa River study area,

2) assess impacts from municipal and industrial wastewater treatment plants, nonpoint sources of pollution, and habitat alterations,

3) determine attainment status of aquatic life and non-aquatic life use designations, and recommend changes where appropriate, and

4) compare results of this survey with previous surveys to assesses changes in water quality and biological integrity.

Previous biological and` water quality studies in the Ottawa River study area by the Ohio EPA Division of Surface Water include: Water Quality Study of the Ottawa River OEPA 79/1 (Ohio EPA, 1979); Ottawa River WQTSD (Ohio EPA, 1985); Summary of the 1989 Biological and Water Quality Survey of the Ottawa River, Allen and Putnam Counties, Ohio and Changes Since 1985 (Ohio EPA, 1989); and Biological and Water Quality Study of the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run (Ohio EPA, 1992).

SUMMARY OF THE 1996 RESULTS

A total of 82 miles of rivers and streams in the Ottawa River subbasin was assessed as part of the 1996 survey. Biological index scores indicated that 14 miles (17.3 %) were in full attainment of the Warmwater Habitat (WWH) biocriteria. Approximately 16 miles (19.3 %) were in partial attainment and 52 miles (63.4 %) were in non-attainment of WWH or Modified Warmwater Habitat (MWH) biocriteria (Table 1).

Ammonia, nutrients, organic enrichment, and pathogens were the leading causes (52 miles, 75 %) of the partial and non-attainment in the basin. The major sources were industrial and municipal point sources, combined sewer overflows (CSOs), and sanitary sewer overflows (SSOs). Associated causes and sources of partial and non-attainment are presented in Table 2.

A narrative matrix (Figure 2) was constructed summarizing selected environmental stressors (*i.e.*, cumulative load, spills, CSOs/SSOs, number of dams/pools, and concentrations of urban/industrial land use), exposures (*i.e.*, sediment and fish tissue contamination levels, toxicity), and response indicators (*i.e.*, fish and macroinvertebrate indices, habitat quality). Designated aquatic life use attainment status was also included as part of the matrix. The shading darkens as the departure from reference widens. While some ratings were necessarily general or based on ralative comparisons, they show that observed reductions in response indicators coincide with increased exposure and the increasing prescence of external stressors from both point and nonpoint sources. The greatest declines in the biological community metrics were noted in segments within and downstream from the Lima WWTP, Clark Oil, and PCS Nitrogen, and coincided with high to very high stressor and exposure indicator levels.

Ottawa River Mainstem

Ohio EPA monitoring in 1996 showed that there is a gradual, longitudinal loss (FULL to PARTIAL to **NON**) of WWH aquatic life use attainment in the Ottawa River as it flows into and through Lima, followed by a gradual recovery (**NON** to PARTIAL to FULL) downstream from Lima between Elida and the confluence with the Auglaize River. Compared to previous surveys, the results through Lima are unchanged, but the rate of improvement has increased in the downstream reaches (Figure 3).

All biological indices attained the WWH criteria at the most upstream station, Thayer Road (RM 46.1), and attained or were in nonsignificant departure at the next site downstream, Fetter Road (RM 44.5). The Ottawa River flows through a series of low-head dams starting with the Metzger Road dam (RM 43.5), and the proportion of tolerant and omnivorous fish increases. Although the macroinvertebrate communities attain WWH, the fish assemblages represent mostly fair conditions in the segment between the Metzger Road dam and Sugar Street, resulting in partial attainment of WWH biocriteria. Chemical water quality exceedences (iron, nitrate, and TDS) in the Ottawa River from Thayer Road to the City of Lima were found only at RM 43.45 and included the statewide criteria for protection of human health for Public Water Supply (see Appendix Table).

Upstream from the Lima CSOs, fish indices downstream from Sugar Street (RM 40.8) to the Lovers Lane dam pool (RM 40.2) did not meet WWH biocriteria. Fish crews sampling in this reach observed thick deposits of sewage solids next to an island near Schoonover Park. An area of unsewered homes (with septic systems) along Findlay Road is the suspected source of the impairment.

Within the series of dams and CSOs from RM 40.8 to RM 38.5, none of the fish sites sampled met WWH criteria. Qualitative Habitat Evaluation Index (QHEI) scores ranged from 44.5 to 51.0 and reflected the characteristics of the modified habitats caused by the series of lowhead dams within the City of Lima. Even the MWH impoundment criteria were not met for fish in this section except for the MIwb at RM 40.8 and RM 38.5. Macroinvertebrates were sampled at RMs 40.1, 39.6, and 38.6 in this reach. The site located in the Elm Street dam tailwaters between the Elm Street dam (RM 39.70) and the Central Street dam (RM 39.58) had good current velocity (>0.3 fps) over the artificial substrates. By contrast, the other two benthic sites sampled in this area had less than optimal flow over the artificial substrates but, more importantly, were directly downstream or adjacent to CSO control structures; neither site met the WWH criterion. Sludge deposits were observed by fish and macroinvertebrate crews downstream from the Lovers Lane and Collette Street control structures. The non-attainment of biological criteria from the Lovers Lane dam (RM 40.14) to the Lima WWTP dam (RM 37.96) was attributed to the City of Lima CSOs. Chemical water quality exceedences detected downstream from the CSOs were mostly for dissolved oxygen. The CSO outfalls 002-006 discharged a combined total of 1.4 MGD of wastewater; 1,125 kg/day of total suspended solids (TSS); and 90 kg/day of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) in 1996. The cumulative loadings from these CSOs occurred during rainfall events, but the impacts of those events were evident well after individual events had subsided.

Partial attainment of WWH biocriteria was observed downstream from the CSO control structures and dams at RM 37.9, immediately upstream from both the Lima WWTP and L5 landfill. Fish indices either met or were in nonsignificant departure from WWH biocriteria. Although the ICI score of 28 did not attain WWH biocriterion at this site, it showed a significant improvement over the score of 6 determined in 1991. Fish and macroinvertebrate indices did not meet the WWH biocriteria at the next station at RM 37.7. An increase in fish anomalies and a decrease in the ICI (28 to 14) was attributed to the L5 landfill. Leachate has been observed seeping into the river from the landfill since 1991 and there was large amount of oil observed adjacent to the landfill in 1996. There was a large release of oil observed and sampled that escaped the containment boom during one of the 1996 sampling events (Sept. 4). There were 6 different chemical parameter exceedences observed at RM 37.7 in 1996. A large number of selenium exceedences (# of samples > 5 ug/l) were documented downstream from the BP Refinery discharge at chemical sampling stations from RM 37.0 to RM 22.94.

The Lima WWTP discharges at RM 37.67. The macroinvertebrate communities improved significantly from previous years at the site downstream from the Lima WWTP (RM 37.4, ICI = 42) and at the Shawnee Country Club (RM 34.5, ICI =38), but sites located downstream from BP Oil and PCS Nitrogen remained poor and fair. Fish indices remained fair to poor at non-mixing zone sites from immediately upstream of the Lima WWTP (RM 37.7) to the Allentown dam (RM 28.9). The most significant change observed in water chemistry attributed to the Lima WWTP in the 1996 survey was an increase in nitrate-nitrite-N in the Ottawa River from an average of 5.2 mg/l upstream to 7.0 mg/l downstream from outfall 001. The average concentration of selenium was greater than 5 ug/l in the Ottawa River for approximately 15 miles downstream from the BP Refinery outfall 001. Also, the BP Refinery outfall 001 had the highest mean oil and grease concentration (of the three major dischargers) reported during the 1996 survey.

The segment of the Ottawa River showing the most severe impact to fish communities was downstream from the PCS Nitrogen outfalls (RM 36.7 to RM 34.7). The lowest MIwb scores (excluding dam pool sites) and the lowest IBI scores were reported downstream from the PCS outfalls (RM 36.0) to the Shawnee Country Club (RM 34.7), despite good habitat conditions. QHEI scores ranged from 79.5 to 84.0 in this section suggesting the potential for at least WWH performance with improved water chemistry. The highest percentages of DELT (25.9 % to 48.8%) anomalies were also reported in this area. The single highest percentage of DELTs in the 1996 Ottawa River survey was 48.8%, reported on 8/29/96 downstream from PCS outfall 001 at RM 36.70. White suckers and common carp collected downstream from the PCS outfalls for biomarker analyses showed the highest levels of blood urea nitrogen (BUN).

During the six chemical runs conducted by the Ohio EPA during the summer of 1996, the average instream concentrations of ammonia, BOD, iron, total Kjeldahl nitrogen, nitrite, phosphorus, and zinc increased in the Ottawa River downstream from the PCS-Nitrogen outfall 001 (RM 36.87). Exceedences of the 30-day average ammonia criterion occurred in 2 out of 6 sampling events at RM 36.80 and 1 of 6 events at RM 36.3, a result of the PCS 001 effluent. Although urea was not a measured instream parameter, the concentrations and loadings from the PCS outfalls are high. The site at RM 36.80 was the only location that chromium (30 ug/l detection level) and free cyanide were detected instream, and these instream concentrations were attributed to the PCS 001 outfall. Chromium, copper, and zinc sediment concentrations were substantially higher downstream from PCS-Nitrogen at RM 36.8 compared to upstream at RM 37.0.

It was difficult to detect significant biological impacts from the Shawnee #2 WWTP (RM 32.5) and Elida WWTP (RM 24.2) because of the overlying degradation extending downstream from Lima's major dischargers. However, fish and macroinvertebrate indices were slightly lower downstream from the Shawnee #2 WWTP and Elida WWTP compared to upstream sites.

The mainstem changes from non attainment to partial attainment downstream from the Allentown dam, and then full attainment is reached in the lower 6 miles. The macroinvertebrate and fish MIwb scores generally attain biocriteria downstream from the Allentown dam to the mouth, but the fish IBI scores do not attain until the lower 6 miles. Relative to previous years, fish trophic function in 1996 in the lower 6 miles, as judged by the relative abundance of omnivores and insectivores, recovers nearly to that expected for the ecoregion and stream size. Correspondingly, the absolute and relative abundance of roundbodied suckers increased in the lower reach of the river. One consequence of the increased abundance of redhorse was a commensurate increase in the number of anomalous deformities, eroded fins, lesions or tumors (DELTs). Redhorse suckers are especially susceptible to accruing DELTs because of their sensitivity to pollution and low dissolved oxygen regimes. The high incidence of DELTs among this group demonstrates that the cumulative pollutant loadings to the river continue to stress the lower reach despite the recovery to full attainment.

Pike Run

Biological communities were in partial attainment of MWH biocriteria at the stations in Pike Run where both fish and macroinvertebrates were collected.

Fish sampling conducted in 1991 and 1996 showed poor and very poor community performance throughout Pike Run. The results did not attain the MWH biocriterion either year at any site. The seven species of fish collected downstream from American Bath WWTP in 1996 was a significant improvement compared to the one species collected in 1991. Although macroinvertebrates collected in 1996 were considered att`aining the MWH criterion at the sites sampled in 1996, the collections represented fair community performance both upstream and downstream from the American Bath WWTP. Upstream impacts from nonpoint sources (City of Lima permitted wet weather overflows) appeared to be the major cause. At downstream sites (RMs 5.7 and 0.1), the benthic community improved to marginally good and good conditions, respectively.

The City of Lima has six permitted wet weather overflow locations (011-016) to Pike Run. Chemical samples collected at RM 8.21 were downstream from the overflows and upstream from the American Bath WWTP. There were high numbers of fecal coliform bacteria (>10,000 and 5,500 per 100 ml.) on the two occasions that fecal bacteria were sampled at this site. Numbers of fecal coliform bacteria remained high at the other Pike Run sites sampled downstream from the American Bath WWTP, despite low numbers in the WWTP effluent.

Plum Creek

Upstream from the Village of Columbus Grove, macroinvertebrate communities reflected fair conditions. Macroinvertebrate communities declined to poor conditions at the site at RM 12.9, downstream from Columbus Grove CSOs but upstream from the Columbus Grove WWTP. The next station at RM 11.5 and the succeeding stations improved to marginally good and good. Benthic communities had higher numbers of taxa and QCTV scores, and caddisflies and mayflies were predominant organisms. Poor habitat quality throughout Plum Creek resulted in fish communities lacking species richness and trophic function. Consequently, IBI scores at every sampling location were in the poor range and did not meet the existing WWH criteria. The Columbus Grove WWTP did not have a significant impact to the biotic communities in light of the severity of the CSOs, other nonpoint, and habitat impacts.

Chemical water quality upstream from the Village of Columbus Grove was generally good to very good, with most pollutants at or below respective MDLs, although a D.O. violation was documented. Within the village limits, a CSO impact was evident, reflected by the D.O., NH_3-N, and fecal coliform bacteria exceedences which were documented. These exceedences occurred due to the accumulation and decomposition of sludges, complicated by low stream gradient and channel modifications. A nutrient enrichment impact resulted from the Columbus Grove WWTP, with increasing nitrate, phosphorus, and BOD_5 concentrations, but it was unclear what portion of the impact was attributable to CSOs. An impact occurred near Kalida, especially with increasing suspended solids concentrations, but it was unknown whether this resulted from upstream agricultural practices or urban sources, such as construction sites.

Little Ottawa River, **Zurmehly Creek**

The macroinvertebrate site on the Little Ottawa River at RM 0.4 had slightly less than optimal community characteristics and was evaluated as marginally good. The macroinvertebrate sample collected at Zurmehly Creek RM 0.1 was evaluated as fair.

Habitat impacts from channelization, intensive agriculture, and in the case of Zurmehly Creek, urbanization, limited the fish communities in both streams. Based on the number of modified habitat attributes, neither stream is currently capable of supporting WWH fish communities.

Inorganic water quality was generally very good in the Little Ottawa River, with most pollutants at or below respective MDLs. Some temporal variability in nutrient and suspended solid concentrations was exhibited, with higher concentrations documented during the 5 August sampling event. These results indicated a slight nonpoint source impact. No Water Quality Standards exceedences were documented at this station.

Water quality was generally very good in Zurmehly Creek, with most pollutants evaluated at or below respective MDLs. Some temporal variability in nutrient and suspended solid concentrations was exhibited, with higher concentrations documented during the 5 August sampling event. These results indicated a slight nonpoint source impact. No Water Quality Standards exceedences were documented at this station. A fecal coliform bacteria count exceeding the Primary Contact Recreation criterion on 16 September indicated a possible source of sanitary wastewater in the drainage.

Table 1. Aquatic life use attainment status for the Ottawa River and selected tributaries based on sampling conducted during June-October 1996 (**bold RM** denotes a reference site; mixing zone sampling locations are *italicized*).

RIVER MILE Fish/Invert.	IBI	Mod. Iwb	ICI[a]	QHEI[b]	Use Attainment Status[c]	Comments
Ottawa River (04-200) 1996						
Eastern Cornbelt Plains - WWH Use Designation (Existing)						
46.1[W]/45.9	46	9.0	48	84.0	FULL	Thayer Rd
44.4[W]/44.5	36[ns]	7.9[ns]	40	71.0	FULL	Fetter Rd.
43.6[B]/--	32*	7.5*	--	45.5	[**NON**]	Metzger Rd. dam pool
43.4[W]/43.4	33*	9.0	40	70.5	PARTIAL	Dst. Metzger Rd. dam
42.3[B]/42.4	28*	7.4*	G	57.5	PARTIAL	Roush Rd.
41.2[W]/41.2	37[ns]	7.4*	42	81.0	PARTIAL	Sugar St.
40.8[B]/--	27*	6.6*	--	51.0	**[NON]**	Dst. Sugar St.
40.2[B]/--	<u>22</u>*	<u>5.0</u>*	--	48.0	**[NON]**	Lovers Lane dam pool
39.9[B]/40.1	<u>25</u>*	<u>5.8</u>*	20*	44.5	**NON**	Elm St. dam pool
-- /39.6	--	--	34[ns]	--	[PARTIAL]	Elm St. tailwaters
38.9[B]/--	<u>23</u>*	<u>4.9</u>*	--	45.5	[**NON**]	Metcalf/Collette dam pool
38.5[B]/38.6	26*	6.8*	<u>6</u>*	47.5	**NON**	Collette St
37.9[W]/37.9	37[ns]	8.8	28*	81.5	PARTIAL	Dst.Lima WWTP/Erie RR dam
37.7[B]/ 37.7	29*	7.6*	14*	69.0	**NON**	Adjacent L-5 landfill
37.66[B]/37.66	*29**	*9.2*	*F**	*73.5*	*NA*	*Lima WWTP mix zone*
37.44[B]/37.4	<u>22</u>*	6.8*	42	65.5	**NON**	Dst. Lima WWTP
37.11[B]/37.1	*28**	*7.7**	*18**	*76.5*	*NA*	*BP America Ref. mix zone*
37.0[B]/37.0	<u>24</u>*	7.5*	20*	58.0	**NON**	Dst. BP America Refinery
36.87[B]/36.87	*<u>22</u>**	*6.9**	*P**	*48.0*	*NA*	*PCS-Nitrogen mix zone*
36.7[B]/--	26*	7.2*	--	59.5	[**NON**]	Dst. PCS-Nitro. outfall 001
36.0[B]/36.1	<u>17</u>*	<u>5.4</u>*	22*	84.0	**NON**	Dst. PCS-Nitro. outfalls
35.5[W]/ --	<u>20</u>*	<u>5.3</u>*	--	--	**NON**	Ust. Shawnee Country Club
34.7[B]/34.5	<u>18</u>*	<u>5.2</u>*	38	79.5	**NON**	Shawnee Country Club
32.8[B]/32.6	<u>21</u>*	7.2*	32[ns]	70.0	**NON**	SR 117, upst Shawnee #2
32.4[B]/32.4	<u>18</u>*	<u>6.2</u>*	F*	80.0	**NON**	Dst. Shawnee #2 WWTP
28.9[B]/--	<u>18</u>*	<u>5.5</u>*	--	75.0	**NON**	Allentown dam pool
28.8[W]/28.8	<u>27</u>*	8.0[ns]	32[ns]	68.0	**NON**	Dst. Allentown dam
25.5[B]/25.8	27*	8.1[ns]	44	65.0	PARTIAL	Ust. Elida WWTP
-- /22.9	-	-	36	--	[FULL]	Dst. Elida WWTP
21.0[B]/--	<u>21</u>*	7.8*	-	60.5	[**NON**]	Dst. Elida WWTP

Table 1. (Continued)

RIVER MILE Fish/Invert.	IBI	Mod. Iwb	ICI[a]	QHEI[b]	Use Attain-ment Status[c]	Comments
Ottawa River (04-200) 1996						
		Huron-Erie Lake Plain - WWH Use Designation (Existing)				
16.2^{B}/16.0	20^{*}	8.4^{ns}	48	71.5	**NON**	Rimer
13.0^{B}/--	26^{*}	8.7	--	79.0	[PARTIAL]	Dst. Ottawa River Church
5.6^{B}/7.8	32^{ns}	9.7	46	77.5	FULL	Adj SR 115/ Putnam Rd
3.8^{B}/3.6	37	9.2	46	55.5	FULL	Ust KalidaWWTP
1.2^{B}/0.8	36	9.9	48	73.5	FULL	Dst Kalida, near mouth
Pike Run (04-208) 1996						
		Eastern Cornbelt Plains - MWH Use Designation (Existing)				
8.3^{W}/8.2	18^{*}	NA	F*	58.5	PARTIAL	Ust. Amer-Bath WWTP
8.1/8.1	18^{*}	NA	F*	62.0	PARTIAL	Dst. Amer-Bath WWTP
4.7/5.7	18^{*}	NA	MG^{ns}	37.5	PARTIAL	Irvin Rd
2.0/--	18^{*}	NA	--	36.5	**[NON]**	Sandy Point Rd
0.6/0.8	20^{*}	NA	G	57.0	PARTIAL	Dst. Gomer
Plum Creek (04-201) 1996						
		Huron-Erie Lake Plains - WWH Use Designation (Existing)				
15.3^{W}/14.9	22^{*}	NA	F*	36.0	**NON**	Ust. Columbus Grove
12.9^{W}/12.9	20^{*}	NA	P*	57.0	**NON**	Ust. Cols. Grove WWTP
12.2^{W}/11.5	18^{*}	NA	MG^{ns}	42.5	**NON**	Dst. Cols. Grove WWTP
8.1^{W}/8.1	24^{*}	NA	G	33.0	**NON**	TR O
5.5^{W}/4.4	22^{*}	7.1^{*}	G	49.5	**NON**	
0.2^{W}/0.2	26^{*}	7.0^{*}	MG^{ns}	39.0	PARTIAL	SR 114
Little Ottawa River (04-213) 1996						
		Eastern Corn Belt Plain WWH Use Designation (Existing)				
0.4/0.4	20^{*}	NA	MG^{ns}	55.0	**NON**	Adjacent cemetery
Zurmehly Creek (04-261) 1996						
		Eastern Corn Belt Plain WWH Use Designation (Proposed)				
0.1/0.1	30^{*}	NA	F*	58.0	**NON**	Near mouth

Table 1. (Continued)

Ecoregional Biological Criteria:

	Eastern Corn Belt Plains (ECBP)			*Huron-Erie Lake Plain (HELP)*		
INDEX - Site Type	WWH	EWH	MWH[d]	WWH	EWH	MWH[d]
IBI - Headwaters	40	50	24	28	50	20
IBI - Wading	40	50	24	32	50	22
IBI - Boat	42	48	24	34	48	20
Mod. Iwb - Wading	8.3	9.4	6.2	7.3	9.4	5.6
Mod. Iwb - Boat	8.5	9.6	5.8	8.6	9.6	5.7
ICI	36	46	22	34	46	22

* Significant departure from ecoregional biocriteria; poor and very poor results are underlined.

ns Nonsignificant departure from ecoregional biocriteria for WWH or EWH ($\leq$4 IBI, $\leq$4 ICI, $\leq$0.5 MIwb units).

NA Not applicable.

a Narrative evaluation used in lieu of ICI (E=Exceptional; VG= Very Good; G=Good; MG=Marginally good; F=Fair; P=Poor; VP=Very Poor).

b Qualitative Habitat Evaluation Index (QHEI) values based on Rankin (1989).

c Attainment status based on one organism group is parenthetically expressed.

d Channel modified.

B Fish sampled using the Boat Method.

H Headwater site (drainage area < 20 square miles) fish sampling was conducted using a wadeable method.

W Fish sampled using the Wading Method.

Table 2. Waterbody segment (305b) summaries for streams sampled in the Ottawa River basin during 1996.

Waterbody (RM) Upper/Lower	Stream Reach Length	Attainment Miles Status				Causes, Sources, and Comments
		FULL	Partial	**NON**	Threatened	
Ottawa River mainstem - WWH						
50.70/35.30	15.40	6.3	4.2	4.9	0.0	*Causes*: Ammonia, organic enrichment *Sources*: Industrial & municipal point sources, CSOs *Comments*:Biological attainment declines from full to partial to non as river passes through Lima area
35.30/22.93	12.37	0.0	5.87	6.5	0.0	*Causes*: Organic enrichment, unknown toxicity *Sources*: Industrial & municipal point sources (Lima area) *Comments*:Reach most impacted from cumulative load from Lima area
22.93/6.57	16.36	1.43	5.9	9.03	0.0	*Causes*: Unknown toxicity *Sources*: Industrial & municipal point sources (Lima area) *Comments*:Reach still impacted from cumulative load from Lima area
6.57/0.00	6.57	6.57	0.0	0.0	0.0	*Causes*: None *Sources*: None *Comments*:Full attainment occurred at the farthest point upstream since OEPA sampling was initiated in the 1970s
Pike Run - MWH						
9.45/0.00	9.45	0.0	9.45	0.0	0.0	*Causes*: Pathogens *Sources*: CSOs, municipal point source *Comments*: Partial attainment due to poor fish community (bugs- fair to good)

Table 2. (cont.) Waterbody segment (305b) summaries for streams sampled in the Ottawa River basin during 1996.

Waterbody (RM) Upper/Lower	Stream Reach Length	Attainment Miles Status				Causes, Sources, and Comments
		FULL	Partial	**NON**	Threatened	
Plum Creek - WWH						
14.40/0.00	14.40	0.0	2.8	11.6	0.0	*Causes*: Organic enrichment, ammonia, pathogens *Sources*: CSOs, municipal point source *Comments*:Most non attainment due to poor performance of fish IBI. Bugs were F-P ust WWTP, MG-G dst.
Zurmehly Creek - WWH						
1.82/0.00	1.82	0.0	0.0	1.82	0.0	*Causes*: Priority organics *Sources*: Urban runoff/storm sewers *Comments*:Non attainment due to poor performance of fish IBI. Bug community performance was marginally good.
Little Ottawa River - WWH						
6.40/0.00	6.40	0.0	0.0	6.40	0.0	*Causes*: Nutrients *Sources*: Urban runoff/storm sewers *Comments*:Both fish and bugs had fair community performance

SEGMENT	DES. USE	RESPONSE INDICATORS				EXPOSURE INDICATORS						STRESSORS				
	Attain ment Status	QHEI	IBI	MIwb	ICI	Water Column Chem.	Sedi-ment Chem	Toxi-city	% Delts	Fish Tissue	Bio-marker	# Dams/ Pools	Urban-Indust. LandUse	Cumu-lative Load	Spills	CSOs SSOs
Ottawa River																
Thayer Rd to Sugar St.	FULL-PART.	68	Fair-Good	Fair-Good	Good	Nitrates	Low	NA	Mod-High	Mer-cury	Low	Mod-erate	Low	Low	Low	Low
Sugar St. to Lima WWTP dam	NON	47	Poor to Fair	Poor to Fair	Poor to M.G.	CBOD TSS D.O.	As,Cr Cd,Cu Ni,Zn	Mod-erate	High	Pesti-cides	BUN Naph B(a)p	High	High	Mod-erate	Mod-erate	High
Lima WWTP dam to Allentown dam	NON	72	Poor	Poor to Fair	Fair to Good	Amm. CBOD TSS D.O. Nitrates Phos Chrom. PAH Pesticid	As,Cr Cd,Cu Ni,Zn PAH	Mod-erate	Very High	Selen-ium Pest-icides	EROD Naph B(a)p BUN	Mod-erate	High	High	High	High
Allentown dam to Kalida	PAR-TIAL	69	Poor -Fair	Fair-Good	Good -Exc.	TSS	Low	NA	High	Pesti-cides	Low	Low	Low	High	Low	Low
Kalida to mouth	FULL	69	Good	Good	Exc.	TSS	Low	NA	Very High	Pesti-cides	Low	Low	Low	High	Low	Low

Figure 2. A matrix of summarized information from environmental response indicators, measurements of pollutant exposure levels, and potential pollutant stressors in segments of the Ottawa River mainstem.

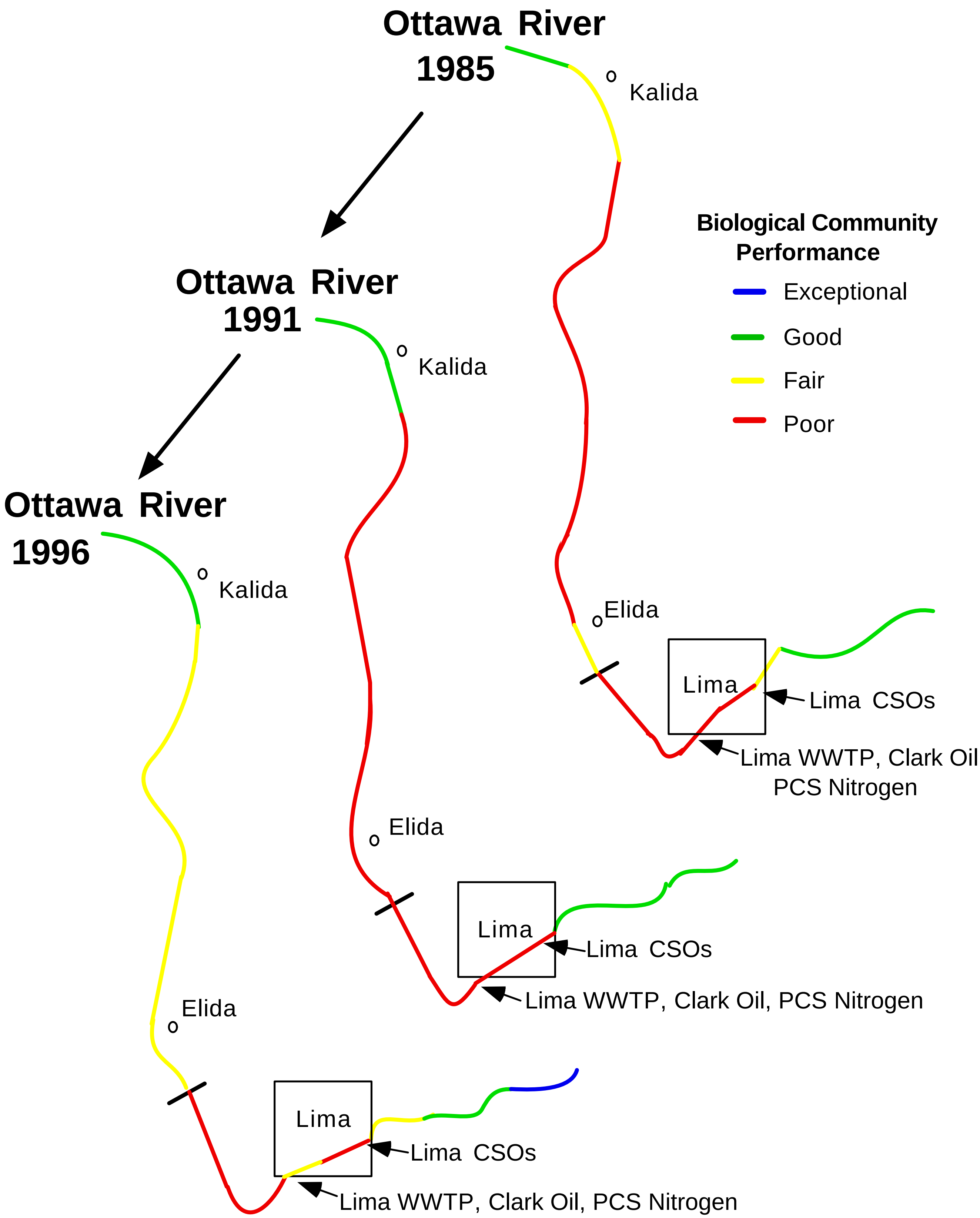

Figure 3. Biological community performance trends in the Ottawa River for 1985, 1991, and 1996.

Point Source Discharge Summaries

Lima WWTP (Ottawa River RM 37.67)

The City of Lima Wastewater Treatment Plant (WWTP), Ohio EPA permit number 2PE00000, is located at 1200 Ft. Amanda Road, Lima, Ohio. The current permit became effective on 1 November, 1993 and expired on 1 June, 1998. The facility was constructed in 1931 and last renovated in 1993 and is an advanced treatment system designed to treat "first flush" combined sanitary and stormwater flows. Treatment technology includes; screening and grit removal, phosphorus removal through the addition of ferrous chloride and polymer, primary settling, biochemical oxygen demand removal through activated sludge aeration, secondary clarification, nitrification through trickle filtration, chlorine disinfection, dechlorination, and anaerobic sludge digestion. Sludge is dewatered and land applied at agronomic rates through an approved sludge management plan. Final effluent discharges to the Ottawa River through outfall 001 at river mile (RM) 37.67. Flows up to the design capacity of 18.5 million gallons per day (MGD) receive full treatment and must meet the most stringent effluent limits, while flows between 18.5 MGD and 33 MGD have somewhat relaxed effluent limits, flows between 33 MGD and the hydraulic capacity of 53 MGD receive primary treatment and chlorination and must meet the least stringent effluent limits, and flows in excess of 53 MGD are bypassed. The annual average discharge is approximately 13.2 MGD. The facility also implements an industrial pretreatment program which was approved in 1984. Seven significant categorical industrial users, one significant noncategorical industrial user, and eighty other noncategorical industrial users discharge to the facility, contributing 20% of the incoming flow.

A significant decline in peak NH_3-N loadings occurred around 1981. A decline in BOD_5 and TSS loadings occurred around 1991 and rates have remained relatively stable since. This presumably occurred due to the upgrading of the sludge digesters and an improvement in sludge handling capabilities. Loadings of NO_3-N have remained relatively constant through the evaluation period. The most significant change observed in water chemistry downstream from the Lima WWTP in the 1996 survey was an increase in nitrate-nitrite-N in the Ottawa River from an average of 5.2 mg/l upstream to 7.0 mg/l downstream from outfall 001.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. A monthly maximum concentration violation for residual chlorine was documented in May. Effluent grab samples collected during the study period were evaluated for monthly maximum concentration exceedences. None were documented. No volatile organic compounds were detected, while chloroform and six organochlorine pesticides were detected at low concentrations. Ohio EPA spill records from 1992 to 1996 contained 7 reported spills attributed to the Lima WWTP system.

Ohio EPA conducted two 48-hr. acute screening bioassays at the Lima WWTP in May and June 1996 as part of a toxics evaluation in conjunction with permit reissuance. There was no significant toxicity to fathead minnows in the May and June bioassays, and no significant toxicity to *Ceriodaphnia dubia* in the June bioassay. However, in the May bioassay, Lima WWTP mixing zone and all effluent samples were lethal (100 % mortality) to *C. dubia*. There was no mortality in the control or the upstream Lima WWTP samples. A concurrent bioassay on Shawnee #2 WWTP reported no mortality from the Shawnee #2 effluents, but the upstream samples collected at SR 117 (RM 32.6) and the Shawnee mixing zone sample (RM 32.4) were lethal to *C. dubia*. The LC_{50} of the Lima WWTP composite sample was measured at 10% effluent. The harmonic mean flow and the discharger flows show that the Lima WWTP mixing zone is approximately 63.6% effluent, and that as far downstream as the Shawnee WWTP mixing zone the Ottawa River is approximately 46.6% effluent from the Lima WWTP.

CSOs and SSOs

Approximately 95% of the facility service area is sewered. The collection system is comprised of 80% combined sanitary and stormwater sewers (CSOs) and 20% separate sanitary sewers. The combined system contains one lift station, which has no bypass, and nineteen overflows, of which five are mechanically controlled and metered. The separate system contains twenty-three lift stations, of which seven have bypasses, and twenty-seven overflows, none of which are mechanically controlled or metered.

Of the combined sewer overflows (CSOs) which the City of Lima is permitted to discharge during wet weather periods, outfalls 002-006 are mechanically controlled and metered for stormwater retention. These control structures are located at Lovers Lane (006), Central Ave. (005), McDonel St. (004), Heindel St. (003), and Collett St. (002). Although discharges from these outfalls are intermittent, they contribute a significant load of pollutants to the Ottawa River and have a potential to impact human health and the aquatic food chain. During a rainfall event (1.08 inches) in July 1996, four of these control structures were sampled and contributed a TSS load ranging from 15,400 to 21,600 pounds each (7,000 kg to 9,800 kg). Expressed in a daily fashion, outfalls 002-006 discharged a combined total of 1.4 MGD of wastewater; 1,125 kg/day of total suspended solids (TSS); and 90 kg/day of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) in 1996. Combined with final effluent pollutant loadings to the Ottawa River from the Lima WWTP, BP Oil Co., and PCS Nitrogen Ohio, L.P. facilities; CSOs contributed 67.9% of the total TSS load and 28.9% of the total $CBOD_5$ load.

The City of Lima submitted a Water Quality Impact Report as required by their NPDES permit. The study collected water samples from the Ottawa River and four of the control structures during two wet weather periods to assess the impact of the CSOs on the Ottawa River. Parameters analyzed were ammonia, CBOD, fecal coliform bacteria, and TSS. Sediment samples were collected at 17 river sites and in two of the control structures.

The two wet weather periods sampled were during rainfall events of 0.74 in. and 1.08 inches. The highest concentrations of ammonia, CBOD, and TSS occurred in the first flush. Although the second wet weather event caused higher loadings of TSS, the concentrations were less due to a dilutional effect of the increased amount of rainfall. Apparently, a considerable load of solids are settling out in the collection system, and are then, consequently, flushed out into the river during rainfall events. The most impacted areas are those areas downstream from the control structures and located in dam pools that act as settling basins for these CSO outfalls.

During dry weather periods, the impact from the CSOs resulted in low D.O. and increased levels of metals, PAHs, and PCBs in the sediments. The Ohio EPA sampled water column chemistry at 8 sites and sediment chemistry at 5 sites from Thayer Road (RM 45.97) to downstream from the Lima WWTP/Erie-Lackawanna Railroad Dam (RM 47.91). Dissolved oxygen fell below 5.0 mg/l at both RM 38.63 and RM 37.91, downstream from the CSOs. Sediment concentrations of cadmium, chromium, copper, lead, nickel, and zinc were higher and considered elevated to extremely elevated (Ohio EPA, 1996) downstream from the CSOs in the dam pool at RM 38.0 compared to upstream from the CSOs (RM 42.61). None of these concentrations exceeded the severe effect level (SEL, Persuad et. al., 1994). Pesticide and PAH sediment concentrations were mostly below detection upstream from the Lima CSOs. Downstream from the CSOs at RM 38.63 and RM 38.0, these organics were present above detection limits, with many of them greater than the Effects Range-Median, ER-M (Long and Morgan, 1991), but at the same time were less than the Severe Effect Level, SEL (Persuad et. al., 1994). The increased concentrations of these parameters in the sediment in the dam pool at RM 38.0 was attributed to the CSOs.

Data collected for the City of Lima Water Quality Impacts Study showed high concentrations of metals in sediments in the Central Avenue and Collette Street control structures (chromium - 178 and 881 ug/g, copper - 205 and 484 ug/g, lead - 202 and 290 ug/g, nickel - 78 and 156 ug/g, zinc - 500 and 1270 ug/g, and total PAHs - 120 and 323 ug/g, respectively).

Fish and Macroinvertebrates

Upstream from the CSOs fish indices in the reach from downstream of Sugar Street (RM 40.8) to the Lovers Lane dam pool (RM 40.2) did not meet WWH biocriteria. Fish crews sampling in this reach observed thick deposits of sewage solids next to an island near Schoonover Park. An area of unsewered homes (with septic systems) along Findlay Road is the suspected cause of impairment.

Within the series of dams and CSOs from RM 40.8 to RM 38.5, none of the fish sites sampled met WWH criteria. Qualitative Habitat Evaluation Index (QHEI) scores ranged from 44.5 to 51.0 and reflected the characteristics of the impounded section caused by the series of dams within the City of Lima. Even the impoundment criteria was not met for fish in this section except for the MIwb at RM 40.8 and RM 38.5. Macroinvertebrates were sampled at RMs 40.1, 39.6, and 38.6 in this section. The site located in the Elm Street dam tailwaters between the Elm Street dam (RM 39.70) and the Central Street dam (RM 39.58) had good flow (>0.3 fps) over the artificial substrates. By contrast the other two benthic sites sampled in this area had less than optimal flow over the artificial substrates, but more importantly were directly downstream or adjacent to CSO control structures, and did not meet the WWH criterion. Sludge deposits were observed by fish and bug crews downstream from the Lovers Lane and Collette Street control structures. The non attainment of biological criteria from the Lovers Lane dam (RM 40.14) to the Lima WWTP dam (RM 37.96) was attributed to the City of Lima CSOs.

Partial attainment of WWH biocriteria was observed downstream from the CSO control structures and dams at RM 37.9. Fish indices either met or were in nonsignificant departure from criteria.

Although the ICI score of 28 did not attain WWH biocriteria at this site, it showed a significant improvement over the score of 6 found in 1991. Fish and macroinvertebrate indices did not meet the WWH biocriteria at the next station at RM 37.7 due to impacts from the L5 landfill.

The Lima WWTP discharges at RM 37.67. Mixing zone collections were indicative of a nutrient enrichment impact. The macroinvertebrate communities improved significantly from previous years in this section at the site downstream from the Lima WWTP (RM 37.4, ICI of 42) and at the Shawnee Country Club (RM 34.5, ICI of 38). Fish indices remained fair to poor at non-mixing zone sites from upstream of the Lima WWTP (RM 37.7) to the Allentown dam (RM 28.9).

<u>Pike Run</u>

The City of Lima also has six permitted wet weather overflow locations (0011-016) to Pike Run. Chemical samples collected at RM 8.21 were downstream from the overflows and upstream from the American Bath WWTP. There were high numbers of fecal coliform bacteria (>10,000 and 5,500 per 100 ml.) on the two occasions that fecal bacteria were sampled at this site. Numbers of fecal coliform bacteria remained high in the other Pike Run sites sampled downstream from the American Bath WWTP, despite low numbers in the WWTPs effluent.

Fish sampling conducted in 1991 and 1996 showed poor and very poor community performance throughout Pike Run and with sites not attaining the MWH biocriterion either year at any site. Although macroinvertebrates collected in 1996 were considered attaining the MWH criterion at the sites sampled in 1996, the collections represented only fair community performance both upstream and downstream from the American Bath WWTP. Upstream impacts from CSOs/SSOs (City of Lima wet weather overflows) appeared to be the major cause for partial and nonattainment of MWH in Pike Run.

Clark Oil (formerly BP Oil Company), Lima Refinery, Ottawa River RM 37.11

The Clark Oil Company, Lima Refinery, Ohio EPA permit number 2IG00001, is located at 1150 South Metcalf Street, Lima, Ohio. The current permit became effective on 1 November, 1996 and expires on 31 October, 1997. The Lima Refinery produces unleaded gasoline, diesel fuel, aviation fuel, kerosene, LPG, heating oils, petroleum coke, benzene, toluene, and tolumen from crude oil transported to Lima from the Gulf Coast and West Texas. Some of the process operations include crude distillation and desalting, hydro treating, fluid catalytic cracking, hydro cracking, delayed coking, and catalytic reforming. Flows from the refinery are treated by an on-site advanced wastewater treatment system (AWWT). Oily process water, cooling water, boiler water, stormwater, and Clark terminals tank water are routed to a three bay API separator followed by dissolved air floatation (DAF) to remove the oily wastes and heavy solids. High benzene (>10 ppm) wastewater generated at the facility is collected in a segregated sewer system designed to comply with National Emission Standards for Hazardous Air Pollutants (NESHAPS). The NESHAPS wastewater is treated using a corrugated plate interceptor followed by an induced gas floatation unit. The benzene removed is incinerated. The API/DAF and NESHAPS streams are combined with sanitary wastewater and process flows from the adjacent PCS Nitrogen facility in an equalization tank and then enter the AWWT. PCS Nitrogen manufactures acrylonitrile, acrylonitrile catalysts, and Barex® resin and recovers and purifies acetonitrile and hydrogen cyanide. The AWWT is comprised of activated sludge aeration, flocculation, chemical conditioning, gravity thickening, rapid sand filtration, and polishing. Treated wastewater discharges from the aerated polishing ponds to the Ottawa River through outfall 001 at RM 37.11. Solids generated in the process are aerobically digested, undergo flocculation and gravity thickening, and put through a biological belt press before being land applied. The annual, average discharge is approximately 5.33 MGD. The facility has a stormwater capacity of 24 million gallons. The primary impoundment is a concrete tank with a capacity of 5 million gallons (G-Tank). The secondary impoundment is a pond with a capacity of 19 million gallons (D-Pond). The stormwater flow is bled back to the AWWT to prevent overflows discharged to the Ottawa River via outfall 002.

A significant decline in loadings of all evaluated pollutants occurred around 1984 and rates have remained relatively stable since. This presumably occurred due to the construction of the AWWT. Facility self-monitoring records for 1996 were evaluated for NPDES permit violations. A monthly maximum loading violation for TSS was documented in July. Effluent grab samples collected during the study period were evaluated for monthly maximum concentration violations. None were documented. No volatile or semi-volatile organic compounds were detected and no organochlorine pesticides were detected. During the 1996 survey, a number of selenium exceedences were documented downstream from the Clark Refinery discharge and were attributed to effluent loadings.

Bioassays

Ohio EPA conducted 48-hr. acute screening bioassays on Clark Refinery effluents as part of a toxics evaluation in conjunction with permit reissuance. Grab and composite derived outfall 001 effluents, Ottawa River upstream, and Ottawa River in the acute (near-field) mixing zone were evaluated using the fathead minnow, *Pimephales promelas*, and crustacean, *Ceriodaphnia dubia*, as test organisms. Bioassay number 96-1664-NW was conducted in May 1996. Test results indicated that outfall 001 effluents were not acutely toxic to either *P. promelas* or *C. dubia*. No mortality or any other adverse acute effects were exhibited by the other samples tested to either test organism. Bioassay number 96-1678-NW was conducted in June 1996. Test results indicated that outfall 001 effluents were acutely toxic to *P. promelas* but not *C. dubia*. There was 40%*P. promelas* mortality in the day 2 effluent grab sample. Magnitude of acute toxicity was not sufficient to calculate a LC50. The 10% mortality in the effluent composite and 5% in each rearing unit control are within acceptable limits. No mortality or any other adverse acute effects were exhibited by *P. promelas* in the remaining samples. No *C. dubia* mortality or adverse acute effects were observed in the samples tested.

Fish and Macroinvertebrates

The Invertebrate Community Index (ICI) scores declined from 42 upstream from the Clark Refinery outfall 001 (RM 37.11) to 20 downstream. There were decreased densities of mayflies and caddisflies and lower numbers of mayfly, caddisfly, dipteran, and total taxa collected from the artificial substrates. The fish IBI and MIwb index scores were unchanged and remained in the poor (IBI) and fair (MIwb) range from upstream to downstream from the BP Refinery outfall.

Oil Contamination

Oil contamination was directly traced to at least three sources in this segment of the Ottawa River in 1996. 1) A release from the L5 landfill observed on 4 September is known to be the source of pesticide and oil and grease violations. Surface water samples collected on this date were extremely oil laden and analytical results indicated highly elevated concentrations of PAHs and pesticides. BP Oil Company (1996) had installed a retaining wall, rip-rap, and oil boom to contain leachate from the landfill and oil absorbent pads are deployed and maintained inside the boom. Even though these control measures have been implemented, releases occasionally occur, as evidenced by the 4 September event. 2) The Clark Refinery outfall 001 had the highest mean oil and grease concentration (of the three major dischargers) reported during the 1996 survey. 3) An abandoned pipe line, that crossed the Ottawa River near RM 36.9 - 37.0 and which had been cut off and removed west of the river, was continuously seeping a small amount of crude oil.

Fish biomarker data showed increases in EROD activity, and BAP-type and NAPH-type metabolites, from upstream to downstream from the BP Refinery outfall 001. EROD measures a class of metabolic enzymes that are induced by planar xenobiotics such as polycyclic aromatic hydrocarbons (PAHs) and halogenated hydrocarbons. EROD activity is an indicator of the induction of hepatic detoxification systems. A common carp score below 50 pmol EROD/mg protein and a white sucker score below 100 pmol EROD/mg protein are a conservative indication of noninduction. Scores greater than these values indicate induction and are a measure of the exposure to these contaminants and detoxification activity by fish. EROD values increased from 49 pmol EROD/mg protein upstream from the BP Refinery outfall to 193 pmol EROD/mg protein downstream in white suckers, and from 18 pmol EROD/mg protein to 49 pmol EROD/mg protein in carp, respectively. In fish, metabolites of PAHs accumulate in the bile. Bile metabolites indicate recent exposure to PAHs. The benzo(a)pyrene, BAP-type, metabolites are generally associated with combustion by-products. BAP-type metabolites increased from 447 ng BAP/mg protein upstream from the BP Refinery outfall to 1224 ng BAP/mg protein downstream in white suckers (500 ng BAP/mg protein, reference value), and from 930 ng BAP/mg protein to 1745 ng BAP/mg protein in carp (500 ng BAP/mg protein, reference value). The naphthalene, NAPH-type, metabolites are associated with oil contamination. NAPH-type metabolites increased from 55000 ng NAPH/mg protein upstream from the Clark Refinery outfall to 115000 ng NAPH/mg protein downstream in white suckers (50000 ng NAPH/mg protein, reference value), and from 121000 ng NAPH/mg protein to 185000 ng BAP/mg protein in carp (100000 ng BAP/mg protein, reference value).

Selenium

Water chemistry data (6 samples per RM) reported an increase in selenium concentrations from an average of 2.5 ug/l upstream Clark Oil outfall 001 at RM 37.30 to 8.8 ug/l downstream at RM 37.00. The average concentration (6 samples collected concurrently with the instream samples) of the BP Refinery outfall 001 was 18.8 ug/l. A large number of selenium exceedences (# of samples > 5 ug/l) were documented downstream from the BP Refinery discharge, in at least half of the samples collected at RM 37.00 (5), RM 36.80 (3), RM 36.30 (5), RM 34.55 (5), RM 32.60 (4), RM 32.41 (3), RM 31.03 (4), RM 28.83 (4), RM 25.75 (3), and RM 22.94 (3). This data suggests that the average concentration of selenium (based on 6 grab samples per site collected during the summer of 1996) was greater than 5 ug/l in the Ottawa River for approximately 15 miles downstream from the BP Oil outfall 001.

Selenium concentrations in both carp and smallmouth bass samples were sharply elevated downstream from the Lima WWTP and BP Refinery complex with respect to upstream samples. Although selenium is a nutrient at trace levels, it becomes toxic at higher concentrations.

PCS Nitrogen (formerly Arcadian Ohio, L.P., formerly BP Chemicals)(Ottawa River RM 36.87)

BP Chemicals Inc. transferred ownership of the nitrogen manufacturing facility to Arcadian Ohio, L.P. in June 1994 and the facility name was changed to PCS Nitrogen Ohio, L.P. in early 1997. PCS manufactures ammonia, urea, nitric acid, ammonium nitrate, nitrogen fertilizer, and carbon dioxide gas. Process wastewater and stormwater from the PCS facility is collected in the #2 process pond and pumped to the #1 process pond and treated using ammonia stripping and ion exchange. A trickling filter is used during summer months to provide additional treatment. The non-contact cooling water, cooling tower blowdown, and steam generator blowdown undergo neutralization and sedimentation. Some sanitary wastewater is pretreated prior to being sent to the Clark Oil Co. AWWT, while the other portion is treated along with the process wastewater. The treated wastewater is then combined with non-contact cooling water, cooling tower blowdown, and steam generator blowdown from the adjacent BP Chemicals in the fire water pond prior to discharge to the Ottawa River through outfall 001 at RM 36.87. The annual average discharge is approximately 5.40 MGD.

Stormwater from the warehouse roofs are subject to deposits of urea from the prill tower. To help alleviate high organic nitrogen discharges to the Ottawa River during storm events, the roof drains are piped into a diversion box which sends the first flush to the stormwater pond under normal conditions. The stormwater pond will contain a 0.75 inch rainfall before it discharges to the Ottawa River through outfall 003. When the stormwater pond is full, the diversion box will redirect the flow from the roofs to outfall 002. During dry periods, the contents of the stormwater pond are pumped to the #1 or #2 process pond. Stormwater discharged through outfall 004 is untreated. Outfalls 002, 003, and 004 discharge to the Ottawa River downstream from outfall 001 between RM 36.8 and 36.0.

Pollutant loading trends from outfall 001 showed that a significant decline in NH_3-N loadings occurred around 1977 and rates have remained relatively stable since. Loadings of phosphorus exhibit a slight increasing trend between 1985-1990 and have stabilized since then. PCS Nitrogen is required to monitor discharges from stormwater outfalls 002, 003, and 004. Expressed in a daily fashion, stormwater outfalls discharged a combined total of 3.4MGD of wastewater. Concentrations and loadings (monthly operating report, MOR, data) of ammonia and urea are high for these outfalls. Maximum concentrations of ammonia for 1996 were 197 mg/l (002), 111 mg/l (003), and 50 mg/l (004). For outfall 001, the 50th percentile and maximum urea concentrations were 9.0 mg/l and 54 mg/l, respectively. Outfall 002 was sampled four times in 1996 and concentrations of urea reported were 342 mg/l, 373 mg/l, 1,357 mg/l, and 2,474 mg/l. Urea concentrations for outfall 003 were sampled twelve times in 1996 and the 50th percentile was below detection, the 75th percentile was 6 mg/l, and the maximum concentration reported was 450 mg/l. Urea concentrations for outfall 004 were sampled thirteen times in 1996 and the 50th percentile was below detection, the 75th percentile was 21 mg/l, and the maximum concentration reported was 1,156 mg/l.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. A monthly maximum loading violation for organic nitrogen was documented in January. Effluent grab samples collected during the study period were evaluated for monthly maximum concentration exceedences. None were documented. No volatile organic compounds were detected, while chloroform and four organochlorine pesticides were detected at low concentrations.

During the six chemical runs conducted by the Ohio EPA during the summer of 1996, the average instream concentrations of the following parameters increased in the Ottawa River from upstream of the PCS Nitrogen outfall 001(RM 36.87) at RM 37.0 to downstream at RM 36.80: ammonia (0.14 to 1.62 mg/l), BOD (2.5 to 5.3 mg/l), iron (330 to 804 mg/l), total Kjeldahl nitrogen (1.1 to 2.9 mg/l), nitrite (0.05 to 0.32 mg/l), phosphorus (0.27 to 0.38 mg/l), and zinc (12.2 to 30.3 ug/l). Additionally, the site at RM 36.80 was the only location that chromium (30 ug/l detection level) and free cyanide were detected instream, and these instream concentrations were attributed to the PCS 001 outfall.

Compared to the upstream site at RM 37.0, sediment metal concentrations were substantially higher downstream from PCS Nitrogen at RM 36.8 for the following parameters: chromium (39 to 227 mg/kg), copper (32 to 92 mg/kg), and zinc (122 to 314 mg/kg). The sediment concentration for arsenic downstream from the PCS outfall 001 at RM 36.80, and for selenium downstream from PCS outfalls 002, 003, and 004, at RM 36.30 were slightly higher than upstream at RM 37.0.

Chromium

The only detection of chromium in the 1996 chemical survey (30 ug/l detection limit) was an instream concentration of 49 ug/l downstream from the PCS outfall 001, and the only detections in the effluents tested were in 4 of 6 PCS outfall 001 effluent samples ranging from 38 to 64 ug/l. (Lima WWTP and Clark Oil Refinery each had six samples below detection). The metal translator study had a much lower detection level (0.05 ug/l) for chromium, but, sampled at only two locations - Thayer Rd and the Fire Station. This study showed total chromium values increased upstream to downstream from 0.37 ug/l to 4.65 ug/l (five sample average).

Apparently chromium is settling out in the sediments in concentrations toxic to aquatic organisms. The highest chromium sediment concentration collected by the Ohio EPA in both 1991 and 1996, and reported in the City of Lima Water Quality Impact Study (1996 data), was downstream from the PCS Nitrogen 001 outfall at levels exceeding the Ontario severe effect level (> 110 ug/g)and considered extremely elevated (Ohio EPA, 1996).

Nitrogenous wastes

During the 1996 survey, the region of the Ottawa River exerting the highest stress to fish communities from nitrogenous wastes was downstream from the PCS Nitrogen outfalls. Samples taken downstream from outfall 001 at RM 36.7 had the highest blood urea nitrogen (BUN) value (4.4 units) for common carp and the highest average incidence of DELT anomalies (38.9 %) in the 1996 survey. The site located downstream from PCS Nitrogen outfalls 002, 003, and 004, at RM 34.7, had the highest BUN value (2.8 units) for white suckers and the third highest incident of DELT anomalies (31.7 %). The lowest fish IBI scores sampled in the Ottawa River during the 1996 survey were also at RMs 36.7 and 34.7. Although BUN values were higher in other sections of the Ottawa River in 1991 and 1993 (indicating improvement in those sections in 1996), fish DELT anomalies and IBI scores downstream from PCS outfalls have remained the lowest observed in the Ottawa River in 1985, 1989, and 1991 surveys, as well as the 1996 survey.

Instream chemical sampling showed increases in ammonia, nitrite, and TKN concentrations in the Ottawa River from upstream of outfall 001 at RM 37.00 to downstream at RM 36.80. Exceedences of the ammonia 30 day average criterion occurred in 2 out of 6 sampling events at RM 36.80 and 1 of 6 events at RM 36.3, a result of the PCS 001 effluent. Although urea was not a measured instream parameter, the concentrations and loadings from the PCS outfalls are high. Although outfalls 003 and 004 are storm water outfalls, during 1996 there was a flow value reported for the 75th percentile indicating that out of 278 sampling events in 1996 these outfalls were flowing for at least 69 days of the year.

Bioassays

PCS conducted annual chronic toxicity tests between 1990-95. Only one of those bioassays showed chronic toxicity. The July 1994 bioassay reported a NOEC of 25 % and LOEC of 50 % to *Ceriodaphnia dubia*, which would be a 2.8 TU_c. Biomonitoring was removed from their permit based on the results of these bioassays submitted by the entity.

Ohio EPA conducted two acute screening bioassays in 1996 of PCS outfall 001 effluents as part of a toxics evaluation in conjunction with permit reissuance. Samples of grab and composite outfall 001 effluents, Ottawa River upstream, and Ottawa River in the acute (near-field) mixing zone were evaluated using the fathead minnow, *Pimephales promelas*, and *Ceriodaphnia dubia* as test organisms. The May 1996 bioassay showed no significant toxicity to either test organism. However, the June 1996 bioassay showed that PCS outfall 001 effluents were acutely toxic to *C. dubia*. Both grabs and the composite resulted in 100% mortality to *C. dubia.* This results in a minimum toxic unit of 1.0 TUa which is greater than the AET of 0.31 TUa calculated in Section 2 of the PCS Nitrogen

PSD. There was no mortality to fathead minnows in any of the test concentrations

During the 1996 survey, macroinvertebrates collected in the mixing zone of the PCS outfall 001 indicated toxic conditions.

Based on the Ohio EPA 1996 field sampling and bioassay testing, further biomonitoring is recommended. Split samples or bioassay samples collected during compliance sampling events should be performed to assure the quality of bioassay sampling results. It should also be noted at this time that there is no rapid and complete mixing of the PCS outfall 001 effluent and the Ottawa River. The effluent stays to the river left.

Fish and Macroinvertebrates

Although macroinvertebrate communities were considered fair both upstream (RM 37.0) and downstream (RM 36.1) from the PCS outfalls, the results from the mixing zone of outfall 001 was considered a response to toxicity. Low numbers of taxa, the absence of caddisfly and tanytarsini midge taxa, the virtual absence of mayflies (except two individuals of the genus *Caenis*, collected on only one of two sampling dates), and the predominance of pollution tolerant organisms were indications of a toxic impact in the PCS outfall 001 mixing zone. Oil and muck were observed in the sediments in the mixing zone area sampled.

The segment of the Ottawa River showing the most severe impact to fish communities was downstream from the PCS outfalls. The lowest MIwb scores (excluding dam pool sites) and the lowest IBI scores were reported downstream from the PCS outfalls (RM 36.0) to the Shawnee Country Club (RM 34.7), despite good habitat conditions. QHEI scores ranged from 79.5 to 84.0 in this section suggesting the potential for EWH performance with improved water chemistry. The highest percentage of DELT anomalies were also reported in this area. The highest percentage of DELTs in the 1996 Ottawa River survey was 48.8 %, reported on 8/29/96 downstream from PCS outfall 001 at RM 36.70. These results have changed little since 1991. White suckers and common carp collected for biomarker analyses showed the highest levels of blood urea nitrogen (BUN) downstream from the PCS outfalls.

Allen County Shawnee #2 WWTP (Ottawa River RM 32.50)

The Shawnee #2 WWTP, Ohio EPA permit number 2PK00002, is located at 3640 State Route (S.R.) 117, Shawnee Township, Allen County, Ohio. The current permit became effective on 1 May, 1996 and expires on 30 June, 1998. The facility was constructed in 1974 and last renovated in 1994 when the present sequencing batch reactors (SBRs) began operation on 13 January. Treatment technology includes: a manual bar screen and comminutor, two SBRs, chlorine disinfection, dechlorination, post aeration, and aerobic sludge digestion. Sludge is dewatered in a gravity thickener and belt filter press and land applied at agronomic rates. Final effluent discharges to the Ottawa River through outfall 001 at RM 32.50. The design capacity of the facility is 2.0 MGD, while the hydraulic capacity is 7.0 MGD. The annual average discharge is approximately 1.56 MGD. Within the service area approximately 80% of the area has sewers. The collection system is comprised of 100% separate sanitary sewers and contains twenty-three lift stations, of which one has a bypass, and seven overflows.

A significant decline in phosphorus loadings occurred around 1990, likely due to the implementation of a phosphate detergent ban in the Lake Erie drainage basin. A slight decreasing trend in NH_3-N and NO_3-N loadings was exhibited since the new facility went on-line in 1994. Facility self monitoring records for 1996 were evaluated for NPDES permit violations. Numerous violations for $CBOD_5$ and TSS were documented from January through April. Instream chemical data from the 1996 survey showed slight increases in BOD, COD, and phosphorus downstream from the Shawnee WWTP in the Ottawa River at RM 32.41 compared to upstream at RM 32.6.

Excessive inflow and infiltration entering the separate sewer collection system causes bypasses to occur and occasionally requires activation of an influent bypass. A general plan for the elimination of the collection system overflows was to be submitted to Ohio EPA by 1 May, 1997. Ohio EPA spill records from 1992 to 1996 contained 67 reported spills attributed to the Shawnee #2 WWTP system.

Ohio EPA conducted two 48-hr. acute screening bioassays at the Shawnee #2 WWTP in May and June 1996 as part of a toxics evaluation in conjunction with permit reissuance. There was no significant mortality in the effluent samples to *Pimephales promelas* or *Ceriodaphnia dubia* in either of the two bioassays. However, in the May bioassay, in the Ottawa River samples both the upstream grab at SR117 and the Shawnee mixing zone were lethal (100 % mortality) to *C. dubia*. The May bioassay was concurrent with a bioassay on Lima WWTP effluents which were also lethal to *C. dubia* and, given the effluent dominated nature of the Ottawa River due to the discharge from the Lima WWTP, the toxicity upstream and downstream from the Shawnee WWTP was attributed to the effluents from the Lima WWTP.

During the 1996 field survey, it was difficult to detect impacts from the Shawnee #2 WWTP because of the degradation extending downstream from Lima's major dischargers. Fish and macroinvertebrate indices were slightly lower downstream from the Shawnee #2 WWTP effluent at RM 32.4 compared to upstream at RM 32.8/32.6. Although the evaluation of the MIwb score decreased from fair to poor, and the macroinvertebrate evaluation from marginally good to fair, the overall non attainment status remained due to the poor performance of the fish IBI score at both sites.

Elida WWTP

The Village of Elida WWTP, Ohio EPA permit number 2PB00046, is located at 4180 North Dutch Hollow Road, Elida, Ohio. The facility was constructed in 1966 and last modified in 1993 when a stormwater equalization basin was installed. Treatment technology includes; comminutor, phosphorus removal through addition of alum, primary settling, trickling filter, final settling, chlorine disinfection, dechlorination, and aerobic sludge digestion. Final effluent discharges to the Ottawa River through outfall 001 at RM 24.20. The design capacity of the facility is 0.50 MGD, while the hydraulic capacity is 0.90 MGD. The annual average discharge is approximately 0.45 MGD. Within the facilities service area, 100% has sewers. The collection system is comprised of 100% separate sanitary sewers and contains no lift stations, bypasses, or overflows. The facility experiences high flows during periods of heavy rain and a cross connection between the sanitary and storm sewers is suspected.

Loadings of BOD_5, NH_3-N, and NO_3-N have remained relatively constant through the evaluation period, with the exception of a slight peak in the mid-1980's. A significant decline in P loadings occurred around 1990, likely due to the implementation of a phosphate detergent ban in the Lake Erie drainage basin. A significant decline in TSS loadings occurred around 1992, likely due to the construction of a stormwater equalization basin.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. Several violations for $cBOD_5$, oil and grease, and residual chlorine were documented.

Kalida WWTP

The Village of Kalida WWTP, Ohio EPA permit number 2PA00047, is located on S.R. 114, Kalida, Ohio. The facility was constructed in 1981 and last modified in 1993 when a ultraviolet (UV) disinfection system was installed. Treatment technology includes; series of three aerated lagoons with a continuous discharge and UV disinfection. Final effluent discharges to the Ottawa River at RM 2.63. The design and hydraulic capacity of the facility is 0.22 MGD. The annual average discharge is approximately 0.14 MGD. Within the facilities service area, 100% has sewers. The collection system is comprised of 100% separate sanitary sewers and contains one lift station, which has no bypass, and no overflows.

Loadings have remained relatively constant since 1988. Prior to this time, the facility experienced difficulties with malfunctioning aerators, which resulted in elevated pollutant concentrations. The peak in flows during the mid-1980's is attributed to an improperly calibrated flow meter.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. A monthly concentration maximum violation for fecal coliform was documented in June.

American Bath WWTP (Pike Run RM 8.20)

The American Bath WWTP, Ohio EPA permit number 2PH 00007, is located at 3226 North Cole Street, Lima, Ohio. The facility is currently regulated under interim effluent limits contained in a Consent Decree effective 3 May, 1996. The facility was constructed in 1966 and completely renovated in 1996 when the present oxidation ditch began operation on 30 April. Treatment technology includes; mechanical bar screen, phosphorus removal through the addition of alum, oxidation ditch, final settling, UV disinfection, and aerobic sludge digestion. Sludge is dewatered in a gravity belt thickener and land applied at agronomic rates. Final effluent discharges to Pike Run at RM 8.16, which flows into the Ottawa River at RM 19.53. The design capacity of the facility is 1.5 MGD, while the hydraulic capacity is 4.0 MGD. The annual average discharge is approximately 1.1 MGD, although accurate figures are not available since the renovated facility has been in operation for only a short period of time. The facilities service area is 100% sewered. The collection system is comprised of 100% separate sanitary sewers and contains three lift stations, which have visual high water alarms, and three overflows.

Ohio EPA conducted two 48-hr. acute screening bioassays in October and November 1996 at American Bath WWTP as part of a toxics evaluation in conjunction with permit reissuance. No mortality or any other adverse effects were displayed by either test organism in the samples tested.

Loadings for most pollutants have generally exhibited an increasing trend through the evaluation period. A significant decline in phosphorus loadings occurred around 1990, likely due to the implementation of a phosphate detergent ban in the Lake Erie drainage basin. The old facility was severely overloaded, due in part to numerous sewer extensions and excessive inflow and infiltration entering the separate sewer collection system. Since the new oxidation ditch facility has only recently gone on-line, it is difficult to evaluate the benefit of this upgrade.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. Numerous violations for $CBOD_5$ and TSS were documented from January-March. These violations resulted from permit limits effective prior to the 3 May, 1996 Consent Decree and prior to the plant renovation going on-line. Effluent grab samples collected during the study period were evaluated for monthly maximum concentration exceedences. None were documented. The most significant change observed in water chemistry downstream from the American Bath WWTP in the 1996 survey was an increase in phosphorus in Pike Run from an average of 0.11 mg/l upstream to 2.28 mg/l downstream from outfall 001.

Pike Run is currently designated MWH due to previous channelization, petitioned ditch status, and the possibility of being put on a maintenance schedule. Per phone conversation with a Douglass Degen of the Allen County Engineer’s office, work will be conducted on Pike Run in 1998 from north of Rob Ave. and east of McCauley Ave. in Lima to Gomer.

The City of Lima has six permitted wet weather overflow locations (0011-016) to Pike Run. Chemical samples collected at RM 8.21 were downstream from the overflows and upstream from the American Bath WWTP. There were high numbers of fecal coliform bacteria (>10,000 and 5,500 per 100 ml.) on the two occasions that fecal bacteria were sampled at this site. Numbers of fecal coliform bacteria remained high in the other Pike Run sites sampled downstream from the American Bath WWTP, despite low numbers in the WWTPs effluent.

Fish sampling conducted in 1991 and 1996 showed poor and very poor community performance throughout Pike Run. The results did not attain the MWH biocriterion either year at any site. The seven species of fish collected downstream from American Bath WWTP in 1996 was a significant improvement compared to the one species collected in 1991. Although macroinvertebrates collected in 1996 were considered attaining the MWH criterion at the sites sampled in 1996, the collections represented only fair community performance both upstream and downstream from the American Bath WWTP. Upstream impacts from nonpoint sources (City of Lima wet weather overflows) appeared to be the major cause for nonattainment in Pike Run.

Columbus Grove WWTP

The Columbus Grove WWTP, Ohio EPA permit number 2PC00004, is located on Church Street, Columbus Grove, Ohio. The current permit became effective on 1 April 1993 and expired on 28 March 1998. The facility was constructed in 1934 and last modified in 1968. Treatment technology includes; grit and grease removal, primary settling, trickling filters, final settling, chlorination, and anaerobic sludge digestion. Sludge is dewatered in drying beds and land applied at agronomic rates through an approved sludge management plan. Final effluent discharges to Plum Creek at RM 12.80, which flows into the Ottawa River at RM 2.67. The design capacity of the facility is 0.82 MGD, while the hydraulic capacity is 2.30 MGD. The annual average discharge is approximately 0.38 MGD. Within the facilities service area, 100% has sewers. The collection system is comprised of 80% combined sanitary and stormwater sewers and 20% separate sanitary sewers. The combined system contains one lift station, which has no bypass, and four overflows, none of which are mechanically controlled or metered. The separate system contains one lift station, which has no bypass, and no overflows.

Loadings have remained relatively constant through the evaluation period for most pollutants. A significant decline in P loadings occurred around 1990, likely due to the implementation of a phosphate detergent ban in the Lake Erie drainage basin. A slight decline in NH_3-N and NO_3-N loadings occurred in the mid-1980's, likely due to the addition of a new primary aerator and final clarifier during this time frame.

Facility self monitoring records for 1996 were evaluated for NPDES permit violations. A monthly concentration maximum violation for NH_3-N was documented in July and September.

CONCLUSIONS

There has been no significant change in the overall attainment status in the Ottawa River from the 1991 survey to the 1996 survey**.** The 1996 evaluation showed more areas of partial attainment than the 1991 survey, however, this partial attainment appears to be more of an artifact of individual sampling location differences between years (more sites sampled in 1996) than actual improvements in water quality.

There is, however, evidence of incremental progress in the Ottawa River, but this progress is not nearly at the rate observed for other major rivers with major WWTP influences in Ohio. Other effluent dominated streams (e.g. Great Miami River downstream from Dayton, Licking River downstream from Newark, Scioto River downstream from Columbus) are now attaining ecoregional expectations for virtually their entire length.

One site that did show improvement to partial attainment was RM 37.9, downstream from the Lima WWTP dam and upstream from the L5 landfill. Additional sampling showed attainment of the macroinvertebrate community between the Elm Street dam and the Central Street dam within the City of Lima. Other areas showed large increases in the ICI (downstream from the Lima WWTP and at the Shawnee Country Club, ICI scores of 42 and 36, respectively). Improvements to the fish community lagged behind the macroinvertebrate scores at some of these sites, due to high percentages of DELT anomalies and/or differences in fish community composition.

Although pollutant loadings from the major municipal and industrial facilities in Lima have significantly declined from the early 1980s to 1991, pollutant loadings have remained stable from 1991 to 1996. [Lima WWTP, BP Oil Co. Refinery, and PCS Nitrogen (formerly L.P.Arcadian Ohio, formerly BP Chemicals)] The 1996 survey does show that the segment of the Ottawa River downstream from the PCS Nitrogen discharges has some of the lowest fish and macroinvertebrate index scores, lowest levels of dissolved oxygen, highest levels of ammonia, and highest percentage of fish anomalies (Figure 2).

Little change in Ottawa River chemical water quality occurred between the 1991 and 1996 study periods. Exceedences of statewide D.O. and ammonia criteria for the protection of aquatic life continue to be documented. Results of D.O. grab samples indicate a significant "sag" downstream from the major point source dischargers within the City of Lima and downstream from the Shawnee #2 WWTP.

The ICI and MIwb indices were in attainment or near attainment in the lower 30 miles (downstream from Lima) of the Ottawa River in 1996. However, the IBI scores were well below ecoregional expectations from RM 30 to RM 13. These trends were also evident in 1989 and 1991, demonstrating little or no improvement has occurred from the 1989-91 period to 1996 (see the Integrated Biological Trends section).

Percentages of DELT anomalies on fish still remain extremely high in the Ottawa River. The Ottawa River had some of the highest DELT anomalies recorded by the Ohio EPA (48.8% on one pass at RM 36.7 in 1996). These high anomalies in 1996 in combination with low IBI scores indicate that toxic conditions persist.

Bioassays conducted by the Ohio EPA in 1996 reported acute toxicity in the effluents of the major municipal and industrial facilities in Lima. [Lima WWTP - May 1996, BP Oil Co. Refinery - June 1996, and PCS Nitrogen Ohio, L.P. (formerly Arcadian Ohio, formerly BP Chemicals) - June 1996]

The full attainment of WWH at predominantly agricultural sites with intact physical habitats (*i.e.*, non-channelized), suggests that agricultural nonpoint runoff is not a significant factor in the non-attainment found in the Ottawa River mainstem. The upstream site at Thayer Road has continually attained WWH criteria throughout the past 20 years. In addition, full recovery has been evident in the lower 5 miles of the mainstem with slight improvements noted between 1991 and 1996. Agricultural land use predominates in and upstream from this area.

Excluding hydromodifications, nonpoint source pollutant loadings (*i.e.*, stormwater runoff, spills, leaks, landfill leachate), which contribute to the use impairment of WWH in the Ottawa River watershed, are primarily the result of urban/industrial sources as opposed to rural land uses.

The discharges from CSOs in the City of Lima during rainfall events result in high loadings of TSS, CBOD, and other pollutants. Outfalls 002-006 discharged a combined 1.4 million gallons per day (MGD) of wastewater, 1,125 kg/day of TSS (67.9% of the total TSS load), and 90 kg/day of $CBOD_5$ (28.9% of the total $CBOD_5$ load) in 1996. A portion of these pollutant loads settle behind the series of lowhead dams in the City of Lima and are associated with low dissolved oxygen levels in this segment of the Ottawa River after individual CSO discharges have subsided. These discharge events are also thought to be associated with contaminated bottom sediments in the mainstem.

Impacts from the BP Oil Co. L5 Landfill continue to be a major concern. A release of oil laden leachate was observed and documented on 4 September, 1996. Analytical results indicate highly elevated concentrations of polynuclear aromatic hydrocarbons (PAHs) and organochlorine pesticides. Several violations of Ohio EPA statewide and Lake Erie drainage basin water quality criteria were documented in the Ottawa River downstream from the L5 Landfill due to this release. Another oil release from an abandoned pipeline near Adgate Road was documented in 1996.

Sediment contamination continues to be associated with the partial and non-attainment of aquatic life uses. Beginning downstream from the Lima CSOs and continuing downstream to the Allentown Road dam, concentrations of metals, especially cadmium, chromium, copper, lead, nickel, and zinc, were measured at levels considered to be highly and extremely elevated. Within this zone, concentrations of organic compounds such as PAHs, PCBs, and organochlorine pesticides are also a major concern. Concentrations of PCBs were highly elevated in the Erie-Lackawanna dam pool and downstream from the BP Oil Co. L5 Landfill (upstream from the Lima WWTP). Concentrations of PAHs were most pervasive, especially downstream from the Lima WWTP, and were detected at levels considered to be potentially toxic to aquatic life.

RECOMMENDATIONS

Execution of the recommendations below will reduce the amounts of pollutants generally entering the river during periods of wet weather and higher stream flows. The management and control of pollutant loadings entering the river during periods of dry weather and critical low stream flow conditions is accomplished through NPDES permit limits on the final wastewater process outfalls.

Pollutant Loadings:
Attainment of the Ottawa River's Warmwater Habitat potential will require further reductions in total pollutant loadings. Specifically, reduction of nitrate-nitrites from the Lima WWTP; reductions of selenium from BP Oil; and reductions of nitrogenous wastes (including urea) from all discharges from PCS Nitrogen.

The City of Lima should address the problems caused by Combined Sewer Overflows (CSOs) through cost effective management, control and treatment measures. The present frequency and duration of CSO discharge events in combination with the series of lowhead dams greatly exceeds the ability of the river to assimilate the wastes without environmental degradation.

Greater attention should be given to accurately measuring the types and quantities of pollutants discharged in stormwater runoff at the Clark Oil and PCS Nitrogen facilities. The most impacted segment of the Ottawa River is downstream from the PCS discharges. The amounts of urea coming into the river should be adequately documented and accurate pollutant loading estimates developed. If appropriate, specific control measures should be required.

Spills:
The release of oil into the Ottawa River continues to impact the biota and every effort should be made to control and abate this pollutant from entering the river. The oil laden sample collected September 4 (1996) downstream from the L5 Landfill had water quality exceedences for oil and grease (1720 mg/l) . Also in 1996, an abandoned pipe near Adgate Road was found to be leaching oil into the river.

Status of Aquatic Life Uses (Table 3):
There are 7 major impoundments on the Ottawa River in the Lima area: Metzger Road dam (RM 43.5), Roush Road dam (RM 42.30), Lovers Lane dam (RM 40.14), Elm Street dam (RM 39.70), Central Street dam (RM 39.58), Metcalf/Collette Street dam (RM 38.7), and the Lima WWTP/Erie -Lackawana RR dam (RM 37.96). While the very nature of the impoundments invites the Modified Warmwater Habitat (MWH) aquatic life use, due consideration should be given to their removal. This would enhance overall quality by improving habitat and the assimilative capacity of the river.

The Ottawa River upstream from the lowhead dam at Metzger Road has recently been designated as Public Water Supply use. The following new designation is recommended based on the 1996 survey results.

Zurmehly Creek: Current habitat conditions are degraded (QHEI = 58), however, Zurmehly Creek is not a petitioned ditch and is not on a scheduled maintenance program. The high gradient should promote a faster rate of improvement of WWH characteristics. The WWH aquatic life use designation is appropriate. There are pools present with a minimum depth of 40 cm., so the Primary Contact Recreation (PCR) applies.

Status of Non-Aquatic Life Uses (Table 3):
Results of the present study support the three non-aquatic life uses (Agricultural, Industrial, and Primary Contact Recreation) currently designated for each of the four streams (Ottawa River, Little Ottawa River, Pike Run, Plum Creek, and Zurmehly Creek).

Future Monitoring:
Biological and water quality sampling should continue in the Ottawa River in accordance with the Five-Year Basin approach for monitoring to track the progress in attaining designated uses and improved water quality. Continued monitoring of external fish anomalies, fish tissue, sediments, and specialized biomarker techniques is appropriate.

Urea should be analyzed instream at sites upstream and downstream from the PCS Nitrogen outfalls. Oil and grease should continue to be analyzed upstream from the L5 landfill to downstream from PCS Nitrogen.

A rainfall study should be conducted to estimate nutrient loads entering the Ottawa River from nonpoint agricultural sources at Thayer Road, and to estimate the concentrations and loadings of nitrogenous wastes (ammonia, urea, etc.) in the Ottawa River from the PCS Nitrogen stormwater outfalls.

Table 3. Waterbody use designations for the Ottawa River basin. Changes to existing use designations appear as a delta symbol (▵); designations based on the 1978 Water Quality Standards as an asterisk(*), and those designations for which results of biological field assessments are now available appear as plus signs (+). Designated use based on justification other than the results of a biological field assessment performed by the Ohio EPA (o).

Stream Segment	Use Designations													Comments
		Aquatic Life						Water			Recreation			
	SRW	WWH	EWH	MWW	SSH	CWH	LRW	AWS	IWS	PWS	BW	PCR	SCR	
Ottawa River		+						+	+			+		
Ottawa River upstream of low head dam at Metzger Road (RM 43.45)		+						+	+	▵		+		
Plum Creek		+						+	+			+		
Sycamore Creek		*						*	*			*		
Sugar Creek		+						*	*			*		
Rattlesnake Creek		*						*	*			*		
Ford Tributary(Sugar Ck at RM 18.8)		+						*	*					
Huber Ditch		*						*	*			*		
Cotner Ditch		*						*	*			*		
Leatherwood Ditch		*						*	*			*		
Pike Run				+				+	+			+		HELP Ecoregion - Channel Modified
Honey Run		*						*	*			*		
Dug Run		*						*	*			*		
Kessler Run		*						*	*			*		
Swalley Ditch		*						*	*			*		
Little Ottawa River		+						+	+			+		
Zurmehly Creek		▵						▵	▵			▵		

STUDY AREA

The Ottawa River Watershed is located in Allen, Hardin, Putnam, and a small portion of Auglaize Counties in west central Ohio. The river is 52.7 miles long with a gradient of 4.0 feet per mile and drains an area of approximately 365 square miles. The 1996 study area included the Ottawa River from Thayer Road (RM 46.1) to Kalida (RM 0.96). The river flows through the City of Lima, other rural communities and predominantly agricultural areas in the watershed. Tributaries included in the study were the Little Ottawa River, Pike Run, Plum Creek, and Zurmehly Creek. A map of the study area is shown in Figure 4.

The Ottawa River originates in the Eastern Corn Belt Plains (ECBP) ecoregion at the confluence of Hog and Little Hog Creeks, and flows southwesterly through Lima along the southern boundary of the Fort Wayne moraine. It then crosses the boulder belt and flows northward into the Huron/Erie Lake Plain (HELP) ecoregion to its confluence with the Auglaize River west of Kalida. The Ottawa River watershed covers 238,080 acres of Wisconsin glaciated till and lake plains. Underlying bedrock of Silurian limestone and dolomite is exposed at various locations in the river and elsewhere is covered by several to more than two hundred feet of drift material.

The Eastern Corn Belt Plains (ECBP) ecoregion is a rich agricultural area that covers the upper portion of the watershed in Allen and Hardin Counties. The relief in this part of the watershed is nearly level to gently rolling, with steeper areas along streams and the three end moraines which traverse the county from east to west. These end moraines are among the areas where soil erosion is most severe in the watershed. Local relief is greater than in the HELP ecoregion, and the streams have a steeper gradient. Little Hog Creek and the Little Ottawa River have gradients of 11.7 and 8.6 feet per mile, respectively.

The Huron/Erie Lake Plain (HELP) ecoregion in the lower part of the watershed (northern Allen and Putnam Counties) is characterized by a broad, almost level, lake plain crossed by low moraines and beach ridges. Local relief is generally only a few feet and streams have a lower gradient. Plum Creek and Sugar Creek have gradients of 3.5 and 5.5 feet per mile, respectively.

Soils in the watershed can be classified by ecoregion location, with the ECBP "till plain" soils generally being derived from glacial till materials , and HELP "lake plain" soils generally being formed from lacustrine sediments. Soils in the Morely-Blount-Pewamo association are found in the upland areas (ECBP ecoregion) of Hardin and Allen Counties. They are characterized as light colored, somewhat poorly drained, fertile soils of the till plains and moraines. Hog Creek Marsh is located on the extreme west edge of the watershed, near Dola in Hardin County. Here you find deep, poorly drained soils of the Milford-Patton association that formed in medium to moderately fine textured lacustrine sediment on lake plains. In the HELP ecoregion of northern Allen County and into Putnam County the soils move from the Blount-Pewamo to the Hoytville-Nappanee associations. These soils are darker colored, very poorly drained soils of the till plains and lake plains. Beach ridge soils in the Haskins-Mermill-Millgrove association are found in the southern part of Putnam County along SR 12 near Columbus Grove.

Grain farming is the predominant land use in the watershed, and since most of the soils are poorly drained, an extensive artificial drainage system must be maintained to make row crop farming possible. Many of the small streams have been extensively channelized to assist these field tile and drainage ditch systems throughout the watershed. In addition, an estimated 30,000 acres of farmland in the watershed contain soils in the highly erodible lands (HEL) category, that are subject to either water or wind erosion above the tolerable erosion rate. HEL lands represent a threat to the productive capacity of the soil resource, as well as the aquatic resource when soil is transported off farmland into the streams. Offsite damage from soil erosion costs millions of Ohio taxpayer dollars every year to remove sediment from drainage ditches, shipping harbors and recreational areas (SCS 1985, USDA 1996).

The Ottawa River watershed is largely rural with a population of 100,230 residents. Lima is the largest urban area with 45% of the county's population. There are eleven other communities located in the watershed: Ada, Lafayette, Fort Shawnee, Cridersville, Beaverdam, Cairo, Columbus Grove, Gomer, Vaughnsville, Elida, and Kalida. Land use is primarily dedicated to agricultural activities with approximately 85% (202,368 acres) of land used for crop production, 5% forest, 1% pasture, and 9% urban and other land uses (Allen SWCD 1994, USDA 1996).

The Ottawa River and its tributaries are impaired by a combination of point and nonpoint sources of pollution. Point source impairment is attributed to industrial and municipal effluents, combined sewer overflow (CSO) and sanitary sewer overflow (SSO) discharges from the City of Lima and other villages in the watershed, as well as inadequately or untreated sewage discharges from several unsewered areas in the watershed. The villages of Gomer, Rimer, and Vaughnsville currently do not have sanitary sewerage systems. The Village of Cairo began construction of a wastewater collection system in 1997 and will be connected to the American Bath wastewater treatment plant. Industrial effluents also continue to contribute to impairment of the river. Table 4 lists the stream characteristics and pollution sources for the streams that were sampled during the 1996 survey.

Significant improvements have been made to wastewater treatment facilities at the major industrial and municipal dischargers in the Lima area since the late 1970s. Ongoing improvements at the Lima WWTP, BP Oil, and PCS Nitrogen Ohio, as well as completely new wastewater treatment facilities at Shawnee and American Bath have further decreased pollutant loadings to the Ottawa River and Pike Run since the Ohio EPA water quality survey in 1991.

In addition to the usual agricultural sources of nonpoint pollution identified in Table 4, the Ottawa River is impaired or impacted by several urban sources including leachate from the old Bath Township landfill, the BP Oil L5 landfill, runoff from heavy manufacturing facilities, and runoff or spills from petroleum transfer and tank farm facilities. Known causes of impairment to the Ottawa River and tributary streams include organic enrichment and low dissolved oxygen, habitat alterations, nutrients, ammonia, metals, oil and grease, and chlorine.

Conservation programs in farming are being promoted by the Natural Resources Conservation Service (NRCS) and local Soil and Water Conservation Districts (SWCDs) throughout the watershed. Conservation tillage practices have increased significantly over the last ten years in all four counties. The 1996 Allen County tillage transect indicates that more than half of the grain crops were planted in no-till or mulch-till with greater than 30% residue (45.4% corn, 63.8% soybeans, 52% wheat)(Allen SWCD 1996).

A USDA Forest Service Report prepared in 1996 for the Ottawa River watershed identified problems such as excessive erosion, inadequate forest management, and degraded water quality and fish habitat in the watershed. The report made recommendations for the establishment of windbreaks, riparian buffers, and trees for streambank stabilization to protect the forest, soil and water resources in the watershed (USDA 1996). Through a Section 319 Nonpoint Source program grant from Ohio EPA and a Nature Works grant from ODNR, over $290,000 was available through 1998 to stabilize stream banks and convert farmland and floodplain land to riparian buffer strips along the river corridor.

In 1994, a local watershed action group, the Ottawa River Coalition, was formed as a non profit organization to coordinate efforts of local residents, landowners, and groups to improve water quality and educate the public on the benefits of protecting the watershed's resources. Over the past four years the Coalition has worked hard to promote nonpoint source and pollution prevention awareness, and has maintained a positive presence throughout the watershed. In 1995 the Ottawa River Coalition received a Section 319 grant from Ohio EPA to implement nonpoint source pollution incentive programs in the watershed. Over the course of this three and a half year grant, nearly $300,000 will be spent on educational and cost share programs that include erosion control and riparian protection projects, pollution prevention workshops, demonstration of wetlands for sewage treatment, storm drain stenciling, and a volunteer stream monitoring program.

Aquatic life use designations for the Ottawa River, Little Ottawa River, and Plum Creek are Warmwater Habitat; and Modified Warmwater Habitat is the designation for Pike Run. All streams in the study area have a recreational use designation of Primary Contact Recreation. As a water supply resource, the Ottawa River is designated as an Industrial and Agricultural Water Supply. The City of Lima Water Treatment Plant also supplies over 16 million gallons of treated water per day to the City of Lima, the Elida area, Fort Shawnee area and into Bath Township in Allen County. The Ottawa River system also provides for local recreation such as fishing, waterfowl hunting, biking or hiking along the corridor path constructed by the Lima Parks, Recreation and Forestry Department, and numerous community and family activities offered by the Johnny Appleseed Metro Parks District.

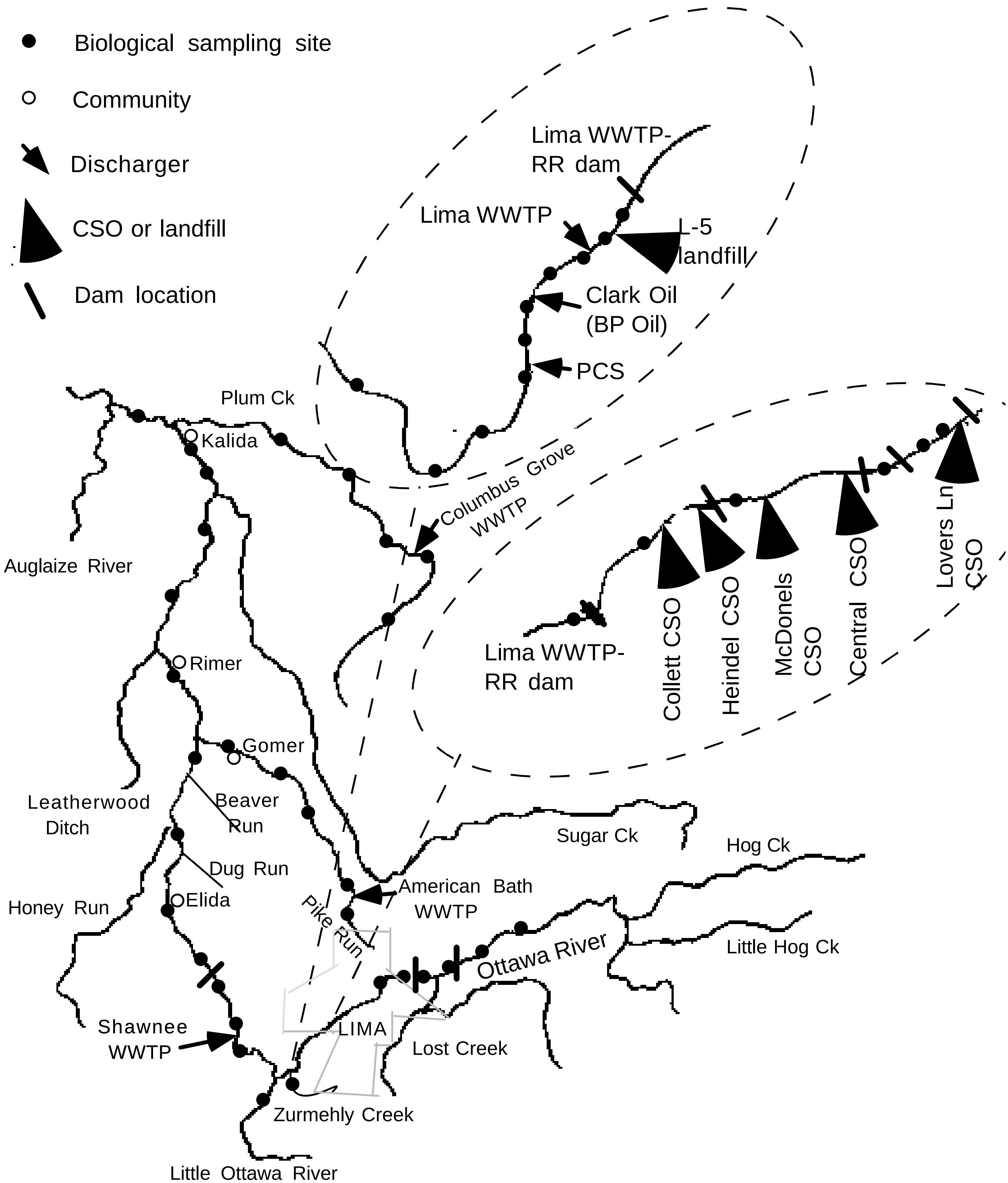

Figure 4. The 1996 Ottawa River study area showing biological sampling sites, principal tributaries, dams, point source dischargers, and major CSO locations.

Table 4. Stream Characteristics and Significant Identified Pollution Sources in the Ottawa River Study Area (ODNR 1954, Ohio EPA 1997)

River/Stream	Length (mi.)	Gradient (ft./mi.)	Drain. Area (sq. mi.)	Nonpoint Sources	Point Sources
Ottawa River	52.7	4.0	365.0	Bath Twp Landfill BP Oil L-5 LF Agriculture Crop production Livestock pasture/ feedlots Specialty crops Hydromodification Storm sewers Sanitary sewers Surface runoff Wastewater San. landfill In place pollutants Surface mining Dam construction Sludge Industrial land trtmt	Lima WWTP Clark Oil (formerly BP Oil) PCS Nitrogen Ohio, LP (formerly Arcadian Ohio LP and BP Chemicals) Shawnee #2 WWTP Elida WWTP Kalida WWTP
Little Ottawa River	6.4	8.6	16.4	Agriculture Crop production Storm sewers Hydromodification Streambank modification	Cridersville WWTP
Pike Run	8.2	7.9	13.0	Agriculture Crop production Storm sewers Hydromodification	American Bath WWTP
Plum Creek	14.4	3.5	39.9	Agriculture Crop production Livestock pasture/ feedlots Urban runoff Hydromodification	Columbus Grove WWTP
Zurmehly Creek		(no information)		Lima Army Tank Plant Various petroleum tank farms and transfer stations	

Table 5. 1996 Sampling locations (effluent sample - E, water chemistry - C, sediment chemistry - S [metals-m, organics-o], datasonde - D, benthos - B, fish - F, fish tissue - FT, biomarker - BM) in the Ottawa River study area.

Stream	RM	Type of Sampling	Latitude/Longitude	Landmark	USES Quad. Map
Ottawa River					
	46.1	F,FT,BM	40°45'58"/84°00'39"	Ust Thayer Rd.	Cairo
	45.97	C,CO,SM,SO	40°45'57"/84°00'43"	Thayer Rd.	Cairo
	45.9	B,D	40°45'55"/84°00'50"	Thayer Rd.	Cairo
	44.5	B	40°45'26"/84°02'02"	Ust Fetter Rd	Cairo
	44.4	F	40°45'26"/84°02'03"	Fetter Rd	Cairo
	44.26	C,SM,SO	40°45'25"/84°02'14"	Fetter Rd	Cairo
	43.6	F	40°45'12"/84°02'50"	Metzger Rd dam pool	Cairo
	43.45	C,CO	NA	Dst Metzger Rd dam	Cairo
	43.4	F,B,D	40°45'03"/84°03'05"	Dst Metzger Rd dam	Cairo
	42.61	C,CO,SM,SO	40°44'51"/84°04'09"	Roush Rd	Lima
	42.4	B,BM	40°44'52"/84°04'15"	Dst Roush Rd dam	Lima
	42.3	F	40°44'55"/84°00'57	Dst Roush Rd dam	Lima
	41.30	C,D	40°44'55"/84°05'16"	Sugar St	Lima
	41.2	F,B	40°44'54"/84°05'14"	Sugar St.	Lima
	40.8	F	40°44'59"/84°05'38"	Dst. Sugar St	Lima
	40.2	F,FT	40°44'34"/84°05'33"	Ust. Lovers Ln (dam pool)	Lima
	40.14	C,CO	40°44'25"/84°05'36"	Dst Lovers Ln dam	Lima
	40.1	B	40°44'26"/84°05'37"	Dst Lovers Ln dam	Lima
	39.9	F	40°44'19"/84°05'49"	Elm St. dam pool	Lima
	39.6	B	40°44'12"/84°06'03"	Dst. Elm St. dam	Lima
	38.9	F	40°43'59"/84°06'48"	Ust. Collette St. dam	Lima
	38.63	C,CO,SM,SO	40°43'55"/84°07'09"	Collette St.	Lima
	38.6	F,FT,B,D,BM	40°43'50"/84°07'22"	Dst. Collett St.	Lima
	38.0	SM,SO	40°43'30"/84°07'33"	Ust. dam & dst. CSOs	Cridersville
	37.91	C,CO	40°43'27"/84°07'36"	Dst. dam	Cridersville
	37.9	F,FT,B,D	40°43'28"/84°07'34"	Dst. dam & CSOs	Cridersville
	37.8	B	40°43'27"/84°07'37"	Dst. dam & CSOs	Cridersville
	37.70	C,CO,SM,SO,F,BM	40°43'25"/84°07'41"	Dst. dam & CSOs	Cridersville
	37.67	E	40°43'23"/84°07'55"	Lima WWTP effluent	Cridersville
	37.66	F,B	40°43'23"/84°07'56"	Lima WWTP mix zone	Cridersville
	37.4	B,BM	40°43'20"/84°08'09"	Dst. Lima WWTP	Cridersville
	37.30	C,CO,SM,SO,D	40°43'20"/84°08'11"	Dst. Lima WWTP	Cridersville
	37.2	F	40°43'14"/84°08'13"	Dst landfill/low water brdg	Cridersville
	37.11	E	40°43'08"/84°08'14"	BP Refinery effluent	Cridersville
	37.10	F,B	40°43'07"/84°08'14"	BP Refinery mix zone	Cridersville
	37.00	C,CO,SM,SO,D,F,B,BM	40°43'05"/84°08'14"	Dst. BP Refinery	Cridersville
	36.87	E	40°43'01"/84°08'15"	Arcadian LP effluent	Cridersville
	36.86	F,B	40°43'00"/84°08'15"	Arcadian LP mix	Cridersville

Table 5. Continued.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USES Quad. Map
36.80	C,CO,SM,SO,F,FT	40°42'58"/84°08'15"	Dst. Arcadian LP	Cridersville
36.7	BM	40°42'47"/84°08'17"	Dst. Arcadian LP	Cridersville
36.30	C,CO,SM,SO,D	40°42'30"/84°08'28"	Dst. Arcadian LP SSO	Cridersville
36.1	B	40°42'28"/84°08'40"	Twp. Fire Station	Cridersville
36.0	F	40°42'35"/84°08'45"	Twp. Fire Station	Cridersville
35.5	F	40°42'25"/84°09'00"	Ust. Shawnee CC	Cridersville
34.7	F,BM	40°42'40"/84°09'22"	Shawnee Country Club	Cridersville
34.55	C,CO,SM,SO	40°42'45"/84°09'25"	Shawnee Country Club	Cridersville
34.5	B	40°42'51"/84°09'28"	Shawnee Country Club	Cridersville
34.3	D	40°42'58"/84°09'34"	Shawnee Country Club	Cridersville
32.60	C,CO,SM,SO,D,F,B	40°43'20"/84°10'27"	Ust. SR 117	Cridersville
32.41	C	40°43'31"/84°10'26"	Dst. Shawnee WWTP	Cridersville
32.4	F,B	40°43'31"/84°10'26"	Dst. Shawnee WWTP	Cridersville
31.03	C,CO,SM,SO	40°44'13"/84°10'51"	Elm St,dst. Seriff Landfil	Cridersville
31.0	D	NA	Elm St,dst. Seriff Landfil	Cridersville
28.9	F,FT,BM	40°45'13"/84°11'42"	Ust. Allentown Dam	Elida
28.87	SM,SO	40°45'19"/84°11'41"	Ust. Allentown Dam	Elida
28.83	C,CO	40°45'19"/84°11'41"	Dst. Allentown Dam	Elida
28.8	F,B,D	40°45'19"/84°11'41"	Dst. Allentown Dam	Elida
25.8	B	40°47'14"/84°12'45"	Ust. Piquad Rd	Elida
25.75	C,CO,SM,SO	40°47'16"/84°12'45"	Piquad Rd	Elida
25.7	F	40°47'17"/84°12'46"	Dst. Piqaud Rd	Elida
24.2	D	40°48'01"/84°12'14"		Elida
22.94	C,CO,SM,SO	40°49'00"/84°12'30"	State Rd	Elida
22.9	B,D	40°48'57"/84°12'28"	Ust. State Rd	Elida
21.1	BM		Ridge Rd	Elida
21.0	F	40°50'14"/84°11'51"	Ridge Rd	Elida
16.2	F	40°52'46"/84°12'30"	Ust. SR 189 (Rimer)	Kalida
16.0	B	40°53'02"/84°12'47"	Ust. SR 189 (Rimer)	Kalida
15.98	C,CO,SM,SO,D	40°53'03"/84°12'47"	SR 189	Kalida
13.0	F	40°54'31"/84°12'26"	Dst. Ottawa River Churc	Kalida
8.12	C,CO,SM,SO,D	40°56'49"/84°11'12"	Putnam CR P	Kalida
7.8	B	40°56'56"/84°11'39"	Adj. Putnam Rd 17N	Kalida
5.6	F	40°58'06"/84°11'26"	Adj. SR 115(Collie prop)	Kalida
3.8	F	40°58'42"/84°12'09"	Ust. US 224	Kalida
3.7	B	40°58'47"/84°12'10"	Ust. US 224	Kalida
3.67	C,D	40°58'50"/84°12'15"	US 224	Kalida
1.2	F,FT	40°59'23"/84°13'24"	Ust. Putnam Rd. 19	Kalida
1.1	BM		Ust. Putnam Rd. 19	Kalida
0.96	C,CO,SM,SO,D	40°59'26"/84°14'36"	Putnam Rd. 19	Kalida
0.8	B	40°59'25"/84°13'45"	Dst. Putnam Rd. 19	Kalida

Table 5. Continued.
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Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USES Quad. Map
Pike Run				
8.22	C,D	40°47'01"/84°07'21"	Ust. A.-Bath WWTP	Cairo
8.2	F,B	40°47'01"/84°07'21"	Ust. A.-Bath WWTP	Cairo
8.20	E	40°47'01"/84°07'21"	American Bath WWTP	Cairo
8.1	C,D,F,B	40°47'06"/84°07'20"	Dst. A.-Bath WWTP	Cairo
5.7	C,B	40°48'07"/84°08'59"	Irvin Rd	Elida
4.7	F	40°48'57"/84°08'53"	State Rd	Elida
4.3 ?	D	NA	State Rd	Elida
2.2	F	40°50'24"/84°09'26"	Ust. Sandy Pt	Elida
2.1	C,D	40°50'25"/84°10'02"	Sandy Point Rd.	Elida
0.84	C	40°50'48"/84°11'09"	Dst. Gomer	Elida
0.8	B	40°50'47"/84°11'12"	Dst. Gomer	Elida
0.6	F	40°50'50"/84°11'19"	Dst. Gomer	Elida
0.2	D			
Plum Creek				
15.3	F	40°54'16"/84°05'00"	Ust. Columbus Grove	Columbus Grove
14.9	C,CO,SM,SO,D,B	40°54'26"/84°04'41"	Ust. Columbus Grove	Columbus Grove
12.94	C	40°55'26"/84°03'45"	WWTP drive, Church St	Columbus Grove
12.9	F,B	40°55'26"/84°03'46"	WWTP drive, Church St	Columbus Grove
12.2	F	40°55'45"/84°04'17"	Road ust. CR-11-J	Columbus Grove
11.5	C,COCSM,SO,D,B	40°55'51"/84°04'54"	CR-11-J	Columbus Grove
8.1	C,D,F,B	40°57'47"/84°06'07"	TR O	Columbus Grove
5.5	F	40°58'34"/84°08'29"	Adjacent M-10	Kalida
4.4	C,D,B	40°58'58"/84°08'39"	US 224 or TR M-10	Kalida
0.2	C,CO,SM,SO,D,F,B	40°59'12"/84°12'33"	SR 114	Kalida
Zurmehly Creek				
0.1	C,CO,SM,SO,F,B	40°42'19"/84°08'51"	Near mouth	Cridersville
Little Ottawa River				
0.4	C,CO,SM,SO,D,F,B	40°42'02"/84°09'15"	Cemetery access	Cridersville

METHODS

All chemical, physical, aquatic habitat, 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), 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, 1995). Chemical, physical, aquatic habitat, and biological sampling locations are listed in Table 5.

Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-14). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multi metric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Numerical endpoints are stratified by ecoregion, use designation, and stream or river size. Three attainment status results are possible at each sampling location - full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the Ohio WQS biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria, or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (see Table 1) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and comments and observations for each sampling location.

The attainment status of aquatic life uses (*i.e.,* full, partial, and non-attainment) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-14). The biological community performance measures 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 multi metric 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 (1995). 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 1987). 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 is 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.

Chemical Sediment Quality Assessment

The quality of sediment concentrations was based on two classification schemes. The Kelly and Hite (1984) and Ohio EPA (1996) classifications grade sediment quality from low concentrations (non-elevated) measured at relatively unimpacted areas to higher concentrations (ie. slightly, highly, or extremely elevated) measured at heavily impacted areas. The Ontario guidelines (Persaud, 1994) are based on the chronic, long term effects of contaminants on macroinvertebrates and grades sediment quality as no effect, lowest effect, and severe effect levels.

Fish Tissue Assessment

Fish tissue sampling procedures are detailed in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a). Mercury and pesticides were compared to the U.S. FDA criteria. PCBs were compared to a tiered sportfish consumption advisory as modified from the Great Lakes Sport Fish Advisory Task Force, 1993. This classification scheme rates fish tissue PCB levels as slightly elevated (i.e., >50 and <300 ug/kg), elevated (i.e., >300 and <1000 ug/kg), highly elevated(i.e., >1000 and <5000 ug/kg), and extremely elevated (i.e., >5000 ug/kg).

Biomarker Assessment

White sucker and common carp were collected for biomarker processing in the Ottawa River during 1996. Fish were kept in a floating livewell until biomarker tissue samples could be taken. Fish were anesthetized with MS222 and length and weight was measured. Fish health/condition was assessed using procedures in Goede (1988). Blood was drawn from the caudal vein through a 21 gauge needle into heparin treated 3 ml blood drawing tubes. Whole blood was centrifuged on-site and the plasma removed (flash frozen at -100 ^{o}C in a liquid nitrogen dry shipper). The liver was excised, wrapped in aluminum foil and frozen in a liquid nitrogen dry shipper. Bile was removed, placed in amber microcentrifuge tubes and placed in a liquid nitrogen dry shipper. Sections of liver and spleen were excised from each fish and placed in buffered formalin for histological evaluation. Tissue samples were transported to the U.S. EPA in Cincinnati for laboratory analysis. Specific biomarker analyses included ethoxyresorufin-O-deethylase (EROD), total hepatic glutathione, blood urea nitrogen, plasma levels of pseudocholinesterase, and bile metabolites. Each bile sample was diluted with distilled/deionized water and measured by fixed fluorescence at four excitation/emission wavelength pairs according to Lin et al. (in preparation). Although more than one compound is known to fluoresce under these conditions, some compounds give a greater response. The metabolites are referred to by one of their most sensitive respondents: pyrenol-type at 340/380 nm, benzo(a)pyrenol-type at 380/430 nm, phenanthrol-type at 256/380 nm and naphthol-type at 290/335 nm. Microsomes for measuring EROD and cytosol for glutathione were prepared from liver tissue. Microsomes were prepared according to Lin et al. (1989) and the cytosolic supernatant resulting from the high speed centrifugation was reserved for glutathione measurement. EROD activity was measured fluorometrically according to Pohl and Fouts (1980) and modified Lin et al. (1989). Glutathione was measured according to Akerboum and Sies (1981) and adapted for use with an automated chemistry analyzer.

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, 1995). 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 instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 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 whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. 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. During the present study, analyses of macroinvertebrate data collected from the natural substrates was supplemented using an assessment tool currently in the field validation phase. This method relies on tolerance values derived for each taxon, based upon the abundance data for that taxon from artificial substrate (quantitative) samples collected throughout Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected are weighted by its abundance on the artificial substrates. The mean of the weighted ICI scores for the taxon results in a value which represents its relative level of tolerance on the 0 to 60 scale of the ICI. For the qualitative collections in the Ottawa River study area, the median tolerance value of all organisms from a site resulted in a score termed the Qualitative Community Tolerance Value (QCTV). The QCTV shows potential as a method to supplement existing assessment methods using the natural substrate collections. Use of the QCTV in evaluating sites in the Ottawa River study area was restricted to relative comparisons between sites and was not unilaterally used to interpret quality of the sites or aquatic life use attainment status.

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 except where the boat method was used on the first pass, and the wading method on the second pass due to low flows.

Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Rankin and Yoder 1991; Yoder and Rankin 1995) 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 expressed as ADV/mile to normalize comparisons between segments, sampling years, 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 used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, 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 1991; Yoder 1995). 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, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the 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), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

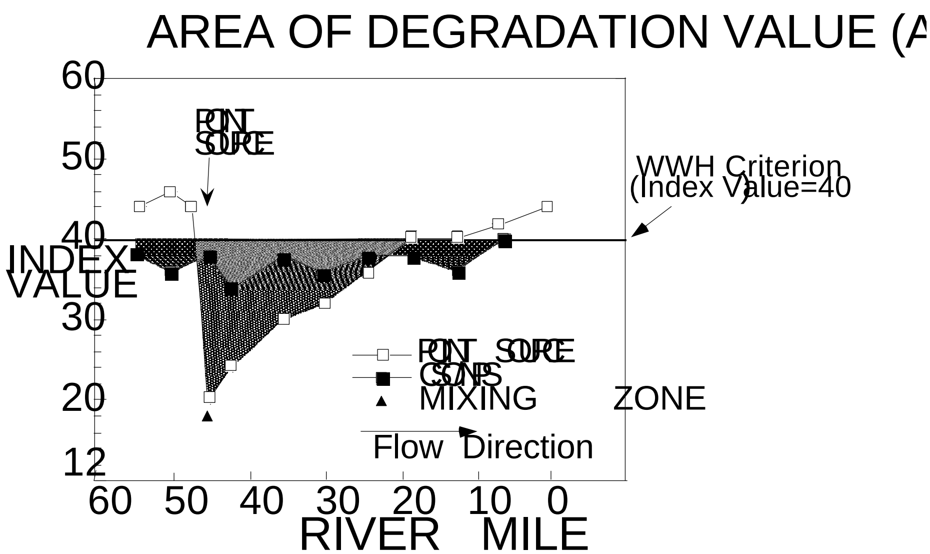


Figure 5. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). the index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears 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.

TRENDS

Chemical Parameters: 1975-1996

Ottawa River

Ammonia

The Clark Oil and PCS Nitrogen plants have had significant reductions allowable ammonia loadings over time (Figures 6 and 7). The 1977-78 reductions were due to federal best practicable treatment (BPT) requirements. The 1986 reductions appear to be due to a combination of best available technology (BAT) and wasteload allocation (WLA) requirements. Ammonia limits have been required for the Lima WWTP for most of its permit history and have not needed revision. The Shawnee WWTP has had water quality based ammonia limits for the summer low-flow period since 1989. Limits are not required during the winter, because the effluent ammonia concentrations typically associated with secondary treatment will allow Water Quality Standards (WQS) to be attained. Similarly, limits have also not been required for the Elida WWTP because of its small flow relative to the Ottawa River. Secondary treatment allows ammonia WQS to be met during all seasons.

Loadings from the Lima WWTP were mostly very low but had a number of “spikes” above limits during the 1980s, especially during the summer (Figure 8). There have been no violations since 1989. The Clark Oil and PCS Nitrogen facilities have reduced ammonia loadings several times, mostly in response to required reductions in limits. Loadings have generally been within limits. The Shawnee WWTP had a significant decrease in ammonia loadings in 1979; however, given problems with reporting, it is difficult to determine when the reductions really occurred. Loadings from the Elida WWTP were highly variable and showed no apparent pattern.

A longitudinal examination of instream ammonia concentrations is presented in Figure 6. These graphs show that the average ambient ammonia concentration has steadily decreased over time throughout the study area. However, ammonia exceedences still occurred downstream from the PCS Nitrogen outfalls in 1991 (RM 36.80) and 1996 (RM 36.80 and RM 36.30), see Appendix Table . PCS Nitrogen continues to discharge the highest loadings of ammonia to the Ottawa River (Figure 7).

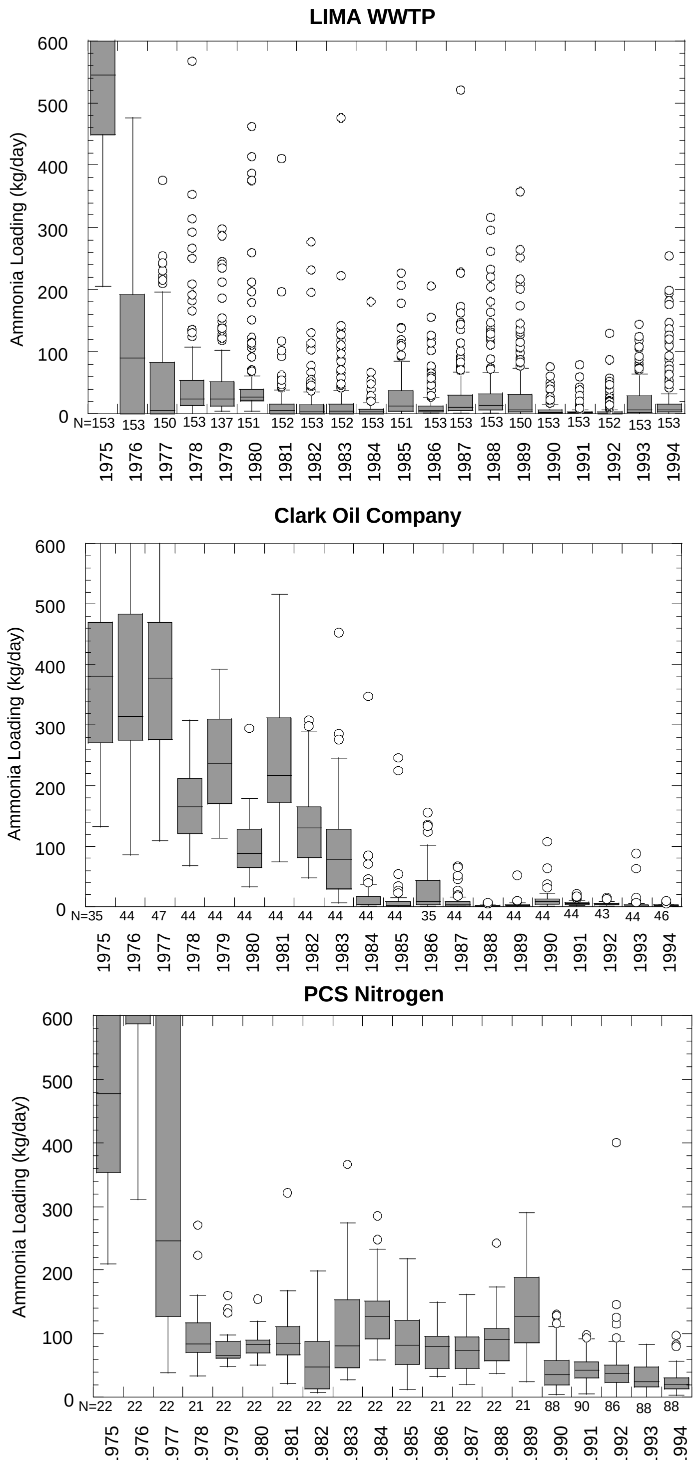


Figure 6. Effluent monitoring data for ammonia from June to October, 1975 to 1994.

Ammonia 50th Percentile Loadings

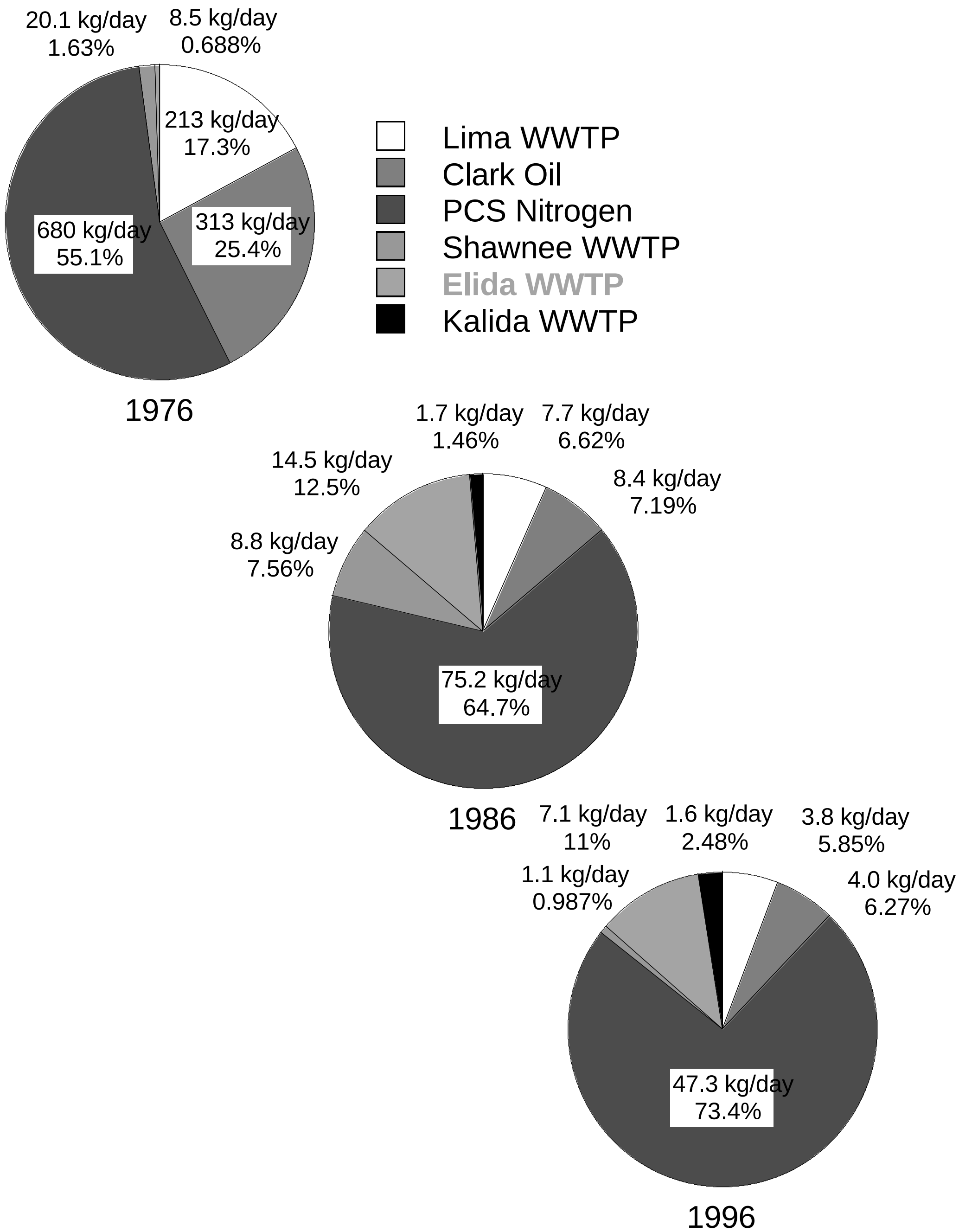


Figure 7. Ammonia 50th percentile monthly operating report (MOR) data, 1976, 1986, and 1996.

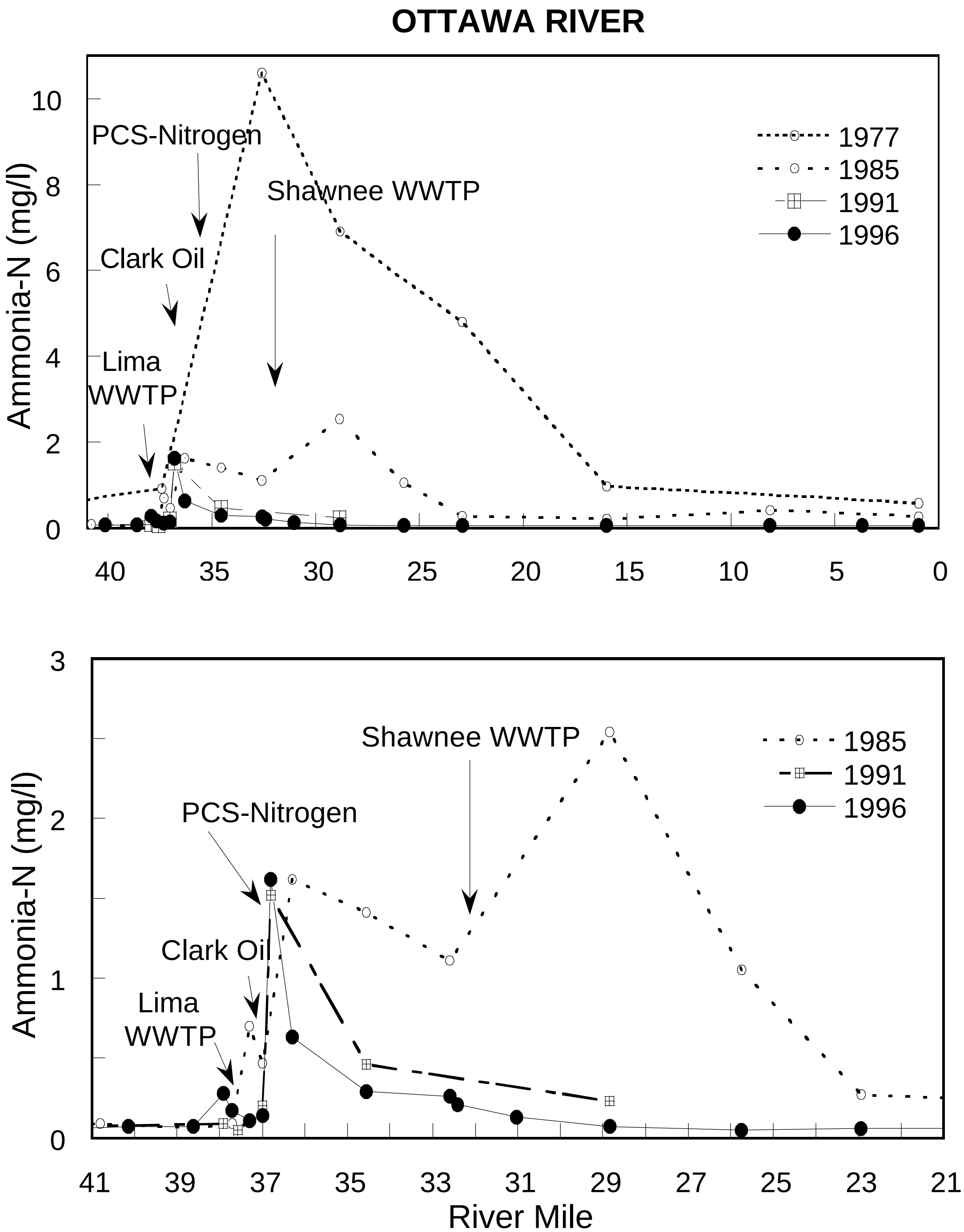


Figure 8. Longitudinal ammonia trends in the Ottawa River. Top graph includes 1977 data. Bottom graph is a different scale to better show more recent trends.

Biochemical/Carbonaceous Biochemical Oxygen Demand (BOD and CBOD)

All of the major dischargers have seen some reduction in their CBOD limits over time (Figures 9 and 10). The largest reduction in CBOD loading limits occurred at the Clark Oil in 1977, which represented changes required by federal best practicable treatment (BPT) effluent guidelines. Significant reductions have also been required for the PCS Nitrogen plant and the Lima and Shawnee WWTPs. These reductions were driven by wasteload allocations for the Ottawa River. Allowable limits for the Elida WWTP, the smallest and most downstream of the dischargers, also appear to be water quality-based during the summer (winter limits reflect secondary treatment standards). The increase in limits observed during the 1980s was apparently due to the practice of extending compliance schedules during the waiting period for construction grant assistance. Water quality based effluent limits (WQBELs) were re-imposed in 1988, when many municipal dischargers were required to comply with these limits.

Effluent sampling results from the Lima WWTP was generally less than permit limits, but did have periods when higher “spike” concentrations occurred. This was particularly true during the summers of 1987 and 1988 and during winters in the late 1980s. Effluent loadings have been slightly lower and significantly more consistent during 1991-94. CBOD loadings from the Clark Oil increased during the early 1980s, with several exceedences, and then decreased significantly beginning in 1984. Presumably this was due to treatment upgrades. Note that Clark Oil was also having problems with “spike” concentrations during the early 1980s, especially during the winter months. Loadings from PCS Nitrogen were cyclic during the 1970s and 1980s with the lowest levels in 1981-82. This trend was more pronounced in the summer data than in the winter. Loadings and concentrations from the Shawnee WWTP showed a similar cyclic pattern. However, the concentration data during the mid-1980s was consistent. It was during this period that the operators of the plant were found to be falsifying data. Monthly operating report (MOR) data for this period can not be used for reliable trend analyses. Loadings from the Elida WWTP were consistently in compliance with limits, except for a few outliers. This was partly due to the 1981 increase in limits which was explained above

The City of Lima CSOs continue to be the largest contributors to the BOD/CBOD loadings to the Ottawa River. Expressed in a daily fashion, outfalls 002-006 discharged a combined total 90 kg/day of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) in 1996. Compared with final effluent loadings to the Ottawa River from the Lima WWTP, Clark Oil, and PCS Nitrogen, CSOs contributed 28.9% of the total $CBOD_5$ load (Figure 10).

Although most sources showed reductions in CBOD loadings from 1991 to 1996, PCS Nitrogen actually showed a slight increase. This trend is reflected in the Ottawa River ambient concentrations, which showed overall reduced instream concentrations of CBOD in 1996 except for a peak downstream from PCS Nitrogen (Figure 11).

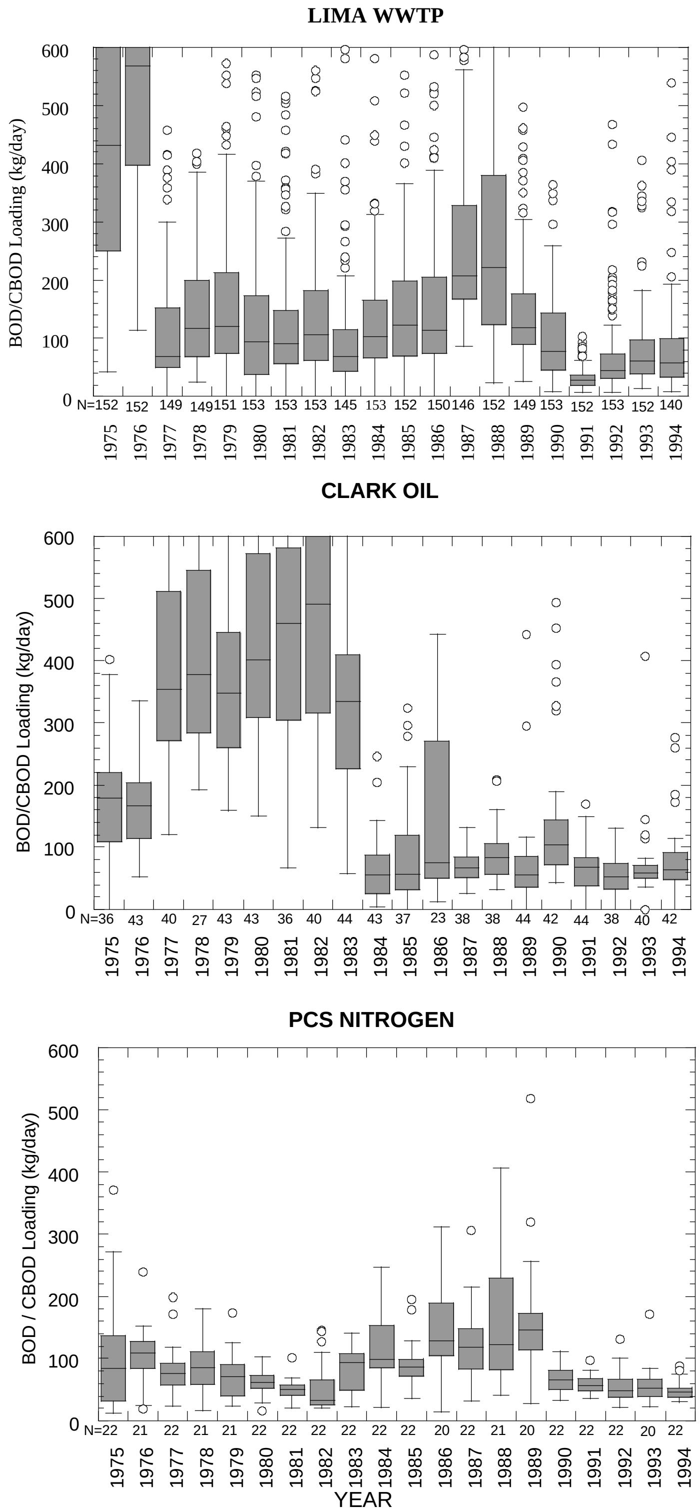


Figure 9. Effluent monitoring data for BOD/CBOD from June to October, 1975 to 1994.

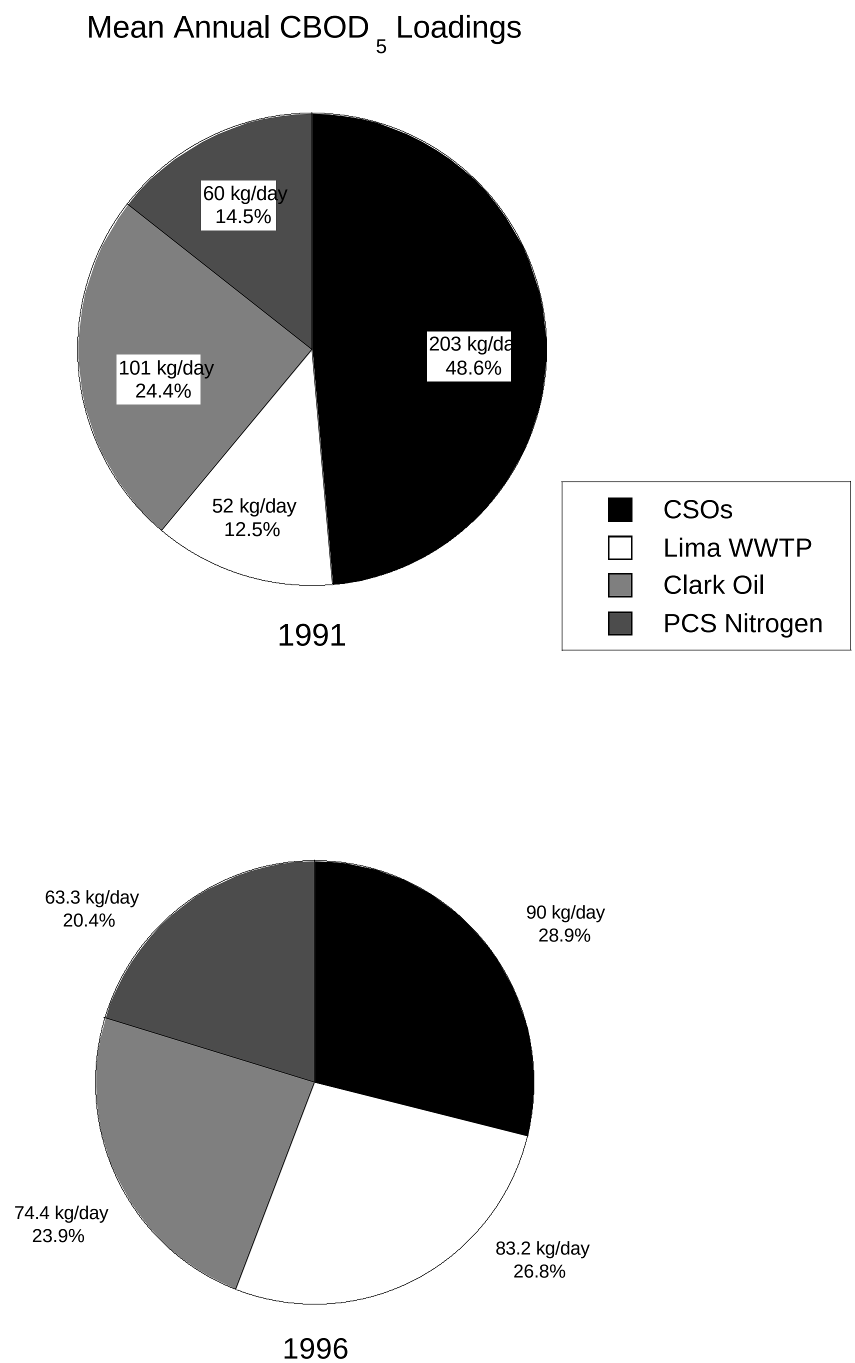


Figure 10. Mean annual CBOD loadings of the Lima CSOs, Lima WWTP, BP Oil, and PCS Nitrogen, 1991 and 1996.

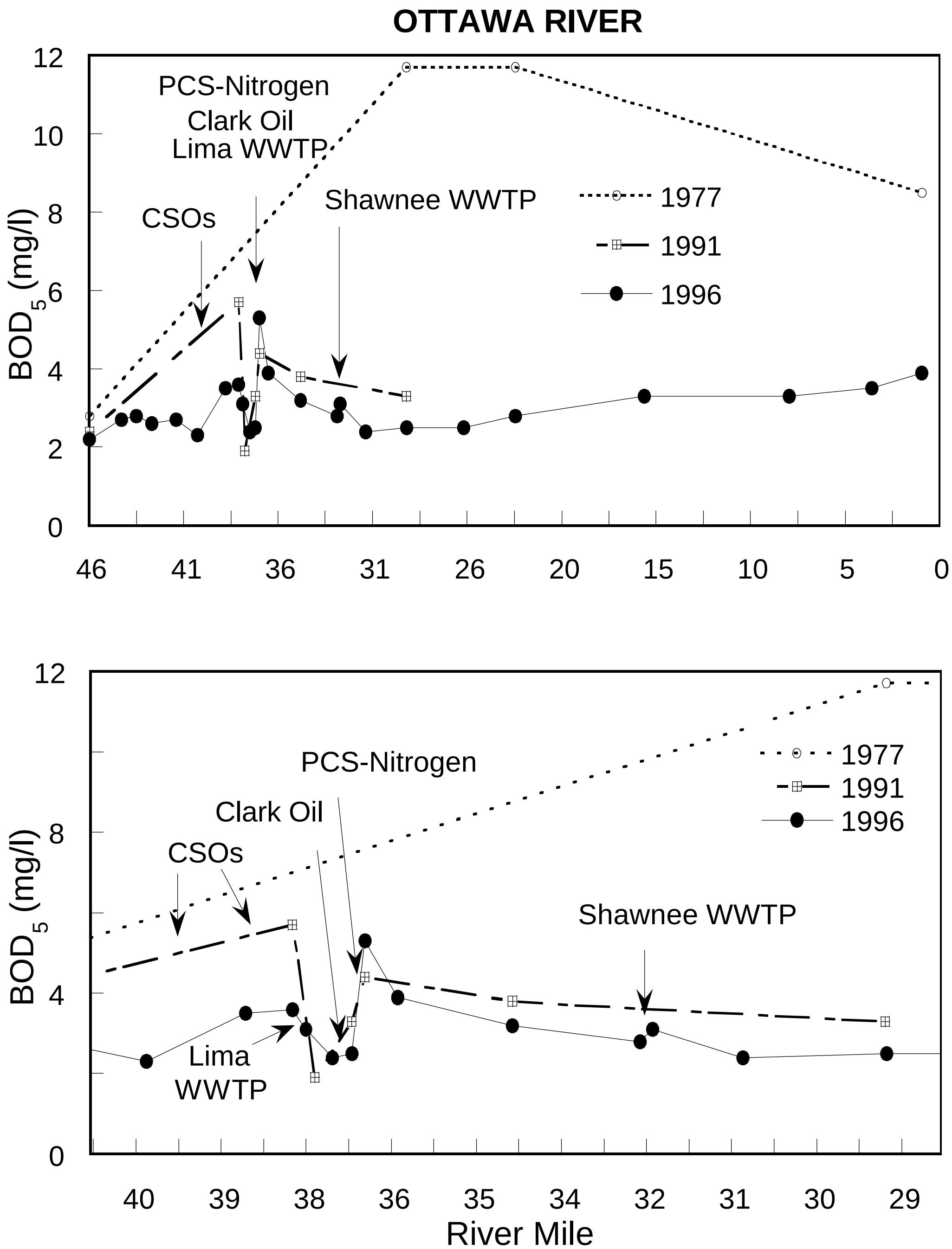


Figure 11. Longitudinal biochemical oxygen demand (BOD_5) trends in the Ottawa River. Top graph includes data from Thayer Road to the mouth. Bottom graph is a different scale to better show more recent trends.

Total Suspended Solids (TSS)

The City of Lima CSOs continue to be the largest contributors of TSS loadings to the Ottawa River. Expressed in a daily fashion, outfalls 002-006 discharged a combined total of 1,125 kg/day of total suspended solids (TSS) in 1996. Compared with final effluent loadings to the Ottawa River from the Lima WWTP, Clark Oil, and PCS Nitrogen, CSOs contributed 67.9% of the total TSS load (Figure 13).

Both the Clark Oil and PCS Nitrogen show slight, gradual reductions in TSS loading over the period of record. Clark Oil's 1984 treatment upgrade appears to have had the largest effect (Figure 12). Most of these reductions were due to changes in allowable loadings under the effluent guidelines. The 1977 changes were due to BPT rules, and the 1986 and 1990 changes were apparently due to revisions in the production figures used to calculate these load limits (the Petroleum Refining BPT/BAT guidelines are very sensitive to changes in the production mix, as well as changes in the overall level of production).

A significant increase in TSS concentrations occurred downstream from Rimer (lower 10-15 miles), possibly due to an ecoregion transition from the ECBP to HELP (Figure 14).

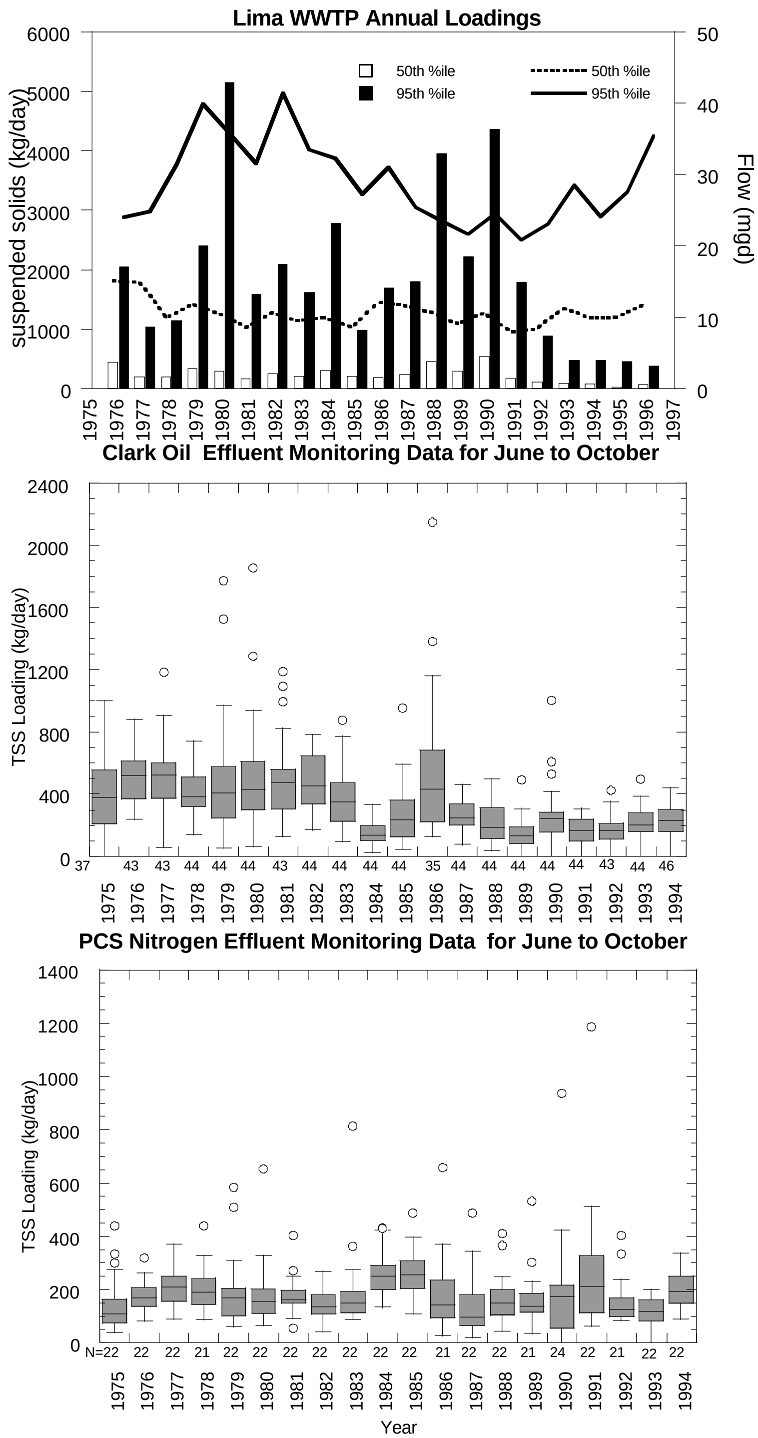


Figure 12. Trends of annual loadings (50th & 95th percentiles) for the Lima WWTP and June to October box plots for Clark Oil and PCS Nitrogen.

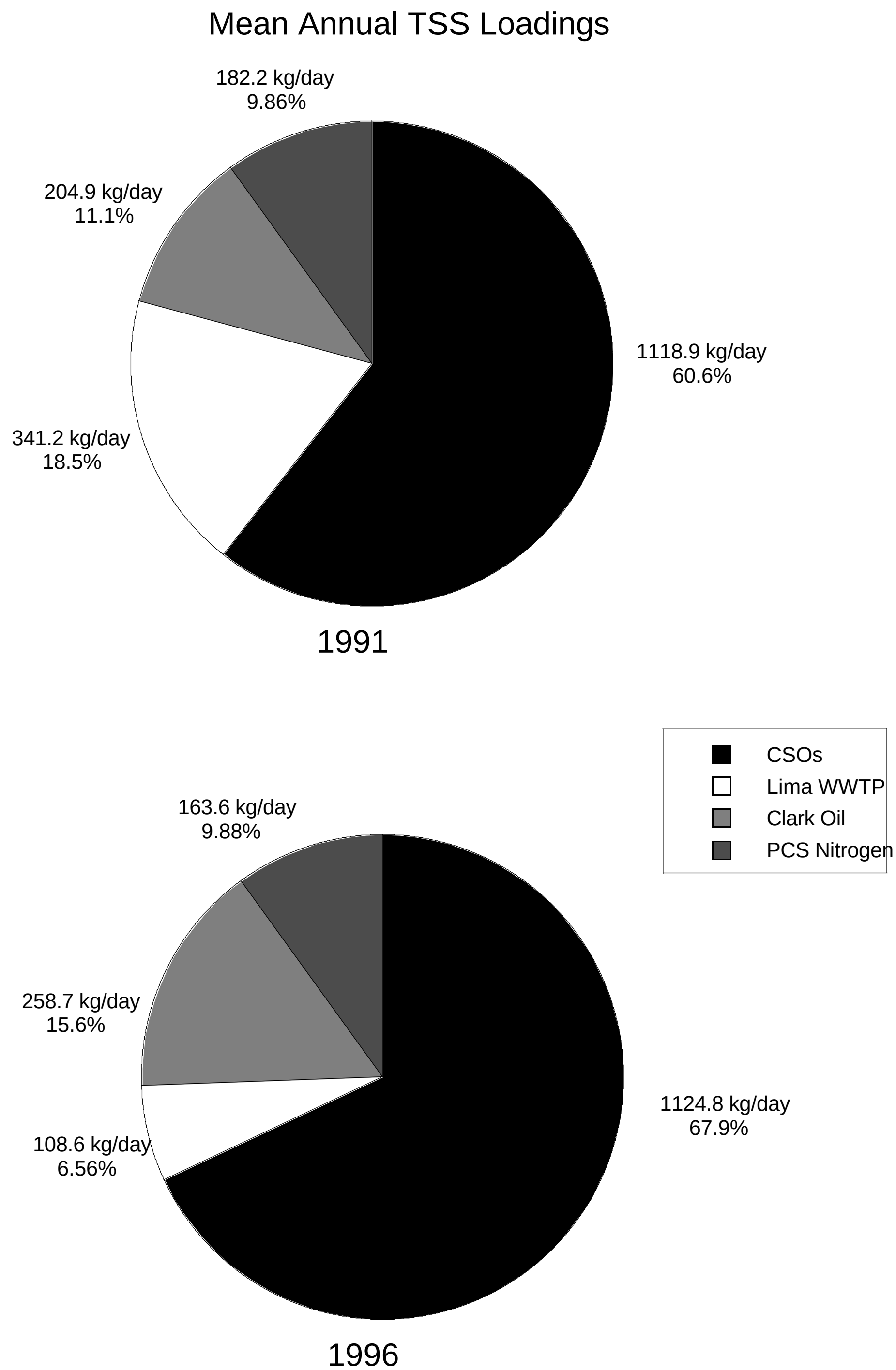


Figure 13. Mean annual total suspended solids (TSS) loadings of the Lima CSOs, Lima WWTP, CLARK Oil, and PCS Nitrogen, 1991 and 1996.

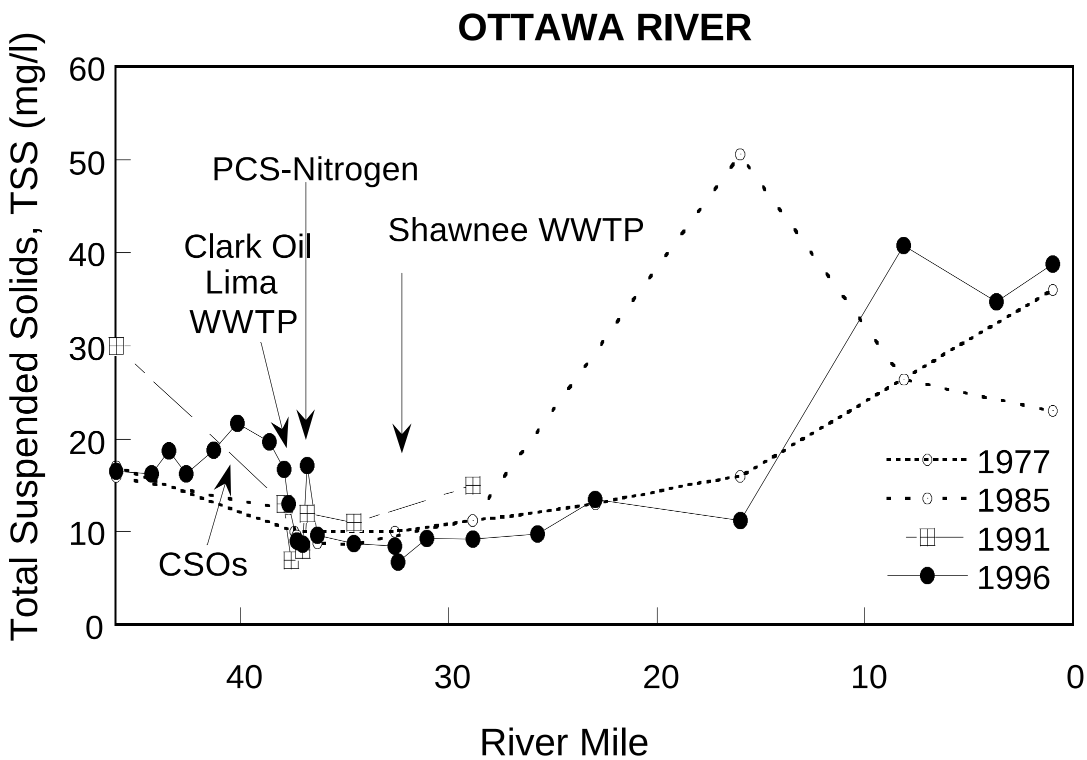


Figure 14. Longitudinal trend data of total suspended solids (TSS) in the Ottawa River, 1977, 1985, 1991, and 1996.

Dissolved Oxygen (D.O.)

Although there was increased instream concentrations of dissolved oxygen during the 1970s, levels of dissolved oxygen have remained relatively stable from 1985 to 1996 (Figure 15). There continues to be two depressions (sags) in oxygen levels, one downstream from the Lima CSOs and the other downstream from the major dischargers.

Water samples were collected from the Ottawa River and four of the control structures during wet weather periods to assess the impact of the CSOs on the Ottawa River (The City of Lima's Water Quality Impact Report, 1996). During a July 30, 1996 rain event dissolved oxygen at Collett Street fell below 4.0 mg/l; and during an August 19 rain event dissolved oxygen fell below 4.0 mg/l at Collett Street and below 3.0 mg/l at High Street (upstream from CSO discharges).

During dry weather periods, the impact from the CSOs resulted in low D.O. in the water column and increased levels of metals, PAHs, and PCBs in the sediments. During 1996, the Ohio EPA sampled water column chemistry at 8 sites and sediment at 5 sites from Thayer Road (RM 45.97) to downstream from the Lima WWTP/Erie-Lackawanna Railroad Dam (RM 47.91). Dissolved oxygen fell below 5.0 mg/l at both RM 38.63 and RM 37.91, downstream from the CSOs and upstream from the major point source dischargers.

An improvement was observed in the dissolved oxygen regime at the site immediately downstream from the Lima WWTP/Erie-Lackawana RR dam (RM 37.9) in 1996 compared to 1991 (Figure 16). In 1996, datasonde data showed all values during a three day period to be above 6.0 mg/l, compared the mean value less than 5.0 mg/l during a three day period in 1991. The macroinvertebrate ICI increased from 6 (poor) to 28 (fair) from 1991 to 1996, respectively, at this site.

Downstream from the major dischargers (between RM 35 and RM 31) during the survey years, dissolved oxygen levels dropped below the average criterion of 5.0 mg/l in 1985 and below the minimum criterion of 4.0 mg/l in 1991 and 1996 (Figure 16). This sag corresponds with increased levels of instream nutrients including ammonia, nitrate-nitrites, and phosphorus.

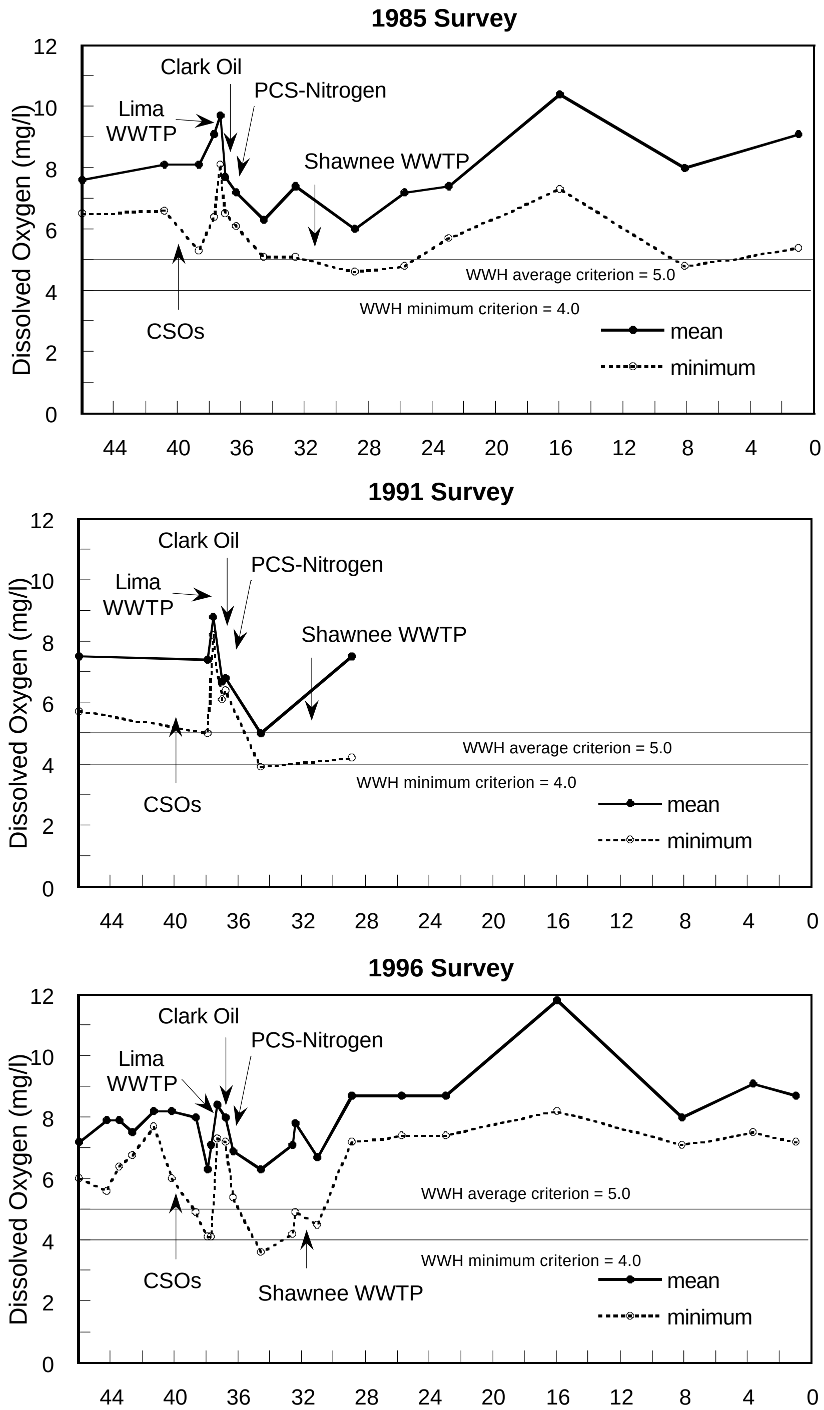
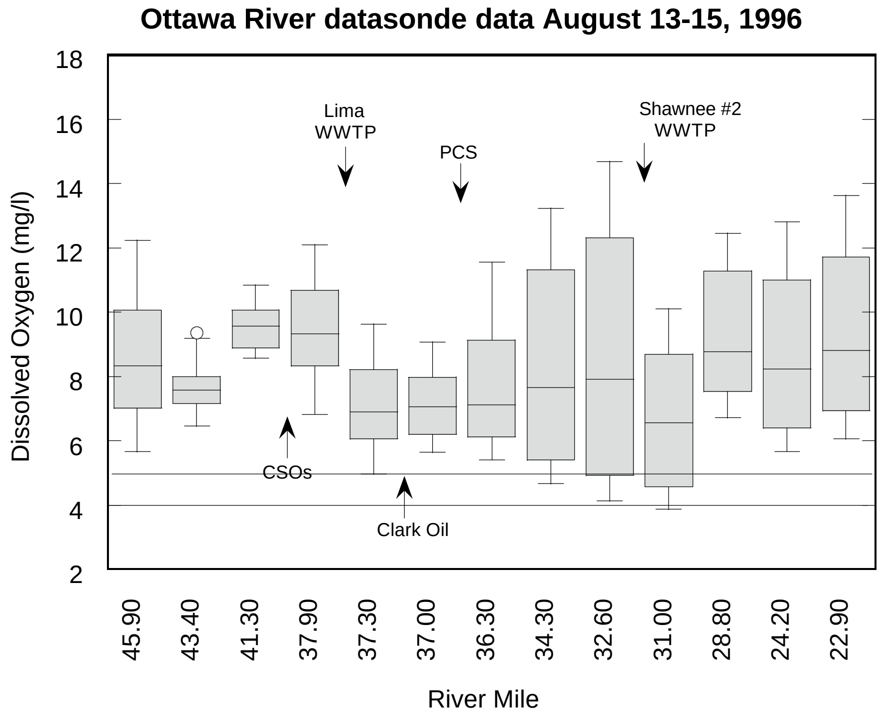


Figure 15. Survey data from 1985, 1991, and 1996 showing trends in dissolved oxygen means and minimums in the Ottawa River.



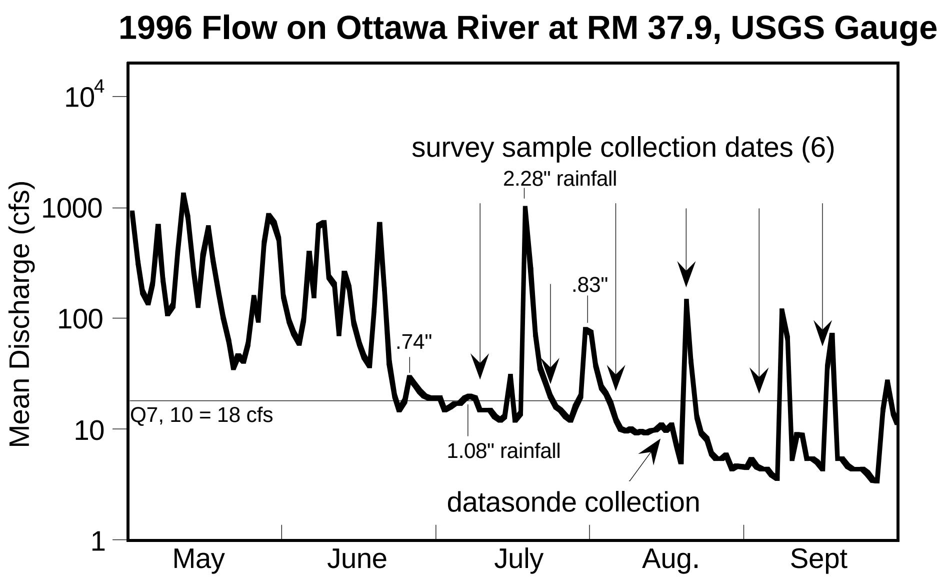


Figure 16. Ohio EPA datasonde data for the Ottawa River from August 13-15, 1996 (top), and 1996 flow data recorded on the Ottawa River at the USES gauge station at RM 37.9, upstream from the Lima WWTP (bottom).

Nitrates-nitrites

Instream levels of NO_2-NO_3 appear to have increased from 1985 and 1991, to 1996 in the upper section of the Ottawa River from Thayer Road to the Lima WWTP. This may be an artifact of the sampling event differences between the years. Three of the six samples collected at Thayer Road in 1996 were below detection (<0.10 mg/l). The two highest concentrations (11.3 and 6.44 mg/l) recorded at Thayer Road in 1996 were collected following rain events (Figure 16). These results were similar from Thayer Road to the Lima WWTP dam (two high values on the same day and four other low values) resulting in an average (of six samples) that was higher than previous years.

The instream data does suggest a nonpoint source loading of NO_2-NO_3 is entering the Ottawa River upstream from Thayer Road during rainfall events, however, the bulk (highest load and highest dry weather concentration) is entering the Ottawa River from the major point sources (Figure 18). Loadings of nitrates-nitrites (NO_2-NO_3) increased at the Lima WWTP in 1976 and 1977 coinciding with reductions of ammonia loadings. Loadings from PCS Nitrogen have increased from 1985 to 1991 (Figure 17).

There is also an indication that NO_2-NO_3 is entering the Ottawa River in the area of the L-5 Landfill. On three sampling dates from August 19 to September 16 (see Appendix), concentrations of NO_2-NO_3 were significantly higher downstream from the landfill at RM 37.7 (8.06, 1.77, and 4.48 mg/l, respectively) compared to upstream at RM 37.9 (0.14, <0.10, and <0.10 mg/l, respectively).

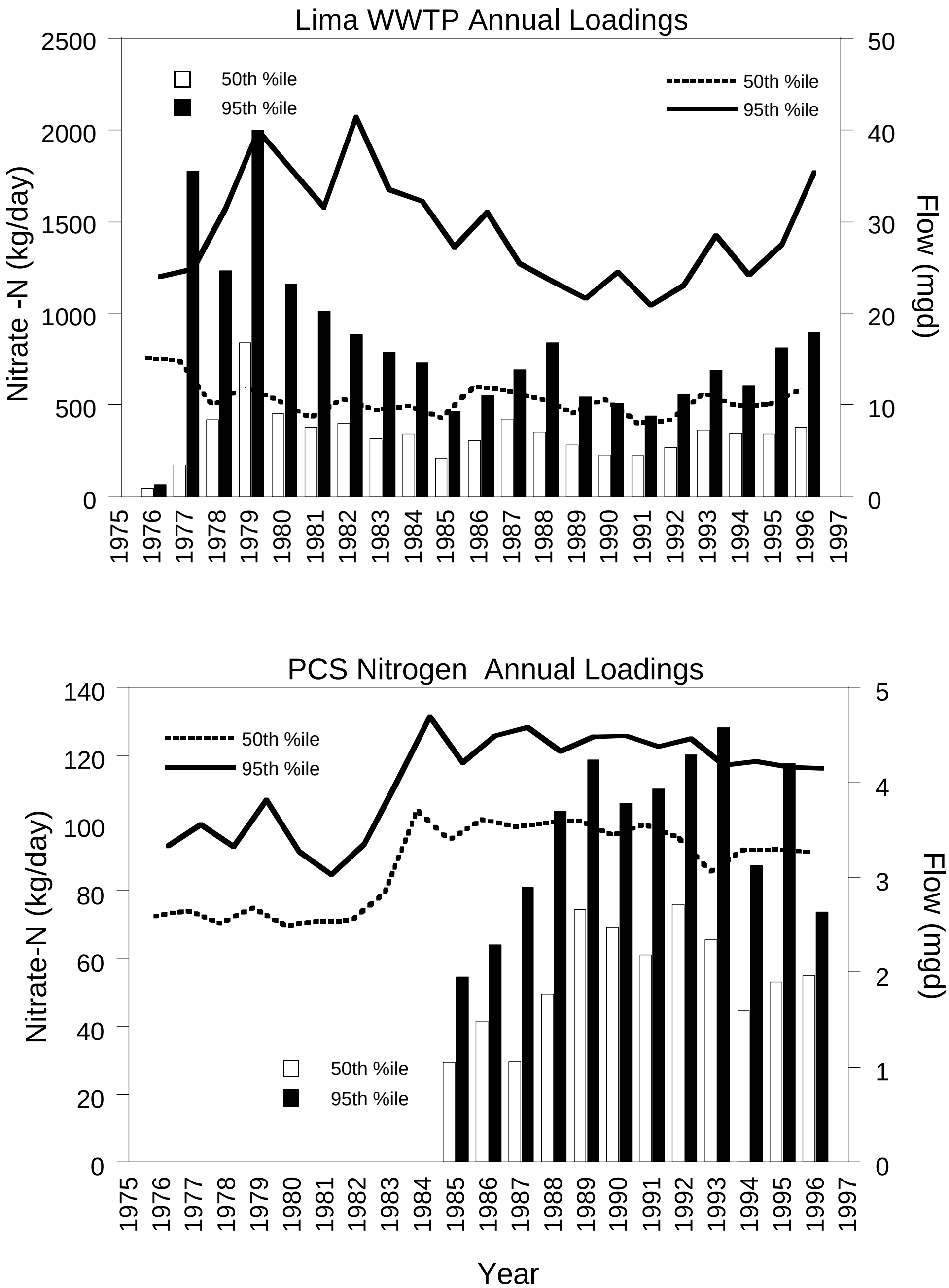


Figure 17. Nitrate loadings trends for the Lima WWTP and PCS-Nitrogen, 1975-1996.

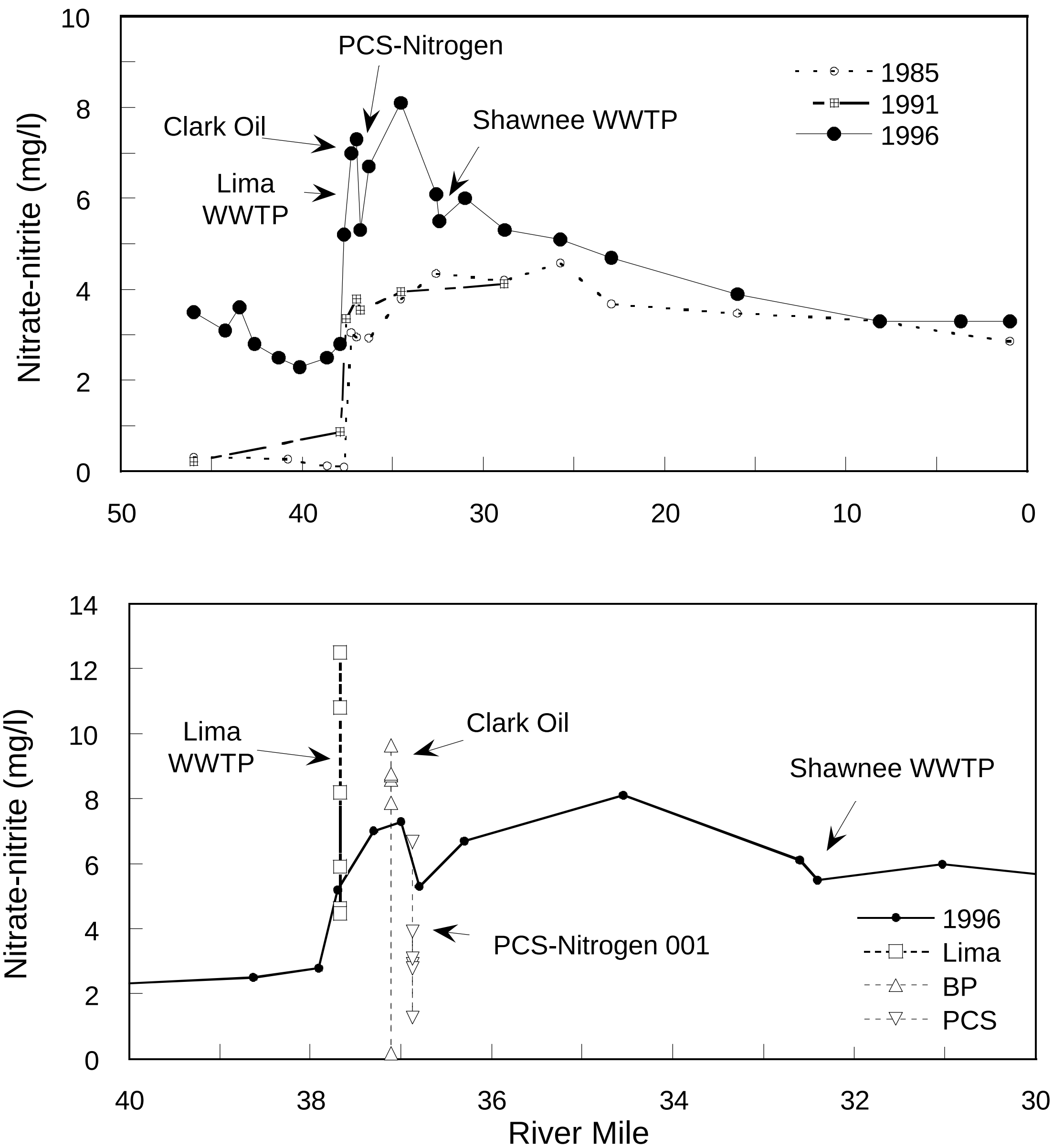


Figure 18. Longitudinal trend of nitrate-nitrite in the Ottawa River for the years 1985, 1991, and 1996 (top). Bottom graph is at a different scale to better demonstrate recent trends in the immediate Lima area.

Phosphorus

Although loadings from the major dischargers were reduced from the 1970s to the 1990s, there was little change from 1985 to the 1996 (Figure 19).

Total phosphorus levels appear to have declined from 1985 to 1991, with little or no change observed from 1991 to 1996 (Figure 20). Increases in the ambient concentration of phosphorus occurred downstream from the major dischargers in the Lima area.

There was one high value of phosphorus at RM 25.75 on 7/22/96 which drove the mean value up. This date coincides with a rainfall event (Figure 16) associated with high levels of nitrate-nitrites in the upper section of the Ottawa River. The other five values of phosphorus at this station were not significantly higher/lower than at the nearest upstream/downstream site collected on the same date. This suggests that a nonpoint source runoff between the Allentown dam and Piquad Road may impact the Ottawa River during high rainfall periods with loadings of phosphorus; however, the bulk (highest load and highest continuous concentration) is entering the Ottawa River from the major point sources.

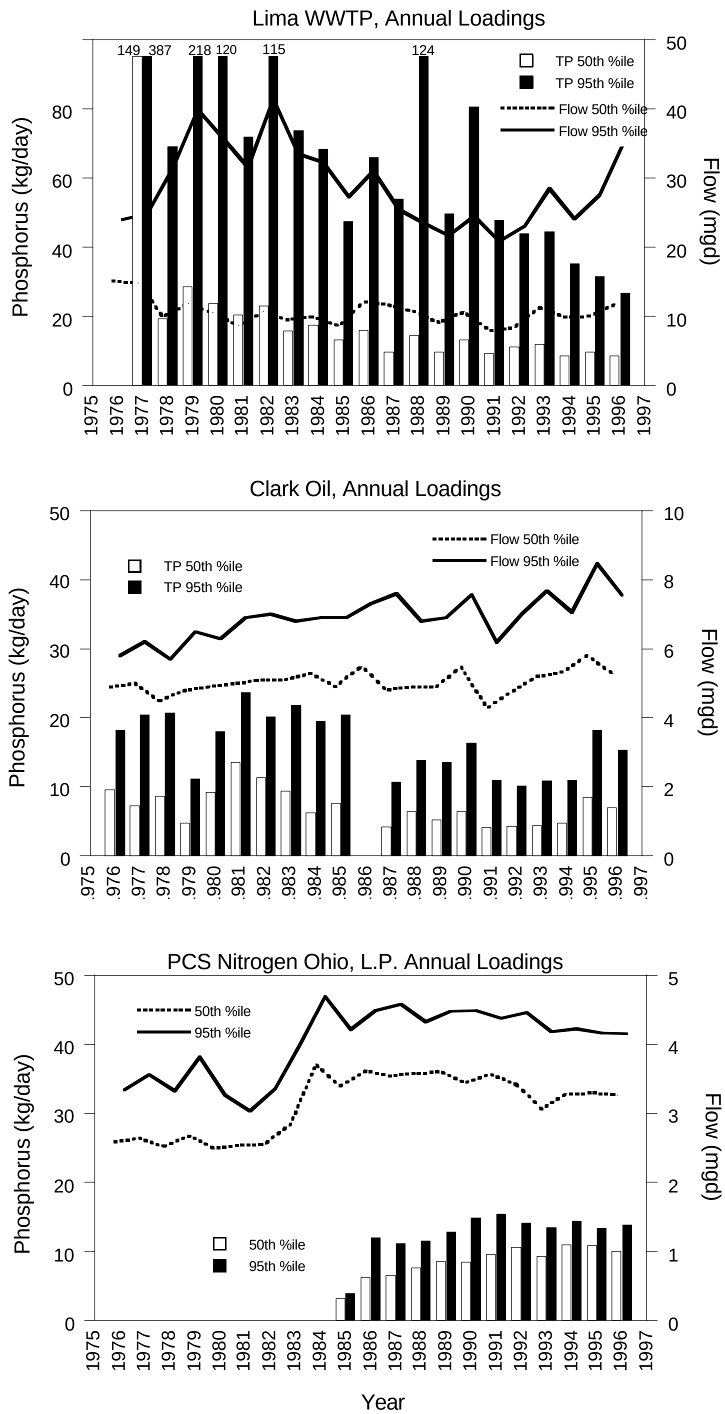


Figure 19. Annual 50th and 95th percentile loadings of phosphorus for Lima WWTP, Clark Oil, and PCS Nitrogen, for the years 1975 to 1996.

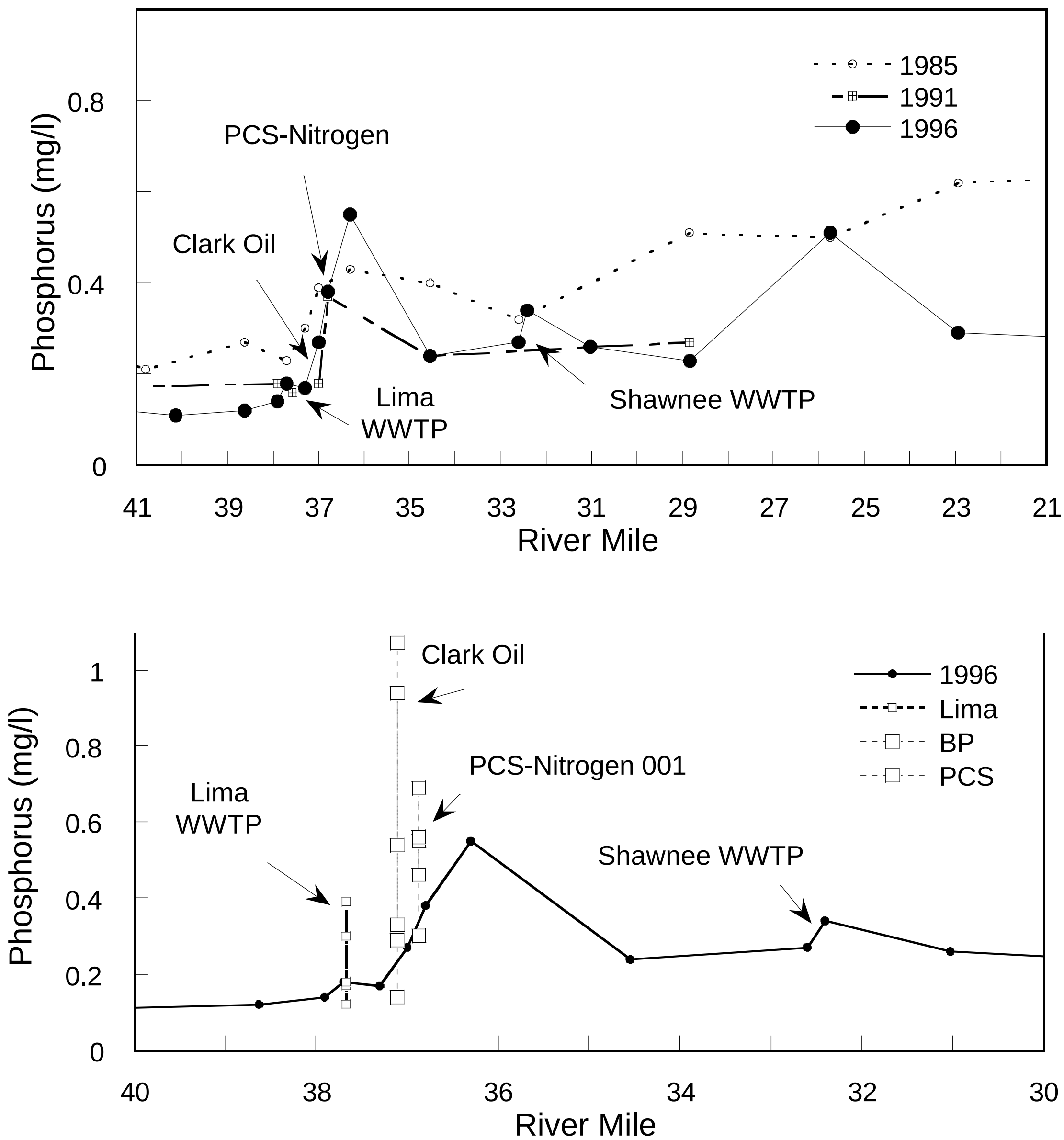


Figure 20. Longitudinal trend of phosphorus in the Ottawa River, 1985, 1991, and 1996 (top). Bottom graph is at a different scale to better demonstrate recent trends in the immediate Lima area.

Chromium

Chromium limits were required in the PCS Nitrogen (formerly BP Chemicals) permit from 1977-88. These limits appear to have been a response to the high levels of chromium observed in the effluent in 1975-76. Chromium may have been used as a cooling water additive at PCS Nitrogen and was replaced by other chemicals in 1977. Chromium is a federal guideline parameter for petroleum refineries and, as such, has been limited in all of the permits for Clark Oil. Federal guidelines require loading limits, but concentration limits have been required at times to help assure that WQS are maintained.

The largest use of chromium at these industrial plants is as a cooling tower additive, used to inhibit biological growth. These additives have been replaced by less toxic and persistent compounds for most uses. Both Clark Oil and PCS Nitrogen have reduced chromium loadings over the period of record. Clark Oil's discharge levels have declined gradually, while PCS Nitrogen levels declined rapidly during the late 1970s. By 1990, concentrations and loadings were low enough with respect to the WLA that limitations were removed. Chromium loadings from the public WWTPs are generally low.

The only detection of chromium in the 1996 water chemistry survey (30 ug/l detection limit) was an instream concentration of 49 ug/l downstream from the PCS outfall 001, and the only detections in the effluents tested were in 4 of 6 PCS outfall 001 effluent samples ranging from 38 to 64 ug/l. (Lima WWTP and BP Refinery each had six samples below detection). The metal translator study had a much lower detection level (0.05 ug/l) for chromium, but was sampled at only two locations - Thayer Rd and the Fire Station. This study showed total chromium concentrations increased from Thayer Road (0.37 ug/l, five sample average) to downstream from PCS Nitrogen at the Fire Station site (4.65 ug/l, five sample average).
Apparently chromium is settling out in the sediments in concentrations toxic to aquatic organisms (Figure 21). The highest chromium sediment concentration collected by the Ohio EPA in both 1991 and 1996, and reported in the City of Lima Water Quality Impact Study (1996 data), was downstream from the PCS-Nitrogen 001 outfall at levels exceeding the Ontario severe effect level (> 110 ug/g).

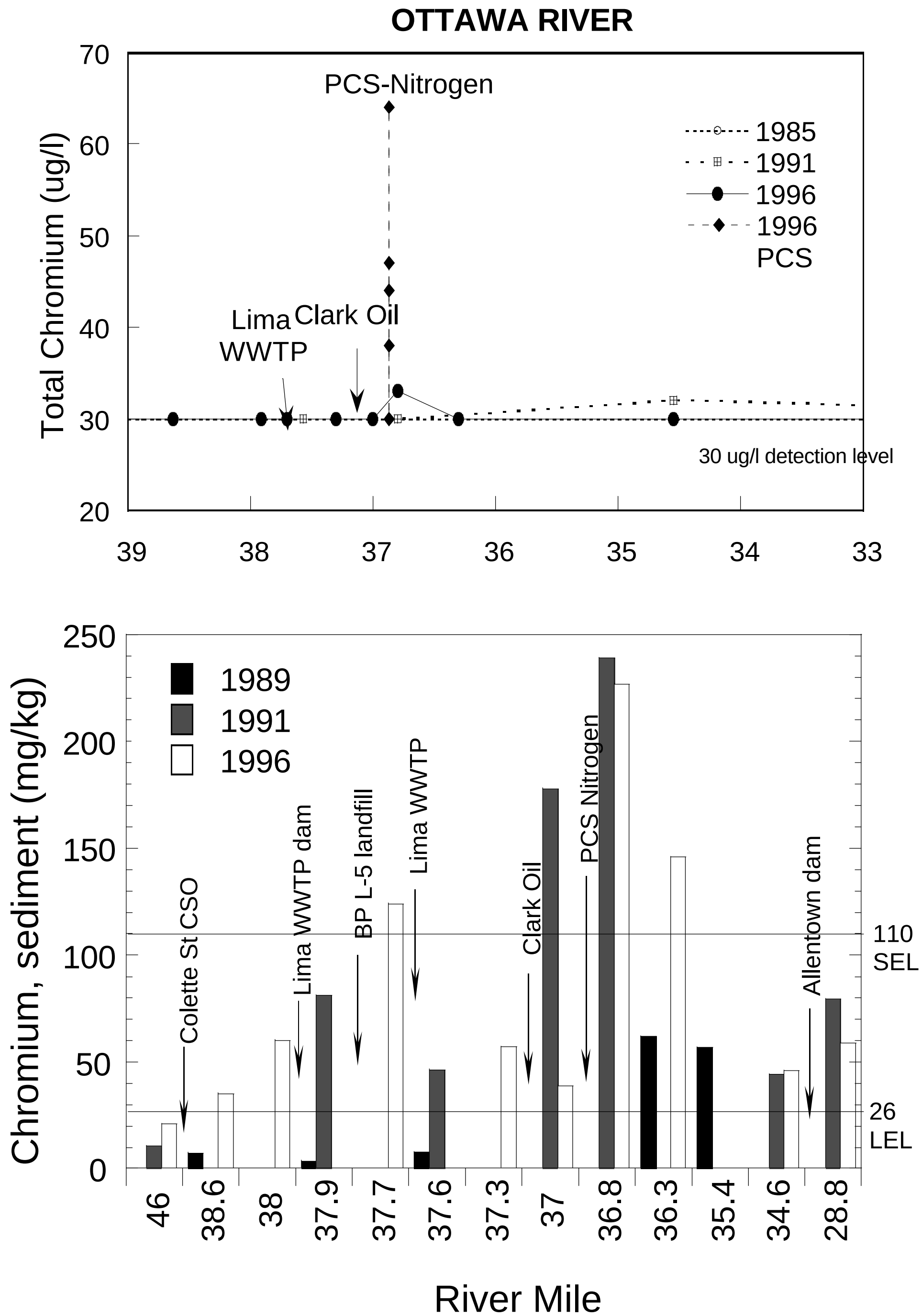


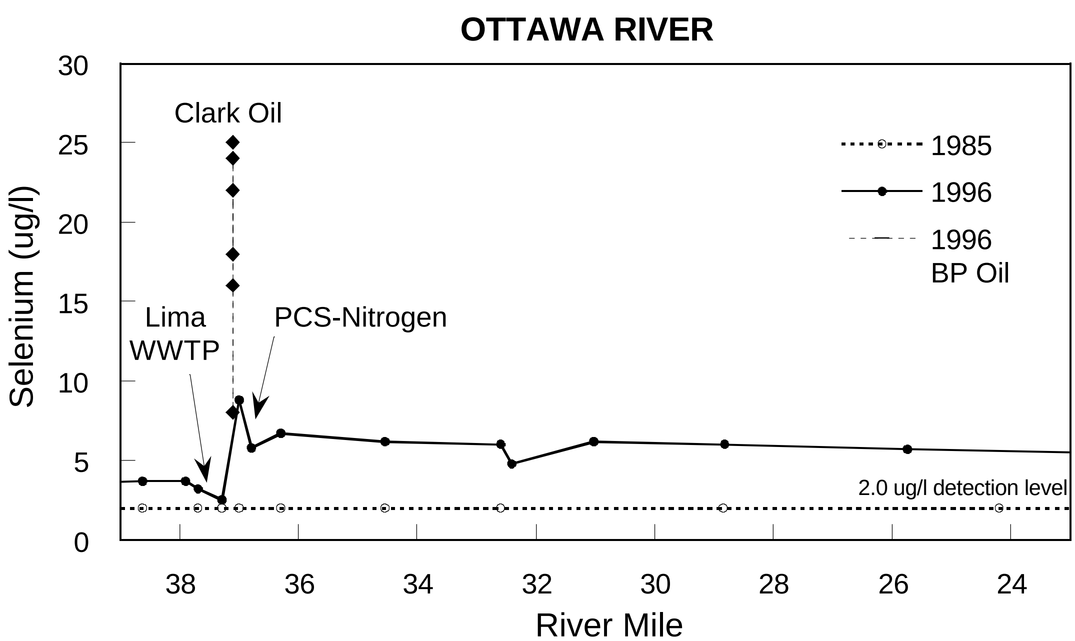
Figure 21. Surface water and sediment quality trend graphs of chromium in the Ottawa River, 1986 to 1996.

Selenium

Water chemistry data (6 samples per site) reported an increase in selenium concentrations from an average of 2.5 ug/l upstream Clark Oil outfall 001 at RM 37.30 to 8.8 ug/l downstream at RM 37.00 (Figure 22). The average concentration (6 samples collected concurrently with the instream samples) of Clark Oil outfall 001 was 18.8 ug/l. A large number of selenium exceedences (# of samples > 5 ug/l) were documented downstream from the Clark Oil discharge, in at least half of the samples collected at RM 37.00 (5), RM 36.80 (3), RM 36.30 (5), RM 34.55 (5), RM 32.60 (4), RM 32.41 (3), RM 31.03 (4), RM 28.83 (4), RM 25.75 (3), and RM 22.94 (3). This data suggests that the average concentration of selenium (based on 6 grab samples per site collected during the summer of 1996) was greater than 5 ug/l in the Ottawa River for approximately 15 miles downstream from the Clark Oil outfall 001.

Selenium concentrations in both carp and smallmouth bass samples were sharply elevated downstream from the Lima WWTP and Clark Oil complex with respect to upstream samples. Although selenium is a nutrient at trace levels, it becomes toxic at higher concentrations.

Figure 22. Clark Oil effluent concentrations and instream concentrations of selenium



in the Ottawa River for the years 1985 and 1996.

Arsenic, Cadmium, Copper, Lead, Nickel and Zinc
Zinc concentrations appeared to decrease over time (Figure 23). Although zinc concentrations have peaked downstream from the major Lima dischargers, sediment levels have consistently been below the severe effect level.

Concentrations for arsenic, cadmium, lead, and nickel were mostly below the detection level in the water column chemistry in 1996. A better indication of any environmental harm would be to assess the sediment concentrations (Figure 24). Of these metals, only nickel was present at levels above the severe effect level (SEL) concentration.

Relative concentrations of metals were ranked based on a stream sediment classification system developed by Ohio EPA (1996). Sediment metal concentrations analyzed in 1996 in the Ottawa River showed nonelevated levels (except for slightly elevated chromium levels) at the two most upstream stations, Thayer Road and Fetter Road, and at the two most downstream stations, Putnam CR P and Putnam Road 19. At least one metal parameter was highly elevated to extremely elevated at sites within the City of Lima from Collett Street to SR 117 (Appendix Table). There were extremely elevated concentrations of cadmium and copper upstream from the Lima WWTP/Erie Railroad dam; chromium, copper, and nickel were extremely elevated downstream from the L5 landfill; and chromium and copper were extremely elevated downstream from PCS Nitrogen.

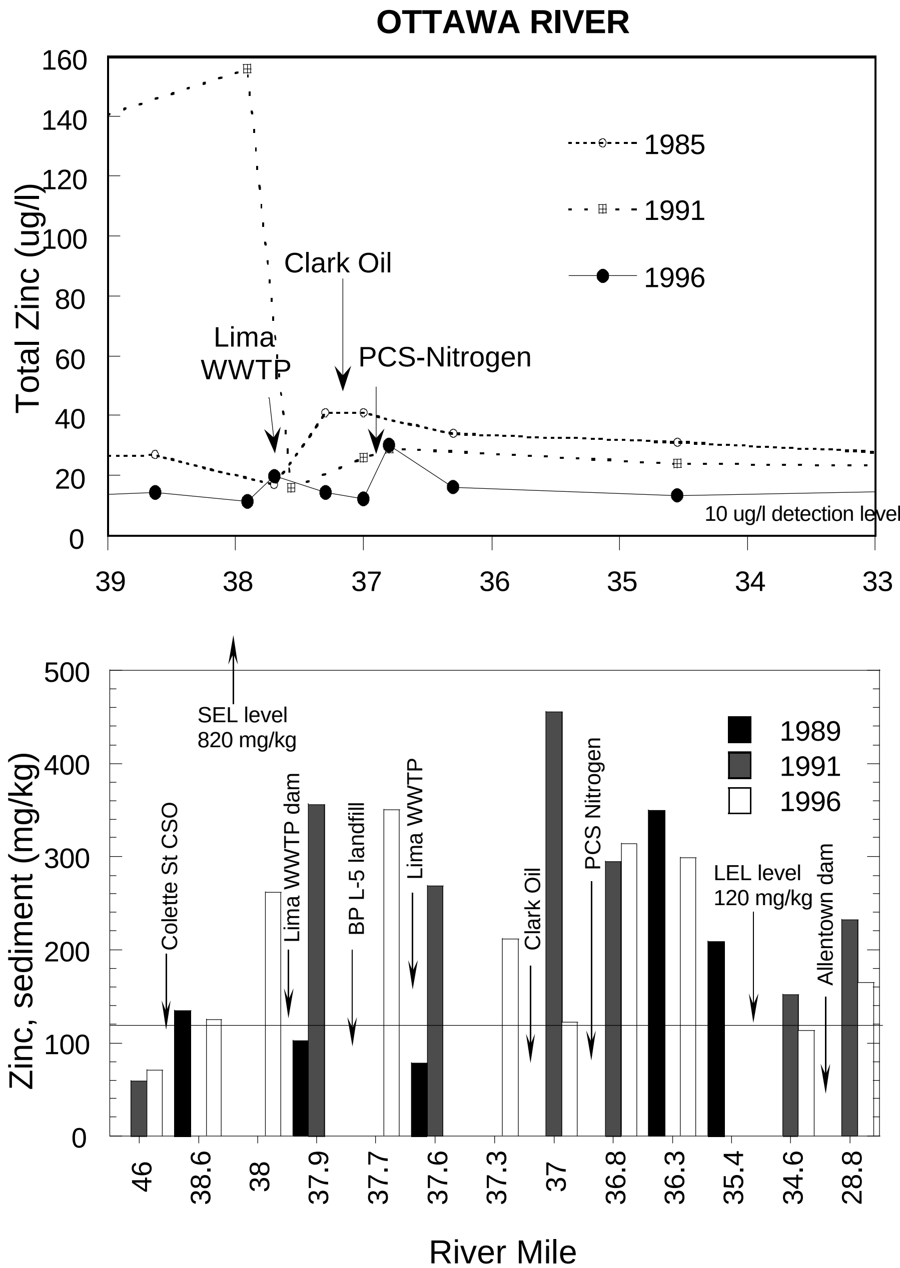


Figure 23. Surface water (top) and sediment (bottom) quality trends of zinc in the Ottawa River, 1985 to 1996.

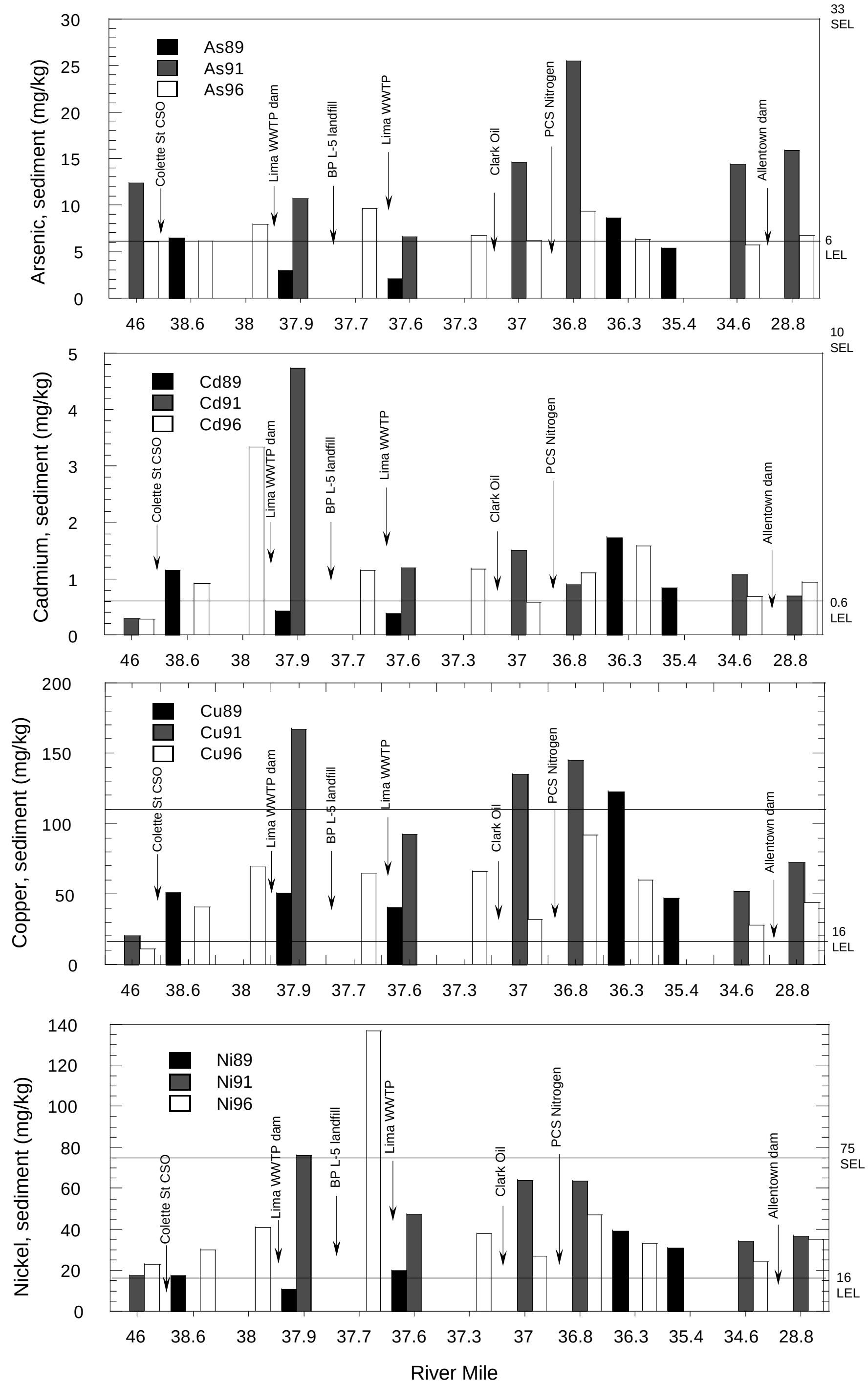


Figure 24. Longitudinal trends in sediment concentrations of arsenic, cadmium, copper, and nickel in the Ottawa River, 1989, 1991, and 1996.

Organic Compounds

Organics were analyzed at 20 surface water sampling stations and 19 sediment sampling stations during the 1996 survey (see Appendix). The 1986 and 1991 surveys sampled only for oil and grease at surface water stations and there only were three organic sediment sites sampled in 1991. Instream data showed water quality exceedences for oil and grease in 1985 (RMs 36.3 and 28.9) and in 1996 (RMs 37.7 and 36.3). Other exceedences in 1996 were y-BHC, 4,4'-DDD, and endrin at RM 37.7, and dieldrin at RM 28.83.

Concentrations of volatile and semi-volatile organic compounds were mostly below detection at the surface water stations, except for xylene at RM 40.14 and chloroform at RMs 37.3, 37.0, 36.8, 36.3, and 34.55. Concentrations of organochlorine pesticides and polychlorinated biphenyls were relatively low with more parameters detected in the lower segment of the 1996 survey than in the upper segment. One exception to these relatively low values was an oil laden sample collected at RM 37.7 downstream from the L5 landfill on September 4, 1996. The analytical results from this sample indicated highly elevated concentrations of PAHs and pesticides.

Except for two low PAH values at RM 42.61, the three sites upstream from Lima (RMs 45.97, 44.26, and 42.61) had PAHs below detection in the sediment. Total PAH values ranged from 27.6 mg/kg to 75.6 mg/kg in the City of Lima from Collett Street (RM 38.63) to the Shawnee Country Club (RM 34.55), except for the highest concentration of 662.4 mg/kg downstream from the Lima WWTP at RM 37.3 which was greater than the Severe Effect Level (SEL). The only other value greater than the SEL (using a TOC value) was 15.1 mg/kg anthracene at the Shawnee Country Club, RM 34.55. Total PAH sediment concentrations were less than 16.6 mg/kg from SR 117 (RM 32.6) to the mouth (RM 0.96), with three of the last four stations reporting values below detection.

Pesticides were below detection in the sediments upstream (Thayer Road to Roush Road) and downstream (from SR 117 to the mouth) from the City of Lima, except for one detection of methoxychlor at Piquad Road (RM 25.75). Sites upstream from the Lima WWTP/Erie-Lackawana Railroad dam (RMs 38.63 and 38.0) and downstream from PCS Nitrogen (RMs 36.8 and 36.3) had between 6 and 8 pesticide parameters detected.

Other organic sediment detections in 1996 included phenol (2 samples) downstream from the L-5 landfill (RM 37.7) and toluene downstream from PCS Nitrogen (RM 36.8). Arochlor-1260, a polychlorinated biphenyl, was detected in the sediment at 8 sites between Roush Road and the Shawnee County Club with the highest value of 340 mg/kg reported downstream from the L5 landfill (RM 37.7).

A comparison of the three common sediment sites between 1991 to 1996 showed generally higher PAH and lower pesticides concentrations in 1996.

Pike Run

Dramatic improvements in Pike Run chemical water quality occurred between the two study periods. The persistent septic conditions which were prevalent in 1991 were not present in the stream in 1996. The American Bath WWTP upgrade which was completed in April 1996 has successfully eliminated the numerous D.O., NH_3-N, and metals exceedences which were documented in 1991. However, a remaining concern in Pike Run is the frequent fecal coliform bacteria exceedences, which result from CSOs in the City of Lima collection system and SSOs in the American Bath collection system. An additional concern is the persistent detection of cadmium, which warrants further investigation.

Plum Creek

Plum Creek is designated with the Warmwater Habitat aquatic life use and the Primary Contact Recreation. Surface water quality was evaluated from near its origin southwest of the Village of Columbus Grove downstream to its confluence with the Ottawa River at RM 2.67 near the Village of Kalida. The primary objectives for evaluating Plum Creek were to assess ambient water quality upstream from the Village of Columbus Grove and evaluate impacts from the Columbus Grove WWTP and CSOs . The wastewater collection system is comprised of 80% combined sanitary and stormwater sewers. The CSOs are located prior to the plant (outfall 002) at RM 12.85, Wayne St.-Church St. (outfall 003) at RM 12.95, N. Main St.-Pendelton St. (outfall 004) at RM 13.15, and Cross St. (outfall 005) at RM 13.25. Inorganic water quality upstream was generally good to very good, with most pollutants at or below respective MDLs, although a D.O. exceedence was documented. Within the village limits, a CSO impact is evident, reflected by the D.O., NH_3-N, and fecal coliform violations which were documented. These exceedences occur due to the accumulation and decomposition of sludges, complicated by low stream gradient and channel modifications. A nutrient enrichment impact results from the Columbus Grove WWTP, with increasing nitrate, phosphorus, and BOD_5 concentrations, but it is unclear what portion of the impact is attributable to CSOs. An additional impact occurs near Kalida, especially with increasing suspended solids concentrations, but it is unknown whether this results from upstream agricultural practices or municipal sources, such as construction sites.

Zurmehly Creek

Surface water quality was evaluated at Ft. Amanda Rd. (RM 0.03) near its confluence with the Ottawa River at RM 35.63. This station was intended to evaluate ambient water quality and potential impacts from the refinery tank farm and Buckeye Road landfill. Inorganic water quality was generally very good, with most pollutants evaluated at or below respective MDLs. Some temporal variability in nutrient and suspended solid concentrations was exhibited, with higher concentrations documented through the 5 August sampling event. These results indicate a slight nonpoint source impact. No Water Quality Standards exceedences were documented at this station. A fecal coliform bacteria count exceeding the Primary Contact Recreation criterion on 16 September indicates a possible source of sanitary wastewater in the drainage.

Little Ottawa River

The Little Ottawa River is designated in the Ohio Water Quality Standards with the Warmwater Habitat aquatic life use and the Primary Contact Recreation use. Surface water quality was evaluated at Ft. Amanda Rd. (RM 0.03) near its confluence with the Ottawa River at RM 35.30. This station was intended to evaluate ambient water quality and potential impacts from the Village of Cridersville WWTP, which discharges to an unnamed tributary that flows into the Little Ottawa River at RM 4.68. Inorganic water quality was generally very good, with most pollutants at or below respective MDLs. Some temporal variability in nutrient and suspended solid concentrations was exhibited, with higher concentrations documented through the 5 August sampling event. These results indicate a slight nonpoint source impact. No Water Quality Standards exceedences were documented at this station.

Fish Kills and Chemical Spills

Pollutant discharges from spills are a significant source of lethal and sublethal stresses for aquatic communities in the Ottawa River. Leading sources (# reported spills) from 1985 to 1991 were PCS Nitrogen (12),Clark Oil (5), Lima WWTP (5), Shawnee #2 WWTP (3), and Elida WWTP (3). Leading sources from 1992 to 1996 were Shawnee #2 WWTP (67),Clark Oil (16), PCS Nitrogen (11), American Bath WWTP (11), and Lima WWTP (7). Although it appears that there were more spills in the later period, most of the spills are reported by the entities, and may have been influenced by factors such as different reporting practices. Such would be the case for the low number of spills reported for the Shawnee WWTP during the earlier period when some of the records were falsified. The large increase in reported spills at Shawnee in the latter period may be a result of this facility reporting every bypass that occurred along with CSO discharges as well, compared to other facilities that may not have reported all bypassing or CSO discharges as spills.

Pollution investigations from 1985 to 1991 list seven fish kill incidents reported compared to nine reported from 1992 to 1996. In the latter period the waterways affected (# reported fish kill incidents) were the Ottawa River (3), Hog Creek (1), Little Ottawa River (1), Leatherwood Ditch (1), Lima Lake (1), Zurmehly Creek (1), and an unnamed tributary to the Ottawa River (1).

Fish Tissue

Tissue samples collected from the Ottawa River in 1996 were analyzed for metals, polychlorinated biphenyls and pesticides. Selenium concentrations in most carp and smallmouth bass samples either approached or exceeded the respective 90th percentiles of concentrations reported in the Statewide database (Figure 25). Selenium concentrations in both carp and smallmouth bass samples were sharply elevated downstream from the Lima WWTP and Clark Oil with respect to upstream samples. Although selenium is a nutrient at trace levels, it becomes toxic at higher concentrations. Toxic responses to selenium that could occur at the concentrations detected in this study are impairment or loss of hepatic and renal function, reduced hematocrit, and increased erythrocyte irregularities (Sorensen 1991). No other fish tissue contaminant showed a defined longitudinal response in relation to either the WWTP or Clark Oil.

Mercury concentrations in both carp and smallmouth bass were highest at RM 45.9, upstream from any significant point sources, and exceeded the 90th percentile for respective samples in the Statewide database (Figure 25).

DDT was present in a fish tissue sample at RM 42.3 and nowhere else, whereas the DDT metabolites, DDD and DDE, were present at all samples collected from RM 42.3 to RM 3.6. Use of DDT in the United States has been banned since 1972; however it is highly resistant to photodegradation and oxidation, and its presence reflects this environmental persistence.

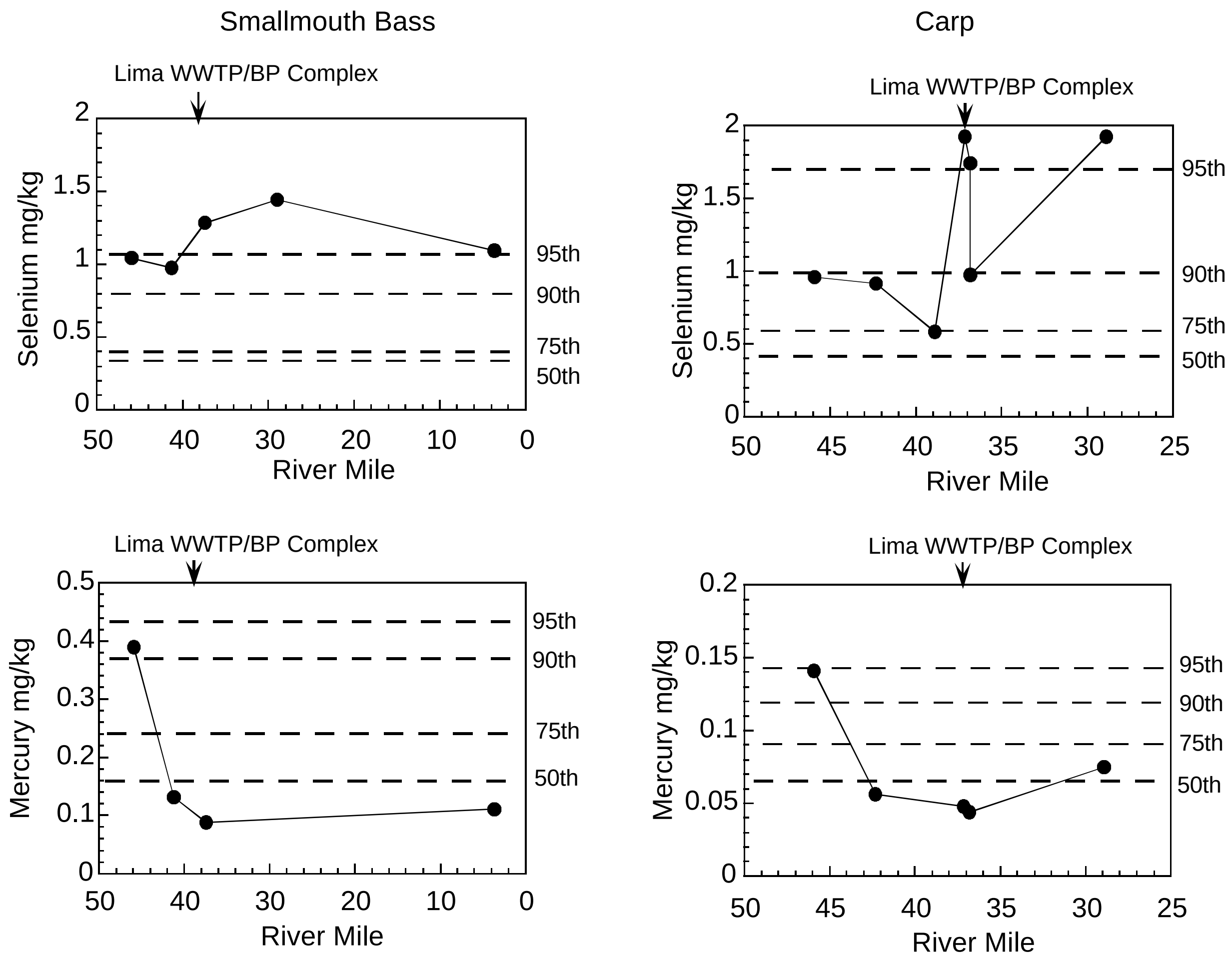


Figure 25. Concentrations of selenium (top row) and mercury (bottom row) in fillet composite samples of smallmouth bass (left column) and whole body composite samples of carp (right column) collected from the Ottawa River in relation to the Lima WWTP and the BP refinery complex (now known as Clark Oil and PCS Nitrogen). The horizontal dashed lines show the percentiles of respective contaminants by sample type from the Statewide database.

Biomarker Trends: 1991, 1993, and 1996

Blood, liver, and bile samples were collected from common carp (10 sites) and white sucker (3 sites) in the Ottawa River in 1996 at RMs 46.1, 42.4, 38.6, 37.7, 37.4, 37.0, 36.7, 34.7, 28.9, and 1.1. Biochemical analyses for ethoxyresorufin-o-deethylase (EROD) activity, bile metabolites, plasma levels of alanine transaminase (ALT), blood urea nitrogen (BUN), albumin (ALB), total protein (TP), pseudo-cholinesterase (CHE), cholesterol (CHOL), and triglycerides (TRIG) were performed for all samples from common carp. EROD measures a class of metabolic enzymes that are induced by planar xenobiotics such as polycyclic aromatic hydrocarbons (PAHs) and halogenated hydrocarbons. EROD activity is an indicator of the induction of hepatic detoxification systems. A common carp score below 50 pmol EROD/mg protein and a white sucker score below 100 pmol EROD/mg protein are a conservative indication of noninduction. Scores greater than these values indicate induction and are a measure of the exposure to these contaminants and detoxification activity by fish. In fish, metabolites of PAHs accumulate in the bile. Bile metabolites indicate recent exposure to PAHs. The benzo(a)pyrene (B(a)P-type metabolites are generally associated with combustion by-products. The naphthalene (NAPH)-type metabolites are associated with oil contamination. High BUN (blood urea nitrogen) values may be expected with fish in waters with a higher ammonia or organic nitrogen level, near sources of fertilizer or ammoniacal industrial chemical solutions, or in carp feeding in areas where ammonia is a component of the toxic sediments. Gill and kidney disfunction can also cause increased BUN.

Fish biomarker data showed increases in EROD activity, and BAP-type and NAPH-type metabolites, from upstream to downstream from the Clark Oil outfall 001. EROD values increased from 49 pmol EROD/mg protein upstream from the Clark Oil outfall to 193 pmol EROD/mg protein downstream in white suckers, and from 18 pmol EROD/mg protein to 49 pmol EROD/mg protein in carp, respectively (Figure 27). BAP-type metabolites increased from 447 ng BAP/mg protein upstream from Clark Oil to 1224 ng BAP/mg protein downstream in white suckers (500 ng BAP/mg protein, reference value), and from 930 ng BAP/mg protein to 1745 ng BAP/mg protein in carp (500 ng BAP/mg protein, reference value). NAPH-type metabolites increased from 55000 ng NAPH/mg protein upstream from Clark Oil to 115000 ng NAPH/mg protein downstream in white suckers (50000 ng NAPH/mg protein, reference value), and from 121000 ng NAPH/mg protein to 185000 ng BAP/mg protein in carp (100000 ng BAP/mg protein, reference value), see Figure 28.

Samples collected downstream from PCS Nitrogen outfall 001 at RM 36.7 had the highest blood urea nitrogen (BUN) value (4.4 units) for common carp and the highest average incidence of DELT anomalies (38.9 %) in the 1996 survey. The site located at RM 34.7 was downstream from PCS-Nitrogen outfalls 002, 003, and 004, and had the highest BUN value (2.8 units) for white suckers and the third highest incident of DELT anomalies (31.7 %). The lowest fish IBI scores sampled in the Ottawa River during the 1996 survey were also at RMs 36.7 and 34.7. Although BUN values were higher in other sections of the Ottawa River in 1991 and 1993 (indicating improvement in those sections in 1996), DELT anomalies and IBI scores downstream from PCS outfalls have remained the lowest observed in the Ottawa River in the 1985, 1989, 1991 and 1996 surveys (Figure 26).

BUN data (blood urea nitrogen)

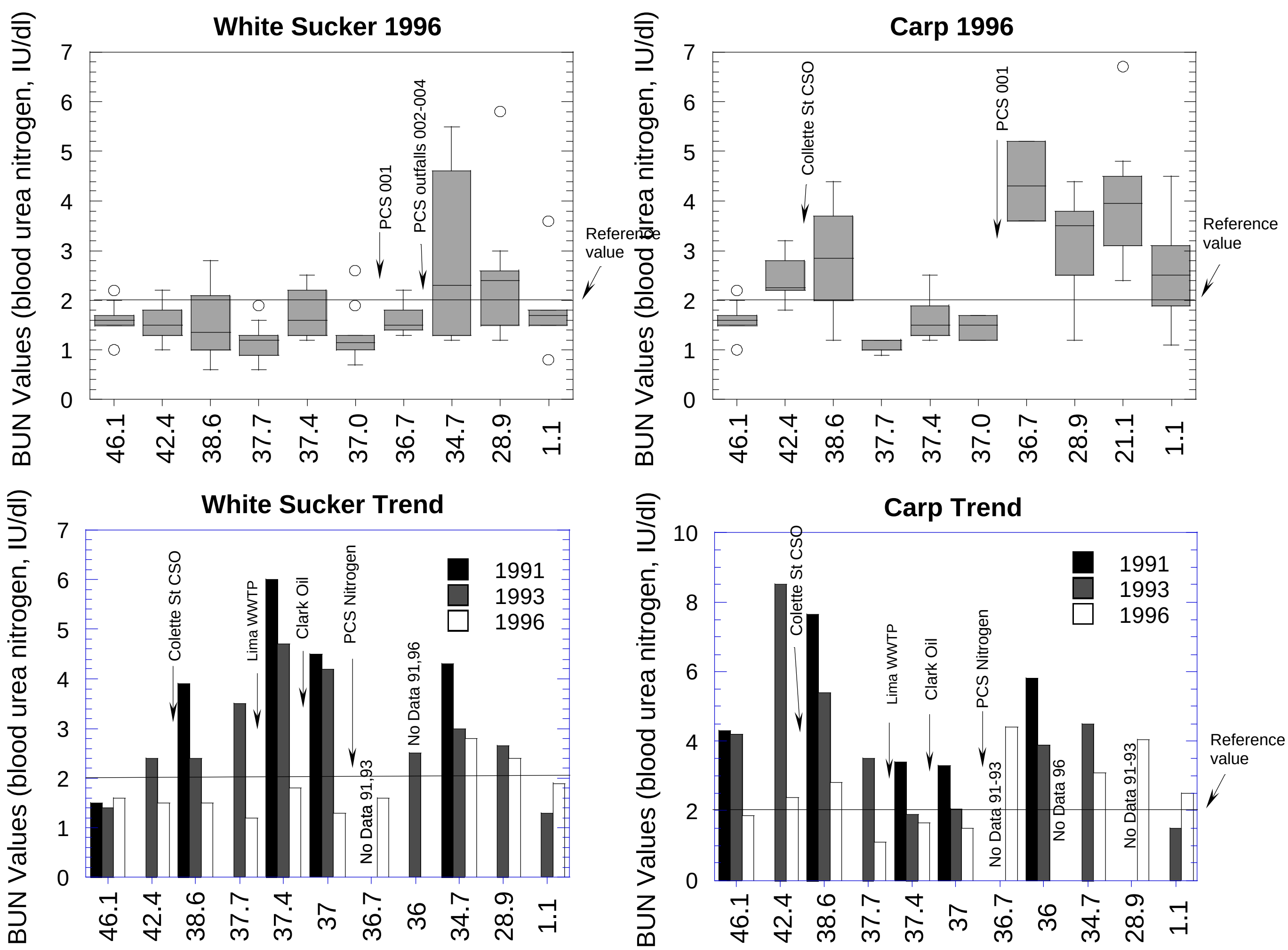


Figure 26. BUN data (blood urea nitrogen, IU/dl) for white suckers and carp in the Ottawa River. Top graphs are boxplots of the 1996 data showing the median, 25th, and 75th percentiles. Bottom graphs are bar graphs of means (average) for the years 1991, 1993, and 1996. In addition to the “no data” listed in the trend graphs, there was no data collected in 1991 at RMs 42.4, 37.7, 28.9, and 1.1.

EROD data (hepatic detoxification system indicator)

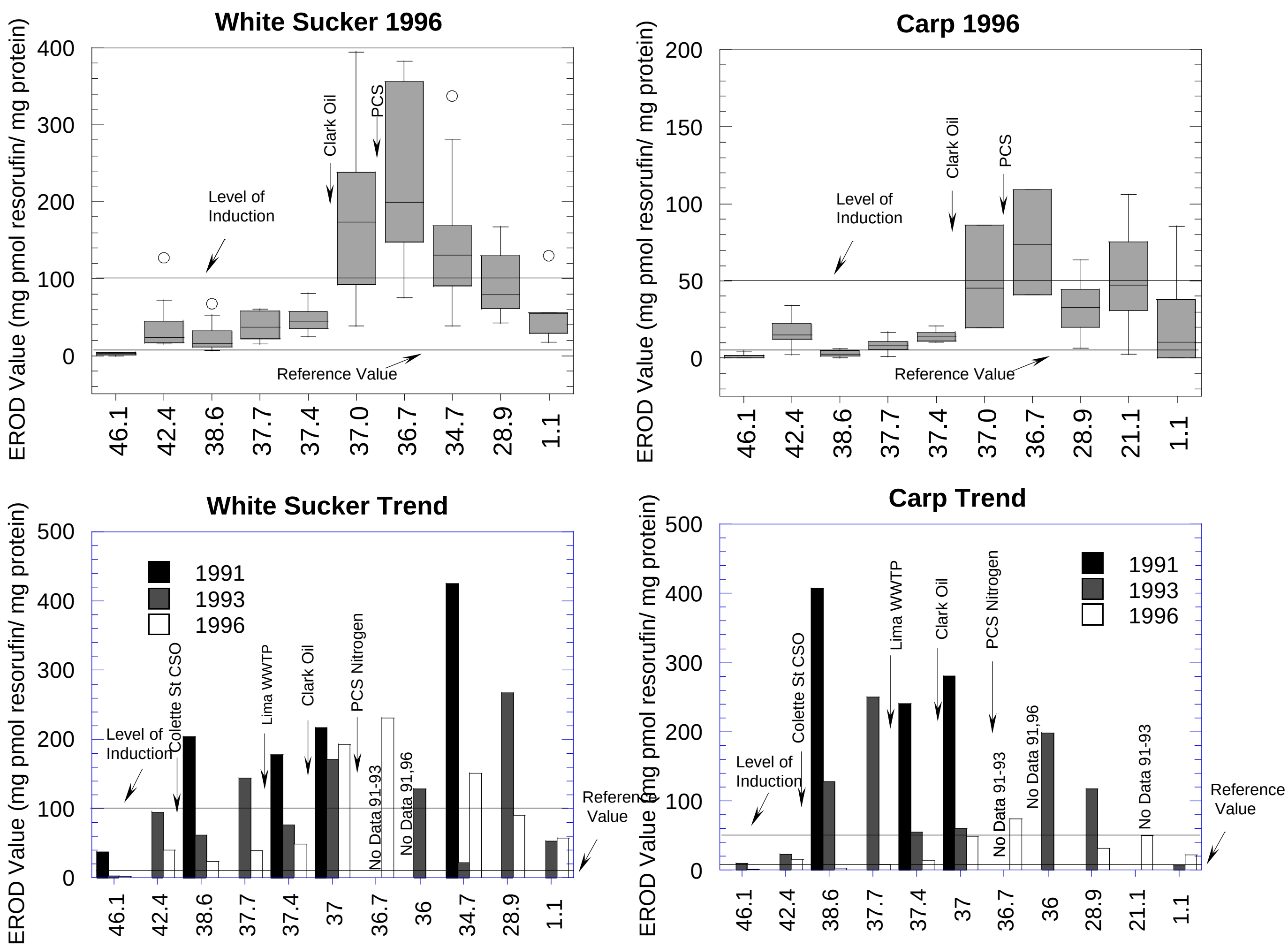


Figure 27. EROD data (mg pmol resorufin/ mg protein) for white suckers and carp in the Ottawa River. Top graphs are boxplots of the 1996 data showing the median, 25th, and 75th percentiles. Bottom graphs are bar graphs of means (average) for the years 1991, 1993, and 1996. In addition to the “no data” listed in the trend graphs, there was no data collected in 1991 at RMs 42.4, 37.7, 28.9, and 1.1 for both white suckers and carp, and no data collected in 1991 at RM 46.1 for carp.

BAP- and NAPH-Type Metabolites (combustion and oil contamination indicators)

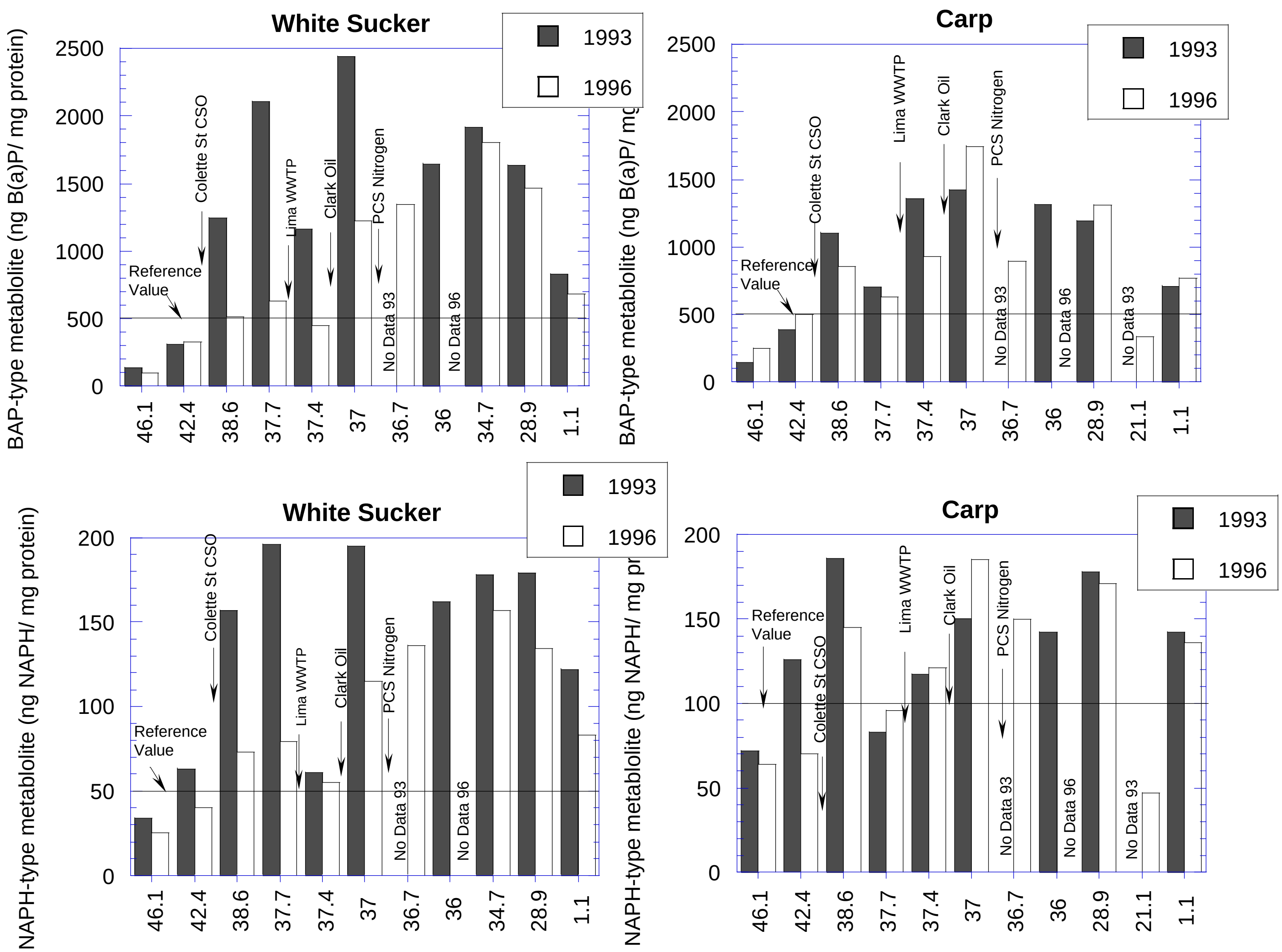


Figure 28. BAP-type (ng B(a)P/ mg protein) and NAPH-type (ng NAPH/ mg protein) metabolite data for white suckers and carp in the Ottawa River for the years 1993 and 1996.

Physical Habitat for Aquatic Life

Ottawa River

A thirty mile stretch of the Ottawa River from RM 46 to RM 16 is composed of an alternating series of high quality free-flowing habitats, and channel modified or impounded habitats. Normal warmwater habitat attributes dominate the free-flowing segments as evidenced by the low ratio of modified to warmwater habitat attributes (0.42 ± 0.22 SD; Table 6). Typically, the habitat within these segments is characterized by a moderately sinuous channel containing well defined riffle-pool-run sequences, an abundance of unembedded boulder and cobble substrates, woody debris, root mats and root wads supplied by wooded riparian buffers, and water willow fringing the margins of the shallows and riffles. The high QHEI scores ($\bar{x}$ = 76.2 ± 5.1 SD) reflect these positive attributes. Conversely, the segments influenced by channelization and impoundment contain few natural warmwater habitat attributes and have more modified attributes than warmwater attributes. In most instances, habitat limitations within these segments include embedded substrates, little or no cover, poor channel development and low sinuosity, and no functional riffles. A 3 mile segment from RM 38 to RM 41 is unduly modified by a relatively contiguous series of low-head dams and other channel modifications. The number of modified habitat attributes within this reach (see Table 6) is likely to preclude warmwater faunas. Although the habitat within the other segments influenced by channelization and impoundment are locally limiting, they are not of sufficient length or frequency to lower the warmwater potential of the remaining free flowing river.

Plum Creek

Plum Creek has been extensively channelized throughout its length. Consequently, the number of modified habitat attributes exceed warmwater attributes at all of the six locations evaluated (Table 6). The channel lacks development, sinuosity, cover, and substrate heterogeneity at all locations. The lack of warmwater attributes is sufficient to preclude establishment of a functional warmwater fauna (Rankin 1995). The average QHEI score for the six sites sampled is 42.8 ± 9.0 SD.

Pike Run

Like Plum Creek, Pike Run has been converted into a drainage ditch lacking functional habitat attributes. The average QHEI score for the five sites sampled is 50.3 ± 12.3 SD.

Little Ottawa River

Though the site evaluated was not channelized, extensive channelization of upstream reaches imparts modified attributes to the site. Little cover is present, sinuosity low, and substrates are relatively homogenous and embedded. The number of modified attributes exceed the number of warmwater attributes (Table 6), thereby limiting the potential to support a warmwater fauna.

Zurmehly Creek

Zurmehly Creek at the site evaluated was previously channelized. Though having recovered some free flowing character, it remains dominated by modified habitat attributes. Substrates are embedded with silt and sand, the sand bedload suffocates riffles rendering them nonfunctional, and sinuosity is low.

The modified character of the stream is augmented by effects of urban runoff as evidenced by the heavy bedload of sand and silt. The QHEI score of 58 indicates a marginal ability to support a fauna consistent with WWH expectations. The high gradient should promote a faster rate of improvement of WWH characteristics.

Table 6. Matrix of Qualitative Habitat Evaluation Index (QHEI) attributes and QHEI scores for sites sampled for fish in the Ottawa River basin, 1996.

Key
QHEI
Components

(04-200) Ottawa River

Year: 96

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max. Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
46.1	84.0	7.81	■	■		■	■	■	■	■	■	■	9						0	-								-				2	0.10	0.30
44.4	71.0	7.94	■			■	■	■		■	■	■	7	●					1					-				-				2	0.25	0.50
43.6	45.5	0.10		■				■			■		3		●				1	-	-			-	-			-	-		-	7	0.50	2.25
43.4	70.5	4.46	■	■		■		■	■	■	■	■	8				●		1					-	-							2	0.22	0.44
42.3	57.5	0.10	■	■				■		■	■		5				●		1		-			-	-			-	-		-	6	0.33	1.33
41.2	81.0	3.62	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
40.8	51.0	0.10	■	■			■	■			■		5		●				1		-			-		-		-	-		-	6	0.33	1.33
40.2	48.0	0.10		■			■	■			■		4						0	-	-			-		-		-	-		-	7	0.20	1.60
39.9	44.5	0.10		■				■			■		3		●		●		2	-	-			-	-			-	-		-	7	0.75	2.50
38.9	45.5	0.10		■							■		2		●		●		2	-	-			-	-			-	-		-	7	1.00	3.33
38.5	47.5	0.10		■				■			■		3		●		●		2	-	-			-	-			-	-		-	7	0.75	2.50
37.9	81.5	5.56	■	■		■		■	■	■	■	■	8						0						-							1	0.11	0.22
37.7	69.0	5.56	■	■		■		■			■		5						0	-	-			-	-			-	-		-	7	0.17	1.33
37.6	73.5	5.56	■	■		■	■	■	■	■	■	■	9						0						-	-		-				3	0.10	0.40
37.4	65.5	5.56	■	■					■	■	■		6				●		1		-		-	-	-					-		5	0.29	1.00
37.1	76.5	5.56	■	■		■		■	■		■		6						0					-	-				-	-		4	0.14	0.71
37.0	58.0	7.81		■		■			■		■		4				●		1					-	-				-	-		4	0.40	1.20
36.8	48.0	7.81		■						■	■		3	●			●		2		-			-	-	-		-			-	6	0.75	2.25
36.7	59.5	7.81		■							■		2	●			●		2	-				-	-			-	-		-	6	1.00	3.00
36.0	84.0	3.47	■	■		■	■	■	■		■		7						0										-	-		2	0.13	0.38
34.7	79.5	3.03	■	■		■	■	■	■		■		7						0		-							-	-	-		4	0.13	0.63
32.8	70.0	5.26	■	■		■	■	■			■		6				●		1	-								-	-	-		4	0.29	0.86
32.4	80.0	5.26	■	■		■	■	■	■		■		7						0									-	-	-		3	0.13	0.50
28.9	75.0	6.25	■	■		■	■	■			■		6						0	-	-			-				-	-	-		6	0.14	1.00
28.8	68.0	6.25	■	■		■		■	■		■		6				●		1						-				-	-		3	0.29	0.71
25.5	65.0	2.22		■		■				■	■	■	5				●		1	-	-			-	-			-	-			6	0.33	1.33
21.0	60.5	1.62	■	■				■			■		4				●		1	-				-	-			-	-	-		6	0.40	1.60
16.2	71.5	5.26	■	■	■	■		■	■	■	■	■	9						0					-	-			-				3	0.10	0.40
5.6	79.0	3.45	■			■	■	■		■	■	■	7						0									-				1	0.13	0.25

Table 6. Continued.

Key
QHEI
Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max. Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(04-200) Ottawa River																																		
Year: 96																																		
3.8	77.5	2.21	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
1.2	73.5	1.68	■	■		■	■	■	■	■	■	■	9						0		-								-			2	0.10	0.30
(04-201) Plum Creek																																		
Year: 96																																		
15.3	36.0	4.27					■	■					2	●	●		●	●	4		-			-				-	-	-		5	1.67	3.33
12.9	57.0	6.02		■						■	■		3				●		1	-				-	-			-		-		5	0.50	1.75
12.2	42.5	6.85		■							■		2	●			●		2					-	-			-	-		-	5	1.00	2.67
8.1	33.0	2.24									■		1	●			●		2		-			-	-	-		-	-	-		7	1.50	5.00
5.5	49.5	1.86	■				■	■			■		4				●		1				-	-		-		-	-	-		6	0.40	1.60
0.2	39.0	2.89	■					■			■		3		●				1		-		-	-	-			-	-	-	-	8	0.50	2.50
(04-208) Pike Run																																		
Year: 96																																		
8.3	58.5	6.85	■	■		■	■	■			■		6						0	-	-			-				-	-	-	-	7	0.14	1.14
8.1	62.0	6.85	■	■		■	■	■			■		6						0					-				-	-	-	-	5	0.14	0.86
4.7	37.5	4.63	■				■	■			■		4		●	●	●		3	-	-			-	-	-		-	-	-	-	9	0.80	2.60
2.2	36.5	4.76						■			■		2		●	●	●		3	-	-		-	-	-			-	-	-		8	1.33	4.00
0.6	57.0	5.75	■			■	■	■			■		5		●				1		-							-	-	-		4	0.33	1.00
(04-213) Little Ottawa River																																		
Year: 96																																		
0.4	55.0	8.33	■	■							■		4			●	●		2					-	-			-	-	-		5	0.60	1.60
(04-261) Zummerly Creek																																		
Year: 96																																		
0.1	58.0	27.78	■	■				■			■		4			●			1		-			-	-			-	-	-		6	0.40	1.60

TRENDS

Biological Assessment - Macroinvertebrate Communities

Ottawa River: 1974-1996

Macroinvertebrates collected at Thayer Road (RM 45.9/46.0) yielded Invertebrate Community Index (ICI) scores that have attained the WWH criterion in the 1980s and 1990s (Figure 29). Sampling from 1985 to 1996 showed very good to exceptional conditions (except for an ICI of 36). Although the ICI scores ranged only from 16 to 24 in the 1970s, each sampling year from that time period was narratively evaluated as good at the time based on the mayfly, caddisfly, stonefly, and tanytarsini taxa present.

Previous surveys have not been as comprehensive as the 1996 survey for the area between Thayer Road and the Lima WWTP. Macroinvertebrates were collected at 8 sites between RM 45.9 and RM 37.9 in 1996, compared to 3 sites in 1985, and less in other years. Benthic communities collected from RMs 44.5, 43.4, 42.4, and 41.2 scored ICI values in the good to very good range in 1996 (Table 7). The site at Sugar Street (RM 41.2) has improved from ICI scores of 16 (fair) in 1985 and 32 (marginally good) in 1989, to 42 (very good) in 1989.

There are five lowhead dams and five major CSOs in the City of Lima (Figure 4). Macroinvertebrates were collected at four locations downstream from these dams and CSOs in 1996. The benthic sample collected at RM 40.1 (ICI of 20 in the fair range) was downstream from the Lovers Lane dam and on the opposite side of the stream from the Lovers Lane CSO control structure. The next site was at RM 37.9. between the Elm Street dam and the Central Street dam. There were no CSOs between these dams and habitat was good despite the urban setting. The ICI score was marginally good and indicated that without impacts from CSOs, this reach has the capability of supporting a WWH community for the macroinvertebrates. However, CSOs in this reach of the river contribute high loads of suspended solids and CBOD during rainfall events and result in low dissolved oxygen levels that persist afterwards. The prime example is the Collett Street CSO (RM 38.63). Not only was the D.O. level low after rainfall events but the turbidity caused by suspended solids interfered with the probe on the dissolved oxygen meter causing it to malfunction in both the Ohio EPA and the City of Lima studies. The effect of the low D.O. and settling of suspended solids on the benthic communities at RM 38.6 resulted in poor communities where pollution tolerant aquatic worms and the midge *Dicrotendipes simpsoni* accounted for 93 % (1985) and 33 % (1996) of the organisms collected from the artificial substrates. Caddisfly and tanytarsini taxa were not found either year at this site.

Benthic communities collected downstream from the Lima WWTP dam at RM 37.9/37.8 have historically had ICI scores in the very poor to poor range from 1974 to 1991.Previously the ICI scores at this site have ranged from a low of 0 (very poor) in the 1970s to 16 (fair) in 1989. Due to increased numbers of EPT, dipteran taxa, and total taxa, and a smaller percentage of tolerant organisms, this site scored an ICI value of 28 (fair) in 1996 (Figures 30 and 31).

The L5 Landfill is located on the river right bank (south bank) between RM 37.9 and 37.7. At the downstream site (RM 37.7) the numbers of dipteran taxa and total taxa decreased and there was an increase in the percentage of tolerant organisms (a reversal of trends seen at the upstream site) resulting in a lower ICI score of 14.

Macroinvertebrate communities downstream from the Lima WWTP at RM 37.4/37.3 have shown a dramatic recovery in 1996 (ICI score of 42) compared to previous sampling years (Figure 29). The ICI score ranged from 0 in the 1970s to 10 in 1991. In 1974 and 1976 there were large percentages of the tolerant midge genus *Chironomus*, representing high amounts of nutrient rich, sewage pollution. No mayflies, caddisflies, or tanytarsini midges were collected at this site from 1974 to 1985. Only one taxon of tanytarsini midges was collected on the artificial substrates in 1989 and 1991, and mayflies (one taxa) didn’t appear until 1991. In 1996, a total of 10 EPT taxa and three tanytarsini midge taxa were collected from the artificial and natural substrates.

The Ottawa River downstream from Clark Oil (RM 37.0) and PCS Nitrogen (RM 36.8/36.1) was also virtually devoid of EPT taxa and tanytarsini midge taxa from 1974 to 1985 with ICI scores in the very poor to poor range (0-6). In 1985, tolerant organisms, including aquatic worms and the tolerant midges *Cricotopus bicinctus* and *Nanocladius distinctus*, accounted for 52% to 75% of the organisms collected from the artificial substrates (Figure 31). Slight improvements in the macroinvertebrate communities were observed from 1989 to 1996 with the appearance of the mayfly *Baetis intercalaris* as a predominant organism collected from the artificial substrates, with generally lower percentages of tolerant taxa and increases in EPT taxa. The highest ICI scores at these sites were still only 20 and 22 (mid-fair range) in 1996.

In the lower 35 miles of the Ottawa River, macroinvertebrate communities were in nonattainment of ecoregion biocriteria (ECBP and HELP) in the 1970s with ICI scores ranging from 0 to 14. The 1985 survey showed the lower seven miles to be in attainment, the 1989 survey showed the lower 20 miles to be in attainment, and the most recent survey in 1996 showed most of the lower 30 miles to be in attainment or nonsignificant departure from the macroinvertebrate ecoregion biocriteria (ECBP and HELP). This pattern of recovery (i.e., attainment progressing in a downstream to upstream direction with less severe near-field impacts) has been observed in many Ohio streams and rivers.

Plum Creek

Upstream from the Village of Columbus Grove, macroinvertebrate communities reflected fair conditions. Sampling yielded a relatively low number of EPT taxa (5) and a low QCTV score (32.6); both were below expectations based on sites in this drainage basin that achieve WWH criteria. Flatworms, clams, and aquatic sowbugs were predominant. Water quality was further degraded to poor conditions at the site at RM 12.9, downstream from Columbus Grove CSOs but upstream from the Columbus Grove WWTP. Only one EPT taxon was collected from this site and the tolerant midge taxon *Chironomus decorus* was one of the numerically predominant organisms.

The next station at RM 11.5 and the succeeding stations improved to marginally good and good macroinvertebrate community conditions. Communities had higher numbers of taxa and QCTV scores, and caddisflies and mayflies predominated.

Pike Run

Although macroinvertebrates collected in Pike Run were considered achieving MWH expectations at the sites sampled in 1996, the collections represented only fair community performance both upstream and downstream from the American Bath WWTP. Upstream impacts from nonpoint sources (City of Lima wet weather overflows) appeared to be the major cause. Downstream sites at RMs 5.7 and 0.1 improved to marginally good and good community conditions.

Little Ottawa River

The qualitative samples in the Ottawa River basin achieving WWH expectations generally had 9 or more EPT taxa, QCTV scores equal to or greater than 37.9, and over 40 total qualitative taxa. The site on the Little Ottawa River (RM 0.4) had slightly less than these optimal characteristics and was evaluated as marginally good.

Zurmehly Creek

The qualitative sample collected at RM 0.1 was evaluated as fair. The sample had a relatively low number of EPT taxa and a QCTV score less than the 75th percentile of comparable ECBP ecoregion sites not achieving the WWH biocriterion.

Table 7. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and from natural substrates (qualitative sampling) in the Ottawa River basin, 1996. Also included are historical collection summaries from 1974-95, where available.

Quantitative Evaluation

Stream/River Mile	Density (#/sq.ft.)	Quant Taxa	Qual Taxa	Qual EPT[a]	Total Taxa	QCTV Score[b]	ICI	Evaluation
Ottawa River (1996)								
	Eastern Cornbelt Plains Use Designation (Existing)							
45.9	617	40	62	16	74	39.5	48	Exceptional
44.5	432	37	51	13	63	39.2	40	Good
43.4	537	30	39	13	52	39.0	40	Good
42.4	-	-	56	12	-	37.7	-	Good
41.2	326	36	39	13	54	39.0	42	Very Good
40.1	779	26	41	8	52	32.9	20*	Fair
39.6	1331	44	45	12	66	32.8	34[ns]	Marginally Good
38.6	473	19	32	2	42	30.5	6*	Poor
37.9	2121	39	41	8	55	32.9	28*	Fair
37.7	561	28	23	4	37	32.8	14*	Fair
37.4	825	40	52	8	66	32.6	42	Very Good
37.1	*313*	*31*	*18*	*1*	*39*	*32.4*	*18*	*Fair*
37.0	536	30	43	4	55	31.9	20*	Fair
36.1	627	24	36	4	45	32.4	22*	Fair
34.5	1049	31	42	9	48	34.3	38	Good
32.6	1491	43	51	8	62	34.3	32[ns]	Marginally Good
32.4	-	-	42	5	-	33.1	-	Fair
28.8	1268	29	48	10	59	34.9	32[ns]	Marginally Good
25.8	801	33	46	12	57	38.7	44	Very Good
22.9	524	24	32	9	44	37.7	36	Good
16.0	1124	41	45	12	65	34.2	48	Exceptional
7.8	1499	31	40	15	52	40.3	46	Exceptional
3.6	1685	61	49	16	58	41.5	46	Exceptional
0.8	1462	24	35	13	46	42.4	48	Exceptional
Ottawa River (1995)								
	Eastern Cornbelt Plains Use Designation (Existing)							
45.9	611	45	46	14	66	40.6	48	Exceptional
28.8	336	28	36	9	52	34.9	30*	Fair

Table 7. (Continued)

			Quantitative Evaluation					
Stream/River Mile	Density (#/sq.ft.)	Quant Taxa	Qual Taxa	Qual EPT[a]	Total Taxa	QCTV Score[b]	ICI	Evaluation
Ottawa River (1991)								
		Eastern Cornbelt Plains Use Designation (Existing)						
45.9	1027	51	53	15	78	34.7	36	Good
37.8	1922	17	39	6	42	26.9	6*	Poor
37.4	906	20	29	1	33	28.5	8*	Poor
37.0	408	25	39	2	46	28.6	14*	Fair
36.1	1081	13	34	2	36	25.1	10*	Poor
34.5	435	17	36	3	39	26.6	18*	Fair
28.8	490	32	46	8	54	29.3	28*	Fair
0.8	2055	30	53	17	65	35.3	[28][c]	Good
Ottawa River (1990)								
		Eastern Cornbelt Plains Use Designation (Existing)						
45.9	423	37	34	13	56	39.5	50	Exceptional
28.8	182	36	33	7	47	35.9	22*	Fair
Ottawa River (1989)								
		Eastern Cornbelt Plains Use Designation (Existing)						
45.9	465	42	53	12	66	39.2	48	Exceptional
41.2	269	30	40	11	53	28.7	32[ns]	Marginally Good
37.9	1535	28	30	2	40	31.8	16*	Fair
37.4	693	15	26	0	29	31.9	10*	Poor
37.0	439	18	38	1	43	29.4	12*	Poor
36.8	606	19	19	1	31	23.9	14*	Fair
36.1a	550	19	26	2	35	27.1	16*	Fair
36.1b	440	20	26	2	37	27.1	14*	Fair
34.5	498	24	33	8	42	31.8	30*	Fair
30.1	343	25	40	9	47	32.4	26*	Fair
28.8	422	29	41	8	53	31.7	34[ns]	Marginally Good
25.8	482	29	45	11	51	35.9	30*	Fair
19.3	430	36	46	12	59	34.9	40	Good
0.8	1114	26	48	16	57	39.4	42	Very Good

Table 7. (Continued)

				Quantitative Evaluation				
Stream/River Mile	Density (#/sq.ft.)	Quant Taxa	Qual Taxa	Qual EPT[a]	Total Taxa	QCTV Score[b]	ICI	Evaluation
Ottawa River (1985)								
	Eastern Cornbelt Plains Use Designation (Existing)							
45.9	855	40	42	10	60	38.4	42	Very Good
41.1	333	27	25	4	39	32.8	16*	Fair
38.6	3035	9	22	2	22	22.6	2*	Poor
37.7	3667	18	35	4	36	27.9	6*	Poor
37.3	271	17	15	0	23	32.8	6*	Poor
37.0	405	19	19	0	26	31.7	6*	Poor
36.1	749	13	25	1	29	23.1	4*	Poor
34.5	547	18	18	1	25	31.7	6*	Poor
32.6	586	18	25	1	31	22.7	6*	Poor
28.8	487	24	25	4	33	32.8	22*	Fair
25.8	425	29	35	7	47	34.8	28*	Fair
22.9	286	27	30	4	43	31.9	24*	Fair
16.0	580	39	29	7	52	33.1	28*	Fair
7.8	1692	32	31	9	47	38.7	42	Very Good
0.8	1914	36	43	15	57	39.5	46	Exceptional
Ottawa River (1977)								
	Eastern Cornbelt Plains Use Designation (Existing)							
46.0	198	26	14	6	35	40.9	[24][c]	Good[e]
37.9	520	9	17	0	21	22.6	0*	Very Poor[e]
37.4	756	14	10	0	20	21.9	8*	Poor[e]
36.8	109	11	11	0	18	22.6	6*	Poor[e]
32.6	428	8	12	0	14	21.9	0*	Very Poor[e]
28.8	346	5	14	1	17	21.7	8*	Poor[e]
22.4	143	14	19	3	28	22.6	4*	Poor[e]
1.0	183	14	13	4	21	32.2	14*	Fair[e]

Table 7. (Continued)

Stream/River Mile	Density (#/sq.ft.)	Quant Taxa	Qual Taxa	Qual EPT[a]	Total Taxa	QCTV Score[b]	ICI	Evaluation
				Quantitative Evaluation				
Ottawa River (1976)								
	Eastern Cornbelt Plains Use Designation (Existing)							
46.0	88	25	8	2	28	40.9	[22]	Good[e]
37.9	22	7	9	1	12	17.7	0*	Very Poor[e]
37.4	417	10	5	0	13	-	0*	Very Poor[e]
36.8	254	7	5	0	9	-	0*	Very Poor[e]
32.6	2327	2	5	0	6	-	0*	Poor[e]
28.8	812	5	6	1	9	-	6*	Poor[e]
16.0	85	14	7	1	17	-	10*	Poor[e]
1.0	91	18	5	1	19	-	10*	Poor[e]
Ottawa River (1974)								
	Eastern Cornbelt Plains Use Designation (Existing)							
46.0	28	17	33	8	44	32.6	[16]	Good[e]
37.9	1067	9	14	0	19	15.9	2*	Poor[e]
37.4	3	4	1	0	5	-	0*	Very Poor[e]
36.8	105	4	9	0	9	14.3	0*	Very Poor[e]
32.6	1038	5	10	0	10	17.7	2*	Poor[e]
28.8	2107	4	15	1	18	17.7	6*	Poor[e]

Qualitative Evaluation

Stream/River Mile	Qual Taxa	QCTV Score[b]	Qual EPT[a]	Relative Density	Predominant Organisms	Narrative Evaluation
Ottawa River (1996)						
42.4	56	37.7	12	Moderate	Hydropsychid caddisflies, mayflies, midges	Good
37.66A	26	34.3	3	Low-Mod.	Baetid mayflies, blackflies,hydropsychid caddisflies	Fair
37.66B	32	34.3	7	Low	Turbellarians, oligochaetes Baetid mayflies	Fair
36.87A	18	22.6	1	Low	Leeches, red midges, beetles	Poor
36.87B	15	22.6	0	Low	Crayfish, oligochaetes,snails.	Poor
32.4	42	33.1	5	Low-Mod.	Midges, mayflies	Fair

Table 7. (Continued)

Stream/River Mile	Qual Taxa	QCTV Score[b]	Qual EPT[a]	Relative Density	Predominant Organisms	Narrative Evaluation
				Qualitative Evaluation		
Pike Run (1996)						
8.2	27	32.8	4	Low	Hydropsychid caddisflies, Nonred midges	Fair
8.1	28	32.6	3	Moderate	Hydropsychid caddisflies, Midges	Fair
5.7	29	34.2	8	Low-Mod.	Hydropsychid caddisflies, Mayflies	Marg. Good
0.8	45	32.8	7	Moderate	Hydropsychid caddisflies, Midges, mayflies	Good
Plum Creek (1996)						
14.9	28	31.8	5	Moderate	Turbellarians, clams, isopods	Fair
12.9	25	32.6	1	Low	Turbellarians, Red midges	Poor
11.5	42	34.9	5	Mod.-High	Hydropsychid caddisflies, Midges	Marg. Good
8.1	49	34.8	9	Moderate	Hydropsychid caddisflies, Nonred midges, mayflies	Good
4.4	41	38.7	10	Low-Mod.	Hydropsychid caddisflies, Nonred midges, mayflies	Good
0.2	35	34.9	6	Low	Hydropsychid caddisflies, Midges, mayflies	Marg. Good
Little Ottawa River (1996)						
0.4	36	37.7	8	Low-Mod.	Hydropsychid caddisflies, Heptagenid mayflies, Turbellarians	Marg. Good
Zurmehly Creek (1996)						
0.1	31	32.9	5	Low	Hydropsychid caddisflies, Heptagenid mayflies	Fair

Table 7. (Continued)

Ecoregion Biological Criteria:

	E. Corn Belt Plains (ECBP)			*Huron Erie Lake Plain (HELP)*		
	WWH	EWH	MWH[d]	WWH	EWH	MWH[d]
ICI	36	46	22	34	46	22

a - EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness.
b - Qualitative Community Tolerance Value (QCTV) derived as the median of the tolerance values calculated for each qualitative taxon present (see discussion in text, page 42).
c - The quantitative sample was affected by slow current speed; evaluation was based primarily on the qualitative sample.
d - Modified Warmwater Habitat for channelized habitats.
e - Evaluation based on 1979 report. Methods of collection were not the same as post 1980 data.
ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).
* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

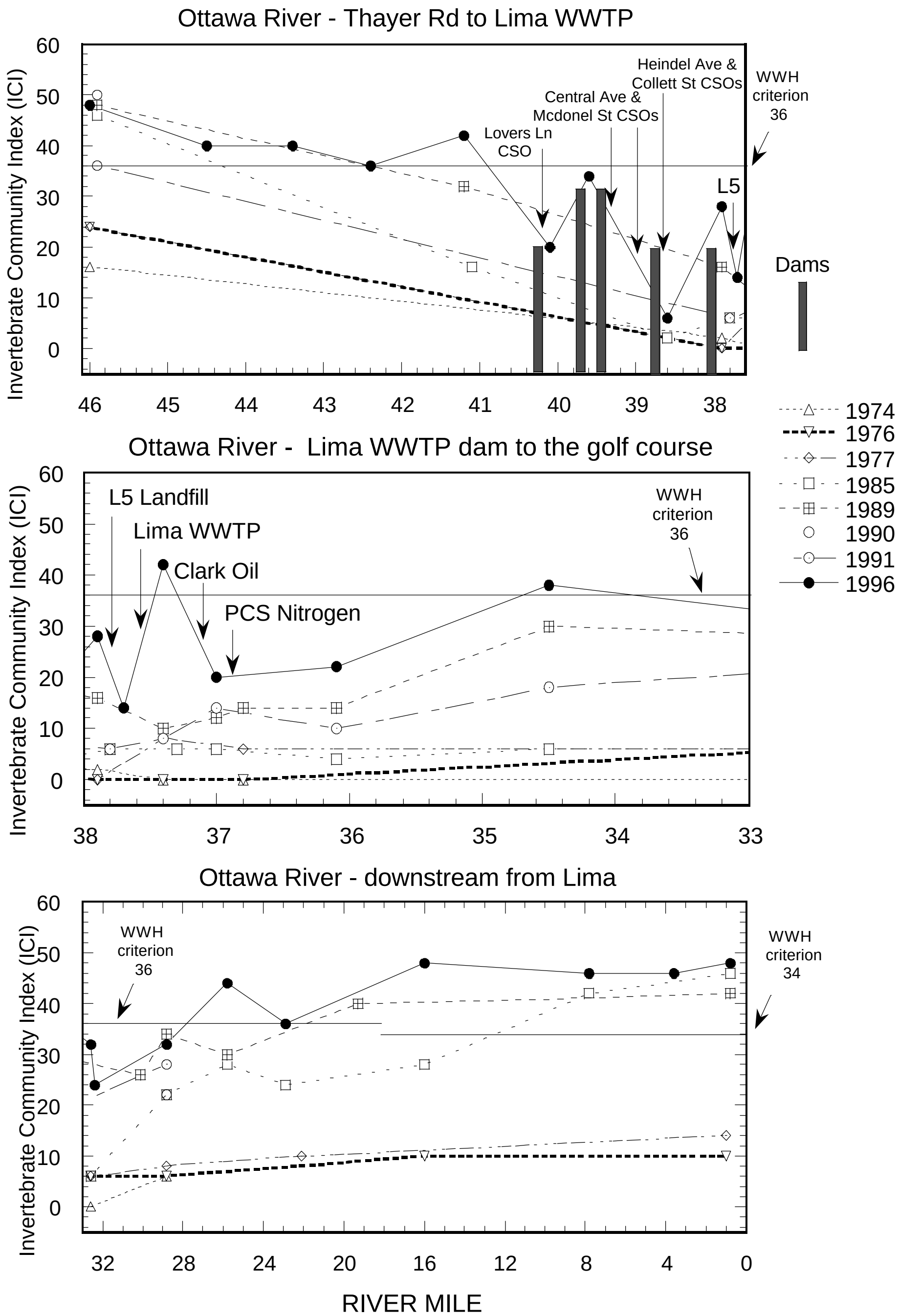


Figure 29. Longitudinal trend of the Invertebrate Community Index (ICI) in the Ottawa River for the years 1974, 1976, 1977, 1985, 1989, 1990, 1991, and 1996.

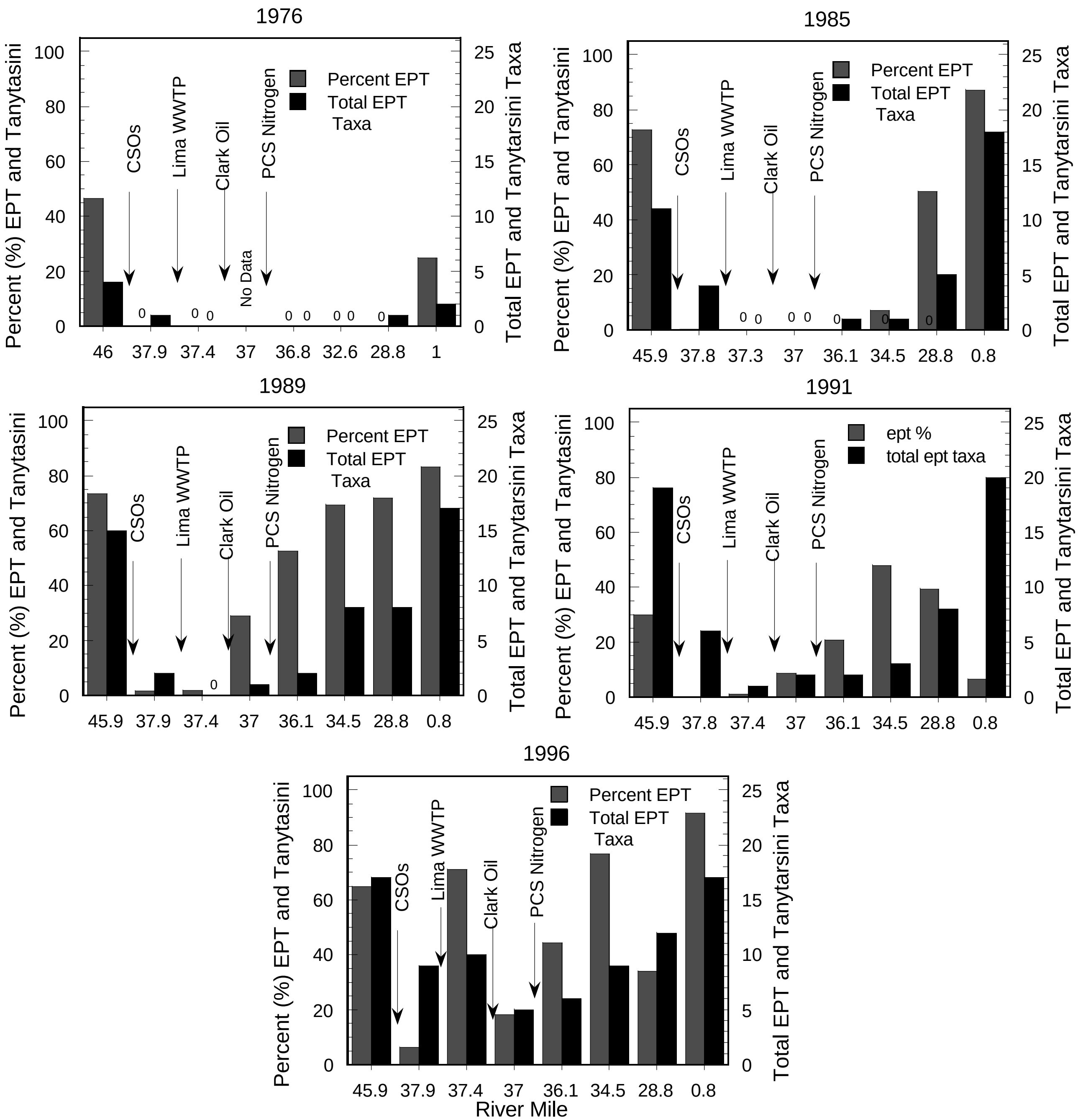


Figure 30. Percent EPT (mayfly, stonefly, and caddisfly) and tanytarsini midge taxa collected on the artificial substrates (left axis), and the total number of EPT and tanytarsini midge taxa collected from both the artificial substrates and from the natural substrates at each site (right axis) for the Ottawa River at selected sites and sampling years, 1976-1996.

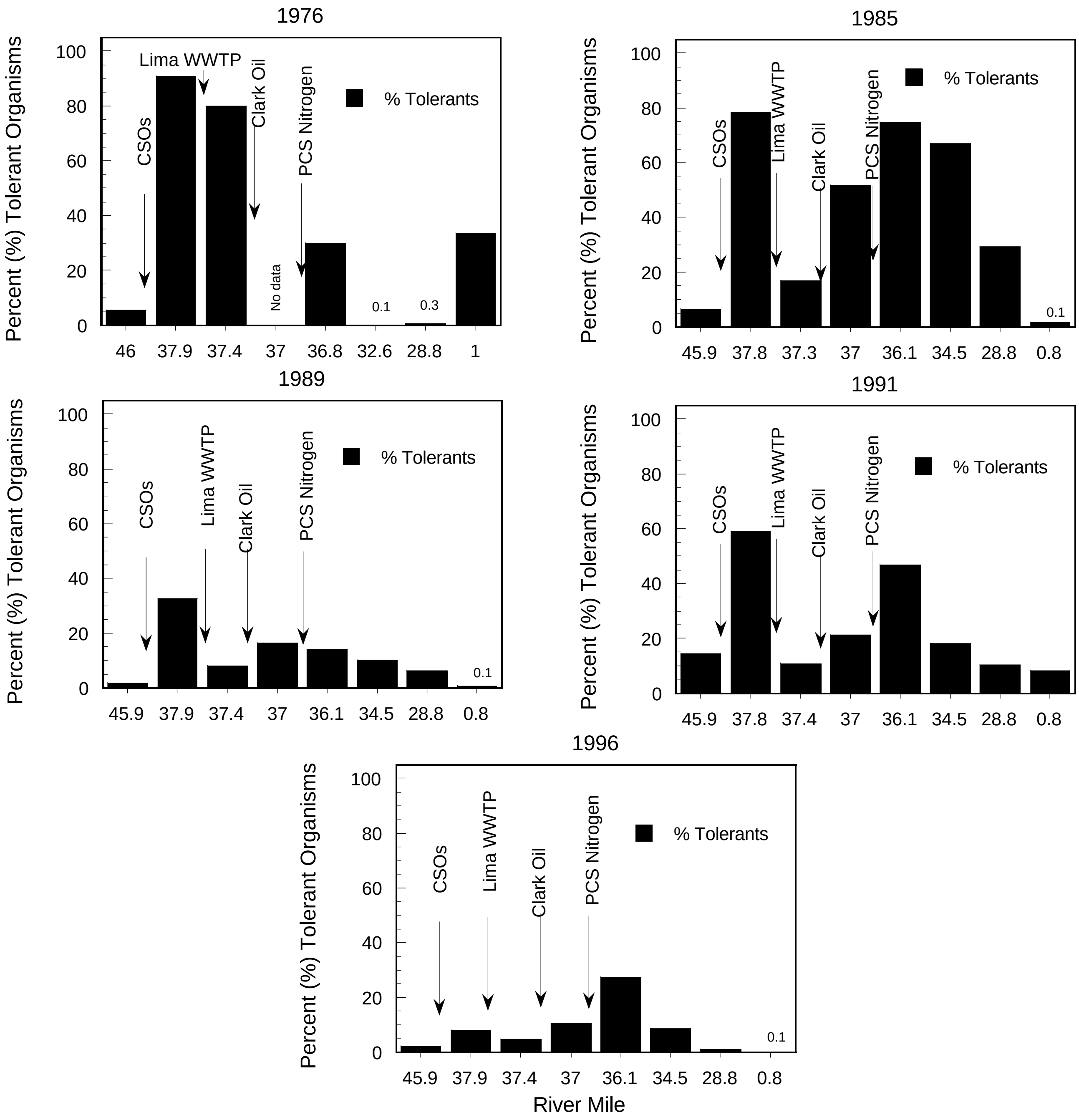


Figure 31. Longitudinal trend of the percent tolerant macroinvertebrates collected from the artificial substrates in the Ottawa River for the years 1976, 1985, 1989, 1991, and 1996.

Biological Assessment - Fish Communities

Ottawa River: 1979-1996

Fish communities in the Ottawa River have been sampled by the Ohio EPA at similar locations in 1979, 1985, 1987, 1989, 1991 and 1996. Each sampling has produced roughly the same longitudinal pattern in biological index scores in response to habitat and a variety of pollution sources (Figure 32), and that pattern is recapped as follows. The upstream most sampling location, RM 46.1, supports a warmwater fish assemblage expected for the WWH aquatic life use within the ECBP ecoregion. Most notably, the fish community is composed primarily of insectivores and top carnivores indicating proper trophic function. Also, the number of darter species fully met expectations based on reference conditions, reflecting the high quality habitat and lack of channel modifications within the immediate reach. However, impacts from intensive agricultural land use within the basin were evident in the slightly elevated abundance of tolerant fishes and incidence of deformities, erosion, lesions, or tumors (DELT anomalies). Effects of widespread habitat degradation (primarily channelization) in the headwaters, and impounding of downstream reaches by lowhead dams were manifest in the complete absence of intolerant species and low numbers of sucker species. The fish community performance at RM 46.1 demonstrates that, while nonpoint source pollution and channel modifications are limiting to the fish community in the Ottawa River mainstem as a whole, those limitations obviously do not preclude a WWH community.

As the river approaches and passes through Lima, it becomes subject to an increasing number of stressors (Figure 32). First, the river flows through a series of low-head dams starting at RM 43.5, and the proportion of tolerant and omnivorous fishes increases. Additionally, sewage solids emanating from an unsewered residential area along Findlay Road result in poor fish community performance at RM 40.2. Next, the first of several combined sewer overflows (CSOs) enters the river at RM 40.13, and with those, so increases the percentage of fish with DELT anomalies, and MIwb and IBI scores drop to the very poor and poor range, respectively (Table 8). The combination of low IBI and MIwb scores coupled with an increased incidence of DELT anomalies implies a toxic component to the CSO discharges (Yoder and Rankin 1995). Downstream from the series of dam pools, the fish community recovers through a stretch of free flowing river. However, the L5 landfill adjacent to the river at RM 37.9 oozes leachate. Although IBI and MIwb scores improved compared to upstream, as the river is free flowing, the number of DELT anomalies increased relative to upstream in response to the landfill, suggesting that the landfill exacerbates problems in the fish community downstream.

Moving downstream from RM 37.7, discharges from the Lima WWTP, BP Oil Refinery, and PCS Nitrogen plant stormwater outfalls enter the river within a 0.8 mi reach. Despite free flowing conditions, biological index scores decline into the poor range especially downstream from the PCS Nitrogen stormwater outfalls; the percentage of DELT anomalies increases from about 10% encountered downstream from the CSOs and the L5 landfill, to over 30% (Figure 32 - bottom panel), characterizing a complex toxic impact (Yoder and Rankin 1995). These results correspond with the high instream ammonia-nitrogen concentrations and detectable concentrations of cyanide found downstream from PCS Nitrogen, and contaminated sediments throughout the reach.

The fish community shows signs of recovery downstream from the Allentown Dam; however, the Elida WWTP (RM 24.2) reverses and delays the trend. Some of the upstream to downstream difference may be attributable to habitat, as deep pools were present at the upstream location but not at the downstream. Consequently sunfish, and correspondingly, the relative abundance of insectivores were more abundant upstream than downstream from Elida. However, despite improved habitat at RM 16.2, the IBI score remained depressed relative to upstream from the plant owing to the continued high abundance of omnivores (primarily bluntnose and fathead minnows). The elevated abundance of omnivores suggests excessive organic enrichment from the Elida WWTP. Recovery to levels approaching that found upstream from Lima is not realized for more than 30 miles at RM 5.6.

The fish community showed only slight improvement in 1996 compared to pre-1989 conditions. The relative abundance of non-tolerant fishes increased downstream from Lima, as reflected by higher MIwb scores (Figure 34), indicating either less of an acute toxic impact or less gross organic enrichment (and ensuing D.O. depletion). Relative to previous years, trophic function in 1996 in the lower 6 miles, as judged by the relative abundance of omnivores and insectivores, recovers nearly to that expected for the HELP ecoregion and stream size. Correspondingly, the absolute and relative abundance of roundbodied suckers increased in the lower reach of the river. One consequence of the increased abundance of redhorse was a commensurate increase in the number of DELT anomalies (Figure 34). Roundbodied suckers, especially redhorse, are susceptible to accruing DELT anomalies because of their sensitivity to pollution and dissolved oxygen regimes. The continued under performing IBI scores combined with the high incidence of DELT anomalies (Figure 34) demonstrates that the aggregate pollutant loadings are overly stressing the river.

Table 8. Fish community indices from samples collected in the Ottawa River study area 1996 through 1979.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (wt./0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
Ottawa River (04-200) 1996 *ECBP Ecoregion - WWH (Existing)*								
46.10[D]	19.5	22	1280	19.47	84.0	9.0	46	Very Good
44.40[D]	19.0	21	523	9.14	71.0	7.9[ns]	36[ns]	Marg. Good
43.60[A]	14.0	17	396	115.94	45.5	7.5[*]	32[*]	Fair
43.40[D]	21.0	23	1907	16.37	70.5	9.0	33[*]	V. Good/Fair
42.30[A]	17.0	18	1186	219.16	57.5	7.4[*]	28[*]	Fair
41.20[D]	19.0	20	461	10.43	81.0	7.4[*]	37[ns]	Fair/M.Good
40.80[A]	13.5	18	308	33.65	51.0	6.6[*]	27[*]	Fair
40.20[A]	11.0	12	260	97.74	48.0	5.0[*]	22[*]	Poor
39.90[A]	14.0	19	521	57.02	44.5	5.8[*]	25[*]	Poor
38.90[A]	11.0	14	520	58.33	45.5	4.9[*]	23[*]	V.Poor/Poor
38.50[A]	16.0	20	419	97.22	47.5	6.8[*]	26[*]	Fair
37.90[D]	23.5	29	1470	40.52	81.5	8.8	37[ns]	Good/M.Good
37.70[A]	*19.5*	*29*	*1183*	*318.61*	*69.0*	*7.6[*]*	*29[*]*	*Fair*
37.66[A]	*19.0*	*24*	*2775*	*399.11*	*73.5*	*9.2*	*29[*]*	*V.Good/Fair*
37.40[A]	18.5	22	777	83.68	65.5	6.8[*]	22[*]	Fair/Poor
37.11[A]	*15.0*	*20*	*2580*	*323.87*	*76.5*	*7.7[*]*	*28[*]*	*Fair*
37.00[A]	16.5	21	1548	23.40	58.0	7.5[*]	24[*]	Fair/Poor
36.87[A]	*11.0*	*15*	*1430*	*28.31*	*48.0*	*6.9[*]*	*22[*]*	*Fair/Poor*
36.70[A]	16.0	20	334	31.23	59.5	7.2[*]	26[*]	Fair
36.00[A]	12.5	16	625	20.40	84.0	5.4[*]	17[*]	Poor
35.50[D]	10.0	10	131	0.87		5.3[*]	20[*]	Poor
34.70[A]	12.5	16	248	53.96	79.5	5.2[*]	18[*]	Poor
32.80[A]	15.5	20	861	55.27	70.0	7.2[*]	21[*]	Fair/Poor
32.40[A]	14.0	18	578	38.96	80.0	6.2[*]	18[*]	Poor
28.90[A]	14.0	17	600	63.38	75.0	5.5[*]	18[*]	Poor
28.80[D]	16.5	21	498	5.34	68.0	8.0[ns]	27[*]	M.Good/Poor
25.50[A]	27.5	32	840	164.54	65.0	8.1[ns]	27[*]	M.Good/Fair
21.00[A]	21.0	24	1006	243.24	60.5	7.8[*]	21[*]	Fair/Poor
HELP Ecoregion - WWH (Existing)								
16.20[A]	19.0	20	2031	174.76	71.5	8.4[ns]	20[*]	M.Good/Poor
13.00[A]	22.0	23	1028	150.76	79.0	8.7	26[*]	Good/Fair
5.60[A]	22.5	26	842	163.88	77.5	9.7	32[ns]	Excpt/M.Good
3.80[A]	22.5	27	516	200.74	55.5	9.2	37	V.Good/Good
1.20[A]	25.5	32	726	177.26	73.5	9.9	36	Excpt/Good

Table 8. Continued.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (wt./0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
1991			*ECBP Ecoregion - WWH (Existing)*					
46.10[D]	18.0	0	801	30.11	80.5	8.5	42	Good
37.70[A]	*15.7*	*1*	*1989*	*348.10*	*75.5*	*6.0**	*22**	*Poor*
37.40[A]	15.7	1	937	93.73	73.5	5.0*	20*	Poor
37.00[A]	*12.7*	*1*	*872*	*62.86*	*77.0*	*6.5**	*21**	*Fair/Poor*
36.70[A]	10.0	2	297	14.18	60.0	4.8*	21*	V.Poor
34.70[A]	8.0	0	297	49.12	81.5	3.4*	15*	V.Poor
28.90[A]	10.7	2	409	36.54	79.5	4.4*	17*	V.Poor
			HELP Ecoregion - WWH (Existing)					
1.20[A]	27.3	3	1351	89.06	71.0	9.2	32[ns]	V.Good/M.Good
1989			*ECBP Ecoregion - WWH (Existing)*					
46.10[D]	20.3	0	1149	17.70	84.5	8.8	45	Good
37.90[D]	19.3	5	1509	34.06	77.0	7.4*	31*	Fair
37.70[A]	17.3	7	1394	221.32	68.0	7.4*	27*	Fair
37.50[A]	19.0	20	2603	181.34	77.0	7.6*	28*	Fair
37.40[A]	17.0	5	741	115.19	70.0	5.4*	23*	Poor
37.00[A]	19.0	7	703	97.79	77.0	7.6*	24*	Fair/Poor
36.70[A]	13.7	10	351	32.20	65.0	6.0*	23*	Poor
36.00[A]	7.3	4	191	8.21	90.5	3.9*	17*	V.Poor/Poor
34.70[A]	10.3	7	258	41.43	76.5	4.3*	19*	V.Poor/Poor
32.40[A]	13.0	18	457	54.90	85.0	6.3*	20*	Poor
28.90[A]	12.0	5	255	78.60	78.5	4.7*	19*	V.Poor/Poor
25.50[A]	24.0	4	713	84.60	76.5	8.1[ns]	29*	M.Good/Fair
			HELP Ecoregion - WWH (Existing)					
19.00[A]	21.3	28	945	275.54	67.0	8.3[ns]	26*	M.Good/Fair
1.20[A]	28.3	2	771	92.05		9.0	35	Good/Good
1988			*ECBP Ecoregion - WWH (Existing)*					
43.00[D]	13.5	15	298	0.64	55.5	7.0*	39[ns]	Fair/M.Good
42.40[D]	14.0	17	556	1.55	56.5	7.3*	35*	Fair
1987			*ECBP Ecoregion - WWH (Existing)*					
47.20[D]	19.0	20	920	55.13	82.0	8.1[ns]	34*	M.Good/Fair
46.10[D]	21.0	5	1098	27.25		8.8	42	Good
44.40[D]	18.0	21	550	22.03	85.0	8.1[ns]	38[ns]	M.Good
43.60[A]	11.7	19	369	97.22	45.0	7.3*	35*	Fair

Table 8. Continued.

Mean Mean Mean

River Mile	Number Species	Cumulative Species	Rel. No (No./0.3 km)	Rel. Wt. (wt./0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
1987 - continued								
43.40^{D}	17.7	22	1328	15.46	69.0	8.4	38^{ns}	Good/M.Good
41.40^{D}	16.0	17	251	17.42	73.0	5.4^{*}	30^{*}	Poor/Fair
41.20^{D}	17.5	21	462	17.22		7.4^{*}	34^{*}	Fair
41.00^{A}	17.0	18	448	69.68	60.5	7.0^{*}	26^{*}	Fair
38.50^{A}	11.3	1	236	82.15	45.5	4.9^{*}	21^{*}	V.Poor/Poor
37.90^{D}	27.0	28	1698	29.45		8.9	34^{*}	V.Good/Fair
37.70^{A}	18.5	7	834	180.71		6.9^{*}	29^{*}	Fair
37.70^{D}	19.0	7	540	29.16		4.8^{*}	32^{*}	Poor/Fair
36.00^{A}	6.0	6	138	2.94		3.2^{*}	16^{*}	V.Poor/Poor
35.50^{D}	6.0	11	74	1.11	78.5	3.3^{*}	15^{*}	V.Poor
34.70^{A}	5.3	5	101	11.57		3.4^{*}	14^{*}	V.Poor
28.90^{A}	11.0	1	300	42.56		4.4^{*}	20^{*}	V.Poor/Poor
28.80^{D}	13.0	13	326	2.93	67.5	6.1^{*}	26^{*}	Fair/Poor
25.50^{A}	22.0	3	504	70.54		7.1^{*}	28^{*}	Fair
		HELP Ecoregion - WWH (Existing)						
16.20^{D}	10.0	1	341	11.83	70.0	4.7^{*}	16^{*}	V.Poor/Poor
7.90^{A}	10.0	4	200	26.35	87.0	5.8^{*}	16^{*}	Poor
7.90^{D}	21.5	4	561	20.95		7.1^{*}	25^{*}	Fair/Poor
1.20^{A}	22.0	6	480	73.25		7.1^{*}	27^{*}	Fair
1986		*ECBP Ecoregion - WWH (Existing)*						
38.50^{A}	13.3	18	223	87.56		5.4^{*}	27^{*}	Poor/Fair
1985		*ECBP Ecoregion - WWH (Existing)*						
46.10^{D}	17.0	20	1389	18.98	80.5	8.8	39^{ns}	Good/M.Good
40.20^{A}	14.0	11	694	38.85	52.0	6.1^{*}	26^{*}	Poor/Fair
38.90^{A}	13.3	13	1444	49.62	47.0	6.3^{*}	25^{*}	Poor
37.70^{A}	19.3	15	2417	253.39		6.6^{*}	24^{*}	Fair/Poor
37.40^{A}	17.0	17	1348	98.27		6.4^{*}	22^{*}	Fair/Poor
37.00^{A}	12.0	19	438	96.47		5.1^{*}	17^{*}	Poor
36.70^{A}	8.0	10	315	25.59		3.5^{*}	19^{*}	V.Poor/Poor
34.70^{A}	5.0	10	81	12.11		2.3^{*}	14^{*}	V.Poor
32.80^{A}	6.7	12	207	15.85	78.5	3.5^{*}	17^{*}	V.Poor/Poor
28.90^{A}	10.0	12	451	57.11		4.3^{*}	17^{*}	V.Poor/Poor
25.50^{A}	20.3	26	664	47.26		7.4^{*}	26^{*}	Fair
22.30^{A}	16.0	22	601	16.22	77.5	5.8^{*}	16^{*}	Poor

Table 8. Continued.

Mean Mean Mean

River Mile	Number Species	Cumulative Species	Rel. No (No./0.3 km)	Rel. Wt. (wt./0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
1985 - continued *HELP Ecoregion - WWH (Existing)*								
16.20[A]	19.3	28	1995	91.34		6.6[*]	20[*]	Fair/Poor
12.30[A]	21.0	31	847	120.43	73.5	6.3[*]	24[*]	Poor/Poor
7.90[A]	21.0	31	795	61.68		7.0[*]	24[*]	Fair/Poor
4.40[A]	24.3	33	885	120.62	77.0	8.1[ns]	28[*]	M.Good/Fair
1.20[A]	24.3	33	647	102.14		8.5	31[ns]	Good/M.Good
1979 *ECBP Ecoregion - WWH (Existing)*								
46.00[G]	17.0	18	755	13.31		8.3	36[ns]	Good/M.Good
45.90[G]	15.0	16	1527	21.17		6.7[*]	30[*]	Fair
42.60[A]	14.0	15	477	174.73		5.2[*]	24[*]	Poor/Poor
40.20[A]	9.0	10	206	28.90		3.5[*]	18[*]	V.Poor/Poor
38.90[A]	5.0	6	369	68.81		3.0[*]	18[*]	V.Poor/Poor
37.70[A]	11.0	12	618	249.39		4.6[*]	20[*]	V.Poor/Poor
37.40[A]	9.0	10	573	57.91		4.7[*]	14[*]	V.Poor
36.70[A]	2.0	3	27	5.19		0.9[*]	12[*]	V.Poor
28.90[A]	4.0	4	25	1.18		2.8[*]	12[*]	V.Poor
22.90[A]	2.0	2	6	0.09		0.7[*]	12[*]	V.Poor
Plum Creek (04-201) 1996 *HELP Ecoregion - WWH (Existing)*								
15.30[E]		10	726	--	36.0	NA	22[*]	--/Poor
12.90[E]		12	874	--	57.0	NA	20[*]	--/Poor
12.20[E]		13	1090	--	42.5	NA	18[*]	--/Poor
8.10[E]		13	916	--	33.0	NA	24[*]	--/Poor
5.50[D]		17	1062	11.73	49.5	7.1[*]	22[*]	Fair/Poor
0.20[D]		17	3520	7.31	39.0	7.0[*]	26[*]	Fair/Poor
Pike Run (04-208) 1996 *ECBP Ecoregion - MWH (Existing)*								
8.30[E]		5	120	--	58.5	NA	18[*]	Poor
8.10[E]		9	318	--	62.0	NA	18[*]	Poor
4.70[E]		8	122	--	37.5	NA	18[*]	Poor
2.20[D]		11	1040	--	36.5	NA	18[*]	Poor
0.60[D]		14	1152	--	57.0	NA	20*	Poor
1991 *ECBP Ecoregion - MWH (Existing)*								
8.20[D]		4	381	2.96	50.0	NA	14[*]	Very Poor
8.10[D]		1	17	0.03	28.5	NA	12[*]	Very Poor
2.10[D]		11	272	11.43	40.0	NA	20*	Poor

Table 8. Continued.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (wt./0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
Little Ottawa River (04-213) 1996 *ECBP Ecoregion - WWH (Existing)*								
0.40[E]		9	752	--	55.0	NA	<u>20</u>*	Poor
Zurmehly Creek (04-261) 1996 *ECBP Ecoregion - WWH (Proposed)*								
0.10[E]		12	1164	--	58.0	NA	30*	Fair

Ecoregion Biological Criteria: Erie-Ontario Lake Plain

SiteType	IBI EWH	IBI WWH	IBI MWH[b]	MIwb EWH	MIwb WWH	MIwb MWH[b]
Eastern Cornbelt Plain Ecoregion (ECBP)						
Headwaters	50	40	24	NA	NA	NA
Wading	50	40	24	9.4	8.3	6.2
Boat	48	42	24	9.6	8.5	5.8
Huron-Erie Lake Plain Ecoregion (HELP)						
Headwaters	50	28	20	NA	NA	NA
Wading	50	32	22	9.4	7.3	5.6
Boat	48	34	20	9.6	8.6	5.7

a - MIwb is not applicable to headwater streams with drainage areas < 20 mi^2.
b - Modified Warmwater Habitat for channelized habitats.
* - Indicates significant departure from applicable biological criteria (> 4 IBI units or > 0.5 MIwb units). Underlined scores are in the Poor to Very Poor range.
ns - Non significant departure from applicable biological criteria (≤4 IBI units or ≤ 0.5 MIwb units).

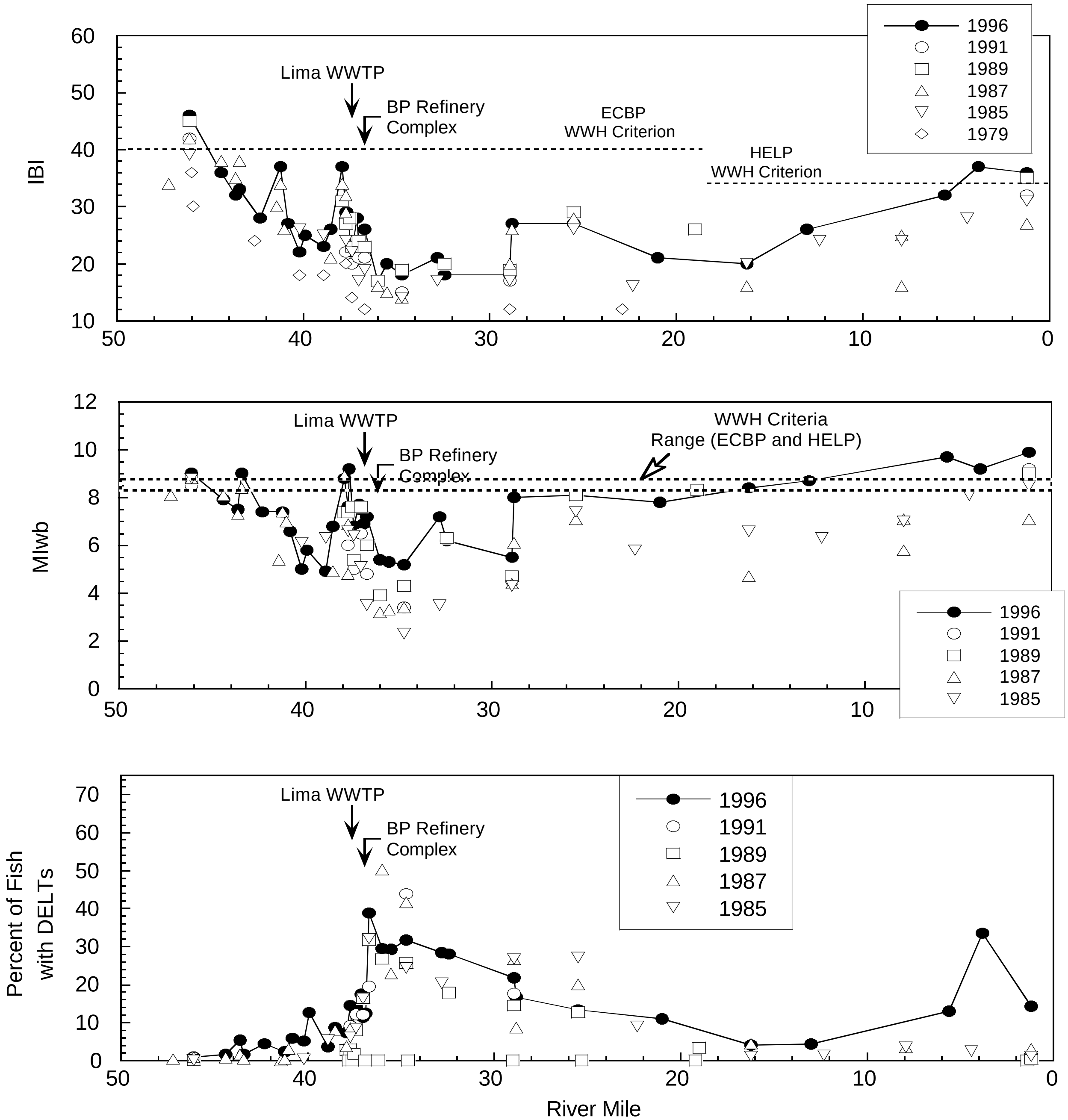


Figure 32. Longitudinal plots of IBI (top) and MIwb (middle) scores, and percent of fish with DELTs (bottom) from the Ottawa River 1979 - 1996 in relation to the Lima WWTP, Clark Oil and PCS Nitrogen (formerly BP Oil Refinery and BP Chemicals, respectively). Figure 33 has an expanded view of the reach flowing through Lima.

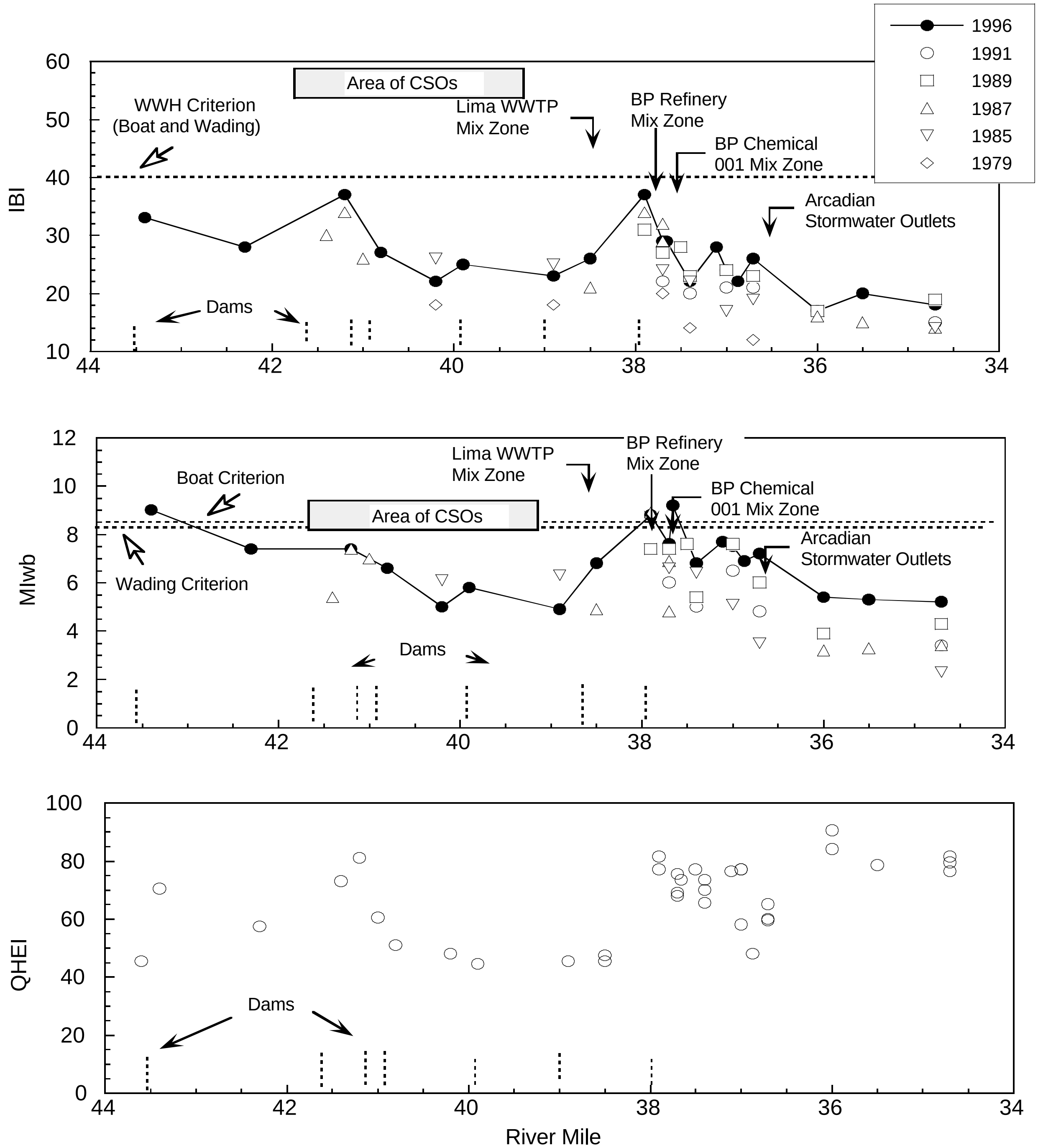


Figure 33. Longitudinal plots of IBI (top), MIwb (middle) and QHEI (bottom) scores from the Ottawa River 1979 - 1996 in relation to the series of low-head dams, the area of CSOs, the Lima WWTP, Clark Oil and PCS Nitrogen (formerly BP Oil Refinery and BP Chemicals, respectively).

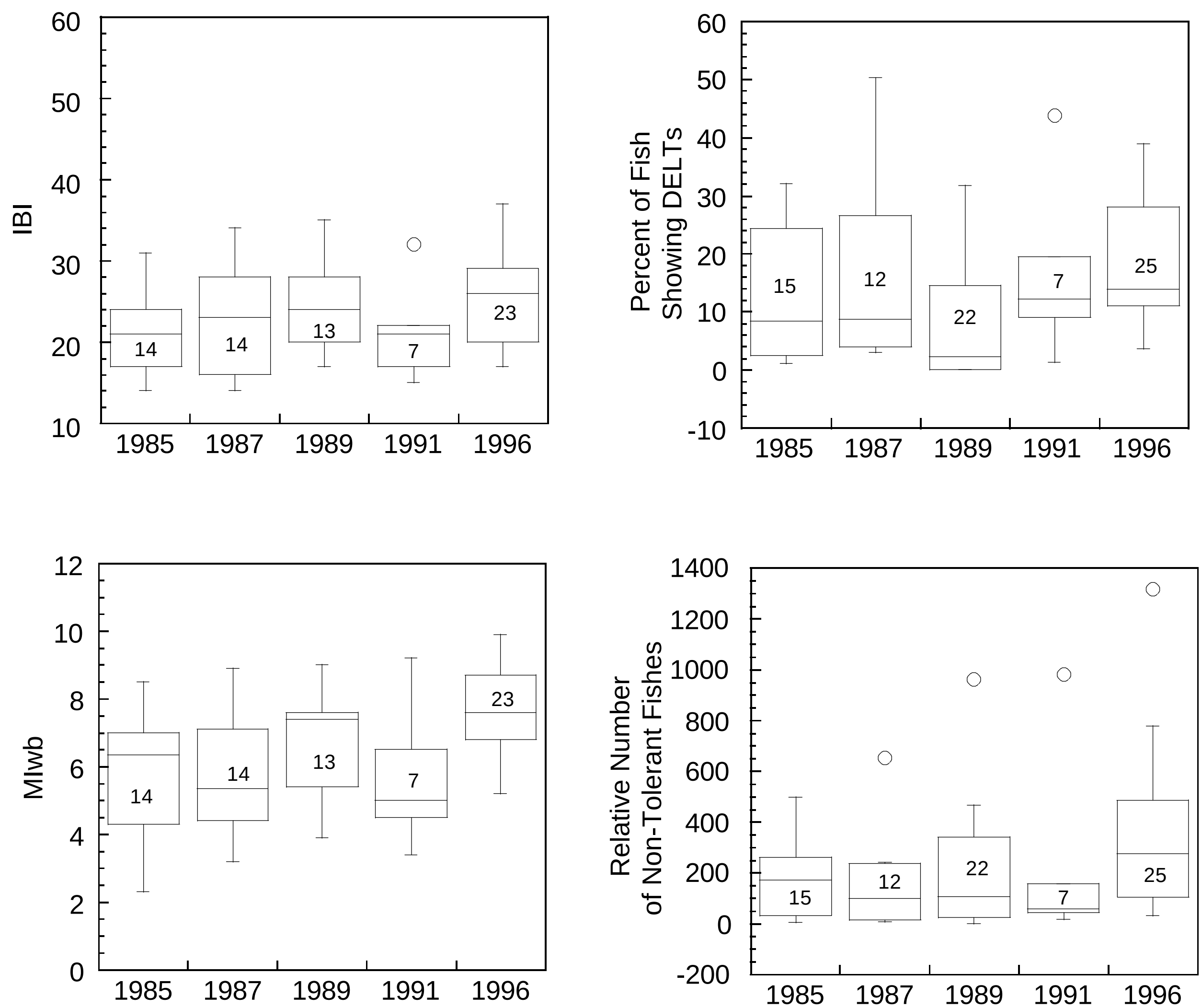


Figure 34. Left to right from top, distributions of IBI scores, percentage of fish with DELTs, MIwb scores, and the relative number of fishes excluding tolerant species from the Ottawa River in an downstream from Lima, Ohio by sample year. Boxes enclose the 25th through 75th percentiles, whiskers represent points falling within 1.5 times the respective upper or lower interquartile distance.

Plum Creek

Poor habitat quality throughout Plum Creek results in fish communities lacking species and trophic function. Consequently, IBI scores at every sampling location were in the poor range and did not meet the existing WWH criteria (Figure 35). The Columbus Grove WWTP did not have a significant, additive impact to the fish community in light of the severity of the overriding nonpoint and habitat impacts.

Pike Run

Pike Run is maintained as an agricultural drainage ditch; consequently, the fish community is commensurately degraded (Figure 35). Although Pike Run is designated MWH, the fish community did not meet those lower standards. One possible cause may be the heavy bedload of soil washed unencumbered by riparian buffers from adjacent agricultural fields. In contrast to 1991 when only one bluegill was collected downstream from the American Bath WWTP, no significant impact from the plant was detectable in 1996.

Little Ottawa River and Zurmehly Creek

Habitat impacts from channelization, intensive agriculture, and in the case of Zurmehly Creek, urbanization, limit the aquatic communities in both streams. Based on the number of modified habitat attributes, neither stream is likely to support fish communities expected for the WWH aquatic life use.

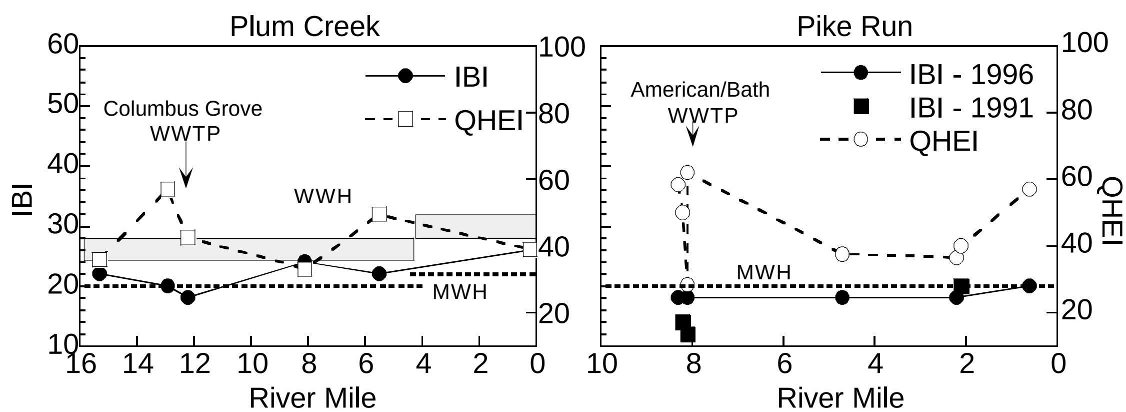


Figure 35. Longitudinal plots of IBI (on the left y-axises) and QHEI (on the right y-axises) scores from Plum Creek (left plot) and Pike Run (right plot) in relation to the Columbus Grove WWTP and the American Bath WWTP. The shaded box in the Plum Creek plot represents the existing WWH IBI criterion. The stippled line shows the respective proposed and existing MWH criterion for both.

Integrated Biological Assessment: Area of Degradation Values (ADVs) and Attainment Status

Improvements in the biological communities have yielded a greater number of river miles in full and partial attainment in 1996 compared to 1985 (Figure 36, Table 9). The recovery was driven largely by the macroinvertebrate ICI and the fish MIwb scores as evidenced by lower ADV per mile for both indices in 1996 relative to 1985 (Table 9). However, a large portion, 24.6 miles, of the Ottawa River remain in the poor or very poor categories reflecting a continued toxic impact associated with Lima CSOs, the Lima WWTP, and the complex of industrial dischargers.

From 1985 to 1996, the upper segment from Thayer Road to the Lima WWTP/Erie-Lackawana RR dam (RM 46.1 to RM 37.9) showed improvement with more miles in partial attainment (+ 3.2 miles) and full attainment (+ 0.4 miles), and less miles in non attainment (- 3.6 miles). Although the area of degradation (ADV) values for the fish indices remained the same for this reach between 1985 and 1996, the positive statistics (Table 9) showed an increase in the area of attainment values (AAV- area of graph above attainment line in Figure 5). ADVs decreased substantially for macroinvertebrates from 122 ADV/mile in 1985 to 35 ADV/mile in 1996. One sampling site in this reach showing improvement was the site at RM 37.9, downstream from the Lima CSOs and upstream from the L5 landfill, which improved to partial attainment in 1996.

The segment of the Ottawa River showing the least improvement in attainment status was between the Lima WWTP/Erie-Lackawana RR dam and the Allentown dam (RM 37.9 to RM 28.8). Biological sampling in the years 1976, 1979, 1985, 1987, 1989, 1991, and 1996 resulted in non attainment for the entire 9.1 miles, except for 0.2 miles (RM 37.9 to RM 37.7) in partial attainment in 1987 and 1996. ADV values for the MIwb and ICI have substantially decreased, but the ADV value for the IBI has remained very high (Figure 36, Table 9).

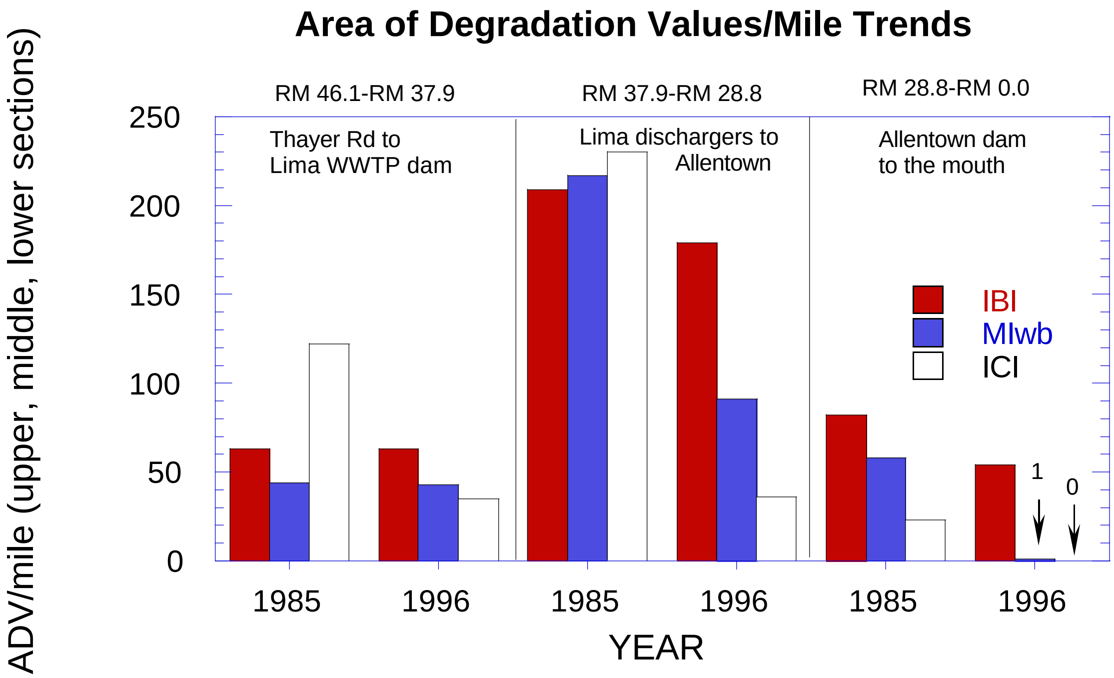
The most improvement to the biological communities from 1985 to 1996 occurred in the lower section between the Allentown dam and the mouth (RM 28.8 to RM 0.0). Full attainment was increased from 2.2 miles in 1985 to 8.0 miles in 1996.The ADV values for the fish Miwb and the macroinvertebrate ICI decreased to essentially zero in 1996. The fish IBI ADV values decreased from 82 ADV/mile in 1985 to 54 ADV/mile in 1996. The IBI scores ranged from poor to fair from RM 28.8 to RM 13.0, contributing to the non attainment (13.9 miles) in this reach in 1996.

Table 9. Area of Degradation Values and Attainment Status for the Ottawa River.

	Min.	Mean	Max		Negative Stats		Attainment Status				Positive Stats	
	Index	Index	Index	No.		ADV/						AAV/
Index	Score	Score	Score	Sites	ADV	Mile	Full	Partial	NON	P/VP	AAV	Mile
				Thayer Road to the mouth			RM 46.1 to RM 0.0					
1996							9.7	11.1	25.3	**24.6**		
IBI	17	27	46	30	3708	**80**					433	9.4
MIwb	5	7.3	9.9	30	1209	**26**					1060	23.0
ICI	6	34	48	23	617	**13**					4470	96.9
1985							3.5	5.6	37.0	**33.0**		
IBI	14	23	39	17	4944	**107**					36	0.7
MIwb	2.3	6.0	8.8	17	4238	**92**					114	2.4
ICI	2	19	46	15	3763	**82**					1640	35.5
	Thayer Road to Lima WWTP/Erie-Lackawana RR dam							RM 46.1 to RM 37.9				
1996							1.7	4.0	2.5	**2.2**		
IBI	22	31	46	11	520	**63**					89	10.8
MIwb	5	7.0	9	11	352	**43**					87	10.6
ICI	6	33	48	8	286	**35**					464	56.6
1985							1.3	0.8	6.1	**2.8**		
IBI	25	30	39	3	520	**63**					19	2.4
MIwb	6.1	7.0	8.8	3	357	**44**					48	5.9
ICI	2	20	42	3	1002	**122**					120	14.6
				Allentown dam to mouth			RM 28.8 to RM 0.0					
1996							8.0	6.9	13.9	**13.9**		
IBI	20	28	37	8	1558	**54**					343	11.9
MIwb	7.8	8.7	9.9	8	28	**1**					966	33.5
ICI	32	43	48	7	0	**0**					3914	136.0
1985							2.2	4.8	21.8	**18.1**		
IBI	16	24	31	7	2366	**82**					16	0.5
MIwb	5.8	7.1	8.6	7	1681	**58**					65	2.2
ICI	22	32	46	6	675	**23**					1520	52.7

Table 9. (continued) Area of Degradation Values and Attainment Status for the Ottawa River.

Index	Min. Index Score	Mean Index Score	Max Index Score	No. Sites	Negative Stats ADV	Negative Stats ADV/ Mile	Attainment Status Full	Attainment Status Partial	Attainment Status NON	Attainment Status P/VP	Positive Stats AAV	Positive Stats AAV/ Mile
Lima WWTP/Erie-Lackawana RR dam to Allentown dam RM 37.9 to RM 28.8												
1996							0	0.2	8.9	**8.5**		
IBI	17	23	37	11	1629	**179**					0.1	0.1
MIwb	5.2	6.6	8.8	11	828	**91**					0.7	0.2
ICI	14	28	42	8	331	**36**					10.0	2.9
1991							0	0	9.1	**9.1**		
IBI	15	19	22	6	1888	**208**					0.0	0.0
MIwb	3.4	5.0	6.5	6	1680	**185**					0.0	0.0
ICI	6	11	18	5	1195	**131**					0.0	0.0
1989							0	0	9.1	**8.7**		
IBI	17	23	31	10	1614	**177**					0.0	0.0
MIwb	3.9	6.1	7.6	10	1193	**131**					0.0	0.0
ICI	10	18	30	7	691	**76**					0.2	0.3
1987 (No ICI data)							0	0.2	8.9	**8.6**		
IBI	14	21	34	6	1775	**195**					0.0	0.0
MIwb	3.2	5.0	8.9	6	1715	**188**					0.6	0.2
1985							0	0	9.1	**9.1**		
IBI	14	19	24	7	1901	**209**					0.0	0.0
MIwb	2.3	4.5	6.6	7	1974	**217**					0.0	0.0
ICI	4	6	6	6	2095	**230**					0.0	0.0
1979 (No ICI data)							0	0	9.1	**9.1**		
IBI	12	15	20	4	2323	**255**					0.0	0.0
MIwb	0.9	3.3	4.7	4	2672	**294**					0.0	0.0
1976 (No IBI, MIwb data)							0	0	9.1	**9.1**		
ICI	0	2	6	4	2563	**282**					0.0	0.0



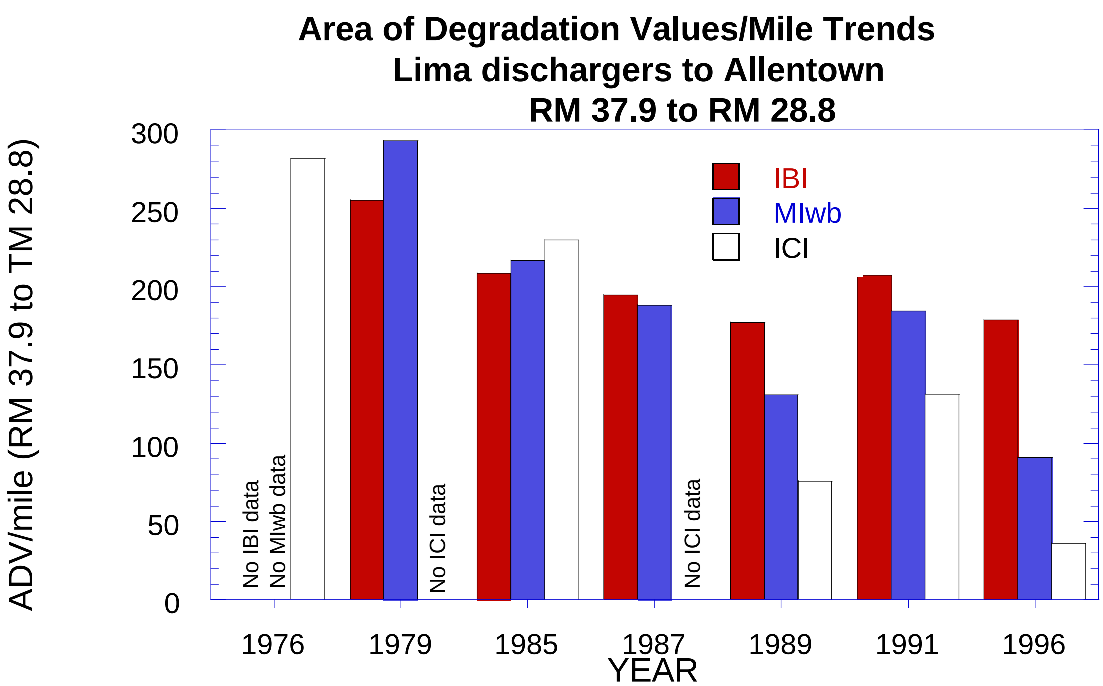


Figure 36. Top: ADV trends 1985 and 1996 for the upper, middle, and lower sections of the Ottawa River. Bottom: ADV trends 1976 to 1996 for the middle section.

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