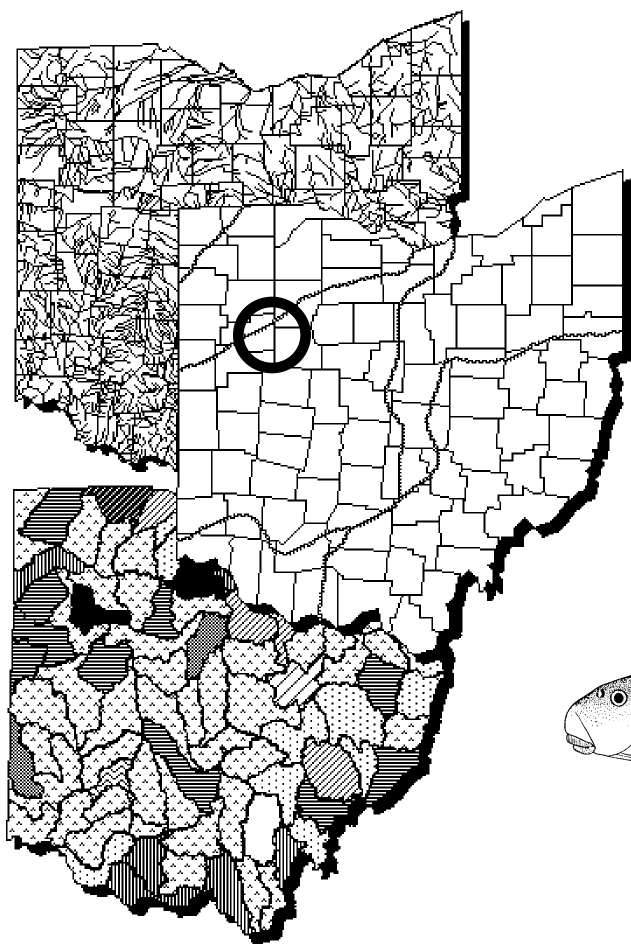
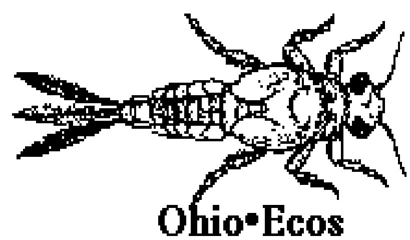
State of Ohio
Environmental Protection Agency

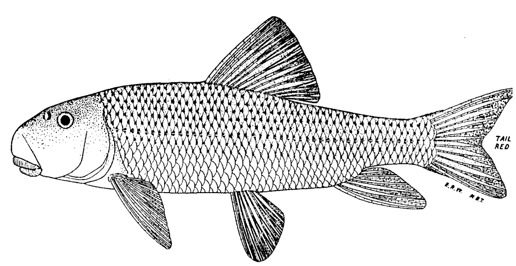
Ecological Assessment Unit
Monitoring and Assessment Section
Division of Surface Water

Biological and Water Quality Study of the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run

Hardin, Allen, and Putnam Counties, Ohio







September 21, 1992

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43216-1049

Biological and Water Quality Study of the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run (Hardin, Allen, and Putnam Counties, Ohio)

September 21, 1992

OEPA Technical Report EAS/1992-9-7

State of Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228
and
Nonpoint Source Management Section
Toxics and Standards Section
1800 WaterMark Drive
Columbus, Ohio 43266-0149
and
Surface Water Section
Northwest District Office
347 North Dunbridge Road
Bowling Green, OH 43402

TABLE OF CONTENTS

NOTICE TO USERS

Ohio EPA adopted 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, and the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio’s surface water resources.

Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring & Assessment, 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. Division of Water Quality Monitoring & Assessment, 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. Division of Water Quality Planning & Assessment, 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. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

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

OEPA - DWQPA
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228
(614) 777-6264

Acknowledgements

The following are acknowledged for their significant contributions to this report.

Report Coordinator and Editor - Randall Sanders
Plates, Introduction & Summary - Randall Sanders
Conclusions - All listed
Recommendations - Dan Dudley
Study Area - Rich McClay
Methods - Chris Yoder
Pollutant Loadings - Tom Balduf, Dan Glomski, Janet Thomas, and Rich McClay
Chemical Water and Sediment Quality - Tom Balduf, Dan Glomski, Janet Thomas, John Estenik, Randall Sanders, and Chris Yoder
Macroinvertebrate Communities - Jack Freda
Fish Communities - Randall Sanders
Data Management - Dennis Mishne and Edward Rankin
Reviewers - All contributors, Marc Smith, Eric Pineiro, Eric Nygaard, and Gary Martin

This evaluation and report would not have been possible without the assistance of the study team and *numerous* full and part time staff in the field and the chemistry analyses provided by the OEPA Division of Environmental Services. DWQPA's Modeling Section are acknowledged for their chemical data. Elizabeth Wick, DWPC, helped summarize past compliance violations for the three major Ottawa River NPDES permits. Jim Otterson, DERR, provided information concerning the L-5 Landfill. John Estenik, DWQPA, provided the information concerning PAHs in the sediments of the Ottawa River and a comparison to other Ohio rivers. Dr. Susan Cormier, U.S. EPA, Environmental Monitoring Systems Laboratory, Office of Research and Development is also acknowledged for providing biomarker data.

Biological and Water Quality Survey of the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run (Hardin, Allen, and Putnam Counties, Ohio)

State of Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment
1800 WaterMark Drive, Columbus, Ohio 43266-0149

Introduction

Historical Perspective:
The Ottawa River, within and downstream from Lima, Ohio has been severely impacted by poor water quality for over a century. Pollution impacts were first reported by Leeson (1885) and have since been the focus of numerous biological and water quality studies (Ohio Dept. of Health 1953, 1966; Patrick *et al.* 1957, 1960, 1965; Clark and Allison 1966; Stuckey and Wentz 1969; Martin *et al.* 1979; Engineering Science 1981; Mount *et al.* 1984; Ohio EPA 1986; Sanders and Altfater 1987, 1988; Sanders and Freda 1990). Results show that discharges of toxic and oxygen demanding substances from industrial and municipal wastewater sources in Lima have been the primary cause of degradation. Impairment was most severe during the 1960s when more than 37 miles were devoid of fish, including the Auglaize River downstream from the Ottawa River. The degree of impairment lessened with improved wastewater treatment and stricter enforcement after the 1972 amendments to the Clean Water Act. Segments of the Ottawa and Auglaize rivers with predominantly agricultural land uses and upstream from Lima's influence have remained comparatively stable.

Recent Studies:
Ohio EPA personnel have conducted biological and/or chemical sampling in the Ottawa River during 1974 through 1977, 1979, 1985 through 1987, 1989, and 1991. The 1991 Ottawa River study area extended from upstream of Ada (Hog Creek RM 10.8) to downstream from Kalida (Ottawa River RM 0.8). Specific objectives of this evaluation were to:

1) Collect biological, physical habitat, and water quality data for continuing chemical and biological trend assessments.
2) Conduct follow-up monitoring to detail any changes in use impairments caused by the major point source discharges (*i.e.*, Lima WWTP and CSOs, BP Oil Company [Lima Refinery], and BP Chemicals, Inc.) and nonpoint source pollution (*i.e.*, agricultural runoff and hydromodifications).
3) Evaluate the existing Warmwater Habitat aquatic life stream use designation of Hog Creek, Little Hog Creek, and Pike Run.

Two additional studies have also been recently conducted in the Ottawa River: 1) URS Consultants, Inc. in association with Limno-Tech, Inc. (funded by BP Oil Company in cooperation with Ohio EPA) studied the sources and causes of dissolved oxygen (D.O.) depletion in the Ottawa River and evaluated which additional management techniques could do the most to increase D.O. concentrations (URS 1992); 2) the United States Environmental Protection Agency, Office of Research and

Development (Environmental Monitoring Systems Laboratory) with Miami University in collaboration with Ohio EPA conducted additional fish sampling at six sites in the Ottawa River as part of a biomarker study.

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

Summary

A biological and water quality study of the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run (Hardin, Allen, and Putnam Counties, Ohio) was conducted during 1991 to: 1) collect additional biological, physical habitat, and water quality data; 2) evaluate potential impact(s) from major point source discharges (*i.e.*, Lima WWTP and CSOs, BP Oil Company [Lima Refinery], and BP Chemicals, Inc.) and nonpoint source pollution (including hydro-modifications); 3) determine the appropriate aquatic life use designations (*i.e.*, Warmwater Habitat [WWH] and Modified Warmwater Habitat [MWH]) of Hog Creek, Little Hog Creek, and Pike Run; and 4) perform a trend assessment (*i.e.*, compare the 1991 results to earlier data). Standardized methods were used to collect quantitative and qualitative biological, chemical and physical data from the Ottawa River, Hog Creek, Little Hog Creek, and Pike Run during the summer of 1991.

Aquatic Life Use Attainment:
The Ottawa River supported FULL attainment of the WWH use designation in the natural, predominantly agricultural segments upstream and far downstream from Lima (Table 1). Attainment was attributed to good water, sediment, and physical habitat qualities. **NON** attainment of WWH, however, occurred throughout a nine mile segment of the Ottawa River due to multiple acute and chronic stresses caused primarily by excessive pollutant loadings of toxic and oxygen demanding substances from urban-industrial sources in Lima. Upstream from Lima, FULL attainment of WWH also occurred in Little Hog Creek downstream from Lafayette, but **NON** attainment of WWH (and MWH) occurred in the extensively channelized segment (Hardin Co.) of Hog Creek due to poor physical habitat and resultant degraded water quality. In the natural segment (Allen Co.), Hog Creek contained a high quality macroinvertebrate community, but achieved only PARTIAL attainment of WWH due to the fish community which was only partially recovered from upstream disturbances. **NON** attainment of WWH (and MWH) also occurred throughout Pike Run due to poor water quality and channelization. The American Bath WWTP, the primary source of pollutant loadings to Pike Run, severely impacted the stream by contributing high levels of ammonia and BOD_5 which resulted in a toxic impact.

Water and Sediment Quality:
The 1991 results show chemical conditions within the study area ranged from very good to very poor quality. Exceedences of Ohio's Water Quality Standards were generally localized and consisted primarily of low dissolved oxygen levels, followed by elevated concentrations of ammonia, zinc, copper, and lead, and fecal coliform bacteria counts. The concentrations of metals in fine sediments of the Ottawa River has generally increased since 1986 downstream from the major point source discharges. During 1991, they contained highly or extremely elevated concentrations of chromium, lead, zinc, copper, arsenic, and cadmium. Chemical spills, leaks, unpermitted bypasses of

wastewater, and stormwater runoff also release significant and largely unknown quantities of pollutants into the Ottawa River and are the most prevalent within and downstream from Lima. Wild animals have been reportedly killed in seven incidents since 1985 (Ohio Department of Natural Resources, Div. of Wildlife Pollution Investigation Reports). A comparison of the estimated total amounts of nitrogen and phosphorus released to the Ottawa River by major point sources in Lima to loadings from upstream nonpoint sources showed greater total amounts are released by nonpoint, but the rate of loadings per river mile (*i.e.*, kg/day/mile) were significantly greater for point sources (approximately 49 times greater for nitrogen and 12 times greater for phosphorus).

Biological Quality:

Biological communities also ranged from very good to very poor quality during 1991. Biological impacts occurred in conjunction with degraded water, sediment, and physical habitat qualities and were most severe in a nine mile segment of the Ottawa River between Lima and Allentown. In the Ottawa River, community responses were indicative of multiple (*i.e.*, toxic, enrichment, and low D.O.) impacts downstream from major point source discharges and characterized by poor to very poor biological index scores, a high number of disfigured fish, and a 50% decline in biological diversity (*i.e.*, fish and macroinvertebrate species). Impacts began downstream from the CSOs and increased with the addition of effluents from the Lima WWTP, BP Oil Company, and BP Chemicals, Inc. suggesting additive, combined and/or synergistic effects occurring with the mixing of effluents. Their close proximity also results in high pollutant loadings with little upstream dilution capacity during low flow periods. The *average* percent occurrence of DELT external anomalies (Deformities, Erosion, Lesions/Ulcers, and Tumors) of fish in the Ottawa River increased from 0.7% upstream from Lima to 9.1 - 43.8% downstream from Lima (eroded fins followed by deformities were predominant). Biomarker results downstream from major point sources show exposure and detoxification responses by white suckers to high levels of nitrogen compounds and halogenated hydrocarbons.

Historical Trends:

Historically, the Ottawa River within and downstream from Lima has been severely impacted by discharges of toxic and oxygen demanding substances from industrial and municipal sources. Impacts were most severe during the 1960s when more than 37 miles were devoid of fish. Negative impacts declined with improved wastewater treatment and stricter enforcement following the 1972 amendments to the Clean Water Act. Overall, the greatest improvements occurred by 1985 with slight to moderate improvements continuing through 1989. The 1991 chemical and biological results suggested a renewal of negative impacts, at a level similar to those observed during 1985. Historically, biological conditions at predominantly agricultural sites (with natural channels) have remained relatively stable.

Management Implications:

Although historically improved, 1991 chemical and biological results show the Ottawa River within and downstream from Lima remains one of the most severely impacted streams in Ohio. The findings of this study suggest that a combination of pollutants are entering the Ottawa River at levels which exceed the natural assimilation process. The Ottawa River will continue to have WWH use impairment without additional pollution abatement measures which address the sources of contamination reported here. *With significant additional pollution abatement measures, the Ottawa River is expected to improve and attain water quality standards and the goals of the Clean Water Act.*

Major Sources and Types of Pollution:

The following is a longitudinal downstream summary of major sources and types of pollutants delivered to the Ottawa River and Pike Run within the most impaired segments.

Ottawa River:

City of Lima Combined Sewer Overflows (RM 40.1 - 37.7): CSOs discharge untreated mixtures of sanitary sewage, industrial wastewater, and stormwater runoff. Although CSOs are intermittent, high volumes of discharge enter the Ottawa River during wet weather events. Due to greater rainfall amounts, loadings discharged during 1990 were approximately three times greater than during 1991. Types of pollutants often include bacteria, suspended solids, heavy metals, floatables, nutrients, oxygen demanding substances, organic compounds, oil and grease, and other pollutants. Within the segment of the Ottawa River where the CSOs discharge, impoundment by a series of low-head dams lowers the physical habitat quality and exacerbates the impairment from bypassing. Discharged pollutants have reportedly killed wild animals. During the 1991 survey, the lowest dissolved oxygen (D.O.) levels, the third highest mean BOD_5, and extremely or highly elevated sediment concentrations of Cd, Cr, Cu, Pb, and Zn occurred in the Ottawa River downstream from the dam pools with CSOs (RM 37.9). A highly elevated Zn concentration was also detected in the water column. Due to the degraded chemical quality, 1991 biological index scores were poor and have declined since 1989. The ICI equaled the 1985 score of 6 and the MIwb and IBI were less than the 1985 values. A few pollution sensitive macroinvertebrates and fish species, however, were collected in low abundance during 1991. Compared to upstream from Lima, the total number of taxa collected decreased for macroinvertebrates, but increased for fish. A high incidence of eroded fins and deformed fish were also found in 1991. During 1987, [PARTIAL] attainment of WWH occurred at RM 37.9 based on fish sampling. The **NON** attainment of the WWH use designation during 1991 is attributed to the upstream CSO discharges and possibly the adjacent L-5 landfill (see below).

BP Oil Company, Lima Refinery L-5 Landfill (RM 37.8 - 37.6): An abandoned landfill is located on the south bank of the Ottawa River between RM 37.8 and 37.6. As the result of observations made during the present and previous studies, actions have been taken by the BP Oil Company in cooperation with the U.S. EPA and Ohio EPA to determine the extent and types of contamination leaching into the Ottawa River and ground water. Oily and tar-like substances have been observed leaching into the river from this nonpoint source of pollution since 1985.

City of Lima WWTP (RM 37.67 - 37.2): Noticeable changes in the Ottawa River downstream from the 001 effluent consisted of increased D.O. and flow, lower suspended solids, a substantial increase in nitrates, and highly elevated nitrogen levels in the blood of white suckers. Fecal coliform bacteria counts were markedly lower than upstream, but due to wastewater treatment, the total residual chlorine concentration was moderately elevated and a possible source of the toxic impact shown by the macroinvertebrate community. Sediment concentrations of metals decreased from the levels recorded downstream from the CSOs. Biological communities were of poor quality here also and showed signs of further impacts with the disappearance of some sensitive species. Longitudinally in the river, the ICI increased slightly, while the IBI and MIwb declined further. Since 1985, biological index scores have been almost entirely in the poor range with indications of a slightly more degraded aquatic fauna during 1991.

BP Oil Company (Lima Refinery) (RM 37.11 - 36.9): During 1991, the refinery 001 effluent had the highest concentrations of BOD_5 (maximum value), COD, cyanide, phenolic, oil and grease, arsenic, and chromium in the study area. The effluent also had a lower pH and warmer temperature than the Ottawa River. For water samples collected during the 1985, 1989, and 1991 surveys, the effluent has the highest summed total percent (44%) of concentrations above detectable concentrations for metals and cyanide in the Ottawa River. Sediment contamination in the Ottawa River at RM 37.0 included the highest zinc (extremely elevated) and iron (highly elevated) concentrations and a significant increase in chromium (extremely elevated). Past reported pollutant discharges to the Ottawa River since 1985, some of which have resulted in wild animal kills, include: gasoline, oil, foam, methanol, and wastewater from leaks, flooding, or permit violations. Stormwater runoff from the Lima Refinery also enters the Ottawa River through Zummerly Creek (local name), which discharges to the Ottawa River at RM 35.7. A gasoline and furnace oil spill (or leak) from BP killed wild animals in Zummerly Creek during 1991. A comparison of biological results at RM 37.0 from 1985 to 1989 to 1991 is presented, but should be interpreted knowing that the refinery discharge was only 50% operational during most of the 1989 survey, and appeared not to be discharging during late June 1991. Macroinvertebrate samples show increasing ICI scores (6 to 12 to 14) reflecting a change from poor to marginally fair quality. Mean fish scores show the MIwb went from a 5.1 to 7.6 to 6.5 and the IBI from 17 to 24 to 21. The highest scores, however, came in the late June 1991 when the refinery appeared not to be discharging, and the second highest scores occurred in 1989 with a reduced discharge. Despite an excellent riffle-run complex downstream from the refinery, acute impacts are evident by the absence of sensitive riffle species.

BP Chemicals, Inc. (RM 36.87 - 36.0): During 1991, the chemical plant 001 effluent had the highest mean concentrations of nitrite, ammonia, total kjeldahl nitrogen, BOD_5 (mean), phosphorus, copper, hardness, and fecal coliform bacteria as well as the warmest water temperature. Downstream from the discharge, WQS exceedences in the Ottawa River during 1991 were detected for ammonia and fecal coliform. The sediment samples from RM 36.8 contained the highest concentrations of arsenic, chromium, summed PAHs, and methoxychlor. Mirex, a pesticide not usually found in Ohio sediments, was also detected at this location. Past reported pollutant discharges to the Ottawa River since 1985 include: ammonia, suspended solids, acrylonitrile, Betz 409, and total nitrogen from leaks or permit violations. Stormwater runoff from the chemical plant also enters the Ottawa River through the 002, 003, and 004 outfalls and during 1990 added considerable loadings of ammonia-N (4.3 kg/d) and urea (40.9 kg/d). Maximum reported concentration values of the stormwater ammonia-N and urea discharges can be extremely high. During 1991 they were 352 mg/l of ammonia-N and 1517 mg/l of urea. Biological scores from 1985 to 1989 to 1991 show small to moderate increases, but remain poor to very poor quality indicative of toxic impacts and enrichment. This location contained the lowest relative number and weight of fish in the Ottawa River during 1991.

Pike Run:

Allen Co. American Bath WWTP: (RM 8.1) The water quality of Pike Run was significantly degraded by the effluent of the 001 outfall which contained highly elevated ammonia. Downstream from the discharge, results also showed increased BOD_5, COD, total phosphorus, total Kjeldahl nitrogen, and water temperature. WQS exceedences were recorded at RM 8.1 for D.O. and ammonia. Fish sampling showed very poor to poor communities throughout the tributary, but relative changes downstream from the plant were indicative of a severe toxic impact, probably due to the high ammonia levels. Excessive sludge deposits were also contributing to the impact. Pike Run has been previously channelized and should be redesignated MWH. Currently, the stream is impacted so severely it would also be in **NON** attainment of the recommended MWH use designation.

Conclusions

Ottawa River:

- The Ottawa River downstream from Lima has shown significant improvement during the past 20 years due to improved municipal and industrial wastewater treatment which have reduced loads of toxic and oxygen demanding substances released to the river. The 1991 survey results show, however, that the Ottawa River has not fully recovered or changed significantly since 1985. The most severely impaired segment remains downstream from the major point source wastewater discharges, but is now approximately nine miles long as opposed to over 40 miles during the 1960s. The severity of impact has also been significantly reduced (*i.e.*, the lowest number of fish species at a site is 10 versus no fish inhabiting more than 37 miles during the 1960s). Compared to other Ohio streams, however, the Ottawa River still remains one of the most impaired; approximately 50% of the expected fish and macroinvertebrate species do not inhabit the most impaired sites due to a combination of toxic and enrichment associated impacts. Lower than expected biological index scores and a high incidence of disfigured fish are indicative of poor aquatic communities throughout most of the nine mile segment.

• Ohio EPA monitoring since 1985 shows longitudinally that there is a gradual loss (FULL to PARTIAL to **NON**) of the aquatic life use attainment WWH 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.

• The **NON** attainment of the WWH use designation in the Ottawa River between RM 37.9 and 28.8 is attributed to multiple impacts (*i.e.*, toxic, enrichment, and low D.O.) caused by excessive pollutant loadings discharged by permitted point sources and other sources (*i.e.*, stormwater runoff, spills, leaks, landfill leachate) from the large, urban-industrial complex in Lima. Within the severely impaired segment, the predominant pollutant loadings come from three principal sources: the City of Lima WWTP and CSOs, BP Oil Company Refinery, and BP Chemicals, Inc.

• Spills and non-permitted pollutant discharges from the Lima area appear to be a significant source of lethal and sublethal stresses for aquatic communities in the Ottawa River study area. Since 1985, Ohio EPA lists 31 *reported* pollutant discharges (*i.e.*, spills, leaks, permit violations) to the Ottawa River. For the 12 incidents with estimated quantities, total flow and loads of pollutants released equaled 26,079,400 gallons and 17,857 kilograms. Leading sources were BP Chemical (12 incidents), BP Oil (5), Lima WWTP (5), Shawnee #2 WWTP (3), and Elida WWTP (3). Leading causes were NPDES permit violations (13) and bypasses (10) followed by pipeline/tank leaks (5). Primary pollutants were sewage/wastewater/solids (17), petroleum products (5), and nitrogen products (4). Ohio Department of Natural Resources pollution investigations for the same seven year period (1985 through 1991) reported a total of 2,985 wild animals (primarily fish) killed in the study area. Primary sources include municipal WWTP systems (including CSOs) and industries (oil refining, chemical production, and packaging).

• The cumulative pattern of noncompliance with NPDES permit limits by the three major dischargers in Lima during the last three years (36 month period from 1989 through 1991) shows there is a high probability that one or more of the sources will record a violation of a permit limit in a given month. This cumulative frequency of permit violations is symptomatic of the effect of varied stresses on the Ottawa River. Additional intervals of potential pollutant stress also arise when CSOs and stormwater outfalls discharge. Thus, a high cumulative frequency of permit violations combine to create frequent episodes of water quality that approach or exceed water quality criteria on nearly a continuing basis. The frequency of such episodes can be a major factor in determining the health of aquatic communities.

• Extreme flow conditions (both high and low) occurred in the Ottawa River from 1988 through 1991. Drought conditions, however, did not significantly affect the quality of biological communities upstream from Lima (Thayer Rd.) or far downstream near its confluence with the Auglaize River. Pollutant loadings from CSO discharges increased significantly during 1990 due to record rainfall amounts and may have contributed to the more degraded conditions observed during 1991. The stability of biological communities upstream and far downstream from Lima, however, suggests the drought was not the cause of impact, but may have indirectly contributed to it by providing less dilution for the existing pollutant loads discharged to the Ottawa River.

• The FULL attainment of WWH at predominantly agricultural sites with natural physical habitats (*i.e.*, non channelized), suggests that agricultural nonpoint runoff is not a significant factor in the

NON attainment found elsewhere within the study area. Excluding hydromodifications, nonpoint sources of pollution (*i.e.*, stormwater runoff, spills, leaks, landfill leachate) which contribute to the use impairment of WWH in the Ottawa River watershed are primarily coming from urban-industrial sources as opposed to rural land uses.

- The 1991 chemical sediment results from the Ottawa River show highly to extremely elevated concentrations of metals in the nine mile long impaired segment downstream from the major point source discharges of wastewater. The most prevalent contamination is by chromium followed by lead and zinc. Since 1986, most parameter concentrations have increased at most locations suggesting the contamination is likely due to recent as opposed to historical sources. Longitudinally, the metals appear to be discharged by multiple sources. No highly or extremely elevated metal concentrations were detected at the four predominantly agricultural sites located upstream from Lima. Compared to background levels, the summed percent of detected metals in the water column increases with point source discharges in Lima (and downstream) and remains elevated in the Ottawa River to the confluence with the Auglaize River.

- The high incidence of disfigured fish in the Ottawa River may raise public concern about potential human health implications. The information indicates that fish populations are being stressed due to exposure to some chemical agents in combination with low dissolved oxygen levels. The average percent occurrence of DELT (Deformities, Erosion, Lesions/Ulcers and Tumors) external anomalies of fish in the Ottawa River increased from 0.7% upstream from Lima to 9.1 - 43.8% downstream from Lima. The primary anomalies recorded were eroded fins followed by deformities. Specialized blood enzyme analyses conducted on white suckers collected in the Ottawa River downstream from Lima indicated increased detoxification activity and probable exposure to high levels of nitrogen compounds and halogenated hydrocarbons. These observations are not unlike that observed in other heavily impacted Ohio streams and rivers such as the Cuyahoga, Black, Mahoning, and upper Tuscarawas rivers.

- The incidence of tumors in fish and elevated concentrations of Polyaromatic Hydrocarbon (PAH) compounds in sediment are two specific factors of potential concern to human health. Some PAH compounds are classified as carcinogens and high concentrations in aquatic sediments have been correlated with increased rates of external and internal fish tumors and liver disfunction. There was a very low incidence of external tumors recorded during the Ottawa River survey (highest site = 1.0%) although several severely deformed and eroded bullheads resembling those collected by Baumann *et al.* (1987) from the Black River were taken in the Ottawa during 1991. Sediment concentrations of PAH compounds at the three locations tested were much lower than at other Ohio sites where tumor incidence and PAH compounds are a concern (*i.e.*, Black, Cuyahoga and Mahoning rivers). The existence of high numbers of tumors in fish and elevated PAH sediment concentrations in these rivers has prompted human health advisories. Although the available evidence indicates such action is unwarranted for the Ottawa River at this time, there is no recent fish tissue or detailed histopathological data available. Additional data should be collected in order to better characterize the impacts on fish and wildlife and the potential risks to human health. Fish tissue sampling is tentatively scheduled for the Ottawa River by Ohio EPA during 1993. Until the results are available in late 1993 or early 1994, common sense would suggest a conservative approach be taken and that people avoid the consumption of fish and other riverine wildlife from the Ottawa River downstream from the Lovers Lane CSO structure to Allentown, Ohio (RM 40.1 to 28.8).

Hog Creek, Little Hog Creek, and Pike Run:

- Physical habitats in the tributaries of the Ottawa River study area are generally good to excellent quality and capable of supporting warmwater assemblages, except for in upper Hog Creek (Hardin Co.) and Pike Run which have been extensively channelized.

Recommendations

The following general recommendations are made based upon the findings of this report.

General:

- The City of Lima should address the problems caused by Combined Sewer Overflows (CSO) through cost effective management, control and treatment measures. The present frequency and duration of CSO discharge events greatly exceeds the ability of the river to assimilate the wastes without environmental degradation. The CSOs also discharge pretreated industrial wastes which contribute to the highly elevated concentrations of heavy metals in the fine sediments of the Ottawa River. Corrective measures to consider include reducing the hydraulic loads to the combined sewer system, retention of flow in stormwater basins, and greater pretreatment or pollution prevention techniques to reduce the amount of heavy metals and other potentially harmful chemicals present in the sewer system. The next renewal of the NPDES permit for the City of Lima should require specific CSO pollution abatement targets.

- Under the terms of the current NPDES permit, the City of Lima WWTP must meet a limit of 20 ug/l TRC (Total Residual Chlorine) after September 1993. Until that time the City of Lima should carefully monitor the chlorine wastewater disinfection operation to minimize the total residual chlorine concentration present in the final effluent.

- The investigation of surface water, sediment, and groundwater impacts from the abandoned BP Oil Company L-5 Landfill should continue. Characterization of the leachate and soils should include the pollutants measured at downstream locations in the Ottawa River. Because of the ongoing release(s) of contaminant(s) from the L-5, an Interim Measure should be constructed as soon as possible to contain current, and potentially larger future releases into the Ottawa River. Depending on the extent and types of contaminants already present in the Ottawa River from the L-5, the Interim Measure should also consider the removal of these existing riverine contaminants.

- Greater attention should be given to accurately measuring the types and quantities of pollutants discharged in stormwater runoff at both BP facilities. Existing permit conditions should be carefully reviewed and enhanced where appropriate. Accurate pollutant loading estimates should be developed. If appropriate, specific control measures should be required.

- Spill prevention and containment practices at both BP facilities should be rigorously examined and enhanced wherever possible. Recent events at the BP Oil facility has prompted Directors Findings and Orders which address this issue for that facility.

- Attainment of the Ottawa River's Warmwater Habitat potential will require reductions in total pollutant loadings. Execution of the above recommendations 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. The next renewals of permits for the City of Lima and both BP facilities should consider the alternative dissolved oxygen management scenarios investigated as part of the separate study conducted by URS Consultants, Inc. (URS 1992) on factors affecting dissolved oxygen in the Ottawa River.

- Compliance with existing permit limits is an obvious recommendation for all facilities in the study area. A review of the records from 1989 through 1991 indicated 43 violations have occurred at the three largest facilities (City of Lima, BP Oil Company, and BP Chemicals) discharging to the Ottawa River. Ohio EPA expects the river would benefit from improved compliance. The evaluation of future enforcement actions should consider the pattern of cumulative violations by all sources on a river segment and the degree and extent of pollution impact caused by the source(s).

- A task force of local and State officials should be created to investigate the feasibility of implementing some of the more promising alternative dissolved oxygen management options identified in URS (1992). These include low flow augmentation of the Ottawa River and removing or breaching the series of low head dams within the City of Lima. Issues worth consideration include water quality and stream habitat improvements, recreational and aesthetic factors, and the best administrative or legal authority for implementing and controlling flow augmentation.

- The scientific data collected to date is insufficient for the issuance of a State Health Advisory warning of possible adverse human health effects from consuming fish caught in the Ottawa River and direct human body contact. However, because of the degree of pollution evident in the Ottawa River, common sense would suggest that people avoid the consumption of fish and other riverine wildlife from the Ottawa River downstream from the Lovers Lane CSO structure to Allentown, Ohio (RM 40.1 to 28.8).

Status of Aquatic Life Uses:

- Three of the four streams evaluated during this study (Hog Creek, Little Hog Creek, and Pike Run) were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. Because this study represents a first use of this type of biological data to evaluate and establish aquatic life use designations, several revisions are recommended. While some of the changes may appear to constitute "downgrades" (*i.e.,* EWH to WWH, WWH to MWH, etc.) or "upgrades" (*i.e.,* LWH to WWH, WWH to EWH, etc.), any changes should not be construed as such because this constitutes the first use of an objective and robust use evaluation system and database. Ohio EPA is under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation. Prior to the present study, aquatic life use designations of the streams surveyed during 1991 were Warmwater Habitat (WWH) (OAC 3745-1). Of these, the Ottawa River was the only stream previously evaluated using biosurvey data. The following recommendations are made based on the 1991 survey results.

> ***Hog Creek:*** The existing WWH designation should remain for Allen County (mouth to County Line Rd., RM 0.0 - 5.6), but should be changed to MWH in Hardin County (the ditch upstream from County Line Rd. [RM 5.6]) because of extensive channelization and ongoing maintenance performed under the Ohio Drainage Law (ORC 6131).

Little Hog Creek: The existing WWH designation should remain.

Pike Run: The existing WWH designation should be changed to MWH based on previous channelization, petitioned ditch status (ORC 6131), and the possibility of being put on a maintenance schedule.

Ottawa River: The existing WWH designation is appropriate and should remain.

Status of Non-Aquatic Life Uses:

- 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, Hog Creek, Little Hog Creek, and Pike Run). During the summer of 1991, fecal coliform bacteria exceeded the Primary and Secondary Contact Recreation criteria in the Ottawa River at Adgate Road (RM 36.8). Other human health risks may also occur in the Ottawa River if contact is made with the sediments which contain extremely or highly elevated concentrations of metals and/or organic compounds. Fish tissue samples were not analyzed during the present study, but previous results from the Lima area are presented by Estenik and Smith (1992).

Future Monitoring:

- Biological and water quality sampling should continue in Ottawa River to track the progress in attaining improved water quality. Based on the five year basin approach, Ohio EPA is scheduled to return to the Ottawa River watershed during the summer of 1996. Future monitoring should also be conducted in Zummerly Creek.

- The degree of sediment contamination with heavy metals is a special concern that merits greater attention in follow-up monitoring. Additional samples and sediment bioassays should be considered.

- Continued monitoring of external fish anomalies and specialized biomarker techniques is appropriate.

- Fish tissue samples should be collected by Ohio EPA during 1993 for analysis of toxic chemical contamination in order to directly assess the potential risks to human health.

Table 1. Aquatic life use attainment status for the existing Warmwater Habitat (WWH) and recommended Modified Warmwater (MWH) use designations in the Ottawa River and tributaries based on data collected during June - September 1991.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comments
Hog Creek *WWH Use Designation (Existing & MWH Use Designation Recommended for Hardin Co. only)*						
10.8/10.7	19*	4.8*	6*	16.5	**NON**	CR. 65; upstream. Grass Cr.
1.0/0.2	30*	6.0*	50	73.5	PARTIAL	Center/Swaney Rds.
Little Hog Creek *WWH Use Designation (Existing & No Change Recommended)*						
0.2/0.2	38[ns]	NA	34[ns]	69.5	FULL	Dst. Lafayette
Ottawa River *WWH Use Designation (Existing & No Change Recommended)*						
46.1/45.9	42	8.5	36	80.5	FULL	Ust. Lima at Thayer Rd.
37.7/37.8	22*	6.0*	6*	75.5	**NON**	Dst. CSOs
37.4/37.4	20*	5.0*	8*	73.5	**NON**	Dst. Lima WWTP
37.0/37.0[d]	26*	8.5	14*	77.0	PARTIAL	Dst. BP Refinery (June)
37.0/37.0[e]	18*	5.5*	14*	77.0	**NON**	Dst. BP Refinery (July - August)
37.0/37.0[f]	21*	6.5*	14*	77.0	**NON**	Dst. BP Refinery (June - August)
36.7/36.1	21*	4.8*	10*	60.0	**NON**	Dst. BP Chemical Plant
34.7/34.5	15*	3.4*	18*	81.5	**NON**	Shawnee Country Club
28.9/28.8	17*	4.4*	28*	79.5	**NON**	Allentown
1.2/0.8	32[ns]	9.2	28/G[a]	71.0	FULL	Putnam Co. Rd. 19
Pike Run *WWH Use Designation (Existing) & MWH Use Designation (Recommended)*						
8.2/-	14*	NA	-	50.0	**[NON]**	Ust. American Bath WWTP
8.1/-	12*	NA	-	28.5	**[NON]**	Dst. American Bath WWTP
2.1/-	20*	NA	-	40.0	**[NON]**	Sandy Point Rd.

BIOCRITERIA:	***Eastern Corn Belt Plains (ECBP)***			***Huron Erie Lake Plain (HELP)***		
INDEX - Site Type	**WWH**	**EWH**	**MWH[g]**	**WWH**	**EWH**	**MWH[g]**
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 (≤ 4 IBI, ≤ 4 ICI, ≤ 0.5 MIwb units).
a Narrative evaluation used in lieu of ICI (E=Exceptional; 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 Attainment status based on using the June 1991 fish sampling results only (distance = 350 m).
e Attainment status based on using the average of the July and August 1991 sampling results (distance = 250 m).
f Attainment status based on using the average of the June thru August 1991 sampling results.
g Modified Warmwater Habitat for channel modified areas.

Study Area: (Plate 1-5; Fig. 1-3; Table 1-3)
The Ottawa River originates in the Eastern Corn Belt Plains (ECBP) ecoregion at the confluence of Hog and Little Hog Creeks and flows south-westerly 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 ecoregion (HELP, RM 18.8) to its confluence with the Auglaize River. The Ottawa's watershed covers 365 square miles (Cross 1967) 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 over 200 feet of drift.

The Eastern Corn Belt Plains (ECBP) ecoregion is a rich agricultural area that covers Allen and Hardin Counties. The gently rolling glacial till plain comprising the ECBP Ecoregion is broken by moraines, kames, and outwash plains. Local relief is greater than in the HELP, but generally less than 50 feet. Soils are derived from glacial till materials and poor soil drainage has prompted extensive stream channelization to assist artificial field drainage systems, particularly in the headwater regions of Hog Creek.

The Huron/Erie Lake Plain (HELP) ecoregion 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 very low gradients. The soils are poorly to very poorly drained and most small streams have been extensively channelized to improve soil drainage. Corn and soybean farming is the predominant land use and requires an extensive drainage ditch system to make row crop farming possible. Land use impacts on water quality in the HELP Ecoregion are primarily from crop and livestock production.

Historical stream flows at Allentown (RM 28.8) over a 50 year period averaged 126 cubic feet per second (cfs) or 81.4 million gallons per day (MGD) (USGS 1981) and include major point source discharges. Historical data shows flows at Allentown are substantially lower, however, during the months May through November (Johnson and Metzker 1981) when only 20% of the flows were higher than 55 cfs (35.5 MGD), 50% higher than 29 cfs (18.7 MGD), 75% higher than 21 cfs (13.6 MGD), and 90% higher than 18 cfs (11.6 MGD).

Wastewater discharges, including three major (Lima WWTP, BP Oil Company, and BP Chemicals) and several minor (*i.e.*, Allen Co. Shawnee #2 WWTP and the Elida WWTP) 001 outfalls contribute flow to the Ottawa River. The total daily contributions to the Ottawa from these five dischargers (based on mean annual flows of 001 outfalls; excludes CSOs) averaged 22.3 MGD (34.5 cfs) from 1985 through 1989. Fig. 2. shows the relative contribution of each discharger.

Since June 1988, a new USGS gaging station has recorded Ottawa River flows (RM 37.9) in Lima downstream from the CSOs, but upstream from the three major 001 discharges. These results show overall similar low flows (drought conditions) during 1989 and 1991, but contrasting high flow during 1990 (record rainfalls). In 1989, 1990, and 1991, respectively, total calendar year discharges were: 21249, 70589, and 21487 cfs; mean discharges were: 58.2, 193.0, and 58.9 cfs; and the ranges (max.-min.) were: (1,920 - 3.8), (3,860 -14), and (1,040 - 3.2) cfs (Shindel *et al.* 1991, 1992, and USGS unpublished data). Ottawa River flows from this gage during the 1991 survey are illustrated in Fig. 3. Since long term flows are not available for RM 37.9, low-flow data from the Scioto River gaging station near Kenton is also illustrated in Fig. 3 ($Q7_{10}$ = 2.0 cfs; 80% duration flow = 4.7 cfs). This segment of the Scioto closely resembles the Ottawa River in drainage area and discharge. During low flow periods, the Ottawa River becomes an effluent dominated stream downstream from Lima.

Lima is the only major urban area in the study area which has a predominantly agriculture land use. Land uses in 1981 were approximately 77% agriculture, 12% urban, 10% forests and 1% water in Allen County; and 97% agriculture, 2% urban and 1% forest in Putnam County (ODNR unpublished data). Corn, soybeans and winter wheat are the principal crops. Allen, Hardin and Putnam counties are consistently among the top counties in Ohio for hog production. The 1990 Ohio Department of Agriculture Annual Report indicated there were 37,000 hogs in Allen County, 37,000 hogs in Hardin County and 71,000 hogs in Putnam County.

The Ottawa River is used for public, industrial and agricultural water supply, and locally provides for recreational uses such as fishing and waterfowl hunting. Table 2 presents the general characteristics of the streams sampled and identified pollution sources in the study area. Table 3 lists sampling locations and types of sampling conducted during the 1991 survey.

Table 2. Stream characteristics (Cross 1967; Krolczyk 1960) and significant identified pollution sources in the Ottawa River study area.

Stream Name	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
Ottawa River	52.7	4.0	365.0	Agriculture Hydromodification San. & storm sewers Urban runoff Landfills	Lima CSOs Lima WWTP BP Oil Company BP Chemicals
Hog Creek	14.2	2.8	68.0	Agriculture Storm sewers Hydromodification	Ada WWTP
Little Hog Creek	4.8	11.7	22.1	Agriculture Sanitary sewers Hydromodification	Lafayette WWTP
Pike Run	8.2	7.9	13.0	Agriculture Storm sewers Hydromodification	American Bath

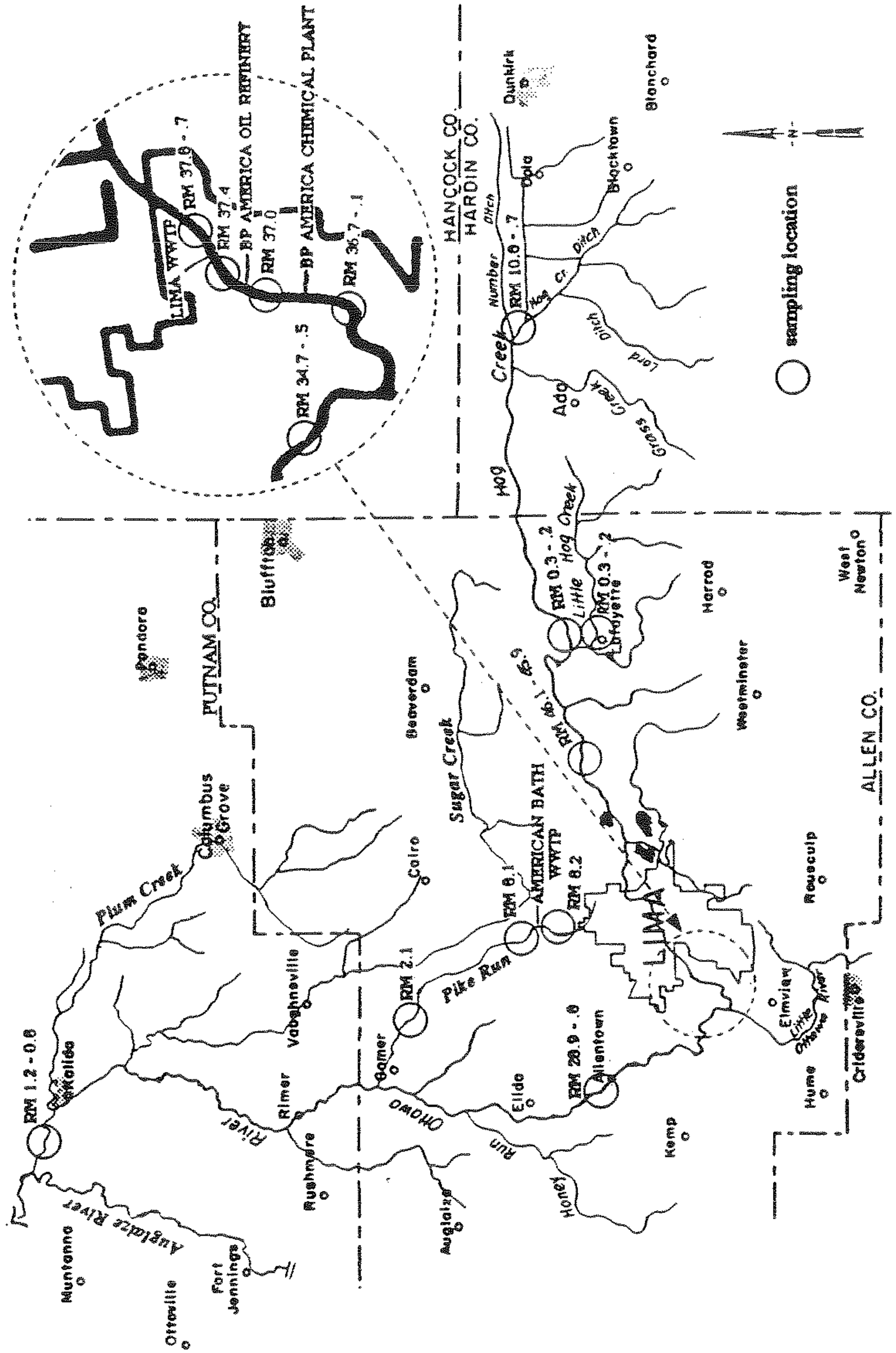


Figure 1. The Ottawa River study area showing principal streams and tributaries, population centers, and pollution sources.

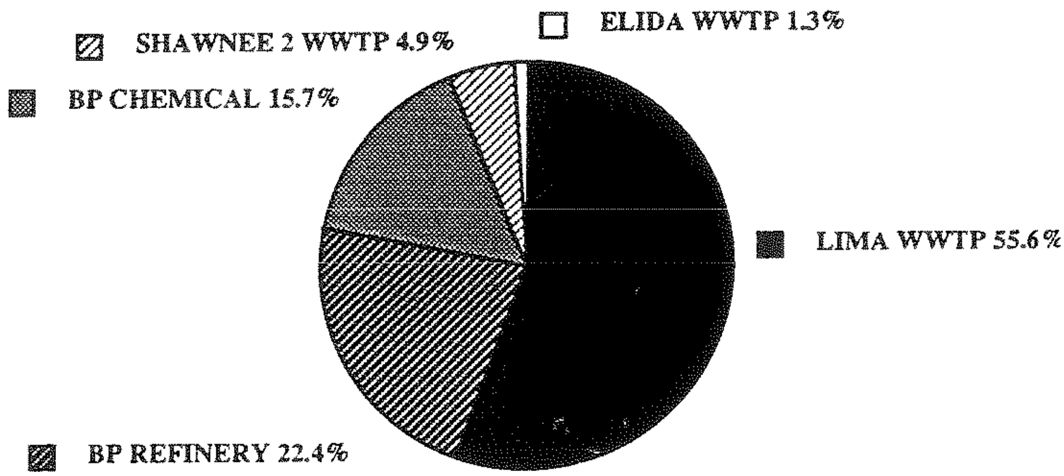


Figure 2. Relative flow contributions from five wastewater dischargers to the Ottawa River in Allen County, Ohio (based on mean annual flows from 001 outfalls from 1985 through 1989; total combined mean annual flow equaled 22.3 MGD).

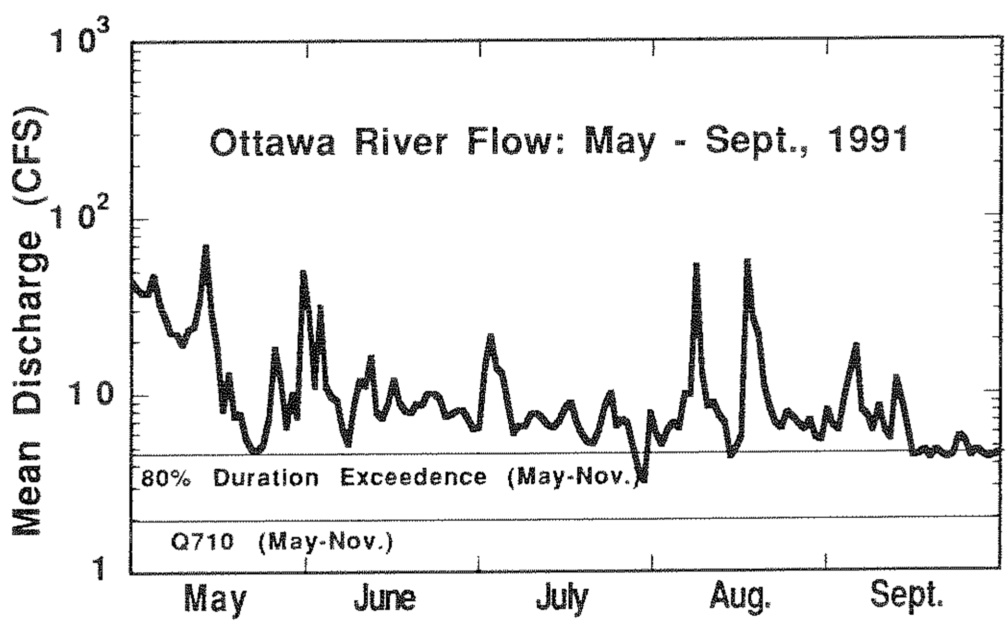


Figure 3. May through September, 1991 flow hydrograph for the Ottawa River at Lima (RM 37.98). Low-flow conditions ($Q7_{10}$[2.0 cfs] and 80% duration flow [4.7 cfs]) are estimated based on the discontinued Scioto River station near Kenton (period of record 1943-1978).

Table 3. Sampling locations (effluent sample - E, water chemistry - C, sediment chemistry - S [metals-m, organics o], benthos - B, fish - F, biomarker - BM) in the Ottawa River study area, 1991.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USGS Quad. Map
Hog Creek				
10.8	C,S(m),F	40°47'47"/83°47'05"	Ust. CR 65	Ada
10.7	B	40°47'46"/83°47'05"	CR 65	Ada
1.0	F	40°46'31"/83°56'16"	Dst. Center Rd.	Beaverdam
0.2	C,S(m),B	40°46'10"/°83'5708"	Swaney Rd.	Beaverdam
Little Hog Creek				
0.6	C,S(m)	40°45'47"/83°57'06"	Swaney Rd.	Beaverdam
0.2	B,F	40°46'05"/83°57'17"	Dst. SR 81	Beaverdam
Ottawa River				
46.1	F,BM	40°45'58"/84°00'39"	Ust Thayer Rd.	Cairo
46.0	C,S(m)	40°45'57"/84°00'43"	Thayer Rd.	Cairo
45.9	B	40°45'55"/84°00'50"	Thayer Rd.	Cairo
38.6	BM	40°43'50"/84°07'22"	Dst. Collett St.	Lima
38.0	S(m)	40°43'30"/84°07'33"	Ust. dam & dst. CSOs	Cridersville
37.9	C	40°43'28"/84°07'34"	Dst. dam & CSOs	Cridersville
37.8	B	40°43'27"/84°07'37"	Dst. dam & CSOs	Cridersville
37.7	F	40°43'25"/84°07'41"	Dst. dam & CSOs	Cridersville
37.6	E,C,S(m,o)	40°43'23"/84°07'55"	Dst. Lima WWTP	Cridersville
37.4	B,F,BM	40°43'20"/84°08'09"	Dst. Lima WWTP	Cridersville
37.1	E	40°43'08"/84°08'14"	BP Refinery	Cridersville
37.0	C,S(m,o),B,F,BM	40°43'05"/84°08'14"	Dst. BP Refinery	Cridersville
36.9	E	40°43'01"/84°08'15"	BP Chemical	Cridersville
36.8	C,S(m,o)	40°42'58"/84°08'15"	Dst. BP Chemical	Cridersville
36.7	F	40°42'47"/84°08'17"	Dst. BP Chemical	Cridersville
36.1	B,BM	40°42'28"/84°08'40"	Twp. Fire Station	Cridersville
34.7	BM,F	40°42'40"/84°09'22"	Shawnee Country Club	Cridersville
34.6	C,S(m)	40°42'45"/84°09'25"	Shawnee Country Club	Cridersville
34.5	B	40°42'51"/84°09'28"	Shawnee Country Club	Cridersville
28.9	F	40°45'13"/84°11'42"	Ust. Allentown Dam	Elida
28.8	C,S(m),B	40°45'19"/84°11'41"	Allentown Dam	Elida
1.2	F	40°59'23"/84°13'24"	Ust. Putnam Rd. 19	Kalida
0.8	B	40°59'25"/84°13'45"	Dst. Putnam Rd. 19	Kalida
Pike Run				
8.2	C,F	40°47'01"/84°07'21"	Ust. A.-Bath WWTP	Cairo
8.1	E,C,F	40°47'06"/84°07'20"	Dst. A.-Bath WWTP	Cairo
2.1	C,F	40°50'25"/84°10'02"	Sandy Point Rd.	Elida

Methods

All chemical, physical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes l-llI (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment. Biomarker methods follow U.S. EPA (1991).

Attainment/non-attainment of aquatic life uses is determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and Modified Index of Well-being (MIwb) which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. IBI and ICI are multi-metric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). 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 applied to fish community information from the Wabash River (Gammon 1976; Gammon *et al.* 1981).

Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes *et al.* 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indexes does not attain and performance does not fall below the fair category, and **NON** (boldface) if all indices either fail to attain or any index indicates poor or very poor performance.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of the type(s) and quality of substrates, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to determine the QHEI score which generally ranges from 20 to 100. The mean 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 much 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 establishment of warmwater faunas. Scores greater than 75 often typify habitat conditions which have the ability to support exceptional warmwater faunas.

Macroinvertebrates were sampled quantitatively using multiple-plate artificial substrate samplers (modified Hester/Dendy) in conjunction with a qualitative assessment of the available natural substrates. Adequate flow velocities (> 0.3 ft./sec.) for the artificial substrates were maintained at all sampling locations except for Hog Creek at RM 10.7, Little Hog Creek, and the Ottawa River at RMs 45.9, 37.8, and 0.8.

During the present study, macroinvertebrates collected from the natural substrates were also evaluated using an assessment tool currently in the developmental 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 ICI's 0 to 60 scale. 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. Its use in evaluating sites in the Ottawa River study area was restricted to relative comparisons between sites with no direct attempt to interpret quality of the sites or aquatic life use attainment status.

Fish were sampled using wading or boat method pulsed DC electrofishing gear. The wading method was used at a frequency of 2X in Hog Creek, Little Hog Creek, and the Ottawa River upstream from Lima (RM 46.1), and for single samples in Pike Run. The boat method, at a frequency of 3X, was employed at the other seven sites in the Ottawa River downstream from the Lima dam pools. Fish collections for the biomarker study were also collected by Ohio EPA personnel. QHEIs were calculated for all fish sampling locations. Chemical/physical and biological sampling locations are listed in Table 3.

An Area Of Degradation Value (ADV; Rankin and Yoder 1991) was calculated for the study area based on the longitudinal performance of the biological communities. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, and ICI) departs from the stream criterion or the upstream level of performance (Fig. 4). The magnitude of impact refers to the vertical departure of each index below the criterion. The total ADV is the area beneath the ecoregional criterion when the results for each index are plotted against river mile. This is also expressed as ADV/mile to normalize comparisons between segments and other areas.

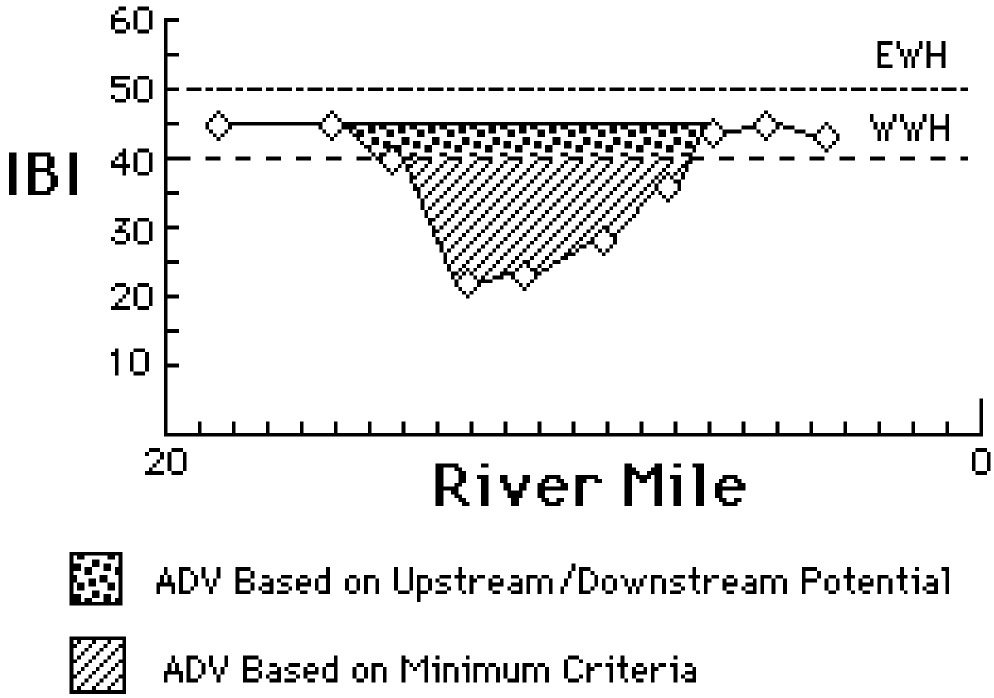


Figure 4. Graphic illustration of the calculation of Area of Degradation Values (ADV) based on upstream potential and the ecoregion warmwater habitat use or minimum criteria (WWH). Criteria for exceptional warmwater habitat use (EWH) is provided for reference.

Results and Discussion

Pollutant Loadings: 1976-1991 (Plate 1-5; Fig. 2,3,5-11; Table 4a-6)

Hog Creek - Village of Ada WWTP:

• Ada operates a secondary wastewater treatment system which utilizes contact stabilization (Ohio EPA permit number 2PB00050) and treats an average of 0.96 million gallons per day (MGD). The plant was originally constructed in 1957 and was last modified in 1979. Effluent is discharged to Grass Creek (RM 2.38) which flows into Hog Creek (RM 10.07). The collection system contains 100% separate sanitary sewers and has no overflows or bypasses.

Little Hog Creek - Village of Lafayette WWTP:

• Lafayette operates an extended aeration (polishing lagoon) wastewater treatment system (Ohio EPA permit number 2PA00049) and treats an average of 0.03 MGD. The plant was constructed in 1980 and the final effluent discharges to Little Hog Creek at RM 1.0. The collection system contains 100% separate sanitary sewers and has no overflows or bypasses.

Ottawa River - City of Lima WWTP and CSOs:

• Lima operates an advanced secondary treatment system (OEPA permit number 2PE00000) and treats an average of 11.2 million gallons per day (MGD). The system was originally constructed in 1931 and was most recently renovated in 1989. Final effluent from the plant enters the Ottawa River at RM 37.67 (Plate 5). The city implements an approved industrial pretreatment program, including 7 significant categorical industrial users. The collection system contains approximately 80% combined sewers, with 13 associated combined sewer overflows (CSOs). The five largest CSOs, located between Lovers Lane and Collett Street, are mechanically controlled and metered with designed flow capacities ranging from 242 - 504 MGD. These overflows are permitted to discharge during wet weather periods (Plate 3) and have discharge monitoring requirements. The plant also has an influent and post - primary treatment bypasses. At flows between 33 MGD and the hydraulic capacity of 53 MGD, only primary treatment and disinfection are achieved before discharge. Flows above 53 MGD are bypassed.

• 1976 - 1991 loading trends of six pollutants discharged to the Ottawa River from the Lima WWTP 001 effluent (mean annual kg/day) are shown in Fig. 5. The ammonia-N annual loadings graph appears to reflect a decreasing trend, particularly after 1980, with the lowest loading rates in 1990 and 1991. The nitrate-N loadings showed a decreasing trend after 1979, but the loadings suggest a leveling off from 1985 through 1990 (1991 data was not available). Phosphorus loadings have shown some fluctuation and the graph suggests that the annual loading has remained relatively low from 1981 through 1991. Suspended solids have fluctuated widely over the period of record, but there is a suggestion of an increasing trend. The 1979 and 1980 loadings for BOD_5 skew the graph, but there is a suggestion of some increase in the trend for this parameter after 1980 (BOD_5 is no longer reported).

• Total mean annual and 50th percentile loadings of ammonia-N from the Lima WWTP, BP Oil Company, and BP Chemicals have decreased markedly since 1980 (Fig. 9). However, the differences between the 50th percentile (median) and 95th percentile values are large and suggests high variability in effluent quality.

• Although intermittent, Lima CSOs can discharge significant quantities of wastewater to the Ottawa River (Plate 3; Fig. 10; Table 4). The total annual amounts bypassed converted to an average daily flow (MGD) during 1989, 1990, and 1991 were 2.01, 6.14, and 1.10 MGD, respectively. Even during a low flow year such as 1991, the CSOs discharged greater total loadings of suspended solids and COD to the Ottawa River than the Lima WWTP, BP Oil Refinery, BP Chemicals, or Shawnee #2 WWTP (Fig. 11). During 1990, an extreme high flow year, total occurrences were approximately two times greater than during 1989 and 1991, while the total hours and flow discharged were approximately three to five times greater.

• Effluent samples from the Lima WWTP were tested for acute and chronic toxicity by U.S. EPA in September 1982 and July 1983, and by Ohio EPA in July 1985 and twice in June 1986 (Bioassay Report Numbers 85-380-NW, 86-440-NW, and 86-441-NW). Results of the 1985 Ohio EPA test indicated acute and chronic toxicity to fathead minnows. Results of the other tests found no toxicity to fathead minnows. All of the test results demonstrated acute and chronic toxicity to *Ceriodaphnia dubia*. Bioassay 86-440-NW reported a four day LC_{50} of 51.2% effluent and test 86-441-NW reported a LC_{50} of 54.7% effluent. The Lima WWTP is currently required to perform quarterly chronic toxicity tests (including acute endpoints and tests of near-field and far-field samples) using *Ceriodaphnia dubia* and fathead minnows. More recently, Lima has submitted two test reports to date with both tests resulting in <1 TUa and TUc for both species (test dates were 12/16/91 and 3/9/92).

Ottawa River - BP Oil Company (Lima Refinery):

• The BP Oil Company operates a refinery which produces unleaded gasoline, LPG, jet fuel, heating oil, diesel fuel, lubricating oils, coke, benzene, toluene, and trolumen. Treated process wastewater (OEPA permit number 2IG00001) average 4.32 MGD and is discharged to the Ottawa River at RM 37.11 (Plate 5). Historically, the refinery discharged to the Ottawa River near RM 37.9 (Plate 1).

• Loading trends of five pollutants discharged to the Ottawa River by the 001 effluent from 1976 through 1991 are shown in Fig. 6. Ammonia-N and BOD_5 loadings have decreased significantly since 1984, while phosphorus and nonfilterable residue loadings have shown smaller relative decreases. Oil and grease loadings have remained similar since 1982.

• Ohio EPA toxicity tests conducted between 1983 and 1986 noted that the effluent was acutely toxic in three of four tests using fathead minnows and Ceriodaphnia; chronic toxic effects were noted for both species.

• Self monitoring records reported no discharges from the BP Oil Refinery emergency bypass during the 1991 survey period.

Ottawa River - BP Chemicals, Inc.:

• BP Chemicals, Inc. manufactures a variety of nitrogen fertilizer solutions along with acrylonitrile and catalysts, CO_2, and barex resins. The waste stream includes process water, stormwater, non-contact cooling water, cooling tower blowdown, and sanitary waste treated by an on-site package plant. An average of 3.46 MGD of treated wastewater (Ohio EPA # 2IF00004) is discharged to the Ottawa River at RM 36.87 (Plate 5).

• Loading trends of five pollutants discharged to the Ottawa River by the BP Chemicals 001 effluent (mean annual kg/day) from 1976 to 1991 are shown in Fig. 7. Ammonia-N loadings declined significantly after 1977, but have since remained relatively unchanged. Phosphorus loadings have declined greatly since 1985, but have shown no subsequent change. BOD_5 appears to be increasing, while total nonfilterable residue amounts have remained similar. Recent oil and grease loadings are not reported.

• BP Chemicals also has three permitted stormwater outfalls which discharge intermittently to the

Ottawa River downstream from Adgate Road. Self monitoring records of the three stormwater outfalls during the 1991 survey period reported a combined average flow of 0.123 MGD and an ammonia loading of 1.1 kg/day. Estimated loadings from the three discharges are shown in Table 4a. Results show considerable total loadings of ammonia-N (4.3 kg/d) and urea (40.9 kg/d) were discharged from the outfalls during 1990; a wetter than normal year. During 1991, the total average daily loading of ammonia-N and urea were lower than the previous year. Maximum reported concentration values of the stormwater ammonia-N and urea discharged to the Ottawa River can also be extremely high. During 1991, they were 352 mg/l of ammonia-N and 1517 mg/l of urea.

• Samples from the BP Chemicals 001 effluent were tested for acute and chronic toxicity by U.S. EPA in September 1982 and July 1983. Results of the first test indicated no significant acute or chronic toxicity to fathead minnows. Both acute and chronic toxicity to *Ceriodaphniadubia*_ were documented. Effluent samples used in these tests only contained cooling waters. The second test indicated no acute toxicity to fathead minnows or *Ceriodaphniadubia*. No chronic toxicity was documented for *Ceriodaphniadubia* and the results from the chronic tests with fathead minnows were inconclusive. Effluent samples were also tested for acute toxicity by Ohio EPA in June 1986 (Bioassay Report Numbers 86-444-NW and 86-445-NW). No significant toxicity to fathead minnows or *Ceriodaphniadubia* was documented in either test. Annual chronic toxicity tests conducted in July 1990 and June 1991(as a biomonitoring requirement) did not exceeded AETS. Additionally, six acute screening tests (001 effluent) were conducted during December 1991 and January 1992 for the approval to use and discharge cleaning solutions, but showed no toxicity for fathead minnows or *Ceriodaphnia dubia.*

Ottawa River - Allen Co. Shawnee #2 WWTP:

• The Allen County Commissioners operate Shawnee #2 WWTP (OEPA number 2PK00002), a secondary wastewater treatment system which treats an average of 1.53 MGD. The plant was constructed in 1974 and was last modified in 1984. Final effluent from the plant discharges to the Ottawa River at RM 32.5. The collection system is 100% separate sewers and presently contains eight unauthorized overflows. Approximately 20% of the service area does not have a sewer system. U.S. EPA is currently conducting enforcement activities against Shawnee #2 for significant permit violations. A civil case is also pending due to alleged falsifying of self-monitoring records.

• Effluent samples from Shawnee #2 WWTP were tested for acute toxicity by Ohio EPA in August 1989 (Bioassay Report Number 89-691-NW). Results of the test indicated no acute toxicity to fathead minnows or *Ceriodaphnia dubia.*

Pike Run - Allen Co. American-Bath WWTP:

• The American Bath WWTP (OEPA permit number 2PH00007) is a secondary wastewater treatment system which is currently overloaded. The plant is operated by the Allen County Commissioners and consistently treats an average of 0.95 MGD, but has a design capacity of only 0.60 MGD. The plant was constructed in 1966 and was last modified in 1988. Final effluent from the plant discharges to Pike Run (RM 8.2) which flows into the Ottawa River at RM 19.53. The collection system is 100% separate sewers, but includes two plant bypasses.

• Loading trends of five pollutants discharged to Pike Run by the American Bath WWTP 001 effluent (mean annual kg/day) from 1976 through 1991 are shown in Fig. 8. ammonia-N loadings have recently increased due most likely to operating above the designed flow capacity. Low nitrate loadings also indicate a low nitrification rate at the WWTP. Phosphorus loadings have decreased since 1987.

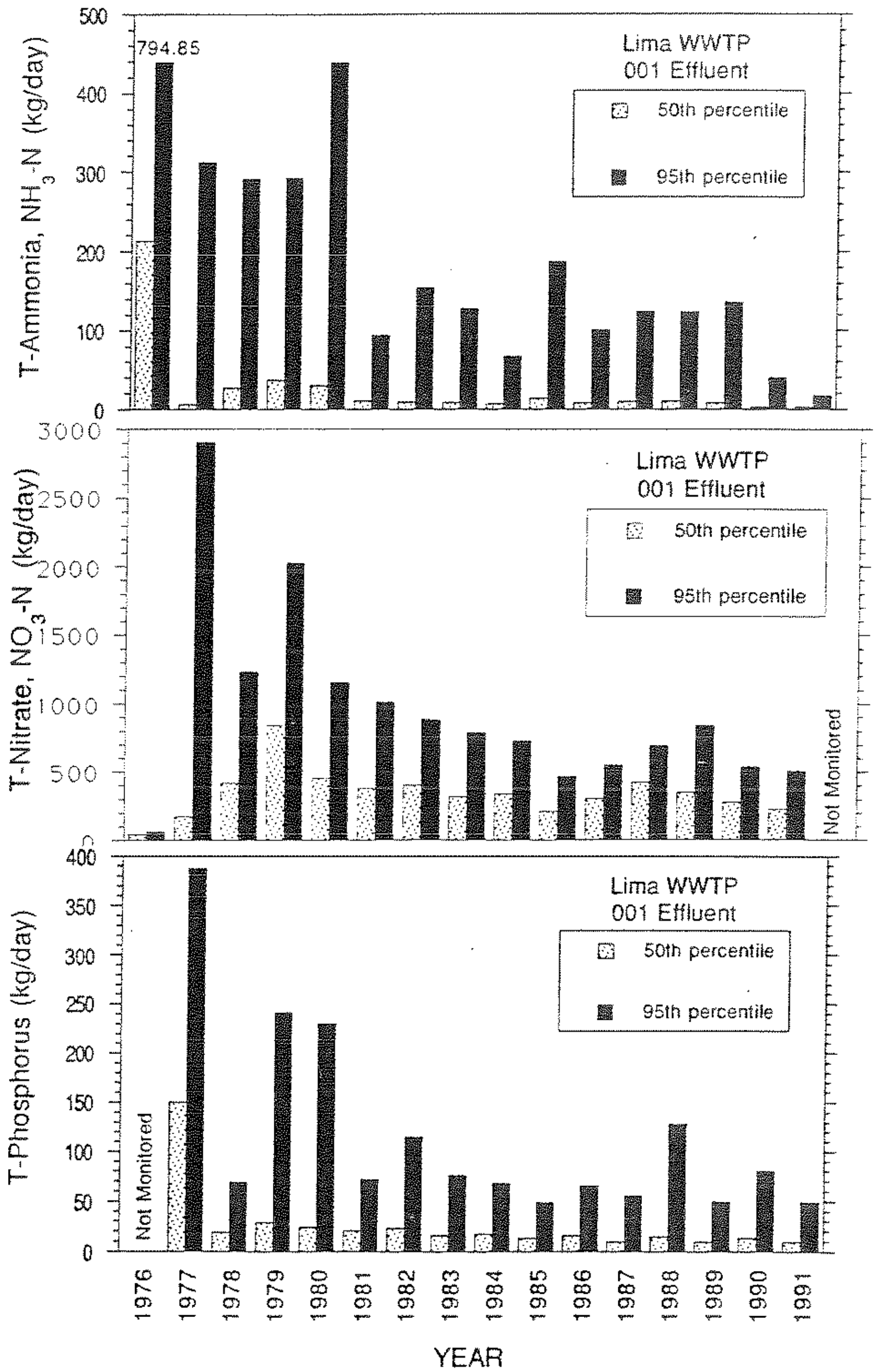


Figure 5a. Loadings (kg/day) of ammonia-N, nitrate-N, and phosphorus from the Lima WWTP 001 effluent to the Ottawa River from 1976 - 1991.

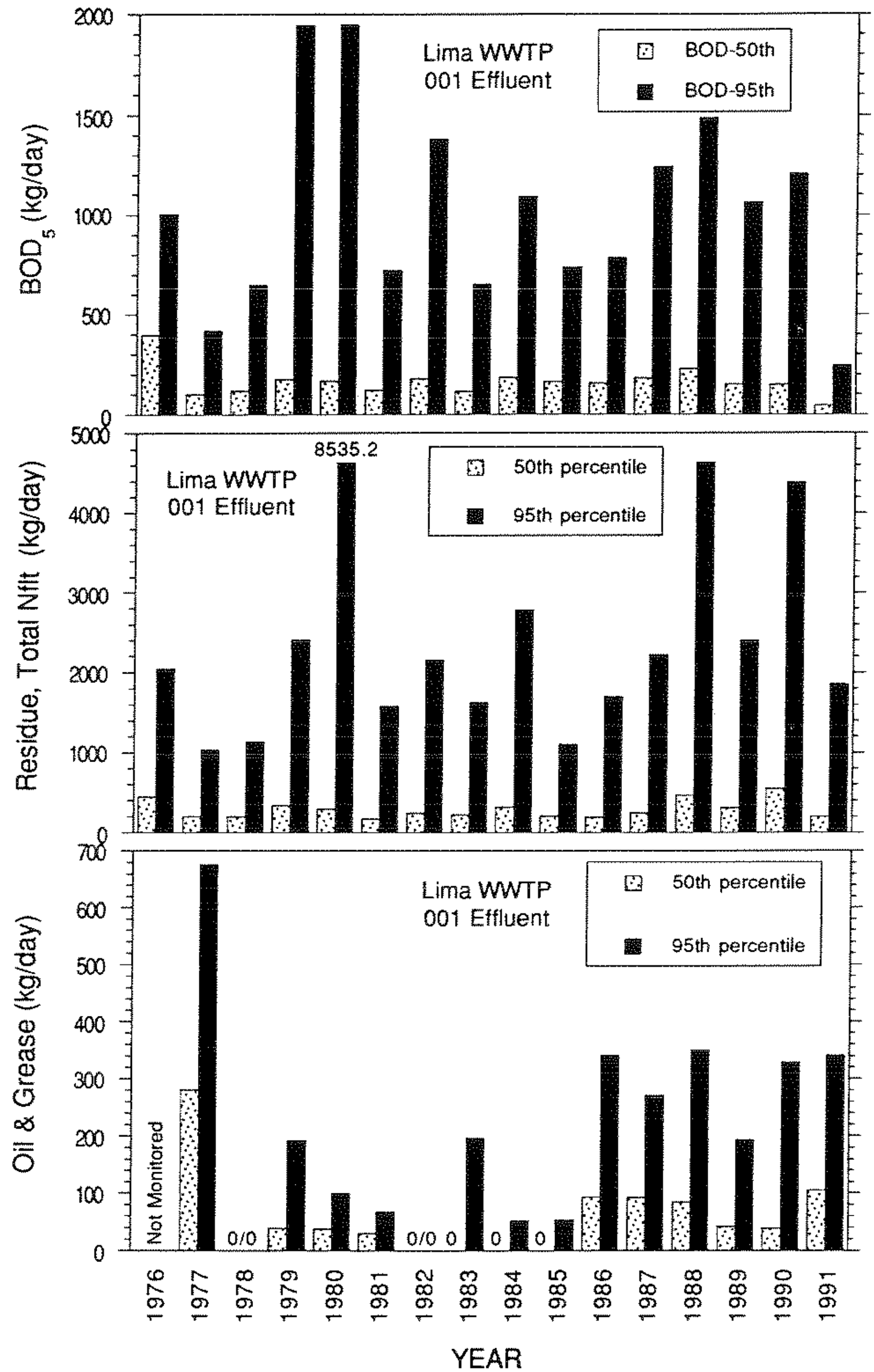


Figure 5b. Loadings (kg/day) of BOD_5, nitrate-N, total nonfilterable residue, and oil & grease from the **Lima WWTP** 001 effluent to the Ottawa River from 1976 - 1991.

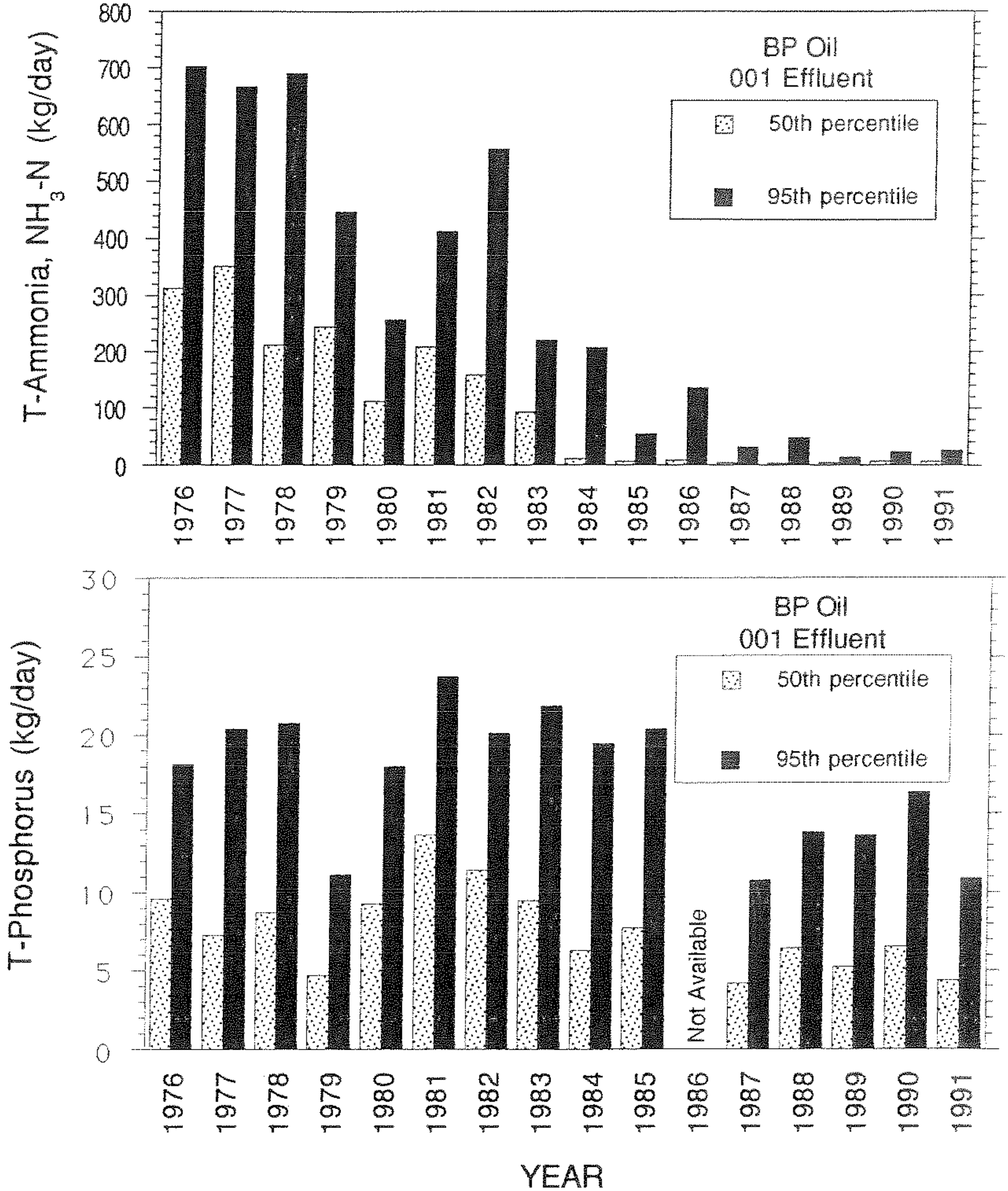


Figure 6a. Loadings (kg/day) of ammonia-N and phosphorus from the **BP Oil Company, Lima Refinery** 001 effluent to the Ottawa River from 1976 - 1991.

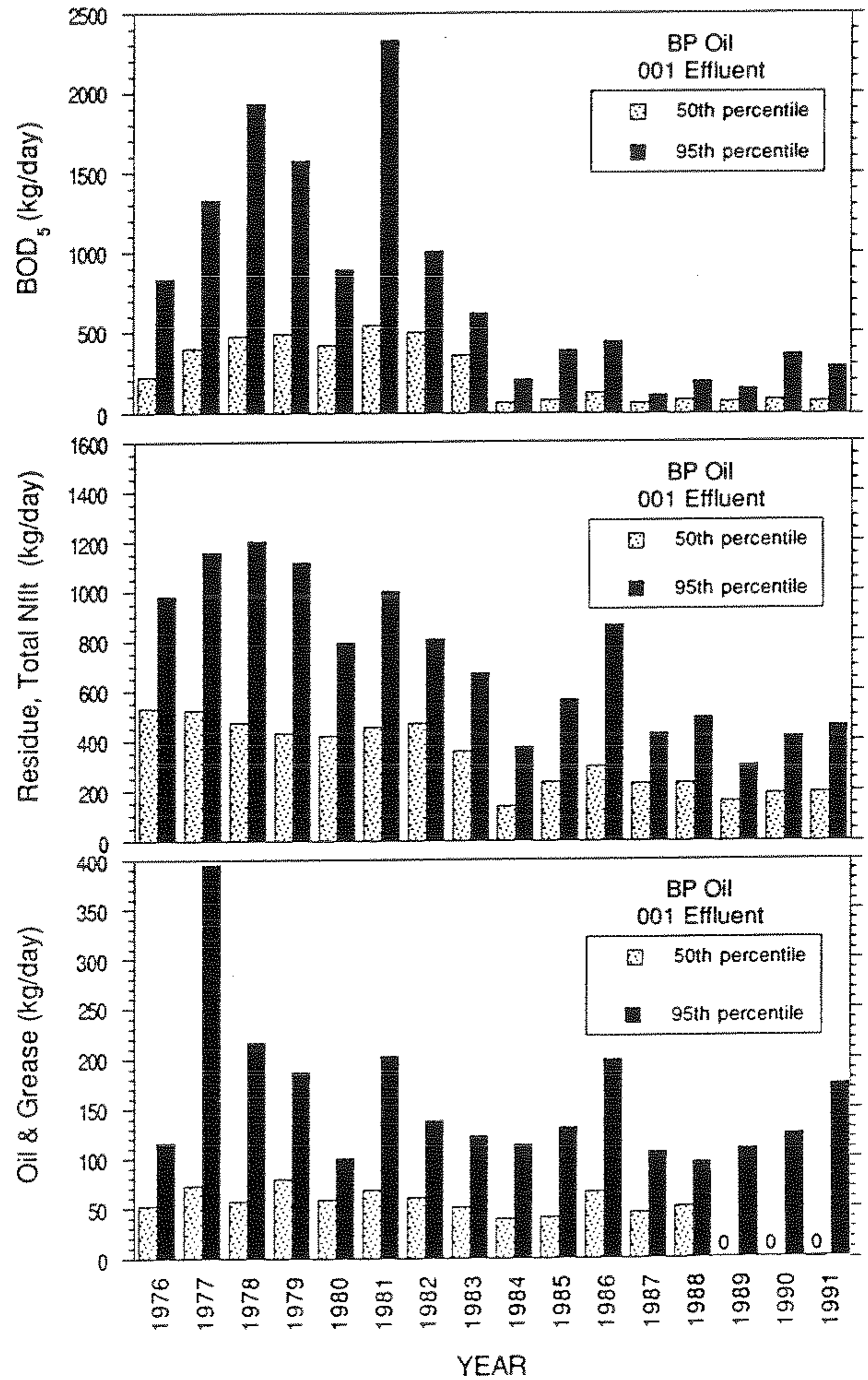


Figure 6b. Loadings (kg/day) of BOD_5, total nonfilterable residue, and oil & grease from the **BP Oil Company, Lima Refinery** 001 effluent to the Ottawa River from 1976 - 1991.

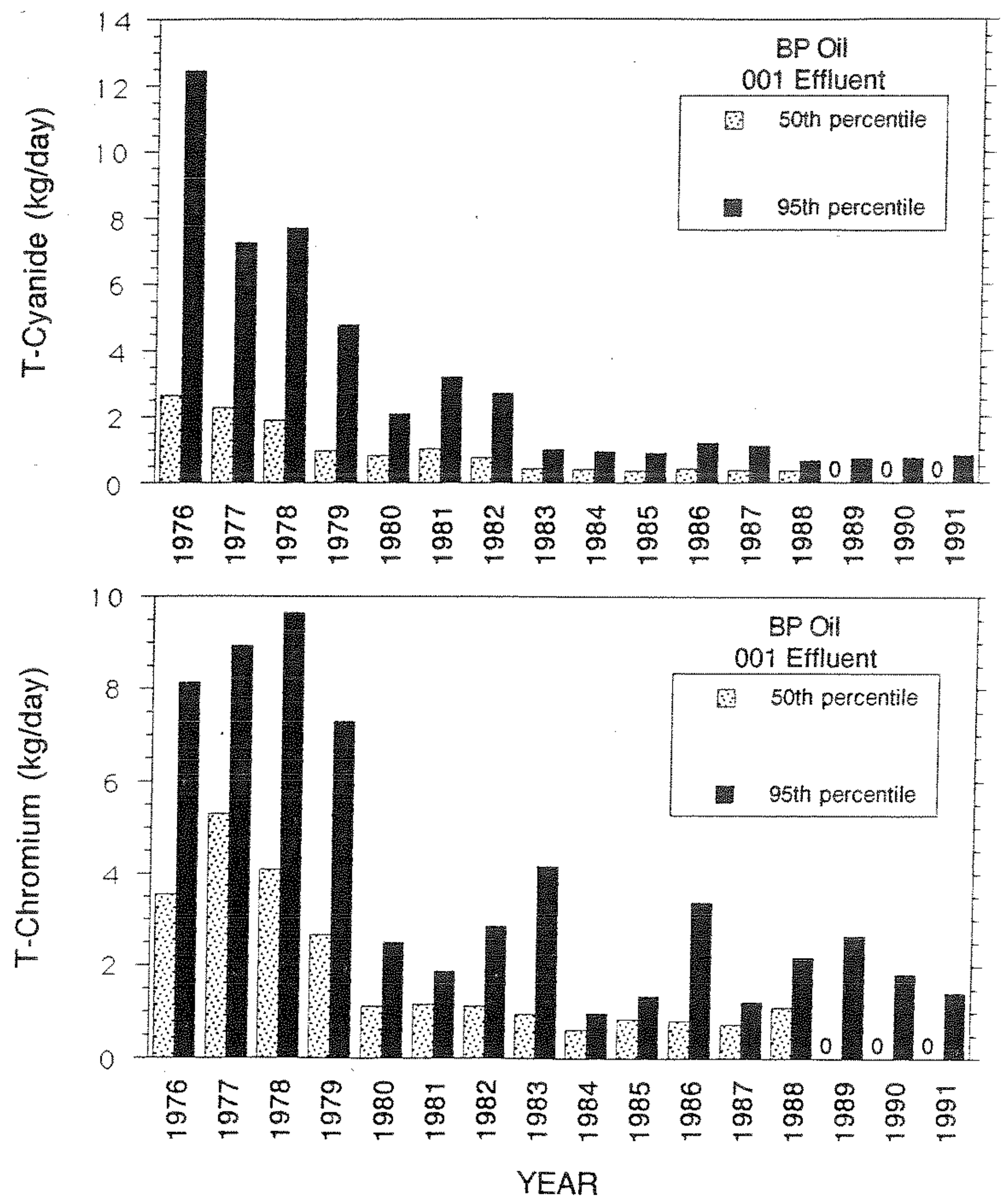


Figure 6c. Loadings (kg/day) of cyanide and chromium from the **BP Oil Company, Lima Refinery** 001 effluent to the Ottawa River from 1976 - 1991.

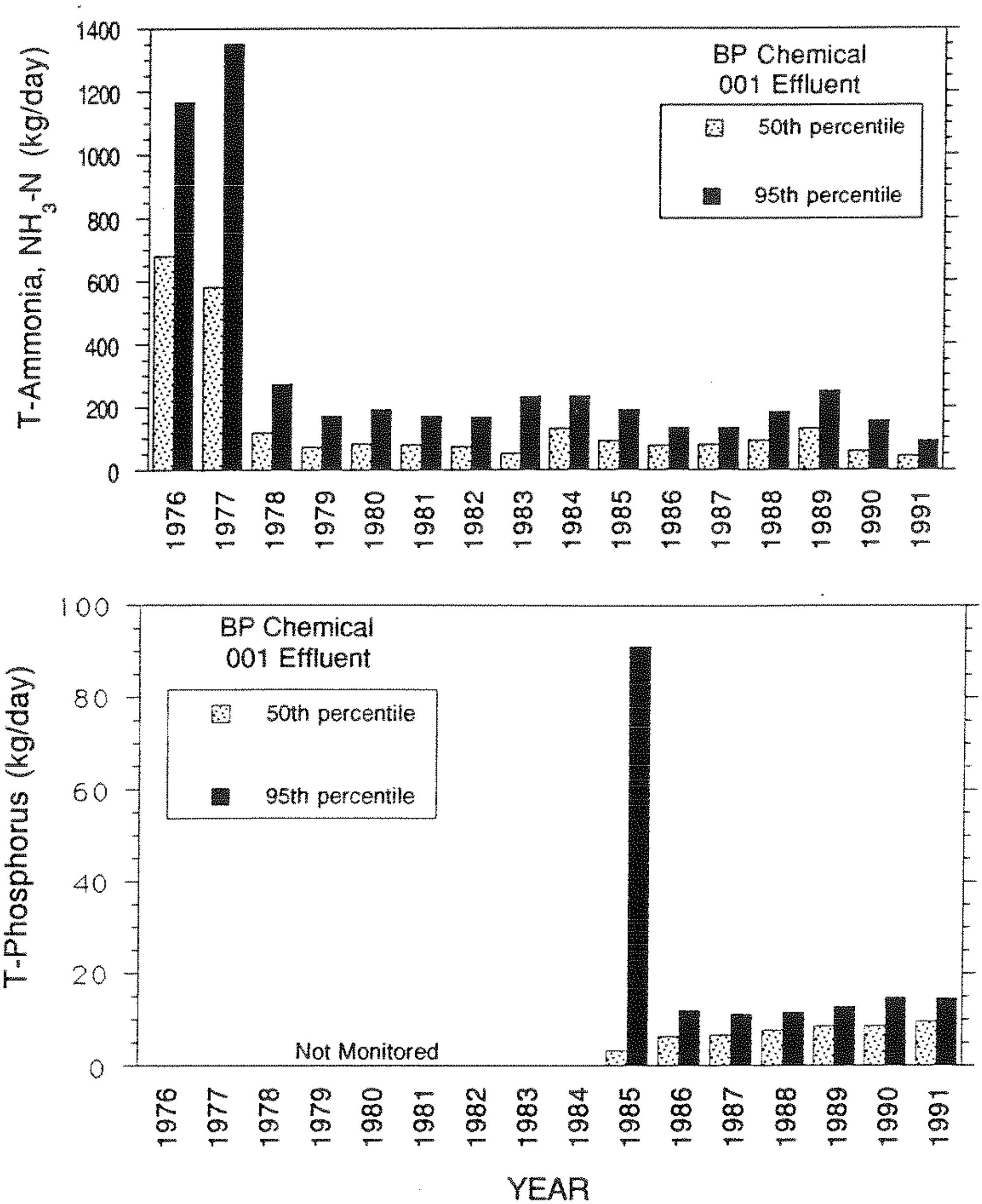


Figure 7a. Loadings (kg/day) of ammonia-N and phosphorus from the **BP Chemicals, Inc.** 001 effluent to the Ottawa River from 1976 - 1991.

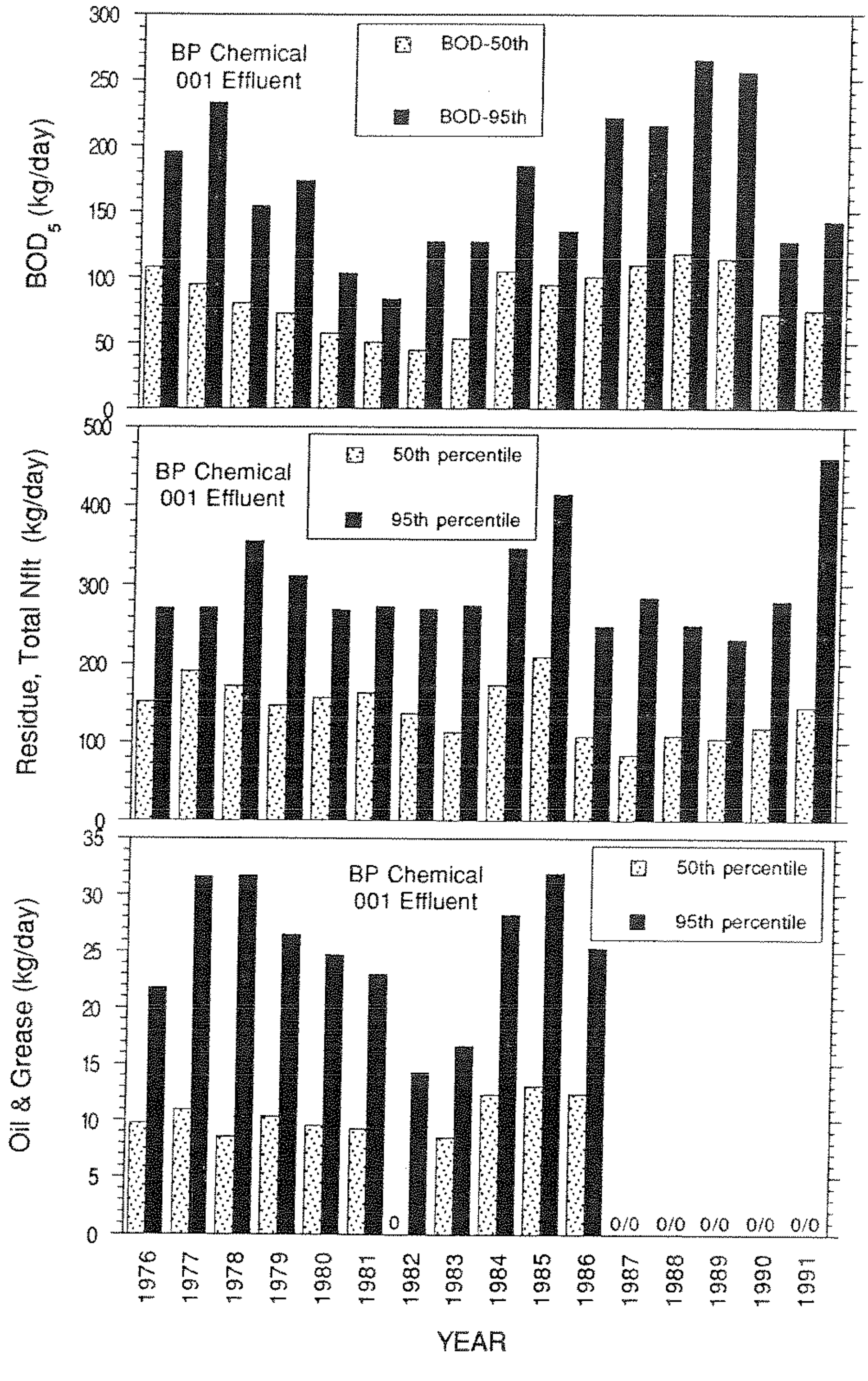
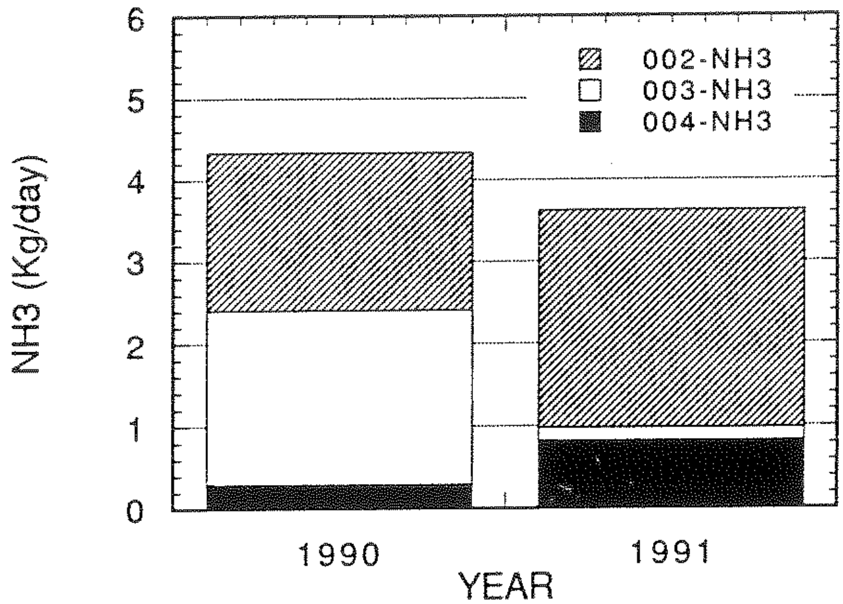


Figure 7b. Loadings (kg/day) of BOD_5, total nonfilterable residue, and oil & grease from the BP **Chemicals, Inc.** 001 effluent to the Ottawa River from 1976 - 1991.



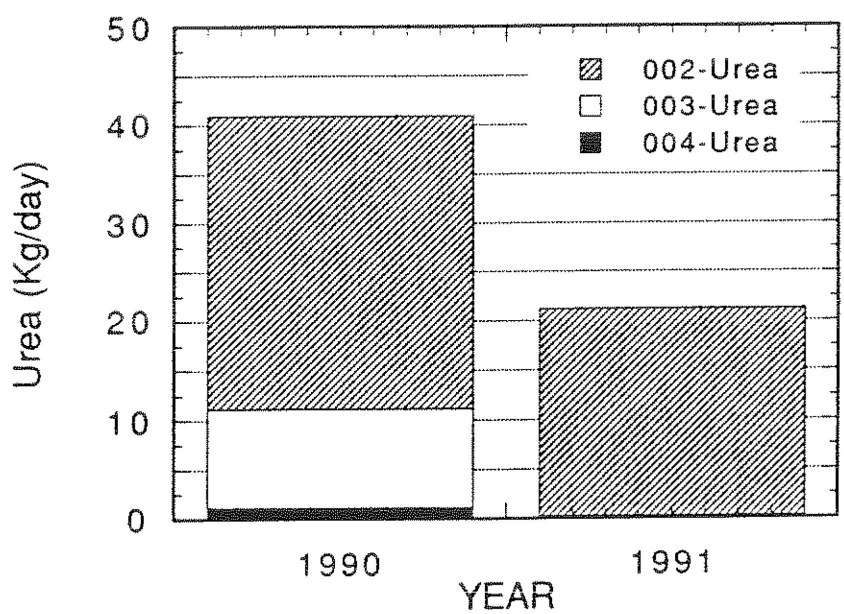


Figure 7c. Estimated loadings (kg/day) of ammonia-N and urea from the **BP Chemicals, Inc.** 002, 003, and 004 stormwater discharges to the Ottawa River during 1990 and 1991.

Table 4a. Comparison of BP-Chemicals,Inc. estimated ammonia-N and urea loadings from stormwater outfalls 002, 003, and 004 during March -December, 1990 and January-December, 1991.

Year/ Outfall	Mean daily flow[a] (MGD)	Mean # days/month discharging	NH_3-H concentration (mg/l) Min.	Max.	NH_3-H estimated loading[b] (kg/day)	Urea concentration (mg/l) Min[c].	Max.	Urea estimated loading[b] (kg/day)
1990								
002	0.018	13	9.6	76.1	1.93	35	1517	29.77
003	0.020	11	1.4	113.5	2.11	AA	391.5	9.93
004	0.027	11	0.4	6.5	0.30	AA	7.0	1.21
Total	0.065				4.34			40.91
1991								
002	0.009	17	11.5	325	2.64	81.2	1556	21.02
003	0.010	13	0.4	13.2	0.15	AA	9.4	0.04
004	0.019	13	0.4	32.9	0.83	AA	12.6	0.18
Total	0.038				3.62			21.24

[a] Mean daily flow = $\sum \frac{\text{total flow each month (MG)}}{\text{number of days (306 for 1990; 365 for 1991)}}$

[b] AA=below detection

[c] Estimated loading (kg/day) = $\frac{\sum \text{(total flow each month (MG)/ \# of days in month x conc. (mg/l) x 3.785)}}{\text{\# of months}}$

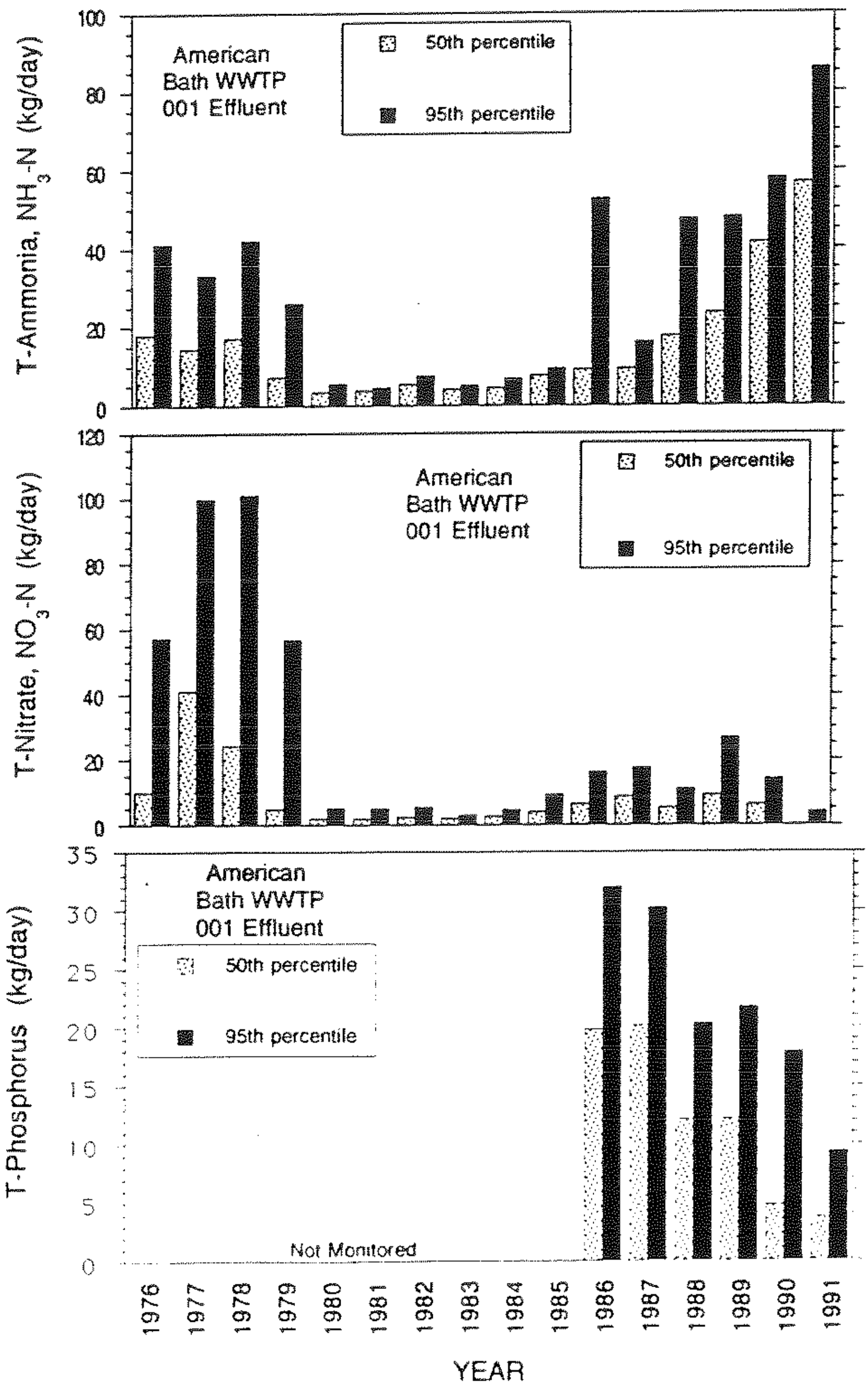


Figure 8a. Annual loadings (kg/day) of ammonia-N, nitrate-N, and phosphorus from the Allen County **American Bath WWTP** 001 effluent to Pike Run from 1976 - 1991.

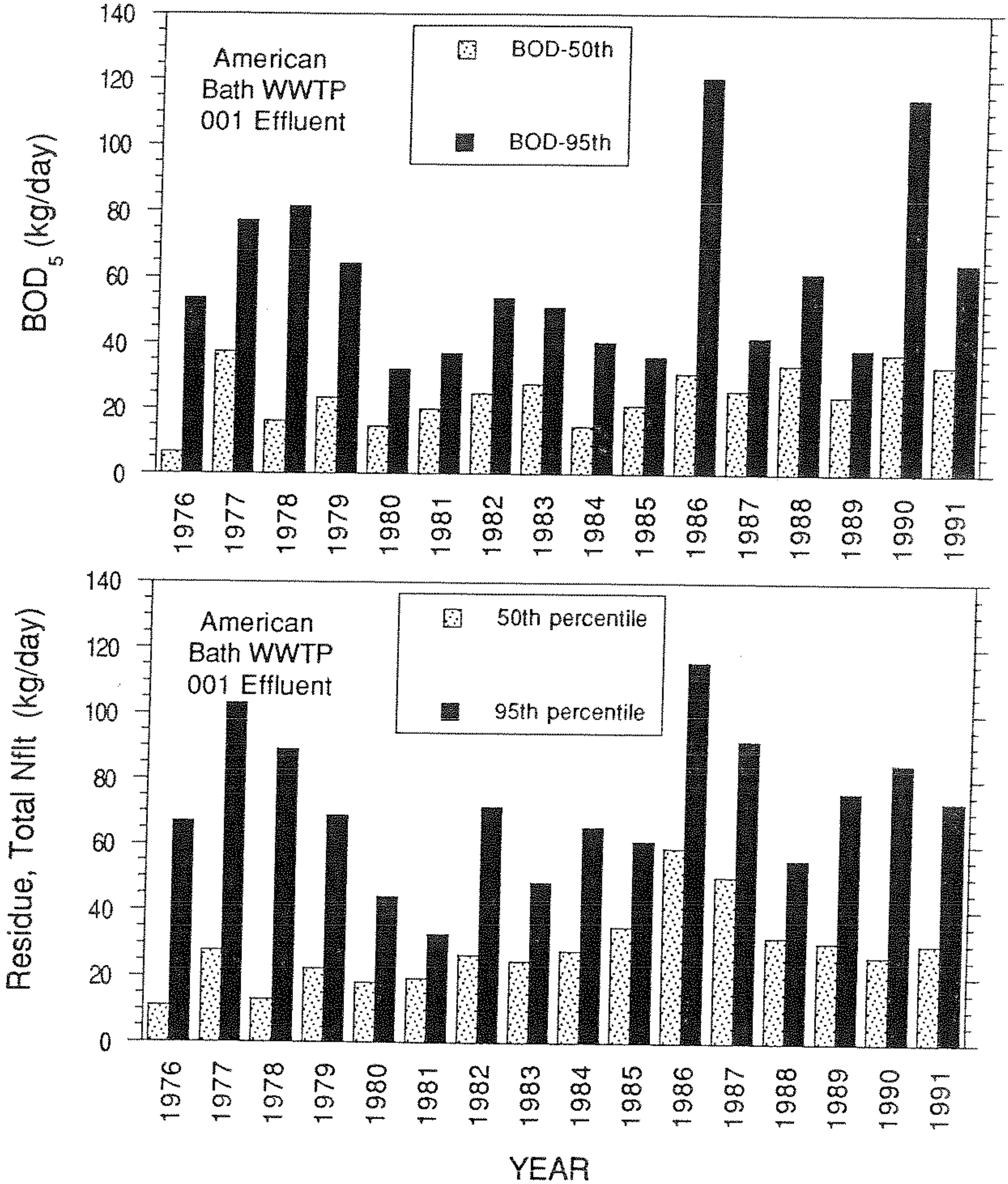


Figure 8b. Annual loadings (kg/day) of BOD_5 and total nonfilterable residue from the Allen County **American Bath WWTP** 001 effluent to Pike Run from 1976 - 1991.

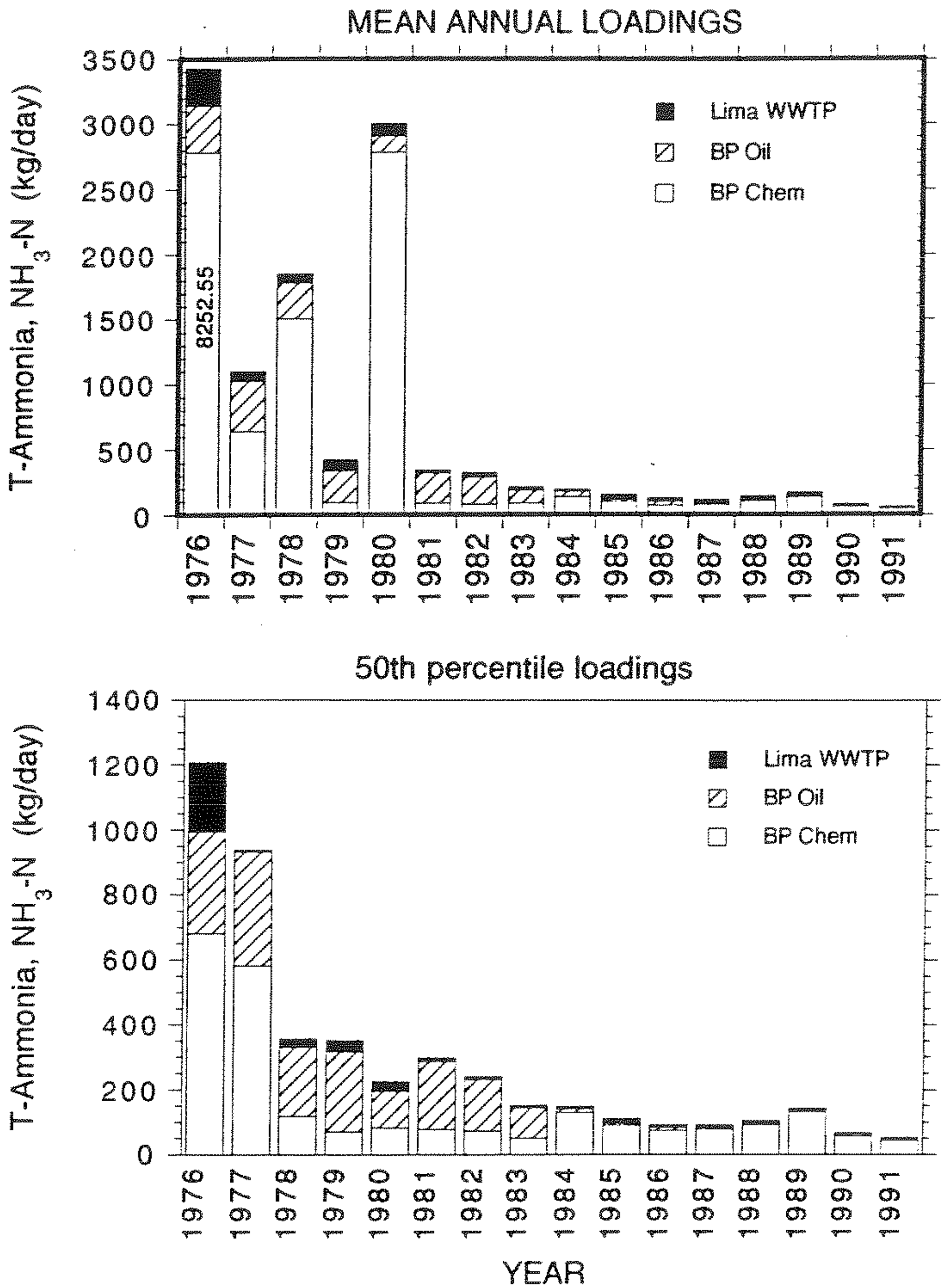


Figure 9. Total and 50th percentile mean annual loadings (kg/day) of ammonia-N from 001 effluents of the Lima WWTP, BP Oil Company, and BP Chemical to the Ottawa River from 1976 - 1991.

Table 4b. Total occurrences, hours of discharge, and flow from the City of Lima's five major Combined Sewer Overflows (CSOs) during 1989, 1990, and 1991 (approximate CSO locations are: 006 - Lovers Lane; 005 - Central Ave.; 004 - McDonel St.; 003 - Heindel St.; 002 - Collett St.).

Year CSO #	Total # Occurrences	Total Hours	Flow Total (MG)	Flow Daily (MGD)
1989				
006	31	121.81	202.24	0.55
005	29	126.31	90.15	0.25
004	29	45.84	49.52	0.14
003	33	64.38	38.26	0.10
002	40	142.18	352.66	0.97
Total	**162**	**500.52**	**732.83**	**2.01**
1990				
006	46	233.11	148.94	0.41
005	57	259.63	265.20	0.73
004	57	207.78	216.23	0.59
003	63	251.57	155.65	0.43
002	78	494.73	1,457.54	3.99
Total	**301**	**1,446.82**	**2,243.56**	**6.15**
1991				
006	24	49.52	22.31	0.06
005	20	41.67	27.35	0.07
004	23	33.51	42.08	0.12
003	33	74.37	59.26	0.16
002	36	108.87	251.19	0.69
Total	**136**	**307.94**	**402.19**	**1.10**

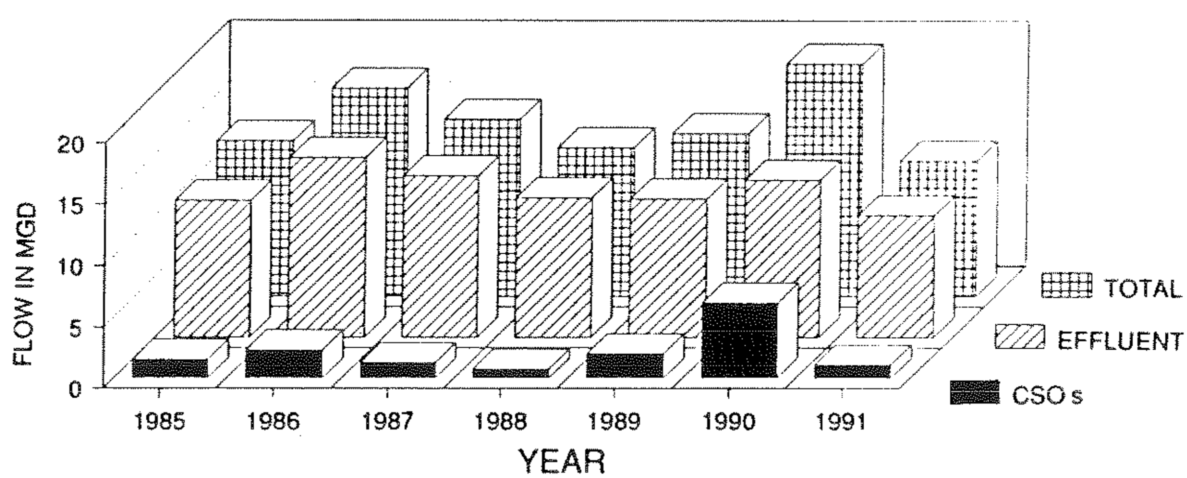
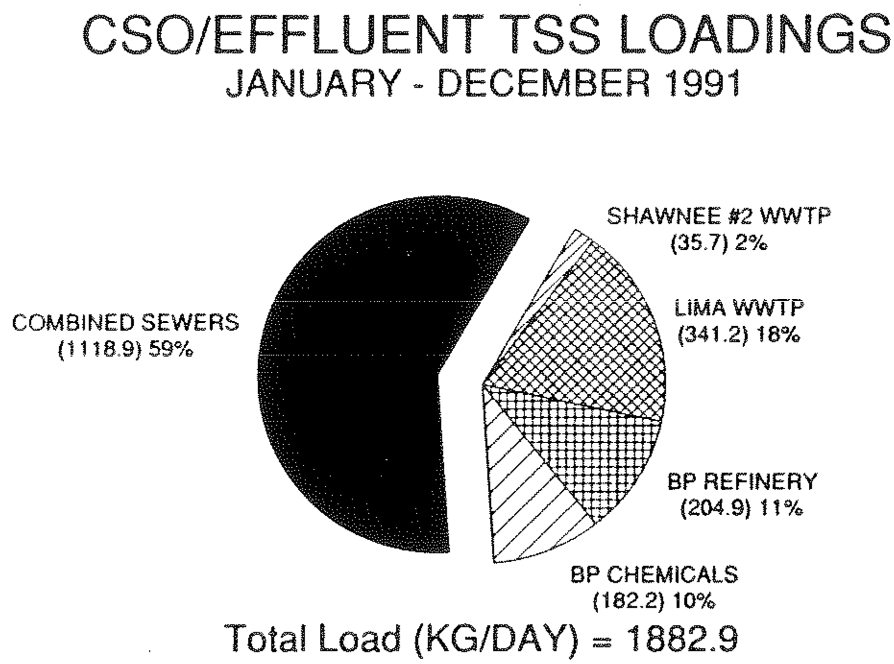


Figure 10. Comparison of the mean annual flow (MGD) from the Lima WWTP 001 effluent and Combined Sewer Overflows (outfalls 002-006) to the Ottawa River from 1985 - 1991.



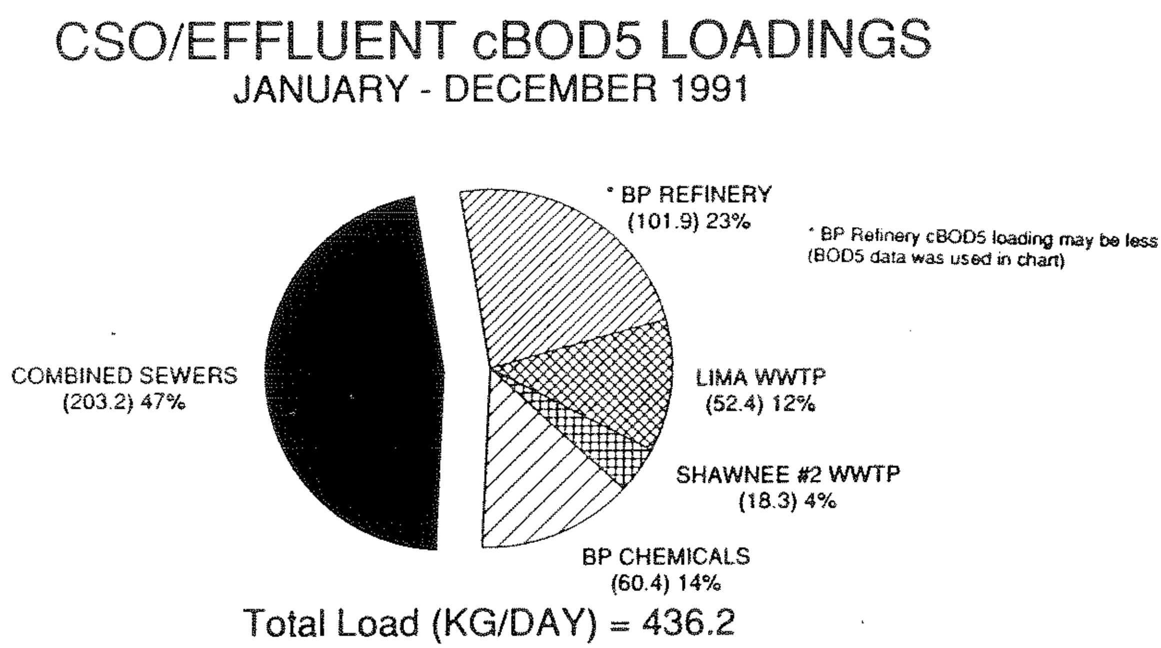


Figure 11. Pie graphs of the total mean daily loadings (kg/day) of total nonfilterable residue (*top:* total suspended solids[TSS]) and $cBOD_5$ (*bottom*) from CSOs (002-006 outfalls) and 001 outfalls of the Lima WWTP, Shawnee #2 WWTP, BP Oil Company, and BP Chemicals to the Ottawa River during 1991.

Nonpoint Versus Point Source Loadings:

• A comparison of the estimated total loadings of nitrogen entering the Ottawa River from major point source discharges (excluding CSOs) in Lima to nonpoint sources within the upstream and surrounding watershed showed mean annual nitrogen loadings of 720 kg/day (range = 583 in 1990 and 857 in 1991) from point sources versus 1027.2 kg/day (range: low= 644.7; high = 1409.8) from nonpoint sources (urban, agriculture, and forestry). Mean annual phosphorus loadings were 30.3 kg/day (34.4 in 1990; 26.1 in 1991) from point sources (excluding CSOs) and 172.9 kg/day (range: low = 56.6; high = 289.2) from nonpoint sources. *Mean total nonpoint loads appear greater, however, significant differences exist in the amounts released per distance of stream.* The major point source loads are released within a one mile segment versus the nonpoint loads being released over approximately 70 river miles. By river mile, mean point source loadings of nitrogen and phosphorus are 720 and 30.3 kg/day/mile, respectively, as opposed to mean estimated nonpoint sources loadings of 14.7 kg/day/mile of nitrogen and 2.5 kg/day/mile of phosphorus. Point source loading rates per mile are approximately 49 times greater for nitrogen and 12 times greater for phosphorus than nonpoint source loadings. Additional important differences are that nonpoint sources are most often episodically dispersed during higher flows as opposed to constant daily discharges; even during critical low flows.

• Lists of ***spills and wild animal kills*** are also indications of possible impacts due to pollutant loadings so reviews were conducted for discharges and kills to the Ottawa River study area as reported by Ohio EPA's Division of Emergency and Remedial Response (for Allen Co.) and Ohio DNR's Division of Wildlife Pollution Investigation Reports (for Putnam, Allen, and Hardin Co.). Results from 1985 through 1991 show:

1) Pollutant discharges from spills and permit violations are a significant source of lethal and sublethal stresses for aquatic communities in the Ottawa River. OEPA lists 31 reported pollutant discharges to the Ottawa River since 1985. For 12 of the incidents with amounts, a total of 26,079,400 gallons and 17,857 kilograms of pollutants were released. Primary pollutants were sewage/wastewater/solids (17) followed by petroleum (5) and nitrogen products (4). Leading causes were NPDES permit violations (13) followed by bypasses (10) and pipeline/tank leaks (5). Leading sources were BP Chemicals (12) followed by the BP Oil Company (5), Lima WWTP (5), Shawnee #2 WWTP (3), and Elida WWTP (3).

2) Pollution investigation reports for the same seven year period list seven incidents where a total of 2,985 wild animals (primarily fish) were killed within the study area. Virtually all of the incidents occurred in the vicinity of Lima. The primary causes were from chemical spills and wastewater discharges from municipal WWTPs (including CSOs) and industries (oil refining, chemical production and packaging). Despite high densities of hog operations within the study area, manure runoff from animal husbandry operations was not listed as a source of kills.

Table 5. Estimated low, high, and mean ranges of nonpoint source (urban[*excluding CSOs*], agriculture and forest land uses) nitrogen and phosphorus loadings to Hog Creek, Little Hog Creek, the Ottawa River, and the combined watershed upstream from the confluence of the Little Ottawa River.

CATEGORY	ACRES	Estimated Range of NPS Nitrogen Load (KG/DAY) LOW	MEAN	HIGH	Estimated Range of NPS Phosphorus Load (KG/DAY) LOW	MEAN	HIGH
Ottawa River Subwatersheds (upstream of the Little Ottawa River confluence)(PEMSO)[a]							
SUBWATERSHED 410801 (Hog Creek)							
URBAN	838	1.41	3.91	6.41	0.18	1.34	2.51
AGRICULTURE	36051	311.78	495.65	679.52	27.98	81.94	135.90
FOREST	4543	14.20	14.20	14.20	0.18	0.18	0.18
TOTAL	41432	327.40	513.76	700.13	28.33	83.46	138.59
SUBWATERSHED 410802 (Little Hog Creek)							
URBAN	261	0.44	1.22	2.00	0.05	0.42	0.78
AGRICULTURE	14895	128.82	204.78	280.75	11.56	33.86	56.15
FOREST	1350	4.22	4.22	4.22	0.05	0.05	0.05
TOTAL	16506	133.48	210.22	286.97	11.67	34.33	56.98
SUBWATERSHED 410831 (Ottawa River, Hog Creek to Little Ottawa River)							
URBAN	6761	11.39	31.56	51.72	1.42	10.83	20.24
AGRICULTURE	19466	168.35	267.63	366.91	15.11	44.25	73.38
FOREST	1291	4.04	4.04	4.04	0.05	0.05	0.05
TOTAL	27518	183.78	303.22	422.67	16.58	55.13	93.67
SUBWATERSHED TOTAL (Subwatersheds 410801, 410802, and 410831)							
URBAN	7860	13.25	36.69	60.13	1.66	12.59	23.53
AGRICULTURE	70412	608.94	968.06	1327.18	54.65	160.04	265.44
FOREST	7184	22.46	22.46	22.46	0.28	0.28	0.28
TOTAL	85456	644.65	1027.21	1409.77	56.58	172.91	289.24

[a] Estimates were calculated using existing land use information from the study areas (1980 Ohio Capability Analysis Program (OCAP) data for the Allen Co. and mid-1970s Planning and Engineering Data Management System for Ohio (PEMSO) for other watersheds) and export coefficients from watersheds with somewhat similar soil, vegetation and land use characteristics. NPS export coefficients were selected from the results of water quality studies conducted in other parts of Ohio and other states. Sources of export coefficients were USEPA (1981) for agricultural, and USEPA (1980) for urban and forest. Two export coefficients were selected for each land use category except for the forest category where only one usable coefficient was found. The selected export coefficients were converted to kilograms per acre per day and multiplied by the acres in each land use category from the OCAP and PEMSO data. **The export coefficients selected were:**

Category	Nitrogen (kg/ha/yr) Low	High	Phosphorus (kg/ha/yr) Low	High
Agriculture	7.80	17.00	0.70	3.40
Urban	1.52	6.90	0.19	2.70
Forest	2.82		0.035	

Table 6. Summary of pollutant discharges to the Ottawa River reported to Ohio EPA Division of Emergency and Remedial Response from January 1985 - December 1991.

Date	Material	Entity	Amount	Incident
03-03-85	28-0-0 fertilizer	BP Chemical	18,000 gals	storage tank leak
04-16-85	sewage	Lima WWTP	unknown	bypass
05-02-85	sewage	Lima WWTP	unknown	bypass
06-17-85	gasoline	BP Oil	20 gals	pipeline leak
12-02-85	ammonia	BP Chemical	551 kg	pipeline leak
03-12-86	sewage	Lima WWTP	20,000,000 gals	bypass
07-03-86	oil	BP Oil	21,000 gals	flooding
09-25-86	waste water	BP Chemical	40,000 gals	permit violation
09-25-86	ammonia	BP Chemical	772 kg	permit violation
11-13-86	diesel fuel	Bernie Furniture	250 gals	truck leak
04-03-87	sewage	Lima WWTP	6,000,000 gals	bypass
06-03-87	sewage	Elida WWTP	unknown	bypass
06-08-87	sewage	Elida WWTP	unknown	bypass
06-09-87	sewage	Elida WWTP	unknown	bypass
01-15-88	foam	BP Oil	unknown	permit violation
01-15-88	waste water	BP Oil	unknown	permit violation
02-02-88	fuel oil	Jones Transfer	unknown	unknown
03-25-88	oil	unknown	unknown	unknown
01-25-90	waste water	BP Chemical	unknown	permit violation
02-28-90	sewage	Lima WWTP	unknown	permit violation
04-16-90	waste water	BP Chemical	unknown	permit violation
08-22-90	suspended solids	BP Chemical	unknown	permit violation
09-28-90	waste water	BP Chemical	unknown	permit violation
09-28-90	acrylonitrile	BP Chemical	unknown	permit violation
04-19-91	acrylonitrile	BP Chemical	30 gals	permit violation
06-27-91	betz 409	BP Chemical	100 gals	permit violation
06-28-91	methanol	BP Oil	16,534 kg	pipeline leak
09-12-91	sewage	Shawnee #2 WWTP	unknown	bypass
11-19-91	sewage	Shawnee #2 WWTP	unknown	bypass
12-02-91	total nitrogen	BP Chemical	unknown	permit violation
12-03-91	sewage	Shawnee #2 WWTP	unknown	bypass

Chemical Water Quality (Plate 1-5; Fig. 5-14b; Table 3-7, A-1, A-2)

Ottawa River:

- The daily flows for May through September 1991 in the Ottawa River at RM 37.98 are shown in Fig. 3. The mean monthly discharge during these months was greatest during May (22.3 cfs) and lowest during July (7.5 cfs). The minimum daily flows during July, August, and September were below the estimated 80% duration value (4.7 cfs), but remained above the estimated $Q_{7,10}$ (2.0 cfs) during the 1991 survey.

- Chemical exceedences of Ohio WQS detected in Ottawa River during 1991 are listed in Tables 7 and A-2. Exceedences, based on grab water samples, consisted of a very high zinc concentration (610 ug/l) downstream from the CSOs; elevated ammonia-N and fecal coliform bacteria counts downstream from BP Chemicals, Inc.; and low D.O. concentrations at the Shawnee Country Club and Allentown. Sources and causes of the exceedences probably include: prior CSOs discharges for the zinc and the BP Chemicals 001 effluent for ammonia-N and fecal coliform bacteria. The lower than expected D.O. values were most likely due to excessive total pollutant loadings to the river by major point source dischargers in Lima.

- During the lowest 1991 flows in late July, diel D.O. violations below the 4 mg/l minimum criterion were also recorded at six locations in the most impaired segment of the Ottawa River (RM 37.9 to 28.8) using Datasonde continuous monitors (Figs. 3, 13; Table A-2). Violations were not detected, however, at the upstream control site (RM 46.1) or immediately downstream from the Lima WWTP (RM 37.6). The lowest values occurred downstream from the Lima CSOs while another general D.O. sag point occurred between RMs 34.3 and 31.05.

- Mean D.O. concentrations, based on grab day time water samples from throughout the 1991 survey, is illustrated in Fig. 14b. It shows a slightly different longitudinal D.O. profile consisting of a slight drop downstream from the Lima CSOs; and a considerable increase downstream from the Lima WWTP followed by a marked decline downstream from the BP Oil and BP Chemicals discharges. The sag point is reached at RM 34.50 and recovery occurs at RM 28.9.

- The BOD_5 trend during the survey (Fig. 14b) showed a sharp increase downstream from the CSOs, followed by a large decline downstream from the Lima WWTP and subsequent increases downstream from the two primary BP discharges.

- The highest mean total nonfilterable residue concentration (Fig. 14b) occurred at the upstream control site (RM 46.0) and appears to be caused by nonpoint source sediment erosion. Concentrations declined downstream from the CSOs (may have been higher if samples had been collected when they were discharging) and the Lima WWTP discharges, then increased downstream from the BP Oil and BP Chemicals discharges. The mean decreased slightly at the next site, but increased again by Allentown to a level lower than upstream from Lima.

- Longitudinally, the mean ammonia-N concentration (Fig. 14a) showed a marked increase downstream from the BP Chemical discharge. Concentrations then declined substantially by Allentown, but remained slightly higher than at the most upstream site.

- The mean nitrate-N concentration showed the greatest increase (Fig. 14a) downstream from the Lima WWTP discharge and remained highly elevated as far as Allentown.

- Mean phosphorus concentrations (Fig. 14a) were highest downstream from the BP Chemicals plant and remained above the background concentration to Allentown.

Hog Creek:

- Based on grab water samples, there were four D.O. violations detected in the channelized section of Hog Creek at RM 10.77. This site is upstream from the confluence of Grass Creek, which receives the Ada WWTP effluent. The violations at RM 10.77 appear to have been caused by a combination of factors including; hydromodification and low flows which exacerbate the effect of agricultural nonpoint source influences. D.O. levels improved significantly in the downstream natural segment (RM 0.3) where there was only a single grab value below 5.0 mg/l. Based on Datasonde continuous monitors, Hog Creek at RM 10.80 had lower diel D.O. concentrations than any location in the Ottawa River (Table A-2).

Little Hog Creek:

- The three D.O. violations in Little Hog Creek (RM 0.64) may be due to poor water quality from the LaFayette WWTP, low flow conditions in a low gradient stream, or a combination of these factors.

Pike Run:

- Low flow conditions occurred in the headwaters of Pike Run during most of the sampling period and single D.O. violations were detected both upstream and downstream from the American Bath WWTP (Table 7). The D.O. violations were most likely due to non-point sources (*i.e.*, hydromodification and runoff) at the upstream site, but also likely due to the poor quality WWTP effluent immediately downstream from the overloaded facility. The ammonia-N violation at RM 8.16 was due to the WWTP effluent. The continued violations for ammonia-N at RM 2.14 suggest a lack of recovery in Pike Run from the effects of the American Bath WWTP, six miles downstream. The source(s) of the metals exceedences are currently unknown, but should be investigated.

Table 7. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in grab samples taken from the Ottawa River study area during 1991 (units are µg/l for metals, colonies/100 ml for fecal coliform, and mg/l for all other parameters). Iron is not listed because 20 of 77 samples (30.0%) exceeded 1.0 mg/l. Additional D.O. violations were measured using Datasonde continuous recorders and are listed in Appendix Table A-2.

Stream	River Mile	Parameter (value)
Ottawa River	37.9	Zn (610 ***)
	36.8	NH_3-N (3.56 *, 2.02 *, 0.84 *, 1.72 *) Fecal coliform (2500 ◊, 5900 ◊◊)
	34.6	D.O. (3.9 ‡‡, 3.9 ‡‡)
	28.8	D.O. (4.2 ‡)
Hog Creek	10.8	D.O. (3.0 ‡‡, 2.5 ‡‡, 3.0 ‡‡, 2.0 ‡‡) 0.3D.O. (4.9 ‡)
L.Hog Creek	0.6	D.O. (2.6 ‡‡, 1.9 ‡‡‡, 2.2 ‡‡)
Pike Run	8.2	D.O. (3.5 ‡‡)
	8.1	D.O. (3.0 ‡‡); NH_3-N (15.2 **)
	2.1	NH_3-N (5.76 *, 3.66 *, 1.26 *); Cu (15 *); Pb (12 *); Zn (145 **)

* indicates an exceedence of numerical criteria for prevention of chronic toxicity (CAC).
** indicates an exceedence of numerical criteria for prevention of acute toxicity (AAC).
*** indicates an exceedence of numerical criteria for prevention of lethality (FAV).
‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
◊ exceedence of the Primary Contact Recreation criterion.
◊◊ exceedence of the Secondary Contact Recreation criterion.

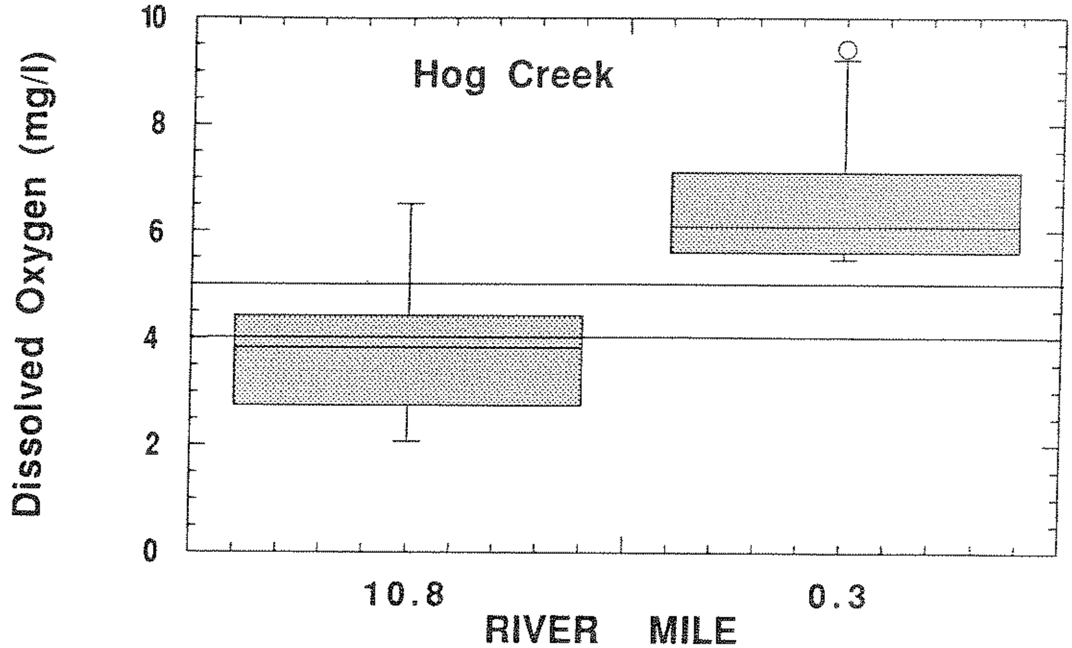


Figure 12. Low-flow longitudinal summary of diel D.O. trends in Hog Creek from Datasonde continuous monitors from 23 - 25 July, 1991.

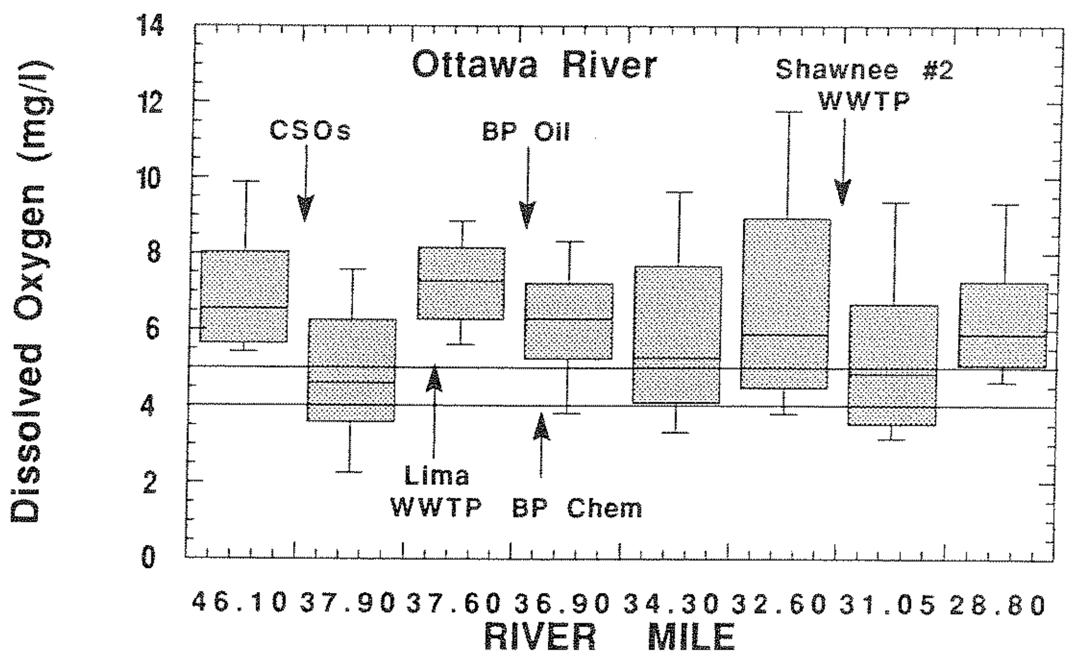


Figure 13. Low-flow longitudinal summary of diel D.O. trends in the Ottawa River from Datasonde continuous monitors from 23 -25 July, 1991.

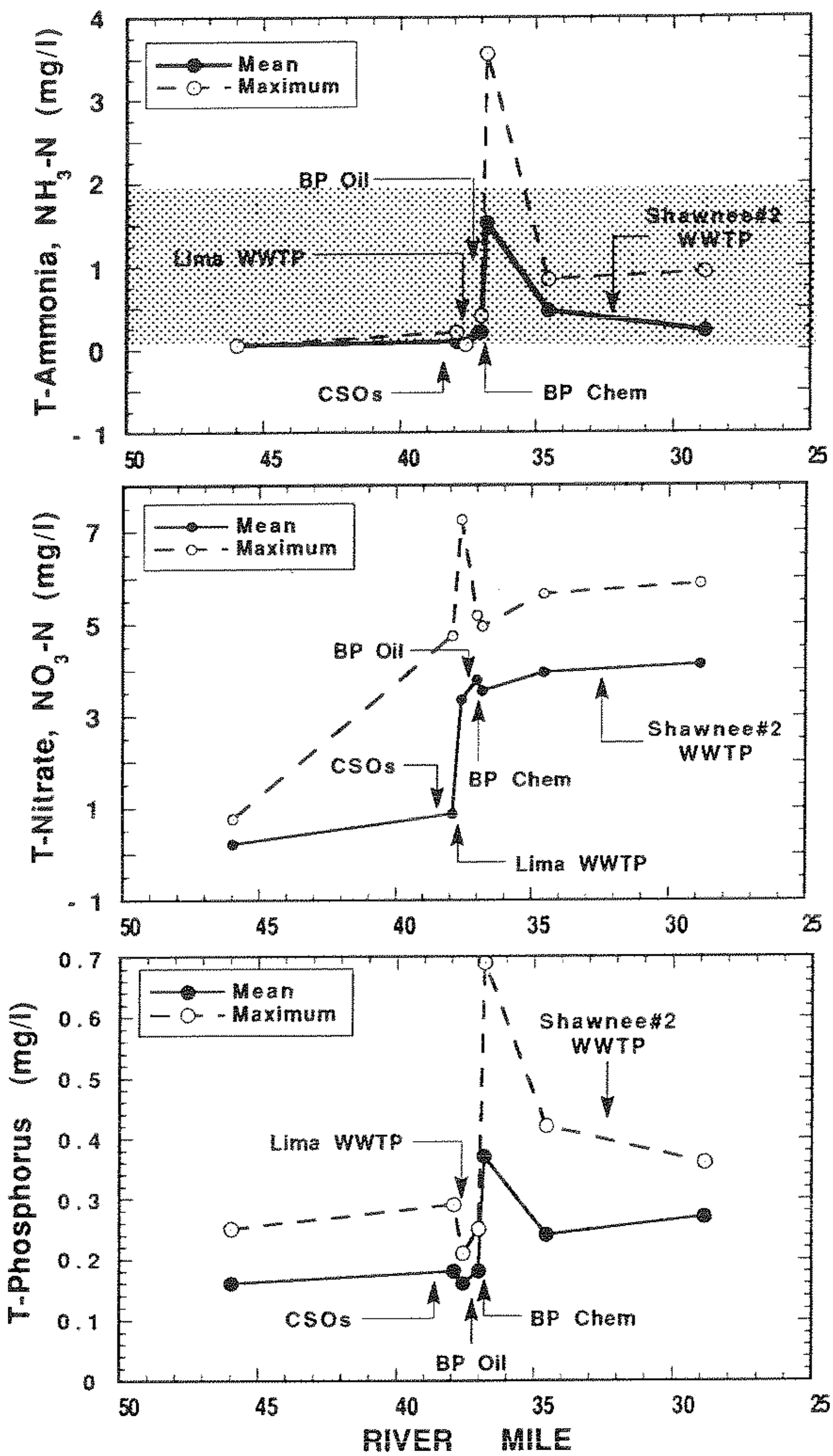


Figure 14a. Longitudinal trends of the mean ammonia-N *(shaded area is the WQS range between the 90th and 25th percentile pH and temperature recorded during sample collection)*, nitrate, and phosphorus concentrations during the 1991 Ottawa River survey.

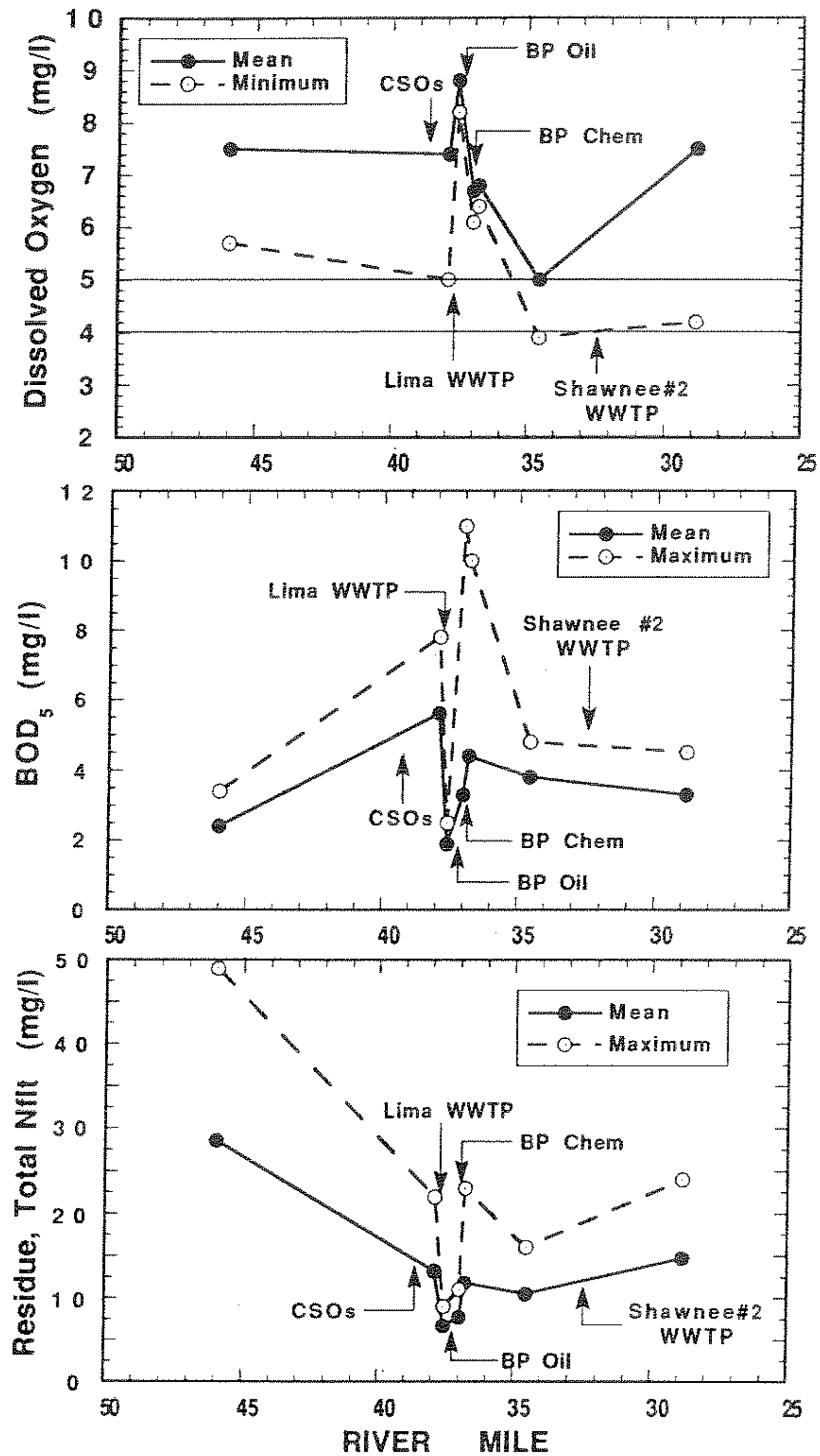
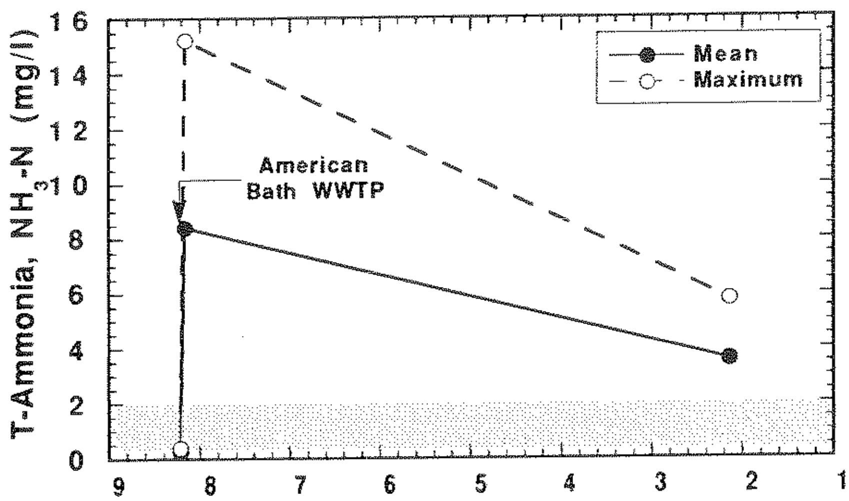


Figure 14b. Longitudinal trends of the mean dissolved oxygen (day time grab samples), BOD_5, and total nonfilterable residue concentrations during the 1991 Ottawa River survey.



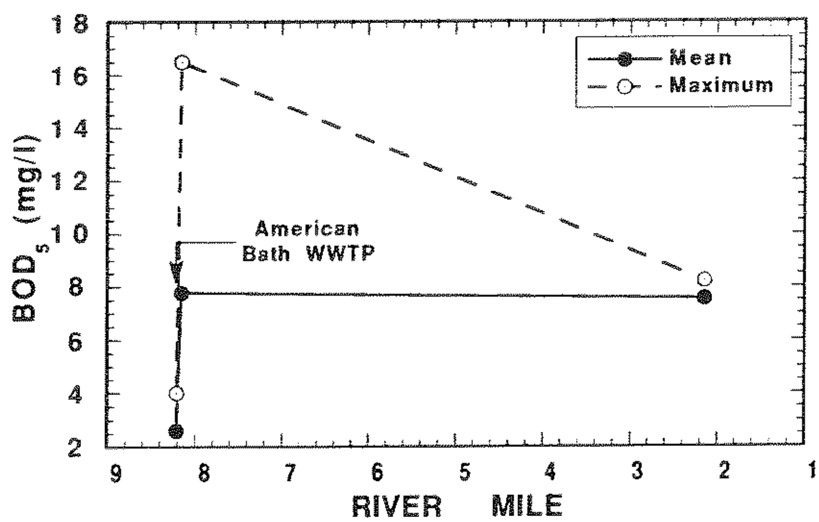


Figure 14c. Longitudinal trends of the mean ammonia-N *(shaded area is the WQS range between the 90th and 25th percentile pH and temperature recorded during sample collection)*, phosphorus, dissolved oxygen (day time grab samples), and BOD_5 concentrations in Pike Run during the 1991 survey.

Chemical Sediment Quality (Plate 3-4; Fig. 1; Table 4,8-9,A-7)

- During the summer of 1991, sediment samples were collected from 10 locations in the study area. All samples (seven from the Ottawa River, two from Hog Creek, and one from Little Hog Creek) were analyzed for concentrations of eight different metals. Priority pollutant scans were also conducted on samples downstream from the Lima WWTP (RM 37.6), BP Oil Company (RM 37.0), and BP Chemicals (RM 36.8).

- Extremely or highly elevated concentrations of metals were found in the fine sediments of the Ottawa River downstream from major wastewater discharges (RM 37.9 - 28.8). **Cadmium (Cd), copper (Cu), lead (Pb),** and **nickel (Ni)** concentrations were greatest downstream from the CSOs (RM 37.9); **zinc (Zn)** was greatest downstream from the BP Oil Company; and **arsenic (As)** and **chromium (Cr)** were greatest downstream from BP Chemicals (RM 36.8). Longitudinally, **lead** concentrations declined with downstream distance from the CSOs. **Chromium** was extremely elevated downstream from the CSOs, but increased downstream from the two BP facilities. **Zinc** also appeared to have multiple contributing sources.

- Within the 9.1 mile impaired segment, the metal with the highest number of extremely or highly elevated concentrations was **chromium** followed by **lead**, and **zinc**. By location, the most severe contamination (the location with the highest number of different extremely or highly elevated metals) occurred at **RMs 37.9, 37.0, and 36.8** followed by RMs 28.8, 37.6, and 34.6.

- In addition to the oily substance recently observed in the Ottawa River at RM 37.7, type(s) and extent of contaminants leaching into the river and groundwater from the BP Oil Company L-5 Landfill should soon be known.

- Summed PAHs, based on the priority pollutant scans at three locations, were highest (47.8 mg/kg) downstream from BP Chemicals and second highest at the site downstream from the Lima WWTP and the L-5 Landfill (37.6 mg/kg). An evaluation of the Ottawa River sediment PAH data is presented in Appendix Table A-7.

- Pesticide results showed elevated concentrations of dieldrin at RM 37.6 and 37.0, and DDT at all three locations. Mirex, which is not usually found in Ohio sediments, was detected at RM 36.8 (it may have also been present at the other two locations, but not detected due to higher detection limits). Methoxychlor was noticeably higher at RM 36.8 than at the two upstream locations.

- The extent of contamination by metals in the Ottawa River is unknown, but may be limited to the deposits of sludge and other fine sediment downstream from major discharges. Extensive areas of fine sediment (*i.e.*, silt, muck, and organic sludge) are localized because Ottawa River sediments are predominantly inorganic (*i.e.*, sand, gravel, cobble, and boulders) throughout much of the affected segment.

- Concentrations of metals in the fine sediments of the four predominantly agricultural sites in the study area were predominantly non-elevated. Arsenic and iron values were, however, classified as elevated at the upper Hog Creek site in Hardin Co. and the Ottawa River site upstream from Lima.

Table 8. Sediment concentrations (mg/kg dry weight) of eight metals in the 1991 Ottawa River study area. Concentrations (excluding nickel) were ranked based on a stream sediment classification system described by Kelly and Hite (1984). The Kelly and Hite classification system addresses relative concentrations, but does not directly assess toxicity.

Stream River Mile	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**	**Ni**	**Zn**
Ottawa River								
46.0	12.4[c]	0.281[a]	10.6[a]	20.4[a]	23800[c]	38.8[c]	17.3	58.7[a]
37.9	10.7[b]	**4.73[d]**	**81.2[e]**	**167.0[d]**	19700[b]	**332.0[e]**	75.9	**356.0[e]**
37.6	6.64[a]	1.19[c]	**46.4[d]**	92.4[c]	27200[c]	**162.0[e]**	47.5	**268.0[d]**
37.0	14.6[c]	1.50[c]	**178.0[e]**	**135.0[d]**	**44600[d]**	**146.0[e]**	63.9	**456.0[e]**
36.3	**25.5[d]**	0.894[b]	**239.0[e]**	**145.0[d]**	24000[c]	**97.3[d]**	63.8	**294.0[d]**
34.6	14.4[c]	1.07[c]	**44.3[d]**	51.9[b]	26800[c]	**84.3[d]**	34.5	**152.0[c]**
28.8	15.9[c]	0.697[b]	**79.5[e]**	72.5[c]	**32900[d]**	**89.5[d]**	36.8	**232.0[d]**
Hog Creek								
10.77	11.3[c]	0.222[a]	8.93[a]	20.8[a]	23100[c]	27.8[a]	17.6	59.9[a]
0.27	6.31[a]	0.421[a]	6.85[a]	17.5[a]	16700[a]	12.6[a]	14.2	70.3[a]
Little Hog Creek								
0.66	4.13[a]	0.279[a]	9.39[a]	15.3[a]	13600[a]	21.2[a]	11.7	61.3[a]

[a] Non-elevated.
[b] Slightly elevated.
[c] Elevated.
[d] Highly elevated.
[e] Extremely elevated.

Table 9. Ottawa River sediment priority pollutant scan detections during 1991. Detection values for non-detected (ND) values for priority pollutants are presented in ( ).

PARAMETER	RM 37.6	RM 37.0	RM 36.8
PAH's (mg/kg)			
Phenanthrene	3.2	1.9	5.5
Anthracene	3.4	ND(1.9)	ND(1.2)
Fluoranthene	6.2	3.4	9.4
Pyrene	3.3	2.3	6.1
Benzo (A) Anthracene	2.8	2.0	5.1
Chrysene	3.2	2.3	4.3
Benzo (K) Fluoranthene	6.2	4.0	10.0
Benzo (A) Pyrene	3.0	2.3	3.4
Indeno (1, 2, 3 - CD) Pyrene	2.7	1.9	2.2
Benzo (G, H, I) Perylene	2.7	2.4	1.8
PHTHALATES (mg/kg)			
Bis (2 - Ethylhexyl) Phthalate	8.3	12.7	ND(5.8)
PESTICIDES (ug/kg) *			
a - BHC	1.55[f]	ND(1.33)	ND(0.91)
d - BHC	10.44[f]	9.93[f]	12.06[f]
Heptachlor	3.56[f]	ND(1.33)	ND(0.91)
Aldrin	ND(0.40)	3.29[f]	ND(0.91)
Dieldrin	7.26[c]	6.99[c]	ND(0.91)
Endrin	4.41[f]	4.89[f]	4.87[f]
Methoxychlor	24.0[f]	19.22[f]	43.39[f]
Mirex	ND(5.2)	ND(6.65)	5.19[f] (4.57)
DDT (sum)**		21.97[c]	26.54[c] 11.14[c]
GC/MS LIBRARY COMPUTER MATCH (mg/kg; non - priority pollutants) ***			
Dodecane	0.35	ND	ND
Tridecane	ND	ND	0.3
Pentyl Cyclohexane	ND	ND	0.23
3, 6 - Dimethyldecane	ND	ND	0.15
2, 6 - Dimethyl Heptadecane	5.3	ND	ND
Mono (2 - Ethylhexyl) Ester Hexadedioic Acid	17.8	34.9	ND
Nonacosane	9.6	ND	ND
2, 3 - Epoxy (2. Alpha., 3. Alpha., 5. Alpha) - Cholestane	13.9	ND	ND
4, 5 - Epoxy (4. Alpha., 5. Alpha.) - Cholestane	ND	12.9	ND

* All pesticide concentrations, unless indicated, were ranked with the following stream sediment classification system described by Kelly and Hite (1984). [a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**; [f] Not evaluated by Kelly and Hite

** Sum DDT is the total of 4, 4' - DDE, 4, 4' - DDD, and 4, 4' - DDT.

*** reported Library matched chemical concentrationsindicated are estimates within one order of magnitude

Physical Habitat for Aquatic Life (Plate 1-2; Fig. 1; Table 3,10,13)

Hog Creek:

- The quality of physical habitats in Hog Creek ranged from good in Allen County (RM 1.0; QHEI = 73.5) to very poor in Hardin County (RM 10.8; QHEI = 16.5) due to extensive channelization and ongoing maintenance. The total number of WWH attributes was higher than the number of MWH attributes in Allen County, but were virtually absent from the highly modified Hardin County section. The extent and severity of channelization and ongoing maintenance practices precludes this section from attaining WWH biocriteria.

Little Hog Creek:

- Little Hog Creek's physical habitats at RM 0.2 also appeared natural and were considered good (QHEI = 69.5).

Ottawa River:

- Aquatic habitats in the Ottawa River are predominantly free-flowing, upstream and downstream from Lima, and consist of long pools interspersed by riffle-run complexes. Water depths are generally shallow and less than 1 meter while stream widths typically range from 20 to 30 meters. Substrates are varied and composed of limestone bedrock, boulders, cobble, gravel, sand, and silt. By segment, QHEI scores reflect good to very good warmwater habitat quality. The highest scores occurred upstream from Thayer Rd, adjacent to the Shawnee Country Club, and upstream from the Allentown Dam (QHEI = 80.5, 81.5, and 79.5 respectively). Scores were slightly lower in the reach adjacent to the Lima WWTP, BP Oil Refinery, and BP Chemical Plant (mean QHEI = 71.5; range = 60.0 - 77.0), but remain good quality and similar to the lower reach upstream from Putnam Road 19 (QHEI = 71.0). The total number of WWH attributes were considerably higher than the total of MWH attributes at all but one location (RM 36.7).

- Approximately three miles of the Ottawa River within Lima are impounded by a series of lowhead dams. Elsewhere, other dams locally impound small portions of the river upstream from Lima and at Allentown. The dams negatively affect the physical quality of the river by reducing the diversity of habitat, increasing siltation, and blocking fish migration during most flows. Other channel alterations occur over relatively short distances, but do not lower the WWH potential of the river.

Pike Run:

- Pike Run contains only fair to poor aquatic habitats due to previous channelization. QHEI scores ranged from 28.5 to 50.0 (mean = 39.5). The stream is listed as a petitioned ditch and there are plans for putting it on a maintenance schedule (Allen County Engineer, pers. comm.). Given this status, existing and future channel-bank modifications preclude the aquatic life potential of warmwater habitat.

Table 10. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for sites in the 1991 Ottawa River study area.

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 Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total (High Influence) MWH Attributes	Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Riffle Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
(04-200) – OTTAWA RIVER																																		
Year: 91																																		
46.1	80.5	7.94	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
37.7	75.5	6.20	■	■		■	■	■		■	■	■	8						0					▲	▲			▲				3	.11	.44
37.4	73.5	6.20		■		■		■	■	■	■	■	7						0	▲				▲	▲				▲			4	.13	.63
37.0	77.0	8.10	■	■		■		■	■	■	■		8						0						▲					▲		2	.11	.33
36.7	60.0	8.10		■						■	■		3				●		1	▲	▲			▲	▲			▲			▲	6	.50	2.00
34.7	81.5	3.10	■	■		■	■	■	■		■	■	8						0										▲			1	.11	.22
28.9	79.5	5.56	■	■		■	■	■	■		■		7						0										▲	▲		2	.13	.38
1.2	71.0	1.68	■	■		■	■	■	■	■	■	■	9						0													0	.10	.10
(04-208) – PIKE RUN																																		
Year: 91																																		
8.2	50.0	6.85		■			■	■			■		4				●		1	▲	▲			▲				▲	▲	▲	▲	7	.40	1.80
8.1	28.5	6.85									■		1	●	●	●	●		4	▲	▲			▲	▲			▲	▲		▲	7	2.50	6.00
2.1	40.0	4.76						■		■	■		3	●	●	●			3	▲	▲			▲	▲			▲	▲		▲	7	1.00	2.75
(04-216) – HOG CREEK																																		
Year: 91																																		
10.8	16.5	1.42									■		1	●	●		●		3		▲		▲	▲	▲	▲		▲	▲		▲	8	2.00	6.00
1.0	73.5	5.88	■	■		■		■		■	■	■	7		●				1		▲				▲			▲				3	.25	.63
(04-221) – LITTLE HOG CREEK																																		
Year: 91																																		
0.2	69.5	5.00	■	■		■	■	■		■	■	■	8						0									▲				1	.11	.22

Macroinvertebrate Communities (Plate 1-2; Fig. 1,15; Table 1,3-4,11-12; A-3,A-4)

Hog Creek:

• Invertebrate community health was poor in the extensively modified (Hardin County) headwaters of Hog Creek (ICI = 6 at RM 10.7; Table 12). The stream was ditched and stagnant with sandy substrates embedded by a thick layer of soft muck. Samples were predominated by nutrient and silt tolerant oligochaetes, dipteran larvae, and backswimmers (Corixidae); all reflected the severe habitat alterations and resultant degraded conditions.

• Downstream in the natural Allen County segment (RM 0.2) of the creek, the macroinvertebrate community showed substantial improvement. The ICI scored a 50 (the highest score in the study area) and was indicative of exceptional quality. Each of the ten ICI metric scores increased by two to six ICI units. While silt deposition in the pooled sections of the stream appeared fairly extensive; the coarse, predominantly bedrock, rubble, and boulder substrates supported numerous, relatively pollution sensitive populations. The quantitative and qualitative results were not indicative of significant agricultural nonpoint source impacts.

Little Hog Creek:

• The ICI score of 34 at RM 0.2 was in the marginally good range and reflected a negative influence from a lack of current over the artificial substrates (Table 12). The absence of flow dependent caddisflies on the samplers resulted in very low metric scores for caddisfly richness and percentages. Seven of the remaining eight metrics scored a “4” or “6” on the 0-6 metric scoring scale and included a “6” score for mayfly and caddisfly EPT richness on the natural substrates. Overall, the results indicated no detectable impacts 0.85 miles downstream from the Lafayette WWTP.

Ottawa River:

• Macroinvertebrates were sampled at eight sites in the Ottawa River from upstream of Lima to Putnam County Road 19 (RMs 45.9 - 0.8; Table 12, Fig. 15). Narrative evaluations, based on ICI scores and/or QCTVs ranged from good at RMs 45.9 and 0.8 (ICIs=36 and 28) to poor at RM 37.8 - 37.4 and at RM 36.1 (ICIs = 6 - 10). At RM 0.8, the ICI was only in the fair range presumably due to a lack of sufficient current over the artificial substrate samplers. Qualitative sampling results, however, were indicative of a good quality community at the most downstream site. Compared to the macroinvertebrate communities at RMs 45.9 and RM 0.8, communities from Lima to Allentown (RM 37.8 - 28.8) were moderately to severely impacted by the major point source discharges in Lima, including the CSOs. Sites within the nine mile segment did not meet the WWH criteria.

• Both quantitative and qualitative samples from the Thayer Rd. site (RM 45.9) were diverse (51 and 53 taxa, respectively) and included numerous pollution sensitive taxa. An interruption of current over the artificial substrates coupled with the resulting silt and solids deposition on the samplers probably contributed to the relatively low scores for each of the percent abundance ICI metrics. However, these influences were not of sufficient severity to drop the overall ICI score below the WWH criterion. In the qualitative sample, pollution sensitive mayflies and caddisflies were abundant (15 taxa) and populations were similar to the high quality collections taken from the site over the past two decades.

• Combined sewer overflows in Lima severely impacted macroinvertebrate communities at RM 37.8. The ICI dropped into the poor range due to declines in nine of the ten ICI metrics. Enrichment tolerant oligochaetes, flatworms, and hemoglobin utilizing midges predominated the artificial substrate sample while the natural substrate sample included a variety of both nutrient and toxic tolerant populations. The presence of six mayfly and caddisfly taxa and the relatively sensitive lepidopteran genus *Petrophila.* indicated conditions were not degraded enough to eliminate all sensitive varieties. Mayfly and caddisfly richness at RM 37.8 was not exceeded until RM 28.8; nine miles downstream. Overall, communities at RM 37.8 reflected degraded and highly enriched conditions.

• Downstream from the Lima WWTP (RM 37.4), the ICI (6) remained in the poor range while the number of mayfly and caddisfly taxa was reduced to a single mayfly individual of the genus *Caenis.* The artificial substrate sample was predominated by midges of the *Cricotopus tremulus* group, which accounted for 47% of the total organisms. Ohio EPA collection records suggest a moderate pollution tolerance for this group, but several varieties within the C. *tremulus* group have been associated with toxic impacts (Eagleson *et al.* 1990). Ohio EPA data also indicates the group is often associated with increasingly lower stream quality (*i.e.*, lower ICI scores) as it increases in predominance (Table 11). At higher percentages (>10 - 20%) it was often found in areas subjected to complex municipal-industrial and urban impacts which included contamination by metals, oil, and sewage. A pungent septic or chemical odor and occasional patches of oil were noted at this location. The 1991 results were indicative of a toxic impact to macroinvertebrates downstream from the Lima WWTP.

• ICI scores increased slightly to the low fair range downstream from the BP Oil Refinery (ICI = 14 at RM 37.0), but declined again to the poor range downstream from BP Chemicals (ICI = 10 at RM 36.1). The mayfly *Baetis intercalaris* and the caddisfly, *Hydropsyche dicantha* were found downstream from both discharges, but improvements in the ICI scoring metrics were minimal. The percent tolerant taxa increased downstream from the BP Refinery (21.3%) and BP Chemicals (47.0%) due primarily to increased numbers of the toxics tolerant midge *Cricotopus bicinctus.* Impacts from the BP Oil Refinery were difficult to assess due to the already degraded conditions upstream. Downstream from the BP Chemicals plant there were indications of additional or cumulative impacts to the macroinvertebrates. Community response patterns characteristic of both toxic and enrichment influences were observed throughout this segment of the river downstream from the series of municipal and industrial discharges in Lima.

• Between the Shawnee Country Club and Allentown (RM 34.5 -28.8), the ICI remained in the fair range, but increased from 18 to 28. This stretch of the river was characterized by sharp increases in the percentages of the mayfly *Baetis intercalaris* on the artificial substrates and declines in the midge genus *Cricotopus* with increased distance downstream. The genus *Baetis* is an intermediate taxon which tends to be associated with enrichment type impacts (Eagleson *et al.* 1990). Ohio EPA has also found it in association with the genus *Cricotopus* in areas of complex industrial-municipal and/or CSO/urban impacts such as the Cuyahoga River and a number of its tributaries in the Akron and Cleveland metropolitan areas. Longitudinal shifts in the predominance of *Cricotopus* and *Baetis* in the Ottawa River suggested a modest recovery with increased downstream distance. Despite these changes, recovery at Allentown was considered incomplete and the macroinvertebrate community remained impaired.

• Twenty-eight miles downstream (RM 0.8), the diversity and quality of macroinvertebrates significantly improved and recovery appeared complete prior to the Ottawa's confluence with the Auglaize River. As mentioned previously, the relatively low ICI score of 28 primarily resulted from a lack of sustained current over the artificial substrates. Numbers of qualitatively collected EPT taxa (17) were the highest in the survey and collections were similar to previous sampling efforts in 1985 and 1989 when the accompanying ICI scores were in the very good to exceptional range.

Table 11. Ranges of abundance (by percent) of midges of the *Cricotopus tremulus* group collected from artificial substrate samplers with corresponding mean ICI scores within each range. Based on quantitative results from the Ohio EPA's data base (Ohio ECOS), 1980-92.

	***Cricotopus tremulus* group**	
Percent Abundance	N	Mean ICI
> 0	450	32.9
> 5	69	24.0
>10	29	21.5
>20	13	16.3
>30	4	13.5

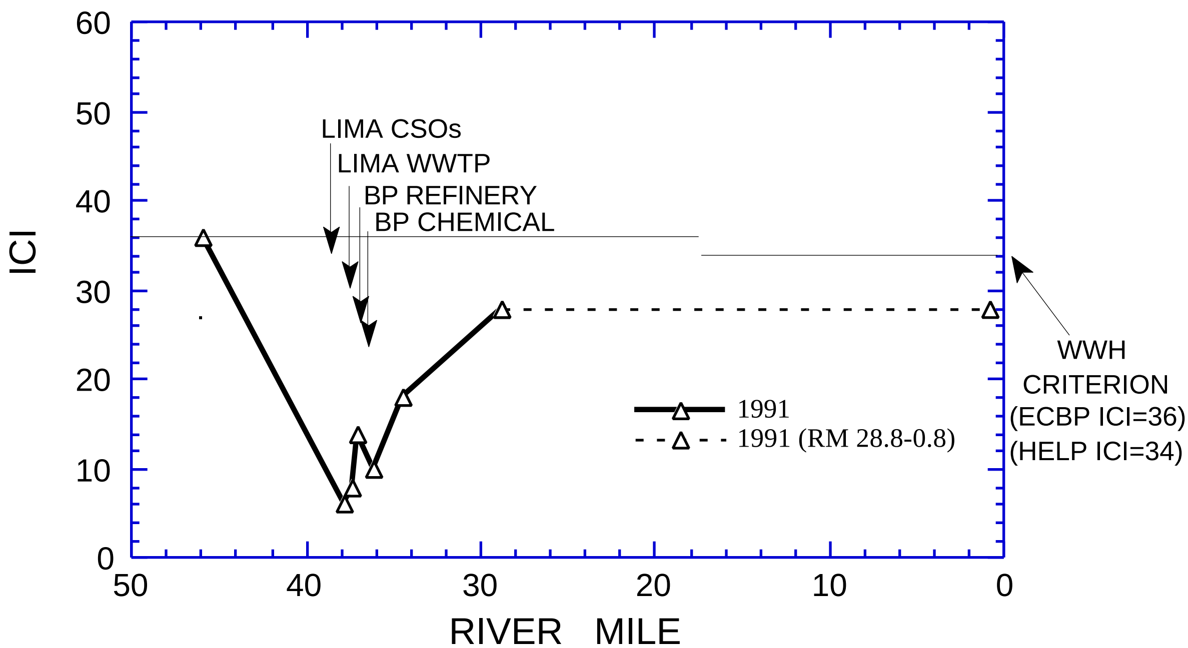


Figure 15. Longitudinal trend of the Invertebrate Community Index (ICI) in the Ottawa River (RM 45.9 - 0.8) during 1991.

Table 12. Summary of the macroinvertebrate data collected from artificial substrate samplers (quantitative sampling) and natural substrates (qualitative sampling) in the Ottawa River study area, July-September, 1991.

Stream River Mile	Relative Density	Total Taxa	Quant. Taxa	Qual. Taxa	Qual. EPT[a]	QCTV[b]	ICI	Narrative Evaluation
Hog Creek								
10.7	1648	32	15	25	3	25.6	6*	Poor
0.2	621	65	44	45	13	37.7	50	Exceptional
Little Hog Creek								
0.2	297	59	29	48	12	34.0	34[ns]	Marg. Good
Ottawa River								
45.9	1027	78	51	53	15	34.7	36	Good
37.8	1922	42	17	39	6	26.9	6*	Poor
37.4	906	33	20	29	1	28.5	8*	Poor
37.0	408	46	25	39	2	28.6	14*	Fair
36.1	1081	36	13	34	2	25.1	10*	Poor
34.5	435	39	17	36	3	26.6	18*	Fair
28.8	490	54	32	46	8	29.3	28*	Fair
0.8	2055	65	30	53	17	35.3	28	Good[c]

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX	WWH	EWH	MWH[d]
ICI	36	46	22

Ecoregion Biocriteria: Huron-Erie Lake Plains (HELP)

INDEX	WWH	EWH	MWH[d]
ICI	34	46	22

a EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).

b QCTV derived as the median of the tolerance values calculated for each qualitative taxon present.

c A qualitative narrative evaluation based on best professional judgement and historical performance was used to evaluate macroinvertebrate attainment status at RM 0.8; insufficient current over the artificial substrates was considered a primary reason for departure of the ICI score from the biocriterion.

* Significant departure from ecoregion biocriteria (>4 ICI units); poor and very poor results are underlined.

ns Nonsignificant departure from biocriterion (<4 ICI units).

d - Modified Warmwater Habitat for channel modified areas.

Fish Communities (Plate 1-2,6; Fig. 1,16; Table 1,3,10,13,A-5,A-6)

Hog Creek:

• Hog Creek supported two markedly different fish communities in Hardin and Allen Counties due primarily to contrasting physical habitats. In the extensively channelized and maintained Hardin Co. segment (RM 10.8), the ditch supported a poor quality fish assemblage comprised of 13 predominantly tolerant species. In the natural Allen Co. segment (RM 1.0), MIwb and IBI values increased to fair quality and a total of 20 fish species were captured, including several pollution sensitive species. Similar to the upstream ditch site, however, the community was still overwhelming dominated by common carp (89.9% of the biomass) which indicates continued impairment from the upstream disturbances.

Little Hog Creek:

• Little Hog Creek supported a marginally good fish assemblage comprised of 19 species and one hybrid downstream from the Lafayette WWTP. Nutrient enrichment from the Lafayette WWTP was evident, however, because of an extremely high numerical abundance of fish at the site (3638 individuals per 0.3 km). As the result, the mean IBI (38) was in the nonsignificant departure range of ECBP headwater biocriteria.

Ottawa River:

• The total catch from the eight Ottawa River locations during 1991 ranged from very good to very poor quality and consisted of 8,228 fish comprised of 47 species and four hybrids (Table 13; Appendix).

• Downstream from the confluence of Hog and Little Hog creeks, but upstream from Lima (RM 46.1), the Ottawa River continues to support a good quality WWH fish assemblage typical of the ECBP ecoregion. The community was comprised of 20 species which included five riffle inhabiting species of darters. Numerically dominant species consisted of greenside darters (22%), rock bass (13%), and fantail darters (12%). Golden redhorse (53%) and rock bass (20%) were predominant by weight. The mean percent of DELT (deformities, erosion, lesions, and tumors) external anomalies on fish, however, was slightly elevated at 0.7% (range = 0.5 - 0.9%). The attainment of WWH biocriteria at this location suggests no impairment from the upstream predominantly agricultural watershed.

• Downstream from the Lima CSOs and adjacent to the BP L-5 Landfill (RM 37.7), the number of fish species captured increased to 25, but biological index scores declined significantly into the poor range. Organizationally, the fish community was poorly structured and dominated by highly tolerant species (numerically by green sunfish [36%], bluntnose minnows [24%], and fathead minnows [11%]; and by weight, common carp [88%]. The predominance by highly tolerant species in addition to the marked increases in the relative number and weight of fish is indicative of high organic loadings from the upstream CSO discharges. The mean percent of fish captured with DELT anomalies was also high at 9.1% (range 2.6 - 16.7%) and further suggests a toxic impact, possibly caused by the high metal concentrations in the sediments. Leachate from the BP L-5 Landfill is also contributing to the impairment at this site. Low numbers of three riffle inhabiting darter species were captured at the site, however.

• Downstream from the Lima WWTP effluent (RM 37.4), MIwb and IBI values declined further in a predominantly pooled segment of the river. Like in previous years, sludge deposits were prominent in portions of the pool. Organizationally, the fish community was poorly structured here also and similar to RM 37.7 (by numbers = green sunfish [20%], bluntnose minnows [24%], and fathead minnows [21%], and white suckers [14%]; by weight = common carp [87%]). The mean percent of fish with DELT anomalies increased to 12.0% (range = 2.4 - 25.1%) and was highest during the June sample. The number of riffle inhabiting darter species captured declined to one.

- Downstream from the BP Refinery effluent (RM 37.0), the total cumulative number of fish species declined to 20 and no riffle inhabiting darters were captured *despite excellent habitat.* During the 28 June sample, the refinery appeared to have no effluent discharge so sampling extended 350 m downstream from their 001 discharge pipe. During the 30 July and 22 August samples, however, the discharge was active so the first 100 m downstream from the discharge (mixing zone) was not sampled. Results from the June sample yielded more species (16) and higher MIwb (8.5) and IBI (26) values than during the July or August samples (12, 13 species; MIwb = 5.5, 5.4; IBI = 16, 20). Results varied narratively from good/fair quality during June to poor quality during July and August. Based on the June -August samples, the fish community was dominated numerically by green sunfish (27%), bluntnose minnows (15%), and fathead minnows (19%), and white suckers (16%); and by weight of common carp (40%) and white suckers (32%). The mean percent of DELT anomalies remained at 12.0% (range 7.2 - 19.4%).

- Downstream from the BP Chemicals effluent (RM 36.7), a total of 15 cumulative species were collected and MIwb and IBI values reflected a very poor to poor quality fish community. The mean DELT increased to 19.3% (range 14.6 - 28.6%). The relative number and weight of fish markedly decreased downstream from BP Chemicals discharge(s) and suggests an additional toxic impact. The mean weight of carp (0.751 kg) at RM 36.7 was substantially lower than the adjacent upstream and downstream sites (1.738 kg and 1.967 kg, respectively, at RM 37.0 and 34.7). The community was poorly organized and dominated by weight by common carp (49%), followed by quillback (15%), and white suckers (12%); and by numbers by green sunfish (56%) followed by fathead minnows (19%). Stormwater containing ammonia-N and urea is also discharged to this segment of the river via the 002, 003, and 004 outfalls.

- The quality of Ottawa River fish assemblages continued to decline to the lowest level at the next site located two miles downstream from Adgate Road (RM 34.7). *Despite excellent physical habitats* (QHEI = 81.5), only 10 highly tolerant fish species were collected. The lowest MIwb and IBI values also occurred at RM 34.7 in addition to the highest percent of DELT anomalies in the study area. The mean percent of DELT anomalies was extremely high at 43.8 % (range = 17.9 - 57.5%). Impairment this severe to fish assemblages in Ohio is presently uncommon and apparently caused by excessive loadings of toxic and oxygen demanding substances into the river from the major dischargers in Lima.

- Downstream at Allentown (RM 28.9), the fish community improved slightly, but remained indicative of poor quality. A total of only 15 fish species were collected and the mean percent of DELT anomalies remained highly elevated, but decreased to 17.6% (range = 13.2 - 23.7%).

- Further downstream near Kalida (RM 1.2), pollution related impacts were considerably less and the Ottawa River supported the most diverse fish assemblage in the study area. A total of 35 cumulative species were captured (75% of the total number of fish species collected from the river), the mean MIwb and IBI values increased respectively, to 9.2 (very good) and 32 (marginally good), while the mean percent of DELT anomalies decreased to 1.3% (range 1.2 - 1.4%). Structural improvements were also evident, as shown by a more even distribution and increased number of pollution sensitive species (greenside darter, logperch, stone cat, silver redhorse, and golden redhorse). Numerically dominant species consisted of gizzard shad (33%), spotfin shiners (16%), bluntnose minnows (11%), and white suckers (10%). By weight, common carp (35%) and white suckers (21%) were dominant. Similar to the rural segment upstream from Lima, the Ottawa River here also supported a recreational fishery (*i.e.*, smallmouth bass, rock bass, and channel catfish) and receives a high percent of agricultural runoff.

Pike Run:

- Results from three locations in Pike Run show the tributary supports very poor to poor quality fish assemblages. IBI scores do not attain WWH or MWH ecoregional biocriteria. The degree of impacts exceed habitat modification alone and are indicative of excessive organic enrichment and ammonia toxicity. Although very poor quality upstream from the American Bath WWTP, results showed an additional rather severe impact (ammonia toxicity likely) from the WWTP (*i.e.*, four species, 381 fish/0.3 km and 3.0 kg/0.3 km upstream [RM 8.2] versus one species, 17 fish/0.3 km and 0.03 kg/0.3 km downstream [RM 8.1]). The stream showed some recovery six miles downstream where it supported 11 species, 272 fish/0.3 km and 11.4 kg/0.3 km.

- The impact from the WWTP appears to be due from excessive instream sludge deposits from bypassed sewage and elevated ammonia-N. Flows from the WWTP during all sampling dates document the facility was operating well above its designed capacity. Low D.O. levels occurred upstream and downstream from the WWTP, however, ammonia-N exceedences occurred only downstream and in the effluent of the WWTP. The NON attainment of biocriteria and low D.O. at RM 8.2 also suggests water quality impacts upstream from the WWTP.

Table 13. Fish community indices based on pulsed D.C. electrofishing samples at 14 locations sampled by Ohio EPA in the Ottawa River study area during June - September, 1991. Ottawa River sites downstream from RM 37.8 were sampled using the boat method and all other sites with wading methods. Relative number and weight are per km for boat sites and 0.3 km for wading sites.

Stream River Mile	Mean # Species	Total # Species	Mean Rel. No.	Mean Rel. Wt.	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation
Hog Creek								
10.8	11.0	13	218	15.7	16.5	4.8*	19*	Poor
1.0	19.0	20	566	88.1	73.5	6.0*	30*	Fair
Little Hog Creek								
0.2	15.5	19	3638	13.9	69.5	NA	38[ns]	M. Good
Ottawa River								
46.1	18.5	20	797	30.0	80.5	8.5	42	Good
37.7	16.7	25	1988	348.1	75.5	6.0*	22*	Poor
37.4	16.7	26	936	93.7	73.5	5.0*	20*	Poor
37.0 (all 3)	13.7	20	872	62.9	77.0	6.5*	21*	Fair - Poor
37.0 (1st pass)	16.0	16	611	76.9	77.0	8.5	26*	Good-Fair
37.0 (2&3 pass)	12.5	17	1034	56.9	77.0	5.5*	18*	Poor
36.7	11.3	15	296	14.2	60.0	4.8*	21*	VP - Poor
34.7	9.0	10	297	49.1	81.5	3.4*	15*	Very Poor
28.9	11.3	15	402	36.5	79.5	4.4*	17*	VP - Poor
1.2	28.3	35	1351	89.1	71.0	9.2	32[ns]	VG - MG
Pike Run								
8.2	4	4	381	3.0	50.0	NA	14*	Very Poor
8.1	1	1	17	0.03	28.5	NA	12*	Very Poor
2.1	11	11	272	11.4	40.0	NA	20*	Poor

BIOCRITERIA:	***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**

* Significant departure from ecoregional biological criterion (>4 IBI or >0.5 Iwb units); underlined values are in the poor and very poor range.

ns Nonsignificant departure from biocriterion (≤4 IBI units or ≤ 0.5 MIwb units)

a Narrative evaluation is based on both MIwb and IBI scores.

NA Headwater site; MIwb is not applicable.

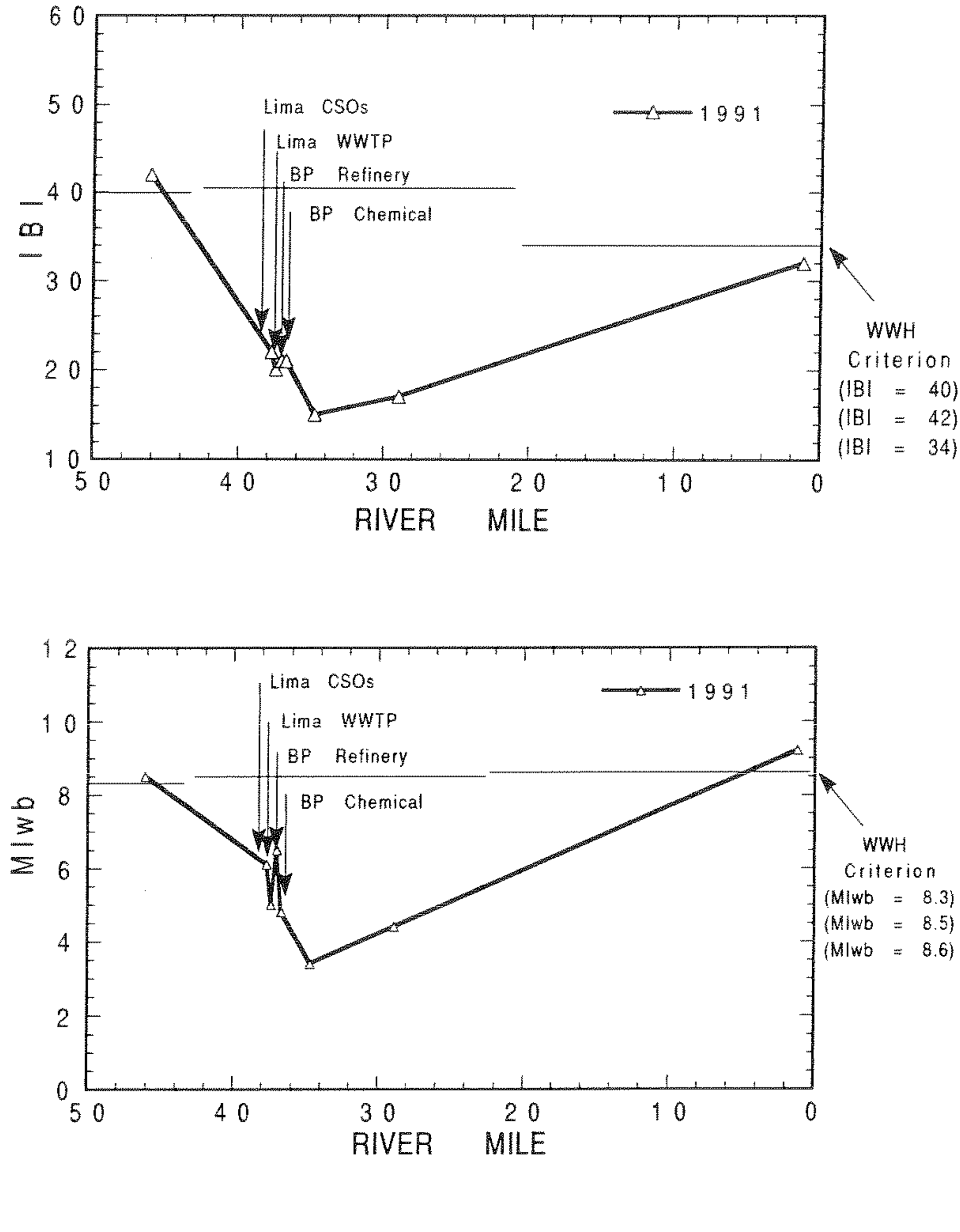


Figure 16. Longitudinal trend of the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb) in the Ottawa River during 1991.

Fish Health (Plate 2,6; Fig. 1, 17; Table 3, 14)

External Anomalies:

- The physical condition of fish in the study area was monitored at each fish sampling site by recording the incidence of gross DELT (Deformities, Erosion, Lesions/Ulcers and Tumors) external anomalies. Biosurvey results collected by Ohio EPA from throughout the state show a high frequency of DELT anomalies is an accurate indication of pollution stress usually caused by multiple sublethal stresses as the result of degraded water quality (*i.e.*, often a combination of toxic impacts combined with marginal D.O. concentrations). Within Ohio, there also appears to be a positive relationship between sites containing chemically contaminated sediments (*e.g.*, metals, PAHs) and high percent occurrence of DELT anomalies (Rankin *et al.* 1992). The percent DELT anomalies is a metric used in Ohio EPA's modified versions of the IBI. Variation in the percent of DELT anomalies between samples was low at the predominantly agricultural sites and higher at sites in the nine mile segment impacted by point sources. Large percent decreases were generally caused by large increases of fish captured at a site rather than a decline in the number of DELT anomalies. Higher numbers of species like fathead minnows which rarely exhibit DELT anomalies, particularly skewed the results later in the sampling period. The actual number of each anomaly type is also presented by sample and shows less variation than percentages.

- During the 1991 survey, DELT anomalies were present at all sites sampled in the Ottawa River and ranged (by pass) from 0.47 - 57.49% of the fish captured. The dominant type of DELT anomaly was fin or gill cover erosion (range 0.33 - 51.73%). Erosion is generally the result of a chronic disease principally caused by a necrosis of the tissue by flexibacteria (Post 1983). Deformities, the second most common form of disfiguration, were also present at all locations and ranged from 0.14 - 12.89%. Deformities can affect virtually any body part as the result of a variety of causes including; toxic chemicals, virus, bacteria, and parasites. Externally visible lesions/ulcers and tumors were less common (0.0 - 1.06%) and occurred only between RM 37.7 and 1.2. Fish with multiple DELT anomalies ranged from 0.00 - 3.38% and also occurred only between RM 37.7 and 1.2.

- Longitudinally, the percent occurrence of DELT anomalies was low in the predominantly agricultural segments of the study area (*i.e.*, upstream and far downstream from Lima) and markedly higher in the urban/industrial segments downstream from major wastewater discharges. The lowest mean percent occurrence occurred upstream from Lima (RM 46.1 = 0.72%) and the highest downstream from the Lima area point sources (RM 34.7 = 43.78%). The greatest variation between samples occurred at RM 37.7 and 37.4.

- Based on the actual number of DELT anomalies at a site (adjusted for a 0.5 km distance) the data suggests that in addition to RM 34.7, the number of disfigured fish is also very high at RMs 37.7 and 37.0.

Table 14. Percent occurrence of gross external DELT (Deformities, Erosion, Lesions/Ulcers, and Tumors) external anomalies recorded in the Ottawa River (Allen and Putnam Co. Ohio) during 1991. The actual number of fish with each anomaly is denoted by ( ) and were not adjusted for distance sampled (all sites were 500 m, except for Rm 46.1 (200 m), 37.7 (250 m), and RM 37.0 (350 m in June, 250 m in July and August).

RM	Date	Deformities	Erosion	Lesions	Tumors	Multiple DELTs	Total %	Total #
46.1	07-09-91	0.39 (1)	0.55 (2)	0.00	0.00	0.00	0.94	(3)
46.1	08-20-91	0.14 (2)	0.33 (1)	0.00	0.00	0.00	0.47	(3)
(RM Total) & Mean %								(6) 0.71%
37.7	06-28-91	1.11 (3)	6.38 (18)	0.32 (1)	0.00	0.00	7.81	(22)
37.7	07-30-91	0.50 (3)	1.75 (14)	0.00	0.00	0.38 (1)	2.63	(18)
37.7	08-22-91	3.08 (5)	12.71 (31)	0.00	0.00	0.95 (1)	16.74	(37)
(RM Total) & Mean %								(77) 9.06%
37.4	06-28-91	5.60 (9)	16.77 (20)	0.97 (1)	0.97 (1)	0.79 (2)	25.10	(33)
37.4	07-30-91	0.19 (1)	6.69 (28)	0.00	0.00	1.66 (5)	8.54	(34)
37.4	08-22-91	0.40 (2)	1.57 (10)	0.00	0.20 (1)	0.21(1)	2.38	(14)
(RM Total) & Mean %								(81) 12.01%
37.0	06-28-91	3.74 (8)	11.68 (22)	1.06 (1)	0.00	2.93 (5)	19.41	(36)
37.0	07-30-91	1.08 (3)	8.45 (19)	0.00	0.00	0.00	9.53	(22)
37.0	08-22-91	0.90 (2)	6.27 (14)	0.00	0.00	0.00	7.17	(16)
(RM Total) & Mean %								(74) 12.04%
36.7	06-28-91	7.14 (5)	18.58 (13)	0.00	0.00	2.85 (2)	28.57	(20)
36.7	07-30-91	0.68 (1)	10.76 (16)	0.00	0.00	3.38 (5)	14.82	(22)
36.7	08-22-91	0.44 (1)	13.66 (31)	0.00	0.00	0.50 (1)	14.60	(33)
(RM Total) & Mean %								(75) 19.33%
34.7	06-27-91	12.89 (9)	43.27 (30)	0.00	0.00	1.33 (1)	57.49	(40)
34.7	07-30-91	2.11 (3)	51.73 (55)	0.00	0.00	2.12 (3)	55.96	(61)
34.7	08-23-91	2.62 (6)	13.10 (30)	0.00	0.00	2.18 (5)	17.90	(41)
(RM Total) & Mean %								(142) 43.78%
28.9	06-27-91	1.95 (2)	12.06 (13)	0.00	0.00	1.97 (1)	15.98	(16)
28.9	07-31-91	2.14 (4)	18.79 (37)	0.00	0.00	2.77 (5)	23.70	(46)
28.9	08-21-91	2.08 (6)	10.03 (29)	0.00	0.00	1.04 (3)	13.15	(38)
(RM Total) & Mean %								(100) 17.61%
1.2	06-27-91	0.49 (1)	0.75 (3)	0.00	0.00	0.00	1.24	(4)
1.2	07-31-91	0.11 (1)	1.02 (3)	0.11 (1)	0.00	0.12 (1)	1.36	(6)
1.2	08-21-91	0.14 (1)	1.11 (7)	0.00	0.00	0.00	1.25	(8)
(RM Total) & Mean %								(18) 1.28%

Biomarker Study:

- In addition to the present Ohio EPA study, additional fish sampling was conducted at six sites in the Ottawa River as part of a statewide 40 site study by the United States Environmental Protection Agency, Office of Research and Development (Environmental Monitoring Systems Laboratory) with Miami University in collaboration with Ohio EPA. The purpose of this joint study was to collect liver and blood plasma samples from selected fish species for various analyses to detect physiological and biochemical responses to various chemical and environmental exposures. Two indicators reported here are ethoxyresorufin-o-deethylase (EROD) activities and blood urea nitrogen (BUN) activities. EROD measures a class of metabolic enzymes that are induced by planar xenobiotics such as polyaromatic hydrocarbons (PAHs) and halogenated hydrocarbons. EROD is not believed to be induced by exposure to metals or radionuclides. A white sucker score below 100 pmol EROD/mg protein is a conservative indication of non-induction. Scores greater than 100 indicate induction and is a measure of exposure to these contaminants and detoxification activity by fish. BUN is a measure of the amount of nitrogenous waste, usually in the form of ammonia or urea, present in fish blood. For white sucker, values greater than 2 mg ammonia/dl plasma are considered elevated. Elevated BUN can be caused by the concentration of nitrogenous compounds in water (nitrites, nitrates, ammonia, etc.), high pH in water, or damage to the gills and kidney.

- White sucker results from five Ottawa River locations (not collected at RM 36.0) show EROD activity was significantly elevated at all sites within or downstream from Lima, but normal upstream at the predominantly agricultural site, RM 46.1 (Fig. 17). Values were moderately elevated between RM 38.6 (Collett St.) and 37.0 (dst. BP Oil Refinery), and highly elevated at RM 34.7 implying various levels of exposures to PAHs and/or halogenated hydrocarbons. Blood urea nitrogen (BUN) values of white suckers were moderately to highly elevated downstream from the major discharges but less than 2 mg ammonia/dl plasma upstream from Lima at RM 46.1 (Fig. 17). RM 37.4 was especially high and coincides with the highest daily loading of nitrates. The data suggests point source nitrogen, as opposed to that from agricultural nonpoint sources, to be stressing Ottawa River fishes.

- Biomarker analyses of fish from the Blanchard River, another Auglaize River tributary with similar land uses, did not have EROD or BUN values as great as the impacted segment of the Ottawa River. The Ottawa River downstream from the major discharges had values two to three times greater than in the Blanchard River. However, the Blanchard River upstream from Findlay had a BUN value greater than 2 mg ammonia/dl plasma possibly suggesting a greater impact due to nonpoint source runoff in the Blanchard River than in the Ottawa River.

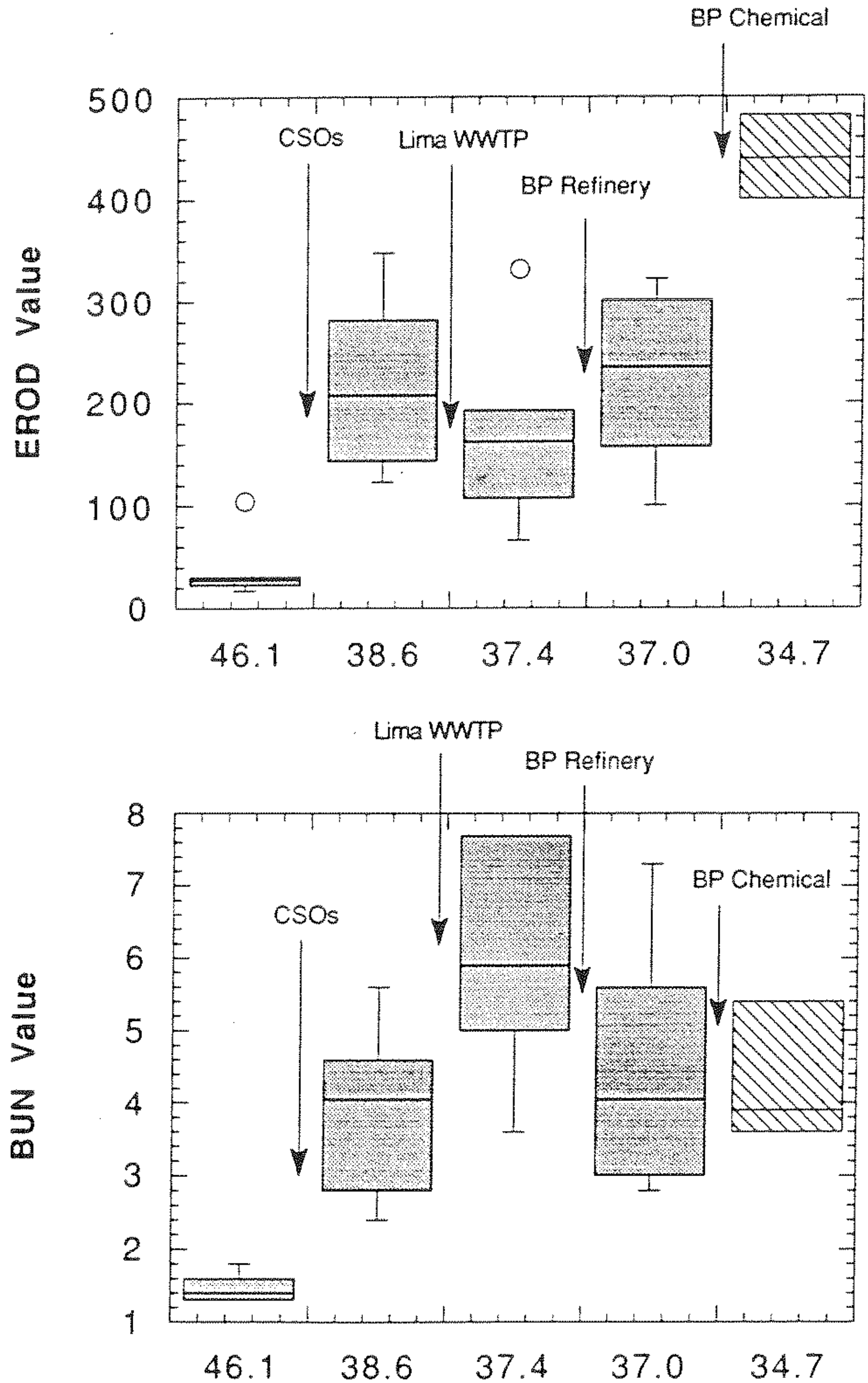


Figure 17. Longitudinal boxplots of EROD (ethoxyresorufin-o-deethylase) and BUN (blood urea nitrogen) values from white suckers in the Ottawa River during 1991.

Trend Assessment: Ottawa River 1985 to 1991

Chemical Changes (Plate 1; Fig. 18a - 18e; Table 15,16)

Water Quality:

- Mean total ammonia-N shows a similar trend for the three years upstream from the major point sources (Fig. 18a). Downstream the mean concentration of ammonia-N increased sharply, but declined more rapidly in each succeeding year which indicates a lessening of the far field impacts of ammonia-N between 1985 and 1991.

- Ammonia-N sample results were combined over the periods 1985-1988 and 1989-1991 and plotted by river mile (Fig. 18c). The most significant change between these two periods occurred downstream from the Shawnee #2 WWTP and the Elida WWTP, with 1989-1991 concentrations being much lower. Some reductions were also evident downstream from the Lima WWTP and BP Oil. The BP Chemicals discharge remains the major source of this parameter as evidenced by peak concentrations downstream from this facility during both periods. Ammonia-N concentrations were generally higher during 1989-1991 than in 1985-1988.

- The principal point source for total nitrate-N for 1985, 1989, and 1991 was the Lima WWTP (Fig. 18a). Relatively high nonpoint source input is also evident in the 1989 results. The 1989 concentrations were elevated in comparison to the 1985 and 1991 results and likely reflected the higher runoff during that year.

- Total phosphorus concentrations declined through the three sampling years (Fig. 18a). Nonpoint source inputs are obviously important given the upstream land use. The major point sources also add significant amounts of total phosphorus as evidenced by the increased concentrations downstream from the RM 36-38 area in each year. The concentration also increases downstream from the Shawnee #2 WWTP, but declined in each succeeding year reflecting reduced inputs from this source between 1985 and 1991.

- The comparative graphs for daytime grab D.O. for 1985, 1989, and 1991 are somewhat similar (Fig. 18b), and reflect the significance of point source loadings in this area of the river. A D.O. “sag” occurs downstream in the vicinity of Allentown with recovery farther downstream. There was an additional decline at the last site in 1985, possibly due to impacts from the Shawnee #2 WWTP effluent.

- Continuously recorded dissolved oxygen concentrations recorded during three contiguous periods in 1988, 1989, and 1991 show the magnitude and spatial extent of dissolved oxygen concentrations and violations of the 5 mg/l average and 4 mg/l minimum criteria for the WWH use designation (Fig. 18d). Violations were most frequent and severe in 1988, less so in 1989, and even less in 1991. Median concentrations were frequently below the 5 mg/l average in 1988 and minimums were in the 2-3 mg/l range. Twenty-fifth percentile concentrations below the 4 mg/l minimum occurred downstream from the Lima WWTP and extended to just upstream from the Elida WWTP and included concentrations less than 3 mg/l. All of the median values less than 5 mg/l and 25th percentile concentrations less than 4 mg/l occurred downstream from the major point sources.

- In 1989, median D.O. concentrations below 5 mg/l were restricted to the segment downstream from the BP Chemicals facility to Allentown (RM 28.84). Twenty-fifth percentile values were all above 3 mg/l and minimums were greater than 2 mg/l. The extent and spatial magnitude of low D.O. concentrations was much less than that observed in 1988.

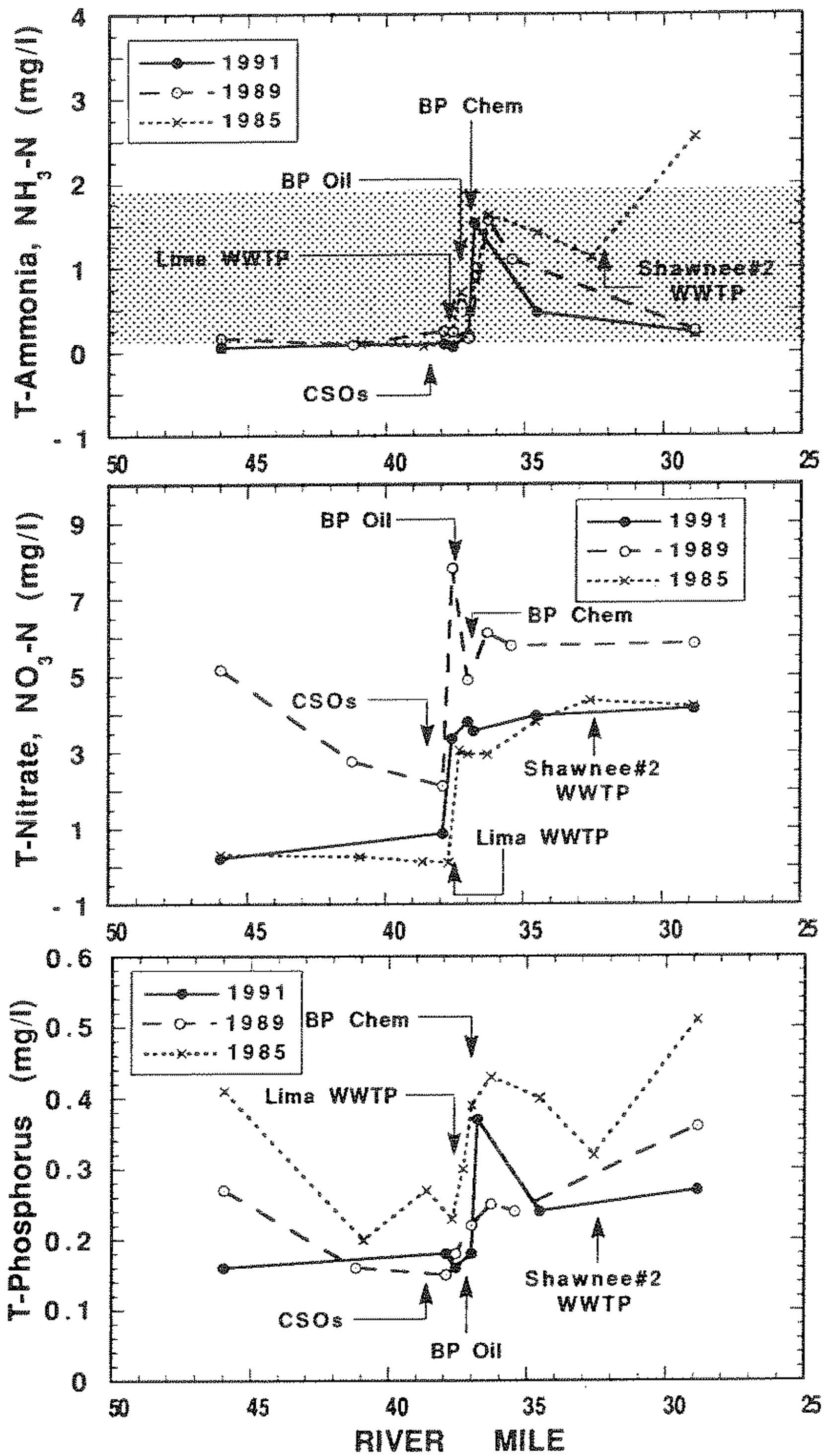


Figure 18a. Longitudinal trends of mean ammonia-nitrogen, nitrate-nitrogen, and total phosphorus concentrations in the Ottawa River during 1985,1989, and 1991.

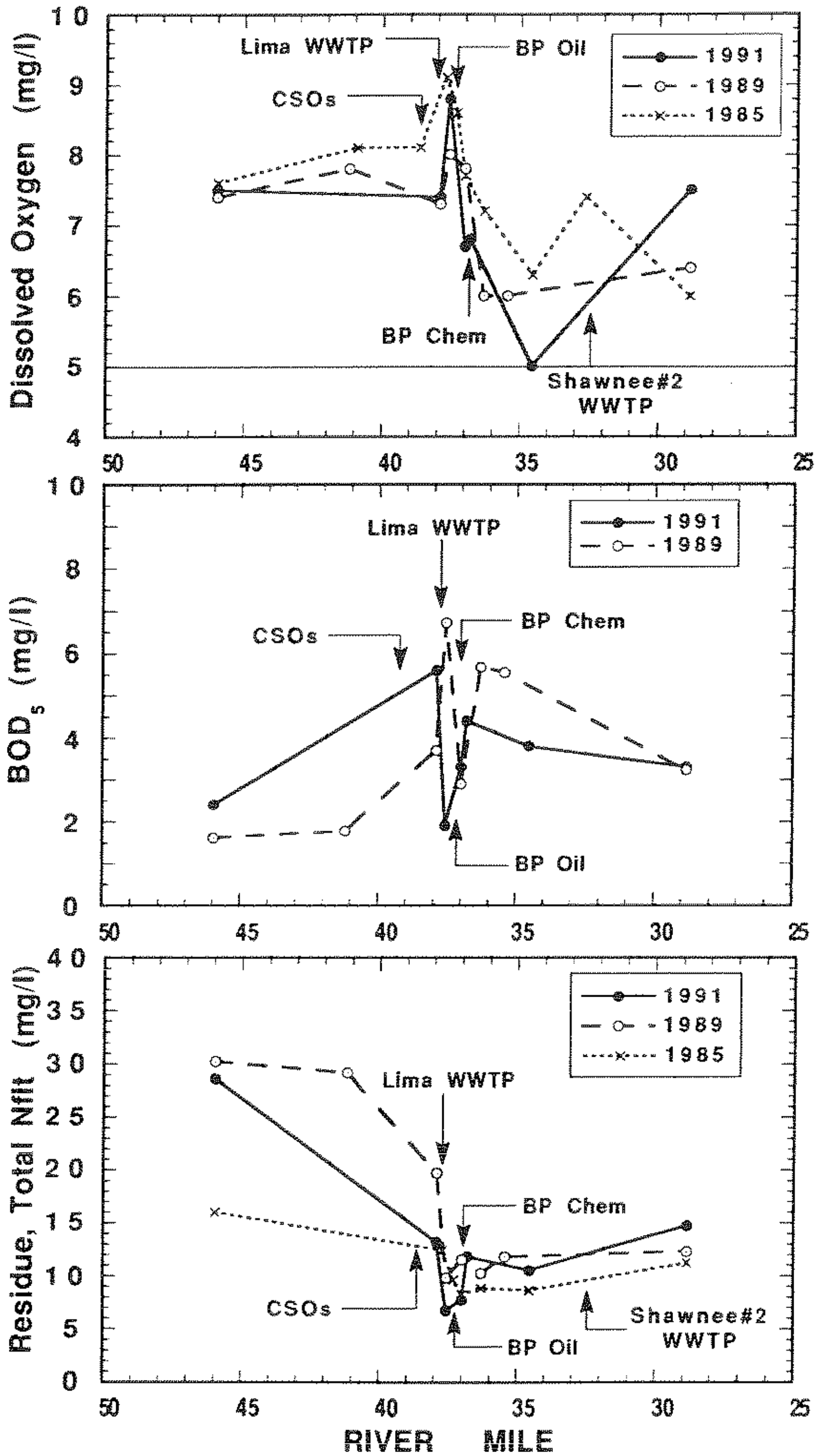


Figure 18b. Longitudinal trends of mean dissolved oxygen (daytime grabs), BOD_5, and total non-filterable residue concentrations in the Ottawa River during 1985,1989, and 1991.

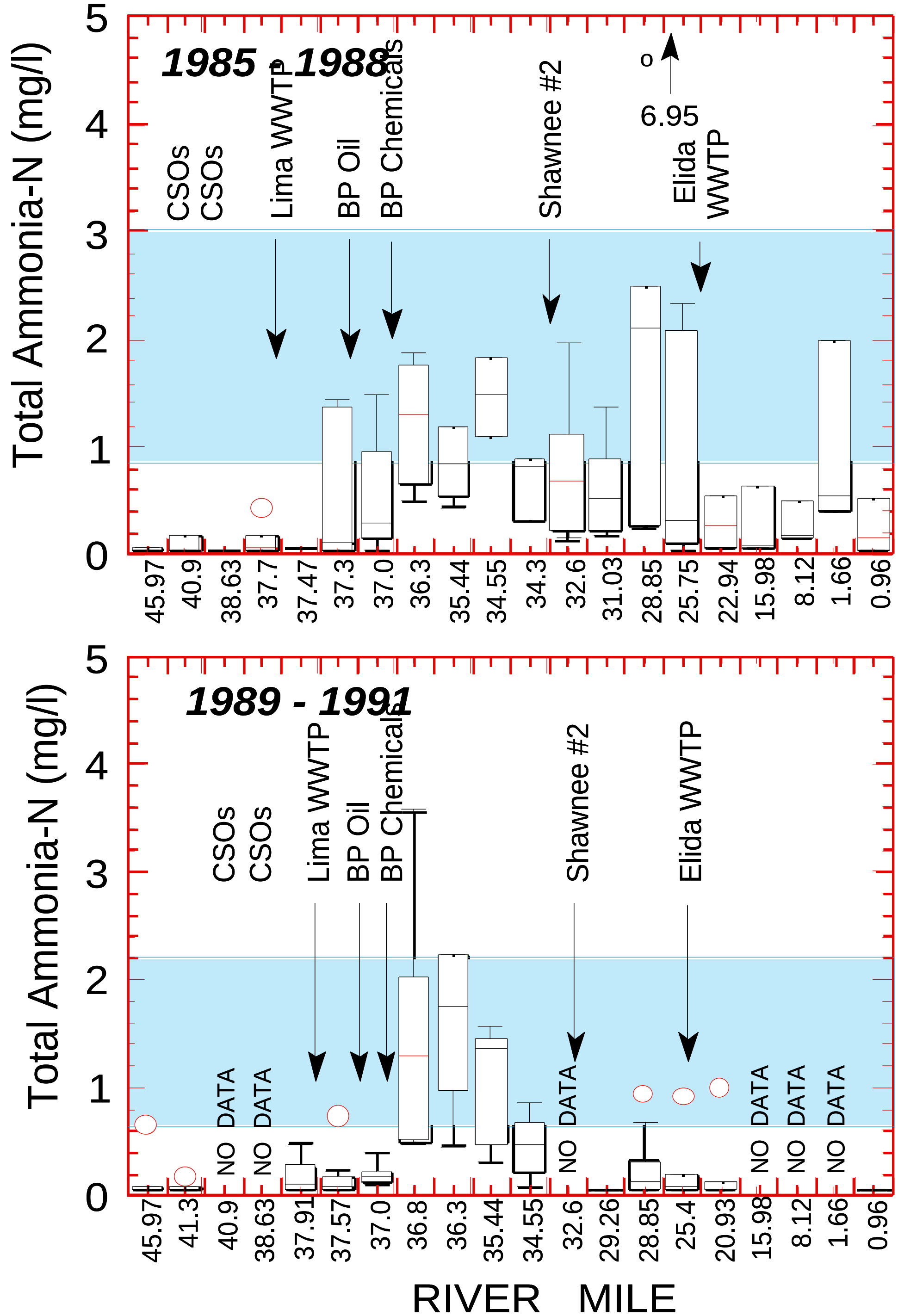


Figure 18c. Boxplots of ammonia-nitrogen concentrations at Ottawa River locations sampled during 1985-1988 and 1989-1991. Shaded areas represent concentrations of total ammonia-N that exceed the chronic aquatic criterion between the 25th and 90th percentile pH and temperature values.

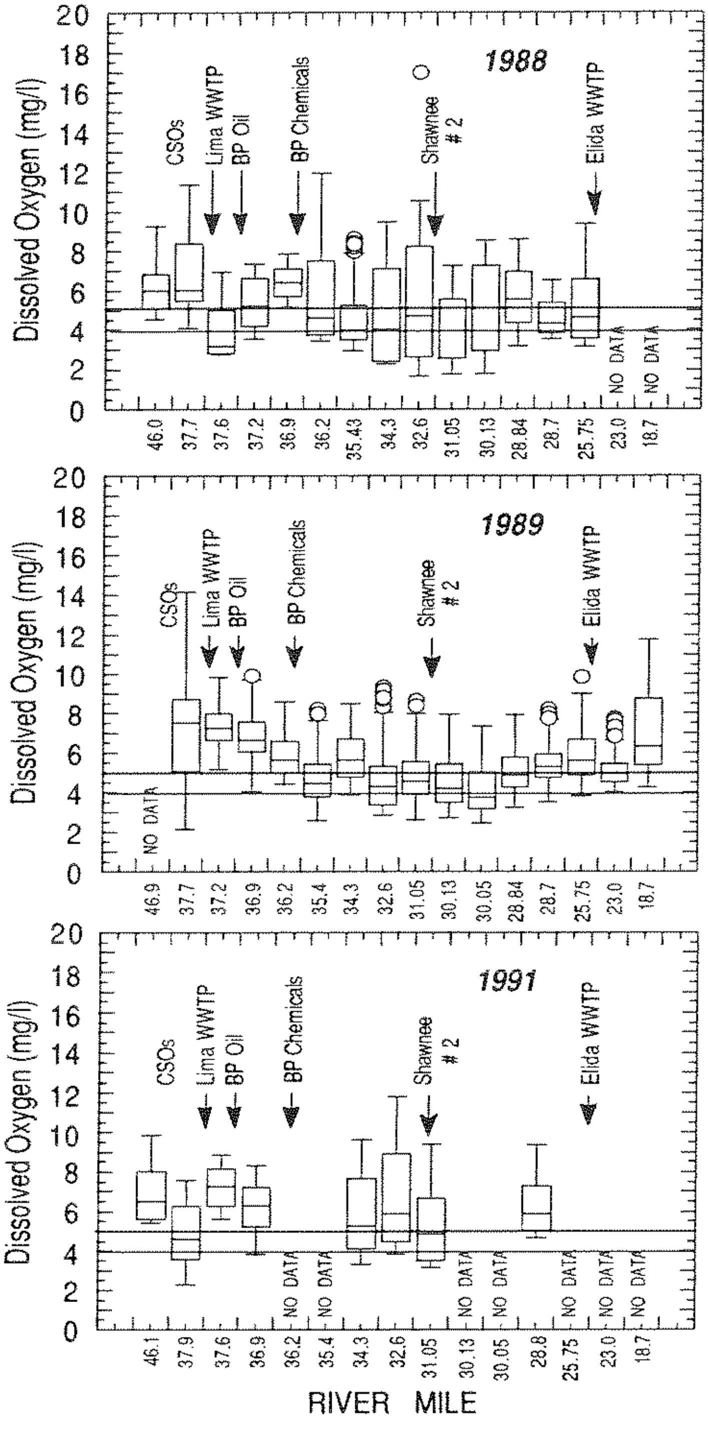


Figure 18d. Dissolved oxygen concentrations measured continuously over three contiguous periods in 1988, 1989, and 1991 in the Ottawa River. Bold horizontal lines indicate the 5 mg/l average criterion for the WWH use designation; plain horizontal line indicates the 4 mg/l daily minimum WWH criterion.

- In 1991, all median concentrations were greater than 5 mg/l with the exception of two locations (RM 37.9 and 31.05). These two locations were also the only occurrence of 25th percentiles less than 4 mg/l. With one exception all minimums were greater than 3 mg/l. The 1991 D.O. regime was most impacted downstream from the CSOs and the Shawnee #2 WWTP. Although the number of sampling sites was less than in 1988 or 1989, the overall the D.O. regime was improved over that in 1989 and 1991 in terms of the severity and extent of D.O. criteria violations.

- The principal source of total nonfilterable residue (total suspended solids, TSS) is of nonpoint origin, presumably from agriculture land use in the upper watershed (Fig. 18b). There is a positive correlation with the amount of rainfall and runoff in each year with the highest concentrations in 1989 followed by 1985 and 1991.

- Data for BOD_5 was available for only 1989 and 1991 and indicates the Lima CSOs were a major source of oxygen demanding substances in both years. Concentrations increased further downstream from the Lima WWTP in 1989, but not in 1991. Both BP facilities were a source of BOD_5 in 1991, although BP Oil did not appear to contribute to an increase in 1989. While BOD_5 declines steadily downstream from the Lima area, the mean concentration is sustained at a higher level than that observed upstream.

- A review of the NPDES compliance records for the Lima WWTP, BP Oil Company, and BP Chemicals showed all three entities have occasionally violated permit limits between 1989 through 1991. A total of 43 violations were evident during the 36 month period. The most consistent problem noted was elevated suspended solids concentrations at the Lima WWTP during the first half of 1990. Otherwise there was no clear pattern of noncompliance with any specific parameter by individual entities over the last three years. Other types of violations from one or more of the facilities have included; pH, total residual chlorine, nutrients (phosphorus, nitrate-N, ammonia-N), BOD_5, acrylonitrile, cyanide, metals (copper, zinc, chromium), oil and grease, and phenolic.

- The cumulative pattern of noncompliance with permit limits by all three major sources during the last three years (36 month period from 1989 through 1991) is illustrated in Fig. 18e. While showing some improvement over the 36 month period, there remains a high probability that one or more of the sources will record a violation of a permit limit in a given month. This cumulative frequency of permit violations is symptomatic of the effect of varied stresses on the Ottawa River. Additional intervals of potential pollutant stress also arise when CSOs and stormwater outfalls discharge. Thus, a high cumulative frequency of permit violations combine to create frequent episodes of water quality that approach or exceed water quality criteria on nearly a continuing basis. The frequency of such episodes can be a major factor in determining the health of aquatic communities.

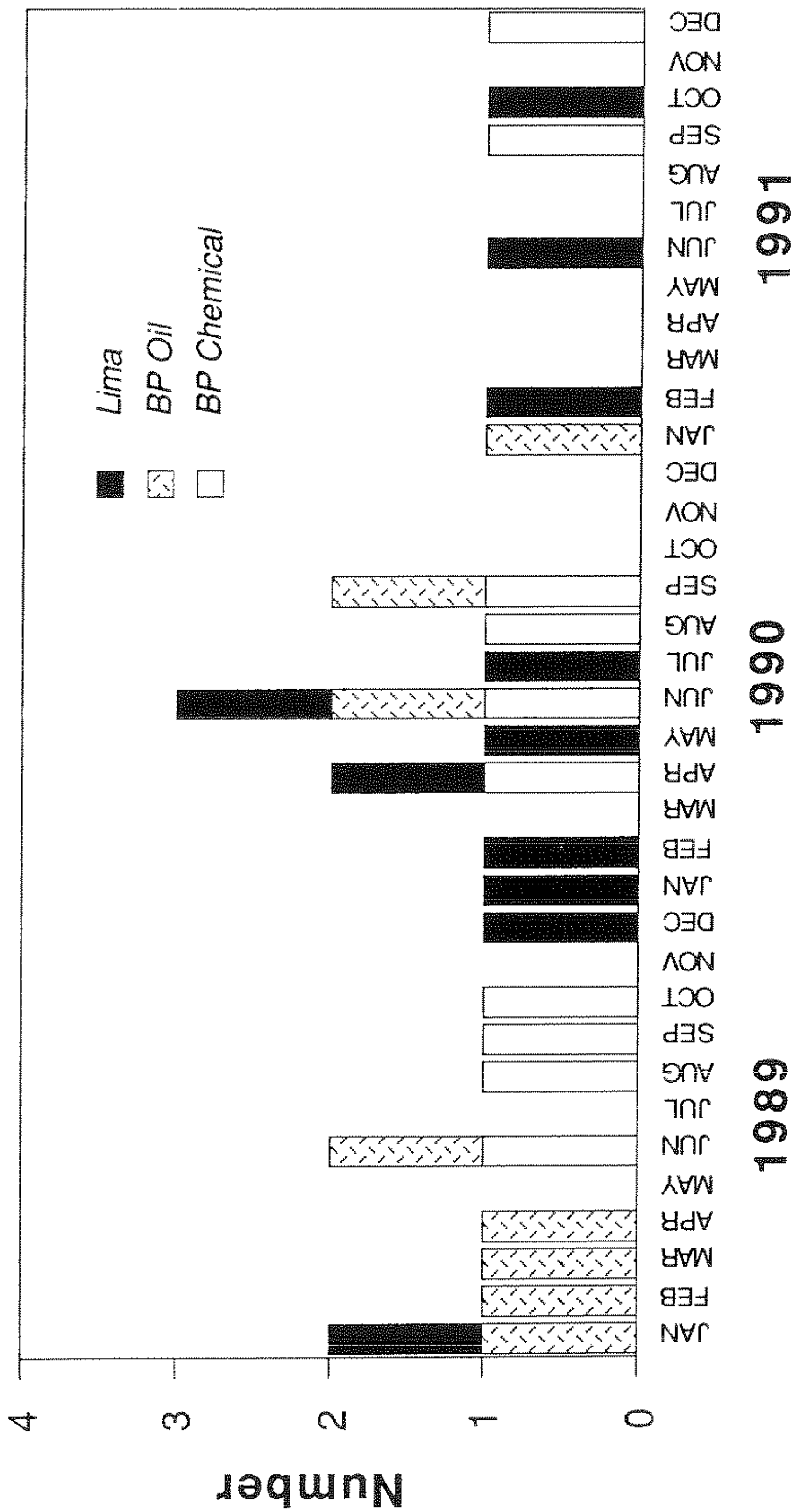


Figure 18e. Stacked histogram showing by month the number of major NPDES entities in noncompliance with permit limits during the 36 month period extending from 1989 through 1991.

Table 15. Ratio of concentrations above detection limit / total number of samples analyzed for metals, cyanide, and zinc ≥ 100 ug/l from grab samples collected during 1985, 1989, and 1991 Ottawa River Biological Water Quality Surveys. Summed total percent is also shown (total number of detections/total number of samples). Parameters with detections in one/third or more samples are denoted in **bold**.

Location	RM	As	Cd	Cr	Cu	Pb	Ni	Zn	CN^-	Summed Total %
Thayer Rd.	45.97	**5/7**	1/17	0/17	1/17	1/17	0/16	1/16	0/17	7.3
Sugar St.	41.18	0/1	0/6	0/6	1/6	1/6	0/5	0/6	0/6	4.8
Collett St.	38.63	---	0/5	0/5	**2/5**	**5/5**	0/5	0/5	---	23.3
dst. Dam	37.91	1/7	0/12	0/12	0/12	**4/12**	0/11	2/12	0/12	7.8
ust. Lima WWTP	37.70	---	1/5	0/5	1/5	**5/5**	0/5	0/5	0/5	20.0
Lima WWTP*	37.67	0/7	0/17	0/17	0/17	**11/17**	5/16	0/17	4/16	16.1
dst Lima WWTP	37.57	0/7	0/12	0/12	2/12	**4/12**	2/11	1/12	1/12	11.1
low-water bridge	37.30	---	0/5	0/5	0/5	**5/5**	**2/5**	0/5	0/4	20.6
BP Oil Refinery*	37.11	**7/7**	2/17	**8/17**	2/17	**14/17**	3/16	2/17	**17/17**	44.0
dst. BP Oil	37.00	**6/7**	1/17	0/17	1/17	**11/17**	2/14	0/17	**10/16**	25.4
BP Chemical*	36.87	**3/7**	1/17	2/17	**9/17**	**6/17**	1/16	0/17	3/17	20.0
dst. BP Chemical	36.80	**4/6**	0/6	0/6	1/6	0/6	0/6	1/6	**3/5**	19.2
adj. Ft. Amanda Rd.	36.30	0/1	1/11	0/11	0/11	**8/11**	2/11	0/11	3/11	18.0
Shawnee Rd.	35.44	0/1	**2/6**	0/6	0/6	**6/6**	0/5	1/6	**2/6**	26.2
Westfield Dr.	34.55	**6/6**	1/11	2/11	3/11	**6/11**	1/11	0/11	**7/10**	26.0
SR 117	32.60	---	1/5	0/5	1/5	**5/5**	1/5	0/5	---	26.7
Shawnee 2WWTP*	32.50	0/1	**4/6**	0/6	1/6	**5/6**	0/5	0/6	**2/6**	28.6
SR 81	28.85	**7/7**	3/17	0/17	1/17	**11/17**	0/16	1/17	**6/16**	23.4
SR 309	25.40	0/1	**3/6**	0/6	1/6	**4/6**	0/5	0/6	0/6	19.1
Elida WWTP*	24.20	0/1	**5/11**	0/11	**7/11**	**7/11**	0/11	0/11	**4/11**	29.5
State Rd.	22.94	---	**2/5**	0/5	0/5	**5/5**	1/5	0/5	---	26.7
Ridge Rd.	20.92	0/1	**4/6**	0/6	**3/6**	**6/6**	0/5	**2/6**	0/6	35.7
SR 189	15.98	---	1/5	0/5	1/5	**5/5**	**2/5**	0/5	---	30.0
CR P	8.12	---	1/5	0/5	**2/5**	**4/5**	1/5	0/5	**2/5**	28.6
CR 19	0.96	0/1	**5/11**	0/11	**4/11**	**8/11**	0/9	1/10	2/11	26.7

* Wastewater discharge (effluent sample).

Sediment Quality:

- A comparison of heavy metal concentrations in the Ottawa River from 1986 to 1991 shows the chemical quality of fine sediments has deteriorated from Lima to Allentown. Concentrations of arsenic and chromium have increased at all locations with multiple years of data, while cadmium, copper, lead, and zinc levels have increased at most locations. Since 1989, increases have generally been the greatest between RM 37.9 and 37.0; downstream from the CSOs, BP L-5 Landfill, Lima WWTP, and the BP Oil Refinery. While most parameter concentrations have doubled or tripled since 1989, chromium concentrations have markedly increased (23.9X at RM 37.9 and 12.4X at RM 37.0).

- With the exception of the BP L-5 Landfill, contaminated sediments appear to be of recent origin (*i.e.*, sludge deposits). Visual observations throughout the study area since 1985 have found few oil releases from disturbed sediment or shore banks despite historical descriptions and photos which document past oil contamination. The predominance by inorganic substrates and scouring capabilities of high stream flows are attributed to the previous cleansing. When the source(s) of the current contamination of metals are removed, the Ottawa should be able to assimilate the existing fine sediment deposits.

- The extent of sediment contamination by the BP L-5 Landfill will be known after sampling is conducted and the data is analyzed. Subsequently, a containment/clean-up strategy may be developed and implemented by the BP Oil Company.

Table 16. Comparison of heavy metal sediment concentrations from six segments of the Ottawa River with multiple year samples from 1986 to 1991. Ranked concentrations follow Kelly and Hite (1984).

Parameter RM	1986	1989	1991	Trend
Arsenic				
37.9		2.96[a]	10.70[b]	Increasing
37.6		2.07[a]	6.64[a]	Increasing
37.0		5.57[a]	14.60[c]	Increasing
36.1-.8		8.62[b]	**25.50[d]**	Increasing
Cadmium				
37.9		0.43[a]	**4.73[d]**	Increasing
37.6		0.38[a]	1.19[c]	Increas-ing
37.0	0.71[b]	0.49[a]	1.50[c]	Increasing
36.1-.8	1.30[c]	1.73[c]	0.89[b]	Decreasing
34.5-.6	0.24[a]		1.07[c]	Increasing
28.9	1.16[c]		0.70[b]	Decreasing

Table 16. Continued.

Parameter RM	1986	1989	1991	Trend
Chromium				
37.9		3.43[a]	**81.20[e]**	Increasing
37.6		7.80[a]	**46.40[d]**	Increasing
37.0	26.30[c]	14.30[a]	**178.00[e]**	Increasing
36.1-.8	24.00[c]	**62.00[e]**	**239.00[e]**	Increasing
34.5-.6	11.70[a]		**44.30[d]**	Increasing
28.9	**51.40[d]**		**79.50[e]**	Increasing
Copper				
37.9		50.4[b]	**167.0[d]**	Increasing
37.6		40.3[b]	92.4[c]	Increasing
37.0	44.5[b]	88.8[c]	**135.0[d]**	Increasing
36.1-.8	80.0[c]	**123.0[d]**	**145.0[d]**	Increasing
34.5-.6	13.5[a]		51.9[b]	Increasing
28.9	**101.0[d]**		72.5[c]	Decreasing
Lead				
37.9		**105.0[e]**	**332.0[e]**	Increasing
37.6		50.9[c]	**162.0[e]**	Increasing
37.0	**69.0[d]**	**90.8[d]**	**146.0[e]**	Increasing
36.1-.8	**3790.0[e]**	**340.0[e]**	**97.3[d]**	Decreasing
34.5-.6	11.3[a]		**84.3[d]**	Increasing
28.9	**103.0[e]**		**89.5[d]**	Decreasing
Zinc				
37.9		102.0[c]	**356.0[e]**	Increasing
37.6		78.3[a]	**268.0[d]**	Increasing
37.0	145.0[c]	108.0[c]	**456.0[e]**	Increasing
36.1-.8	**264.0[d]**	**349.0[e]**	**294.0[d]**	Decreasing
34.5-.6	55.6[a]		152.0[c]	Increasing
28.9	**216.0[d]**		**232.0[d]**	Increasing

a Non-elevated.
b Slightly elevated.
c Elevated.
d Highly elevated.
e Extremely elevated.

of degradation, based on Area of Degradation (ADV) statistics, decreased from 1985 to 1989, but subsequently increased from 1989 to 1991. Compared to 1985, 1991 ADV per mile values suggest no change to slightly better fish assemblages (IBI deviation shows no change; slightly less degradation based on the MIwb [10.8% decrease]) and a moderate improvement for macroinvertebrates (moderately less degradation based on the ICI [42.8% decrease]).

- Upstream from the major 001 effluents, but downstream from the CSOs and adjacent to the BP Landfill, aquatic communities are primarily indicative of excessive organic loadings including high abundances and predominance by tolerant taxa, but also the presence but reduced abundance of pollution sensitive taxa (mayflys, caddisflys, and riffle darters).

- Macroinvertebrates have shown the most impact downstream from the Lima WWTP (RM 37.4) with considerable recovery by Allentown, OH. ICI scores downstream from the Lima WWTP have consistently fallen in the poor range with indications of toxicity. Artificial substrate samples have been typified by low species richness, a lack of pollution sensitive varieties, and communities almost entirely composed of midges and/or blackflies. ICI scores have increased immediately downstream from the refinery and chemical plant discharges since 1985 but have remained in the marginally fair or poor ranges. The most noticeable positive changes have been the appearance of significant numbers of the intermediate mayfly *Baetis intercalaris* in 1989 and the caddisfly *Hydropsyche dicantha* in 1991. These improvements, however, were offset by increasingly higher percentages of pollution and toxic tolerant taxa downstream from the discharges. The Ottawa River in Shawnee Country Club has exhibited the most improvement in ICI scoring of any Lima to Allentown site from 1985 to 1989 (6 to 30) yet showed the greatest decline at any site from 1989 to 1991 (30 to 18).

- Fish have consistently shown the greatest impact downstream from all of the major dischargers at RM 34.7 followed by only slight recovery at Allentown. The lowest relative number and weight of fish collected also occurred at RM 34.7 during 1985, but occurred downstream from the BP Chemicals Plant (RM 36.7 - 36.0) during 1989 and 1991.

- Three different locations within the segment have shown the potential for partial attainment of WWH. PARTIAL attainment occurred at RM 37.9 in 1987 (based on one fish sample) and at RM 37.0 during the June fish sample. Marginally good macroinvertebrates were also recorded at RM 28.8 during 1989.

RM 1.2 - 0.8 (Downstream from Kalida):

- Similar to upstream from Lima this predominantly agricultural segment of the Ottawa River continues to support good biological communities characteristic of ecoregional expectations. The greatest diversity of fish in the study area was found at this location. Given the ability of impacts from Lima dischargers to extend this far downstream, as they did during the 1960s, biological communities should further improve with additional pollution abatement in the vicinity of Lima.

Biological Performance Changes (Plate 1; Fig. 19a-22; Table 17-18)

Macroinvertebrate and Fish Communities:

- Results since 1985 show stable, good quality macroinvertebrate and fish assemblages have inhabited the Ottawa River in predominantly agricultural segments upstream and far downstream from Lima, but contrasting less stable fair to very poor quality assemblages have inhabited the river downstream from major wastewater discharges near Lima. The data further shows that in most severely impacted segment, (between Collett Street and Allentown) the quality of biological communities improved slightly to moderately from 1985 to 1989. The 1991 results indicated a moderate decline throughout most of the impacted nine mile segment. Overall, there has been no marked change, or continued improving trend, which is necessary for FULL attainment of the WWH use designation.

- ADV per mile values (Table 18) by index (IBI, MIwb, ICI) show the same trend and quantify the changes which have occurred to macroinvertebrate and fish communities during the last seven years. From 1985 to 1989, the IBI ADV/mile decreased slightly (14.4%) from 208 to 178. The MIwb ADV/mile decreased moderately (39.0%) from 213 to 130. During the same period, the ICI ADV/mile value showed the greatest improvement with a large decrease (65.9%) from 229 to 78. The degree of impact increased, however, for each index from 1989 to 1991. The IBI ADV increased to a slightly greater value than during 1985, the MIwb ADV increased from 130 to 190, while the ICI ADV/mile value increased from 78 to 131. Compared to the 1985 ADV/mile values, the 1991 values for the IBI show the same degree of impact while the MIwb and ICI show slight to moderate (MIwb = 10.8% decrease and ICI = 47.1% decrease) overall degree of improvement.

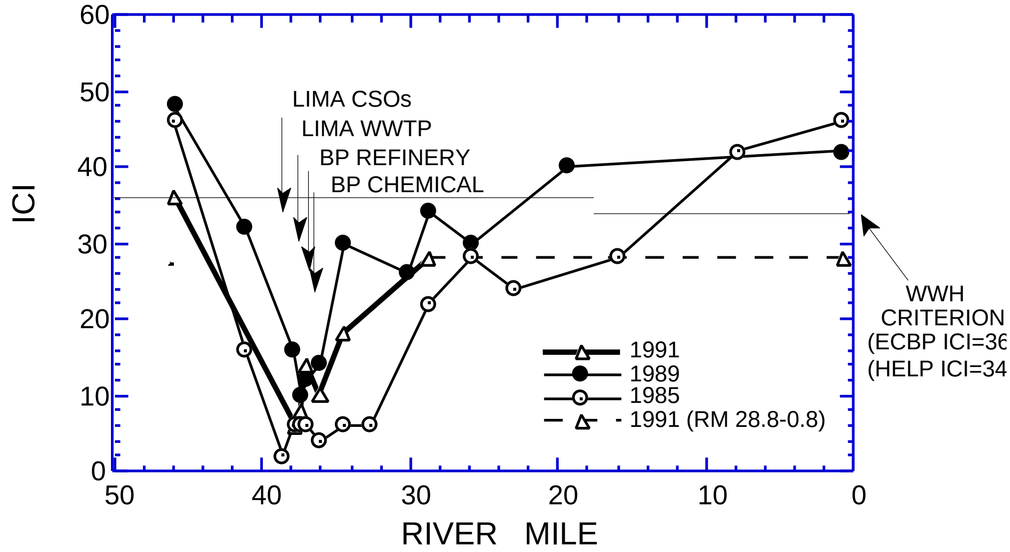
- Trends in the response of the macroinvertebrate community were also evaluated using the Qualitative Community Tolerance Value (QCTV) The median (50th percentile) QCTV from similar sites in the 1985-91 intensive surveys and an earlier, 1974 survey, are plotted in Fig. 19b. Since 1985, longitudinal trends in the mainstem have remained relatively similar. At stations upstream and well downstream from Lima (RM 45.9 and 0.8), scores were very near ecoregional reference site performance levels. Lower scores are evident in the Lima to Allentown area (RM 37.9-28.8), and reflected a shift towards more pollution tolerant populations downstream from the Lima CSOs and major point source discharges. While scores during the more recent surveys have tended to stabilize, these values were considerably higher than those found in the 1974 survey.

RM 46.1 - 45.9 (Upstream from Lima):

- In the vicinity of Thayer Road, the Ottawa River has historically supported good quality biological communities, despite a predominantly agricultural watershed. Since 1985, macroinvertebrate and fish assemblages have attained (FULL) the WWH use designation during and after the extreme flows recorded between 1988 and 1991. This location continues to support the greatest diversity of macroinvertebrates in the Ottawa River (total taxa = 66 in 1989, 78 in 1991). Fish assemblages are not as diverse as within Lima (RM 37.7 - 37.4), but contain structural and functional attributes indicative of a healthy warmwater fauna within the ECBP ecoregion. Fish and macroinvertebrate communities at this location are also dominated by pollution sensitive species.

RM 37.9 - 28.8 (Lima to Allentown):

- This nine mile segment of the Ottawa River has improved considerably since the 1950s and 1960s when it was virtually devoid of aquatic life. Although improved, biological communities have shown NON attainment of the WWH use designation. Narrative evaluations during 1991 ranged from fair to poor for macroinvertebrates and from good to very poor for fish assemblages. Overall, the segment continued to reflect severely degraded conditions. Sampling results from the last seven years shows the extent



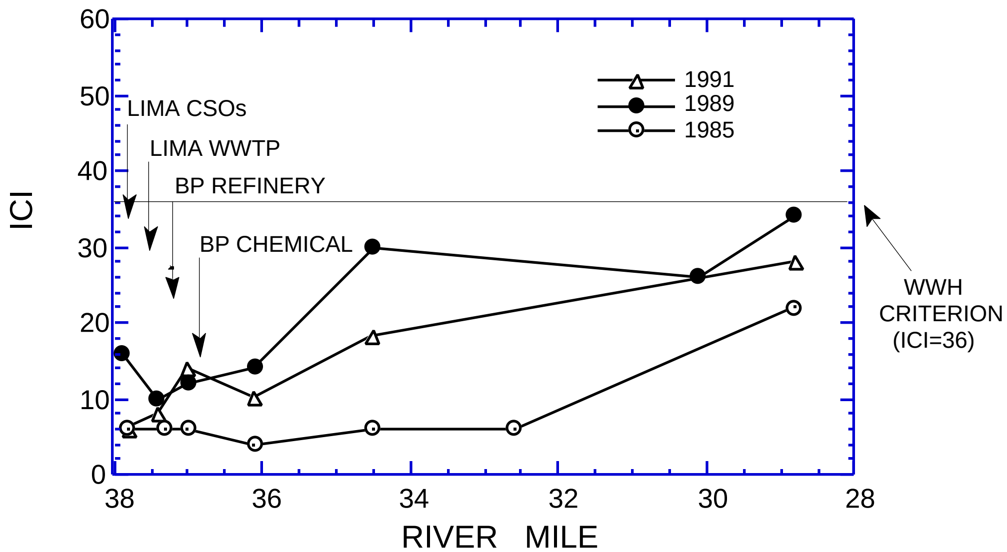


Figure 19a. Longitudinal trend of the Invertebrate Community Index (ICI; mean values) in the Ottawa River *(**top graph:** RM 45.9 -0.8; **bottom graph:** RM 37.8 - 28.8)* during 1985, 1989, and 1991.

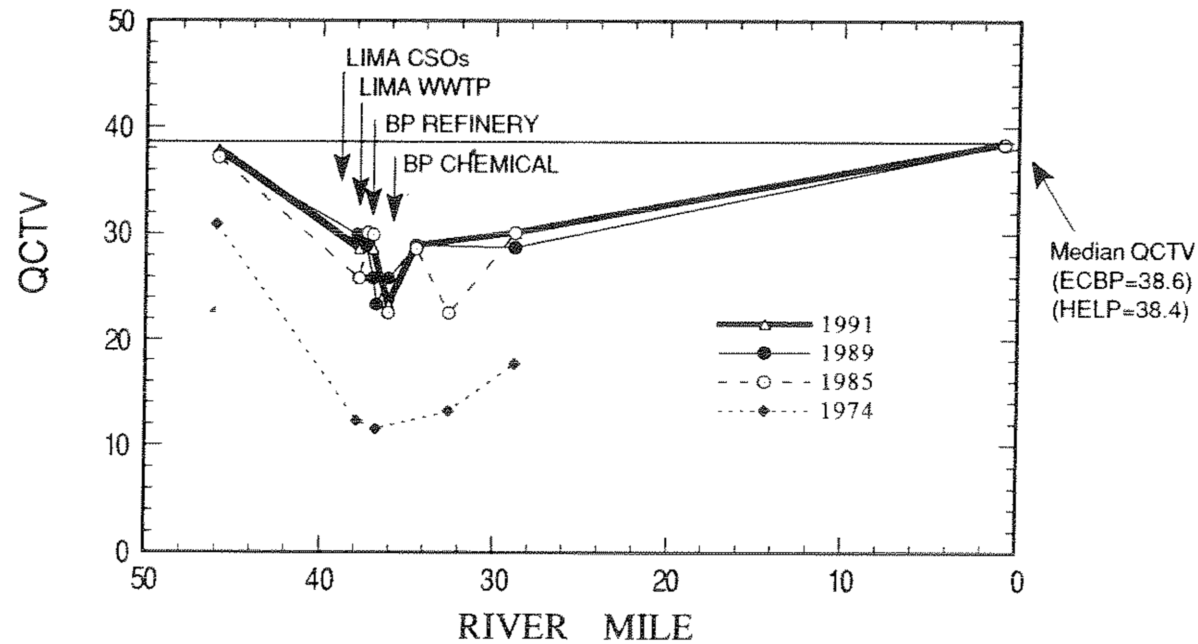
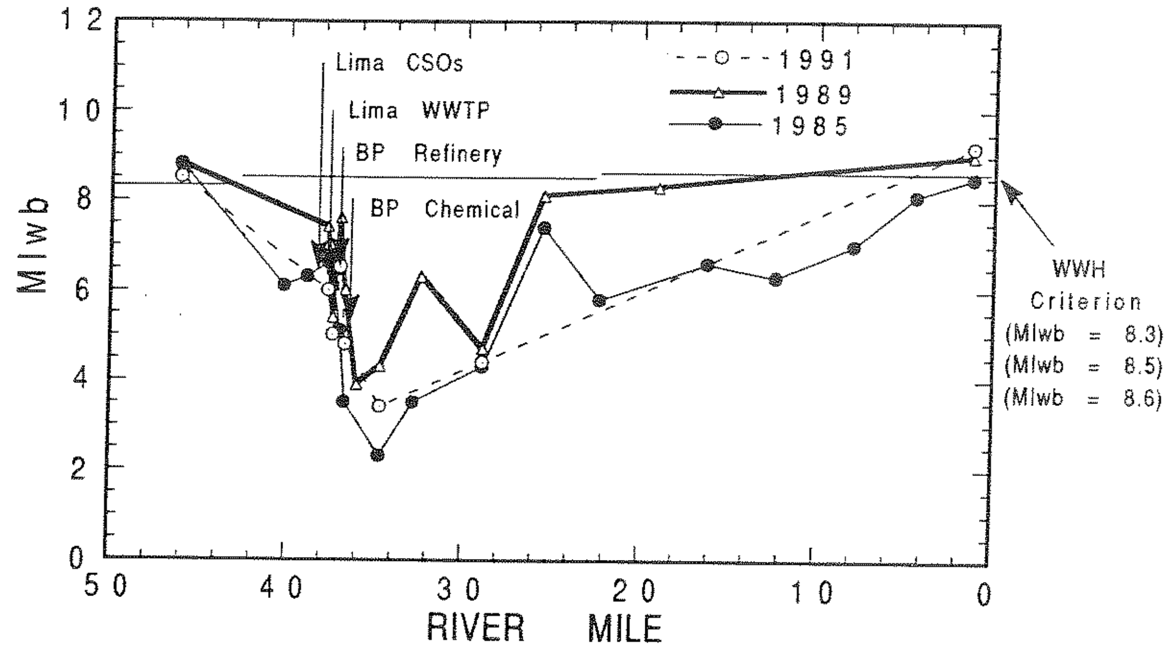


Figure 19b. Longitudinal trend of the median (50th percentile) Qualitative Community Tolerance Value (QCTV) in the Ottawa River mainstem during July-September, 1991, 1989, 1985 and 1974. The horizontal line represents the median QCTV for the Eastern Corn Belt Plain (ECBP) and Huron Erie Lake Plain (HELP) ecoregional reference site data bases.



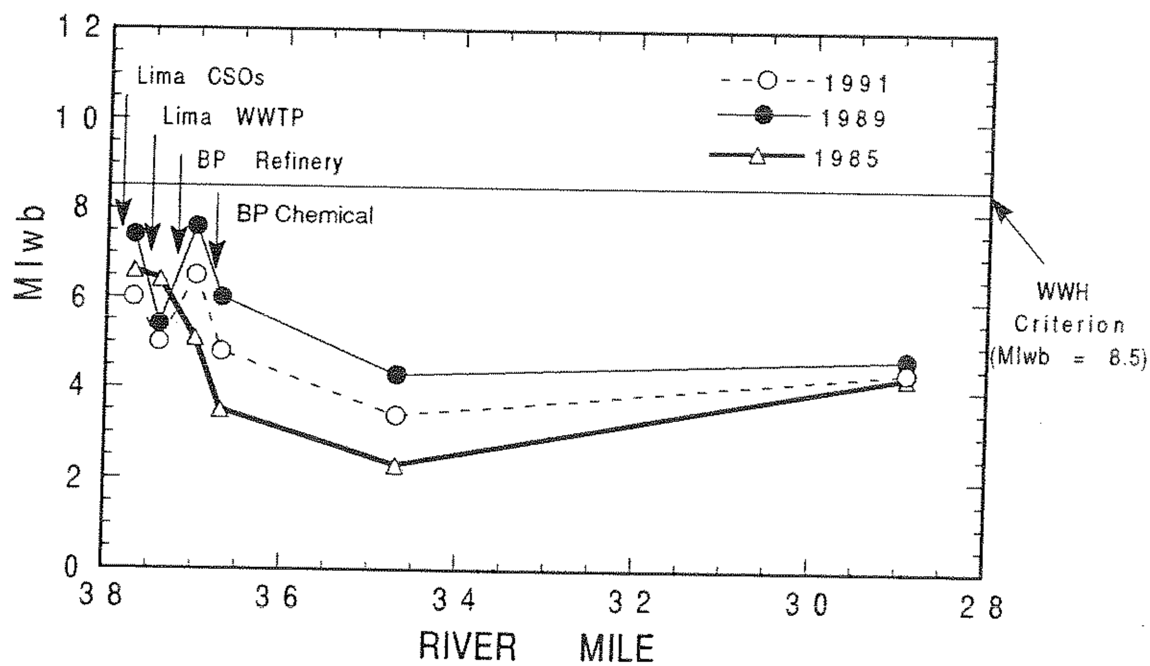
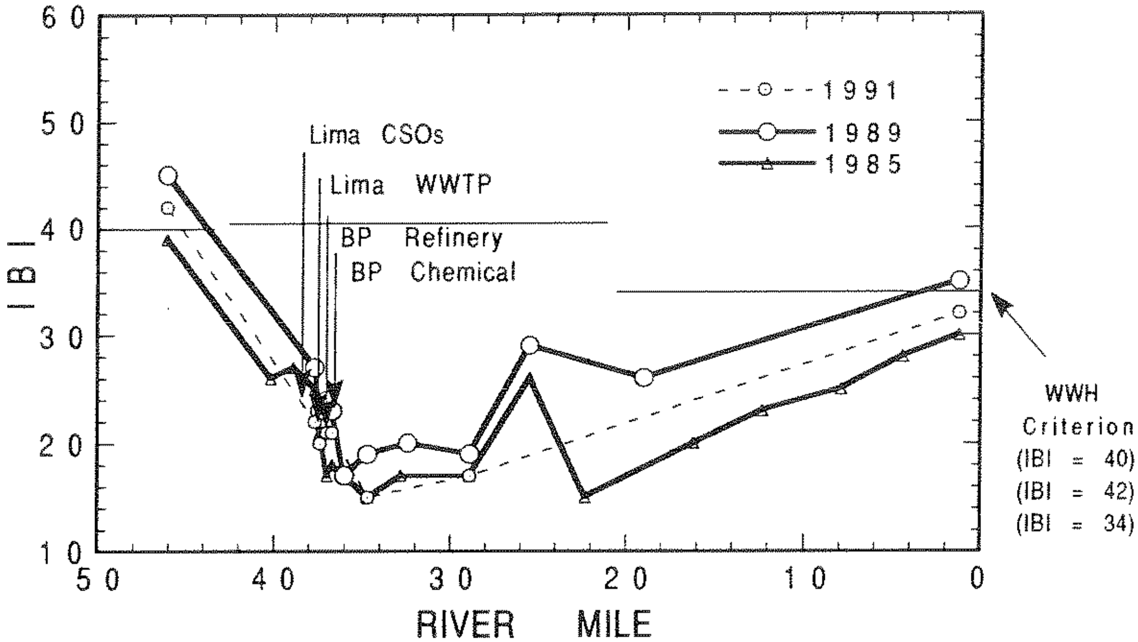


Figure 20. Longitudinal trend of the Modified Index of Well-Being (MIwb; mean values) in the Ottawa River *(top graph: RM 46.1 -1.2; bottom graph: RM 37.7 - 28.9)* during 1985, 1989, and 1991.



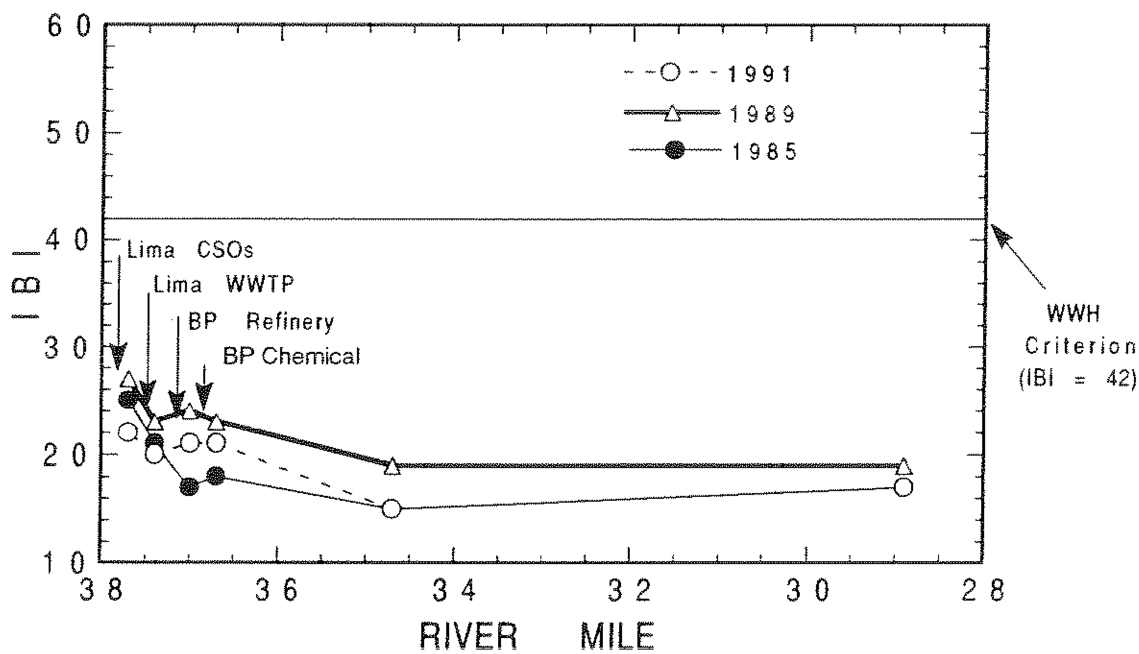


Figure 21. Longitudinal trend of the mean Index of Biotic Integrity (IBI; mean values) in the Ottawa River *(**top graph:** RM 46.1 -1.2; **bottom graph:** RM 37.7 - 28.9)* during 1985, 1989, and 1991.

DELT Anomalies:

• Since 1985, longitudinal trends in the percent DELT anomalies have remained similar and show there is a distinct pattern of marked increase as the river flows through Lima, OH past major wastewater discharges (Fig. 22). Notable increases begin downstream from the Collett Street CSOs and continue downstream from confluences of the three consecutive 001 outfalls, with the greatest percentage occurring downstream from all of the major sources. This persistent pattern which shows a positive relationship with pollutant loadings from major point sources and the low incidence found in the predominantly agricultural areas (*i.e.*, upstream and far downstream from Lima) strongly suggests the greater occurrence of disfiguration are the result of impacts primarily caused by the series of major dischargers. The positive relationship with the major pollutant loadings also supports idea that it is multiple stresses causing the aquatic life use impairment (*i.e.*, a combination of toxic, enrichment, and low D.O.) as opposed to single components alone (*i.e.*, D.O. or metals in the sediments).

• Survey results since 1985, show little ($\leq$ 1.0%) change in the mean percent occurrence of DELT anomalies upstream and far downstream from Lima, and moderate changes at sites within the most impacted nine mile segment (RM 37.8 -28.8). Downstream from the CSOs (RM 37.7), the percent was greater during 1987 (8.0%) and 1991 (9.1) than in 1985 (2.3) and 1989 (2.8). Downstream from the Lima WWTP (RM 37.4), the percent has shown an increase since 1985 (3.8% to 7.8 in 1989 to 12.0% in 1991). Downstream from the BP Oil Refinery (RM 37.0) there has been a slight increase during 1989 followed by a small decrease (15.3 to 16.2 to 12.0). Downstream from the BP Chemicals Plant (RM 36.7), sampling showed a marked increase from 1985 to 1989 (18.0 to 30.9) and a subsequent decrease in 1991 to 19.3%.

• The highest percent occurrence of DELT anomalies (by individual sample) recorded in the Ottawa River by Ohio EPA since 1985, occurred during 1991 at RM 34.7 (57.5% in June and 56.0% in July). During the seven year period, the highest mean values occurred at RM 34.7 during 1985 (43.0%) and 1991 (43.8%), and upstream, closer to the principal dischargers during 1987 (RM 36.0 = 50.3% based on a single boat sample) and 1989 (RM 36.7 = 30.9%).

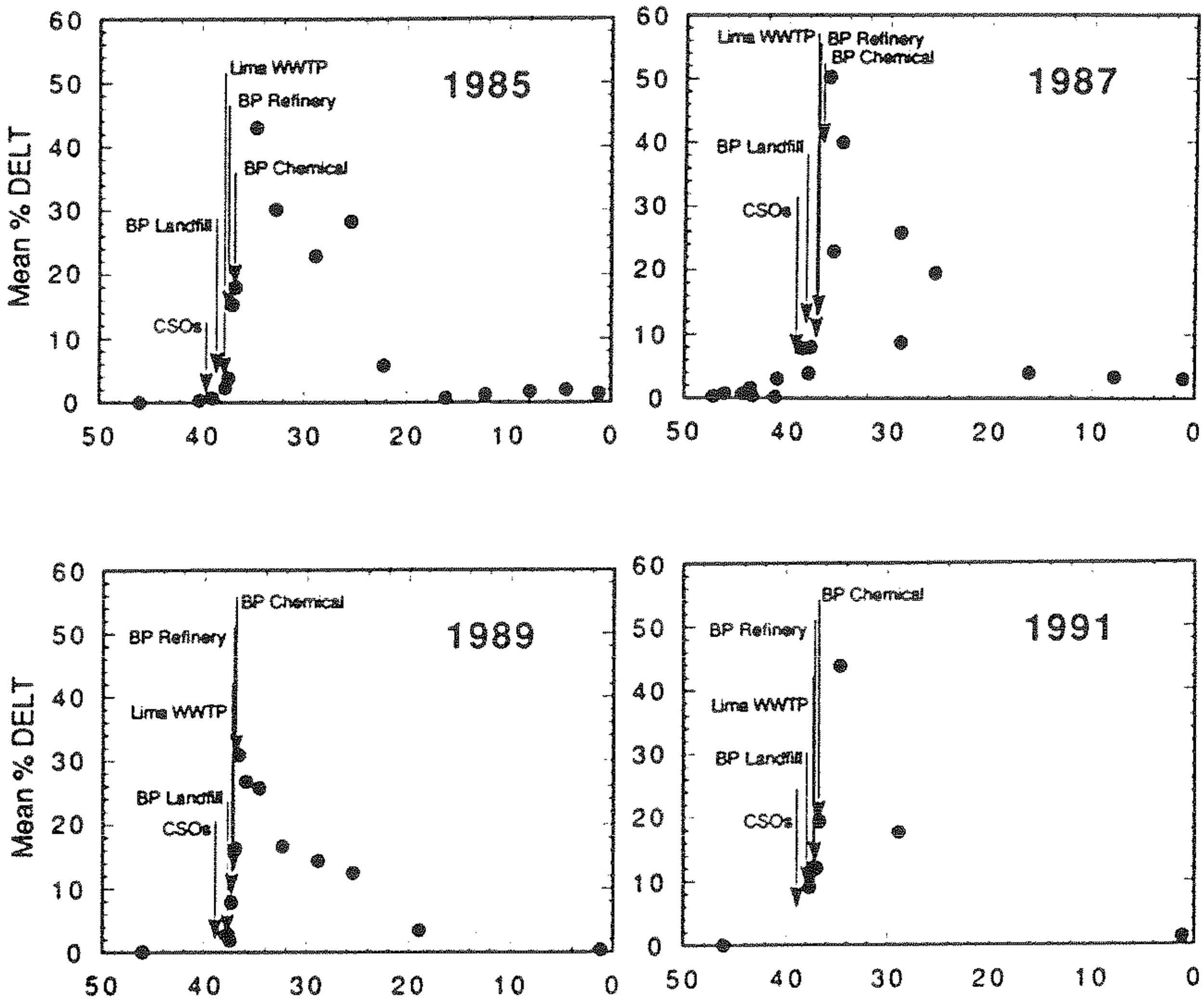


Figure 22. Longitudinal scatter plots of the mean percent incidence of DELT (Deformities, Erosion, Lesions, and Tumors) anomalies of fishes in the Ottawa River during 1985, 1987, 1989, and 1991.

Use Attainment Status Changes (Table 17, 18)

• With two exceptions, the aquatic life use attainment status of the Ottawa River since 1985 has remained unchanged. Survey results have consistently shown FULL attainment in predominantly agricultural areas upstream and far downstream from Lima, **NON** attainment downstream from major discharges The two exceptions are PARTIAL attainment of WWH at RM 37.9 (1987) and RM 37.0 (the June sample during minimal discharge from the BP Refinery).

• During the last seven years, study results show pollution related impacts were reduced between 1985 and 1989, but subsequently increased by 1991. Since no significant net changes have occurred, study results show major loading reductions are still needed within the affected reach in order to fully attain the WWH aquatic life use. Increased impacts since 1989 are likely due to a combination of higher pollutant loadings received during 1990 (*i.e.*, CSOs and stormwater discharges from BP Chemicals, *etc.*) followed by less dilution water during 1991. The extreme flow events during 1990 and 1991, however, are not directly responsible for the increased impacts, but show that existing wastewater strategies are not adequate for the protection of the Ottawa River within and downstream from Lima.

Table 17. Comparison of 1985, 1989, and 1991 biological index scores and use attainment status for eight commonly sampled reaches of the Ottawa River.

RM Fish/Macro.	MIwb 1985/89/91(diff.)	IBI 1985/89/91(diff.)	ICI 1985/89/91(diff.)	Attainment Status 1985/1989/1991
46.1/45.9	8.8/8.8/8.5(0/-.3)	39/45/42(+6/-3)	46/48/36(+2/-12)	FULL/FULL/FULL
37.7/37.8-.9	6.6/7.4/6.0(+.8/-1.4)	25/27/22(+2/-5)	6/16/6(+10/-10)	**NON/NON/NON**
37.4/37.3-.4	6.4/5.4/5.0(-1/-.4)	21/23/20(+2/-3)	6/10/8(+4/-2)	**NON/NON/NON**
37.0 (1st pass*)	5.1/7.6/8.5(+2.5/+.9)	17/24/26(+7/+2)	6/12/14(+6/+2)	**NON/**/**PARTIAL
37.0 (2nd & 3rd pass)	5.1/7.6/5.5(+2.5/-2.1)	17/24/18(+7/-6)	6/12/14(+6/+2)	**NON/**/NON**
37.0 (all passes)	5.1/7.6/6.5(+2.5/-1.1)	17/24/21(+7/-3)	6/12/14(+6/+2)	**NON/**/NON**
36.7/36.1-.8	3.5/6.0/4.8(+2.5/-1.2)	18/23/21(+5/-2)	4/14/10(+10/-4)	**NON/**/NON**
34.7/34.5	2.3/4.3/3.4(+2/-.9)	15/19/15(+4/-4)	6/30/18(+24/-12)	**NON/NON/NON**
28.9/28.8	4.3/4.7/4.4(+.4/-.3)	17/19/17(+2/-2)	22/34/28(+12/-6)	**NON/NON/NON**
1.2/0.8	8.5/9.0/9.2(+.5/+.2)	30/35/32(+5/-3)	46/42/28G(+2/-14)	FULL/FULL/FULL

* 1st, 2nd, and 3rd passes are for the 1991 samples.

Table 18. Area of Degradation (ADV) statistics for the Ottawa River study area, 1985 and 1991 (calculated using ecoregion criteria as the background community performance).

Biological Index Scores			ADV Statistics					Attainment Status (miles)			
***Stream* Index**	Lower RM	Upper RM	Mini-mum	Maxi-mum	**ADV**	ADV/ Mile	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
Ottawa River (1985)											
IBI	28.8	37.8	15	25	**1913**	208	717	0.0	0.0	**9.2**	9.2
MIwb			2.3	6.6	**1960**	213	234				
ICI			4	22	**2104**	229	388				
Ottawa River (1989)											
IBI	28.8	37.9	17	31	**1640**	178	465	0.0	0.0	**9.2**	8.9
MIwb			3.9	7.6	**1200**	130	93				
ICI			10	34	**717**	78	7				
Ottawa River (1991)											
IBI	28.8	37.8	15	22	**1918**	208	722	0.0	0.0	**9.2**	9.2
MIwb			3.4	6.5	**1750**	190	192				
ICI			6	28	**1207**	131	45				

References Cited

Baumann, P. C., W. D. Smith and W. K. Parland. 1987. Tumor frequencies and contaminant concentrations in brown bullhead from an industrialized river and a recreational lake. Trans. Am. Fish. Soc. 116 (1): 79-86.

Clark, C. F. and D. Allison 1966. Fish population trends in the Maumee and Auglaize Rivers. ODNR, Division. of Wildlife Pub. NRW - 317, Columbus, OH. 51 p.

Cross, W. P. 1967. Drainage areas of Ohio streams (supplement to Gazetteer of Ohio streams). ODNR, Division. Water, Ohio Water Plan Inventory Rpt. No. 12a.

Eagleson, K. W., D. L. Lenat, L. W. Ausley, and F. B. Winborne. 1990. Comparison of measured instream biological responses with responses predicted using the *Ceriodaphniadubia* chronic toxicity test. In: Environmental Toxicology and Chemistry, Vol. 9. pp. 1019-1028.

Engineering-Science 1981. Ottawa River Study. Report for Standard Oil Co., Cleveland, OH.

Estenik, J. and M Smith. 1992. 1992 Ohio water resource inventory Vol. ll: Fish tissue contamination monitoring program. Ohio EPA, Division. of Water Quality Planning and Assessment, Columbus, OH. 42 p.

Fausch, D.O., Karr, J.R. and P.R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Trans. Amer. Fish. Soc. 113:39-55.

Gammon, J.R. 1976. The fish populations of the middle 340 km of the Wabash River. Tech. Report No. 86. Purdue University. Water Resources Research Center, West Lafayette, IN. 73 p.

____ A. Spacie, J.L. Hamelink, and R.L. Kaesler. 1981. Role of electrofishing in assessing environmental quality of the Wabash River. pp. 307-324. In: Ecological assessments of effluent impacts on communities of indigenous aquatic organisms. ASTM STP 703, J.M. Bates and C.I. Weber (eds.). Philadelphia, PA.

Hughes, R. M., D. P. Larsen, and J. M. Omernik. 1986. Regional reference sites: a method for assessing stream pollution. Env. Mgmt. 10(5): 629-635.

Johnson, D. P. and K. D. Metzker 1981. Low-flow characteristics of Ohio streams. U.S. Geological Survey & Ohio EPA, Columbus, OH.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6 (6): 21-27.

____ and D.R. Dudley. 1981. Ecological perspective on water quality goals. Env. Mgmt. 5(1): 55-68.

Kelly, M. H., R. L. Hite. 1984. Evaluation of Illinois stream sediment data: 1974-1980. Illinois Environmental Protection Agency, Division of Water Pollution Control. Springfield, IL.

Krolczyk, J. C., ed. 1960. Gazetteer of Ohio streams. ODNR, Division. Water, Ohio Water Plan Inventory Rpt. No. 12. Columbus, OH.

Leeson, M. A. 1885. History of Allen County, Ohio. Warner, Beers & Co., Chicago. 824 p.

Martin, G. L., T. J. Balduf, D. D. McIntyre and J. P. Abrams 1979 Water quality study of the Ottawa River, Allen and Putnam Counties, Ohio. Ohio EPA Tech. Rept. OEPA 79/1. Division. Surveillance and Water Quality Standards, Columbus, OH. 35 p.

Mount, D. I., N. A. Thomas, T. J. Norberg, M. T. Barbour, T. H. Roush and W. F. Brandes 1984. Effluent and ambient toxicity testing and instream community response on the Ottawa River, Lima, Ohio. U.S. EPA Tech. Rept. EPA-600/3-84-080. Duluth, MN.

Ohio Dept. Health 1966 A report on recommended water quality criteria for the Maumee River basin including interstate waters Ohio - Indiana and Ohio - Michigan. Division. Eng., ODH, Columbus, OH. 81 p.

____ 1953. Report of water pollution study of Maumee River basin 1950-1951. Sanitary Eng. Division., ODH, Columbus, OH. 90 p.

Ohio Environmental Protection Agency 1986. Draft Ottawa River WQTSD for the 1985 survey. Division. of Water Quality Monitoring and Assessment, Columbus, OH.

____ 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, OH.

____ 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, OH.

____ 1989a. Ohio EPA manual of surveillance methods and quality assurance practices, updated edition. Division. of Environmental Services, Columbus, OH.

____ 1989b. Addendum to biological criteria for the protection of aquatic life: Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning and Assessment, Surface Water Section, Columbus, OH.

____ 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning and Assessment, Columbus, OH.

____ 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, OH.

Omernik, J. M. 1988. Ecoregions of the conterminous United States. Ann. Assoc. Amer. Geogr. 77(1): 118-125.

Patrick, R., R. Grant, Jr. and C. W. Hart, Jr. 1965. Ottawa-Auglaize-Maumee River survey for the Standard Oil Co. Acad. Nat. Sci. of Philadelphia, Dept. Limnology, Philadelphia, PA. 11p.

____ J. Cairns, Jr., J. M. Bates and F. B. Draper 1960. Ottawa-Auglaize River survey. Biological studies for the Sohio Chemical Co. Acad. Nat. Sci. of Philadelphia, Dept. Limnology, Philadelphia, PA. 42 p.

____ J. M. Bates, J. R. Gabel, M. H. Hohn, H. Jacobs, S.S. Roback, S. Ruigh and Y. Swabey 1957. Biological and chemical studies for the Lima Refinery Standard Oil Co. (Ohio). Acad. Nat. Sci. of Philadelphia, Dept. Limnology, Philadelphia, PA. 106 p.

Post, G. 1983. Textbook of fish health. TFH Publications, Inc., Neptune City, NJ. 256 p.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Division of Water Quality Planning and Assessment, Columbus, OH.

____ and C. O. Yoder 1991 Calculation and uses of the Area of Degradation Value (ADV). Division of Water Quality Planning and Assessment, Surface Water Section, Columbus, OH.

____ C. O. Yoder and D. Mishne 1992. Ohio water resource inventory. Vol. 1: Summary, status, and trends. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, OH.

Sanders, R. E. and J. T. Freda 1990. A summary of the 1989 Biological and water quality survey of the Ottawa River, Allen and Putnam Counties, Ohio and changes since 1985. Ohio EPA, Division. Water Quality Planning and Assessment, Columbus, OH.

Sanders, R. E. and D. J. Altfater 1988. Ottawa River fish communities: 1893 to 1987. Ohio J. Sci. 88 (2): 7-8.

____ 1987. Ottawa River fish communities: Responses to wastewater discharges from 1955 to 1985. Twenty-seventh Ohio Fish and Wildlife Conference, Columbus, OH.

Shindel, J. H. Klingler, J. P. Mangus, and L. E. Trimble 1991. Water resources data for Ohio: water year 1990. Vol. 2, St. Lawrence River Basin Statewide Project Data. Water-Data Report OH-90-2, Columbus, OH.

____ 1992 Water resources data for Ohio: water year 1991. Vol. 2, St. Lawrence River Basin Statewide Project Data. Water-Data Report OH-91-2, Columbus, OH.

Stuckey, R. L. and W. A. Wentz 1969. Effect of industrial pollution on the aquatic and shore angiosperm flora in the Ottawa River, Allen and Putnam Counties, Ohio. Ohio J. Sci. 69 (4): 226-242.

URS Consultants, Inc. 1992. Draft final report of Ottawa River study. Cleveland, OH.

U.S. EPA 1991. Environmental monitoring and assessment program field and laboratory methods manual pilot lakes survey, summer, 1991. Preliminary Draft. EPA/600/4-91/XXX. EMSL Office Res. and Development, Cincinnati. 50 pp.

____ 1981. Maumee River pilot watershed study, continued watershed monitoring (1978-1980). EPA/905/9-79-005-C, GLNP, Chicago.

____ 1980. Modeling phosphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. EPA/440/5-80-011, OWRSC, Washington, D.C.

APPENDIX TABLES

Table A-1. Ohio EPA mean (maximum-minimum)[a] values of the chemical/physical sampling results from the Ottawa River study area during July-September, 1991 (RMs 37.67, 37.11, 36.87, and 8.20 are effluent samples).

River Mile (n)	Dissolved Oxygen (mg/l)	Temperature (oC)	pH (S.U.)	Nonfilterable Residue (mg/l)
OTTAWA RIVER				
45.97(6)	[illegible]	[illegible]	8.4(7.6-8.8)	30(6-49)[b]
37.91(6)	[illegible]	[illegible]	8.2(7.8-8.5)	13(5-22)
37.67(6)	[illegible]	[illegible]	8.3(8.1-8.7)	6(5-7)
37.57(6)	[illegible]	[illegible]	8.2(7.9-8.4)	7(5-9)
37.11(6)	[illegible]	[illegible]	7.8(7.3-8.4)	8(5-12)
37.00(6)	[illegible]	[illegible]	7.7(7.2-7.9)	8(5-11)
36.87(6)	[illegible]	[illegible]	7.8(7.2-8.5)	21(14-32)
36.80(6)	[illegible]	[illegible]	7.8(7.3-8.3)	12(6-23)
34.55(6)	[illegible]	[illegible]	7.6(7.1-8.0)	11(5-16)
28.85(6)	[illegible]	[illegible]	8.2(7.5-8.9)	15(5-24)
HOG CREEK				
10.77(6)	[illegible]	[illegible]	8.0(7.6-8.7)	138(65-205)
0.27(6)	[illegible]	[illegible]	8.3(7.9-8.6)	23(6-42)
LITTLE HOG CREEK				
0.64(6)	[illegible]	[illegible]	8.3(7.9-8.7)	12(7-20)
PIKE RUN				
8.21(3)	[illegible]	[illegible]	7.7(7.5-8.0)	25(21-34)
8.20(3)	[illegible]	[illegible]	7.7(7.5-8.0)	7(5-8)
8.16(3)	[illegible]	[illegible]	7.5(7.3-7.7)	11(5-22)
2.14(3)	[illegible]	[illegible]	8.1(7.9-8.3)	90(18-227)

Table A-1. (continued)

River Mile (n)	Specific Conductance (microhmo)	BOD_5 (mg/l)	Total COD (mg/l)	Phosphorus (mg/l)
OTTAWA RIVER				
45.97(6)	913(8092.4(1.03-3.4)	17(12-26)	0.16(0.10-0.25)[b]	
37.91(6)	1008(795.7(2.2-7.8)	22(12-31)	0.18(0.13-0.29)	
37.67(6)	924(8601.2(1.0-1.8)	18(10-29)	0.27(0.14-0.70)	
37.57(6)	934(8871.9(1.0-2.5)	19(11-33)	0.16(0.13-0.21)	
37.11(6)	2300(26.8(2.7-29.0)	51(13-76)	0.29(0.08-0.83)	
37.00(6)	1393(13.0(1.6-11.0)	31(25-39)	0.18(0.12-0.25)	
36.87(6)	1940(17.4(3.7-37.0)	28(16-41)	0.98(0.36-3.65)	
36.80(6)	1502(14.4(2.0-10.0)	30(22-39)	0.37(0.13-0.69)	
34.55(6)	1460(123.8(2.0-4.8)	27(20-36)	0.24(0.17-0.42)	
28.85(6)	1903(135.3(3.0-4.5)	28(17-42)	0.27(0.12-0.36)	
HOG CREEK				
10.77(6)	973(858.1(3.3-14.7)	25(13-36)	0.44(0.09-1.72)	
0.27(6)	953(8692.0(1.2-3.5)	17(11-25)	0.38(0.19-1.14)	
LITTLE HOG CREEK				
0.64(6)	1617(143.0(1.7-8.4)	14(10-25)	0.53(0.39-0.76)	
PIKE RUN				
8.21(3)	614(4032.6(1.7-4.0)	24(16-32)	0.13(0.08-0.16)	
8.20(3)	981(799.6(1.7-23.4)	24(12-34)	1.98(1.28-2.83)	
8.16(3)	842(437.8(2.0-16.5)	36(25-53)	1.83(0.30-3.21)	
2.14(3)	831(3437.0(0.6-8.2)	29(22-42)	0.85(0.44-1.18)	

Table A-1. (continued)

River Mile (n)	Nitrate-Nitrite-N (mg/l)	Nitrite-N (mg/l)	Ammonia -N (mg/l)	Tot. Kjeldahl Nitrogen (mg/l)
OTTAWA RIVER				
45.97(6)	0.21(0.10-0.76) 0.02(0.02-0.02)	0.05(0.05-0.05)	0.5(0.2-0.6)	
37.91(6)	0.87(0.10-4.74) 0.02(0.02-0.02)	0.09(0.05-0.20)	1.0(0.8-1.2)	
37.67(6)	3.05(2.02-4.22) 0.03(0.02-0.02)	0.05(0.05-0.05)	0.7(0.2-0.9)	
37.57(6)	3.36(1.91-7.25) 0.02(0.02-0.02)	0.05(0.05-0.05)	0.8(0.4-0.9)	
37.11(6)	5.78(2.12-8.65)b 0.09(0.05-0.14)	0.42(0.15-1.12)	2.4(0.5-5.4)	
37.00(6)	3.79(1.36-5.13) 0.06(0.03-0.09)	0.20(0.11-0.40)	1.5(1.0-2.2)	
36.87(6)	3.17(1.42-4.86) 0.61(0.13-1.08)	3.65(2.36-5.84)b	5.6(3.6-8.2)b	
36.80(6)	3.55(2.23-4.93) 0.38(0.05-0.67)	1.52(0.47-3.56)	3.2(0.7-5.4)	
34.55(6)	3.95(2.17-5.65) 0.16(0.05-0.31)	0.46(0.08-0.84)	2.1(1.1-3.0)	
28.85(6)	4.13(2.11-5.88) 0.10(0.03-0.34)	0.23(0.05-0.93)	1.5(1.0-2.6)	
HOG CREEK				
10.77(6)	0.10(0.02-0.12) 0.02(0.02-0.02)	0.05(0.05-0.05)	0.7(0.2-1.4)	
0.27(6)	0.37(0.12-0.94) 0.02(0.02-0.03)	0.05(0.05-0.05)	0.5(0.2-0.6)	
LITTLE HOG CREEK				
0.64(6)	1.33(0.35-2.49) 0.08(0.04-0.11)	0.08(0.05-0.14)	0.7(0.5-0.9)	
PIKE RUN				
8.21(3)	0.56(0.14-1.33) 0.04(0.03-0.05)	0.26(0.14-0.38)d	0.7(0.4-1.0)	
8.20(3)	0.63(0.14-1.00)d 0.16(0.10-0.20)d	15.7d	12.7(8.8-15.4)	
8.16(3)	0.49(0.11-1.27) 0.10(0.07-0.12)	8.40(1.60-15.2)d	11.8(2.3-17.4)	
2.14(3)	1.96(1.25-2.34) 0.35(0.31-0.39)	3.56(1.26-5.76)	3.9(1.6-5.4)	

Table A-1. (continued)

River Mile (n)	Hardness (mg/l)	Total Calcium (mg/l)	Total Magnesium (mg/l)	Lab pH (S.U.)
OTTAWA RIVER				
45.97(6)	399(340[illegible]-99)	41(31-49)	8.23(8.10-8.36)	
37.91(6)	475(3[illegible]122)	52(31-69)	8.01(7.83-8.18)	
37.67(6)	209(196[illegible]-56)	18(16-20)	8.03(7.99-8.09)	
37.57(6)	268(218[illegible]-77)	26(19-33)	8.08(7.99-8.20)	
37.11(6)	547([illegible]180)	43(39-45)	7.91(7.40-8.68)	
37.00(6)	364(31[illegible]115)	31(27-37)	7.86(7.73-7.94)	
36.87(6)	600([illegible]173)	63(50-77)	7.91(7.63-8.40)	
36.80(6)	502(3[illegible]133)	54(31-77)	7.90(7.69-7.99)	
34.55(6)	411(3[illegible]112)	38(35-41)	7.79(7.63-7.95)	
28.85(6)	413(3[illegible]115)	39(34-42)	8.18(7.68-8.62)	
HOG CREEK				
10.77(6)	504([illegible]147)	48(34-56)	7.85(7.35-8.20)	
0.27(6)	432(3[illegible]110)	44(38-53)	8.03(7.91-8.15)	
LITTLE HOG CREEK				
0.64(6)	536([illegible]127)	63(60-69)	8.21(7.64-9.09)	
PIKE RUN				
8.21(3)	244(145[illegible]-80)	20(11-26)	7.72(7.50-7.90)	
8.20(3)	209(189[illegible]-59)	17(15-19)	7.64(7.50-7.70)	
8.16(3)	191(145[illegible]-57)	16(11-19)	7.53(7.50-7.60)	
2.14(3)	223(10[illegible]-74)	19(9-24)	7.79(7.60-8.00)	

Table A-1. (continued)

River Mile (n)	Total Arsenic (ug/l)	Total Cadmium (ug/l)	Total Chromium (ug/l)	Total Copper
OTTAWA RIVER				
45.97(6)	3(2-4)	0.2(0.2-0.2)	30(30-30)	10(10-10)
37.91(6)	2(2-2)	0.2(0.2-0.2)	30(30-30)	10(10-10)
37.67(6)	2(2-2)	0.2(0.2-0.2)	30(30-30)	10(10-10)
37.57(6)	2(2-2)	0.2(0.2-0.2)	30(30-30)	10(10-10)
37.11(6)	9(7-12)	0.2(0.2-0.2)	38(30-50)	10(10-10)
37.00(6)	4(3-5)	0.2(0.2-0.2)	30(30-30)	10(10-10)
36.87(6)	3(2-4)	0.2(0.2-0.2)	30(30-30)	13(10-20)
36.80(6)	3(2-5)	0.2(0.2-0.2)	30(30-30)	10(10-10)
34.55(6)	3(2-5)	0.2(0.2-0.2)	32(30-40)	10(10-10)
28.85(6)	3(2-5)	0.2(0.2-0.2)	30(30-30)	10(10-10)
HOG CREEK				
10.77(6)	6(4-10)	0.2(0.2-0.3)	30(30-30)	10(10-10)
0.27(6)	3(2-5)	0.2(0.2-0.2)	30(30-30)	10(10-10)
LITTLE HOG CREEK				
0.64(6)	2(2-3)	0.2(0.2-0.2)	30(30-30)	10(10-10)
PIKE RUN				
8.21(3)	3(2-3)	0.5(0.2-0.7)	30(30-30)	10(10-10)
8.20(3)	2(2-2)	0.2(0.2-0.2)	30(30-30)	10(10-10)
8.16(3)	2(2-2)	0.2(0.2-0.2)	30(30-30)	10(10-10)
2.14(3)	4(2-6)	0.6(0.2-1.0)	30(30-30)	12(10-15)

Table A-1. (continued)

River Mile (n)	Total Iron (ug/l)	Total Lead (ug/l)	Total Nickel (ug/l)	Total Zinc (ug/l)
OTTAWA RIVER				
45.97(6)	1154(440-1600)[b]	2(2-2)	40(40-40)	43(10-175)[b]
37.91(6)	322(170-440)	2(2-2)	40(40-40)	156(10-785)
37.67(6)	528(390-660)	2(2-2)	42(40-50)	23(15-30)
37.57(6)	438(280-540)	2(2-2)	43(40-50)	16(10-20)
37.11(6)	152(140-170)	3(2-4)	40(40-40)	50(20-100)
37.00(6)	395(250-580)	2(2-3)	40(40-40)	26(20-35)
36.87(6)	1117(960-1320)	2(2-4)	40(40-40)	15(10-20)
36.80(6)	720(260-990)	2(2-2)	40(40-40)	29(10-105)
34.55(6)	490(350-660)	3(2-4)	43(40-60)	24(10-45)
28.85(6)	402(240-530)	2(2-4)	40(40-40)	22(10-45)
HOG CREEK				
10.77(6)	5857(4120-8640)	2(2-2)	40(40-40)	33(20-60)
0.27(6)	870(370-1210)	2(2-2)	40(40-40)	14(10-25)
LITTLE HOG CREEK				
0.64(6)	450(260-620)	2(2-4)	43(40-60)	13(10-25)
PIKE RUN				
8.21(3)	1503(1310-1630)	2(2-2)	40(40-40)	43(25-65)
8.20(3)	157(120-210)	3(2-4)	40(40-40)	13(10-20)
8.16(3)	643(220-1410)	2(2-3)	40(40-40)	27(10-60)
2.14(3)	4250(1190-10150)	5(2-12)	40(40-40)	55(10-145)

Table A-1. (continued)

River Mile(n)	Total Cyanide (mg/l)	(ug/l)	Phenolics (mg/l)	Oil & Grease
OTTAWA RIVER				
45.97(6)	5(5-5)	10(10-10)	1.10(1.00-1.28)	
37.91(6)	5(5-5)	10(10-10)	1.05(1.00-1.28)	
37.67(6)	5(5-6)b	10(10-10)	1.05(1.00-1.28)	
37.57(6)	5(5-5)	10(10-10)	1.07(1.00-1.37)	
37.11(6)	21(7-36)	15(10-28)	1.34(1.00-2.33)b	
37.00(6)	10(5-16)b	10(10-10)	1.22(1.00-1.77)b	
36.87(6)	5(5-5)	10(10-11)	1.32(1.00-2.41)b	
36.80(6)	8(5-16)b	11(10-13)	1.19(1.00-1.68)b	
34.55(6)	7(5-12)b	10(10-10)	1.12(1.00-1.52)b	
28.85(6)	7(5-9)b	10(10-10)	1.25(1.00-2.46)	
HOG CREEK				
10.77				
0.27				
LITTLE HOG CREEK				
0.64				
PIKE RUN				
8.21(3)	5(5-5)	10(10-11)	1.33(1.00-1.65)d	
8.20(3)	8(5-13)	10(10-11)	1.64(1.60-1.69)d	
8.16(3)	5(5-5)	11(10-13)	1.68(1.00-2.35)d	
2.14(3)	5(5-5)	10(10-10)	1.09(1.00-1.18)d	

Table A-1. (continued)

River Mile (n)	Fecal Coliform (#/100 ml)	Total Residual Chlorine (mg/l)
OTTAWA RIVER		
45.97(6)	137(40-200)[c]	
37.91(6)	287(140-440)[c]	
37.67(6)	30(10-40)[c]	0.32(0.23-0.48)
37.57(6)	163(30-310)[c]	
37.11(6)	60(10-100)[c]	0.07(0.00-0.10)
37.00(6)	153(80-290)[c]	
36.87(6)	9567(1300-22000)[c]	
36.80(6)	3400(1800-5900)[c]	
34.55(6)	627(240-1300)[c]	
28.85(6)	287(130-520)[c]	
HOG CREEK		
10.77(6)	293(90-550)[c]	
0.27(6)	240(150-380)[c]	
LITTLE HOG CREEK		
0.64(6)	147(20-230)[c]	
PIKE RUN		
8.21(3)		
8.20(3)		0.25(0.09-0.40)[d]
8.16(3)		
2.14(3)		

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n < 6.
[c] n =3.
[d] n <3.

Table A-2. Summary of diurnal D.O.(mg/l) data recorded with Datasonde continuous monitors at ten locations in the Ottawa River study area from 23 - 25 July, 1991.

River Mile	Hours	Mean (mg/l)	Median (mg/l)	Min. (mg/l)	Max. (mg/l)	25th %ile (mg/l)	75th %ile (mg/l)
OTTAWA RIVER							
46.10	48	6.93	6.55	5.42	9.87	5.64	8.00
37.90	46	4.71‡	4.60‡	2.26‡‡	7.57	3.58‡‡	6.25
37.60	46	7.23	7.26	5.59	8.85	6.26	8.15
36.90	45	6.18	6.28	3.81‡‡	8.32	5.24	7.22
34.30	44	5.78	5.26	3.31‡‡	9.63	4.12‡	7.66
32.60	44	6.78	5.88	3.80‡‡	11.77	4.56‡	8.86
31.05	44	5.25	4.84‡	3.14‡‡	9.37	3.54‡‡	6.64
28.80	43	6.28	5.88	4.63‡	9.34	5.07	7.27
HOG CREEK							
10.80	47	3.82‡‡	3.82‡‡	2.06‡‡	6.52	2.74‡‡	4.42‡
0.30	47	6.49	6.09	5.46	9.41	5.60	7.11

‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
‡‡‡ violation of the “nuisance prevention” minimum dissolved oxygen (D.O.) criterion.

Table A-3. Invertebrate Community Index (ICI) metrics and scores (by RM) for locations sampled in the Ottawa River study area during 1991.

		Number of				Percent:							
River Mile	Drainage Area (sq mi)	Total Taxa	Mayfly Taxa	Caddisfly Taxa	Dipteran Taxa	Mayflies	Caddis-flies	Tany-tarsini	Other Dipt/NI	Tolerant Taxa	Qual. EPT	Eco-region	ICI
OTTAWA RIVER - 04-200													
Year: 91													
45.9	98.5	51(6)	7(4)	5(6)	28(6)	15.4(2)	0.6(2)	14.0(2)	67.7(0)	14.4(2)	15(6)	5	36
37.8	129.6	17(2)	0(0)	0(0)	8(2)	0.0(0)	0.0(0)	0.0(0)	99.9(0)	59.1(0)	6(2)	5	6
37.4	130.9	20(2)	0(0)	0(0)	12(2)	0.0(0)	0.0(0)	1.0(2)	98.2(0)	10.8(2)	1(0)	5	8
37.0	131.4	25(4)	1(0)	1(2)	12(2)	6.0(2)	1.8(2)	0.8(2)	90.3(0)	21.3(0)	2(0)	5	14
36.1	132.9	13(2)	1(0)	1(2)	7(2)	12.0(2)	8.6(2)	0.0(0)	79.4(0)	46.9(0)	2(0)	5	10
34.5	151.0	17(2)	1(0)	1(2)	11(2)	46.0(6)	1.3(2)	0.6(2)	51.8(2)	18.1(0)	3(0)	5	18
28.8	160.0	32(4)	3(2)	4(4)	17(4)	32.7(6)	1.7(2)	5.0(2)	58.6(0)	10.4(2)	8(2)	5	28
.8	364.0	30(4)	5(2)	6(6)	10(2)	5.1(2)	1.2(2)	0.1(2)	91.0(0)	8.3(2)	17(6)	1	28
HOG CREEK - 04-216													
Year: 91													
10.8	31.8	15(2)	1(0)	0(0)	8(2)	2.4(2)	0.0(0)	0.0(0)	95.2(0)	35.6(0)	3(0)	5	6
.2	73.8	44(6)	8(4)	4(6)	21(6)	34.3(6)	24.9(6)	3.8(2)	35.1(4)	4.7(6)	13(4)	5	50
LITTLE HOG CREEK - 04-221													
Year: 91													
.2	15.1	29(4)	5(4)	0(0)	15(4)	22.2(4)	0.0(0)	15.8(4)	61.3(2)	8.2(6)	12(6)	5	34

Table A-4. Macroinvertebrate collection summary (by RM) for locations sampled in the Ottawa River study area during 1991.

Collection Date: 09/11/91 River Code: 04-200 River: Ottawa River RM: .8

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	91 +	69400	*Stenelmis sp*	145 +
03360	*Plumatella sp*	3 +	74501	*Ceratopogonidae*	8
03451	*Urnatella gracilis*	1	77120	*Ablabesmyia mallochi*	16
03600	*Oligochaeta*	848 +	77750	*Hayesomyia senata*	80 +
06700	*Crangonyx sp*	0 +	80370	*Corynoneura taris*	32
08250	*Orconectes (Procericambarus) rusticus*	0 +	80410	*Cricotopus (C.) sp*	0 +
11130	*Baetis intercalaris*	0 +	81230	*Nanocladius (N.) crassicornus*	0 +
12200	*Isonychia sp*	0 +	81240	*Nanocladius (N.) distinctus*	0 +
13000	*Leucrocuta sp*	0 +	83004	*Dicrotendipes Type 4*	0 +
13400	*Stenacron sp*	95 +	83040	*Dicrotendipes neomodestus*	80
13550	*Stenonema mexicanum integrum*	5 +	83050	*Dicrotendipes lucifer*	962
13570	*Stenonema terminatum*	0 +	83300	*Glyptotendipes sp*	7054 +
16700	*Tricorythodes sp*	313 +	84450	*Polypedilum (P.) convictum*	0 +
17200	*Caenis sp*	101 +	84470	*Polypedilum (P.) illinoense*	0 +
18100	*Anthopotamus sp*	9 +	84475	*Polypedilum (P.) ophioides*	0 +
18750	*Hexagenia limbata*	0 +	84520	*Polypedilum (Tripodura) halterale group*	0 +
21300	*Hetaerina sp*	0 +	84540	*Polypedilum (Tripodura) scalaenum group*	0 +
22001	*Coenagrionidae*	0 +	84750	*Stictochironomus sp*	0 +
22300	*Argia sp*	103 +	84790	*Tribelos fuscicorne*	160
24710	*Dromogomphus spinosis*	0 +	85625	*Rheotanytarsus exiguus group*	0 +
42700	*Belostoma sp*	0 +	85814	*Tanytarsus glabrescens group*	16
45100	*Palmacorixa sp*	0 +	87501	*Empididae*	16
47600	*Sialis sp*	0 +	94400	*Fossaria sp*	0 +
51206	*Cyrnellus fraternus*	90	95100	*Physella sp*	2 +
51400	*Nyctiophylax sp*	1	98600	*Sphaerium sp*	0 +
51600	*Polycentropus sp*	4			
52200	*Cheumatopsyche sp*	20 +			
52430	*Hydropsyche (Ceratopsyche) morosa group*	0 +			
52520	*Hydropsyche (H.) bidens*	3 +			
52530	*Hydropsyche (H.) depravata group*	0 +			
52540	*Hydropsyche (H.) dicantha*	0 +			
52801	*Potamyia flava*	4 +			
53501	*Hydroptilidae*	0 +			
59970	*Petrophila sp*	0 +			
66500	*Enochrus sp*	0 +			
67000	*Helophorus sp*	0 +			
67700	*Paracymus sp*	0 +			
68201	*Scirtidae*	0 +			
68708	*Dubiraphia vittata*	6 +			
68901	*Macronychus glabratus*	7 +			

No. Quantitative Taxa: 30 Total Taxa: 65

No. Qualitative Taxa: 53 ICI: 28

Table A-4. Continued.

Collection Date: 09/11/91 River Code: 04-200 River: Ottawa River RM: 28.8

Taxa Code	Taxa	Quan/Qual
00401	*Spongillidae*	0 +
03360	*Plumatella sp*	14 +
03600	*Oligochaeta*	36 +
04964	*Mooreobdella microstoma*	0 +
05900	*Lirceus sp*	0 +
06700	*Crangonyx sp*	0 +
08250	*Orconectes (Procericambarus) rusticus*	1 +
11130	*Baetis intercalaris*	798 +
13400	*Stenacron sp*	2 +
13521	*Stenonema femoratum*	1 +
21200	*Calopteryx sp*	0 +
22300	*Argia sp*	45 +
28955	*Plathemis lydia*	0 +
45100	*Palmacorixa sp*	0 +
45300	*Sigara sp*	0 +
47600	*Sialis sp*	0 +
48410	*Corydalus cornutus*	0 +
52200	*Cheumatopsyche sp*	14 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	16 +
52530	*Hydropsyche (H.) depravata group*	1 +
52540	*Hydropsyche (H.) dicantha*	10 +
53800	*Hydroptila sp*	0 +
59970	*Petrophila sp*	0 +
60900	*Peltodytes sp*	0 +
63900	*Laccophilus sp*	0 +
65800	*Berosus sp*	0 +
66700	*Helochares maculicollis*	0 +
67800	*Tropisternus sp*	0 +
69400	*Stenelmis sp*	4 +
77120	*Ablabesmyia mallochi*	0 +
77500	*Conchapelopia sp*	113 +
77750	*Hayesomyia senata*	70 +
77800	*Helopelopia sp*	291 +
78450	*Nilotanypus fimbriatus*	35
79020	*Tanypus neopunctipennis*	0 +
80410	*Cricotopus (C.) sp*	18
80420	*Cricotopus (C.) bicinctus*	18 +
80430	*Cricotopus (C.) tremulus group*	18
81230	*Nanocladius (N.) crassicornus*	53 +
81240	*Nanocladius (N.) distinctus*	18
82730	*Chironomus (C.) decorus group*	0 +
82820	*Cryptochironomus sp*	0 +
83300	*Glyptotendipes sp*	421 +
84010	*Parachironomus abortivus*	18
84040	*Parachironomus frequens*	18
84450	*Polypedilum (P.) convictum*	0 +
84460	*Polypedilum (P.) fallax group*	140 +
84470	*Polypedilum (P.) illinoense*	18 +
84540	*Polypedilum (Tripodura) scalaenum group*	105 +
85625	*Rheotanytarsus exiguus group*	18
85814	*Tanytarsus glabrescens group*	105
95100	*Physella sp*	20 +
96900	*Ferrissia sp*	5 +
98600	*Sphaerium sp*	4 +

No. Quantitative Taxa: 32 Total Taxa: 54

No. Qualitative Taxa: 46 ICI: 28

Table A-4. Continued. Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/11/91 River Code: 04-200 River: Ottawa River RM: 34.5

Taxa Code	Taxa	Quan/Qual
03360	*Plumatella sp*	1 +
03600	*Oligochaeta*	16 +
04964	*Mooreobdella microstoma*	0 +
08250	*Orconectes (Procericambarus) rusticus*	3 +
11130	*Baetis intercalaris*	1000 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	6 +
28955	*Plathemis lydia*	0 +
42700	*Belostoma sp*	0 +
52530	*Hydropsyche (H.) depravata group*	0 +
52540	*Hydropsyche (H.) dicantha*	28 +
60900	*Peltodytes sp*	0 +
63300	*Hydroporus sp*	0 +
63900	*Laccophilus sp*	0 +
65800	*Berosus sp*	0 +
67000	*Helophorus sp*	0 +
67800	*Tropisternus sp*	0 +
69400	*Stenelmis sp*	0 +
74501	*Ceratopogonidae*	0 +
77120	*Ablabesmyia mallochi*	0 +
77750	*Hayesomyia senata*	369 +
77800	*Helopelopia sp*	135 +
80410	*Cricotopus (C.) sp*	25
80420	*Cricotopus (C.) bicinctus*	113 +
80430	*Cricotopus (C.) tremulus group*	0 +
81230	*Nanocladius (N.) crassicornus*	113 +
81240	*Nanocladius (N.) distinctus*	76 +
82820	*Cryptochironomus sp*	0 +
83051	*Dicrotendipes simpsoni*	0 +
83300	*Glyptotendipes sp*	25 +
84460	*Polypedilum (P.) fallax group*	138
84470	*Polypedilum (P.) illinoense*	50 +
84540	*Polypedilum (Tripodura) scalaenum group*	63 +
84750	*Stictochironomus sp*	0 +
85814	*Tanytarsus glabrescens group*	13
87400	*Stratiomys sp*	0 +
95100	*Physella sp*	0 +
96900	*Ferrissia sp*	0 +
98600	*Sphaerium sp*	0 +

Taxa Code	Taxa	Quan/Qual

No. Quantitative Taxa: 17 Total Taxa: 39

No. Qualitative Taxa: 36 ICI: **18**

Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/11/91 River Code: 04-200 River: Ottawa River RM: 36.1

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
03360	*Plumatella sp*	1 +			
03600	*Oligochaeta*	96 +			
04666	*Helobdella triserialis*	0 +			
04964	*Mooreobdella microstoma*	0 +			
06700	*Crangonyx sp*	0 +			
08250	*Orconectes (Procericambarus) rusticus*	0 +			
11130	*Baetis intercalaris*	648 +			
21200	*Calopteryx sp*	0 +			
22001	*Coenagrionidae*	0 +			
22300	*Argia sp*	2 +			
28955	*Plathemis lydia*	0 +			
52540	*Hydropsyche (H.) dicantha*	464 +			
63900	*Laccophilus sp*	0 +			
65800	*Berosus sp*	0 +			
67800	*Tropisternus sp*	0 +			
69400	*Stenelmis sp*	0 +			
77120	*Ablabesmyia mallochi*	0 +			
77750	*Hayesomyia senata*	1353 +			
77800	*Helopelopia sp*	0 +			
78401	*Natarsia species A*	0 +			
78650	*Procladius sp*	0 +			
78702	*Psectrotanypus dyari*	0 +			
79020	*Tanypus neopunctipennis*	0 +			
80410	*Cricotopus (C.) sp*	50 +			
80420	*Cricotopus (C.) bicinctus*	2005 +			
80430	*Cricotopus (C.) tremulus group*	251			
81240	*Nanocladius (N.) distinctus*	401 +			
82770	*Chironomus (C.) riparius group*	0 +			
83051	*Dicrotendipes simpsoni*	0 +			
83300	*Glyptotendipes sp*	50			
84040	*Parachironomus frequens*	0 +			
84470	*Polypedilum (P.) illinoense*	0 +			
84540	*Polypedilum (Tripodura) scalaenum group*	50 +			
96900	*Ferrissia sp*	35 +			
98200	*Pisidium sp*	0 +			
98600	*Sphaerium sp*	0 +			

No. Quantitative Taxa: 13 Total Taxa: 36

No. Qualitative Taxa: 34 ICI: **10**

Table A-4. Continued. Ohio EPA Ecological Assessment Section

Macroinvertebrate Collection

Collection Date: 09/11/91 River Code: 04-200 River: Ottawa River RM: 37.0

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	0 +
03360	*Plumatella sp*	5 +
03600	*Oligochaeta*	46 +
04666	*Helobdella triserialis*	0 +
04964	*Mooreobdella microstoma*	0 +
08250	*Orconectes (Procericambarus) rusticus*	0 +
11130	*Baetis intercalaris*	121 +
22001	*Coenagrionidae*	2 +
22300	*Argia sp*	12 +
28908	*Perithemis tenera*	0 +
28955	*Plathemis lydia*	0 +
52540	*Hydropsyche (H.) dicantha*	37 +
60800	*Haliplus sp*	0 +
60900	*Peltodytes sp*	0 +
63900	*Laccophilus sp*	0 +
65800	*Berosus sp*	2
67800	*Tropisternus sp*	0 +
68075	*Psephenus herricki*	0 +
68601	*Ancyronyx variegata*	1
68901	*Macronychus glabratus*	1
69400	*Stenelmis sp*	3 +
74100	*Simulium sp*	0 +
77120	*Ablabesmyia mallochi*	0 +
77750	*Hayesomyia senata*	492 +
77800	*Helopelopia sp*	0 +
79020	*Tanypus neopunctipennis*	0 +
79030	*Tanypus punctipennis*	0 +
80410	*Cricotopus (C.) sp*	103 +
80420	*Cricotopus (C.) bicinctus*	275 +
80430	*Cricotopus (C.) tremulus group*	430 +
80510	*Cricotopus (Isocladius) sylvestris group*	0 +
81230	*Nanocladius (N.) crassicornus*	34
81240	*Nanocladius (N.) distinctus*	17
82730	*Chironomus (C.) decorus group*	0 +
82770	*Chironomus (C.) riparius group*	17
82820	*Cryptochironomus sp*	0 +
83300	*Glyptotendipes sp*	103 +
83330	*Glyptotendipes barbipes*	0 +
84470	*Polypedilum (P.) illinoense*	17 +
84540	*Polypedilum (Tripodura) scalaenum group*	223 +
85814	*Tanytarsus glabrescens group*	17
87501	*Empididae*	10 +
95100	*Physella sp*	24 +
96900	*Ferrissia sp*	37 +
98200	*Pisidium sp*	0 +
98600	*Sphaerium sp*	1 +

No. Quantitative Taxa:	25	Total Taxa:	46
No. Qualitative Taxa:	39	ICI:	**14**

Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/11/91   River Code: 04-200   River: Ottawa River   RM: 37.4

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	1 +			
03600	*Oligochaeta*	160 +			
06700	*Crangonyx sp*	1			
08250	*Orconectes (Procericambarus) rusticus*	0 +			
17200	*Caenis sp*	0 +			
22300	*Argia sp*	17 +			
28908	*Perithemis tenera*	0 +			
59970	*Petrophila sp*	0 +			
60900	*Peltodytes sp*	0 +			
68075	*Psephenus herricki*	0 +			
69400	*Stenelmis sp*	17 +			
74100	*Simulium sp*	1 +			
74501	*Ceratopogonidae*	0 +			
77500	*Conchapelopia sp*	0 +			
77750	*Hayesomyia senata*	423 +			
77800	*Helopelopia sp*	47 +			
78650	*Procladius sp*	0 +			
79020	*Tanypus neopunctipennis*	0 +			
80410	*Cricotopus (C.) sp*	141 +			
80420	*Cricotopus (C.) bicinctus*	235 +			
80430	*Cricotopus (C.) tremulus group*	2113 +			
82730	*Chironomus (C.) decorus group*	0 +			
82820	*Cryptochironomus sp*	0 +			
83051	*Dicrotendipes simpsoni*	47			
83300	*Glyptotendipes sp*	282 +			
84450	*Polypedilum (P.) convictum*	0 +			
84470	*Polypedilum (P.) illinoense*	47 +			
84540	*Polypedilum (Tripodura) scalaenum group*	940 +			
85814	*Tanytarsus glabrescens group*	47			
87501	*Empididae*	8 +			
96900	*Ferrissia sp*	1 +			
98200	*Pisidium sp*	1 +			
98600	*Sphaerium sp*	1			

No. Quantitative Taxa: 20   Total Taxa: 33

No. Qualitative Taxa: 29   ICI: **8**

Collection Date: 09/10/91 River Code: 04-200 River: Ottawa River RM: 37.8

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	1356 +
03360	*Plumatella sp*	0 +
03600	*Oligochaeta*	4906 +
04666	*Helobdella triserialis*	4 +
04964	*Mooreobdella microstoma*	0 +
08250	*Orconectes (Procericambarus) rusticus*	2 +
11130	*Baetis intercalaris*	0 +
17200	*Caenis sp*	0 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	0 +
47600	*Sialis sp*	0 +
52200	*Cheumatopsyche sp*	0 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	0 +
53501	*Hydroptilidae*	0 +
57900	*Pycnopsyche sp*	0 +
59970	*Petrophila sp*	0 +
60900	*Peltodytes sp*	0 +
65800	*Berosus sp*	0 +
67800	*Tropisternus sp*	0 +
68075	*Psephenus herricki*	0 +
69400	*Stenelmis sp*	3 +
77750	*Hayesomyia senata*	128 +
80410	*Cricotopus (C.) sp*	43
80420	*Cricotopus (C.) bicinctus*	128 +
80500	*Cricotopus (Isocladius) reversus group*	43
82730	*Chironomus (C.) decorus group*	598 +
82770	*Chironomus (C.) riparius group*	0 +
82820	*Cryptochironomus sp*	0 +
83040	*Dicrotendipes neomodestus*	0 +
83051	*Dicrotendipes simpsoni*	0 +
83300	*Glyptotendipes sp*	1976 +
84020	*Parachironomus carinatus*	0 +
84030	*Parachironomus directus*	128 +
84450	*Polypedilum (P.) convictum*	0 +
84540	*Polypedilum (Tripodura) scalaenum group*	214 +
87501	*Empididae*	0 +
93200	*Hydrobiidae*	0 +
95100	*Physella sp*	41 +
96900	*Ferrissia sp*	5 +
96930	*Laevapex fuscus*	0 +
98200	*Pisidium sp*	6
98600	*Sphaerium sp*	30 +

No. Quantitative Taxa:	17	Total Taxa:	42
No. Qualitative Taxa:	39	ICI:	6

Table A-4. Continued. Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date:09/10/91 River Code: 04-200 River: Ottawa River RM: 45.9

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	157	69400	*Stenelmis sp*	1 +
01801	*Turbellaria*	53 +	74100	*Simulium sp*	0 +
02960	*Paragordius sp*	0 +	74501	*Ceratopogonidae*	12 +
03360	*Plumatella sp*	20 +	77120	*Ablabesmyia mallochi*	62
03600	*Oligochaeta*	456 +	77500	*Conchapelopia sp*	123
05900	*Lirceus sp*	0 +	77750	*Hayesomyia senata*	123 +
08250	*Orconectes (Procericambarus) rusticus*	0 +	78130	*Labrundinia neopilosella*	8
11020	*Acerpenna sp*	4 +	80370	*Corynoneura taris*	136
11130	*Baetis intercalaris*	0 +	82121	*Thienemanniella Type 3*	8
11300	*Centroptilum sp*	0 +	82141	*Thienemanniella xena*	0 +
11400	*Cloeon sp*	6	82730	*Chironomus (C.) decorus group*	62 +
13400	*Stenacron sp*	41 +	82820	*Cryptochironomus sp*	0 +
13570	*Stenonema terminatum*	2	83040	*Dicrotendipes neomodestus*	954
13580	*Stenonema tripunctatum*	4	83051	*Dicrotendipes simpsoni*	123
16700	*Tricorythodes sp*	2	83158	*Endochironomus nigricans*	31
17200	*Caenis sp*	730 +	83300	*Glyptotendipes sp*	523 +
18100	*Anthopotamus sp*	0 +	83310	*Glyptotendipes amplus*	31
18750	*Hexagenia limbata*	0 +	83840	*Microtendipes pedellus group*	246 +
21200	*Calopteryx sp*	0 +	84060	*Parachironomus pectinatellae*	62
22001	*Coenagrionidae*	0 +	84450	*Polypedilum (P.) convictum*	62 +
22300	*Argia sp*	101 +	84460	*Polypedilum (P.) fallax group*	31
43300	*Ranatra sp*	0 +	84470	*Polypedilum (P.) illinoense*	62 +
45100	*Palmacorixa sp*	0 +	84520	*Polypedilum (Tripodura) halterale group*	31
47600	*Sialis sp*	1 +	84540	*Polypedilum (Tripodura) scalaenum group*	31 +
50315	*Chimarra obscura*	1 +	84750	*Stictochironomus sp*	0 +
51400	*Nyctiophylax sp*	1 +	84790	*Tribelos fuscicorne*	62
51600	*Polycentropus sp*	0 +	85230	*Cladotanytarsus mancus group*	31
52200	*Cheumatopsyche sp*	26 +	85500	*Paratanytarsus sp*	31
52430	*Hydropsyche (Ceratopsyche) morosa group*	3 +	85625	*Rheotanytarsus exiguus group*	31
52530	*Hydropsyche (H.) depravata group*	2 +	85700	*Stempellina sp*	8
53800	*Hydroptila sp*	0 +	85800	*Tanytarsus sp*	277
58505	*Helicopsyche borealis*	0 +	85814	*Tanytarsus glabrescens group*	308 +
59970	*Petrophila sp*	0 +	85840	*Tanytarsus guerlus group*	31
60900	*Peltodytes sp*	0 +	86100	*Chrysops sp*	0 +
63300	*Hydroporus sp*	0 +	87501	*Empididae*	0 +
67700	*Paracymus sp*	0 +	93900	*Elimia sp*	0 +
68075	*Psephenus herricki*	0 +	96900	*Ferrissia sp*	4
68201	*Scirtidae*	0 +	98600	*Sphaerium sp*	4 +
68708	*Dubiraphia vittata*	7 +			
68901	*Macronychus glabratus*	10 +			

No. Quantitative Taxa: 51 Total Taxa: 78

No. Qualitative Taxa: 53 ICI: 36

06/29/92

Table A-4. Continued.

Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/10/91 River Code: 04-216 River: Hog Creek RM: .2

Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	44
01801	*Turbellaria*	16 +
03360	*Plumatella sp*	40 +
03600	*Oligochaeta*	28 +
05900	*Lirceus sp*	21 +
06201	*Hyalella azteca*	0 +
08250	*Orconectes (Procericambarus) rusticus*	0 +
08601	*Hydracarina*	4
11020	*Acerpenna sp*	229 +
11120	*Baetis flavistriga*	65
11130	*Baetis intercalaris*	662 +
12200	*Isonychia sp*	3 +
13000	*Leucrocuta sp*	2 +
13400	*Stenacron sp*	87 +
13521	*Stenonema femoratum*	0 +
13570	*Stenonema terminatum*	11
17200	*Caenis sp*	7 +
18700	*Hexagenia sp*	0 +
21200	*Calopteryx sp*	0 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	1 +
23909	*Boyeria vinosa*	0 +
43300	*Ranatra sp*	0 +
45100	*Palmacorixa sp*	0 +
47600	*Sialis sp*	1 +
50315	*Chimarra obscura*	2 +
51600	*Polycentropus sp*	0 +
52200	*Cheumatopsyche sp*	762 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	7 +
52530	*Hydropsyche (H.) depravata group*	3
58505	*Helicopsyche borealis*	0 +
68075	*Psephenus herricki*	0 +
68601	*Ancyronyx variegata*	1
68708	*Dubiraphia vittata*	0 +
68901	*Macronychus glabratus*	41 +
69400	*Stenelmis sp*	11 +
77120	*Ablabesmyia mallochi*	0 +
77500	*Conchapelopia sp*	146 +
77750	*Hayesomyia senata*	66
77800	*Helopelopia sp*	26
78140	*Labrundinia pilosella*	0 +
78450	*Nilotanypus fimbriatus*	20
78650	*Procladius sp*	0 +
80370	*Corynoneura taris*	206
80430	*Cricotopus (C.) tremulus group*	20
81240	*Nanocladius (N.) distinctus*	10
82141	*Thienemanniella xena*	60
82730	*Chironomus (C.) decorus group*	0 +
83004	*Dicrotendipes Type 4*	10 +
83040	*Dicrotendipes neomodestus*	20
83300	*Glyptotendipes sp*	20
83820	*Microtendipes caelum*	10
83840	*Microtendipes pedellus group*	70 +
84020	*Parachironomus carinatus*	20 +
84040	*Parachironomus frequens*	20
84060	*Parachironomus pectinatellae*	0 +
84210	*Paratendipes albimanus*	0 +
84450	*Polypedilum (P.) convictum*	99 +
84460	*Polypedilum (P.) fallax group*	89
84470	*Polypedilum (P.) illinoense*	20 +
85625	*Rheotanytarsus exiguus group*	30 +
85814	*Tanytarsus glabrescens group*	89
87501	*Empididae*	4
96900	*Ferrissia sp*	0 +
98600	*Sphaerium sp*	0 +

No. Quantitative Taxa: 44 Total Taxa: 65

No. Qualitative Taxa: 45 ICI: **50**

Table A-4. Continued. Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/10/91 River Code: 04-216 River: Hog Creek RM: 10.8

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	34			
03360	*Plumatella sp*	4 +			
03600	*Oligochaeta*	1228			
06201	*Hyalella azteca*	0 +			
08250	*Orconectes (Procericambarus) rusticus*	0 +			
13400	*Stenacron sp*	0 +			
17200	*Caenis sp*	200 +			
18700	*Hexagenia sp*	0 +			
22001	*Coenagrionidae*	0 +			
22300	*Argia sp*	191 +			
28955	*Plathemis lydia*	0 +			
45100	*Palmacorixa sp*	0 +			
60900	*Peltodytes sp*	0 +			
63300	*Hydroporus sp*	0 +			
65800	*Berosus sp*	0 +			
67800	*Tropisternus sp*	0 +			
68201	*Scirtidae*	0 +			
68702	*Dubiraphia bivittata*	6 +			
69400	*Stenelmis sp*	0 +			
74501	*Ceratopogonidae*	163			
78650	*Procladius sp*	126			
79020	*Tanypus neopunctipennis*	0 +			
82730	*Chironomus (C.) decorus group*	126 +			
82820	*Cryptochironomus sp*	0 +			
83040	*Dicrotendipes neomodestus*	126			
83051	*Dicrotendipes simpsoni*	1578			
83300	*Glyptotendipes sp*	4333 +			
84010	*Parachironomus abortivus*	63 +			
84030	*Parachironomus directus*	63 +			
84470	*Polypedilum (P.) illinoense*	0 +			
87400	*Stratiomys sp*	0 +			
95100	*Physella sp*	1			

No. Quantitative Taxa: 15 Total Taxa: 32
No. Qualitative Taxa: 25 ICI: 6

Table A-4. Continued.

Ohio EPA Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/10/91 River Code: 04-221 River: Little Hog Creek RM: .2

Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	26
01801	*Turbellaria*	3 +
03600	*Oligochaeta*	43 +
04964	*Mooreobdella microstoma*	0 +
06201	*Hyalella azteca*	0 +
08250	*Orconectes (Procericambarus) rusticus*	1 +
11120	*Baetis flavistriga*	0 +
11130	*Baetis intercalaris*	0 +
11400	*Cloeon sp*	2
13400	*Stenacron sp*	41 +
13521	*Stenonema femoratum*	16 +
13580	*Stenonema tripunctatum*	5 +
17200	*Caenis sp*	266 +
21200	*Calopteryx sp*	0 +
22001	*Coenagrionidae*	1 +
22300	*Argia sp*	2 +
27500	*Somatochlora sp*	0 +
43300	*Ranatra sp*	0 +
45400	*Trichocorixa sp*	0 +
45900	*Notonecta sp*	0 +
47600	*Sialis sp*	0 +
50315	*Chimarra obscura*	0 +
51600	*Polycentropus sp*	0 +
52200	*Cheumatopsyche sp*	0 +
52530	*Hydropsyche (H.) depravata group*	0 +
53800	*Hydroptila sp*	0 +
58505	*Helicopsyche borealis*	0 +
60900	*Peltodytes sp*	0 +
65800	*Berosus sp*	1 +
67700	*Paracymus sp*	0 +
68075	*Psephenus herricki*	4 +
68708	*Dubiraphia vittata*	1 +
69400	*Stenelmis sp*	0 +
71300	*Limonia sp*	0 +
77120	*Ablabesmyia mallochi*	23
77355	*Clinotanypus pinguis*	0 +
78130	*Labrundinia neopilosella*	16
78140	*Labrundinia pilosella*	23
78650	*Procladius sp*	0 +
79020	*Tanypus neopunctipennis*	0 +
80370	*Corynoneura taris*	235
82730	*Chironomus (C.) decorus group*	16 +
82770	*Chironomus (C.) riparius group*	0 +
82820	*Cryptochironomus sp*	0 +
83004	*Dicrotendipes Type 4*	164 +
83040	*Dicrotendipes neomodestus*	39
83051	*Dicrotendipes simpsoni*	8
83840	*Microtendipes pedellus group*	227 +
84210	*Paratendipes albimanus*	31 +
84460	*Polypedilum (P.) fallax group*	55
84470	*Polypedilum (P.) illinoense*	0 +
85500	*Paratanytarsus sp*	8
85800	*Tanytarsus sp*	55 +
85814	*Tanytarsus glabrescens group*	125 +
85840	*Tanytarsus guerlus group*	47
87400	*Stratiomys sp*	0 +
87501	*Empididae*	0 +
98200	*Pisidium sp*	0 +
98600	*Sphaerium sp*	0 +

No. Quantitative Taxa: 29 Total Taxa: 59

No. Qualitative Taxa: 48 ICI: 34

Table A-5. Index of Biotic Integrity (IBI) metrics and scores for locations sampled in the Ottawa River study area during 1991.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Number of: Sunfish species	Number of: Sucker species	Number of: Intolerant species	Percent of Individuals: Rnd-bodied suckers	Percent of Individuals: Simple Lithophils	Percent of Individuals: Tolerant fishes	Percent of Individuals: Omni-vores	Percent of Individuals: Top carnivores	Percent of Individuals: Insect-ivores	Percent of Individuals: DELT anomalies	Rel.No. minus tolerants /(1.0 km)	Modified IBI	Iwb
Ottawa River - (04-200)																	
Year: 91																	
37.7	A	08-22-91	130	12(3)	3(3)	2(1)	0(1)	1(1)	15(1)	88(1)	38(1)	0(1)	61(5)	16.7(1)	148(1)	20	6.0
37.7	A	07-30-91	130	21(5)	3(3)	5(3)	0(1)	0(1)	3(1)	94(1)	54(1)	0(1)	44(3)	2.6(3)	224(3)	26	7.0
37.7	A	06-28-91	130	14(3)	2(3)	3(3)	0(1)	0(1)	3(1)	92(1)	51(1)	2(1)	46(3)	7.8(1)	96(1)	20	5.2
37.4	A	08-22-91	130	16(3)	2(3)	2(1)	0(1)	0(1)	10(1)	98(1)	67(1)	0(1)	30(3)	2.4(3)	26(1)	20	3.8
37.4	A	07-30-91	130	18(3)	3(3)	3(3)	0(1)	0(1)	18(1)	91(1)	68(1)	1(1)	25(1)	8.5(1)	94(1)	18	5.8
37.4	A	06-28-91	130	13(3)	3(3)	3(3)	0(1)	0(1)	33(3)	83(1)	52(1)	0(1)	39(3)	25.6(1)	56(1)	22	5.5
37.0	A	08-22-91	131	12(3)	2(3)	3(3)	0(1)	0(1)	6(1)	97(1)	65(1)	1(1)	31(3)	7.2(1)	28(1)	20	5.4
37.0	A	07-30-91	131	11(3)	1(1)	1(1)	0(1)	0(1)	15(1)	87(1)	56(1)	0(1)	40(3)	9.5(1)	144(1)	16	5.5
37.0	A	06-28-91	131	15(3)	2(3)	5(3)	0(1)	4(1)	61(5)	61(1)	55(1)	0(1)	41(3)	19.4(1)	240(3)	26	8.5
36.7	A	08-22-91	131	11(3)	2(3)	3(3)	0(1)	0(1)	11(1)	97(1)	43(1)	0(1)	55(5)	14.5(1)	14(1)	22	4.4
36.7	A	07-30-91	131	9(1)	1(1)	3(3)	0(1)	0(1)	4(1)	95(1)	28(3)	0(1)	70(5)	14.8(1)	16(1)	20	4.3
36.7	A	06-28-91	131	10(1)	2(3)	3(3)	0(1)	1(1)	4(1)	86(1)	29(1)	0(1)	61(5)	28.6(1)	20(1) *	20	5.6
34.7	A	08-23-91	151	8(1)	2(3)	1(1)	0(1)	0(1)	4(1)	96(1)	79(1)	0(1)	19(1)	17.9(1)	18(1)	14	3.2
34.7	A	07-30-91	151	9(1)	2(3)	1(1)	0(1)	0(1)	7(1)	63(1)	67(1)	0(1)	32(3)	56.0(1)	104(1)	16	4.8
34.7	A	06-27-91	151	7(1)	1(1)	1(1)	0(1)	0(1)	17(1)	97(1)	48(1)	0(1)	33(3)	57.5(1)	4(1) *	14	2.3
28.9	A	08-21-91	160	11(3)	2(3)	1(1)	0(1)	0(1)	6(1)	93(1)	78(1)	2(1)	15(1)	13.2(1)	42(1)	16	4.4
28.9	A	07-31-91	160	11(3)	2(3)	1(1)	0(1)	0(1)	5(1)	89(1)	80(1)	2(1)	12(1)	23.6(1)	44(1)	16	4.5
28.9	A	06-27-91	160	10(1)	3(3)	2(1)	1(1)	1(1)	34(3)	80(1)	34(1)	2(1)	47(3)	14.8(1)	50(1)	18	4.7
1.2	A	08-21-91	364	32(5)	5(5)	6(5)	1(1)	2(1)	20(1)	25(3)	57(1)	1(1)	35(3)	1.3(3)	1066(5)	34	9.8
1.2	A	07-31-91	364	26(5)	5(5)	4(3)	1(1)	0(1)	14(1)	22(3)	68(1)	1(1)	28(3)	1.4(3)	1384(5)	32	9.1
1.2	A	06-27-91	364	24(5)	3(3)	5(3)	0(1)	3(1)	38(3)	43(1)	40(1)	4(1)	53(3)	1.2(3)	492(5)	30	8.8

Table A-5. Continued.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	Modified IBI Iwb
Ottawa River - (04200)																
Year: 91																
46.1	D	08-20-91	98	19(3)	3(3)	2(1)	0(1)	7(5)	32(3)	30(3)	16(5)	12(5)	61(5)	0.5(3)	741(3)	40 8.9
46.1	D	07-09-91	98	17(3)	3(3)	2(1)	0(1)	6(5)	47(5)	15(5)	5(5)	16(5)	70(5)	0.9(3)	461(3)	44 8.2
Hog Creek - (04216)																
Year: 91																
10.8	D	08-20-91	31	7(1)	2(3)	0(1)	0(1)	0(1)	0(1)	72(1)	40(1)	0(1)	60(5)	1.4(1)	60(1)	18 4.3
10.8	D	07-01-91	31	11(3)	2(3)	1(1)	0(1)	0(1)	5(1)	79(1)	36(1)	0(1)	63(5)	3.5(1)	47(1)	20 5.3
1.0	D	08-20-91	73	18(3)	4(5)	2(3)	0(1)	3(3)	8(1)	65(1)	42(1)	4(3)	39(3)	2.0(1)	257(3)	28 6.5
1.0	D	07-01-91	73	17(3)	4(5)	2(3)	0(1)	3(3)	13(1)	56(1)	31(3)	2(3)	58(5)	0.7(3)	179(1)	32 5.5

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Percent of Individuals: Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
Little Hog Creek - (04-221)																
Year: 91																
0.2	E	08-20-91	15.1	17(5)	5(3)	0(1)	3(3)	4(3)	4(3)	34(3)	28(3)	38(3)	14(1)	0.0(5)	2509(5)	38
0.2	E	07-09-91	15.1	13(3)	3(1)	0(1)	2(1)	5(5)	5(3)	27(5)	20(3)	25(5)	6(1)	0.1(5)	2524(5)	38
Pike Run - (04-208)																
Year: 91																
8.2	D	06/27/91	2.9	4(1)	2(1)	0(1)	0(1)	0(1)	1(1)	89(1)	45(1)	86(1)	10(1)	0.6(3)	41(1)	14
8.1	D	06/28/91	2.9	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	100(1)	0.0(1)	17(1)**	12
2.1	D	06/28/91	10.1	11(3)	4(3)	0(1)	0(1)	0(1)	1(1)	86(1)	62(1)	64(1)	12(1)	0.0(5)	38(1)	20

na - Qualitative data, Modified Iwb not applicable.

Table A-6. Catch summary for fish collected at each location (by RM) sampled in the Ottawa River study area during 1991.

RIVER CODE: 04-200	BASIN NAME: MAUMEE RIVER		DATA SOURCE: 01
RIVER MILE: 1.2	STREAM NAME: OTTAWA RIVER		PURPOSE:
SAMPLE DATE: 1991	TIME FISHED: 5734 SEC		DATE RANGE: 06/27/91
SAMPLER TYPE: A	DIST FISHED: 1.50	PASSES: 3	THRU: 08/21/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
20-003	GIZZARD SHAD	677	451.33	33.42	8.509	9.55	18.85
37-001	GRASS PICKEREL	1	.67	.05	.027	.03	40.00
40-005	QUILLBACK CARPSUCKER	14	9.33	.69	3.684	4.14	394.71
40-008	SILVER REDHORSE	5	3.33	.25	4.356	4.89	1,306.66
40-010	GOLDEN REDHORSE	5	3.33	.25	1.197	1.34	359.20
40-015	NORTHERN HOG SUCKER	11	7.33	.54	2.117	2.38	288.64
40-016	WHITE SUCKER	195	130.00	9.62	18.852	21.17	145.01
40-018	SPOTTED SUCKER	4	2.67	.20	.599	.67	224.75
43-001	COMMON CARP	51	34.00	2.52	34.799	39.08	1,023.51
43-013	CREEK CHUB	8	5.33	.39	.059	.07	11.13
43-015	SUCKERMOUTH MINNOW	52	34.67	2.57	.139	.16	4.02
43-020	EMERALD SHINER	128	85.33	6.32	.304	.34	3.56
43-023	REDFIN SHINER	6	4.00	.30	.005	.01	1.33
43-025	STRIPED SHINER	1	.67	.05	.002	.00	3.00
43-032	SPOTFIN SHINER	318	212.00	15.70	.470	.53	2.21
43-034	SAND SHINER	52	34.67	2.57	.044	.05	1.26
43-042	FATHEAD MINNOW	5	3.33	.25	.004	.00	1.20
43-043	BLUNTNOSE MINNOW	231	154.00	11.40	.287	.32	1.86
43-044	CENTRAL STONEROLLER	1	.67	.05	.001	.00	1.00
43-045	COM. CARP X GOLDFISH	3	2.00	.15	1.173	1.32	586.33
47-002	CHANNEL CATFISH	21	14.00	1.04	2.254	2.53	161.00
47-004	YELLOW BULLHEAD	11	7.33	.54	.715	.80	97.46
47-008	STONECAT MADTOM	4	2.67	.20	.115	.13	43.00
47-013	TADPOLE MADTOM	1	.67	.05	.003	.00	5.00
54-002	BL'KSTRIPE TOPMINNOW	4	2.67	.20	.003	.00	1.00
77-003	ROCK BASS	10	6.67	.49	.652	.73	97.80
77-004	SMALLMOUTH BASS	20	13.33	.99	2.535	2.85	190.14
77-006	LARGEMOUTH BASS	7	4.67	.35	.799	.90	171.14
77-008	GREEN SUNFISH	51	34.00	2.52	1.181	1.33	34.72
77-009	BLUEGILL SUNFISH	3	2.00	.15	.040	.04	20.00
77-010	OR'GESPOTTED SUNFISH	4	2.67	.20	.003	.00	1.00
77-011	LONGEAR SUNFISH	34	22.67	1.68	.533	.60	23.50
80-005	BLACKSIDE DARTER	1	.67	.05	.001	.00	1.00
80-011	LOGPERCH	4	2.67	.20	.043	.05	16.00
80-015	GREENSIDE DARTER	26	17.33	1.28	.041	.05	2.35
85-001	FRESHWATER DRUM	57	38.00	2.81	3.514	3.95	92.48
	MILE TOTAL	2,026	1,350.68		89.060		
	NUMBER OF SPECIES	35					
	NUMBER OF HYBRIDS	1					

Table A-6. Continued.

RIVER MILE: 28.9 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 5748 SEC DATE RANGE: 06/27/91
SAMPLER TYPE: A DIST FISHED: 1.50 PASSES: 3 THRU: 08/21/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
20-003	GIZZARD SHAD	20	13.33	3.32	.222	.61	16.65
40-016	WHITE SUCKER	55	36.67	9.12	5.846	16.04	159.44
40-018	SPOTTED SUCKER	1	.67	.17	.201	.55	302.00
43-001	COMMON CARP	23	15.33	3.81	26.596	72.95	1,734.50
43-003	GOLDEN SHINER	12	8.00	1.99	.133	.36	16.59
43-013	CREEK CHUB	46	30.67	7.63	.885	2.43	28.87
43-020	EMERALD SHINER	13	8.67	2.16	.049	.14	5.69
43-032	SPOTFIN SHINER	4	2.67	.66	.017	.05	6.50
43-042	FATHEAD MINNOW	206	137.33	34.16	.160	.44	1.17
43-043	BLUNTNOSE MINNOW	123	82.00	20.40	.134	.37	1.63
47-004	YELLOW BULLHEAD	1	.67	.17	.114	.31	171.00
77-006	LARGEMOUTH BASS	11	7.33	1.82	.161	.44	21.91
77-008	GREEN SUNFISH	79	52.67	13.10	1.745	4.79	33.13
77-009	BLUEGILL SUNFISH	4	2.67	.66	.053	.14	19.75
77-010	OR'GESPOTTED SUNFISH	1	.67	.17	.005	.01	7.00
77-999	HYBRID X SUNFISH	4	2.67	.66	.136	.37	51.00
	MILE TOTAL	603	402.02		36.457		
	NUMBER OF SPECIES	15					
	NUMBER OF HYBRIDS	1					

RIVER CODE: 04-200 BASIN NAME: MAUMEE RIVER DATA SOURCE: 01
RIVER MILE: 34.7 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 6346 SEC DATE RANGE: 06/27/91
SAMPLER TYPE: A DIST FISHED: 1.50 PASSES: 3 THRU: 08/23/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
20-003	GIZZARD SHAD	54	36.00	12.11	.536	1.09	14.88
40-016	WHITE SUCKER	33	22.00	7.40	2.218	4.52	100.83
43-001	COMMON CARP	34	22.67	7.62	44.594	90.79	1,967.39
43-003	GOLDEN SHINER	6	4.00	1.35	.037	.07	9.17
43-013	CREEK CHUB	20	13.33	4.48	.511	1.04	38.35
43-032	SPOTFIN SHINER	5	3.33	1.12	.022	.04	6.60
43-042	FATHEAD MINNOW	184	122.67	41.26	.143	.29	1.17
43-043	BLUNTNOSE MINNOW	7	4.67	1.57	.017	.03	3.57
77-008	GREEN SUNFISH	99	66.00	22.20	.967	1.97	14.65
77-009	BLUEGILL SUNFISH	3	2.00	.67	.051	.10	25.67
77-999	HYBRID X SUNFISH	1	.67	.22	.020	.04	30.00
	MILE TOTAL	446	297.34		49.116		
	NUMBER OF SPECIES	10					
	NUMBER OF HYBRIDS	1					

RIVER MILE: 36.7 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 5049 SEC DATE RANGE: 06/28/91
SAMPLER TYPE: A DIST FISHED: 1.50 PASSES: 3 THRU: 08/23/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
20-003	GIZZARD SHAD	8	5.33	1.80	.240	1.69	45.00
40-002	BIGMOUTH BUFFALO	2	1.33	.45	.373	2.63	279.50
40-005	QUILLBACK CARPSUCKER	7	4.67	1.57	2.073	14.62	444.29
40-016	WHITE SUCKER	30	20.00	6.74	1.763	12.43	88.14
40-018	SPOTTED SUCKER	2	1.33	.45	.433	3.06	325.00
43-001	COMMON CARP	14	9.33	3.15	7.009	49.43	750.93
43-002	GOLDFISH	1	.67	.22	.287	2.02	430.00
43-003	GOLDEN SHINER	14	9.33	3.15	.118	.83	12.64
43-013	CREEK CHUB	12	8.00	2.70	.439	3.09	54.84
43-020	EMERALD SHINER	2	1.33	.45	.011	.08	8.50
43-042	FATHEAD MINNOW	84	56.00	18.88	.097	.68	1.72
43-043	BLUNTNOSE MINNOW	15	10.00	3.37	.010	.07	1.00
77-008	GREEN SUNFISH	251	167.33	56.40	1.294	9.13	7.73
77-009	BLUEGILL SUNFISH	1	.67	.22	.027	.19	40.00
77-013	PUMPKINSEED SUNFISH	1	.67	.22	.005	.04	8.00
	MILE TOTAL	445	295.99		14.179		
	NUMBER OF SPECIES	15					

RIVER CODE: 04-200 BASIN NAME: MAUMEE RIVER DATA SOURCE: 01
RIVER MILE: 37.0 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 3489 SEC DATE RANGE: 06/28/91
SAMPLER TYPE: A DIST FISHED: 0.85 PASSES: 3 THRU: 08/23/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
20-003	GIZZARD SHAD	40	50.29	5.77	1.115	1.77	23.95
40-002	BIGMOUTH BUFFALO	2	2.29	.26	4.128	6.57	1,812.50
40-005	QUILLBACK CARPSUCKER	10	9.52	1.09	3.918	6.23	411.40
40-010	GOLDEN REDHORSE	4	3.81	.44	1.411	2.25	370.50
40-016	WHITE SUCKER	126	140.19	16.08	20.342	32.36	139.38
40-018	SPOTTED SUCKER	5	5.14	.59	2.190	3.48	428.20
43-001	COMMON CARP	12	13.33	1.53	25.226	40.13	1,737.92
43-003	GOLDEN SHINER	20	24.76	2.84	.160	.25	7.95
43-013	CREEK CHUB	20	24.38	2.80	.548	.87	22.95
43-020	EMERALD SHINER	51	48.95	5.61	.228	.36	4.66
43-023	REDFIN SHINER	1	1.33	.15	.001	.00	1.00
43-042	FATHEAD MINNOW	130	167.62	19.23	.260	.41	1.58
43-043	BLUNTNOSE MINNOW	100	131.81	15.12	.104	.16	.80
43-044	CENTRAL STONEROLLER	3	3.24	.37	.003	.01	1.00
47-004	YELLOW BULLHEAD	1	1.33	.15	.144	.23	108.00
77-006	LARGEMOUTH BASS	4	5.33	.61	.105	.17	19.75
77-008	GREEN SUNFISH	179	231.05	26.50	1.675	2.67	7.89
77-009	BLUEGILL SUNFISH	4	4.19	.48	.208	.33	52.50
80-005	BLACKSIDE DARTER	1	1.33	.15	.001	.00	1.00
85-001	FRESHWATER DRUM	2	1.90	.22	1.095	1.74	575.00
	MILE TOTAL	715	871.79		62.862		
	NUMBER OF SPECIES	20					

Table A-6. Continued.

RIVER CODE: 04-200 BASIN NAME: MAUMEE RIVER DATA SOURCE: 01
RIVER MILE: 37.4 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 6907 SEC DATE RANGE: 06/28/91
SAMPLER TYPE: A DIST FISHED: 1.50 PASSES: 3 THRU: 08/23/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
20-003	GIZZARD SHAD	21	14.00	1.50	.230	.25	16.43
37-001	GRASS PICKEREL	1	.67	.07	.067	.07	100.00
40-002	BIGMOUTH BUFFALO	1	.67	.07	1.000	1.07	1,500.00
40-005	QUILLBACK CARPSUCKER	6	4.00	.43	1.083	1.16	270.83
40-016	WHITE SUCKER	192	128.00	13.68	2.818	3.01	22.02
40-018	SPOTTED SUCKER	1	.67	.07	.133	.14	200.00
43-001	COMMON CARP	70	46.67	4.99	81.818	87.31	1,753.24
43-003	GOLDEN SHINER	90	60.00	6.41	.114	.12	1.90
43-013	CREEK CHUB	49	32.67	3.49	1.809	1.93	55.37
43-015	SUCKERMOUTH MINNOW	1	.67	.07	.001	.00	2.00
43-020	EMERALD SHINER	20	13.33	1.42	.072	.08	5.40
43-023	REDFIN SHINER	3	2.00	.21	.001	.00	.67
43-042	FATHEAD MINNOW	294	196.00	20.94	.253	.27	1.29
43-043	BLUNTNOSE MINNOW	341	227.33	24.29	.188	.20	.83
47-004	YELLOW BULLHEAD	1	.67	.07	.017	.02	25.00
47-006	BLACK BULLHEAD	1	.67	.07	.146	.16	219.00
77-006	LARGEMOUTH BASS	7	4.67	.50	.099	.11	21.14
77-008	GREEN SUNFISH	281	187.33	20.01	2.881	3.07	15.38
77-009	BLUEGILL SUNFISH	7	4.67	.50	.080	.09	17.14
77-011	LONGEAR SUNFISH	1	.67	.07	.003	.00	4.00
77-013	PUMPKINSEED SUNFISH	1	.67	.07	.014	.01	21.00
77-999	HYBRID X SUNFISH	4	2.67	.28	.085	.09	31.75
80-005	BLACKSIDE DARTER	2	1.33	.14	.001	.00	1.00
80-011	LOGPERCH	1	.67	.07	.001	.00	2.00
80-014	JOHNNY DARTER	1	.67	.07	.001	.00	1.00
80-015	GREENSIDE DARTER	4	2.67	.28	.003	.00	1.00
85-001	FRESHWATER DRUM	3	2.00	.21	.793	.85	396.67
	MILE TOTAL	1,404	936.04		93.711		
	NUMBER OF SPECIES	26					
	NUMBER OF HYBRIDS	1					

Table A-6. Continued.

:VER CODE: 04-200	BASIN NAME: MAUMEE RIVER		DATA SOURCE: 01
:VER MILE: 37.7	STREAM NAME: OTTAWA RIVER		PURPOSE:
.MPLE DATE: 1991	TIME FISHED: 4595 SEC		DATE RANGE: 06/28/91
.MPLER TYPE: A	DIST FISHED: 0.75	PASSES: 3	THRU: 08/23/91

'ECIES :ODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
)-003	GIZZARD SHAD	56	74.67	3.76	3.541	1.02	47.42
'-001	GRASS PICKEREL	3	4.00	.20	.241	.07	60.33
)-002	BIGMOUTH BUFFALO	1	1.33	.07	4.700	1.35	3,525.00
)-005	QUILLBACK CARPSUCKER	3	4.00	.20	1.977	.57	494.33
)-010	GOLDEN REDHORSE	1	1.33	.07	.749	.22	562.00
)-016	WHITE SUCKER	68	90.67	4.56	5.961	1.71	65.75
)-018	SPOTTED SUCKER	4	5.33	.27	1.787	.51	335.00
3-001	COMMON CARP	99	132.00	6.64	307.673	88.39	2,330.86
3-002	GOLDFISH	1	1.33	.07	.380	.11	285.00
3-003	GOLDEN SHINER	139	185.33	9.32	1.446	.42	7.80
3-013	CREEK CHUB	13	17.33	.87	.155	.04	8.92
3-039	SILVERJAW MINNOW	1	1.33	.07	.001	.00	1.00
3-042	FATHEAD MINNOW	158	210.67	10.60	.252	.07	1.19
3-043	BLUNTNOSE MINNOW	362	482.67	24.28	.272	.08	.56
3-044	CENTRAL STONEROLLER	3	4.00	.20	.004	.00	1.00
3-045	COM. CARP X GOLDFISH	4	5.33	.27	7.233	2.08	1,356.25
7-006	BLACK BULLHEAD	8	10.67	.54	.777	.22	72.88
7-002	BLACK CRAPPIE	1	1.33	.07	.105	.03	79.00
7-006	LARGEMOUTH BASS	5	6.67	.34	.480	.14	72.00
7-008	GREEN SUNFISH	531	708.00	35.61	5.769	1.66	8.15
7-009	BLUEGILL SUNFISH	16	21.33	1.07	.386	.11	18.08
7-011	LONGEAR SUNFISH	2	2.67	.13	.051	.01	19.00
7-999	HYBRID X SUNFISH	1	1.33	.07	.160	.05	120.00
0-015	GREENSIDE DARTER	2	2.67	.13	.004	.00	1.50
0-022	RAINBOW DARTER	2	2.67	.13	.003	.00	1.00
0-023	ORANGETHROAT DARTER	1	1.33	.07	.001	.00	1.00
5-001	FRESHWATER DRUM	6	8.00	.40	3.992	1.15	499.00
	MILE TOTAL	1,491	1,987.99		348.100		
	NUMBER OF SPECIES	25					
	NUMBER OF HYBRIDS	2					

Table A-6. Continued.

RIVER CODE: 04-200 BASIN NAME: MAUMEE RIVER DATA SOURCE: 01
RIVER MILE: 46.1 STREAM NAME: OTTAWA RIVER PURPOSE:
SAMPLE DATE: 1991 TIME FISHED: 5700 SEC DATE RANGE: 07/09/91
SAMPLER TYPE: D DIST FISHED: 0.40 PASSES: 2 THRU: 08/23/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
40-010	GOLDEN REDHORSE	80	60.00	7.53	15.868	52.96	264.47
40-016	WHITE SUCKER	36	27.00	3.39	3.184	10.62	117.89
43-001	COMMON CARP	2	1.50	.19	.362	1.21	241.00
43-013	CREEK CHUB	93	69.75	8.75	.567	1.89	8.13
43-023	REDFIN SHINER	83	62.25	7.81	.054	.18	.87
43-043	BLUNTNOSE MINNOW	90	67.50	8.47	.078	.26	1.15
43-044	CENTRAL STONEROLLER	8	6.00	.75	.017	.06	2.84
47-004	YELLOW BULLHEAD	8	6.00	.75	.932	3.11	155.25
54-002	BL'KSTRIPE TOPMINNOW	9	6.75	.85	.004	.01	.50
77-003	ROCK BASS	141	105.75	13.26	5.910	19.72	55.88
77-004	SMALLMOUTH BASS	5	3.75	.47	.880	2.94	234.60
77-008	GREEN SUNFISH	38	28.50	3.57	.472	1.58	16.56
77-011	LONGEAR SUNFISH	52	39.00	4.89	.449	1.50	11.50
77-999	HYBRID X SUNFISH	7	5.25	.66	.268	.89	51.00
80-005	BLACKSIDE DARTER	2	1.50	.19	.002	.01	1.00
80-011	LOGPERCH	25	18.75	2.35	.282	.94	15.00
80-014	JOHNNY DARTER	10	7.50	.94	.008	.03	1.00
80-015	GREENSIDE DARTER	233	174.75	21.92	.419	1.40	2.39
80-022	RAINBOW DARTER	15	11.25	1.41	.023	.08	2.00
80-023	ORANGETHROAT DARTER	1	.75	.09	.001	.00	1.00
80-024	FANTAIL DARTER	125	93.75	11.76	.189	.63	2.02
	MILE TOTAL	1,063	797.25		29.969		
	NUMBER OF SPECIES	20					
	NUMBER OF HYBRIDS	1					

Table A-6. Continued.

RIVER CODE: 04-216
RIVER MILE: 10.8
SAMPLE DATE: 1991
SAMPLER TYPE: D

BASIN NAME:
STREAM NAME: HOG CREEK
TIME FISHED: 3720 SEC
DIST FISHED: 0.40 PASSES: 2

DATA SOURCE: 01
PURPOSE:
DATE RANGE: 07/01/91
THRU: 08/20/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
40-016	WHITE SUCKER	7	5.25	2.41	.240	1.52	45.71
43-001	COMMON CARP	46	34.50	15.86	12.665	80.44	367.10
43-002	GOLDFISH	2	1.50	.69	.104	.66	69.00
43-003	GOLDEN SHINER	7	5.25	2.41	.038	.24	7.14
43-013	CREEK CHUB	1	.75	.34	.015	.10	20.00
43-023	REDFIN SHINER	30	22.50	10.34	.042	.26	1.83
43-043	BLUNTNOSE MINNOW	55	41.25	18.97	.068	.43	1.65
43-044	CENTRAL STONEROLLER	1	.75	.34	.006	.04	8.00
47-004	YELLOW BULLHEAD	48	36.00	16.55	1.643	10.43	45.64
47-006	BLACK BULLHEAD	2	1.50	.69	.289	1.84	192.50
54-002	BL'KSTRIPE TOPMINNOW	31	23.25	10.69	.017	.10	.71
77-008	GREEN SUNFISH	53	39.75	18.28	.505	3.21	12.70
77-009	BLUEGILL SUNFISH	7	5.25	2.41	.116	.73	22.00
	MILE TOTAL	290	217.50		15.748		
	NUMBER OF SPECIES	13					

RIVER CODE: 04-216
RIVER MILE: 1.0
SAMPLE DATE: 1991
SAMPLER TYPE: D

BASIN NAME:
STREAM NAME: HOG CREEK
TIME FISHED: 5700 SEC
DIST FISHED: 0.40 PASSES: 2

DATA SOURCE: 01
PURPOSE:
DATE RANGE: 07/01/91
THRU: 08/20/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE(GM) WEIGHT
37-001	GRASS PICKEREL	12	9.00	1.59	.351	.40	39.00
40-010	GOLDEN REDHORSE	4	3.00	.53	1.129	1.28	376.25
40-016	WHITE SUCKER	33	24.75	4.37	2.375	2.69	95.94
43-001	COMMON CARP	70	52.50	9.27	79.223	89.88	1,509.00
43-002	GOLDFISH	1	.75	.13	.057	.06	75.00
43-013	CREEK CHUB	58	43.50	7.68	1.072	1.22	24.64
43-023	REDFIN SHINER	127	95.25	16.82	.104	.12	1.09
43-043	BLUNTNOSE MINNOW	183	137.25	24.24	.268	.30	1.95
43-044	CENTRAL STONEROLLER	35	26.25	4.64	.229	.26	8.72
47-004	YELLOW BULLHEAD	12	9.00	1.59	.347	.39	38.50
47-013	TADPOLE MADTOM	3	2.25	.40	.024	.03	10.67
54-002	BL'KSTRIPE TOPMINNOW	9	6.75	1.19	.004	.00	.56
77-003	ROCK BASS	12	9.00	1.59	.901	1.02	100.00
77-006	LARGEMOUTH BASS	2	1.50	.26	.115	.13	76.50
77-008	GREEN SUNFISH	108	81.00	14.30	1.428	1.62	17.63
77-009	BLUEGILL SUNFISH	15	11.25	1.99	.171	.19	15.13
77-011	LONGEAR SUNFISH	8	6.00	1.06	.144	.16	23.88
77-999	HYBRID X SUNFISH	5	3.75	.66	.139	.16	37.00
80-005	BLACKSIDE DARTER	5	3.75	.66	.013	.01	3.40
80-014	JOHNNY DARTER	23	17.25	3.05	.018	.02	1.04
80-015	GREENSIDE DARTER	30	22.50	3.97	.030	.03	1.32
	MILE TOTAL	755	566.25		88.142		
	NUMBER OF SPECIES	20					
	NUMBER OF HYBRIDS	1					

Table A-6. Continued.

RIVER CODE: 04-221
RIVER MILE: 0.2
SAMPLE DATE: 1991
SAMPLER TYPE: E

BASIN NAME:
STREAM NAME: Little HOG CREEK
TIME FISHED: 5580 SEC
DIST FISHED: 0.32 PASSES: 2

DATA SOURCE: 01
PURPOSE:
DATE RANGE: 07/09/91
THRU: 08/20/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
37-001	GRASS PICKEREL	1	.94	.03	.076	.55	81.00
40-016	WHITE SUCKER	223	209.07	5.75	.934	6.73	4.47
43-001	COMMON CARP	1	.94	.03	.002	.01	2.00
43-003	GOLDEN SHINER	2	1.88	.05	.008	.05	4.00
43-013	CREEK CHUB	220	206.25	5.67	4.520	32.56	21.91
43-023	REDFIN SHINER	25	23.44	.64	.010	.07	.40
43-043	BLUNTNOSE MINNOW	718	673.13	18.51	.753	5.42	1.12
43-044	CENTRAL STONEROLLER	2,301	2,157.19	59.30	4.934	35.55	2.29
47-004	YELLOW BULLHEAD	7	6.57	.18	.179	1.29	27.29
54-002	BL'KSTRIPE TOPMINNOW	3	2.82	.08	.003	.02	1.00
77-003	ROCK BASS	11	10.32	.28	.793	5.71	76.82
77-004	SMALLMOUTH BASS	1	.94	.03	.007	.05	7.00
77-006	LARGEMOUTH BASS	4	3.76	.10	.323	2.33	86.00
77-008	GREEN SUNFISH	25	23.44	.64	.939	6.76	40.03
77-999	HYBRID X SUNFISH	2	1.88	.05	.075	.54	40.00
80-005	BLACKSIDE DARTER	1	.94	.03	.001	.01	1.00
80-014	JOHNNY DARTER	108	101.25	2.78	.069	.49	.67
80-015	GREENSIDE DARTER	21	19.69	.54	.033	.23	1.63
80-022	RAINBOW DARTER	44	41.26	1.13	.056	.40	1.34
80-023	ORANGETHROAT DARTER	162	151.88	4.18	.170	1.22	1.11
	MILE TOTAL	3,880	3,637.59		13.885		
	NUMBER OF SPECIES	19					
	NUMBER OF HYBRIDS	1					

RIVER CODE: 04-208
RIVER MILE: 8.2
SAMPLE DATE: 1991
SAMPLER TYPE: D
BASIN NAME:
STREAM NAME: Pike Run
TIME FISHED: 2100 SEC
DIST FISHED: 0.17 PASSES: 1
DATA SOURCE: 02
PURPOSE:
DATE RANGE: 06/27/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
40-016	WHITE SUCKER	7	12.36	3.24	.212	7.17	17.14
43-013	CREEK CHUB	75	132.38	34.72	1.681	56.85	12.70
43-042	FATHEAD MINNOW	90	158.85	41.66	.437	14.78	2.75
77-008	GREEN SUNFISH	21	37.07	9.72	.441	14.91	11.90
77-015	GREEN SF X BLUEGILL	23	40.60	10.65	.186	6.29	4.57
	MILE TOTAL	216	381.26		2.957		
	NUMBER OF SPECIES	4					
	NUMBER OF HYBRIDS	1					

RIVER CODE: 04-208
RIVER MILE: 8.1
SAMPLE DATE: 1991
SAMPLER TYPE: D
BASIN NAME:
STREAM NAME: Pike Run
TIME FISHED: 1500 SEC
DIST FISHED: 0.14 PASSES: 1
DATA SOURCE: 02
PURPOSE:
DATE RANGE: 06/28/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
77-009	BLUEGILL SUNFISH	8	17.14	100.00	.032	100.00	1.88
	MILE TOTAL	8	17.14		.032		
	NUMBER OF SPECIES	1					

RIVER CODE: 04-208
RIVER MILE: 2.1
SAMPLE DATE: 1991
SAMPLER TYPE: D
BASIN NAME:
STREAM NAME: Pike Run
TIME FISHED: 2100 SEC
DIST FISHED: 0.20 PASSES: 1
DATA SOURCE: 02
PURPOSE:
DATE RANGE: 06/28/91

SPECIES CODE	SPECIES NAME	NO FISH	REL NO	% BY NUMBER	REL WT	% BY WEIGHT	AVE (GM) WEIGHT
40-005	QUILLBACK CARPSUCKER	1	1.50	.55	.036	.31	24.00
40-016	WHITE SUCKER	29	43.50	16.02	6.742	58.97	154.99
43-003	GOLDEN SHINER	6	9.00	3.31	.108	.94	12.00
43-013	CREEK CHUB	30	45.00	16.57	1.754	15.34	38.97
43-042	FATHEAD MINNOW	28	42.00	15.47	.120	1.05	2.86
43-043	BLUNTNOSE MINNOW	54	81.00	29.83	.345	3.02	4.26
47-004	YELLOW BULLHEAD	6	9.00	3.31	1.275	11.15	141.67
47-006	BLACK BULLHEAD	1	1.50	.55	.165	1.44	110.00
77-008	GREEN SUNFISH	3	4.50	1.66	.075	.66	16.67
77-009	BLUEGILL SUNFISH	4	6.00	2.21	.105	.92	17.50
77-013	PUMPKINSEED SUNFISH	2	3.00	1.10	.030	.26	10.00
77-014	B'GILL X PUMPKINSEED	4	6.00	2.21	.075	.66	12.50
77-015	GREEN SF X BLUEGILL	13	19.50	7.18	.603	5.27	30.91
	MILE TOTAL	181	271.50		11.433		
	NUMBER OF SPECIES	11					
	NUMBER OF HYBRIDS	2					

Table A-7. Evaluation of the Ohio EPA Ottawa River sediment data for PAHs.

Summary/Conclusions

There is no indication of significant tumor incidence in the fish population in Ottawa River segment RM 37.6 to RM 36.8. Contaminant concentrations for four (4) PAHs were either two (2) orders of magnitude (Benzo(a)anthracene, Benzo(a)pyrene, and Phenanthrene) or one (1) order of magnitude (Fluoranthenes) greater than uncontaminated reference sites. There is a potential to induce tumors based upon a comparison of three PAH parameters, Benzo(a)anthracene, Benzo(a)pyrene and Fluoranthenes.

1. Total PAH and "Common" PAH ratios were two (2) orders of magnitude less than one (1), indicating a very low level of PAH Ottawa River contamination compared to the Black River.

2. Ottawa River PAH concentrations for Phenanthrene, Fluoranthene, Benzo(a)anthracene, and Benzo(a)pyrene were either one (1) or two (2) orders of magnitude less than concentrations reported for the Black River, and one (1) to three (3) orders of magnitude less than Mahoning River segment mean contaminant concentrations.

3. If contaminant concentrations of three (3) PAHs (Benzo(a)anthracene, Benzo(a)pyrene and Fluoranthenes) are combined, the combined values 12 (RM 37.6), 7.7 (RM 37.0) and 17.9 (RM 36.8) are similar to values for the Cuyahoga River (9.4) and Buffalo River (6.7) where significant tumor incidence has been reported.

4. Contaminant concentrations for Phenanthrene, Fluoranthene, Benzo(a)anthracene, and Benzo(a)pyrene were at the low end of the range of values where epizootics of neoplasia in fish have occurred.

5. Observed external tumor fish community incidence based upon Ohio EPA 1991 data are low (less than one percent). NOTE - these data may not include bullhead (a species likely to be affected) and do not include an internal tumor evaluation.

OTTAWA RIVER SEDIMENT PAH EVALUATION FOR FISH TUMOR POTENTIAL

Ohio EPA organic chemical data for Ottawa River sediment includes ten (10) PAHs identified and quantified at three (3) stations located at river mile (RM) 37.6, RM 37.0 and RM 36.8 (Table 1). Total PAH concentrations were calculated and organized by decreasing river mile and were reported in parts per million (ppm) dry weight for each station.

I. Ottawa River/Black River PAH Ratios

PAH ratios were calculated based upon a comparison of Ottawa River sediment data to Black River sediment data. The Black River was used as a contaminated site for comparison because it was the first Ohio River to have a fish consumption/primary contact advisory based upon the presence of high concentrations of PAHs in the sediment and fish tumors (Ohio Department of Health 1983). Brown bullhead three (3) years and older had a liver tumor (hepatoma) rate of 33% (Baumann et al. 1982) and a 13% incidence of external tumors (epidermal and oral neoplasms) (Black and Baumann 1991).

Sediment PAH ratios were calculated using two (2) procedures (Table 2). Both methods were used for calculation because each data source analyzed and quantified different PAH compounds. Nine (9) "Common" PAH parameters were included in both analyses (Table 3).

Sediment PAH Ratios were calculated using the following methods:

$$\text{"Common" PAH Ratio} = \frac{\text{9 "Common" PAH Concentrations in the Ottawa River}}{\text{9 "Common" PAH Concentrations in the Black River}}$$

$$\text{Total PAH Ratio} = \frac{\text{Total Ottawa River PAH Concentration}}{\text{Total Black River PAH concentration}}$$

Both methods used to calculate PAH ratios gave similar results for each station (Table 2). Ratios greater than one (1), indicate a sediment PAH concentration greater than that reported for Black River sediment (Baumann et al. 1982). The "Common" and Total PAH ratios for all three (3) Ottawa River sediment locations were two (2) orders of magnitude below one (1), indicating a low level of PAH contamination compared to the Black River.

There is no indication of a significant fish tumor incidence based upon a comparison of Ottawa River sediment PAH data to Black River sediment PAH data.

II. Evaluation of PAH Fish Tumor Potential Based Upon Four PAHs

PAHs are a diverse Class of compounds. U.S. EPA lists 22 PAHs that were included in their review of this Class of compounds in Ambient Water Quality Criteria for Polynuclear Aromatic Hydrocarbons (U.S. EPA 1980). An evaluation of a PAH contaminated site by comparing total PAH concentrations to a contaminated location, even if corrected for "Common" PAH compounds identified and quantified at both sites, is inadequate. Only some of the PAHs have been identified as carcinogens (Table 4), and those identified have different inherent carcinogenic potency.

Therefore, specific PAH compounds should also be compared in any evaluation attempting to determine if there is a potential for sediment to cause tumors in fish. Four (4) PAH compounds (Phenanthrene, Flouranthrene, Benzo(a)pyrene and Benz(a)anthracene) at each Ottawa River station were evaluated for fish tumor initiation potential (Table 5). These compounds were selected based upon information contained in a letter to Jeff DeShon (Ohio EPA) from Dr. Paul Baumann (Ohio State University), dated June 6, 1988. Dr. Baumann selected the four (4) compounds from a list of eight (8) PAHs generally identified and quantified in studies where multiple sediment samples were collected in areas with epizootics of neoplasia in fish.

A. Ottawa River Station Evaluation Using Four PAHs

Ottawa River station concentrations for Phenanthrene, Flouranthrene, Benzo(a)pyrene and Benzo(a)anthracene were compared to reference sites and to the means and ranges computed by Baumann (1988) for contaminated areas with epizootics of neoplasia in fish (Table 5). The Ottawa River contaminant concentrations for phenanthrene, Benzo(a)anthracene and Benzo(a)pyrene were two (2) orders of magnitude greater than uncontaminated PAH reference sites. The Ottawa River contaminant concentrations for Flouranthrene was one (1) order of magnitude greater.

Concentrations for the four (4) PAHs at each Ottawa River station were within the range of values where epizootics of neoplasia in fish have occurred, however, the PAH contaminant concentrations were at the low end of the range. Ottawa River concentrations for Phenanthrene and Flouranthene were two (2) orders of magnitude less than Black River concentrations; Benzo(a)pyrene and Benzo(a)anthracene were one (1) order of magnitude less (Table 5).

If contaminant concentrations of three (3) PAHs (Benzo(a)anthracene, Benzo(a)pyrene, Fluoranthenes) are combined, the combined values 12 (RM 37.6), 7.7 (RM 37.0) and 17.9 (RM 36.8) are similar to values for the Cuyahoga River (9.4) and Buffalo River (6.7) where significant tumor incidence has been reported (Black and Baumann 1991).

B. Ottawa River Segment Evaluation Using Four PAHs

Four (4) PAH means were computed and ranges were identified for the three (3) Ottawa River stations (Table 5). These values were compared to means and ranges for the four (4) PAHs where epizootics of neoplasia occurred. The Ottawa River PAH means for Phenanthrene and Flouranthrene were one order of magnitude less than those for tumor sites. The Ottawa River PAH means for Benzo(a)anthracene and Benzo(a)pyrene were within the same order of magnitude as those for tumor sites. The Ottawa River PAH range for each PAH was included within the low end of the range for each PAH parameter at tumor sites.

The Ottawa River PAH contaminant concentrations were one (1) to three (3) orders of magnitude less than Mahoning River PAH contaminant concentrations (Table 5). External fish tumors have been observed on bullhead collected in the Mahoning River Youngstown segment (Schroeder 1992).

Based upon the comparisons of Ottawa River stations and segment to reference and tumor sites, there is a low probability for a significant fish tumor incidence due to PAH contaminant concentrations. However, the Ottawa River PAH sediment concentrations have a potential to cause tumors in fish based upon a combined PAH concentration of three (3) PAHs when compared to values for the Cuyahoga and Buffalo Rivers (Black and Baumann 1991).

III. Tumor Incidence

The incidence of tumors in a fish community is dependent upon many factors including: species affected, potential for and duration of exposure, bioavailibility of contaminants, specific carcinogens present, concentration of contaminants of concern, inherent carcinogenic potency and other chemical/physical stresses present. External tumors observed during a 1991 Ohio EPA biological survey were recorded twice at station RM 37.4. One fish was observed during two of the three collection events (community tumor incidence = 0.97 and 0.20 percent). The same fish may have been caught during both collecting events. No additional external tumors were observed during three collecting events at Ottawa River stations located both upstream and downstream (seven (7) stations total) from Ottawa River station RM 37.4.

NOTE - these data may not include bullhead (a species likely to be affected) and do not include internal tumor evaluation.

Summary/Conclusions

There is no indication of significant tumor incidence in the fish population in Ottawa River segment RM 37.6 to RM 36.8. Contaminant concentrations for four (4) PAHs were either two (2) orders of magnitude (Benzo(a)anthracene, Benzo(a)pyrene, and Phenanthrene) or one (1) order of magnitude (Fluoranthenes) greater than uncontaminated reference sites. There is a potential to induce tumors based upon a comparison of three PAH parameters, Benzo(a)anthracene, Benzo(a)pyrene and Fluoranthenes.

1. Total PAH and "Common" PAH ratios were two (2) orders of magnitude less than one (1), indicating a very low level of PAH Ottawa River contamination compared to the Black River.

2. Ottawa River PAH concentrations for Phenanthrene, Fluoranthene, Benzo(a)anthracene, and Benzo(a)pyrene were either one (1) or two (2) orders of magnitude less than concentrations reported for the Black River, and one (1) to three (3) orders of magnitude less than Mahoning River segment mean contaminant concentrations.

3. If contaminant concentrations of three (3) PAHs (Benzo(a)anthracene, Benzo(a)pyrene and Fluoranthenes) are combined, the combined values 12 (RM 37.6), 7.7 (RM 37.0) and 17.9 (RM 36.8) are similar to values for the Cuyahoga River (9.4) and Buffalo River (6.7) where significant tumor incidence has been reported.

4. Contaminant concentrations for Phenanthrene, Fluoranthene, Benzo(a)anthracene, and Benzo(a)pyrene were at the low end of the range of values where epizootics of neoplasia in fish have occurred.

5. Observed external tumor fish community incidence based upon Ohio EPA 1991 data are low (less than one percent). NOTE - these data may not include bullhead (a species likely to be affected) and do not include an internal tumor evaluation.

Table 1: Ohio EPA Ottawa River sediment PAH scan (mg/kg dry weight) 1991[1].

RIVER MILE PARAMETER	37.6	37.0	36.8
Phenanthrene	3.2	1.9	5.5
Anthracene	3.4	ND (1.9)	ND (1.2)
Flouranthene	6.2	3.4	9.4
Pyrene	3.3	2.3	6.1
Benzo(A)Anthracene	2.8	2.0	5.1
Chrysene	3.2	2.3	4.3
Benzo(K)Flouranthene	6.2	4.0	10.0
Benzo(A)Pyrene	3.0	2.3	3.4
Indeno *1,2,3-CD)Pyrene	2.7	1.9	2.2
Benzo(G,H,I)Perylene	2.7	2.4	1.8

[1] ND = not detected

Table 2: Ottawa River/Black River PAH Ratios[a].

RIVER MILE PAH RATIO	37.6	37.0	36.8
9 "Common"	0.03	0.02	0.04
Total	0.02	0.01[b]	0.03[b]

a. Black River Total PAHs = 1,253.7 mg/ky dry weight;
Black River 9 "Common" PAHs = 1,020 mg/ky dry weight (Baumann et al. 1988).

b. ND concentrations reported for Anthracene = 0

Table 3: "Common" Black River/Ottawa River PAH Parameters

Benzo(a)anthracene
Benzo(a)pyrene
Benzofluoranthenes
Benzo(g,h,i)perylene
Chrysene
Flouranthene
Indeno-(1,2,3-cd)pyrene
Phenanthrene
Pyrene

Table 4: PAHs Identified as Carcinogens[a]

COMPOUND	SOURCE	TYPE
Benz(a)anthracene	4	Suspected/anticipated human carcinogen
Benzo(b) fluoranthene	4	Suspected/anticipated human carcinogen
Benzo(a)pyrene	1	Ambient Water Quality Criterion
	3	Limited human/sufficient animal evidence
	4	Suspected/anticipated human carcinogen
	5	Suspected carcinogenic potential
Chrysene	5	Suspected carcinogenic potential
Dibenz(a,h)anthracene	4	Suspected/anticipated human carcinogen
Dibenzo(a,h)pyrene	4	Suspected/anticipated human carcinogen
Dibenzo(a,i)pyrene	4	Suspected/anticipated human carcinogen

a. 1. Chemicals specified as carcinogens in U.S. EPA Ambient Water Quality Criteria Documents (1980); 2. IARC listing of chemicals and industrial processes associated with carcinogenicity (Group 1 Carcinogens)(1982); 3. International IARC listing of chemicals and industrial processes associated with carcinogenicity (Group 2A and 2B Carcinogens)(1982); 4. Carcinogens listed in the Third Annual Report of the National Toxicology Program (1982); and 5. Occupational carcinogens listed by ACGIH 1985.

Table 5: A Comparison of Means and Ranges of Selected PAHs[1]

DATA SOURCE YEAR	RIVER MILE		PHENAN.	FLOURAN.	B(a)A	B(a)P
			9 TUMOR SITES			
Baumann 1988	--	MEAN RANGE	49.3 1.0-390	39 1.8-220	9.0 0.83-51	7.6 0.36-43
			5 REFERENCE SITES			
Baumann 1988	--	--	0.08	0.15	0.05	0.07
			BLACK RIVER			
Baumann 1982	--	--	390	220	51	43
			MAHONING RIVER WARREN SEGMENT			
Estenik 1988	--	MEAN RANGE	14.45 1.1-34.0	16.28 0.79-53.0	6.47 0.53-16	6.56 0.77-16
			MAHONING RIVER YOUNGSTOWN/BRIER SEGMENT			
Estenik 1988	--	MEAN RANGE	356 3.1-3,200	150.29 0.79-1,600	96.44 3.5-850	86.78 2.0-630
			MAHONING RIVER CAMPBELL SEGMENT			
Estenik 1988	--	MEAN RANGE	2,360.9 2.5-18,000	1,035.06 0.4-9,500	465.09 1.7-2,000	555.6 3.4-3,400
			OTTAWA RIVER			
OEPA 1992	37.6	--	3.2	6.2	2.8	3.0
	37.0	--	1.9	3.4	2.0	2.3
	36.8	--	5.5	9.4	5.1	3.4
	--	MEAN RANGE	3.5 1.9-5.5	6.3 3.4-9.4	3.3 2.0-5.1	2.9 2.3-3.4

1. Phenan = Phenanthrene; Flouran = Flouranthenes; B(a)A = Benzo(a)anthracene; B(a)P = Benzo(a)pyrene

REFERENCES

Baumann. P. C. 1982. Hepatic Tumor Rates and Polynuclear Aromatic Hydrocarbo Levels in Two Populations of Brown Bullhead (_Ictalurus_ _nebulosus_). In: _Polynuclear Aromatic Hydrocarbons, Sixth International Symposium on Physical and Biological Chemistry_. Edited by M. W. Cooke, A. J. Dennis and G. I. Fisher. Battelle Pres. Columbus, Ohio. pp. 93-102.

Baumann. P. C. 1988. Letter to Jeff DeShon (Ohio EPA) from Paul Baumann (Ohi State University). June 6, 1988. pp.3.

Black, John J. and Paul C. Baumann. 1991. Carcinogens and Cancers in Freshwater Fishes. Environmental Health Perspectives. Vol. 90. pp. 27-33.

Estenik, J.F. 1988. Fish Tissue and Sediment Organic Chemical Evaluation - Lower Mahoning River. Ohio EPA. June 24, 1988.

International Agency for Research on Cancer. 1982. _Chemicals, Industrial Processes and Industries Associated with Cancer in Humans (IARC Monograph Volumes 1 to 29). Supplement 4._ World Health Organization Publications Center, Albany, 292pp.

National Toxicology Program. 1982. _Third Annual Report on Carcinogens. Summary._ National Toxicology Program Public Information Office, Research Triangle Park, 229 pp.

Ohio Department of Health. 1983. Black River Fish Advisory and Technical Support Document.

Schroder. 1992. Youngstown State University. Personal Communication. September 11, 1992

U.S. Environmental Protection Agency. 1980. _Ambient Water . Quality Criteria for Polynuclear Aromatic Hydrocarbons_. Criteria and Standards Division, Office of Water Regulation and Standards, U.S. Environmental Protection Agency, Washington, D.C.