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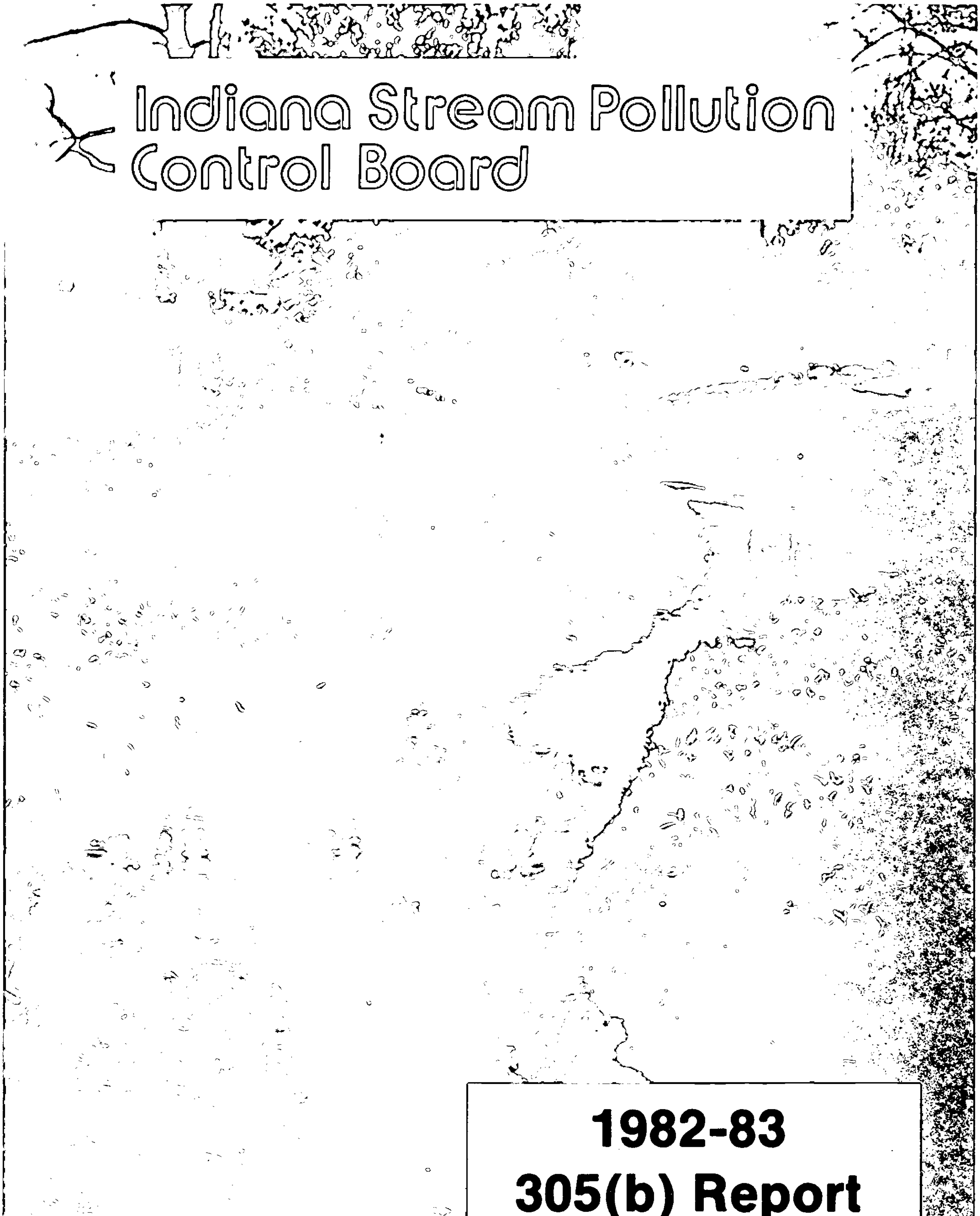

1982-83 305(b) Report

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EXECUTIVE SUMMARY

The 1982-83 305(b) Report is organized into the following sections, and Indiana's activities in these areas are summarized or discussed:

1. Surface Water Quality - a discussion of the present status of water quality in Indiana rivers, lakes, and streams along with any water quality trends that are apparent; a discussion of the toxics monitoring studies that have been undertaken; a summary of the surface water quality in each of the major river basins; and a brief discussion of Indiana's special water quality problems and remaining concerns.

2. Groundwater Quality - Indiana's new groundwater monitoring program is outlined and discussed.

3. Water Pollution Control Program - Indiana's water pollution control program is discussed as to improvements in municipal and industrial wastewater treatment facilities achieved through the Construction Grants Program and the NPDES system; how compliance and enforcement procedures are used to maintain and improve water quality; and a group of "success stories" are presented detailing specific instances where improved wastewater treatment has resulted in documented water quality improvements. The monitoring programs Indiana uses to obtain necessary water quality data is discussed.

There are an estimated 90,000 miles of rivers and streams in Indiana and about 520 publically-owned lakes and reservoirs of 50 or more acres with a combined surface area of some 92,800 acres. In addition, Indiana controls 154,000 acres of Lake Michigan. There are also 190,000 acres of wetlands remaining in the state. The Indiana Stream Pollution Control Board has responsibility for protecting the quality of all of these.

In order to improve water quality, an increased level of treatment has been provided by both municipalities and industries throughout the state. In 1972, 6% of the population was served by primary treatment only. In 1982, only 0.4% of the population was served by primary plants. In 1972, there were no advanced wastewater treatment plants. In 1982, 18% of the population is served by AWT plants.

Since 1972, Indiana has received nearly one billion dollars in federal construction grant monies and has spent over 120 million dollars in state money and 175 million dollars in local matching funds for new or upgraded treatment plants and sewer systems. There is no up-to-date information on the amount of money spent for industrial waste treatment or control, but there were 139 claims for more than $633,440,000 in tax exemptions for industrial wastewater treatment or control facilities in 1983.

As a result, our data indicate that since 1972, water quality has been improved in at least 800 stream miles, and only about 230 miles of waterways have significant water quality problems remaining. Since 1972, no new stream miles have been degraded.

A review of the data from our 92 Fixed Water Quality Monitoring Stations discloses that, between 1975 and 1980, 54% of these stations had water quality which was periodically unsuitable for warmwater fish communities because of low dissolved oxygen and/or high ammonia or metals concentrations. Moderate to severe impairment of the fishery occurred at 18% of the locations. Since then, only 25% of the stations have water quality periodically unsuitable for fisheries, and the impairment was moderate to severe at only 7% of the sites. Ammonia remains the major cause of stream fisheries impairment. However, ammonia removal is being required at all locations where it is necessary to meet stream standards.

Fish populations downstream from nearly all of the major municipal and industrial wastewater treatment facilities have significantly improved in recent years. However, in some areas, two agricultural pesticides and/or PCBs have accumulated in fish tissue to levels in excess of FDA action levels. This has prompted the issuance of consumption advisories for fish taken from six stream areas and Lake Michigan. Where tissue contamination has been traced to a specific source or sources, corrective action has been initiated.

INTRODUCTION

On December 11, 1816, Indiana became the nineteenth state to join the Union and the second to be created from the Northwest Territory. At that time, there were less than 100,000 residents in the state, but the water resource was already playing an important role in the lives of these early settlers. The Indiana of 1816 was composed of a principally agrarian society that was concerned with draining much of the land to convert it to agricultural use; that used the streams and waterways as principal sources of transportation and water power; and that depended on the ground water in wells and springs for domestic uses.

Today, the State of Indiana, with a surface area of approximately 36,532 square miles, has approximately 5.5 million inhabitants. Although nearly 70 percent of the land in the state (16 million acres) is still devoted to agriculture, Indiana also has a diverse manufacturing economy with a total value of products produced in excess of $45 billion annually. There are over 14 billion kilowatts of electricity generated in the state each year to meet the demands for heat, light, and power. Most of these economic pursuits in some way depend on or impact Indiana's water resources. Also, much of the wastes produced by Indiana's 5.5 million inhabitants is ultimately discharged to Indiana's waterways.

In addition to the demands placed on the water resource by agriculture, industry, utilities and municipalities, the increased leisure time available to Indiana residents as a result of the many technological advances over the last few decades has produced a rapid growth in demand for recreational usage of Indiana's waters. Boating, fishing, swimming, water-skiing, and "enjoying nature" are recreational activities which have recently placed heavier demands for a share of the water resource. There is now much greater concern for the preservation of some of Indiana's waterways in their natural state and to protect the waters and riparian habitat for fish, other aquatic life forms, and wildlife.

Although the population of Indiana and its demands on the water resource have increased greatly since 1816, the extent of the water resource remains the same (or less). There are approximately 90,000 miles of rivers and streams in Indiana. These miles include 356 miles of the Ohio River, which forms the border between Indiana and Kentucky, and approximately 200 miles of the lower Wabash River, which forms the border between Indiana and Illinois. Indiana has approximately 520 publicly owned lakes, ponds, and reservoirs of 50 or more acres with a combined surface area of some 92,800 acres and a gross storage capacity around 606 billion gallons. Indiana also claims some 241 square miles (154,240 acres) of Lake Michigan and has approximately 43 miles of Lake Michigan shoreline.

Indiana's wetlands are also a part of the water resource. These are commonly described as marshes, swamps, bogs, potholes, sloughs, and shallow ponds or lakes. Wetlands are considered to be the most productive aquatic habitats for both plants and animals as they provide breeding and nesting areas, abundant food sources, and excellent protection or cover. An estimated one million acres of wetland in Indiana have been drained and utilized for other purposes, a reduction of more than 80 percent of the original resource. Of the approximately 190,000 acres of wetlands remaining, most are located in the northern two tiers of counties and along the Ohio River. Wetlands in the remaining parts of the state consist of small, widely scattered pockets.

With Indiana's experience of increasingly diverse and ever growing demands on its water resource being duplicated in most of the other states, Congress, in 1972, passed, and the President signed, the Clean Water Act (PL 92-500). The objective of this Act was "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." It's two goals were: (1) by 1983 all waters should be clean enough for swimming, boating, and the protection of fish and wildlife, and (2) by 1985 the discharge of pollutants into the nation's waters should be eliminated. One of the sections of this Act (Section 305(b)) requires each state to submit a report to Congress every two years documenting progress toward meeting the goals of the Act. This report discusses Indiana's progress toward meeting the goals of the Clean Water Act.

SURFACE WATER QUALITY

Status and Trends

Waterways in Indiana range in size from the lower Wabash River, where the average flow is 17 billion gallons a day, to tiny drainage ditches that contain water only after a rain. Because of the way streams are formed in nature, the number of miles of small headwater streams is far larger than the miles of permanent streams. In Indiana, no more than 45,000 miles of streams and rivers are large enough to be fishable throughout the year. The rest are often pooled or dry, especially in the summer. A vast majority of these small streams are not impacted by point source pollution discharges and are assumed to have good water quality but are too small to be fishable or swimmable.

Water quality in many of the permanent streams and rivers is assessed by chemical sampling, biological sampling, and observations by professional biologists and other water pollution control specialists. In 1972, there were an estimated 455 miles of these streams with water quality too poor to support aquatic life much of the time and an additional 800 miles in which the aquatic community was periodically depressed in abundance or diversity of organisms. Since 1972, water quality has been improved in at least 800 stream miles, and there remain only about 250 miles where aquatic life is seriously depressed. No additional stream miles have been degraded on these permanent streams. The greatest improvements have occurred in the upper West Fork of White River, the East Fork of White River, the upper Wabash River and the Maumee River. In the 1982-1983 reporting period, the most serious remaining problems were in the Little Calumet and Grand Calumet River basins in Lake and Porter counties, Trail Creek at Michigan City, and the West Fork of White River below Indianapolis.

"Since 1972, water quality has been improved in at least 800 stream miles, and there remain only about 250 miles where aquatic life is seriously depressed. No additional stream miles have been degraded on these permanent streams."

Water quality for recreational use, including wading and swimming, is measured by the number of coliform bacteria (especially those associated with the excreta of warm-blooded animals) present in the water. There is one standard designed to minimize the risk of disease associated with wading (partial-body contact) and another, more stringent standard for swimming (whole-body contact). All of the lakes and reservoirs and a few of the streams in the state are classified for whole-body contact. The remainder of the streams (over 99% of all stream miles) are designated for partial body contact.

Few, if any, public beaches on Indiana lakes and reservoirs have been closed recently because of high bacterial counts, although no statewide statistics have been collected. Of the Fixed Water Quality Monitoring Stations on permanent streams which are monitored monthly for coliform bacteria, only about 20% regularly meet the standard for partial body contact. None of the Fixed Stations on streams designated for whole body contact regularly meet the standards for that use. However, it should be noted that a large number of these stations are located downstream from point sources that would influence the results. These figures have changed very little during the last decade.

Despite the elevated bacterial counts measured on most Indiana streams, experts generally agree that the risks to public health from current levels of bacterial pollution are small. In fact, it has been pointed out that there is presently a greater chance of being killed by lightning or dying from insect bites and stings than from waterborne diseases. The current indicators of bacterial water quality are less than ideal, and more effective but practical methods for bacteriological assessment are being sought.

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A few public lakes and reservoirs received discharges of metals and other pollutants and many occasionally have nuisance algae problems. Nevertheless, all have relatively diverse fish populations and little or no impairment to their use by swimmers or fishermen. Close to one-third of all the water stored in Indiana's lakes and reservoirs is used for drinking water supply. No water quality problems associated with this use have been identified.

In addition to the open water wetlands represented by lakes and reservoirs, Indiana has approximately 100,000 acres of other wetland types. Most of these are marshes and shrub swamps, although bogs and wooded swamps are also present. While they may have little direct fisheries value, these wetlands support many other kinds of wildlife, serve as sediment and nutrient traps, and aid in flood control. No significant wetland areas are known to be adversely affected by point source wastewater discharges in Indiana. However, wetlands are disappearing at a significant rate as they are drained or filled for agriculture or residential development.

The greatest quantity of water is in the 154,000 acres of Lake Michigan in northwestern Indiana. These waters and the 43 miles of shoreline are used extensively for sport and commercial fishing, swimming and boating, drinking water supply and industrial water supply. The only use of these waters which is occasionally impaired is whole-body contact (swimming). In 1972, an estimated 5 miles of Lake Michigan beachfront were closed because of high bacterial counts. A few of these beaches are still closed occasionally, but water quality along all of the shoreline has improved.

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Municipal dischargers account for roughly three-fourths of the number of stream miles and Lake Michigan shoreline miles which are not presently supporting their designated uses. Low dissolved oxygen and high fecal coliform concentrations are the primary problems associated with these discharges. Industrial discharges and nonpoint runoff account for the remaining areas with poor water quality. Low dissolved oxygen, elevated temperatures and toxic substances are the major problems associated with industrial discharges. The effects of nonpoint sources of pollution are very difficult to quantify, but runoff from urban and agricultural areas and abandoned surface mines cause turbidity and may contain pesticides and heavy metals. Other areas of concern are water quality problems associated with oilfield brines.

A summary of trends in water quality in Indiana is shown in Table 1. The uses of a body of water are judged to be supported when state water quality standards are exceeded less than 10 percent of the time or when the aquatic life is shown to be diverse in numbers and types of organisms. Waters do not support their uses when standards are exceeded more than 25 percent of the time or when few or none of the species expected to exist in the water occur there. Waters partially support their uses in intermediate situations. Figure 1 is a map of Indiana showing the major waterways and the degree to which they meet their use designations.

Toxic Parameters and Public Health/Aquatic Life Concerns

The release of toxic materials into the aquatic environment produces effects in several ways: 1) in sufficient amounts to be acutely toxic, they may directly kill fish and other aquatic organisms; 2) when present in lesser amounts, these substances can reduce densities and growth rates and/or bioaccumulate in fish tissues until the fish are unsafe for human consumption, often resulting in advisories on eating fish from the water so affected; and 3) toxic materials in the water may directly affect human health by contaminating public water supplies. At this time, we have no data which indicate that there have been any adverse human health effects from primary contact recreation activities (e.g., swimming) due to toxic materials in the water. Any of these situations results in greater public concern than many other types of water pollution problems.

Although many substances, if present in sufficient amounts, would be considered "toxic," this section of the report is limited to the "priority pollutants" as defined by EPA. In the last several years, advances in analytical capabilities and techniques and the generation of more and better information as to the toxicity of these substances has led to an increased concern about their presence in and effects on the aquatic environment and human health. These concerns have resulted in more time and money being spent on the collection, analysis and interpretation of data on toxic substances in Indiana waters. The following portion of the report discusses the studies Indiana has done in the past few years to discover the scope of the toxic problem and the causes and possible solutions to these problems.

Table 1. Evaluation of support of designated uses.

	Supported 1972	Supported 1983	Partially Supported 1972	Partially Supported 1983	Not Supported 1972	Not Supported 1983	Unknown 1972	Unknown 1983	Improved water quality since 1972
Rivers and Streams (in stream miles)	43,745	44,000	800	750	455	250	45,000*	45,000*	810
Lakes and Reservoirs (in acres)	92,800	92,800	0	0	0	0			Unknown
Lake Michigan (in shoreline miles)	38	40	5	3	0	0			43

*Majority are first and second order streams not impacted by point source discharges.

River and Stream Studies

Monitoring for toxic materials in fish flesh at 21 Indiana "CORE" network stations (Figure 2) provides information on the general location and scope of toxic problems in Indiana's rivers and streams. Sampling has been done at these "CORE" stations since 1979, and all stations have been sampled at least three times during the five-year period.

At each station, an attempt was made to collect two samples of "forage" fish (carp, suckers, etc.) and one sample of a "predatory" species (bass, channel catfish, etc.), each consisting of five fish. When possible, fish of similar sizes and weights were used to make the 5 fish composite samples, and larger individuals were selected over smaller ones. Fish collected but not used in the samples were identified, counted and released. For purposes of the "CORE" sampling program, whole fish samples were submitted for analysis, but in some instances additional fillet samples were also collected. Parameters for which the fish are analyzed are shown in Table 2.

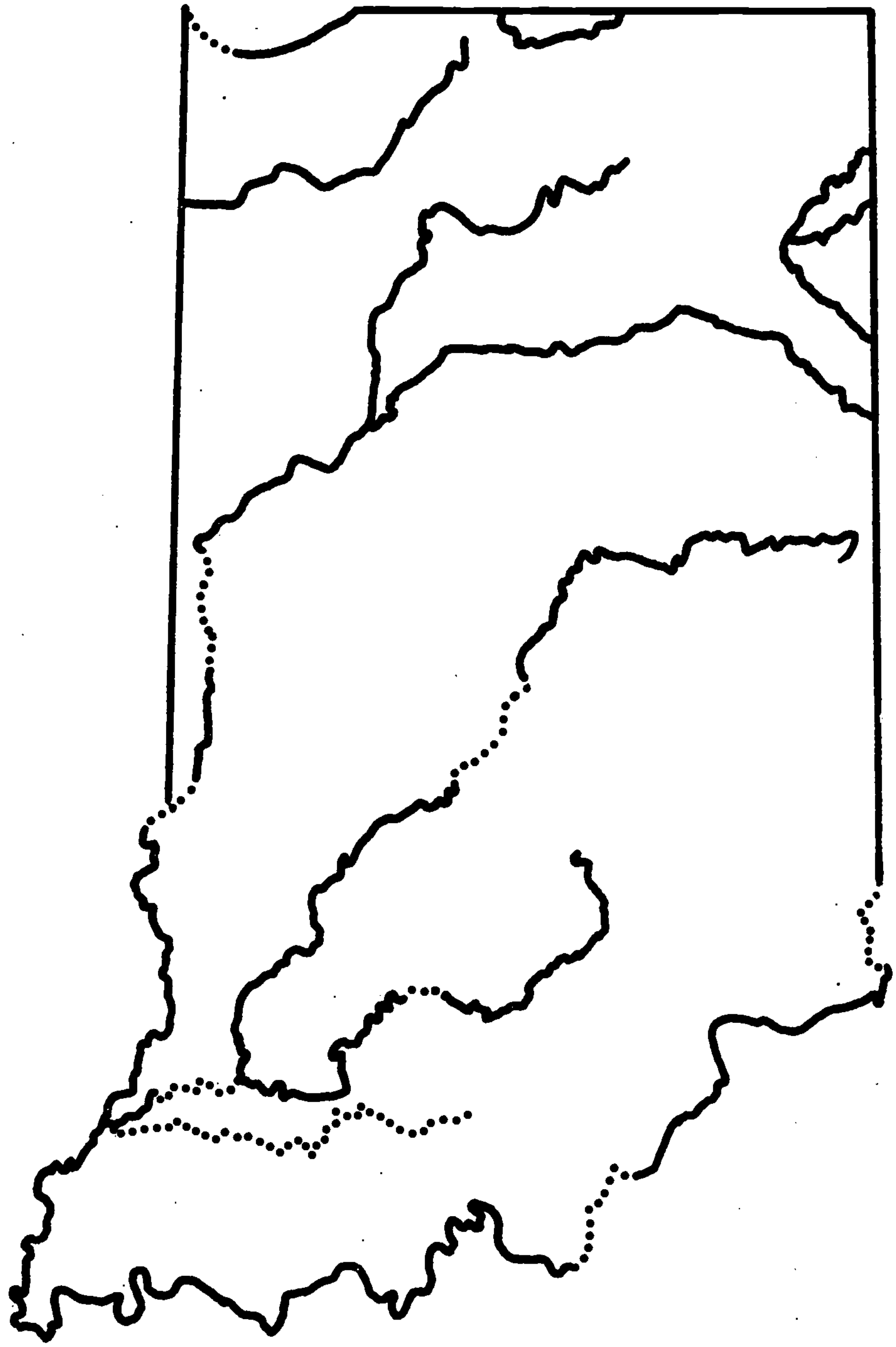
Table 2. List of parameters for which "CORE" fish flesh samples are analyzed.

PCB (total)	DDE,O,P'
BHC (Alpha)	DDD,P,P'
BHC (Beta)	DDD,O,P'
BHC (Delta)	DDT,P,P'
BHC (Gamma)	DDT,O,P'
Hexachlorobenzene	Methoxychlor,P,P'
Pentachloroanisole	Methoxychlor,O,P'
Heptachlor	Dieldrin
Heptachlor Epoxide	Endrin
Trans-Nonachlor	Mercury
Cis-Nonachlor	Chromium
Trans-Chlordane	Cadmium
Cis-Chlordane	Copper
Oxychlordane	Lead
Aldrin	Arsenic
DDE,P,P'	% Lipid content

A summary of fish flesh data from the Indiana "CORE" stations (except for the Lake Michigan stations) collected since 1979 is shown in Table 3. It would appear that the bioaccumulation of chlordane and dieldrin (pesticides) and, to some extent, polychlorinated biphenyls (PCBs) is a problem in the middle and lower portions of the Wabash River, East Fork of White River and West Fork of White River. Between 46% and 100% of the whole fish samples collected at stations on these streams in 1979, 1980 and 1981 contained levels of one or more of these contaminants which exceed the Food and Drug Administration (FDA) action levels for edible portions listed in Table 4. Other pollutants for which the fish tissue was analyzed were not found in quantities which exceed FDA action limits or would be of concern. Analyses of tissue samples collected from these streams in 1983 are not completed, so it is uncertain if these levels remain high.

Whole fish samples collected from the Wabash River near Lafayette and on downstream to New Harmony contain levels of chlordane and/or dieldrin which are high enough to be of concern. Levels of chlordane ranged from less than 0.020 mg/kg up to 0.974 mg/kg, and the average value was 0.288 mg/kg. Species in which chlordane values above FDA action levels have been found include: river carpsucker, channel catfish, carp, and freshwater drum. Levels of dieldrin found in whole fish samples from this portion of the Wabash River ranged from 0.020 mg/kg to 1.382 mg/kg and averaged 0.355 mg/kg. Species in which dieldrin values exceeded the FDA action levels were: channel catfish, redhorse suckers, carp, smallmouth bass, and freshwater drum.

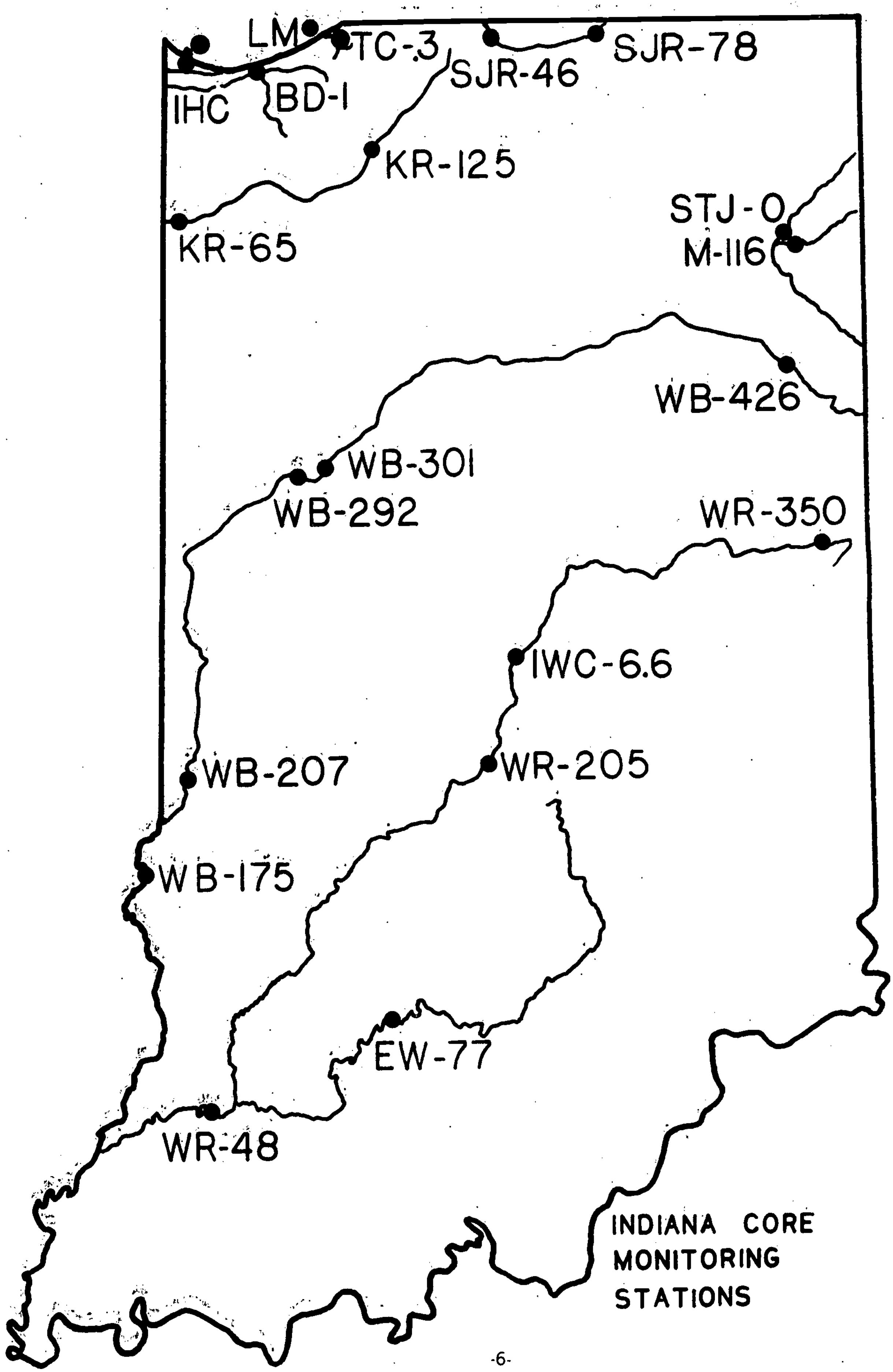
Figure 1. Major rivers in the state indicating designated uses being fully supported, or only partially supported.



USE SUPPORTED ————

USE PARTIALLY SUPPORTED ....

Figure 2. Location of Indiana CORE Monitoring Stations.



Whole fish samples which contained levels of dieldrin and/or PCBs which exceeded FDA action levels were collected in the West Fork of White River only at the Indianapolis Waterway Canal and in the East Fork of White River at Williams. PCB values in whole fish samples from the five White River stations ranged from 0.082 mg/kg to 15.449 mg/kg and averaged 2.499 mg/kg. Fish species which contained levels of PCBs above FDA action levels in whole fish samples were: largemouth bass, carp, and channel catfish.

Dieldrin values from the five White River stations ranged from 0.010 mg/kg to 1.012 mg/kg and averaged 0.184 mg/kg in whole fish samples. Species which contained levels of dieldrin above FDA levels were: channel catfish, smallmouth buffalo, and carp.

Fewer problems with fish tissue contamination by toxics were found in rivers and streams in the northern third of the state which included the Kankakee River, St. Joseph River at South Bend and Bristol, the St. Joseph and Maumee rivers at Fort Wayne, Trail Creek, Burns Ditch, and the Indiana Harbor Ship Canal-Grand Calumet River. Only four whole fish samples from three stations had levels of contaminants which exceeded FDA action levels (Table 3). Fish tissue samples exceeding FDA action levels for chlordane were found at each of the three stations and one sample from the Indiana Harbor Ship Canal-Grand Calumet River also exceeded PCB action levels. Fish species which had values for chlordane or PCBs above FDA action levels on a whole fish basis were carp and shorthead redhorse.

At stations in this area of the state, chlordane values ranged from less than 0.020 mg/kg to 0.779 mg/kg and averaged 0.113 mg/kg for whole fish samples. Values for dieldrin ranged from less than 0.001 mg/kg to 0.273 mg/kg and averaged 0.031 mg/kg, and values

Table 3. Pollutants of concern and percent of exceedances of FDA action levels for edible portions at stream stations sampled for toxics in fish flesh (1979-1982) through the "CORE" monitoring program. Samples are of whole fish.

Locality	Total No. Samples	No. Exceeding FDA Limits	Pollutants of Concern	% Exceedances
Wabash River at Bluffton (WB-426)	9	2	chlordane*	22%
Wabash River above Lafayette (WB-301)	9	5	chlordane, dieldrin	56%
Wabash River below Lafayette (WB-292)	7	4	chlordane, dieldrin	57%
Wabash River above Terre Haute (WB-207)	7	4	chlordane, dieldrin	57%
Wabash River below Terre Haute (WB-175)	9	7	chlordane, dieldrin	78%
Wabash River at New Harmony (WB-52)	3	3	chlordane, dieldrin	100%
White River at Winchester (WB-350)	9	3	chlordane	33%
White River at Indpls. Water Canal (IWC 6.6)	9	6	chlordane, dieldrin, PCBs	67%
White River at Henderson Ford (WR-205)	8	8	chlordane	100%
East Fork White River at Williams (EW-77)	11	5	chlordane, dieldrin, PCBs	46%
White River at Petersburg (WR-48)	8	4	chlordane	50%
Kankakee River at Kingsbury (KR-125)	9	0	—	0
Kankakee River at IN-IL State Line (Kr-65)	9	1	chlordane	11%
Indiana Harbor Ship Canal (IHC-1)	3	1	chlordane, PCBs	33%
Burns Ditch (BD-0)	6	0	—	0
Trail Creek (TC-0.3)	5	0	—	0
St. Joseph River at Bristol (SJR-78)	8	0	—	0
St. Joseph River below South Bend (SJR-46)	9	2	chlordane	22%
St. Joseph River at Fort Wayne (STJ-0)	9	0	—	0
Maumee River at Fort Wayne (M-116)	9	0	—	0

*Chlordane includes all isomers of this compound.

Table 4. Federal Food and Drug Administration (FDA) action levels for various parameters in edible portions of fish.

Parameter	Action Level
Aldrin + Dieldrin	0.3 mg/kg
DDT (total)	5.0 mg/kg
Endrin	0.3 mg/kg
Heptachlor + Heptachlor epoxide	0.3 mg/kg
Kepone	0.3 mg/kg
Mirex	0.1 mg/kg
Toxaphene	5.0 mg/kg
Chlordane (total)	0.3 mg/kg
Mercury	1.0 mg/kg
PCBs (Total)	5.0 mg/kg

for PCBs ranged from 0.043 mg/kg to 12.504 mg/kg and averaged 0.849 mg/kg. These whole fish values are considerably lower than those from the stations in the central and southern part of the state (Wabash and White rivers systems).

Although the values for chlordane, dieldrin, and PCBs and the number of whole fish samples which exceeded FDA action levels appear to be high for those samples from the Wabash and White rivers, they might have been somewhat misleading as FDA action levels are based on the edible portion (fillet) and not whole fish values. Our experience has shown that fillet samples generally have lower values than whole fish samples when samples of fillets and whole fish from the same species, size group and locality are compared. However, when fillet data are examined, violations are still found. In 1980-81, fillet (edible portion) samples were collected from stations on the Wabash and White rivers and analyzed for the same set of parameters as the whole fish samples.

Sixteen fillet samples were collected from five stations on the middle and lower Wabash River (Table 5). Of these samples, three (18%) exceeded FDA action levels for total chlordane and six (37%) exceeded the action level for dieldrin. No metals, PCB or DDT values were found which exceeded their action levels.

Channel catfish were of greatest concern as four of the five (80%) channel catfish fillets analyzed exceeded FDA action levels for chlordane, dieldrin or both. One of the seven (14%) carp fillets examined exceeded action levels for dieldrin, and one of three (33%) flathead catfish fillets examined exceeded the action limits for both chlordane and dieldrin. Fish fillet samples which exceeded FDA action levels for one or more of the pesticides were found at each Wabash River station from above Lafayette to below Terre Haute.

Twenty-two fish fillet samples were analyzed from five White River stations (Table 6). Of these, eight (36%) exceeded the FDA action level for chlordane, two (9%) exceeded the action level for dieldrin, and three (14%) exceeded the action level for PCBs. Again, channel catfish appear to be of greatest concern as four of five (80%) channel catfish fillets were above the FDA action level for chlordane, and one (20%) exceeded the level for dieldrin. Four of the nine (44%) carp fillets exceeded the FDA action level for chlordane, one (11%) was above the recommended level for dieldrin and two (22%) were above the PCB action level.

Values which exceeded the FDA action level for chlordane were found in samples from each White River station except the one at Broad Ripple (above Indianapolis). Values above the recommended level for dieldrin were found at Henderson Ford and Williams, and values greater than the action level for PCBs were found at Broad Ripple and Indianapolis.

Fillets containing higher levels of fats were most likely to have values exceeding the FDA action levels for these pollutants. When average percent fat values for channel catfish and carp fillets which did not exceed recommended levels of these substances were compared to percent fat values from fillets from these species that did exceed these levels, those that exceeded these levels had 1.5 to 10 times higher percent fat values.

Skinning as well as filleting fish would appear to be of value in reducing the amounts of these pollutants to which humans might be exposed. Table 7 shows the results of four fish which were filleted and one fillet from each fish analyzed with the skin on and the other fillet skinned before analysis. Substantial reductions in % fat and pollutant concentrations were seen in the skinned fillets.

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Table 5. 1980-81 fish fillet data from Wabash River.

Locality	Date	Species	Total Chlordane (mg/l)	Dieldrin (mg/l)	Total (mg/l)	DDT (mg/l)	PCBs % Fat
Wabash R. above Lafayette	1980	Largemouth Bass	0.096	0.107	0.392	0.364	0.81
	1980	Channel Catfish	0.091	0.022	0.030	0.223	1.61
	1981	Carp	0.119	0.226	0.063	0.774	2.73
	1981	Channel Catfish	0.277	0.413*	0.238	1.681	3.96
Wabash R. below Lafayette	1981	Carp	0.025	0.272	0.008	0.426	2.87
Wabash R. above Terre Haute	1980	Flathead Catfish	0.048	0.136	0.014	0.286	1.53
	1980	Channel Catfish	0.936*	1.01 *	0.425	3.271	14.7
	1981	Carp	0.110	0.279	0.060	0.597	3.79
	1981	Carp	0.134	0.345*	0.073	0.760	4.36
	1981	Channel Catfish	0.263	0.572*	0.092	1.109	8.56
	1981	Flathead Catfish	0.090	0.150	0.027	0.369	1.15
Wabash R. below Terre Haute	1980	Carp	0.054	0.085	0.011	0.294	1.85
	1980	Flathead Catfish	0.400*	0.316*	0.060	0.823	2.95
	1980	Channel Catfish	0.598*	0.968*	0.118	1.372	14.37
	1981	Carp	0.098	0.276	0.087	0.365	4.37
Wabash R. at New Harmony	1981	Carp	0.145	0.225	0.016	0.186	1.87

*Violation of FDA recommended action level.

Table 6. 1980-81 fish fillet data from White River.

Locality	Date	Species	Total Chlordane (mg/l)	Dieldrin (mg/l)	Total DDT (mg/l)	PCBs (mg/l)	% Fat
White R. at Broad Ripple (IWC 6.6)	1980	Largemouth Bass	0.043	0.027	—	0.532	0.38
	1980	Largemouth Bass	—	0.014	—	0.308	0.25
	1981	Largemouth Bass	—	0.001	—	0.158	0.11
	1981	Largemouth Bass	—	0.003	—	0.288	0.19
	1981	Carp	0.176	0.083	—	6.7 *	2.37
	1981	Carp	0.289	0.094	—	11.443*	4.3
White R. at Indianapolis (Washington Street)	1980	Bluegill	0.02	—	—	0.187	0.68
	1980	Largemouth Bass	0.022	—	—	0.358	0.36
	1980	Carp	0.577*	—	2.203	5.60	
	1980	River Carpsucker	0.156	—	—	5.659*	0.67
White R. at Henderson Ford	1980	Channel Catfish	0.953*	0.204	—	1.711	8.61
	1980	Channel Catfish	1.369*	0.439*	—	2.487	8.40
	1980	Channel Catfish	0.958*	0.289	—	2.747	11.38
	1980	Carp	1.028*	0.278	—	3.112	9.49
	1980	Carp	1.019*	0.146	—	2.895	9.01
	1981	Carp	0.196	0.086	—	0.622	4.19
	1981	Carp	0.297	0.135	—	1.631	6.09
East Fork White River at Williams	1981	Smallmouth Buffalo	0.018	0.006	—	0.593	0.24
	1981	Channel Catfish	0.307*	0.271	—	3.879	4.4
White R. at Petersburg	1980	Carp	0.954*	0.455*	—	0.514	2.49
	1981	Channel Catfish	0.25	0.118	—	0.776	2.4
	1981	Carp	0.028	0.016	—	0.259	0.96

*Violation of FDA recommended action level.
**Values were all quite low—none violative.

Table 7. Comparison of fillets from the same fish, one analyzed with skin, the other without skin. Pollutant concentrations were in mg/kg.

	%Fat		Chlordane		PCB		Dieldrin	
Species	Skin On	Skin Off	Skin On	Skin Off	Skin On	Skin Off	Skin On	Skin Off
Carp	4.36	3.79	0.134	0.110	0.760	0.597	0.345	0.279
Carp	4.30	2.37	0.289	0.176	11.443	6.700	0.094	0.083
Carp	6.09	4.19	0.297	0.196	1.631	0.622	0.135	0.086
Largemouth Bass	0.19	0.11	*	*	0.288	0.158	0.003	0.001

* - No analysis

These data from the "CORE" station monitoring program would indicate that there are problems with chlordane, dieldrin and/or PCBs for most of the length of the Wabash and White rivers, at least with regard to their concentrations in fish tissue. Indiana has initiated programs to locate and eliminate the sources of these contaminants to the extent possible.

In November 1981, an extensive sediment survey was conducted along the entire length of the West Fork of the White River and its major tributaries. Samples of sediment were collected at 30 stations (Figure 3) and analyzed for 31 toxic parameters—polychlorinated biphenyls (PCBs), pesticides and heavy metals. The results of the analysis of sediments collected from the West Fork of White River for PCBs, total chlordane, and dieldrin are shown in Figure 4.

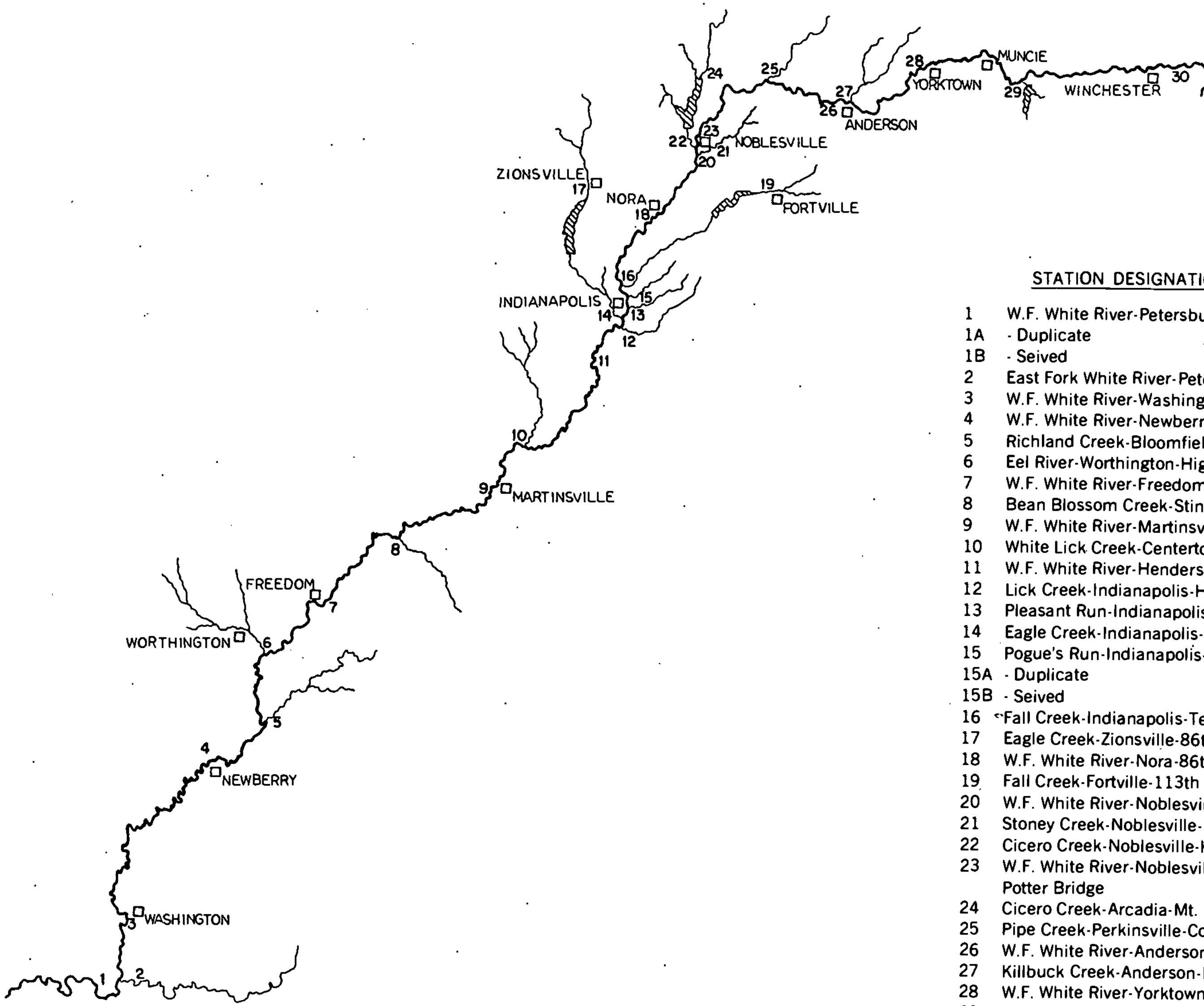
For the most part, PCB values were at or below 0.1 mg/kg in the river sediment samples. Two notable exceptions are sediment collected just downstream of Noblesville and at Nora on the northern edge of Indianapolis (Stations 18 and 20 on Figure 3). Values at these localities were 3 to 4 times as high as at the other stations. Sediments collected from Stoney Creek, a tributary which enters the river just upstream of Station 20, contained relatively high concentrations of PCBs (8.7 mg/kg). This was probably the major contributor to the increased PCB concentrations in the West Fork of White River at Noblesville and possibly Nora. We feel that this may also be a significant source of the higher than normal PCB concentrations in the fish tissue samples from the Broad Ripple "CORE" monitoring station, since it is only a short distance downstream from the Nora sediment station. A source of the PCB contamination of Stoney Creek has been identified, and it does not appear to be a point source problem at this time. The state and the facility involved are working to determine the extent of the contamination and the proper cleanup procedures to initiate.

Dieldrin does not appear to be a problem in West Fork of White River sediments. No values greater than 0.007 mg/kg were found at any localities sampled.

Total chlordane values in the sediments were very high at the sampling station near Washington (Station 3) in the downstream portion of the river. This value (0.225 mg/kg) was almost an order of magnitude greater than any other chlordane value found. No explanation for this value is apparent as total chlordane values are relatively low both upstream and downstream of this station, and no significant tributaries enter the river between the Newberry and Washington stations. This value may reflect local heavy agricultural usage in the past, although we do not have strong evidence to support this.

Another relatively high total chlordane value was found in sediments collected at the Henderson Ford station just downstream of Indianapolis (Station 11). This value is three to four times as high as the next upstream station (Nora), and the area between the two stations is mainly urban, not agricultural. Use of chlordane for termite control (approved use) and lawn insect control (no longer an approved use) in this urban area may contribute to the higher value at Henderson Ford, but we have no evidence to support this assumption.

Figure 3. Sediment collection sites on the West Fork White River in November 1981.



STATION DESIGNATIONS

1 W.F. White River-Petersburg-Highway 61
1A - Duplicate
1B - Seived
2 East Fork White River-Petersburg-Highway 57
3 W.F. White River-Washington-Highway 150
4 W.F. White River-Newberry-Highway 57
5 Richland Creek-Bloomfield-Highway 231
6 Eel River-Worthington-Highway 67
7 W.F. White River-Freedom-Pottersville Road
8 Bean Blossom Creek-Stinesville-Moon Road
9 W.F. White River-Martinsville-Highway 39
10 White Lick Creek-Centerton-County Road 600N
11 W.F. White River-Henderson Ford-County Road 390E
12 Lick Creek-Indianapolis-Harding Street
13 Pleasant Run-Indianapolis-Bluff Road
14 Eagle Creek-Indianapolis-Raymond Street
15 Pogue's Run-Indianapolis-Kentucky Avenue
15A - Duplicate
15B - Seived
16 Fall Creek-Indianapolis-Tenth Street
17 Eagle Creek-Zionsville-86th Street
18 W.F. White River-Nora-86th Street
19 Fall Creek-Fortville-113th Street
20 W.F. White River-Noblesville-146th Street
21 Stoney Creek-Noblesville-Highway 37A
22 Cicero Creek-Noblesville-Highway 32
23 W.F. White River-Noblesville-Edith Avenue at Potter Bridge
24 Cicero Creek-Arcadia-Mt. Pleasant Road
25 Pipe Creek-Perkinsville-County Line Road
26 W.F. White River-Anderson-County Road 600W
27 Killbuck Creek-Anderson-Broadway Street
28 W.F. White River-Yorktown-County Road 750W
29 W.F. White River-Prairie Creek Reservoir-County Road 431E
30 W.F. White River-Winchester-Highway 27
30A - Duplicate
30B - Seived

Although no other organic compounds were found in the sediments from the West Fork of White River and its major tributaries in concentrations great enough to cause concern, some stations had rather high concentrations of certain metals. Even though metals concentrations in fish tissue samples were relatively low, these metals may be having an adverse affect on other forms of aquatic life. In an attempt to interpret the metals data, the guidelines for evaluation of dredged sediments developed by the U.S. EPA Great Lakes National Program Office were used to evaluate the sediments from the West Fork of White River. These were used on an interim basis until more scientifically sound guidelines are developed. The guidelines for the metals examined are shown in Table 8.

Table 8. Interim guidelines for sediment concentrations of metals as developed by U.S. EPA Great Lakes National Program Office (1977).

Substance	Nonpolluted	Moderately Polluted	Heavily Polluted
Arsenic (mg/kg)	Less than 3	3-8	Greater than 8
Cadmium (mg/kg	-	—	Greater than 6
Chromium (mg/kg)	Less than 25	25-75	Greater than 75
Copper (mg/kg)	Less than 25	25-50	Greater than 50
Lead (mg/kg)	Less than 40	40-60	Greater than 60

Mercury (mg/kg) Polluted and unacceptable - greater than or equal to 1

Mercury and cadmium contamination was not apparent in any of the samples. Concentrations of chromium, copper, and lead at levels considered by U.S. EPA to be moderately or heavily polluted were found in sediments at stations below Washington, Indianapolis, Noblesville, and Anderson and at four tributary stations mainly in the Indianapolis area. Arsenic was more widespread. Urban runoff and combined sewer overflows from industrial areas possibly account for the metals concentrations in the tributary streams, since we know of no point sources which would account for these levels. Values at the four river stations are harder to explain and probably warrant further investigation.

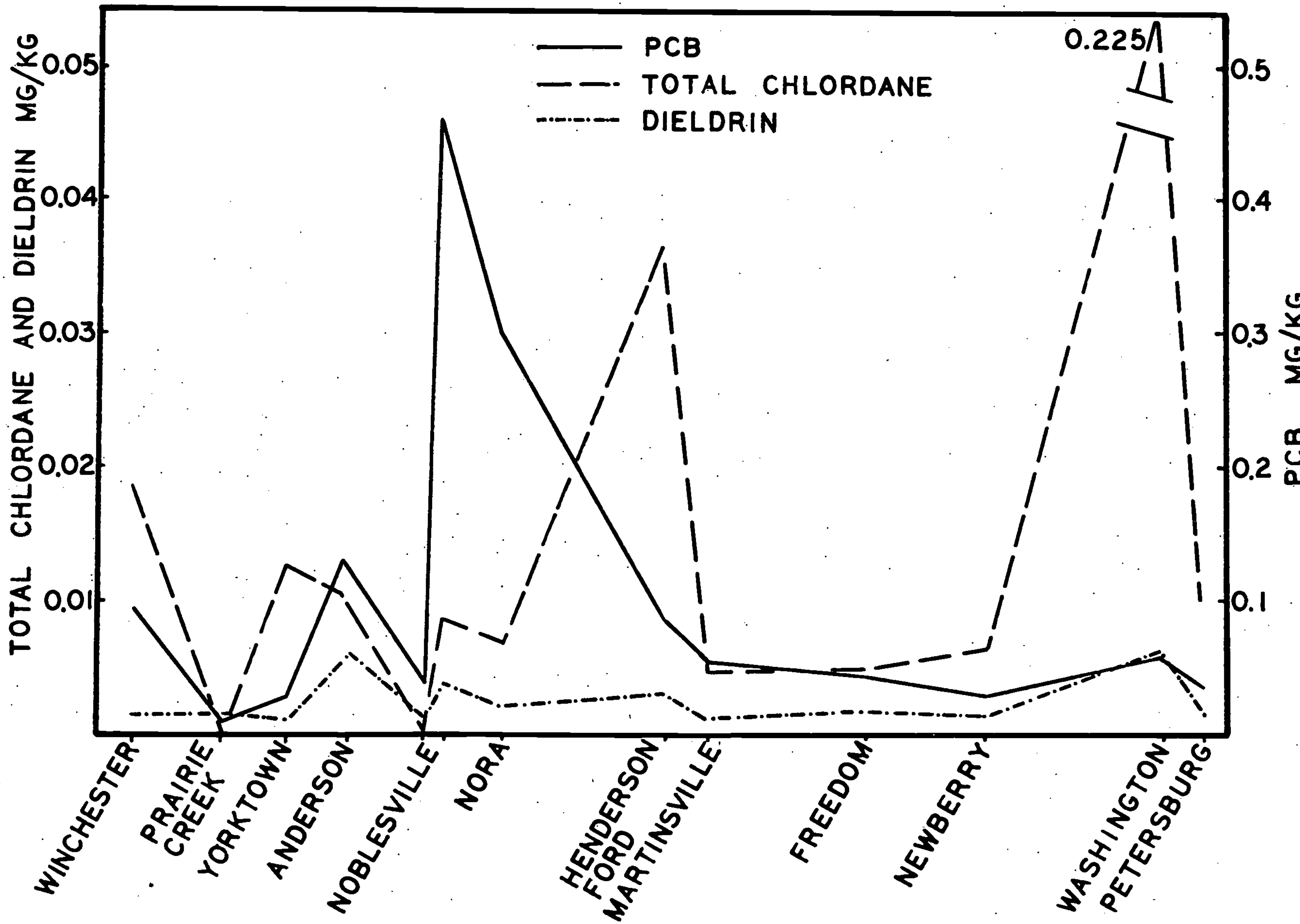
In the summer and fall of 1983, a sediment, mussel (shell), and fish (tissue and scales) survey of the East Fork of White River and its tributaries was conducted. Samples were collected at 32 stations from upstream of New Castle in Henry County to downstream of Bedford in Lawrence County. These are being analyzed for the priority pollutants. Analytical results for these samples are not available at this time. A similar fish, mussel, and sediment survey is planned for 1984 on the Wabash River and its tributaries from Lafayette in Tippecanoe County to Terre Haute in Vigo County. Effluents from dischargers in these two watersheds will be sampled in 1984.

Unless results from these two surveys give evidence to the contrary, the high levels of chlordane and dieldrin found in fish tissue samples from the Wabash and White River "CORE" monitoring stations are best explained as the result of the extensive use of these pesticides on agricultural crops, especially corn, in the recent past. Aldrin and dieldrin have been banned for agricultural use since 1974 and chlordane was banned for this use in 1980, although it still is used for termite control. These compounds are quite persistent and may remain in the environment for a long time (5 to 25 years). The residues found in fish tissues now are probably the result of the runoff and/or erosion of these materials from agricultural fields, lawns, etc., which were treated with these pesticides before they were banned for such use.

"The residues found in fish tissues now are probably the result of the runoff and/or erosion of these materials from agricultural fields, lawns, etc., which were treated with these pesticides before they were banned for such use."

The Wabash and White rivers drain the most heavily farmed areas of the state, and corn is the main agricultural crop. Erosion of soil particles from treated fields into these rivers result in fish and other aquatic life being exposed to these chemicals. Vanderford and Hamelink (7) have shown that concentrations of certain pesticides in fish from corn crop area reservoirs are directly proportional to the turbidity and true color of the reservoirs which are indicators of sediment loadings. The Wabash and White rivers carry significant sediment loads, and the same relationship could be inferred to explain the higher concentrations of pesticides in fish from these localities.

Figure 4. PCBs, total chlordane and dieldrin in the main stem and West Fork White River sediments from Winchester to Petersburg.



If the chlordane and dieldrin levels are due to past agricultural use, there is not much that can be done to alleviate or control these problems at the present time. It is probable that the concentration of chlordane and dieldrin in fish from these rivers will decrease as the amount of these pesticides remaining in the soil is reduced.

"If the chlordane and dieldrin levels are due to past agricultural use, there is not much that can be done to alleviate or control these problems at the present time."

Sampling of fish, water, and sediment for PCB contamination in Clear Creek, Salt Creek, Pleasant Run, and the East Fork of White River in Monroe and Lawrence counties in 1980 revealed rather high levels of PCBs at some localities. In the mid-1970s, effluent from the Bloomington sewage treatment facility discharging to Clear Creek and the General Motors Central Foundry plant discharging to Pleasant Run near Bedford were found to contain higher than acceptable levels of PCBs. The discharges have contaminated Clear Creek and Salt Creek downstream from Monroe Reservoir and are a major source of the PCB levels in the fish collected at the "CORE" monitoring station on the East Fork of White River at Williams. The locations sampled in 1980 are shown in Figure 5. These are essentially the same locations sampled in a similar study done in 1977. The results of the 1980 survey of fish, water, and sediment in these streams are shown in Table 9.

Clear Creek received PCB contaminated effluent from the old Bloomington Winston Thomas Sewage Treatment Plant which received wastewater from Westinghouse Corporation in Bloomington. Higher than desirable PCB levels were found in fish, water, and sediment from the two Clear Creek stations (CC-1 and CC-3). Eight fish samples were collected at these two stations, and 5 (62%) exceeded FDA action levels for PCBs. In June of 1982, the Winston Thomas facility was closed with the completion of the new facility at Dillman Road.

Fish and sediment samples collected in Salt Creek below the confluence of Clear Creek (SC-3 and SC-5) also had8 elevated PCB levels. Three of the 7 fish samples (43%) from the two stations exceeded FDA action levels. One of the fish samples collected at the upstream Salt Creek station (SC-2) also exceeded FDA action levels, but this may be due to upstream movement of contaminated fish. The PCB concentrations in the water at all Salt Creek stations were at or below detection levels.

Pleasant Run receives effluent from the General Motors Central Foundry Plant near Bedford. PCB concentrations were found in both water and sediment samples from the Pleasant Run station (PR-1). Although these 1980 numbers are still high, they are 40% lower for water and 75% lower for sediment than values found in 1977.

"Although these 1980 numbers are still high, they are 40% lower for water and 75% lower for sediment than values found in 1977."

PCB concentrations in sediment and water samples from the East Fork of White River were below detection levels at all stations but EW-4, immediately downstream from Salt Creek. No fish samples which exceeded FDA action levels were collected upstream of Salt Creek (EW-3). Of the 14 fish samples collected from the three East Fork of White River stations downstream of Salt Creek (EW-4, EW-5, and EW-6), only three (21%) exceeded FDA action levels. Two of these three samples were collected at EW-4 immediately downstream of Salt Creek.

Considerable monies have been spent over the last few years by the City of Bloomington, the State of Indiana, U.S. EPA, Westinghouse Corporation, and General Motors to eliminate the direct discharge of PCBs into these streams. A report prepared for General Motors by a consultant (1) indicates that the main sources of PCBs appear to be the sediments and soil along the banks of the streams into which General Motors discharged. Contaminated soils and sludges at these facilities, and leaching from the various landfills and dumps where PCB containing wastes have been deposited, also may contribute to the PCB concentration. Studies are now underway to determine how to best handle these aspects of the problem.

Several other small streams in this area have been sampled in the last 2 to 3 years due to possible PCB contamination from several landfills in which PCB containing wastes have been deposited. At some of these sites, PCBs had been suspected to be entering the streams by leaching or runoff. The location of these landfills are shown in Figure 6.

Figure 5. Map of Clear Creek, Salt Creek, Pleasant Run and East Fork White River in Monroe and Lawrence Counties, showing sampling locations.

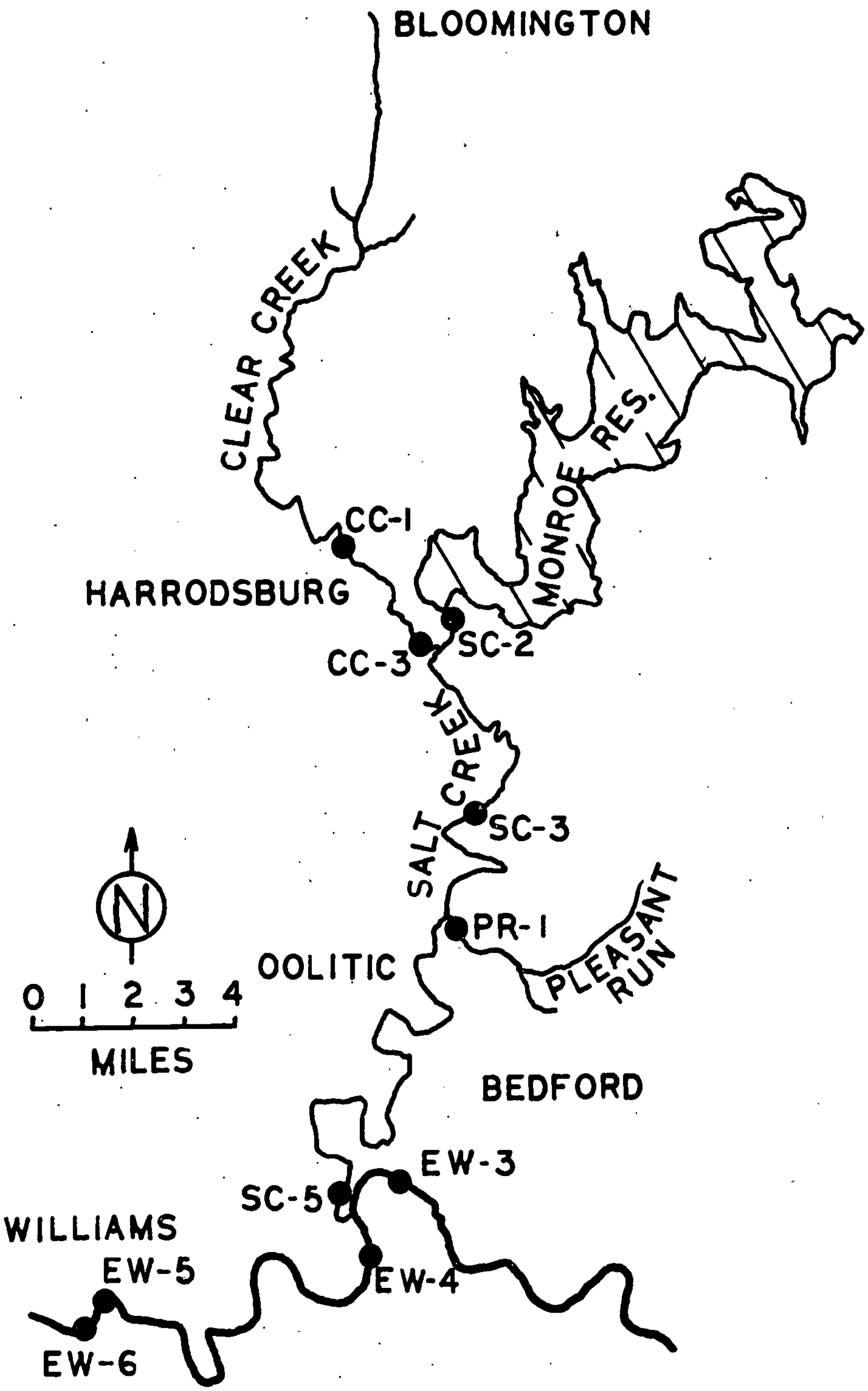
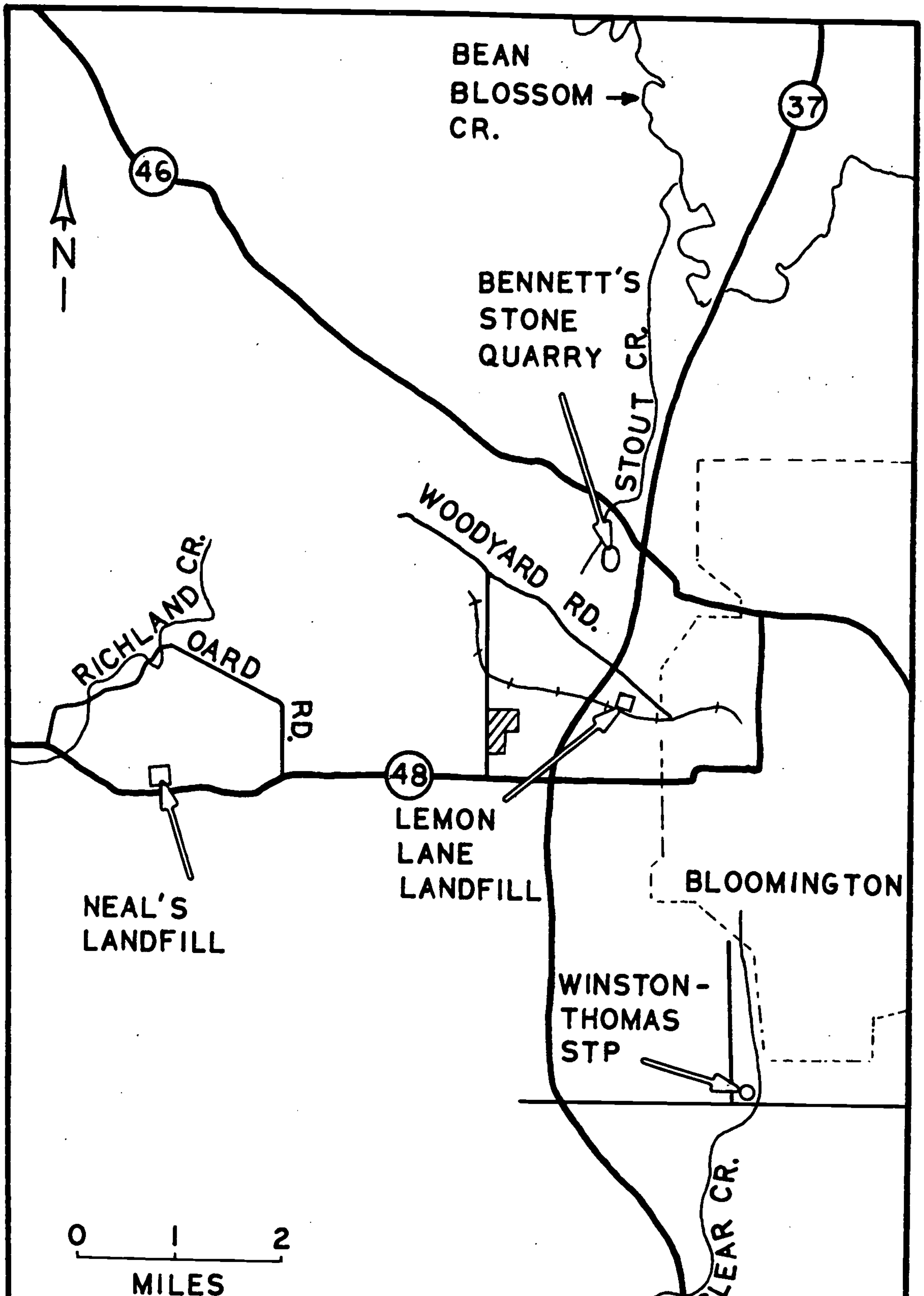


Table 9. PCB concentrations in fish, water, and sediment from Clear Creek, Salt Creek, Pleasant Run, and East Fork White River in Monroe and Lawrence counties in 1980.

			PCB Concentrations					
			Whole Fish	Fillet	Sediment (mg/kg)		Water (mg/l)	
Station	Species	% Fat	Basis (mg/kg)	Basis (mg/kg)	As 1242	As 1254	As 1242	As 1254
Clear Creek -1 (CC-1)	Creek Chub	4.75	19.8*					
	Bluegill Sunfish	1.47	1.2		2.2	0.2	0.22	0.1
	Longear Sunfish	6.89	25.3*					
	Largemouth Bass	1.04	5.1					
Clear Creek-3 (CC-3)	Northern Pike	0.19		2.0				
	Largemouth Bass	1.02		1.5				
	Bluegill Sunfish	6.98	19.8*		0.54		0.26	
	Longear Sunfish	5.22	16.0*					
Salt Creek-2 (SC-2)	Striped Bass	2.93	0.1					
	Bluegill Sunfish	4.32	3.9		0.15	0.1		
	Longear Sunfish	4.67	8.2					
Salt Creek-3 (SC-3)	Largemouth Bass	1.09		1.1				
	Largemouth Bass	4.20	7.3*					
	Longear Sunfish	5.65	11.2*	2.2		0.1		
	Longear Sunfish	4.18	8.8*					
Pleasant Run-1					315.0	0.2	8.5	0.1
Salt Creek-5 (SC-5)	Largemouth Bass	0.44		4.0				
	Largemouth Bass	0.32		3.0	2.0		0.12	
	Longear Sunfish	0.65		2.6				
East Fork White River-3 (EW-3)	Spotted Bass	0.33		0.07				
	Channel Catfish	0.93		0.16				
	Flathead Catfish	1.46		0.52	0.25	0.2	0.1	0.1
	Sunfish	1.85		3.4				
East Fork White River (EW-4)	White Croppie	0.57		1.5				
	Longear Sunfish	8.08	19.2*					
	Channel Catfish	8.55		4.6	1.1	0.41	0.16	0.1
	Channel Catfish	8.24		9.0*				
	Channel Catfish	5.65		3.4				
East Fork White River-5 (EW-5)	Largemouth Bass	0.68		0.51				
	Longear Sunfish	0.29		0.66	0.25	0.2	0.1	0.1
	Longear Sunfish	0.52		1.1				
	Channel Catfish	3.19		5.9*				
East Fork White River-6 (EW-6)	Longear Sunfish	1.44		2.4				
	Bluegill Sunfish	1.18		1.5				
	Longear Sunfish	0.04		0.03	0.25	0.2	0.1	0.1
	Bluegill Sunfish	4.24		3.5				
	Largemouth Bass	0.09		0.29				

*Exceeds FDA Action Level

Figure 6. Location of Bennett's Stone Quarry, Neal's Landfill and Lemon Lane Landfill in Monroe County near Bloomington, IN.



In 1981, Richland Creek downstream of Neal's Landfill was sampled for PCB contamination in fish. Whole fish samples were taken at the State Road 43 bridge in Owen County near Whitehall and the State Road 54 bridge near Bloomfield in Green County. Three of the four samples collected at the State Road 43 bridge (site closest to the landfill) contained levels of PCBs which exceeded the FDA action level. Fish species which exceeded the action level were yellow bullhead (6.312 mg/kg), northern hogsucker and white sucker (7.446 mg/kg), and longear and green sunfish (5.619 mg/kg). A striped shiner sample collected at this site and a northern hogsucker sample collected at the State Road 54 site did not exceed the FDA action level (2.306 mg/kg and 0.142 mg/kg, respectively).

In October of 1983, fish and sediment samples were collected from Stout Creek and Beanblossom Creek in Monroe County near Bloomington (Figure 6). These streams receive drainage from Bennett's landfill and runoff from the Westinghouse Corporation property. Both areas are suspected to be contributing PCBs to the streams. One sample containing eleven creek chubs was collected in Stout Creek downstream of Bennett's Landfill and Westinghouse Corporation property. This sample exceeded FDA action levels for PCBs (6.5 mg/kg). A sediment sample collected at this locality contained 350 ug/kg PCBs.

Fish samples collected at sites on Beanblossom Creek both upstream and downstream of the confluence of Stout Creek did not exceed FDA action levels for PCBs (all were under 1 mg/kg), and sediment samples from these two localities in Beanblossom Creek had levels of PCBs below detection limits (< 100 ug/kg). Negotiations are now underway involving the State of Indiana, U.S. EPA, the City of Bloomington, and Westinghouse Corporation to determine the extent of cleanup necessary at these landfills (and other sites) to alleviate the potential health hazards from PCBs, and to determine the responsibilities of the various parties involved for the cleanup activities and expenses.

"Fish samples collected at sites on Beanblossom Creek both upstream and downstream of the confluence of Stout Creek did not exceed FDA action levels for PCBs (all were under 1 mg/kg), and sediment samples from these two localities in Beanblossom Creek had levels of PCBs below detection limits (< 100 ug/kg)."

In March 1981, water and sediment samples were collected from Finley Creek in Boone County near Zionsville, northwest of Indianapolis. Finley Creek flows alongside a landfill and hazardous waste recycling facility and then into Eagle Creek (Figure 7). Eagle Creek in turn flows into Eagle Creek Reservoir which is a water supply source for Indianapolis. Samples were collected at several locations upstream and downstream of the landfill and recycling facility on Finley Creek and at several locations within the landfill boundaries (Figure 7) to determine if hazardous wastes were escaping from the area into Finley Creek. Water and sediment samples were analyzed for 77 different parameters including conventional pollutants, metals, PCBs, and chlorinated hydrocarbon compounds.

Only five substances (all chlorinated organic compounds) were found in Finley Creek in higher quantities in the water samples collected downstream of the landfill facility than upstream (Table 10). Concentrations of these substances in the downstream water samples do not approach levels which are toxic to aquatic life.

Substances found in higher quantities in Finley Creek sediment samples collected downstream of the facility than in upstream samples are shown in Table 10. Five of the eight are metals, but only lead, chromium, and possibly copper are present in concentrations downstream which are approximately twice the upstream value.

It appears from the analytical results that the cooling water pond at the recycling facility (station 15) is polluted with a variety of compounds including copper, free cyanide, lead, mercury, nickel, zinc, potassium, strontium, toluene, xylene, ethyl benzene, methylene chloride, 1,1- dichloroethane, tetrachloroethylene, methylethylketone, 1,1,2,2- tetrachloroethane, chloroform, carbon tetrachloride, t-1,3 dichloropropene and c-1,3- dichloropropene. At least six of these compounds were also found at downstream stations (stations 5 and 3) in the unnamed tributary to Finley Creek at greater levels than upstream station samples. This seems to indicate that materials were escaping from the cooling pond into the tributary.

Figure 7. Location of sample stations in Finley Creek and Northside Sanitary Landfill in Boone County near Zionsville, IN.

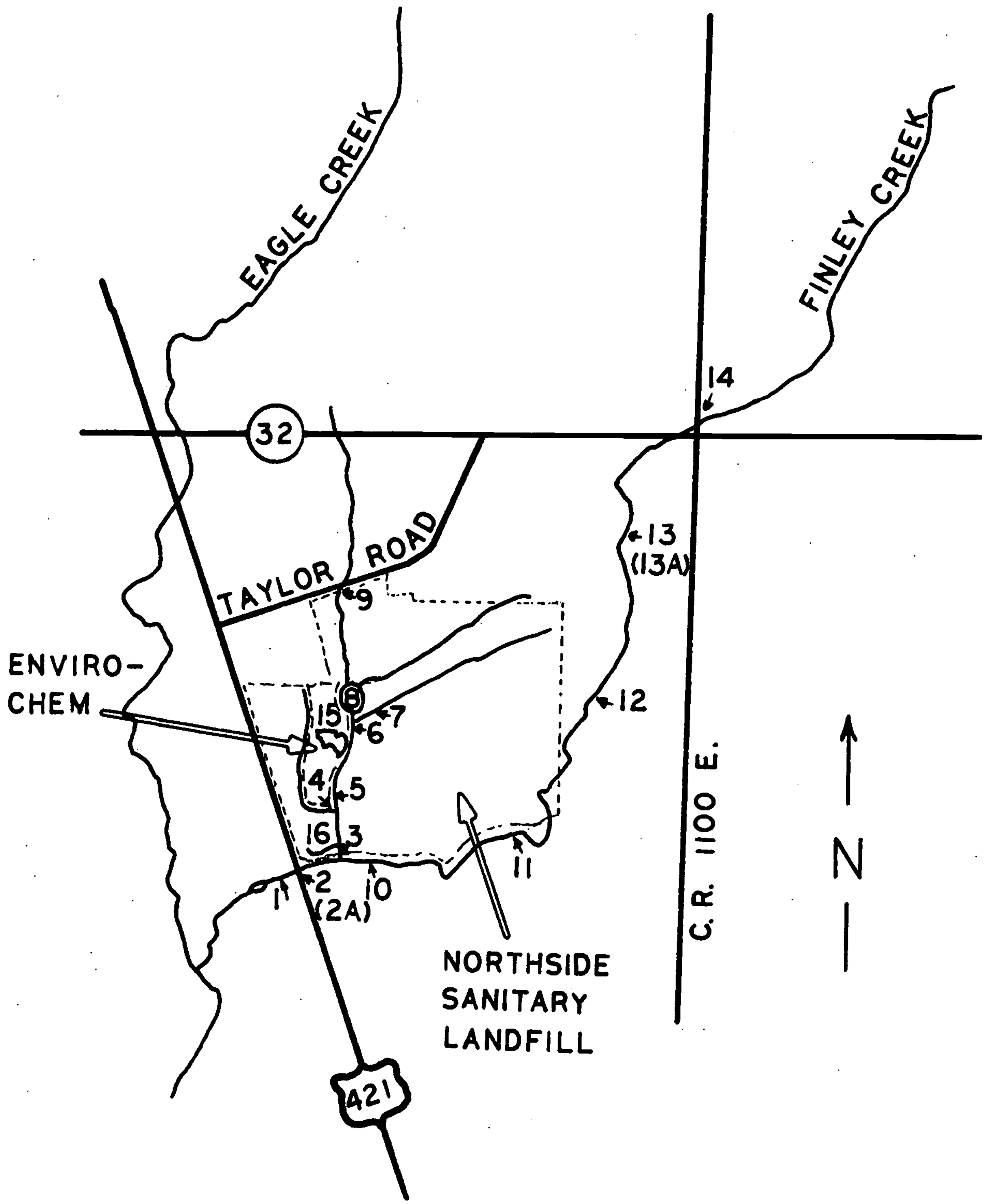


Table 10. Pollutants found in water and sediment from Finley Creek downstream of Northside Sanitary Landfill and Enviro-Chem in March 1981.

Parameter	Upstream Stations (10,11,12,13,14) Range of Values	Downstream Stations (1 and 2) Range of Values
Water		
Methylene Chloride	< 1.0 ug/l	< 1.0 to 1.3 ug/l
1-1 Dichloroethane	< 1.0 ug/l	1.6 to 1.9 ug/l
Trichloroethylene	< 1.0 ug/l	4.4 to 4.5 ug/l
Tetrachloroethylene	< 1.0 ug/l	1.1 to 1.4 ug/l
1,1,1 trichloroethane	< 1.0 ug/l	5.9 to 11 ug/l
Sediment		
Total Chromium	3,000 to 4,000 ug/kg	6,000 to 11,000 ug/kg
Copper	5,000 to 11,000 ug/kg	8,000 to 27,000 ug/kg
Lead	4,000 to 9,000 ug/kg	20,000 to 160,000 ug/kg
Mercury	10 to 50 ug/kg	10 to 70 ug/kg
Nickel	5,000 to 8,000 ug/kg	5,000 to 11,000 ug/kg
Xylene	< 0.10 ug/kg	< 0.10 to 0.32 ug/kg
Ethyl Benzene	< 0.05 ug/kg	< 0.05 to 0.11 ug/kg
1,1,1 trichloroethane	< 0.05 ug/kg	< 0.05 to 0.12 ug/kg

Based on available information, it does not appear that the contaminants found in Finley Creek, downstream of the landfill, were present in amounts that individually would be harmful to aquatic life. It is possible that in combination these contaminants may adversely affect aquatic life, but little information is available concerning the synergistic effects of these substances. This possibility is worth considering as no aquatic life was observed in the unnamed tributary at the time of the survey. A study by Dr. James R. Gammon and students at DePauw University (5) in conjunction with an EPA grant to evaluate the biological impacts of the Model Implementation Program for nonpoint source pollution control showed reduced numbers and diversity of aquatic life forms downstream of the landfill in Finley Creek. At the least, these data show that some contaminants were escaping from the landfill area which was a violation of their operating permit.

"Based on available information, it does not appear that the contaminants found in Finley Creek, downstream of the landfill, were present in amounts that individually would be harmful to aquatic life."

At the present time, the recycling facility has been closed, and the process of cleaning up and removing all hazardous materials from the site has begun. The landfill is no longer licensed to accept hazardous waste of any kind and has not been permitted to expand its facilities.

A study of the effects of metals in Julia Creek in Marion County has been carried out since 1980. Metals originated from the effluent and stormwater runoff of a battery recycling company in the watershed. Arsenic, cadmium, copper, zinc and lead were present in unusually high concentrations in Julia Creek water and sediments. Most fish and other aquatic organisms were periodically eliminated from the creek by poor water quality. Mussels placed in wire baskets in the stream had tissue concentrations of lead increase from 0.7 to 17.5 parts per million within six weeks. Results of the study have been used in ongoing enforcement proceedings against the company.

Biological monitoring of the upper Big Blue River was carried out in 1983 after bioassay results indicated a potentially toxic effluent from a steel company in New Castle. A great accumulation of metals (copper, chromium, iron, arsenic, and nickel) was observed in sediments for at least 1.5 miles below the discharge. Aquatic organisms living in or close to these sediments were greatly reduced in abundance and diversity. Some groups intolerant of metals contamination were entirely eliminated. Results of the survey were used to help draft a new discharge permit for the company.

In August 1983, staff conducted fish sampling in Elliott Ditch and Wea Creek near Lafayette in Tippecanoe County in response to a report submitted by the Aluminum Company of America (ALCOA) (8) that indicated high levels of PCBs in these two streams. Results of our analysis of whole fish samples indicated that fish from Elliott Ditch, downstream of the ALCOA discharge, and in Wea Creek, downstream of the confluence of Elliott Ditch, contained levels of PCBs substantially above FDA action levels. (Elliott Ditch, downstream of ALCOA - 126 mg/kg; Wea Creek, upstream of Elliott Ditch - 2.12 mg/kg; Wea Creek, downstream of Elliott Ditch -18.6 mg/kg). Both the state and ALCOA are attempting to locate and eliminate the PCB source(s).

Lake Studies

With the exception of Lake Michigan, which will be discussed later, only a few studies involving toxic materials have been done on Indiana lakes in the last few years. Studies involving toxic substances have been conducted on Wolf Lake in Lake County, Sylvan Lake in Noble County, and Lake Monroe in Monroe County. These studies were completed in response to specific incidents which might have been causing problems.

In October 1981, several fish samples were collected from Sylvan Lake in Noble County in conjunction with a study to determine the effects of lake drawdown on eutrophication. One concern, from a toxic substance standpoint, was that potentially harmful metals might be entering the lake from the Kendallville Sewage Treatment Plant. Another major concern was that metals may have accumulated in the sediments from heavy algacide use over the past several years. Four whole fish samples (largemouth bass, pumpkinseed sunfish, bluegill sunfish, and yellow perch) and two fillet samples (carp and largemouth bass) were collected and analyzed for metals, pesticides, and PCBs. None of the fish samples contained sufficient concentrations of any of these substances to warrant concern.

"None of the fish samples contained sufficient concentrations of any of these substances to warrant concern."

During 1981 and 1982, studies were conducted to determine the presence of toxic materials in Wolf Lake in Hammond. Several industrial and combined sewer overflow discharges to a channel on the north end of the lake have contaminated the lake sediments with PCBs, toluene, chlordane, and DDT metabolites as well as mercury, chromium, cadmium, copper, lead, and arsenic. These contaminants decreased with increasing distance from the channel, so that little or no sediment contamination is present at the southern end of the lake. Recent effluent sampling of discharges to the northern channel indicates that most of the pollution has been stopped and that the contaminated sediments remain as a record of past discharges.

A fish kill in the southernmost basin on the Illinois side of Wolf Lake in 1982 was attributed to a hazardous waste storage facility in Indiana. Spills from this facility had contaminated water and sediments in the adjacent lake basins. Toluene, methylene chloride, hexachlorobenzene, and bis-2-ethylhexyl phthalate were detected in lake sediments near the facility, and chromium and lead concentrations were much higher than normal. Fish collected in the Indiana basin nearest the facility were analyzed for various pesticides and metals. All those measured were at safe levels for human consumption.

In October 1983, fish samples were collected from Monroe Reservoir in Monroe County near the Ramp Creek inlet. This area reportedly was used as an informal dump before the reservoir was built, and PCB-containing waste may have been deposited there. Two largemouth bass fillet samples, one carp fillet sample, and one redear sunfish whole fish sample were collected from this inlet and analyzed for PCBs. Concentrations of PCBs in these samples were all less than 0.15 mg/kg which is far below the FDA action level. Therefore, the fear of PCB contamination in this large, recreational water body appears to be unwarranted.

"Concentrations of PCBs in these samples were all less than 0.15 mg/kg which is far below the FDA action level. Therefore, the fear of PCB contamination in this large, recreational water body appears to be unwarranted."

Monitoring of fish tissue in Lake Michigan for toxic substances began in the early 1970s. A number of samples were collected by the Indiana Department of Natural Resources each autumn in Lake Michigan and some of its tributaries. Fish were then analyzed at the ISBH laboratories for PCBs, DDT, mercury, and a small number of other compounds. In the late 1970s the number of parameters grew to include chlordane isomers and other compounds reflective of the expanding BH laboratory capabilities and the analysis run on the "CORE" fish samples (Table 2). Samples were usually a composite of three anterior steaks of the same species and size fish. In 1982, the procedure was modified from analyzing anterior steaks to skinless fillets. Of all the parameters analyzed, only four (PCBs, chlordane, dieldrin, and DDT) were found to exceed FDA action levels at any time.

Since the first PCB results were obtained in 1973, lake trout have always exceeded FDA action levels of 5.0 ppm. These values appeared to have peaked in 1976 at over 100 ppm, with samples in subsequent years declining in PCB concentrations. The most recent information, collected in the fall of 1982, show lake trout still exceed FDA action levels for PCBs by two- or threefold.

Although PCB levels in chinook salmon were not as high as in lake trout, many have equalled or exceeded FDA action levels in samples collected since 1974. The most recent samples are large (36") chinook salmon collected in 1982. PCB levels in these fish only marginally exceed 5.0 ppm PCB.

PCB concentrations in coho salmon, steelhead trout and brown trout have exceeded FDA action levels in the past. The 1980, 1981 and 1982 data, however, show PCB values of these fish to be below 5.0 ppm.

Chlordane analysis in fish tissue began in 1980. As with PCBs, chlordane values (total) in lake trout and chinook salmon exceed the FDA action level of 0.3 ppm. Samples from brown trout, steelhead trout, and coho salmon exceeded the FDA action level in the 1980 and 1981 samples. In 1982, samples for the latter three species were at or below the 0.3 ppm level. However, this drop is possibly due to the change in analysis from steaks in 1980 and 1981 to skinless fillets in 1982. The number of samples were limited, but the skinless fillets of brown trout, steelhead trout, and coho salmon appear to have approximately half the fat content of the anterior steak samples. This may account for a drop in these fat soluble toxicants and give some guidance on the proper method of preparation for consumption.

DDT and dieldrin are still found in excess of FDA action levels in large old lake trout. The values in the 1982 samples, however, are only slightly higher than the 5.0 ppm DDT and 0.3 ppm dieldrin FDA limits. Compared with mid- and late 1970s samples, these most recent data indicate a declining trend to levels that may soon meet FDA action levels on a regular basis. Other species of salmonids in Lake Michigan do not indicate DDT and dieldrin problems.

"Compared with mid-and late 1970s samples, these most recent data indicate a declining trend to levels that may soon meet FDA action levels on a regular basis. Other species of salmonids in Lake Michigan do not ndicate DDT and dieldrin problems."

Bioassay Program

Since November 1980, the State of Indiana has conducted twenty three 48-hour static bioassays on industrial effluents using immature Daphnia magna as the test organism. The bioassays are intended to screen effluents for their potentially toxic effects in state waters. Nearly 80% of the tests were for industries discharging to the Lake Michigan, Wabash River, and East Fork of White River basins.

Toxicity was observed in 61% of the tests. Copper and zinc were the most common toxic agents, being found in potentially toxic concentrations in 22% and 13% of the tests, respectively. In at least 17% of the tests, more than one toxic agent was probably involved. The toxic agent(s) was (were) unknown in 43% of the tests in which toxicity was observed.

All of the five metal plating effluents tested were toxic to some degree, while effluents from the two petroleum refineries tested were not toxic. Other industry groups for which more than one bioassay was conducted had both toxic and nontoxic effluents.

One flow-through, onsite bioassay has been completed. This was a 96-hour test using fathead minnows (Pimephales promelas) at a metal plating facility in Union City. The effluent did not appear to be toxic, as only one fish (in 100% effluent) died during the test period.

In addition, one 96-hour static bioassay using fathead minnows as the test organism has been conducted. This bioassay was run on effluent from a plating industry, and the LC 50 value was calculated to be 42% effluent.

Fish Consumption Advisories

As a result of the various toxic studies done by the State of Indiana, fish consumption advisories have been issued for several waters of the state by the Bureau of Food and Drugs at the ISBH. The advisory affecting the most people is that issued for chinook salmon and lake trout from Indiana's portion of Lake Michigan and the salmon run tributaries. Fisherman are advised not to eat lake trout or chinook salmon due to levels of PCBs and chlordane which are considerably above FDA action levels in most of the fish analyzed. Levels of all pollutants examined in steelhead trout, coho salmon, and brown trout are presently below FDA action levels. However, women of child-bearing age, women who are pregnant or nursing, and pre-school age children are advised to restrict intake of these fish to no more than one meal (½ pound) every two weeks. No advisories have been issued for other fish species found in the Indiana waters of Lake Michigan.

Fish consumption advisories have also been issued for Richland Creek in Monroe, Owen, and Greene counties; Clear and Salt Creeks in Monroe and Lawrence counties; the East Fork of White River from Salt Creek to Williams in Lawrence County; and Elliott Ditch and Wea Creek downstream from the Elliott Ditch confluence in Tippecanoe County. These advisories were due to PCB values in fish samples exceeding FDA action levels. The advisories recommend that no fish should be eaten from Elliott Ditch or Wea Creek, and that no more than one meal (½ pound) per week of fish from the other streams be consumed. Women of child-bearing age, women who are pregnant or nursing, and pre-school age children are advised not to eat fish from any of these streams.

Indiana's first fish consumption advisory was issued in 1977 for lake trout in Lake Michigan due to PCB levels above FDA action levels. This advisory was updated in 1983 to also include chinook salmon as both of these species were found to have high chlordane and PCB levels. The fish consumption advisory on Clear Creek, Salt Creek, and the East Fork of White River from the confluence of Salt Creek to Williams was first issued in 1978, the advisory on Richland Creek was issued in 1982, and the advisory on Elliott Ditch and Wea Creek was issued in 1983. These advisories will remain in effect until subsequent sampling indicates the fish no longer contain amounts of these substances above FDA action levels.

Fish consumption advisories have been issued for approximately 125 miles of rivers and streams in Indiana. All of the Indiana portion of Lake Michigan (241 square miles, 43 shoreline miles) is affected by toxic substances to the degree that fish consumption advisories for lake trout and chinook salmon have been issued due to high levels of PCBs and chlordane. Other Indiana lakes studied do not appear to have problems with toxic pollutants.

Fish Kill Reports

A diverse healthy fish population is considered an indication of good water quality. Serious public concern is generated when dead and dying fish are noted in the aquatic environment since this can indicate the potential long-term loss of use of the affected waters for a fishery.

A fish kill can result from the accidental or intentional discharge of a toxic or oxygen depleting material into the aquatic environment. Fish kills may also occur downstream of a continuous industrial or municipal discharge which may release, due to a system upset, an atypical effluent containing high concentrations of oxygen demanding materials.

The number of reported fish kills has decreased greatly since the 1980-81 reporting period (106 down to 59). However, as depicted in Figure 8, the general trend from 1960 to present is a gradual increase in the number of reported incidents. This is probably due to increased public awareness of whom to contact when a fish kill is discovered.

"The number of reported fish kills has decreased greatly since the 1980-81 reporting period (106 down to 59)."

The dramatic decrease in the number of fish kills noted from the 1980-81 reporting period to the 1982-83 reporting period is in part due to the decrease in the number of animal waste spill related fish kills, depicted in Figure 8. Interestingly, only 42% of the total number of animal waste discharges to waters of the state resulted in a fish kill. This may be due in part to chronic discharge situations where stream quality has been lowered to a point that precludes the establishment of healthy fish populations.

Forty-seven percent (28) of the fish kills in 1982 and 1983 were caused by some agriculturally related material (Figure 9). Animal waste was the number one cause (37%) (22 fish kills), followed by pesticide spills (7%) (4). Approximately (3%) (2) of the kills resulted from a spill of fertilizer of some type.

The distribution of fish kills on a month-by-month basis is shown in Figure 9. The majority of fish kills occur during late summer and early fall. This time of year is generally dry, and low flow conditions often exist. This intensifies the effects of a sudden discharge of toxic and/or oxygen demanding material thereby increasing the potential for a fish kill.

Investigation of Spills of Oil, Hazardous and Objectionable Materials

During 1982-1983, a total of 709 reported spill incidents resulted in the release of 5.2 million gallons and 3,057 tons of material. More than one type of material was lost during several of the reported incidents.

Figure 8. The number of major fish kills by year 1960-1983, and the number of animal waste spills 1970-1983.

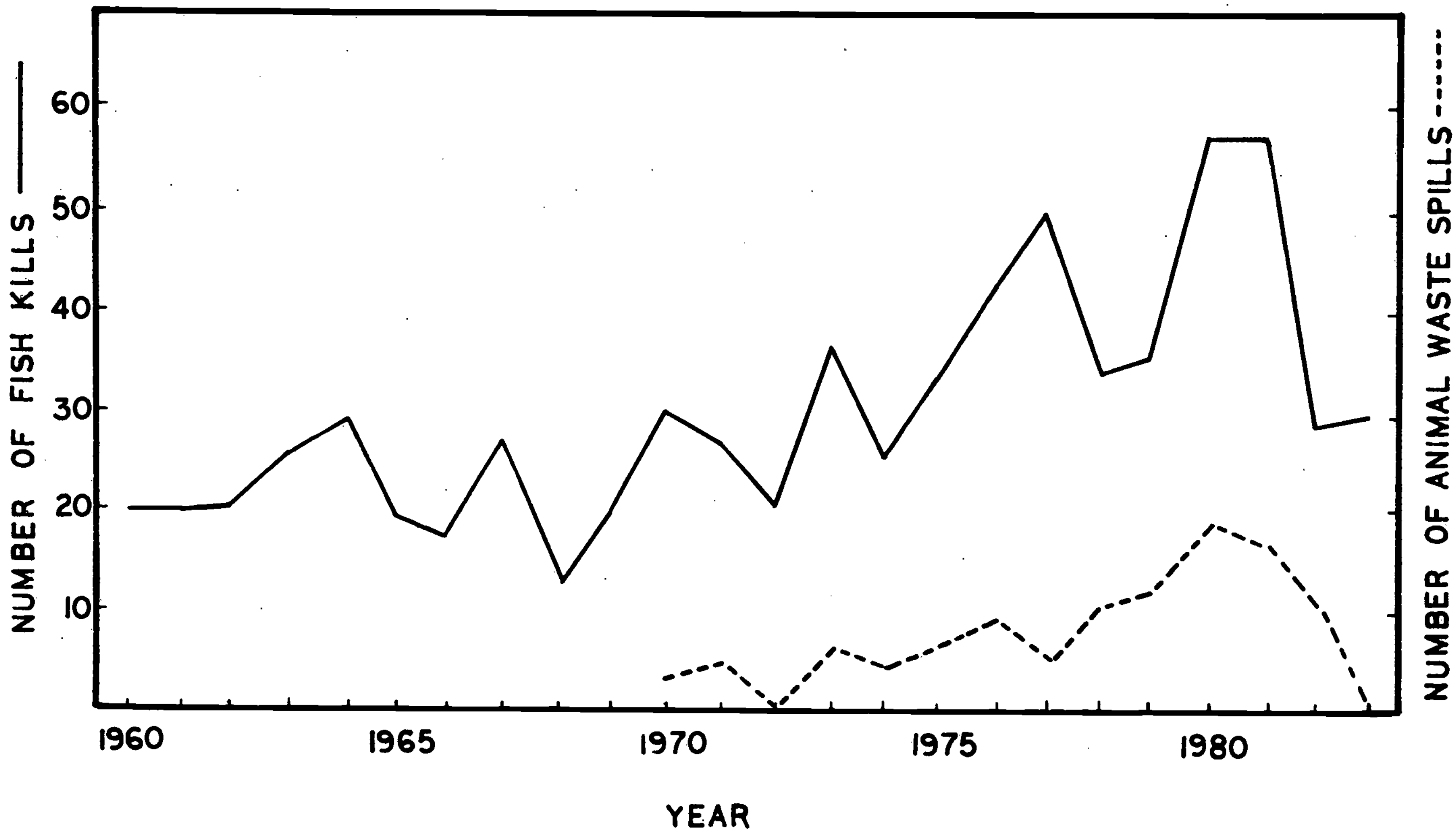
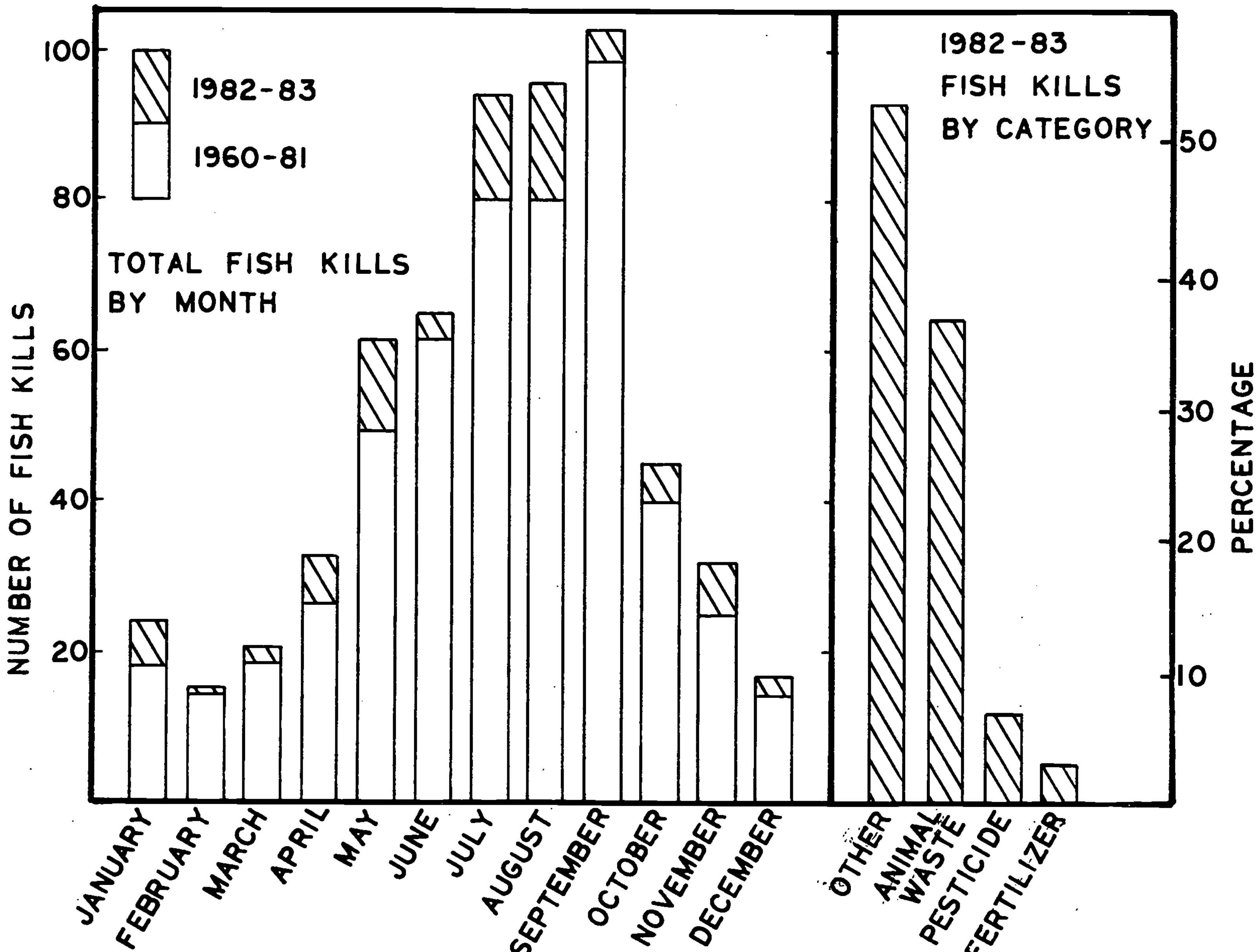


Figure 9. Total fish kills by month 1960-1983, and fish kills by category 1982-1983.



The types of materials spilled are shown in Table 11. Petroleum products accounted for the largest number of incidents (287), followed by miscellaneous chemicals with about half that number. Other materials, with the fewest number of spills, had the greatest volume with 3.1 million gallons of liquid (mostly acid mine waste) and 2,905 tons of dry material.

The sources of materials spilled were broken down into six categories (Table 12). The industrial related grouping accounted for the largest number of reported incidents with 248. These were identified as spills where the loss was from sources involved in manufacturing or mining. The semipublic and municipal STP category had the most liquid spilled and none of the lost material was recovered. Commercial spills were those where the material lost originated from businesses involved in the wholesale

Table 11. Types of materials spilled in 1982-1983

	No. of Incidents	Percent	Amount	Percent Recovery
1. Petroleum Products	287	41	0.8 million gal.	83
2. Miscellaneous Chemicals	144	21	115,000 gallons 49 tons	57 17
3. Agricultural Related Prod.	106	15	757,000 gallons 95 tons	48 89
4. Food Products	65	9	70,000 gallons 8 tons	26 100
5. Acids or Bases	64	9	369,000 gallons	53
6. Other Materials	43	5	3.1 million gallons 2,905 tons	0.7 59
Total	709		5.2 million gallons 3,057 tons	

Table 12. Sources of materials spilled in 1982-1983

	No. of Incidents	Percent	Amount	Percent Recovery
1. Industrial	248	35.0	767,000 gallons 26 tons	86 18
2. Transportation	201	28.3	560,000 gallons 2,936 tons	77 59
3. Commercial	85	12.0	36,000 gallons	72
4. Agricultural	63	8.9	725,000 gallons 95 tons	47 89
5. SemiPublic, Municipal STP	38	5.4	3.0 million gallons	0.0
6. Unknown, Other, Individual	74	10.4	74,000 gallons	11.9
Total	709	100	5.2 million gallons 3,057 tons	

or retail handling of the product. The agricultural spills were directly related to farm chemicals and agricultural wastes. Animal waste spills fall into this latter category, and the amounts spilled often are difficult to quantify. The known volume spilled is probably underestimated for this reason. Spills from transportation related activities included not only railroad and truck accidents, but spills resulting from barge traffic and pipeline operations.

The causative circumstances for spills fell into seven categories (Table 13). Equipment malfunction accounted for almost half of all spills (46.8%), with transportation accidents and employee error the next largest categories. Intentional discharge, vandalism, miscellaneous and unknown categories combined accounted for only 24% (170) of all incidents.

Title 330 of the Indiana Administrative Code, Article 1, Rule 6 requires the notification of the Indiana Stream Pollution Control Board or its designee of all spills of oil, hazardous, and/or objectionable substances that enter or threaten to enter waters of the state. The prompt containment, recovery, and/or neutralization of the threatening substance is also required by the Rule. The Rule specifically requires the responsible party to make the requested notification. This notification requirement is not deemed fulfilled unless the Board or its designee has received the report from the responsible party.

Table 13. Causative circumstances of spills of oil, hazardous and objectionable materials 1982-1983.

	No. of Incidents	Percent
1. Equipment	332	46.8
2. Transportation	106	15.0
3. Employee Error	101	14.2
4. Miscellaneous	57	8.0
5. Intentional Discharge	27	3.8
6. Vandalism	21	3.0
7. Unknown	65	9.2
Total	709	100

During 1982-83, 709 spills of oil, hazardous, and/or objectionable substances were reported. Of these, 382 incidents (54% of the total) were reported by the responsible party as required. The remaining 327 spills were reported by other governmental agencies and/or private citizens. An education program, developed in 1980, to familiarize state and local governmental agencies, industries, businesses, and interested citizens with the provisions of 330 IAC 1-6, has been continued during 1982-83 and has been well received. Increased compliance is the anticipated result of this program.

The term "contain" as defined by this Rule, is to dam, bury, block, restrain, or as may be otherwise necessary, affirmatively act so as to most effectively prevent spilled substances from entering the waters of the state. The term "cleanup" is defined as action taken to neutralize, remove, collect, gather, pump, separate, cover, or, as may be otherwise necessary, affirmatively act so as to most effectively prevent, minimize or mitigate damage or threatened damage to the public health, safety, and welfare, and to aquatic biota, animal life, plant life, or recreational, domestic, commercial, industrial, or agricultural water uses.

Spill cleanup success depends on several critical factors: the nature of the material involved, the time elapsed between the spill event and cleanup initiation, the expertise of the cleanup contractor, methodology employed, topographical characteristics of the spill site, and climatic conditions. When immediate action is taken to contain and cleanup a spill, it greatly increases the chance of a successful operation. Experience has demonstrated that if time is lost in the cleanup initiation the resultant cost will increase, and the success rate will decrease. Immediate cleanup is therefore of optimum importance.

During 1982-83, 411 (58%) of the reported incidents had either complete or partial cleanup. This represents a 15% increase over the 1980-81 period. In some cases, cleanup was impossible or unnecessary. In many situations, the people reporting the incident lack knowledge of the appropriate cleanup methods and/or how to contact a cleanup contractor. This demonstrates the need for the reporting requirement. When a report is received, this critical information can be provided to the responsible party so that containment and cleanup can be initiated immediately.

During 1982-83, water quality violations resulted from 153 (22%) of the 709 reported incidents. Thirty-nine percent of the incidents which caused water quality violations resulted in a fish kill. Fifty percent of the reported incidents did not involve a water quality violation because the lost material did not reach waters of the state. Due to a lack of information, no determinations as to water quality violations could be made for the remaining incidents.

Special State Concerns and Remaining Problems

Since its inception, the Stream Pollution Control Board has been greatly concerned with controlling what have been called "conventional" pollutants—those associated with sewage or common industrial processes. At one time the effects of these pollutants were highly visible. Clear streams became dark and foul-smelling and oil slicks and sludge banks were frequently present. Algal blooms caused water to look like green paint. Bathing beaches were closed because lakes were too polluted for swimming. At times, hundreds of dead fish could be seen along waterways. Much has been done to reduce or eliminate these conventional pollutants in surface waters, particularly during the last ten years.

Programs are in place to continue dealing with conventional pollutants in the future. Ammonia reduction and other benefits from advanced waste treatment will occur where such facilities are approved and constructed. Expansion of municipal facilities will be required as increased loading or old age make the present systems obsolete. A program to assist municipal sewage plant operators solve technical problems associated with unforeseen or unusual conditions at their treatment facilities is being planned.

As previously indicated, toxic pollutants will be increasingly important in future water pollution control programs. Toxic pollutants include various metals and synthetic organic compounds. They rarely have visible effects on the water or sediments, and their presence can only be detected with sophisticated analytical tools. Yet they can kill, injure or impair life forms which come into contact with sufficient amounts of them. They are of concern both from the human health and aquatic ecosystem standpoints. Efforts to control toxic pollutants in surface waters are now focusing on industrial NPDES and pretreatment programs as well as placing additional emphasis on sludge management and monitoring programs to locate unknown sources.

"Efforts to control toxic pollutants in surface waters are now focusing on industrial NPDES and pretreatment programs as well as placing additional emphasis on sludge management and monitoring programs to locate unknown sources."

Future water pollution control programs must also address problems caused by previous toxic pollutant contamination. Some fish contain rather high levels of chlorinated hydrocarbons. Toxic pollutants exist in high concentrations in sediments at several locations, and periodic release from the sediments can cause water pollution problems. Management of these contaminated sediments is currently being addressed in several areas where sources have been identified.

Groundwater contamination by toxic substances is another problem yet to be dealt with on a statewide basis. In the past, there has been no single authority in the state to act on groundwater pollution problems. Little is known about the extent of present contamination, but public concern has greatly increased in recent years. Where contamination exists, the state will need to develop adequate remedial programs.

Expansion of the state's toxics monitoring programs is limited by present laboratory capacity. A greatly increased volume of toxics samples will require increased laboratory capacity, equipment, and manpower. Therefore, laboratory expansion is a prerequisite for addressing some of the state's major remaining water pollution problems.

Much effort has been expended during the last decade to improve water quality in the Lake Michigan basin. Continued improvement will be a future goal as the state tries to expand its unique and valuable salmonid fishery. This fishery contributes as much economic value to northwestern Indiana as a 1,000 employee factory. Sport fisherman come from all over the midwest and spend money attempting to catch the five salmonid species stocked by the state. Especially sought- after are the Skamania steelhead trout. These fish grow to trophy size, are excellent fighting fish, and can be caught in the spawning streams during summer when fishing for the other salmonid species is slow. Indiana Skamania steelhead from Trail Creek are presently the only acceptable source of eggs for steelhead hatcheries in the country, and the demand for broodstock of this species is high. Stocking of steelhead trout and chinook salmon in the St. Joseph River will soon be started as well. Future programs to protect and improve this fishery should include: (1) achieving greater municipal and industrial compliance with discharge permits in the basin, (2) designating the St. Joseph River as a salmonid spawning, rearing or imprinting area, and (3) requiring upgraded wastewater treatment where necessary to improve water quality.

"This fishery contributes as much economic value to northwestern Indiana as a 1,000 employee factory. Sport fisherman come from all over the midwest and spend money attempting to catch the five salmonid species stocked by the state."

Several of Indiana's public glacial lakes have serious macrophyte and algal problems which periodically interfere with fishing, swimming, or boating uses. During the last decade the state has assisted in the planning of programs for alleviating some of these problems. Lake renovation remains an area of special concern in Indiana.

Finally, the toxic effect of residual chlorine from wastewater treatment plants on aquatic life is a remaining problem in Indiana. Most sewage treatment plants in the state use chlorine to disinfect their effluents before discharge. The chlorine reduces bacterial numbers, at least temporarily, but also has adverse effects on the natural stream community. Chlorine toxicity is especially evident in small streams with little dilution. Encouraging practical alternatives to chlorine disinfection and educating sewage treatment facility operators on the importance of maintaining proper chlorine dosage are necessary features of future water pollution control programs.

Basin Information and Summaries

Lake Michigan Basin

Lake Michigan is located in the northwest corner of the state, comprising the largest water body under Indiana's jurisdiction. Indiana governs approximately 40 miles of shoreline and 240 square miles, about 1% of the total surface area. The states of Illinois, Michigan, and Wisconsin have responsibility for the balance of the lake.

The Lake Michigan drainage basin includes four major waterways in Indiana: the Grand Calumet River-Indiana Harbor Ship Canal, the Little Calumet River, Trail Creek, and the St. Joseph River (Figure 10). The first three empty into Lake Michigan within the boundaries of Indiana, while the St. Joseph returns to Michigan where it empties into the lake approximately 25 miles north of the state line at the towns of St. Joseph-Benton Harbor.

Managing the many uses of Lake Michigan is no small task. Five major municipalities: Michigan City, East Chicago, Gary, Hammond, and Whiting use Lake Michigan for potable water supply and eventually return treated municipal wastewater to the lake. In addition, a number of industries also use the lake as a raw water source. The Indiana Stream Pollution Control Board (ISPCB) has designated Lake Michigan and its contiguous harbor areas for multiple use purposes including recreation, aquatic life, potable water supply, and industrial water supply in Regulation 330 IAC 2-1. This regulation outlines the criteria and minimum standards of water quality that must be maintained in the lake.

A total of 1,565 samples were collected in Lake Michigan during an intensive sampling program conducted by the ISBH in 1980-1981 (2). Almost no violations of water quality standards were found. Occasionally, total phosphorus, phenolics, dissolved oxygen, cyanide, and a few other parameters would violate standards. This, however, was not the trend, but an ephemeral occurrence usually located near harbor mouths and in tributary areas. From this analysis, it appears the designated uses (in 330 IAC 2-1) are being supported.

"A total of 1,565 samples were collected in Lake Michigan during an intensive sampling program conducted by the ISBH in 1980-1981 (2). Almost no violations of water quality standards were found."

Water quality in Lake Michigan does vary in the Indiana portion. Nearshore areas, although meeting state standards, exhibit different water quality characteristics than offshore areas. Concentrations of certain parameters in the nearshore zone reflect the wastewater and tributary contributions from the watershed. Traditional nutrient pollutants (total phosphorus, ammonia, TKN, NO_2+NO_3-N) were shown in both 1980 and 1981 to be higher nearshore. The highest values consistently appeared at the mouths of Trail Creek and the Indiana Harbor Ship Canal. The thermal bar phenomenon, common in the spring on the Laurentian Great Lakes, accentuated this nearshore-offshore delineation. Offshore values of the parameters sampled were similar to those found in other southern Lake Michigan studies as documented in the ISBH Lake Michigan Report (2).

The limited information collected by this agency on toxic substances in Lake Michigan water and sediment indicates that there is little cause for concern. Tissue from some species of fish, however, have contained concentrations of contaminants in excess of FDA action levels since testing began in the early 1970s. Fish are collected for pesticides and PCB analysis in the fall of the year by the Indiana Department of Natural Resources (IDNR) and analyzed at ISBH laboratories. PCBs are a problem in lake trout with values in excess of the Food and Drug Administration (FDA) guidelines of 5.0 mg/l. Chlordane is also found in excess of the FDA guideline of 0.3 mg/l in both lake trout and chinook salmon. The State of Indiana issued an updated consumption advisory to fisherman and consumers of these fish in the spring of 1983. Fish samples were analyzed for twenty-five other compounds or isomers,

Figure 10. Lake Michigan Drainage Basin.

but only an occasional DDT violation in large, old lake trout (year class VIII or older, length greater than 32") was found.

There are currently several other state programs involving Lake Michigan. Water samples are collected monthly at the water supply intakes at East Chicago, Gary, Hammond, Whiting, and Michigan City as part of the Fixed Station Water Quality Monitoring Program, and compliance monitoring and inspections remain on a routine schedule for NPDES dischargers.

Trail Creek is located in LaPorte County in the northwest corner of the state, and flows into Lake Michigan at Michigan City. The drainage area is 59.1 square miles, with an approximate average annual flow of 75 cfs. It is Indiana's most noted salmonid stream due to the IDNR stocking program that began in the early 1970s. Since it is a salmonid stream, it is included in ISPCB Regulation 330 IAC 2-4 (Natural Spawning, Rearing or Imprinting Areas; Migration Routes for Salmonid Fishes). Historically, many water quality problems have been associated with this waterway. Inadequately treated sewage, combined sewer overflows, and industrial effluents have contributed to its poor condition and resulted in fish kills at different times. It appears that projects being initiated by Michigan City will largely eliminate many remaining water quality problems.

"It appears that projects being initiated by Michigan City will largely eliminate many remaining water quality problems."

Because of Trail Creek's designation as a salmonid stream, a more stringent set of water quality standards apply than for general use streams. However, these standards are frequently violated. Dissolved oxygen violations in the lower reaches of the creek presently occur 25-40% of the time according to ISBH Fixed Water Quality Monitoring Station records. Fecal coliforms criteria are violated approximately 40% of the time, and violations of un-ionized ammonia standards occur often, especially during the summer. Temperature standards are almost always exceeded in June, July, and August, and violations will continue as these standards appear to be lower than "background" or "ambient" levels. Rains of over ¼ to ½ inch usually cause bypassing of partially treated sewage to the stream by the sewage treatment facility as well as combined sewer overflows. Existing sludge banks and extensive recreational boating activity cause the additional problems.

Fish kills due to low dissolved oxygen, high temperature, and/or ammonia have occurred regularly in the past. An ISBH CORE monitoring survey found that there were almost no resident fish in the lower two miles of Trail Creek in the fall of 1982. Salmonid fish attempting to migrate through this area must subject themselves to conditions that are detrimental to this type of fishery.

A model and wasteload allocation study has been completed for Trail Creek and defines the extent and causes of these pollution problems. The study indicates that control of combined sewer overflows, final filters, and super saturation of the effluent are required in order to restore the fishery to its potential. Lake Michigan and Trail Creek provide a sport and commercial fishery worth an estimated 17 million dollars each year to Michigan City. The need to protect this resource, therefore, is readily apparent.

"Lake Michigan and Trail Creek provide a sport and commercial fishery worth an estimated 17 million dollars each year to Michigan City."

Biological sampling in Trail Creek occurred in 1979, 1980, and 1982. Hester-Dendy macroinvertebrate samplers at Franklin Street bridge near the stream mouth indicated a community dominated by pollution-tolerant chironomid larvae and oligochaetes. Fish sampling in 1979 and 1980 revealed only limited numbers of native fish. However, native fish tissue samples tested had values of the organic and metal parameters below FDA action levels for consumption.

The Little Calumet River flows through Lake and Porter counties in northwest Indiana. A portion of the west branch drains to Lake Michigan via Burns Ditch while flow reversal near Griffith takes a portion of the flow into Illinois, and eventually the Illinois River. The east branch of the Little Calumet and its tributaries drain the major cities of Porter, Chesterton and Valparaiso in Porter County. This portion of the river, including the Salt Creek tributary, is designated for salmonid migration, or for rearing and imprinting by ISPCB Regulation 330 IAC 2-4. The west branch is not designated as such and is covered by ISPCB Regulation 330 IAC 1-1. Deep River is the major tributary to the portion of the west branch that drains to Lake Michigan. The section that flows west into Illinois includes Hart Ditch.

The Little Calumet River Basin is a highly populated, urban area. The steel industry is the major economic provider in the basin with the large plant of Bethlehem Steel the most visible. Supportive industries and the population base that subsequently developed encompass most of the watershed. Urban runoff, combined sewer overflows, and municipal and industrial wastewater effluents are common, especially in the west branch of the Little Calumet River. Although these problems are not specific to this watershed, they appear to be more concentrated here, with little time for the stream to recover from individual pollution sources.

The Salt Creek tributary receives the effluent of the Valparaiso sewage treatment facility. Chronic violations of the facility's NPDES permit in the past have caused poor water quality of this salmonid stream. Advanced waste treatment, scheduled for completion in December 1984, includes nitrification and dechlorination and should help alleviate this problem. Control of combined sewer overflows is also required.

Crown Point completed a new sewage treatment facility in 1979 that dramatically improved water quality in Beaver Dam Ditch and Deep River. Current permit limits for this AWT plant are being met. The most recent sampling inspection indicated BOD_5 and suspended solids of less than 3.0 mg/l in the final effluent.

"Crown Point completed a new sewage treatment facility in 1979 that dramatically improved water quality in Beaver Dam Ditch and Deep River."

Hobart is also planning to provide improved wastewater treatment. Plans for a new plant or for regionalization with Gary are in the review stages. The improved treatment, whichever method employed, will improve the west branch of the Little Calumet River when completed.

The portion of the Little Calumet River that flows west into Illinois has violated water quality standards for a number of years. Dissolved oxygen values below 4.0 mg/l at Fixed Water Quality Monitoring Station LCR-13 occurred approximately 50% of the time from 1975 to 1982. The 1983 data show fewer violations. This is largely due to the sewer separation project at Griffith which improved the quality of Cady Marsh Ditch, Hart Ditch and the Little Calumet River. A similar pattern for ammonia occurred in the same period. Although standards are still being violated for unionized ammonia, total ammonia values have been cut in half from a mean of 3.86 mg/l in 1975-1980 to 1.73 mg/l in 1981-1983 at the Hohman Avenue Fixed Water Quality Monitoring Station, GCR-34.

The U.S. EPA, Region V, denied funding for upgrading the Schererville sewage treatment facility to include final filters in December 1983. This decision was based on an analysis which indicated that the current treatment facilities would meet the effluent limitations that were determined by an ISBH Model and Wasteload Allocation. Aeration bubblers proposed to be added to the Schererville chlorine contact tank should reduce the chlorine concentration in the plant effluent and alleviate the chlorine toxicity problem which inhibits aquatic life in the receiving streams.

The Dyer sewage treatment facility has undergone an upgrading by adding filters to its activated sludge plant. This was expected to improve the quality of the effluent to the point that NPDES permit limits for BOD and suspended solids of 10 mg/l (monthly average) would be met. However engineering, construction, and operational problems currently plague the facility. The new treatment facilities are not yet operational, and the NPDES permit limits are not being met as a result.

Steel production in the area in the last few years has been reduced, and this has probably caused a decline in the volume of wastewater entering the Little Calumet River. Although difficult to determine exact cause-effect relationships in this instance, improving water quality may be partly due to this fact.

The east branch of the Little Calumet River receives effluents from Bethlehem Steel. One of these is a high flow cooling water discharge that enters the river upstream of Salt Creek. It appears that this warmer water is inhibiting salmonid migration in the late summer and fall, possibly diverting some fish up Salt Creek. Bethlehem is now negotiating with a consultant to assess the extent of the problem and to find a way to lower the elevated temperatures that periodically occur in this salmonid stream.

"Inspection reports and compliance surveys of this facility all indicate that Midwest Steel is meeting its NPDES permit limits and having little or no adverse effect on the water quality in the receiving waters."

Midwest Steel also discharges wastewater to the east branch of the Little Calumet River. Inspection reports and compliance surveys of this facility all indicate that Midwest Steel is meeting its NPDES permit limits and having little or no adverse effect on the water quality in the receiving waters.

Benthic macroinvertebrate sampling of Burns Ditch using Hester-Dendy plate samplers was done in 1979, 1980, and 1982. A low diversity of organisms existed on the samplers each year, and they often were covered with a heavy layer of silt. Chironomid larvae were the dominant organisms found each year.

Carp were collected from Burns Ditch in 1979, 1980, and 1982 for fish flesh analysis for toxic substances. No violations of FDA action levels were found, although most of the fish were relatively small (less than two lbs).

The Grand Calumet River in Lake County consists of an east and west branch, with the two branches meeting to form the Indiana Harbor Ship Canal. The east portion originates in Gary just upstream from the outfalls of the U.S. Steel Corporation mill. It flows west and empties into Lake Michigan via the Indiana Harbor Ship Canal (IHC). The west portion, like the Little Calumet River, flows both east and west, with the point of change located 1-2 river miles west of the IHC. The western flow into Illinois eventually reaches the Illinois River Basin and the Mississippi River.

The Grand Calumet River basin drainage area is small, but includes some of the most industrialized and populated areas in the entire state. ISPCB Regulation 330 IAC 2-2 was written specifically for this watershed, designating it for industrial water supply, limited aquatic life and partial-body contact. The intense industrial and municipal use of this waterway, along with its readily apparent lack of recreational or aesthetic value, contributed to this designation.

The Grand Calumet River-Indiana Harbor Ship Canal has been designated as a Class A area of concern by the International Joint Commission. Standards violations are common, and, in some instances, the norm (examples: phenol, total phosphorus, ammonia, fecal coliform, and dissolved oxygen standards were violated over 80% of the time from 1981-1983 at Fixed Water Quality Monitoring Station GCR-34).

Three major sewage treatment plants, Gary, Hammond, and East Chicago discharge to the Grand Calumet River. All three municipalities are engaged in some type of enforcement action with the state and U.S. EPA.

The City of Hammond and the Hammond Sanitary District have been named in an enforcement action by the State of Indiana and U.S. EPA. This action is to address the inadequate sludge disposal methods currently employed by the Sanitary District. Leaching of material from the District's sludge storage lagoons to the Grand Calumet River has been alleged. A proposed Consent Judgment is being developed at this time.

The City of East Chicago and the East Chicago Sanitary District have entered into a Consent Judgment with the State of Indiana, U.S. EPA, and the State of Illinois. The judgment outlines specific tasks to be undertaken by the city to improve the wastewater treatment facility operation and return the plant to compliance. A court appointed oversight committee has been formed as part of this action to assure that terms of the judgment are met. Current inadequate sludge handling and disposal facilities as well as overflows of inadequately treated sludge are a part of this action.

The City of Gary and the Gary Sanitary District have entered into a Consent Judgment with the State of Indiana and the U.S. EPA that requires effluent limitations to be met in accordance with the Gary NPDES permit. In addition, the State of Indiana recently initiated a request for enforcement to address the inadequate storage of sludge and alleged leaching of material from the Gary Ralston Street lagoon to the Grand Calumet River.

Recently constructed additions to the Gary sewage treatment facility have resulted in some water quality improvement in the Grand Calumet River even though some operational problems have been experienced at the plant. Values at Fixed Water Quality Monitoring Station GCR-41 immediately below the plant indicate improvements since 1981 in fecal coliform, ammonia, cyanide, phosphorus, and oil and grease concentrations.

"Values at Fixed Water Quality Monitoring Station GCR-41 immediately below the plant indicate improvements since 1981 in fecal coliform, ammonia, cyanide, phosphorus, and oil and grease concentrations."

An additional source of water quality degradation in the basin is the extensive network of combined sewer systems. These allow for significant bypassing during wet weather flows.

Industrial inputs to the river include discharges from U.S. Steel, Inland Steel, J & L Steel, DuPont, Vulcan Material, Material Handling, and American Steel. Additional inputs are found along the river, and, although they may not be as great in magnitude as those mentioned, they do contribute to the pollution of the waterway. These inputs are not only from point sources, but include barge traffic in the IHC, parking lot runoff, etc.

In an effort to define more exactly the problems in the watershed, HydroQual, Inc., was contracted to develop a model and a wasteload allocation study of the Grand Calumet River and Indiana Harbor Canal. This modeling effort will define the effects of various wasteloads on the river and assist the state in its efforts to clean up and manage water quality in this area.

A dredging project has been proposed by the Army Corps of Engineers for portions of the IHC. Difficulties in locating a suitable disposal site for the dredged spoils have delayed action on this project. However, sediments continue to accumulate in the IHC, and action in the near future is imperative if intended uses of the harbor are to be maintained.

Trend analysis in this river can be addressed using gross comparisons. Although the water quality is far from being desirable, it is showing improvement. Aquatic life now can be found in places of the IHC where a few years ago it did not exist. Resident fish populations are evident (yellow perch, spotfin shiners, golden shiners, and mud minnows were observed in 1980 and 1982), and even some salmonids have strayed up the river in autumn. Tolerant benthic macroinvertebrates can be found throughout the system where none existed before. Waterfowl can be found roosting in the wetlands and marsh areas that border portions of the Grand Calumet River near the IHC. These observations could be due to both better treatment of wastewater as well as a reduction in wastewater discharged to the river due to the lower production of the steel mills in the most recent years.

"Although the water quality is far from being desirable, it is showing improvement. Aquatic life now can be found in places of the IHC where a few years ago it did not exist."

Sediment surveys of the IHC-GCR conducted by the EPA (1977), the Army Corps of Engineers (1979), and HydroQual, Inc. (1983), indicate some trends in the system. The concentrations of PCBs in surface sediments have declined (Table 14). Although these appear to be real trends, only three samples are used for comparisons. Other parameters have been sampled and also appear to be declining. However, strict comparisons are impossible since the remaining samples were not collected at the same locations sampled previously.

Table 14. Values of PCBs at selected sites in the sediments of the IHC-GCR.

	PCB Concentration mg/kg		
Station	EPA 1977	COE 1979	Hydroqual 1983
C-14, CIH 1-79	25.7	29.40	0.45
C-16, CIH 4-79	20.9	11.71	7.7
C-17, CIH 5-79	23.1, 17.9	33.56	1.1

Fish flesh sampling for toxics in the IHC-GCR system was done in 1980 and 1982. Tissue samples for small and medium size (less than 2.5 pounds) carp were at or below FDA action levels for all parameters sampled. In 1982, however, a sample of larger carp weighing 3 to 6 pounds exceeded FDA action levels for PCBs and chlordane.

The St. Joseph River enters the state from Michigan and flows south to Bristol in Elkhart County. From there it flows west through Elkhart and South Bend (St. Joseph County) where it bends north and returns to Michigan. The river segment in Indiana is less than 40 miles long, although the Indiana drainage basin covers 1,778 square miles and six counties. The major tributary to the St. Joseph River in Indiana is the Elkhart River.

The lower end of the St. Joseph River in Michigan is a salmonid stream. Through a cooperative effort between Indiana and Michigan, several fish ladders are being constructed at the dams on the river and a new cold water hatchery has recently been placed in operation at Mishawaka, Indiana. The additional stocking and removal of barriers will enable trout and salmon to move up the river to Mishawaka. This will enhance the fishery of the river and also change the water quality use designation in Indiana to salmonid migration, rearing and imprinting (330 IAC 2-4).

Problems in the watershed are not extensive. However, the sewage treatment facilities at Elkhart need upgrading. The addition of new aerators, clarifiers, and sludge handling capability is now in progress and scheduled for completion in December 1986.

Biological studies indicate diverse benthic macroinvertebrate and fish communities at the "CORE" Stations STJ-78 and STJ-46. Analysis of fish flesh for toxic substances since 1979 has shown no toxic problems in this stretch of the river.

A sediment survey for 11 toxic parameters took place in 1981. Values from the five stations from Bristol to South Bend were all below detection limits. No evidence of toxic pollution exists in this waterway.

"No evidence of toxic pollution exists in this waterway."

Maumee River Basin

The Maumee River is located in the northeastern portion of the state and drains parts of Allen, Dekalb, Wells, Adams, and Noble counties (Figure 11). The drainage area in Indiana is 1,216 square miles, with the land use approximately 80% agriculture, 10% urban, and the balance forested and other classifications. The Maumee River originates in Fort Wayne with the confluence of the St. Joseph and the St. Mary's rivers. It then flows east into Ohio where it traverses across the northern portion toward Toledo where it empties into Lake Erie. The $Q_{7,10}$ low flow, as measured at New Haven, is 70 cfs. This basin is covered under ISPCB Regulation 330 IAC 1-1. In this regulation, the St. Joseph River in Allen County is designated for whole-body contact recreational use, and Cedar Creek has been designated as a State Resource Water from river mile 13.7 in Dekalb County to its confluence with the St. Joseph in Allen County. The balance of the basin is designated for aquatic life and partial-body contact.

The ISBH Fixed Water Quality Monitoring Network in this basin includes two stations on the St. Mary's River (STM-33, STM-12), one on the St. Joseph River (STJ-0), and three on the Maumee River (M-116, M-110, M-95). Phosphorus values in the St. Mary's River are consistently among the highest found in the state, except for those located just below point source dischargers. The drainage area is used heavily for agriculture, and suspended solids in the two rivers are high. No major sewage treatment plants are located on the St. Mary's except Decatur (2.8 mgd capacity). Central Soya in Decatur is a major contributor of phosphorus.

The headwaters of the St. Mary's River originate in Ohio. Although no major cities are located in this area, several small Ohio towns appear to be affecting the water quality. Some of these towns have only primary sewage treatment facilities, while others have operational problems. The Rockford, Ohio, sewage treatment facility had a lift station failure in September 1982, bypassing raw sewage to the river. This caused a major fish kill which extended some 15 miles downstream into Indiana. These problems, coupled with the absence of a phosphorus detergent ban in Ohio, adversely impact the water quality of the St. Mary's River before it enters Indiana.

Central Soya is a soybean processing plant in Decatur, Indiana, that discharges wastewater to the St. Mary's River. A 1978 NPDES permit allowed for a maximum discharge of phosphorus of ten pounds per day. In 1983, an Order of Compliance issued by the Indiana Stream Pollution Control Board increased the allowable discharge of phosphorus to thirty pounds per day. However, the Central Soya treatment system is not functioning properly at present, and the level of phosphorus removal provided is unknown. Efforts to correct the problem are currently underway.

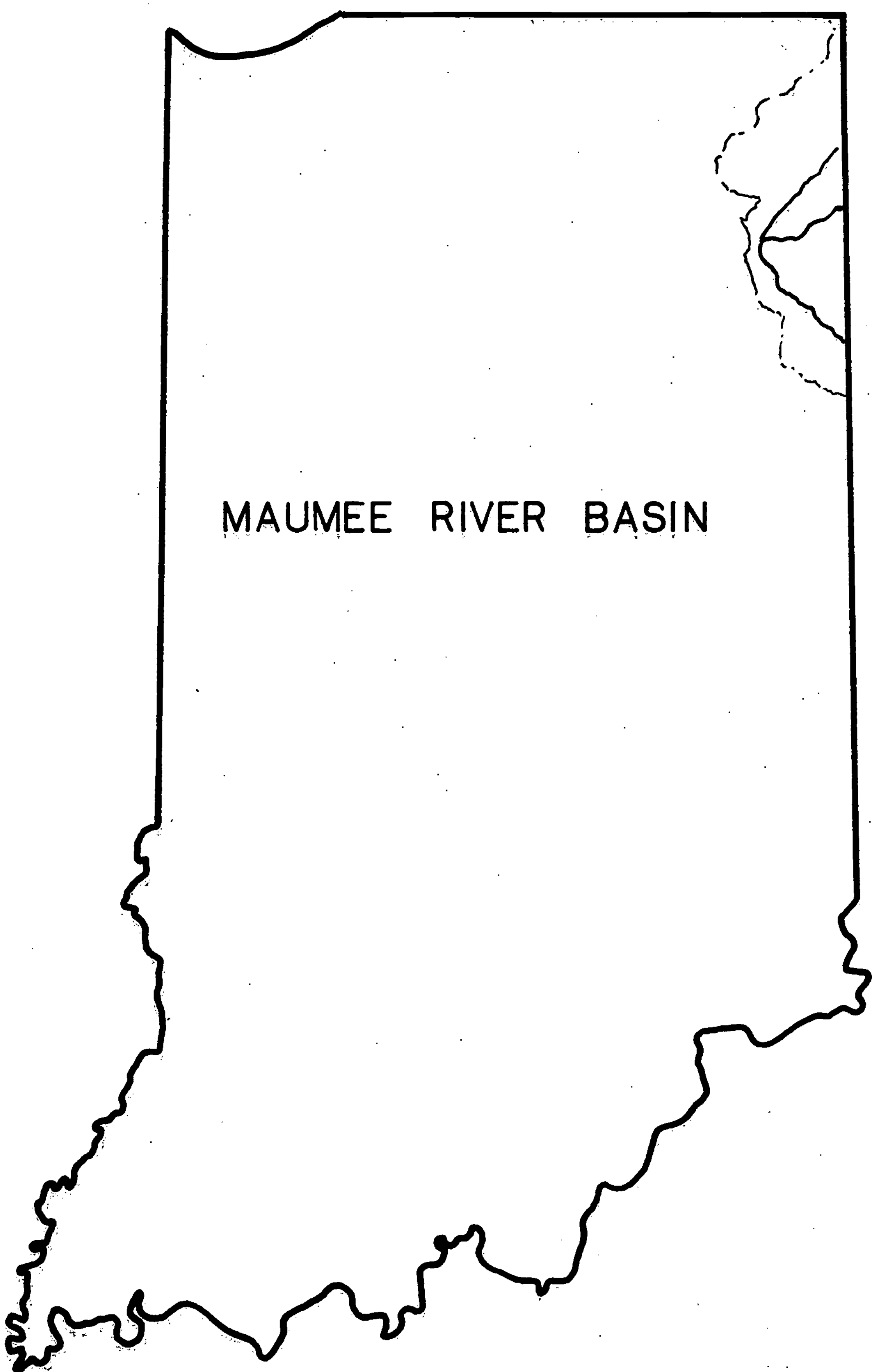
The St. Joseph River enters Indiana from Ohio northeast of Fort Wayne and flows to the southwest. The area it drains is largely agricultural, and contains no major metropolitan areas. The water quality at the single ISBH Fixed Water Quality Monitoring Station near the mouth appears good from data collected. Only fecal coliform concentrations occasionally exceeded the applicable water quality standards.

The river is dammed north of Fort Wayne in Allen County forming Cedarville Reservoir, a shallow, eutrophic water supply impoundment. In the winter of 1983-84, a fish kill occurred here, apparently due to the extended ice cover and subsequent dissolved oxygen depletion.

"The Auburn sewage treatment facility has experienced hydraulic overloading and currently is operating at design capacity or above. Expansion of this plant, expected to be completed in 1984, should alleviate the water quality problem."

Cedar Creek is an important tributary to the St. Joseph River. Unfortunately, in portions upstream of the area designated as a State Resource Water, some water quality problems exist. The Auburn sewage treatment facility has experienced hydraulic overloading and currently is operating at design capacity or above. Expansion of this plant, expected to be completed in 1984, should alleviate the water quality problem.

Figure 11. Maumee River Drainage Basin.



A number of industrial dischargers are also found in this watershed, with one of the most notable being Kitchen Quip in Waterloo. A 1977 biological survey of Cedar Creek below this facility showed excellent habitat, but the stream appeared to be void of living organisms. This was in sharp contrast to the diverse and abundant aquatic life in Cedar Creek above the Kitchen Quip discharge. In the past this company has had a number of NPDES permit violations, but none since April of 1981. Their treatment system currently appears to be operating satisfactorily. The most recent inspection reports (1983) indicate their plating waste has been reduced, probably in response to lowered plating activity, and discharges have been limited to only a few days per month.

Gridcraft Corporation in Huntertown has also had a history of wastewater problems. This metal plater discharges to a branch of Willow Creek, a tributary of Cedar Creek. The plant effluent is not treated sufficiently before it leaves the site and is severely impacting the receiving water and sediments. A March 1984 survey indicated a number of metals violations in the final effluent. In addition, high levels of chromium (0.45%), copper (2.5%), iron (2.2%), lead (1.0%), tin (3.0%), and silver (0.25%) were found in the sediments immediately below the outfall. The stream bottom was a light blue color, indicating the presence of high concentrations of these metals.

A Daphnia magna 48-hour toxicity bioassay included in this survey was stopped after 17 hours because all organisms were killed. All fathead minnows (Pimephales promelas) died within four hours after they were placed in 100% effluent. Since this was a simple screening test, no dilutions were used with the fish. Enforcement proceedings are currently underway to bring the company into compliance.

Another industry with a history of water quality problems in the St. Joseph River basin is Ralph Sechler and Sons, Inc., in St. Joe. This is a fruit and vegetable pickling firm that discharges seasonally. BOD and suspended solids waste are treated in an aerated lagoon system. However, since 1976, notices of NPDES permit violations have been issued regularly. An inspection in 1977 revealed that their lagoons were not functioning properly because they were full of pickle sludge. A 1982 permit review indicated they could not meet their NPDES effluent limitations because of an inadequate treatment system. A 1982 investigation of the receiving stream by ISBH staff indicated extensive sludge deposits were found below the treatment lagoon discharge to Hindman Ditch, a tributary to Bear Creek and the St. Joseph River. The receiving stream is small, and Sechler supplies most, if not all, of the flow during portions of the year. The company is now taking the necessary action to alleviate these water quality problems.

The Maumee River originates in Fort Wayne at the confluence of the St. Joseph and St. Mary's rivers. The Fort Wayne sewage treatment facility, which discharges a short distance downstream, was expanded in the mid-1970s from 32 mgd to 60 mgd with AWT facilities and storm water retention ponds. The effluent from the plant is of excellent quality and is causing little or no degradation of the Maumee River. Sewage problems still exist in the Fort Wayne area, however, with 47 combined sewer overflows discharging to the Maumee River from its point of origin to New Haven. Three thousand three hundred fish were killed by low dissolved oxygen in July 1982 as a result of combined sewer overflows after a heavy rain. The CSO problem is currently being addressed.

"The effluent from the plant is of excellent quality and is causing little or no degradation of the Maumee River. Sewage problems still exist in the Fort Wayne area, however, with 47 combined sewer overflows discharging to the Maumee River from its point of origin to New Haven."

The metropolitan Fort Wayne area includes a number of industries. The most concentrated area is on the east side where an industrial complex is located. Rea Magnet Wire, Phelps Dodge, Gladieux Refinery, ITT-Aerospace/Optical Division, and Falstaff Brewing Company all discharge directly to the Maumee River or to small tributaries. Until its recent closing, the International Harvester production facility discharged to Harvester Ditch, a Maumee River tributary.

In 1982, a soil conservation demonstration project sponsored by the U.S. EPA Great Lakes National Program Office was conducted in the Maumee River Basin in Indiana. The object of the project was to demonstrate that no-till or ridge-till farming practices would be economically feasible while minimizing soil erosion and improving water quality in the basin. Approximately 1,800 acres in six Indiana counties were involved. Guidelines for the farming methods were outlined, and the yields from the test plots that were farmed using these methods were presented. These data indicated that no-till or ridge-till farming could benefit water quality and be economically advantageous for farmers in many instances.

"These data indicated that no-till or ridge-till farming could benefit water quality and be economically advantageous for farmers in many instances."

Comparison of the Maumee River Fixed Water Quality Monitoring Station upstream of the Fort Wayne sewage treatment facility and industrial complex (M-116) with the downstream station in New Haven (M-110) show little differences except for ammonia concentrations, which are higher downstream. The relatively high phosphorus values in the Maumee come from the St. Joseph and St. Mary's watersheds as discussed previously.

State water quality standards in almost all cases are being met for the whole basin. Exceptions are fecal coliform values (exceed standard in approximately 20% of samples) and a limited number of dissolved oxygen and copper values. From these data, it can be concluded that the designated uses of the Maumee River Basin are being attained.

Biological surveys in the basin since 1979 have included collections of fish tissue for toxic analysis at stations STJ-0 (mouth of St. Joseph) and the Maumee River downstream from the Fort Wayne sewage treatment facility discharge (approximate river mile 114). Tissue samples collected in 1979, 1980, and 1982 contained no materials in excess of Federal Food and Drug Administration action levels. The fish community appears to be healthy and diverse in both the St. Joseph and Maumee rivers. An abundance of game fish was found, including walleye, bass, and northern pike. The significance of these findings is discussed later in this report.

"The fish community appears to be healthy and diverse in both the St. Joseph and Maumee rivers."

Kankakee River Basin

The Kankakee River Basin (Figure 12) drains about 3,000 square miles of northern Indiana before flowing westward into Illinois. Major tributaries in Indiana include the Iroquois and Yellow rivers. The largest cities in the watershed are LaPorte and Plymouth, and most of the area is extensively farmed. There are relatively few industrial or municipal discharges in the basin.

Many of the present characteristics of the Kankakee Basin are due to the geologic history of the area. Glaciers flattened the region, and moraines formed by the melting ice made the basin lower than surrounding areas. Sand was deposited in this low area by the melting glacier, and much of this lowland became a gigantic marsh. Beginning in the mid- 1800s, ditches were dug throughout the basin to improve drainage for farming. Today most of the streams in the basin have been dredged and straightened. The basin is still flood-prone, but nearly all of it is farmed. Most of the streamflow is made up of groundwater, providing a relatively constant discharge of cool water throughout the year.

Despite extensive channelization, the Kankakee Basin still provides some excellent stream fisheries. The Little Kankakee River is a put-and-take trout fishery. The state record northern pike was taken from the Yellow River in 1983. Forty-eight species of fish, including a variety of game fish, were collected in the Kankakee River by the Indiana Department of Natural Resources in 1981. The Kankakee also supports a unique and extremely diverse population of caddisflies, whose larval stage is completely aquatic and is an important fish food. Parts of the river are used frequently for canoeing. The use designations for streams in the basin include aquatic life (for both cold water and warm water fisheries) and partial-body contact.

"Despite extensive channelization, the Kankakee Basin still provides some excellent stream fisheries."

There are two Fixed Water Quality Monitoring Stations in the basin (KR-65 and KR-125). Water quality is suitable for aquatic life at both stations.

"Water quality continues to be good throughout most of the basin."

Coliform bacteria criteria for partial-body contact recreation is frequently not met at one station (KR-125), but no specific point source discharges appear to be responsible. Water quality continues to be good throughout most of the basin.

Figure 12. Kankakee River Drainage Basin.

Water quality in the upper Yellow River has improved since 1980 with the expansion of the Bremen sewage treatment facility. Ammonia, biochemical oxygen demand and suspended solids concentrations have been reduced, and fewer sewage bypasses occur. Other towns in the Kankakee Basin with new or expanded sewage treatment facilities include Schneider, Brook, Lowell, Hebron, and DeMotte.

Problems still exist in the Yellow River downstream of Plymouth. A major fish kill occurred in the river in September of 1983 due to the discharge from the Plymouth sewage treatment facility. Compliance sampling inspections in November of 1983 on both the sewage treatment facility and four of the major industries revealed that the poor operation of the sewage treatment facility was primarily due to heavy industrial loadings. These 24-hour surveys at the industries showed their effluents had: rapidly fluctuating pH values; pH values which ranged from less than 4.0 to greater than 10.0; high oil and grease concentrations; high BOD_5 concentrations; high temperatures in some instances; and low dissolved oxygen values. Many of these same problems were reflected in the effluent from the sewage treatment facility. Under these raw sewage loadings, the sewage treatment facility was unable to meet its NPDES permit limits. Bypassing of sewage may also add to the problem in the Yellow River. The city has applied for funding for an industrial pretreatment program, and approval of the program is expected. This program should help alleviate some of the problems at the sewage treatment facility. At the present time, enforcement action against the city and the industries involved is pending.

Toxic substances do not appear to be a threat to water use in the Kankakee Basin. Metals and pesticide concentrations in fish collected from the Kankakee since 1979 are among the lowest in the state and are well below the levels affecting human health.

"Toxic substances do not appear to be a threat to water use in the Kankakee Basin."

Wabash River Basin

The Wabash River Basin provides drainage for approximately 33,000 square miles of the surface area of Illinois, Indiana, and Ohio. The greatest portion of the basin is in Indiana, where it drains two-thirds of the state's surface area (Figure 13). The portion of the river system which will be addressed here excludes the White River drainage basin, and is therefore limited to about 21,000 square miles.

There are five large Corps of Engineers impoundments on the 450 mile river mainstem and its tributaries, and two elongated lakes were created on one tributary by construction of hydroelectric power facility dams. All of these water bodies provide a variety of uses which affect the degree of quality that must be maintained in their waters.

ISPCB Regulation 330 IAC 1-1 establishes the water quality standards of the Wabash River Basin. In general, the river and its tributaries are designated for partial body contact recreation and maintenance of a warm water fish community; the lakes and reservoirs are more protectively designated for whole-body contact recreation, as is the portion of the river mainstem which forms the common boundary with Illinois.

A number of streams within the basin have been proposed for designation as either "limited" or "exceptional" use and would be subject to a wider range of limitations. Exceptional use streams provide unusual aquatic habitat, are an integral feature of an area of exceptional natural character, or support unique assemblages of aquatic organisms; their quality must be maintained without degradation. All eight of the streams proposed for exceptional use to date are Wabash River tributaries. In addition, two of the state's four "State Resource Waters" are tributary segments within the basin.

Because of its size, and the variety of uses to which it is subjected, water quality within the basin varies widely. Urbanization, agriculture, and industry all have affected the basin with a diversity of wastes from, in part, municipal sewage treatment facilities, cropland runoff, chemical manufacturing facilities, steam-electric power plants, steel processing plants, and coal mines. (Figure 14 shows the relationship of the state's coal mine area to the basin.)The combined impact which oxygen demanding waste waters have on the middle portion of the river mainstem has been sufficient to warrant an extensive sampling and modeling venture for preparation of a wasteload allocation governing the significant dischargers.

Of the variety of factors affecting the streams in this basin, one which is seldom addressed is the combined effect of confined feedlots which are concentrated in several of the northern counties. In general, well operated swine, poultry, and cattle operations collectively form a significant industry and are an asset to the economy. Unfortunately, however, incidents can occur which are detrimental to the environment. Although there is no permitted discharge from these facilities, inadequate care in their operation or excessive

Figure 13. Wabash and Patoka River Drainage Basin.

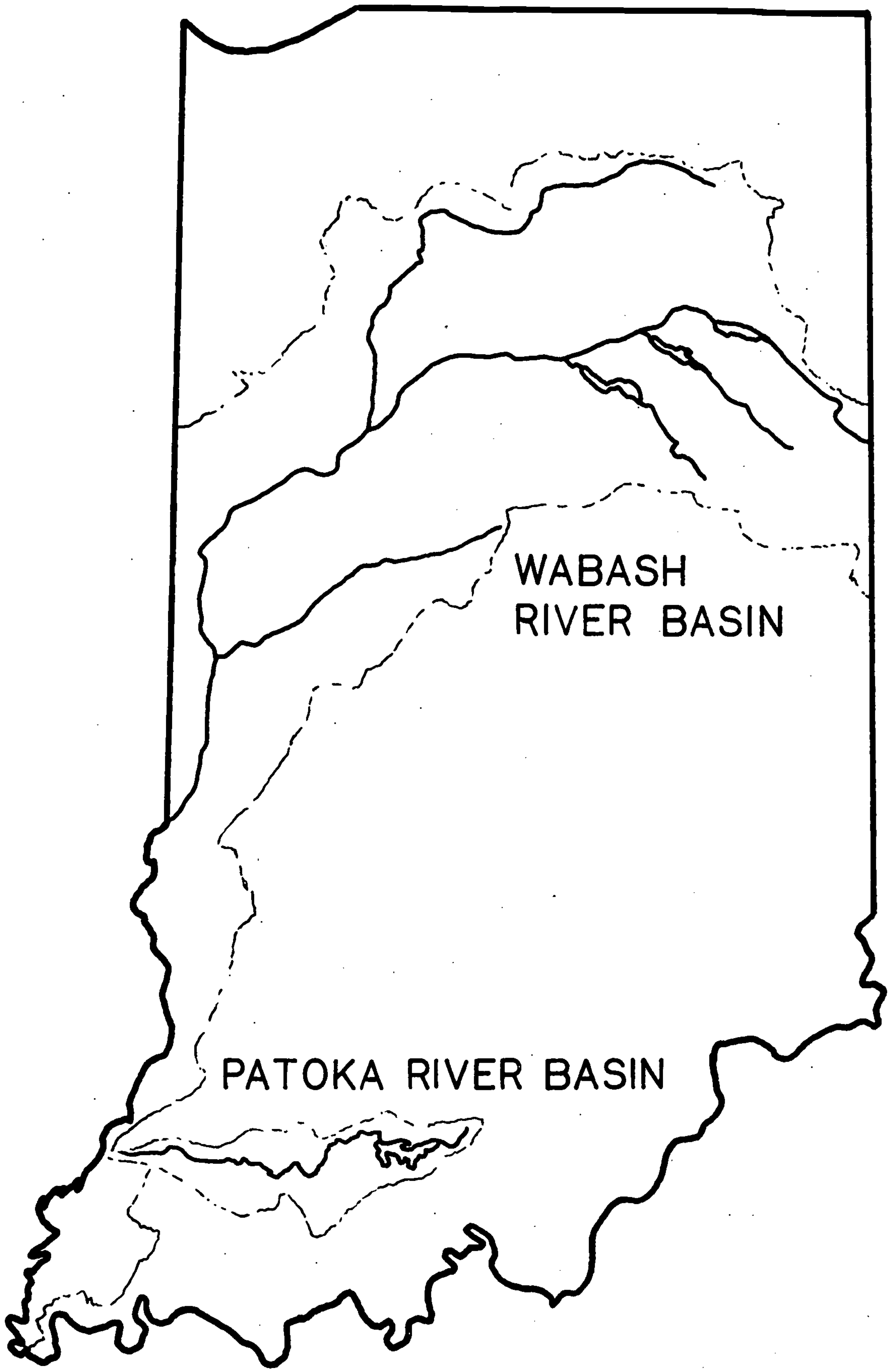
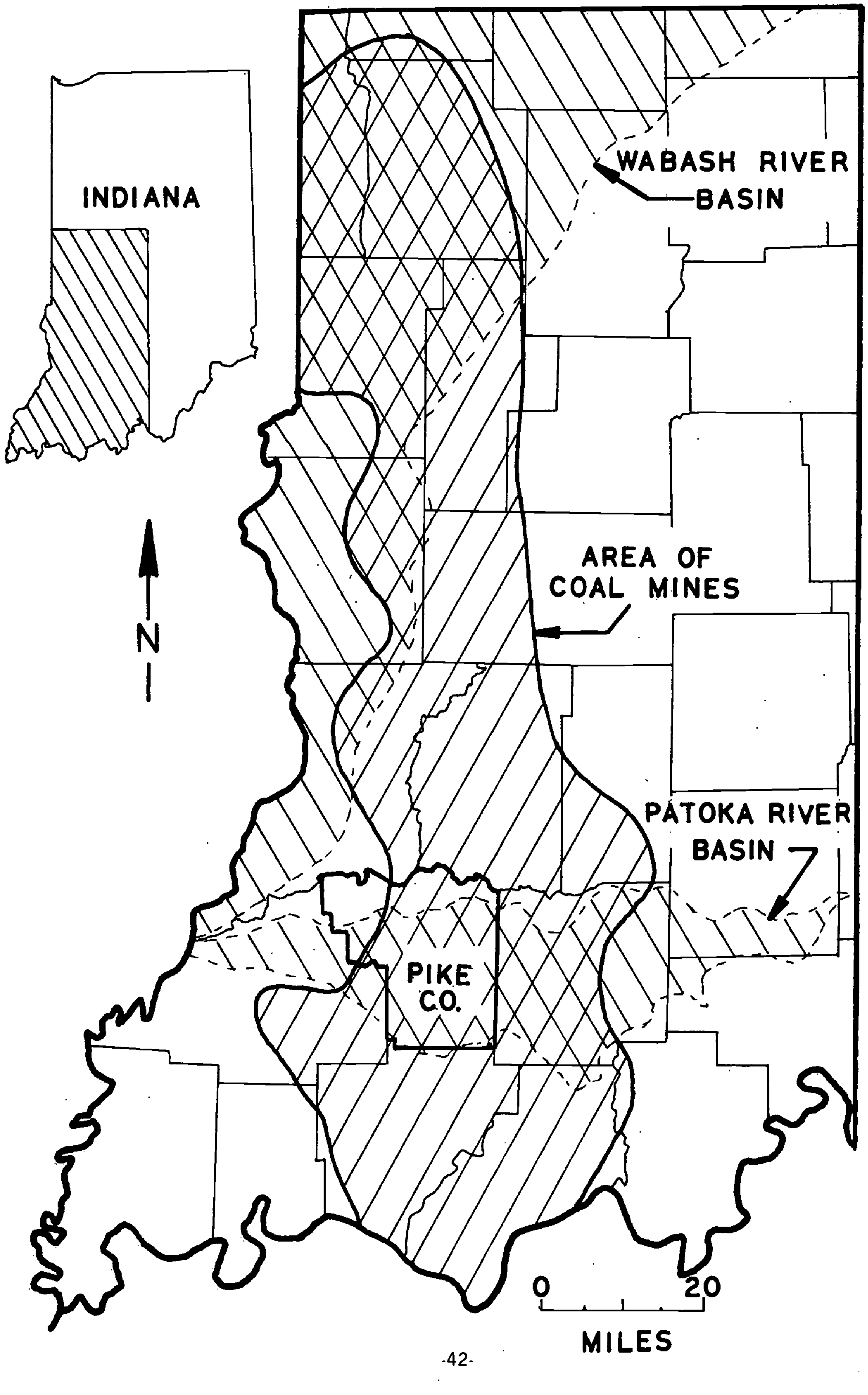


Figure 14. The southwest portion of Indiana showing the area of coal mining activity in the state.



It is impossible to assess the total impact which the confined feeding operations have on streams in the river basin, but, because of the large number of facilities which exist and the number of documented problems with some, it is probable that there is an impact in some areas. This is particularly true if the effect of nonpoint source runoff is considered in the assessment, for a portion of even properly land applied waste will be washed into nearby streams during heavy rains and produce some effect.

Because of its size, the basin can be subdivided into major tributary systems and mainstem segments for a more definitive analysis. The uppermost portion of the Wabash River proper originates at Grand Lake in Mercer County, Ohio. It flows westward approximately 15 miles to the Indiana/Ohio state line (R.M. 465.6), and then through parts of four Indiana counties to become 900 acre Huntington Reservoir, with its dam at river mile 411.4. Three municipal sewage treatment facilities, as well as a number of industries, discharge their wastewaters to this portion of the river.

In general, this entire river segment is consistently able to meet the standards for all designated uses, i.e., partial-body contact recreation in most portions, whole body contact recreation in the reservoir and potable water supply in the vicinity of Bluffton and Huntington. Biological sampling for fish and macroinvertebrates from the Fixed Water Quality Monitoring Station near Bluffton (WB-426) shows that communities of these organisms are healthy and diverse and indicate good water quality.

"Biological sampling for fish and macroinvertebrates from the Fixed Water Quality Monitoring Station near Bluffton (WB-426) shows that communities of these organisms are healthy and diverse and indicate good water quality."

Downstream from Huntington Reservoir the river is joined by the Little River, which passes through the City of Huntington. Although the city's advanced waste treatment (AWT) facility discharges a high quality effluent to the Wabash River mainstem, the city's combined sewer overflows into Little River continue to be a problem.

The Salamonie River is the first major tributary to the Wabash and joins it at R.M. 394 in Wabash County. Prior to that point of confluence, the Salamonie River is impounded to form the 2,800 acre Salamonie Reservoir.

Of the municipal sewage treatment facilities which are located on the Salamonie River, the Portland plant, which is the farthest upstream, is the most significant. Its recent conversion to activitated sludge has resulted in a remarkable improvement in the quality of its effluent. As a result, ammonia and fecal coliform bacteria values downstream from the plant have decreased greatly. However, bypassing and combined sewer overflows present a water quality problem that is yet to be resolved.

In general, the condition of the Salamonie River and Reservoir is acceptable, in terms of water quality. Aside from storm-related sewer overflows, occasional operational problems, and spills, the various municipal and industrial dischargers are having little adverse effect on the stream.

The Mississinewa River, which is the next major tributary of the Wabash, has its confluence upstream from Peru at R.M. 375 after having passed through parts of five counties and forming a 3,180 acre flood control and recreational reservoir (Mississinewa Reservoir). The most significant discharges to this river system are from Hartford City and Marion. The Hartford City municipal treatment facility has been extensively upgraded and operates quite efficiently. However, Little Lick Creek, its receiving stream, is still plagued by combined sewer overflows. The Marion sewage treatment facility has been improved and also produces a high quality effluent. Data collected from Fixed Water Quality Monitoring Stations along the river do not indicate any significant water quality problems and generally indicate an overall improvement in the degree of waste treatment provided. The data also indicate that discharges from industrial facilities into the river do not cause any violations of water quality standards. The river and reservoir are therefore able to meet the uses for which they are designated.

"Data collected from Fixed Water Quality Monitoring Stations along the river do not indicate any significant water quality problems and generally indicate an overall improvement in the degree of waste treatment provided."

The Eel River, which joins the Wabash at R.M. 354, and its tributaries drain portions of seven counties. This river system receives effluent from four municipal sewage treatment facilities as well as a number of industries and semipublic facilities. Water quality overall is adequate to sustain a notable smallmouth bass fishery, although recent evaluations have shown a decline in that population over a ten-year period. Since the fish apparently flourished in the stream when wastewater from the treatment facilities was, for the most part, inadequately treated, it would be illogical to deduce that the apparent decline is attributable to point source pollution as Columbia City's sewage treatment facility is the only plant which still periodically produces a substandard effluent. It would seem that either the river is possibly overfished or bass reproduction is being impeded by physical alteration of the stream channel and/or nonpoint source pollutants such as those carried by cropland runoff.

The Tippecanoe River, which enters the Wabash at R.M. 322, arises in northeastern Indiana from a multitude of lakes which provide an almost continuous flow, even in the extreme headwaters. The 160+ mile long river provides drainage for five counties and, at its lower end, powers two hydroelectric generation units at dams which form a pair of recreational lakes, in series.

Water quality in the Tippecanoe River and its tributaries is typically satisfactory, and the quality of the fishery is quite high. The most significant industrial dischargers are concentrated in Kosciusko County on the upstream portions of the river. Although most of their wastewaters have been improved to the point of compliance, there are still periodic localized water quality problems in tributaries. A short distance downstream, the wastes are satisfactorily assimilated by the river and all designated uses are readily attained. At its lower end, the river is transformed into Lakes Freeman and Shafer by dams constructed in the 1920s. The two popular recreational lakes provide high quality water for their users. The most significant problem is the wet-weather bypasses which enter Lake Freeman from Monticello sewers.

"Water quality in the Tippecanoe River and its tributaries is typically satisfactory, and the quality of the fishery is quite high."

Carroll County, through which the Tippecanoe River passes, also accommodates a portion of the Wabash River and a number of its lesser tributaries. The county is heavily populated by confined feeding operations which, although a boon to the economy, can be detrimental to the water quality of the tributaries. These operations have, over the years, been responsible for a large number of fish kills, as well as less noticeable problems, in small streams in the county. As was previously mentioned, the events are attributable to improper disposal of the facilities' wastes.

The next significant downstream tributary of the Wabash is 80 mile long Wildcat Creek, which is most affected by discharges in the Kokomo area. Recent improvements (1977-1979) in the Kokomo sewage treatment facility have resulted in a high quality effluent and water quality improvements downstream. Improved waste treatment at several industries has also contributed to improved water quality in Wildcat Creek. These improvements are reflected in comparisons of water quality data from the Fixed Water Quality Monitoring Station (WC-63) just downstream of Kokomo. Comparisons of data from 1974 to 1976 with that from 1981 to 1983 show that concentrations of un-ionized ammonia, fecal coliform bacteria, copper, and zinc have dramatically decreased while dissolved oxygen concentration have increased. Violations of state water quality standards, which once were common, rarely occur now. However, combined sewer overflows and some industrial discharges still affect the stream periodically, and the fish community has not yet fully recovered in this portion of Wildcat Creek. As these problems are resolved, the fishery is expected to return.

"Violations of state water quality standards, which once were common, rarely occur now."

The Frankfort sewage treatment facility, which discharges to a tributary of the South Fork of Wildcat Creek, has been upgraded and now discharges a high quality effluent. The receiving stream quality has been greatly improved, and it now meets its use designations. Downstream from its affected portion, the lower 40 miles of the mainstem of Wildcat Creek, and the last 15 miles of the South Fork provide excellent canoeing opportunities with abundant wildlife, picturesque riparian vegetation, and quality fishing. Because of that high quality, these portions of the streams have been designated as a State Resource Water which "...shall be maintained in their present high quality without degradation."

"The receiving stream quality has been greatly improved, and it now meets its use designations."

Downstream from its confluence with Wildcat Creek the Wabash passes through the cities of Lafayette and West Lafayette where heavy municipal and industrial wastewater loads begin to test the river's assimilative capacity. This is the upstream starting point for a 150 mile section which is presently the object of an extensive sampling and computer analysis program designed to resolve disagreements between the Indiana Stream Pollution Control Board (ISPCB) and the river's industrial dischargers regarding their effluent limitations. The necessary data have been collected and a consultant is now developing a model to be used for wasteload allocations.

The reach of the Wabash River just below Lafayette has been an area where water quality problems have occurred. Poorly treated wastes from the Lafayette municipal treatment facilities combined with inadequately treated effluents from some of the local industries had a noticeable impact on the water quality and biota of this part of the Wabash. Gammon (3), in a study of the fish populations of the Middle Wabash River published in 1976, indicated that these influences drastically altered the fish community for 10-15 miles below Lafayette. Redhorse suckers and game fish (except for an occassional sauger) were virtually absent from this area.

The Lafayette sewage treatment facility has been upgraded and expanded since 1976 and now discharges highly treated, good quality effluent. Most industrial dischargers have also improved their treatment processes, and water quality in this reach of the river seems to be improving. Fish collections made since 1979 in conjunction with the CORE program at the station below Lafayette (WB-292) have indicated that the fish community may be improving in this reach, although, admittedly, these data are not as detailed as the 1976 study. However, redhorse suckers, white bass, largemouth and smallmouth bass, sauger, crappie, and several other centrarchid species are found in these collections. Collections usually consist of 15 to 18 species which would be comparable to the diversity found in other CORE samples from areas where water quality is relatively good. Population sizes in some instances may still be depressed as large numbers of some species are not taken. Macroinvertebrate data from Hester-Dendy samples from this station (since 1979) show numbers and kinds of organisms comparable to the samples collected upstream from Lafayette and are generally indicative of good water quality.

"Macroinvertebrate data from Hester-Dendy samples from this station (since 1979) show numbers and kinds of organisms comparable to the samples collected upstream from Lafayette and are generally indicative of good water quality."

An even more specific problem which has been identified in the Lafayette area has resulted from wastewater discharge and stormwater runoff from an industrial facility into Elliot Ditch, and then to Wea Creek (a tributary of the Wabash). PCBs from the wastewater have accumulated in fish and sediment in the streams and have rendered the fish unsuitable for consumption. The state and the responsible industry are working together to remedy the situation.

In contrast, the next downstream tributary, Big Pine Creek, which has a drainage area of approximately 325 square miles, is a scenic stream of exceptional quality which is subjected to significant recreational usage, particularly by canoeists and fishermen. Approximately 25 miles of Big Pine Creek and its tributaries have been designated for "Exceptional Use." The creek flows into the Wabash River near Attica, where a municipal and several industrial wastewater discharges are located.

The Big Vermilion River, which joins the Wabash River near Cayuga, Indiana, drains approximately 1,400 square miles of largely agricultural land principally in Illinois. The last ten miles of the river, which are within Indiana's borders, often show signs of pollution from upstream municipal and industrial dischargers in Illinois, as well as runoff from abandoned surface coal mines and cropland. Studies of the Vermilion River's fish communities from Danville, Illinois, to its confluence with the Wabash (4) have revealed evidence of an environmentally impaired fishery which is inconsistent with the high quality natural habitat. It was surmised that wastewater-related degradation which is evident in the Danville area is compounded downstream by lateral erosion.

Approximately 5 miles downstream from the Big Vermilion River the 1,075 megawatt Public Service Indiana Cayuga Electrical Generating Station utilizes the river for once-through cooling. The potential effect of the plant is a concern because of its ability to withdraw a major portion of the river's flow for its cooling needs. Obviously, such a situation could have a disastrous impact on the aquatic biota in the river bend between the intake and discharge.

More controversy arises from the plant's more usual, day-to-day operations and their effect on river temperatures, however. Disputes regarding the discharge have revolved around the issues of whether the river's fish community has been significantly altered by the added heat and possibly the effect of the intake. The issues would be much simpler to resolve if it were not for the fact that organic discharges, such as that from nearby Inland Container, also have a potential affect on the dissolved oxygen content of the water, the oxygen-retaining capability of which has already been limited by its increased temperature. Sampling data have revealed that a significant oxygen "sag" does occur in the section of the river between Cayuga and Montezuma. The exact causes of the depletion have not yet been ascertained, but it is related to a combination of factors, including a rather high sediment oxygen demand. Downstream from the oxygendepleting zone, oxygen content of the water returns to normal levels, consistent with state water quality standards. The dispute is further compounded by another heated discharge from the 937 megawatt Wabash Valley Generating Station downstream, as well as other significant industrial and municipal oxygen-consuming discharges at various points along the river as far downstream as Terre Haute.

"Overall, water quality in the creek's upper reaches is acceptable, as the result of improvements to the various sewage treatment facilities which discharge into it."

Sugar Creek, the next major tributary downstream, enters the Wabash from the east. Overall, water quality in the creek's upper reaches is acceptable, as the result of improvements to the various sewage treatment facilities which discharge into it. The most notable of these have been at Darlington and downstream at Crawfordsville near R.M. 40. The only evidence of sewage pollution at this time is intermittent violations of the fecal coliform bacteria standard, probably attributable to combined sewer overflows. As was noted by Gammon and Riggs (4), downstream from the zone of potential pollution..." from R.M. 30 to R.M. 10 Sugar Creek flows through a rugged, forested region..." which provides a wooded corridor that buffers the creek from agricultural fields. They found the creek's best fish communities in that region, terming them "...perhaps as good as any in the State of Indiana... with a particular abundance of smallmouth bass." Unfortunately, "...another zone of degradation occurs in the lower 15 miles of stream largely because of agriculture." Generally, though, the creek's quality is good and it is an important recreational resource for "...thousands of campers, canoeists, and fishermen."

"They found the creek's best fish communities in that region, terming them "...perhaps as good as any in the State of Indiana... with a particular abundance of smallmouth bass."

Big Raccoon Creek, the next tributary of significant size, is dammed approximately halfway down its length to form 2,060 acre Mansfield Reservoir (Cecil M. Harden Lake). The creek and reservoir are noted for their excellent fishery—particularly for the white bass which are most evident during upstream spring spawning runs.

"The creek and reservoir are noted for their excellent fishery—particularly for the white bass which are most evident during upstream spring spawning runs."

As the Wabash River flows through Terre Haute it receives biochemically oxygen demanding wastewaters from the municipal sewage treatment facility and industrial dischargers. Coal Creek, which enters upstream, and Sugar Creek, which merges with the Wabash downstream of Terre Haute, contribute acid mine drainage to the river. Biological data indicate that certain fish species are absent or numerically depressed both above and below Terre Haute at least during certain times of the year (summer and fall). This section of the river is the third (after the Lafayette and Montezuma areas) where the fish community seems to be negatively affected by human activity. However, macroinvertebrate samples collected above and below Terre Haute are similar to each other and to macroinvertebrate samples collected at other Wabash River macroinvertebrate sampling stations. These samples generally contained organisms indicative of good water quality. Thus, although physical, chemical, and macroinvertebrate data would indicate generally good water quality in this section of the river, fish populations do appear to be affected.

From approximately ten miles downstream from Terre Haute to its confluence with the Ohio River, the Wabash River becomes the boundary between Illinois and Indiana. The only significance of this, with regard to water quality, is that limitations for "whole-body contact" rather than "partial-body contact" recreation are applicable.

Throughout its middle and lower portions the Wabash is utilized to some extent by commercial fishermen. One effect of the various discharges on the river has been a decline in the fishery in the three previously noted areas, but a variety of temperature and pollution-tolerant fish species can still be found in numbers sufficient to support a minor industry. In addition to this fin fishery, the Wabash is noted for the large number of shellfish which are commercially harvested, constituting an important resource. Although the volume of shells is now only a small percentage of its peak at the turn of the century, it is nonetheless significant, for the shells are highly valued by the Japanese cultured pearl industry.

Approximately twenty miles downstream from Terre Haute, the river receives cooling water from the 420 megawatt Indiana & Michigan (I&M) Breed Generating Station and then, after ten more miles, from an electrical generating plant at Hutsonville, Illinois. Ten miles downstream from that point, at Merom, Indiana, Turtle Creek has been dammed to create 1,550 acre Merom Lake (Turtle Creek Reservoir). The impoundment, which was designed as a cooling water reservoir for Hoosier Energy's 980 mw powerplant, also serves as a fishing lake. The Indiana Department of Natural Resources stocked the completed reservoir with a mixture of game fish and will manage the reservoir for sport fishing. Plant operation began in 1982, and it is still too early to determine how the heated water from the plant will affect the fishery.

The next major downstream tributary of the Wabash is Busseron Creek, which provides drainage for a large portion of Sullivan County. There are a number of large, active surface coal mining operations in the county whose discharges are generally in compliance with their NPDES permits. However, there are also abandoned mining facilities whose unreclaimed terrain and gob piles at times contaminate surface waters of smaller tributaries such as Sulphur Creek.

As the Wabash River continues its course along the western border of Knox County, it is met at R.M. 130 by Smalls Creek which, like Sulphur Creek, is afflicted by drainage from an abandoned strip mine and sustains almost no aquatic life for most of its length. Approximately two miles downstream, the river passes through Vincennes which has an efficient, underloaded municipal sewage treatment facility and few industrial dischargers. Consequently, although the wastewater quantity is significant, it has no great impact on the water quality of the Wabash. Three miles further downstream, the Embarras River flows eastward from a relatively undeveloped portion of Illinois to converge with the Wabash. Although it provides drainage for 2,400 square miles, it has little negative effect on the Wabash.

The White River, which is discussed separately, joins the Wabash at R.M. 95 and is its largest tributary. Less than a mile downstream from the White River confluence, the Patoka River merges with the Wabash. This stream, which originates in Orange County in the midst of the Hoosier National Forest, is dammed at R.M. 118, near its headwaters, to form 2,010 acre Patoka Lake. The lake was created for flood control and recreation. The middle portion of the river's drainage basin, particularly in Pike County, has for many years been subjected to persistent pollution by runoff from abandoned surface coal mining facilities. Pike County ranks higher than any other in the state, in terms of quantity of derelict land resulting from mining activities, with a total of 3,800 acres (Figure 14). The South Fork of the Patoka is virtually surrounded by derelict land, and its effect on water quality in the Patoka mainstem is shown by the decreased fishery downstream from the confluence. Significant efforts are underway, however, to attempt reclamation of portions of the area, and fish are reported to be returning to the South Fork of the Patoka River.

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The Town of Winslow, located in the center of Pike County, withdraws water from the river for its potable use, and the town has been plagued for decades by poor raw water quality. Even today the town must filter the water through carbon and subject it to a variety of other treatments in order to render it suitable for consumption.

Public Service Indiana operates its Gibson Power Plant a few miles downstream from the Patoka/Wabash River confluence. The plant was constructed on the shore of man-made Gibson Lake, which is used as a condenser cooling water reservoir and precludes the need for discharge of heated water to the Wabash River. Millions of gallons of water are pumped from the river each day for plant make-up water, however.

For the remaining eighty miles to the Ohio River, the Wabash flows through a sparsely inhabited, unindustrialized area. There is little notable effect on water quality from discharges on the Indiana side, aside from typical agricultural runoff.

The West Fork of the White River Basin

The West Fork of White River system begins in Randolph County about five miles southeast of Winchester in eastern Indiana. The two headwaters giving rise to the West Fork of White River are the White River Branch and Owl Creek which join to form the main stream. The West Fork of White River flows southwest from this site through eleven Indiana counties and drains approximately 5,600 square miles (Figure 15). The major tributaries to this river would include: Pipe Creek, Fall Creek, Cicero Creek, Eagle Creek, Killbuck Creek, White Lick Creek, Eel River, and the East Fork of White River. The East Fork of White River joins the West Fork of White River a few miles upstream of Petersburg in Pike County, and the White River then flows west to the Wabash River near the western Indiana town of East Mount Carmel in Gibson County.

Nonpoint agricultural runoff causing siltation, phosphorus and nitrogen enrichment, and possible pesticide contamination is of present and future concern now that the point sources are largely under control. All of the counties bordering the West Fork of White River have some degree of nonpoint runoff problems. Most of the stabilizing forest cover was indiscriminately cut many years ago throughout these counties, and present farming methods, which are designed to place the maximum amount of land under crop production, have caused the removal of fence rows and brush cover which formerly greatly reduced erosion and runoff. However, some improvements in watershed management have been noted along the West Fork of White River and its tributaries during the past decade. Federal and county agencies have promoted soil conservation practices with the cooperation of many farmers; however, nonpoint runoff is expected to remain a matter of concern.

All of the counties bordering the West Fork of White River and its tributaries contain livestock confined feeding operations. Some of these operations have caused severe water quality problems when there were accidental or intentional discharges of animal wastes to the streams, ditches and fields. More stringent confined feeding control laws, which have been in existence for at least 10 years, have resulted in decreased water quality problems from this source.

Much has also been done on the West Fork of White River to reduce or eliminate point sources of pollution. Several communities have built new sewage treatment facilities or upgraded existing plants in the past few years. As a result, vast improvements in the water quality of the West Fork of White River have been seen, especially in the portion above Indianapolis. The recent (1983) upgrading of the two municipal sewage treatment facilities at Indianapolis will result in similar water quality improvements downstream of Indianapolis in the near future.

"As a result, vast improvements in the water quality of the West Fork of White River have been seen, especially in the portion above Indianapolis."

Winchester, Parker City, and Farmland are all relatively small communities which have sewage treatment facilities that discharge to the West Fork of White River or its tributaries in Randolph County. Data from the Fixed Water Quality Monitoring Station (WR-250) located upstream of Winchester indicate few water quality problems in this area. The standard for fecal coliform bacteria was violated at this station in approximately 20% of the samples from 1978 to 1983. These violations were relatively small and may have originated from livestock, as the station is located in an area where many cattle are kept. These are the only water quality violations found.

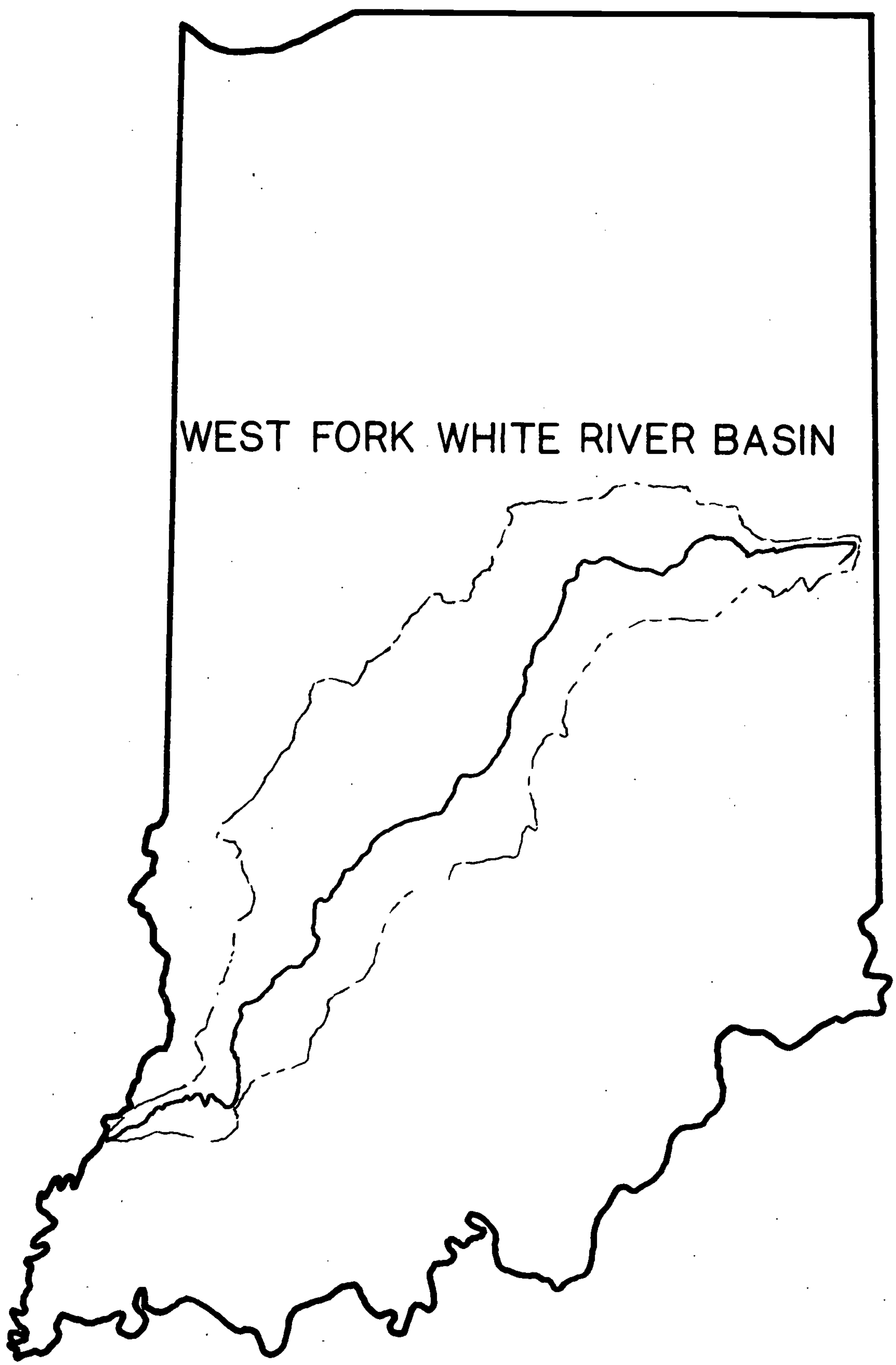
Sediment samples collected at this station in 1981 contained relatively high levels of certain metals, some chlordane isomers and PCBs. In 1982, analysis of sediment samples collected from a small tributary near this station and both upstream and downstream of the tributary in the West Fork of White River indicated that materials found in the downstream sediments came from this tributary. This tributary originates at a field tile which apparently drains an area near the Anchor Hocking Plant. Indiana State Board of Health (ISBH) records indicate that Anchor Hocking discharged wastewater to this tributary in the past, but apparently does not at the present time. The situation is being investigated to determine the source of these pollutants and to initiate appropriate corrective action.

Despite contamination of the sediment, a rather diverse fish community exists at this "CORE" staton (WR-350). In 1982, 15 species of fish including several species of centrarchids (bass and sunfish) grass pickerel, darters, and minnows were collected. Artificial substrate samplers contained diverse assemblages of macroinvertebrates including several genera that are regarded as "clean water" or "pollution-intolerant." These samples included the juvenile stages of stoneflies, mayflies and caddisflies.

Two Fixed Water Quality Monitoring Stations are located in Delaware County. Station WR-319 is located downstream of Winchester, Parker City, and Farmland and upstream of Muncie. The fecal coliform bacteria standard is occasionally violated at this station, but no other water quality violations have occurred here during the past few years. Water quality is sufficient to support the designated uses of the West Fork of White River at this locality.

Fixed Water Quality Station WR-310 is located downstream of Muncie and upstream of Yorktown. Muncie is the largest city that discharges to the West Fork of White River in Delaware County. The sewage treatment facility was first placed in operation in 1941 and has been upgraded since 1978.

Figure 15. West Fork White River Drainage Basin.



Between 1975 and 1980, the standard for dissolved oxygen at station WR-310 was violated in 7 of 58 samples (12%). The lowest value was 2.1 mg/l. The fecal coliform standard was volated in 30 of 61 samples (49%), with a high value of 47,000/100 ml. Two of 41 samples (5%) had unionized ammonia values greater than 0.05 mg/l.

From 1981 to 1983, data from this station do not show any violations of dissolved oxygen standards, and fecal coliform violations (28%) were cut almost in half. The highest fecal coliform count was 11,000/100 ml. No un-ionized ammonia values above 0.05 mg/l were found. The improvement of water quality at this station reflects the improved treatment from the Muncie wastewater treatment facility.

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This improvement in water quality is also reflected in fish kill data. From 1973 to 1978 there were 10 fish kills in the Muncie area. Eight of these were in the West Fork of White River, and 2 were in tributaries. The causes of some of these fish kills were never positively determined, but they are believed to have resulted from bypassing of municipal and industrial waste. Since 1980, only 3 fish kills have occurred in this area of the West Fork of White River. One of these was reported as a "natural" die off.

The major population center in Madison County is Anderson. The Anderson sewage treatment facility was built in 1940 and was upgraded in 1976. The communities of Edgewood, Daleville, and Chesterfield are also served by the Anderson sewage treatment facility which discharges to the West Fork of White River.

Fixed Water Quality Monitoring Station WR-295 is located on the West Fork of White River in Anderson upstream from the sewage treatment facility. In the period from 1975 to 1980, the standard for fecal coliform bacteria was violated in 14 of 64 samples (22%) and one high copper value (60 ug/l) was found. Fecal coliform values ranged up to 97,000/100 ml.

Improvements have been seen at this station since 1981. No high copper values and only 5 exceedances of the fecal coliform standard have been reported. The highest fecal coliform value was 5,000/100 ml.

Fixed Water Quality Monitoring Station WR-280 is located at Perkinsville on the Hamilton/Madison County line. Data collected from this station reflects the water quality of the West Fork of White River after it is impacted by direct and indirect discharges in the Anderson area and before it is impacted by Pipe Creek and major Hamilton County sources. In the period from 1975 to 1980, copper values above 43 ug/l (the standard for water of 200 mg/l hardness from the EPA criteria document for copper) were found in 12 of 73 samples (16%), with values ranging up to 220 ug/l. The fecal coliform standard was exceeded in 17 of 74 samples (23%), with values ranging up to 20,000/100 ml.

Since 1981, no copper values above 43 ug/l and only 4 fecal coliform violations were found. These data would indicate that although water quality was good in this reach of the river, it has improved even more since 1981.

"These data would indicate that although water quality was good in this reach of the river, it has improved even more since 1981."

Pipe Creek either directly or indirectly receives municipal and/or industrial wastes from several relatively small communities in Madison County (Alexandria, Orestes, Gaston, and Summitville) and is a potential source of pollution of the West Fork of White River (although most of the length of Pipe Creek is in Madison County, the stream actually joins the West Fork of White River in Hamilton County). Water quality in Pipe Creek seems to be improving, based on fish kill reports. In the period from 1970 to 1973, there were 5 recorded fish kills in Pipe Creek; since 1973 no fish kills have been reported.

"In the period from 1970 to 1973, there were 5 recorded fish kills in Pipe Creek; since 1973 no fish kills have been reported."

The small communities of Atlanta, Sheridan, Arcadia, and Cicero in Hamilton County and Tipton (in Tipton County) all have sewage treatment facilities that discharge directly or indirectly to Morse Reservoir.

Although the treatment at these facilities has improved, they still contribute to the enrichment of the reservoir. At present, Cicero has phosphorus removal facilities, and a recent wasteload allocation study shows that phosphorus removal will be needed at Sheridan. The Sheridan sewage treatment facility discharges to Symon's Ditch which goes into Little Cicero Creek and then to Morse Reservoir. In 1980, Symon's Ditch was found to be severly degraded by poorly treated organic and inorganic waste from municipal and industrial sources, and Little Cicero Creek was also degraded periodically.

Sheridan has received a Step 3 construction grant for sewer construction and expansion and upgrading of the sewage treatment facility. Construction has begun on the project, and the water quality in Symon's Ditch and Little Cicero Creek is expected to be much improved when the project is completed.

Morse Reservoir is a highly eutrophic body of water. The reservoir's waters contain excess concentrations of phosphorus and nitrogen, and the bottom waters are depleted of oxygen during quiet, hot, summer and early fall periods. The discharge from Morse Reservoir can contribute water that is low in oxygen and potentially high in ammonia to Cicero Creek which goes to the West Fork of White River.

Noblesville, Westfield, Carmel, and Fishers are other towns with sewage treatment facilities that discharge to the West Fork of White River or its tributaries in Hamilton County. Most of these facilities were built or upgraded in the mid-1970s. Westfield has recently received a Step 4 grant to construct sewers connecting them to the Carmel sewage treatment facility which has already been upgraded and expanded.

Stoney Creek which joins the West Fork of White River near Noblesville contained rather high levels of PCBs (8.7 mg/kg) in the sediment when sampled in 1981. The source of these PCBs has been tentatively identified, and efforts are being made to determine the extent of the problem and the proper cleanup procedures.

There are few water quality problems in the West Fork of White River as it enters Marion County. The stream is a highly used resource, and conditions for boating and fishing are excellent. The aquatic life populations of the river are diverse and include "clean water" forms such as mayfly and caddisfly larvae and fresh water mussels. The fishery includes smallmouth bass, largemouth bass, crappie, bluegill, channel catfish, flathead catfish, carp, and other species.

"There are few water quality problems in the West Fork of White River as it enters Marion County. The stream is a highly used resource, and conditions for boating and fishing are excellent. The aquatic life populations of the river are diverse and include "clean water" forms such as mayfly and caddisfly larvae and fresh water mussels. The fishery includes smallmouth bass, largemouth bass, crappie, bluegill, channel catfish, flathead catfish, carp, and other species."

Fixed Water Quality Monitoring Station WR-249 is located at Nora in northern Marion County and reflects the condition of the river before it is affected by Indianapolis and other Marion County sources. In the period from 1975 to 1980, 2 copper values above 43 ug/l were recorded for this station, with the highest value being 130 ug/l. Fecal coliform standards were exceeded in 20% of the samples, with values ranging up to 89,000/100 ml. Since 1981, no copper values above 43 ug/l have been recorded, and fecal coliform numbers appear to have decreased. Approximately the same percentage of the samples show violations of the standard (18%), but the highest count since 1981 has been only 4,300/100 ml.

The Fixed Water Quality Monitoring Station IWC 6.6 is located at the point where the Indianapolis Water Company Canal branches off of the West Fork of White River in Broad Ripple. This station is also upstream of most of the Indianapolis and Marion County influences on the river. In the years 1975 to 1980, two copper values above 43 ug/l (3% of the samples) were found at this station, with a high value of 110 ug/l. Fecal coliform violations occurred about 11% of the time, with concentrations ranging up to 35,000/100 ml. Since 1981, no copper values above 43 ug/l have been found and fecal coliform concentrations have gone down (high value 5,100/100 ml). Large flocks of wild and domestic ducks are year round residents of this portion of the river and canal and may contribute to the fecal coliform violations.

The Broad Ripple Station (IWC 6.6) is also a "CORE" station for monitoring aquatic life. Hester-Dendy samplers placed in the river and canal at this location have revealed large, diverse communities of aquatic macroinvertebrates. A diverse fish community also exists at this locality including several species of suckers, several species of centrarchids (bass and sunfish), catfish, and minnows. However, fish tissue samples which have been analyzed for toxic substances show that there may be problems with chlordane, dieldrin, and PCBs in some fish at this locality.

The flow of the Indianapolis Water Company Canal is channeled south from the West Fork of White River in Broad Ripple, through northern Indianapolis, to the center part of the city where it discharges from an outfall near the Washington Street bridge. The canal is underground for several hundred feet in some sections. The water quality is relatively high in the canal, and it supports a good fish population along most of its length. Catches of better than average largemouth bass are taken from some sections of the canal. Indianapolis is planning to beautify segments of the canal and incorporate them into the new White River State Park.

The waters of the West Fork of White River are of good quality when they reach Indianapolis. As a result, the recreational use potential of the river has risen, and people are coming to the river for boating, canoeing and raft racing. The river supports a diverse warm water fishery. There are smallmouth bass from downstream of Noblesville to below Sixteenth Street in Indianapolis, and an extensive largemouth bass and channel catfish fishery exists in the river throughout Indianapolis. A noticeably large number of people each year are fishing the river, especially those stretches along White River Drive. (An excellent smallmouth bass fishery is also reported to exist in the West Fork of White River within the northern city limits of Muncie.)

The West Fork of White River, from the Nora water quality station downstream through Indianapolis as far as the discharges of the Indianapolis sewage treatment facilities, has greatly improved during the last decade. Communities and industries in upstream counties have installed better treatment facilities, watershed management practices have improved, and confined feeding operations are more closely regulated. Major and significant municipal and industrial dischargers are regularly monitored, and enforcement action has been taken against violators that repeatedly exceed permit limits.

"The West Fork of White River, from the Nora water quality station downstream through Indianapolis as far as the discharges of the Indianapolis sewage treatment facilities, has greatly improved during the last decade."

Several industries that formerly discharged to the West Fork of White River as it flowed through metropolitan Indianapolis are now connected to city sewers. Many defects in the sewer system of Indianapolis that caused untreated wastes to be discharged to the river have been corrected. However, there are still several storm sewers that discharge to Fall Creek and the river during storm events.

The nationally known Indianapolis Sports Center as well as sections of the Indiana University Medical and Law Schools have been constructed near the river. A multi-million dollar White River State Park is being planned along the river. This will result in increased water-based and water-enhanced recreational activities to be enjoyed by countless visitors each year. It is obvious that the West Fork of White River in Indianapolis would not have been a suitable site for such wide ranging developments without the improvements in water quality that have been made. It is equally obvious that an ongoing water quality maintenance program must be an important part of city and state planning.

The Whitestown and Zionsville sewage treatment facilities, Dow Chemical Company, and Economy Plating Company are major dischargers to Eagle Creek (a tributary to the West Fork of White River) and its tributaries in Boone County upstream of Eagle Creek Reservoir. The Northside Landfill and the now defunct EnviroChem recycling operation are located along Finley Creek, which also joins Eagle Creek above the reservoir. Drainage or seepage from this landfill area was suspected to be entering Finley Creek and then Eagle Creek. However, studies conducted on the streams involved indicate no concentrations of chemicals which would be harmful to aquatic life in Finley Creek, Eagle Creek, or Eagle Creek Reservoir. The potential for a problem remains, although it is lessened somewhat by the closing and cleanup of EnviroChem and the prohibition of dumping hazardous materials at Northside Landfill. These sites have had monitoring wells installed and an ongoing monitoring program is in operation.

The Fixed Water Quality Monitoring Station on Eagle Creek at Zionsville (EC-21) reflects water quality upstream of Eagle Creek Reservoir. In the period 1975 to 1980, one value for copper was greater than 43 ug/l and one value for mercury was greater than 4.1 ug/l. Fecal coliform standards were exceeded in about 12% of the samples. Since 1980, no copper or mercury values have been above 43 ug/l or 4.1 ug/l, respectively, but the number of fecal coliform violations have remained about the same.

Eagle Creek Reservoir is a heavily used water supply and recreational impoundment. It bounds the large Eagle Creek Park, and it has a beach and exclusive residential areas. Thousands of bank and boat fishermen use the reservoir, although it is not known as a particularly good fishery. No toxic problems with fish have been discovered.

Limnological surveys have revealed that Eagle Creek Reservoir is a euthrophic body of water and high in phosphorus and nitrogen. The bottom waters are periodically depleted of dissolved oxygen. There are extensive populations of planktonic algae in the reservoir, including blue-green species that are common in nuisance algal blooms. Filamentous green algae is common in bays and coves.

Although all the aforementioned characteristics indicate some eutrophy, the problems at Eagle Creek Reservoir have not yet reached proportions that would in any way discourage use. Siltation and premature filling of the reservoir basin are the most obvious problems. There are times when water treatment is made more difficult and expensive because of excess algae and other suspended solids in the water column.

The Zionsville sewage treatment facility, located upstream from the reservoir, is an advanced waste treatment facility with phosphorus removal. Also, the Eagle Creek watershed was included in a Model Implementation Project that strived to educate farmers as to the benefits of Best Management Practices (BMP) such as no-till farming, seeding of drainageways, cover crops, stripcropping, contour farming, construction of erosion control structures, etc., and provided cost-sharing funds for their implementation. These efforts should help reduce sediment and nutrient loadings to the reservoir.

Eagle Creek flows southeast from Eagle Creek Reservoir to the West Fork of White River. It reaches the West Fork of White River about 1.5 miles downstream of Raymond Street in south Indianapolis.

The Speedway sewage treatment facility also discharges to Eagle Creek. The facility was constructed in 1955 and upgraded in 1972. However, additional operational improvements and upgrading have occurred since 1972. There have been impressive improvements in the waters of Eagle Creek since the late 1960s and early 1970s. Formerly, the creek at the outfall and downstream was severely degraded by poorly treated waste effluent. The substrate of Eagle Creek contained deposits of black, putrid sludge, and sewage fungus (Sphaerotilus) was abundant. Raw fecal matter was often observed in the stream below the plant. The stream was usually discolored, and the water was low in dissolved oxygen and malodorous. Aquatic life, except for certain algae, bacteria, and fungi, was absent downstream of the plant. Besides the obvious aesthetic problems, Eagle Creek presented a real human health hazard.

"There have been impressive improvements in the waters of Eagle Creek since the late 1960s and early 1970s."

Since the improvements in the Speedway plant's equipment and operations, the condition of Eagle Creek downstream of the discharge has dramatically improved. The substrate is clean sand and gravel, and there are no objectionable deposits of sludge and Sphaerotilus. Dissolved oxygen levels are high enough to support aquatic life and eliminate objectionable odors.

The Fixed Water Quality Monitoring Station on Eagle Creek at Raymond Street (EC-1) reflects the water quality of Eagle Creek just before its confluence with the West Fork of White River. At this point Eagle Creek has received the effluent from the Speedway sewage treatment facility and eight industrial dischargers. From 1975 to 1980, copper values above 43 ug/l were found in approximately 50% (33 of 71) of the samples. These values ranged upward to 900 ug/l. Fecal coliform bacteria standards were exceeded about 30% of the time, with values ranging upward to 540,000/100 ml. Since 1981, concentrations of copper and fecal coliforms appear to have been reduced (maximum values of 120 ug/l and 54,000/100 ml, respectively), but the frequency of values above satisfactory levels has remained about the same—48% for copper and 37% for fecal coliforms. No dissolved oxygen violations have been found.

Un-ionized ammonia concentrations still appear to be a problem at this station. Recent data (1981-1983) from this Fixed Water Quality Monitoring Station indicate that approximately 20% of the samples have un-ionized ammonia concentrations greater than 0.05 mg/l. Part of the problem is with one industry that discharges wastewater high in ammonia. However, the ammonia problem does not originate with the industry. Groundwater from wells is used as a raw water source for their plant processes, and the groundwater contains high levels of ammonia (20-50 mg/l). The state and the industry are now negotiating an ammonia limit for this facility. A wasteload allocation study and model completed on the lower portion of Eagle Creek in 1981 (and revised in 1983) indicated that ammonia removal may be required at all facilities discharging to lower Eagle Creek (1 municipal and 3 industrial dischargers) in order to meet dissolved oxygen requirements. The economic impacts of this proposal are now being evaluated.

Fall Creek, another tributary which joins the West Fork of White River in Marion County, originates with several headwater streams in Madison and Henry counties. Fall Creek, or its tributaries, receives wastes from Middletown, Markleville, Pendleton, the Pendleton Reformatory, Fortville and, periodically, the Brookside Corporation before it enters Geist Reservoir in Hamilton and Marion counties.

Geist Reservoir is a multi-purpose impoundment that has been used for many years for public water supply, flood control, and recreation. Many exclusive residential areas have been constructed on the reservoir banks. Sailing is especially popular, and the fishing attracts thousands of people from the surrounding area. Geist Reservoir is a highly eutrophic impoundment, and excessive concentrations of phosphorus and nitrogen enter the reservoir from Fall Creek.

Both Middletown and Fortville have phosphorus removal requirements at present. Construction of a 1.96 mgd sewage treatment facility at Pendleton is expected to be completed by 1985. Pendleton will then regionalize into the Fall Creek Regional Waste District which will also serve the Town of Ingalls and the Pendleton Reformatory. This new facility will be required to have phosphorus removal. This should help reduce nutrient loadings to Fall Creek and, ultimately, Geist Reservoir, as 12 to 15% of the phosphorus loadings to the reservoir come from these areas.

Geist Reservoir dam is in Marion County. Fall Creek flows southwest from the dam through Indianapolis until it joins the West Fork of White River near the Tenth Street bridge. The water discharged from Geist Reservoir is rich in phosphorus and nitrogen. From the dam, Fall Creek is a slowly moving watercourse with only a few riffles for natural reaeration. The stream is adversely affected by nonpoint urban runoff and storm sewer overflows. At the present time, low dissolved oxygen and excessive ammonia concentrations are potential water quality problems in Fall Creek.

The Fixed Water Quality Monitoring Station on Fall Creek at the Keystone Avenue bridge in Indianapolis (FC-7) is immediately upstream of the raw water intake of the Indianapolis Water Company. Data from this station indicate that water quality may be improving. In the period from 1975 to 1980, copper values occassionally exceeded 43 ug/l (maximum value 740 ug/l), and dissolved oxygen concentrations were below 4.0 mg/l in about 12% of the samples; some values were below 1.0 mg/l. Fecal coliform value exceeded standards in about 27% of the samples, with individual concentrations as high as 2,700,000/100 ml.

"The Fixed Water Quality Monitoring Station on Fall Creek at the Keystone Avenue bridge in Indianapolis (FC-7) is immediately upstream of the raw water intake of the Indianapolis Water Company. Data from this station indicate that water quality may be improving."

Since 1981, no copper values above 43 ug/l or dissolved oxygen values below 4.0 mg/l have been found at this station. Fecal coliform concentrations have been reduced (maximum value 150,000/100 ml), but the percentage of exceedances has remained about the same (22%). The fecal coliform problem may be associated with combined sewer overflows and nonpoint urban runoff. Recent connections of the Fort Harrison and Lawrence sewage treatment facilities to Indianapolis have improved conditions in Fall Creek.

The extensive amount of nonpoint urban runoff from Indianapolis' streets, parking lots, rooftops, and crowded dwelling places contribute heavily to the contamination of Fall Creek. Myriad drains, storm sewers, and combined sewer overflows continue to cause water quality problems. Progress has been made in the last few years in eliminating some combined sewer overflows and illegal discharges; however, defining and eliminating the degrading influences to Fall Creek will be an extensive job.

Pogue's Run, discharging to the West Fork of White River in the center city area near the I-70 bridge, has been a known source of contamination. The watercourse receives many discharges along both its aboveground and subterranean length. It has been a difficult and ongoing project to determine the source of many of the discharges; however, the majority of the outfalls are storm sewers which discharge rainwater and snowmelt water. Storm water contains many contaminants such as excessive phosphorus and nitrogen, oil and grease, suspended solids, and fecal coliform bacteria. The Eli Lilly Company has two permitted discharges to Pogue's Run. Significant parameters discharged are BOD, suspended solids, oil and grease, residual chlorine, and heated water.

In recent years all incorporated communities (except Speedway) and many of the industries that formerly discharged directly to the West Fork of White River or its tributaries have been connected to sewer systems that lead to one of the two Indianapolis sewage treatment facilities. The tremendous amount of municipal and industrial waste loads contributed by the many new connections added to the existing problems of handling the municipal sanitary waste load of the growing population of Indianapolis. In addition, at least 15 permitted industrial discharges to the West Fork of White River or its tributaries in Marion County remain in this area.

In the past, the West Fork of White River downstream of the Indianapolis sewage treatment plants could not adequately assimilate this treated waste effluent even when the river was at normal flow. During low flow periods and occasions when the bypassing of untreated wastes to the river occurred, the water quality was severely degraded. For many years, the river was discolored and produced odors. Sludge banks were deposited on river margins and the substrate downstream of the sewage treatment facilities' discharges. The high oxygen demand of the organic load depleted the dissolved oxygen supply of the river, and reaeration took place slowly. There were also problems with high ammonia concentrations. Poor water quality conditions often existed for more than 50 miles downstream of Indianapolis, and fish kills were frequent. From 1975 to 1980, 7 extensive fish kills occurred in the river in the Indianapolis area and extended downstream, one as far as 150 miles. Since 1981, only 1 minor fish kill has occurred.

"From 1975 to 1980, 7 extensive fish kills occurred in the river in the Indianapolis area and extended downstream, one as far as 150 miles. Since 1981, only 1 minor fish kill has occurred."

The West Fork of White River has the natural characteristics that should support a well-rounded warm water fishery. However, fishing, except for carp, has been relatively poor immediately downstream of Indianapolis. Boating, canoeing, and camping along the river has not been popular because of poor aesthetic conditions and poor water quality. The potential for recreational activities has always been high on the West Fork of White River, but it could not be realized.

All this has begun to change. An extensive multi-million dollar renovation project on the two municipal sewage treatment facilities was completed in 1983 by the City of Indianapolis. The facilities were expanded and advanced waste treatment and nitrification processes were put into operation.

Improvements in the condition of the West Fork of White River have been recorded since the new facilities have been put into operation (late 1983). The organic load on the river has been reduced, and dissolved oxygen concentrations have increased. Although it will require time to learn to operate the new equipment properly before the full benefits of the new sewage treatment facilities can be realized, water quality in the West Fork of White River is already noticeably better. As the recreational potential of this portion of the West Fork of White River appears to be quite high, improved water quality will greatly enhance the use of this river and should become a real water pollution control success story.

"Improvements in the condition of the West Fork of White River have been recorded since the new facilities have been put into operation (late 1983)."

The West Fork of White Lick Creek, East Fork of White Lick Creek, and main stem of White Lick Creek are the major receiving waters that are tributary to the West Fork of White River just downstream of Marion County. White Lick Creek flows south through Hendricks and Morgan counties.

Pittsboro, Danville, Brownsburg, Plainfield, Mooresville, and Brooklyn all have sewage treatment facilities that discharge to the West and Main Forks of White Lick Creek. Although water quality problems can occur periodically for short distances downstream of these facilities, the stream is not seriously affected for long distances.

The East Fork of White Lick Creek originates in western Marion County and flows south to its confluence with White Lick Creek near the Mooresville sewage treatment facility in Morgan County. The stream has good fish habitat and high potential for recreational use.

The East Fork of White Lick Creek originates in a heavily settled and industrialized region, and the stream and its tributaries receive several permitted discharges as well as nonpoint runoff. There are also some large package plants which discharge to the stream. The result is that the East Fork of White Lick Creek has been severely degraded through the years. The most obvious result has been a serious decline of the aquatic life, especially the fishery.

Julia Creek, a tributary of the East Fork of White Lick Creek, has received high metals concentrations, apparently by nonpoint drainage from the Quemetco Corporation grounds on West Morris Street. High metals concentrations were found in sediment samples from the company's grounds as well as in sediments taken from Julia Creek.

There also was a serious problem for quite some time with an Indianapolis Department of Public Works lift station which regularly bypassed to the East Fork of White Lick Creek near the bridge on Bridgeport Road. The discharge, caused by sewer defects, contained both sewage and industrial waste. This situation has recently been improved by modifications to the lift station. A new interceptor is now under construction to effect a more permanent remedy and to serve the development in this area. It is hoped that the cleanup of known pollution problems on the East Fork of White Lick Creek and its tributaries will result in the return of a diverse fishery to the stream. This will take time, and aquatic life will be assessed again in 1984. The water quality of White Lick Creek appears to be good when it enters the West Fork of White River near Bethany.

The Fixed Water Quality Monitoring Station at Henderson Ford (WR-205) reflects river water quality a short distance below Indianapolis. Dissolved oxygen values were below state standards about 10% of the time from 1975 to 1980, and this percentage remained the same in the 1981 to 1983 periods. However, minimum dissolved oxygen values were higher in the 1981 to 1983 period. The percentage of fecal coliform violations has decreased by about 40% in the last two years when compared to the earlier period. Un-ionized ammonia values greater than 0.05 mg/l were found 15-20% of the time during both time periods at this station. More dramatic improvements in water quality are anticipated as the effect of the improved treatment at the two Indianapolis sewage treatment facilities becomes apparent in our water quality monitoring data.

"More dramatic improvements in water quality are anticipated as the effect of the improved treatment at the two Indianapolis sewage treatment facilities becomes apparent in our water quality monitoring data."

This station (WR-205) is also a "CORE" station and biological data collected there has reflected the somewhat lower water quality. Numbers of fish collected are usually small, and the community is not diverse. Only 8 species of fish were found there in 1983. Centrarchids (bass and sunfish), catfish, suckers, carp, and gizzard shad were among those collected. Fish tissue samples analyzed for toxic parameters show that chlordane exceeds FDA action levels in the fish sampled. Macroinvertebrate samples collected at this station have always been dominated by pollution-tolerant midge larvae, and the diversity has been low. Hopefully, the biological community will begin to show more diversity and quantity as the water quality improves.

Fixed Water Quality Monitoring Stations at Centerton (WR-197), Paragon (WR-185), and Spencer (WR-166) show the same trends as at Henderson Ford. There are occassional dissolved oxygen violations (3-4%), fecal coliform violations (40-45%), and un-ionized ammonia values above 0.05 mg/l (10-15%). Again, minimum dissolved oxygen values have increased and maximum fecal coliform concentrations have decreased in recent years. Un-ionized ammonia values have remained about the same. Continued improvements are expected.

"Water quality below Spencer is generally good, and this is reflected in the fishery."

Bargersville, Trafalgar, Morgantown, Paragon, Martinsville, Bloomington (North Plant), Ellettsville, and Spencer all have sewage treatment facilities that discharge to the West Fork of White River or its tributaries in this portion of the river. These plants do not appear to have any effect on the West Fork of White River and minimal effects on the tributaries to which they discharge. Water quality below Spencer is generally good, and this is reflected in the fishery.

Stout Creek, a tributary of Beanblossom Creek in Monroe County, has been contaminated by PCBs draining from the Bennett Quarry Landfill area west of Bloomington. Fish samples collected from Stout Creek in 1983 disclosed that some fish contained levels of PCBs exceeding the FDA action level (5.0 mg/kg). Fish and sediment samples from Beanblossom Creek showed no high PCB values. Plans are now being finalized to clean up the Bennett's Quarry Landfill area and eliminate this problem.

Richland Creek in Monroe, Owen, and Greene counties has also been contaminated by PCBs, and fish samples collected from this stream contained PCB concentrations above 5.0 mg/kg (FDA action level). The source of these PCBs appears to be material leaching from Neal's Landfill which borders the stream in Monroe County. A fish consumption advisory has been issued for this stream, and plans are being developed to control or eliminate the release of PCBs from this landfill.

The Eel River enters the West Fork of White River near Worthington. The Eel River drains the agricultural and strip mined land of Clay and Greene counties. The river often carries a heavy silt load and receives some acid mine drainage from the many abandoned and working strip mines in its drainage basin. However, water quality in the Eel River is generally good, and it does not contribute any significant pollution to the West Fork of White River.

"However, water quality in the Eel River is generally good, and it does not contribute any significant pollution to the West Fork of White River."

Data from the Fixed Water Quality Monitoring Station at Edwardsport in Knox County (WR-80) show only occasional violations of fecal coliform standards, and the magnitude of these violations has decreased in recent years. Although some un-ionized ammonia values greater than 0.05 mg/l were found at this station in the past, none have been found since 1981. An electrical generating station located at Edwardsport is used only as a "peaking" plant and does not appear to affect the river to any extent.

The West Fork of White River is joined by the East Fork of White River just upstream of Petersburg in Pike County. At this point both streams exhibit good water quality.

There are two generating stations located on the White River near Petersburg—the Ratts Generating Station owned by Hoosier Energy and the Petersburg Generating Station owned by Indianapolis Power and Light Company. Under conditions of high ambient temperatures, low flow, and high electrical power demand, these plants can raise the temperature of the river significantly downstream of their cooling water dischages. At these times, fish populations may leave certain parts of the river.

Petersburg's sewage treatment facility discharges to Pride's Creek which flows into White River. This discharge degrades Pride's Creek somewhat, but does not significantly affect the White River. Data from the Fixed Water Quality Monitoring Station located at Petersburg (WR-48) indicate that only occasional fecal coliform violations are found.

WR-48 is also a "CORE" monitoring station. Fish collected at this station includes spotted bass, black crappie, bluegill, buffalo, carpsuckers, catfish, drum, gar, and others. From ISBH collections and reports published in connection with thermal studies done at the two electrical generating stations, it would appear that a rather diverse fish community exists in this part of the river. Some fish tissue samples collected at this station show chlordane values above FDA action levels. Macroinvertebrate samples indicate good water quality and are typical of medium to large, nutrient-enriched Indiana rivers.

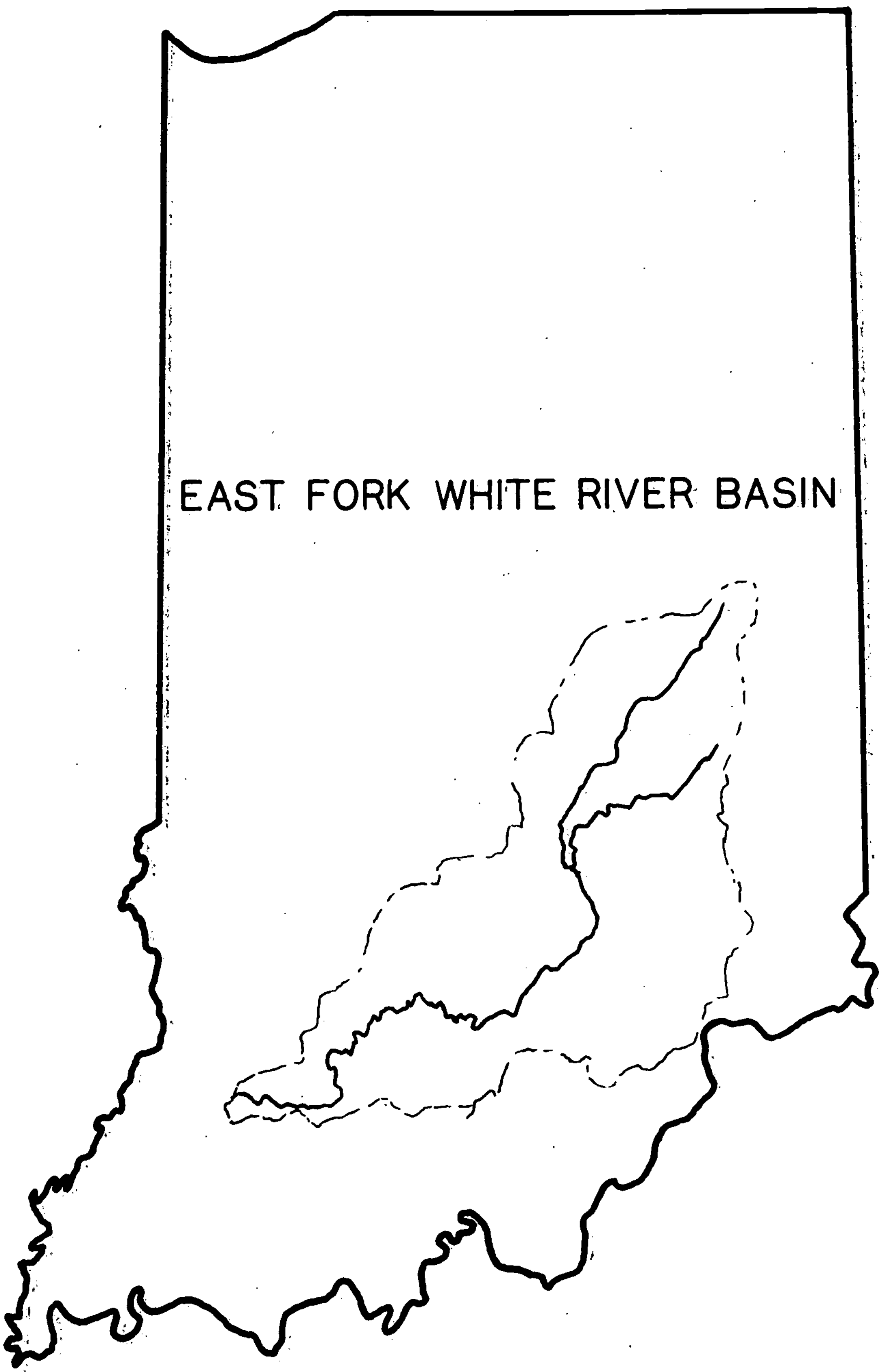
"Macroinvertebrate samples indicate good water quality and are typical of medium to large, nutrient-enriched Indiana rivers."

From Petersburg, the White River flows west to join the Wabash. The stream is of generally good water quality when it reaches the Wabash, although some of the White River's tributaries in the counties of Pike, Gibson, and Knox receive periodic runoff from oil operations and active and abandoned strip mines. These points of pollution are hard to locate and equally hard to control.

East Fork of White River Basin

The East Fork of White River drains about 5,600 square miles of southern Indiana (Figure 16). Roughly 15,000 miles of streams are included in the basin. Sugar Creek and Big Blue River join to form the

Figure 16. East Fork White River Drainage Basin.



Driftwood River which becomes the East Fork of White River after the confluence of the Flatrock River. The Muscatatuck River and Salt Creek in the lower portion are the river's major tributaries. The largest cities in the watershed are Columbus, Seymour, and Bloomington.

The topography of this basin ranges from flat to rugged as it crosses seven of southern Indiana's eight physiographic regions. The basin includes unique underground streams in the Karst region of caves and sinkholes in Orange and Lawrence counties. Agriculture is important in the flatter regions, but much of the watershed is forested. The groundwater contribution to stream flow in the basin is low, so flow depends largely on rainfall, and variations can be great. Compared to other basins, stream channelization projects in the East Fork Basin have been minimal.

The East Fork of White River has always been an important sport fishery. State records for flathead catfish, freshwater drum, rock bass, and smallmouth bass have all come from this river or its tributaries. The river is also used widely for canoeing. The cities of Bedford, Mitchell, and Seymour have drinking water supply intakes on the river. Therefore, the use designations for the basin include aquatic life, partial body contact, and potable water supply at the three municipal intakes.

"The East Fork of White River has always been an important sport fishery. State records for flathead catfish, freshwater drum, rock bass, and smallmouth bass have all come from this river or its tributaries."

There are eight Fixed Water Quality Monitoring Stations in the basin. Water quality is suitable for aquatic life at all the stations. Frequent violations of fecal coliform bacteria criteria for partial body contact recreation occur only at the two Big Blue River stations. Water quality is generally satisfactory for potable water supply at the three drinking water intakes on the East Fork.

Localized water quality problems still exist in the basin. Sewage treatment and/or collection facilities at Nashville, Greensburg, and North Vernon are responsible for periodic sewage bypasses or inadequately treated discharges. Low dissolved oxygen and/or high ammonia concentrations frequently occur downstream from these towns. Aquatic life is probably adversely affected to some extent downstream from all sewage treatment facilities by chlorination of the effluents. Industrial discharges in New Castle have caused the accumulation of metals in stream sediments which can degrade water quality. PCB contamination of sediments and fish in the Salt Creek watershed remains a problem, but point source discharges of PCBs have been greatly reduced or eliminated in recent years. Nonpoint discharges from agricultural and urban areas probably contribute to water quality degradation, but the extent of their effects in this watershed have not been measured. An advisory against eating fish from Clear Creek and Salt Creek in Monroe County and from Salt Creek, Pleasant Run, and the East Fork of White River from Salt Creek to Williams Dam in Lawrence County remains in effect due to high PCB concentrations in the flesh.

Five bioassays of industrial effluents discharging to streams in the basin have been conducted. Only discharges to the upper Big Blue River near New Castle and to Pleasant Run near Bedford have been identified as potentially serious hazards to aquatic organisms in the streams. Much new information on the presence of toxic substances in the watershed is being generated by the agency. Sediments, fish flesh, and mussel shells were collected for toxics analysis from stations throughout the basin in 1983, and results should be available soon.

A former hazardous waste disposal site, Seymour Recycling Corporation at Seymour, lies in this basin. U.S. Environmental Protection Agency Superfund money has been used to remove hundreds of barrels of chemicals accumulated at the site over many years. In 1980, before the cleanup began, a study of sediments and fish tissue in the area was made by the U.S. Fish and Wildlife Service. An intermittent tributary drains the site and flows about a mile to the East Fork of White River. Sediments in the tributary contained higher than normal concentrations of certain metals, primarily zinc, copper, and chromium. Low levels of volatile organic substances were also detected.

Sediments in the East Fork of White River were relatively uncontaminated, and no substances originating from Seymour Recycling were found in the flesh of fish collected from the river which would make them unsafe to eat. Contamination of surface water appears to have been limited to the immediate area, and the source of contamination has recently been removed.

"Sediments in the East Fork of White River were relatively uncontaminated, and no substances originating from Seymour Recycling were found in the flesh of fish collected from the river which would make them unsafe to eat."

Water quality in the basin has noticeably improved since 1980. Violations of the state's dissolved oxygen standard occurred at five of the eight monitoring stations between 1975 and 1980. Since then, only one violation has been recorded. The number of fecal coliform violations has decreased slightly at most stations. Concentrations of certain metals were previously high enough to have a potential adverse effect on aquatic organisms at several stations. Since 1980, all metal concentrations have been at safe levels. Average total ammonia concentrations were greater than 0.2 mg/l at half the stations between 1975 and 1980. Now none of the stations have average concentrations that high. Following the phosphate detergent ban and implementation of the phosphorus removal requirements for sewage treatment plants at Columbus, Seymour, Brownstown, and Beford in the 1970's, the numerous algal complaints at and upstream from the Williams Dam reservoir have subsided.

"Following the phosphate detergent ban and implementation of the phosphorus removal requirements for sewage treatment plants at Columbus, Seymour, Brownstown, and Beford in the 1970's, the numerous algal complaints at and upstream from the Williams Dam reservoir have subsided."

Many of the improvements in water quality in this watershed are due to upgraded municipal sewage treatment facilities in the area. Advanced waste treatment plants have been built at Greenfield, Columbus, Seymour, Bedford, New Castle, and Bloomington since 1978. All of these plants have shown improved effluent quality, including lower biological oxygen demand, suspended solids, and ammonia. Sewer bypasses have also been reduced. The Greenfield facility was awarded the EPA, Region V, Best Plant Award in 1983.

Water quality in the Muscatatuck River has improved considerably since Morgan Packing Company at Austin upgraded its treatment in 1979. Before the improvements, the mean annual dissolved oxygen concentration of the river downstream from the company was usually below the state standard for aquatic life. Sludge deposits were widespread, and only a few kinds of pollution-tolerant organisms were present for at least 25 miles below the outfall. Now the average dissolved oxygen concentration is well above the state standard, and only one standard violation has been recorded since 1980. Fish kills, sometimes extending from Austin to the East Fork of the White River, were once common. No fish kills have been reported in this portion of the river since the treatment has been upgraded. Fish, mussels, and other aquatic organisms have moved back into the river. In a recent bioassay, the test organisms (Daphnia magna) not only survived, they thrived on the phytoplankton-rich effluent from Morgan Packing Company's treatment lagoon.

The Ohio River Basin

The Ohio River forms the southern boundary of Indiana. Until recently, the waters and bed of the river were not considered part of Indiana, and Kentucky claimed all of the river to the high water mark on the Indiana shore. Indiana claimed that the boundary should be the low water mark as it existed on the north shore of the Ohio River in 1792, the year Kentucky became a state. A recent (1981) United States Supreme Court ruling was in favor of the Indiana position, and procedures are now underway to determine the exact location of the 1792 low water line along the northern shore.

The Ohio River and its Indiana tributaries drain approximately 5,800 square miles in Indiana (Figure 17). The major Indiana tributaries in the basin are: the Whitewater River (via the Great Miami River in Ohio), the Blue River, the Little Blue River, the Anderson River, Laughery Creek, Big Indian Creek, and Pigeon Creek. The major land use in the basin is agriculture, but much of the land is hilly and rolling, and much is still heavily forested. Strip mining operations are important in certain portions of the basin.

Water quality monitoring of the Ohio River itself is done by the Ohio River Valley Water Sanitation Commission (ORSANCO), a consortium composed of eight states, six of which border the Ohio River mainstem. ORSANCO maintains Fixed Water Quality Monitoring Stations on the portion of the Ohio River which borders Indiana. The State of Indiana maintains Fixed Water Quality Monitoring Stations on some of the tributaries, and Indiana State Board of Health (ISBH) personnel conduct compliance surveys and other water quality monitoring activities on Indiana facilities and water bodies that discharge to the Ohio River.

The U.S. Army Corps of Engineers operates a series of 20 locks and dams on the Ohio River to allow year round navigation. Four of these are located along Indiana's southern boundary, and these dams create slowly moving lakes or pools in the Ohio River.

Figure 17. Ohio River Drainage Basin.

The water backed up by the Ohio River dams reaches a considerable distance upstream into the streams flowing into the Ohio, and a series of embayments have been created. The larger of these are used as sheltered, floating marina sites. Nearly all of embayments and inflowing streams are excellent fish habitat.

ORSANCO stated in its 1982-83 305(b) report that the overall quality of the Ohio River is good and is continuing to support established uses. However, there are parameters that need further intensive study to insure that the high quality of the river is maintained. The parameters of particular concern are: phenolics, fecal coliform, mercury, and dissolved oxygen.

"ORSANCO stated in its 1982-83 305(b) report that the overall quality of the Ohio River is good and is continuing to support established uses."

On July 12-14, 1983, ORSANCO coordinated sampling of the Ohio River from Cincinnati to Louisville to assess levels of fecal coliform and mercury. Additional measurements for temperature, specific conductance, pH, and dissolved oxygen were made. Very briefly, some of the conclusions of this study were:

1. Waste discharges in the Cincinnati area have major deleterious effects on Ohio River dissolved oxygen and fecal coliform levels.
   a. Dissolved oxygen levels were depressed for a distance of 100 miles below Cincinnati.
   b. Due to the long travel times during the sampling period and fairly rapid dieaway, fecal coliform levels returned to satisfactory levels 25 miles below Cincinnati.
2. Thermal stratification was significant at Ohio River locations downstream of Cincinnati. Effects on dissolved oxygen were most pronounced at locations in the Louisville area.
3. Human wastes appear to be the major cause of high fecal coliform bacteria levels in the Ohio River from Cincinnati to Louisville.
4. No conclusions could be drawn from the results for mercury and volatile organics. Mercury was found in only 3 of 52 samples at the detection limit of 0.1 ug/l while no volatile organics were found. The lack of detectable amounts of these compounds in this survey cannot be taken to mean that they are never present in the study area.

ORSANCO began Ohio River lock chamber studies of fish in 1957. The studies have two purposes: 1) fish are identified and tallied for evaluation of populations present, and 2) fish are also collected for tissue analysis. The results for the 1983 fish tissue samples are not yet available.

There has been a general trend towards increasing numbers of taxa caught in the fish studies. Total numbers of fish caught have varied; this may be due to yearly variation in influences such as weather and to the sampling method as much as to any water quality changes. The 1982-83 results showed lower diversity at almost all locations than in recent years, but total numbers of fish increased. This increase may be attributable to the large numbers of certain species (shad, carp, and drum) taken at some locations. The overabundance of a certain species relative to the whole catch at a location tends to lower the diversity.

"There has been a general trend towards increasing numbers of taxa caught in the fish studies."

In a paper entitled Radioactivity in the Ohio River (December 1983), ORSANCO states that data collected by the agency clearly show that radioactivity is not a threat to drinking water supplies using the Ohio River as a source. Average levels of gross alpha and beta radiation are well within the limits of the standards, as are amounts of strontium 90 and tritium.

ORSANCO published a booklet entitled Fishes of the Ohio River: A Testimony to Clean Water (March 1983). The text states that the Commission regularly receives telephone calls asking if the fish caught in the Ohio River are safe to eat. The answer is simply that ORSANCO data show that they are. The data also show that the fishery of the Ohio River is abundant and diverse. Although many species of fish thrive in the Ohio, some species do not, and never will, because the river is a controlled river - its depth, speed, and gradient are carefully managed to support a number of uses.

"The data also show that the fishery of the Ohio River is abundant and diverse."

The streams in Fayette, Franklin, Union, and Wayne counties in Indiana which drain to the Ohio River generally flow in a north to south direction through the Whitewater River system in Indiana. The Whitewater

River then flows into Ohio into the Great Miami River which flows to the Ohio River. The main stem of the Whitewater River is formed by the confluence of the East and West Forks of the Whitewater River.

The largest of the West Fork of the Whitewater River tributaries are the West Fork Branch, Martindale Creek, Greens Fork Creek, and Nolands Branch. These streams join in Wayne County to form the main stem of the West Fork of Whitewater River. Water quality in these tributaries is generally considered good, based upon available information, and these streams usually meet their aquatic life/partial-body contact designations.

"Water quality in these tributaries is generally considered good, based upon available information, and these streams usually meet their aquatic life/partial-body contact designations."

The Connersville sewage treatment facility in Fayette County is the largest point source discharge to the West Fork of Whitewater River. There are occasional fecal coliform bacteria standard violations below Connersville, but dissolved oxygen and ammonia violations are seldom recorded, and general water quality is rated as good. The Indiana Department of Natural Resources (IDNR) rates the aquatic habitat suitability high from Connersville to Brookville.

The East Fork of Whitewater River is formed upstream of Richmond in Wayne County by the Clear Creek/Lick Creek system, the East Fork Branch and the Middle Fork Branch. The Richmond sewage treatment facility was upgraded in 1983 to provide advanced waste treatment with phosphorus removal, ammonia removal, and rapid sand filters. Water quality in these streams is considered good, with only occasional fecal coliform violations found.

Data from the Fixed Water Quality Monitoring Station located on the East Fork of Whitewater River at Abington (WHE-27) downstream of Richmond and upstream of Brookville Reservoir show only occasional violations of the fecal coliform standard (15-20%). These violations are not large and have remained about the same in the periods 1976 to 1980 and 1981 to 1983. No other water quality standards violations were found.

The Liberty sewage treatment facility discharges to Town Run just upstream of its confluence with Silver Creek in Union County. Silver Creek flows south into Whitewater Lake in Whitewater State Park. Whitewater Lake is a 200-acre, high use, eutrophic lake which was renovated in the mid- 1970s and supports a good sport fishery. The Liberty sewage treatment facility is meeting its NPDES limits (10/10) for BOD and suspended solids. A habitat evaluation of Town Run and Silver Creek in 1979 revealed no organic degradation of either stream. However, excess chlorine from the sewage treatment facility discharge had eliminated all aquatic life in Town Run. Chlorine did not appear to effect the aquatic life in Silver Creek at that time.

Brookville Reservoir, located in Franklin and Union counties on the East Fork of the Whitewater River, is operated for flood control in the Whitewater River valley and also contributes to the reduction of flood flows in the Ohio River. In addition, the lake was developed for general recreational use as well as for fish and wildlife. Construction was started in 1965 and completed in 1974. Recreation facilities include boat launching ramps, camping, picnic units, a swimming beach, a tailwater fishing area, and associated roads and parking areas. Two large state recreational areas have been built at Brookville Reservoir, Quakertown and Mounds, and several smaller recreation areas have been established along the shoreline. Nearly all these areas offer easy access to good fishing waters. Brookville Reservoir supports excellent, reproducing populations of catfish, bass, and panfish. Great numbers of trout, walleye, and some northern pike and muskellunge have been stocked. Recently, the white bass population has been doing well, and large numbers are taken in the spring during their runs up the East Fork of the Whitewater River. Good success has been achieved with a white bass/striped bass hybrid which grows very large in the reservoir. Trout, walleye, and smallmouth bass are taken by fishing from the bank or by wading in the tailwaters of the reservoir.

The Brookville sewage treatment facility discharges to the East Fork of Whitewater River just downstream of Brookville Reservoir and a short distance upstream of the confluence of the East and West Forks. In the past there have been problems with fecal coliform bacteria concentrations at this plant. Data from the Fixed Water Quality Monitoring Station (WHW-24) located near Brookville downstream of the confluence of the East and West Forks reflect these problems. This reach of the river is designated for whole body contact recreation due to its heavy recreational use. Fecal coliform standards were violated approximately 40% of the time in the period 1976 to 1980, with high values up to 110,000/100 ml. Since 1981, these violations have occurred only 30% of the time, and maximum values have decreased to around 3,000/100 ml. No other standards' violations have occurred. Thus, except for the periodic occurrence of fecal coliform violations, which have been greatly reduced recently, the water quality of the Whitewater River is good when it flows out of Indiana into Ohio's Great Miami River.

"Thus, except for the periodic occurrence of fecal coliform violations, which have been greatly reduced recently, the water quality of the Whitewater River is good when it flows out of Indiana into Ohio's Great Miami River."

Laughery Creek is another prominent Indiana tributary to the Ohio River. This stream and its tributaries drain portions of Dearborn, Ohio, Ripley, and Switzerland counties in southeastern Indiana. There are several small municipal discharges to the upper portion of Laughery Creek and/or its tributaries, and these can sometimes cause very localized violations of dissolved oxygen, ammonia, and fecal coliform standards. These do not appear to be detrimental to Laughery Creek to any extent.

One of the two sewage treatment facilities at Versailles discharges to Laughery Creek. This plant was constructed in 1940 and is inadequate. There were fish kills below the plant in 1969 and 1982. A habitat evaluation of Laughery Creek immediately downstream of the Versailles sewage treatment facility in 1981 revealed that the stream was severely degraded for several hundred yards. The substrate was covered by sludge and sewage fungus, and the dissolved oxygen concentration was 2.0 mg/l during daylight hours. These conditions improve long before Laughery Creek reaches the Ohio River, but ammonia levels may exceed the state standard for several miles.

As stated previously, one of the two sewage treatment facilities at Versailles currently discharges to Laughery Creek; the other discharges to Graham Creek. Versailles has received Step 1 grant money, and their facility plan is currently under review by the state. The town is in the fundable range on the Project Priority List (PPL), and if the Step 1 plan is approved, they will submit a Step 4 application before the end of FY 84. The facility plan calls for the expansion and upgrading of the Graham Creek facility to accept all the sewage from Versailles and the elimination of the discharge to Laughery Creek. The Laughery Creek facility would be used as a collection system with pumpage to the Graham Creek plant. This plan would eliminate the problem on Laughery Creek.

Indian Creek and Thurston Creek in Switzerland County each receive only one very small discharge. No current water quality data are available on these streams, but they do not influence the quality of the Ohio River. Indiana-Kentuck Creek in Jefferson County reportedly receives no discharges.

The Sellersburg and Clarksville North sewage treatment facilities both discharge to Silver Creek. Both plants need to be expanded and upgraded in order to adequately protect Silver Creek. A habitat evaluation done by ISBH biologists in 1981 revealed that Silver Creek was visibly degraded for a short distance downstream of the Clarksville facility by poor quality effluent. Because of low flow conditions a limited fishery existed. Further downstream toward the Ohio River, a true sport fishery existed.

Both Sellersburg and Clarksville have received money for Step 1 grants, and their plans are now currently under review by the state. These towns are both in the fundable range on the PPL. If these Step 1 plans are approved, both are expected to submit applications for Step 4 grants before the end of FY 84.

At present, Clarksville has two sewage treatment facilities—a North plant and a South plant. The North plant discharges to Silver Creek and the South plant discharges to the Ohio River. The proposed facility plan calls for the construction of a new sewage treatment facility which would discharge directly to the Ohio River and eliminate both the North and South plant discharges. Should these plans be realized, the conditions in Silver Creek should be improved.

At Sellersburg, a biodisk has recently been added to improve the quality of the effluent. The facility plan calls for expansion of the facility from the current 0.7 mgd capacity to 1.2 mgd. These improvements should also improve the water quality in Silver Creek.

"The plant was upgraded in 1971, and water quality in Big Indian Creek seems to have improved since then."

Big Indian Creek in Harrison County receives nine NPDES point source discharges. The Corydon sewage treatment facility discharges directly to Big Indian Creek, and the BOD loading from this plant is more than three times that from all the smaller facilities combined. It is the most significant point source in Harrison County. There have been fish kills reported downstream of Corydon, but none have been reported since 1969. The plant was upgraded in 1971, and water quality in Big Indian Creek seems to have improved since then. The town submitted a facility plan in 1980, but the grant has been inactive since then. The town appears to be too low on the PPL to receive funding.

The Blue River, draining portions of Harrison, Crawford, and Washington counties in south-central Indiana is one of Indiana's more pristine rivers. Some early pioneer settlements were established, but intensive development bypassed the rugged, forested, cave-pocked country along the Blue River. In many places, the Blue River remains much the same as the early settlers first saw it, with only a few traces of the old mill sites which tell of the former activity on the river.

In the past ten years the discovery by canoeists, fishermen, and nature lovers of the beauty and adventure to be experienced on the Blue River has revived much interest in it. For this reason, portions of the Blue River were among the first to be included in Indiana's Natural, Scenic and Recreational River System. Additional portions are expected to be proposed for designation as "Exceptional Use" waters in 1985.

Blue River begins in upper Washington County with two major headwaters - the West Fork and Middle Fork of Blue River. The South Fork of Blue River joins the main river at Fredericksburg near the Washington/ Harrison county lines.

The Salem sewage treatment facility discharges to the West Fork of Blue River. The plant was constructed in 1939 and upgraded in 1976. In the 1960s and early 1970s there were many sewerage difficulties, and bypassing occured at this facility. This periodically resulted in serious degradation of the receiving waters. Benthic life was degraded for several hundred yards downstream, and there was a fish kill downstream of the facility's discharge in 1975. Conditions improved after 1976, and water quality now appears to be satisfactory.

Water quality is generally excellent in the Blue River although there may be localized periodic violations of the fecal coliform standards. The Blue River from near Fredricksburg down to Rothrock Dam (river miles 57 to 11.5) is designated as a State Resource Water and must meet whole body contact recreation standards. Data from the Fixed Water Quality Monitoring Station at Fredricksburg (BLW-53) have shown periodic fecal coliform violations but no others. Fredricksburg has no sewage treatment facility, and seepage from septic tanks or other sources in the area may be contributing to the fecal coliform problems. There are also several confined feeding operations in the area.

"Water quality is generally excellent in the Blue River although there may be localized periodic violations of the fecal coliform standards."

The Blue River is the home of several of Indiana's unique, threatened and/or endangered animal species. This is the only stream in Indiana in which the hellbender salamander (Cryptobranchus alleganiensis) has been found, and it appears that there is a rather large, reproducing population there. Spotted darters (Eheostoma maculatum), bluebreast darters (E. camurum), variegate darters (E. variatum), rosefin shiners (Notropis ardens), and the cottonmouth water mocassin (Agkistrodon piscivorous) are other unique species which have been found in the Blue River and its environs.

The Little Blue River originates from several headwaters in northern Crawford County. The Little Blue River valley is periodically flooded during extended rains and the Town of English, the only community on the Little Blue River, has been nearly destroyed at times. A habitat evaluation of the stream at English in 1981 during extreme low flow revealed no visible degradation from the town, although there are probably some localized high fecal coliform concentrations from septic tanks. The water quality of the Little Blue River is generally very good, and the aesthetic qualities of the stream and its forested watershed are quite high. The stream is a unique resource and has been considered for designation as an "Exceptional Use" stream. The Indiana Department of Natural Resources has stated that the Little Blue River may support a remnant population of the endangered Ohio River muskellunge in the lower segment.

"The water quality of the Little Blue River is generally very good, and the aesthetic qualities of the stream and its forested watershed are quite high."

The Anderson River and its tributaries drain parts of Perry, Spencer, and Dubois counties. For the most part, water quality in these streams is good. Potential water quality problems are the result of mining, fertilizer and insecticide applications to agricultural lands, and road construction. Most of the Middle Fork of the Anderson River flows through the Hoosier National Forest, and there are few known point sources of pollution. Several small watershed lakes were built by impounding the waters of the Middle Fork and its tributaries. These impoundments are of generally good water quality and are managed for recreation by the U.S. Forest Service.

There is little recent data on many of the streams which are tributaries of the Ohio River in the southwestern portion of the state (Posey, Vanderburg and Warrick counties). A 1979 U.S. Geological Survey of the Cypress Creek watershed in Warrick County revealed that Cypress Creek periodically receives acid mine drainage from unreclaimed strip mines in its watershed. The Boonville sewage treatment facility, at the time of this and subsequent surveys, was also impacting the stream producing high fecal coliform and ammonia levels in the creek. Boonville has received Step 1 money, and their plan is currently under review by the state. The town is in the fundable range of the PPL. A Step 4 application is expected before the end of FY 84 if the Step 1 plan is approved.

Pigeon Creek and its tributaries drain portions of Warrick, Vanderburg and Gibson counties. These streams traverse through several different strip mines and undoubtedly receive runoff from these areas as well as from the permitted point source discharges. At its confluence with the Ohio River near Evansville, Ohio River water often backs up several miles into Pigeon Creek, and the stream is quite sluggish. The industrial and municipal dischargers, combined sewer overflows and mine drainage to this stream undoubtedly affect the water quality which is marginal at best in this area.

A survey of the fishes of Posey County by Kozel et al. (6) in 1980, revealed that there has been an overall decrease in species diversity from earlier studies due principally to the absence of many darters and madtoms. He believed this was due to habitat alteration resulting from increasing agricultural use (90%) of the land in Posey County.Many streams are now channelized with steep banks and no cover. Farming is done right up to the stream bank. The resulting siltation and runoff, including herbicides, pesticides and sewage have probably contributed to the alteration of the fish habitat in these streams. Pollution associated with oil well operations is also a problem in some areas of the county.

GROUNDWATER QUALITY

Groundwater Program

Until early 1984, the Indiana State Board of Health had no official groundwater program even though about 3.3 million people in Indiana derive at least some of their drinking water from groundwater sources. Recently, it has become apparent that contamination of groundwater by chemicals can occur more readily than previously thought. Potential sources of contamination would include: underground storage tanks, landfills and waste disposal sites, agricultural bulk chemical storage and handling facilities, accidental chemical spills, etc. Consequently, a program is being developed to deal with these potential problems, and staffing began in early 1984. The various aspects of the proposed groundwater program are presented below.

"Consequently, a program is being developed to deal with these potential problems, and staffing began in early 1984."

Objectives

In initiating this program, there will be two prime, concurrent objectives:

1. Provide a more timely and complete response to alleged or known existing contamination cases; and

2. Initiate systematic procedures to evaluate existing and potential groundwater contamination statewide. This is to assess public water supply—well water quality with respect to anthropogenic chemicals, identify susceptible aquifers likely to be impacted by known waste sources, and describe those factors which result in contamination so that informed decisions on the need for preventive measures can be made.

Staffing and Support

A groundwater unit will be established in the Water Quality Surveillance and Standards Branch, Division of Water Pollution Control in FY 84, consisting of three technical staff. In addition, two senior grade chemists and two gas chromatographs were budgeted for the Water and Sewage Laboratory Division to provide the analytical capability for groundwater priority pollutant analyses on a two week turnaround time. If laboratory space is allocated, this laboratory unit could be operational by the end of FY 84. At least three additonal technical positions will be budgeted for the groundwater unit for FY 85, beginning October 1, 1984. Outside contracts will likely be made for compiling inventory data, aquifer assessment, and mapping and artwork outside the staffing limits of the groundwater unit.

Approach

Objective No. 1

Groundwater contamination complaints or potential situations will be forwarded to the groundwater unit. Staff will investigate and take groundwater samples. They will evaluate the laboratory results and inform and advise the affected party. If the contamination is such as to render the water unusable, attempts will be made to identify the responsible party. If a responsible party can be identified (shown to use the chemical causing the contamination and located in close proximity and upgradient), action will be initiated to require the responsible party to mitigate the contamination. If a responsible party cannot be identified, the case may be put in an indefinite status or into the Emergency Remedial Response Inventory System (ERRIS) under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), if the situation warrants.

Depending on whether the contamination occurs in a private or public well, the type of contaminant, and the source, the above actions will be coordinated with the Public Water Supply Division, other regulatory programs of the Division, the Division of Land Pollution Control and other state regulatory agencies such as the Indiana Department of Natural Resources and State Chemist's Office.

The mitigation approach will emphasize restoration and protection of the resource. It will not be sufficient to merely protect the user by either removing or reducing the contaminants by treatment at the point of use or by abandoning the supply and utilizing an alternate supply. In addition, the responsible party will be required to study and evaluate various remedial actions such as source removal, contaminant purging, in situ treatment, etc. The state, along with local authorities and EPA, as appropriate, will select the best alternative and impose that remedial action on the responsible party or parties. Enforcement actions will me managed by the Compliance Section of the Divison of Water Pollution Control.

Objective No. 2

These activities constitute the planning activities of the group and include the following:

Documentation of Contamination

Past, current and future documented cases of contamination will be logged to indicate the location, contaminant constituents, source, cause and remedial action taken to serve as a basis for eventually describing the severity of contamination. Also, this will allow staff to discern which sources (or types of operations) appear to be causing the greatest problems and what kinds of preventive measures may be required.

Evaluation of Public Water Supply Wells

Since these wells serve the greatest number of users per well, it is important to monitor these for anthropogenic chemicals. EPA is currently monitoring Indiana public wells for volatile organic chemicals, but it would be well for the state to augment this activity to shorten the time by which all wells can be checked. In addition, we may wish to check for other chemical groups. Also, if significant concentrations are found, the groundwater unit will investigate to find the source and initiate remedial actions and coordinaton as required.

Identification and Evaluation of Potential Sources in Susceptible Aquifers

Utilizing existing, as well as newly generated data and studies, known potential contaminant sites will be identified and the susceptibility and use of the aquifer in which sites are located will be evaluated. Potential sites include landfills, pits, ponds, lagoons, petroleum product tank farms, bulk agricultural chemical facilities, oil fields, and manufacturing facilities in unsewered areas or adjacent to well fields.

The approach will be to identify these sites and the chemicals used. Then, both the susceptibilty of the aquifer to penetration of surface or near surface contaminants and the degree of groundwater use of the aquifer will be determined for each site.

For those situations in which all factors combine to indicate a high probability of contamination by health significant chemicals in highly used aquifers, staff will conduct field investigations to sample existing down-gradient wells. If contamination is shown, or if there is no contamination in existing wells, but it is likely that contamination is present but not detected, the owner(s) of the potential contaminant site(s) will be required to initiate subsurface testing to document the situation and initiate actions to mitigate the contamination.

A high degree of coordination and data sharing with various program areas and agencies will be required and will be effected. Where groundwater contamination appears to be widespread in a specific locality by a multiplicity of sources and conditions, local groups and governmental units will be involved in developing a program for encouraging the elimination of surface or subsurface waste disposal or product loss and for providing uncontaminated water to affected users. Eventually, the information gained will serve as the basis for discerning the need for groundwater protection programs and tools over and above those now existing.

WATER POLLUTION CONTROL PROGRAM

Point Source Control Program

The point source control program in Indiana primarily involves two types of "point source" discharges—those originating from municipal sewage treatment facilities and those from industrial facilities. In order to meet the goals of the Clean Water Act, federal, state and local governments, as well as industry, have spent considerable monies to improve the degree of wastewater treatment they provide and, in turn, the water quality of Indiana's lakes, rivers and streams. The concentrations of polluting materials in these discharges are regulated by the National Pollutant Discharge Elimination System (NPDES) permit program which places limits on the pollutants each discharge may contain. All facilities which discharge to Indiana waters must apply for and receive a NPDES permit. The limits, set in the permit, are designed to protect all designated uses of the river, lake or stream into which the discharge flows.

"The limits, set in the permit, are designed to protect all designated uses of the river, lake or stream into which the discharge flows."

Municipal Facilities

Table 15 depicts the changes in the degree of wastewater treatment provided by municipal facilities in Indiana in the period from 1972 to 1982. During this time, the percentage of people who are served by municipal treatment plants has not changed appreciably. The degree of treatment has improved considerably, however. The percentage of the population served by only primary treatment has decreased to less than one percent. The percentage of the population served by secondary plants has also decreased, whereas the percentage served by advanced waste treatment facilities of some type has increased dramatically.

In 1972, there were no advanced waste treatment facilities operating in Indiana. In 1982, almost one-fifth of the population was being served by these types of systems. Of the 40 percent of the population not served by municipal treatment plants, the great majority (about 90 percent) has been determined to have adequate individual septic tank disposal systems or are served by semi-public facilities. The effect of this increased level of wastewater treatment has been an improvement in the water quality of many of Indiana's lakes, rivers and streams.

"The effect of this increased level of wastewater treatment has been an improvement in the water quality of many of Indiana's lakes, rivers and streams."

Table 15. Changes in degree of wastewater treatment provided by municipal facilities to the population of Indiana in the period 1972-1982.

	1972	1982
Population size	5,195,392	5,490,129
No municipal treatment	40%	40%
Primary treatment	6%	0.4%
Secondary treatment	54%	41%
Advanced treatment	0%	18%

In order to achieve this increased level of wastewater treatment and resulting improved water quality, large sums of money have been spent by various governmental agencies. The federal government began appropriating money for construction of sewage treatment facilities in 1956 when Congress passed the Federal Water Pollution Control Act (FWPCA). Even though the amounts provided (50 million dollars) were modest, they did provide the impetus to state and local governments to plan and construct better sewage treatment facilities. Under this act, federal grants would cover only 30 percent of a project with a maximum of $250,000 for any one project. In 1966, amendments to the FWPCA eliminated the dollar ceiling on individual grants and, in some cases, increased the federal share of project costs up to 55 percent. In 1970, the United States Environmental Protection Agency (U.S. EPA) was created, and this agency took over the operation of the construction grants program. In 1971, congressional appropriations reached one billion dollars. In 1972, amendments to the FWPCA (PL 92-500) increased the federal share of project costs up to 75 percent, and an additional 18 billion dollars was authorized for construction projects.

The 1977 amendments to the FWPCA (known as the Clean Water Act) appropriated 24.4 billion dollars for construction grants purposes, and the federal share of project costs was raised to 85 percent if innovative or alternative technology was employed. The Supplemental Appropriations Act provided an additional 1.4 billion dollars for construction grants projects. In 1981, other amendments to the Clean Water Act (PL 95-117) authorized an additional 9.5 billion dollars for construction grants for fiscal years 1982-1985. However, after October 1, 1984, the federal share of these projects will revert back to only 55 percent. These amendments also stressed utilization of innovative or alternative technologies.

Since 1972, Indiana has received approximately one billion dollars in federal construction grants money and has spent over 120 million dollars in state money to construct new wastewater treatment facilities, upgrade and expand existing facilities, construct sewer systems, eliminate combined sewer overflows, etc. In addition, local governmental agencies have spent over 175 million dollars in matching funds for these projects.

"Since 1972, Indiana has received approximately one billion dollars in federal construction grants money and has spent over 120 million dollars in state money to construct new wastewater treatment facilities, upgrade and expand existing facilities, construct sewer systems, eliminate combined sewer overflows, etc. In addition, local governmental agencies have spent over 175 million dollars in matching funds for these projects."

Construction grants money is awarded not only for the actual construction of wastewater treatment facilities but also their planning and design. Grants for planning purposes are referred to as Step 1 projects, grants for design are Step 2 projects and grants for construction are Step 3 projects. Grants which include both design and construction in one phase are called Step 4 projects. Table 16 shows the number of construction grants projects awarded and completed from 1980 through 1983.

Table 16. Construction grants projects awarded and physically completed from 1980 through 1983.

	Projects Awarded	Projects Physically Completed
Step 1	22	43
Step 2	26	56
Step 3	43	113
Step 4	48	9
Total	139	221

In FY 1983 alone, 198.1 million dollars were invested at 36 wastewater treatment facilities in Indiana. Of this amount, 148.6 million dollars were from federal grant awards. These awards were either for completion of plant construction or were new grant awards. Six of these awards (17 percent) were for projects on priority water bodies. A breakdown of these awards is shown in Table 17.

"In FY 1983 alone, 198.1 million dollars were invested at 36 wastewater treatment facilities in Indiana. Of this amount, 148.6 million dollars were from federal grant awards. These awards were either for completion of plant construction or were new grant awards."

Table 17. Physical completions and new grant awards in Indiana for FY 1983

	Minor Treatment Facilities (less than 1 MGD)	Major Treatment Facilities
Number Completed	10	9
Number New Awards	10	7
Number in Compliance*	100%	100%
Number Completed on Priority Water Bodies	1	3
Number New Awards on Priority Water Bodies	0	2
Federal Grant Amounts	35.4 million dollars	113.2 million dollars

*Compliance is anticipated for the plants with new grant awards.

Industrial Facilities

By July 1, 1977, industrial dischargers were required to meet Best Practicable Control Technology Currently Available (BPT) or achieve water quality standards, whichever was more stringent. Nearly all Indiana industries met BPT by this time. For those which did not comply, enforcement action was initiated and eventually resolved to achieve compliance. However, there was a concern that toxic pollutants, which are the primary focus of Best Available Technology Economically Achievable (BAT), were not sufficiently addressed. Many permittees now have installed treatment that can meet BAT, primarily because of an overriding site-specific water quality issue. Applicants for permit reissuance are required to specifically identify toxic substances which are or may be discharged to the waters of the state from their facility. The permit reissuance process involves the detailed review of these applications, and toxic pollutants are limited to safe levels. If there is a question as to the presence of a particular substance in sufficient quantities to be of concern, a monitoring requirement is established in the permit. A final permit limit is based on these additional monitoring data.

Although the total amounts of money expended by industry for wastewater treatment has not been reported, it has been considerable. Data from claims for tax exemptions for wastewater treatment equipment provide some idea of these expenditures. The number of claims and total amounts claimed for each year from 1978-1983 by Indiana industries are shown in Table 18. This amount has nearly doubled in this time period.

"Although the total amounts of money expended by industry for wastewater treatment has not been reported, it has been considerable."

Table 18. The number of tax exemption claims and the total dollars claimed by Indiana industries for wastewater treatment facilities from 1978 to 1983.

Year	Number of Claims	Amount Claimed
1978	102	$369,186,717
1979	123	394,712,641
1980	113	400,895,352
1981	124	518,478,055
1982	126	607,093,628
1983	139	633,443,520

In the past, industrial effluents have caused water quality problems even though they were not discharged directly to a waterbody. These effluents would often "upset" the various treatment processes at the municipal sewage treatment facility to the extent that little or no wastewater treatment would occur. Also, these pollutants can pass through the wastewater treatment facility at levels that are still toxic to the aquatic life in the receiving stream. Toxic substances can also accumulate in the municipal sludge at levels which make its disposal much more expensive.

To prevent these occurrences, Indiana has developed a pretreatment program that requires industries to reduce concentrations of toxic or harmful substances to "safe" levels before releasing them to the sewer system. Municipalities with sewage treatment facilities which are designed to treat 1.0 mgd or more and have an adequate industrial base are required to work directly with the industries which need pretreatment to develop their own plans for control of these discharges. In general, the state works with the smaller municipalities and their associated industries to develop their pretreatment plans and controls.

"Indiana has developed a pretreatment program that requires industries to reduce concentrations of toxic or harmful substances to "safe" levels before releasing them to the sewer system."

Compliance and Enforcement

In order to assure compliance with NPDES permit limits on substances in the dischargers effluent, a variety of data is reviewed. These data would include such things as: self monitoring data submitted on monthly monitoring reports forms, data collected during compliance sampling inspections conducted by ISBH staff, water quality monitoring data, bioassay data and other information which may be available. When NPDES permit or water quality violations are found, appropriate enforcement action is taken.

"When NPDES permit or water quality violations are found, appropriate enforcement action is taken."

This enforcement action will insure the quickest return to compliance by the permittee and may include such things as Notice of Violation letters, warning letters, prehearing conferences, Stream Pollution Control Board hearings and, if necessary, judicial proceedings. Table 19 shows the number and kinds of enforcement actions taken by the state between January 1981 and December 1983.

Table 19. Actions taken from January 1981 through December 1983 against municipal and nonmunicipal facilities in significant noncompliance.

	1981	1982	1983	TOTAL
Total Number of Facilities	1,019*	1,019	1,019	1,019
Number of Pre-Administrative Hearings	200	127	140	467
Number of Administrative Actions	38	63	42	143
Number of Judicial Actions	6	5	29	40

*Does not include state and federal facilities

In Indiana, compliance with NPDES requirements is tracked with the assistance of computers. Tracking is performed monthly for each permittee identified on the state compliance monitoring priority list, Once each quarter, a Quarterly Compliance Report is prepared which highlights the status of each permittee and provides a plan for returning noncomplying facilities to compliance. The compliance rate for major dischargers has been about 90% for municipalities and 95% for industries. Nonmajor dischargers experience a somewhat lower compliance rate due to the lower priority assigned this category with regard to state resources. As facilities return to compliance, improvements in water quality are expected especially since most discharge permits in Indiana are based, at least in part, on water quality consideratons.

"The compliance rate for major dischargers has been about 90% for municipalities and 95% for industries."

In addition to compliance tracking, which focuses on significant noncompliance at all types of facilities, the Municipal Compliance Strategy (MCS) will be implemented to achieve maximum municipal compliance by July 1, 1988. This would be in accordance with the 1981 amendments to the Clean Water Act and subsequent National Municipal Compliance Strategy. The MCS is a plan designed not only to help municipalities achieve and maintain compliance with their permit limits, but also to provide information and guidance to allow the municipality to plan for future expansion, replacement, and operational and maintenance costs independant of outside financial assistance.

Success Stories

Many recent improvements in water quality in Indiana have gone unnoticed because the formerly polluted areas were small and scattered throughout the state. These areas were not always visibly polluted with black sludge, foul-smelling water or strangely colored sediments. Instead, they may have appeared normal but were biologically depressed. These stream areas supported few fish, and those present were often pollution-tolerant "rough" fish. More sensitive game fish avoided such areas. The main problems were the periods, especially during hot weather and low stream flows, when oxygen levels fell below those required by most fish or when ammonia or metals concentrations increased to toxic amounts. Inadequate treatment of wastewater from industries and sewage treatment facilities was almost always responsible for such conditions in the larger streams regularly monitored by the state.

In Indiana, there are 73 Fixed Water Quality Monitoring Stations on streams designated for warm water aquatic life, 12 stations on streams and lakes designated for salmonids and 7 stations on streams designated for limited aquatic life. Upgraded wastewater treatment since 1980 has resulted in remarkable improvements in water quality at many of the scattered sites on the "warm water" streams. Between 1975 and 1980, 54% of these stations had waters which were periodically unsuitable for warm water fish communities because of low dissolved oxygen and/or high ammonia or metals concentrations. Moderate to severe impairment of the fisheries (water quality violations more than 10% of the time) occurred at 18% of the localities. Since then, only 25% of the stations had water quality periodically unsuitable for fisheries, and the impairment was moderate to severe at only 7% of the sites.

"Upgraded wastewater treatment since 1980 has resulted in remarkable improvements in water quality at many of the scattered sites on the "warm water" streams."

Responsibility for water quality impairments to fisheries from 1975 to 1980 could be divided almost equally among dissolved oxygen, ammonia and metals (primarily copper) problems. Dissolved oxygen and metals problems have decreased greatly since then, but ammonia toxicity still impairs stream fisheries to almost the same degree. The percentage of stations at which ammonia is a problem has only decreased from 23 to 18 percent between the periods. Moderate to severe impairment occurred at 6% of the stations during both periods. Treatment to reduce ammonia concentrations in municipal and industrial discharges is being required at all locations where such treatment is necessary to meet water quality standards.

"Treatment to reduce ammonia concentrations in municipal and industrial discharges is being required at all locations where such treatment is necessary to meet water quality standards."

In order to document the improvements in water quality that have resulted from the various aspects of the Point Source Control Program (the construction grants program, improved wastewater treatment by industry, and the compliance and enforcement programs) several "Success Stories" are presented. These provide information on improved water quality that has occurred in specific streams or stream reaches as a result of improved wastewater treatment. In some areas, chemical and/or physical data provide the bulk of the evidence of improvement, and in others much of it is biological. There are more instances where water quality improvements have occurred as a result of improved wastewater treatment, but some of them have yet to be fully documented.

West Fork White River

The upper 200 miles of the West Fork of White River in central Indiana has long been polluted by municipal wastes, primarily from the cities of Winchester, Muncie, Yorktown, Anderson and Indianapolis. A 1942 study of fish populations in the river showed that poor water quality below Indianapolis and Anderson allowed only a few pollution-tolerant fish to survive. A single carp was the only fish seined from the river below Muncie. Dissolved oxygen concentrations in 1945 fell below optimum levels downstream from sewage outfalls from Winchester to Indianapolis. At Muncie, no oxygen was recorded.

To determine the full extent of polluted conditions in the river, a biological survey of bottom-dwelling organisms was conducted in 1963. Pollution-tolerant organisms such as sludgeworms, certain midge larve, leeches and snails were predominant downstream from each of these cities. Over half of the upper 200 miles of river were judged to be adversely affected by sewage wastes.

Eleven fish kills occurred in this stretch of the river during the 1960s. Fewer than 5% of the fish identified were gamefish. As recently as the period from 1973 to 1980, dissolved oxygen and ammonia concentrations frequently violated state water quality standards below Winchester, Muncie, and Indianapolis. Eight fish kills involving at least 20,000 fish occurred in the river below Muncie during this time. Many of these were due to low dissolved oxygen attributed to nocturnal respiration by dense algae populations which thrived in the sewage-fertilized waters. In 1976, high ammonia concentrations downstream from Indianapolis killed approximately 5 million fish in 160 miles of the river—the largest fish kill recorded in this state in recent years.

Since 1976, EPA has granted a total of 30 million dollars for municipal sewage treatment improvements at Winchester, Muncie, Yorktown, and Anderson and another 250 million dollars for improvements at Indianapolis. The money was spent primarily for design and construction of advanced waste treatment facilities and for structures to reduce combined sewer overflows. The effect has been to greatly decrease the amount of oxygen-consuming materials reaching the river and to lower the concentrations of ammonia. There have been no recorded violations of dissolved oxygen standards in stream areas upstream from Indianapolis since 1980. Average ammonia concentrations are now five times lower below Muncie and two times lower below Anderson than they were from 1975 to 1980.

"The effect has been to greatly decrease the amount of oxygen-consuming materials reaching the river and to lower the concentrations of ammonia. There have been no recorded violations of dissolved oxygen standards in stream areas upstream from Indianapolis since 1980. Average ammonia concentrations are now five times lower below Muncie and two times lower below Anderson than they were from 1975 to 1980."

Another improvement in water quality is the reduction of copper concentrations below Anderson. Before 1980, concentrations were potentially toxic to aquatic organisms about 16% of the time. Since then, no potentially toxic concentrations of copper have been recorded, and the average concentration has decreased threefold. This decrease can be attributed to improved pretreatment of industrial wastes received by the Anderson sewage treatment facility and to improved treatment at the plant itself.

Aquatic communities dominated by pollution-tolerant sludgeworms below Winchester, Muncie, and Anderson have recently been replaced by more normal, clean water species of caddisflies and mayflies. The entire 50 miles of river between Muncie and Noblesville had once been biologically depressed. Now a normal fauna is found even near sewage treatment facility outfalls. Where only a single carp was found at Muncie in 1942, at least 21 species of fish, including smallmouth bass, largemouth bass, rock bass, and bluegills were present in 1980. Accumulations of sludge immediately below Muncie may still cause occasional localized problems, but these should decrease with improved operation of the sewage treatment facility and as the accumulated sludge is flushed away during high water periods.

Advanced wastewater treatment facilities at Indianapolis were not in full operation until 1983. Before that time, much of the river between Indianapolis and Spencer was adversely affected by sewage to some extent. During the next few years, chemical and biological monitoring will be conducted to determine the extent that water quality in this last chronically polluted stretch of the West Fork of White River has been improved.

New Whiteland (East Grassy Creek)

New Whiteland is a community of about 5,000 people in northern Johnson County. The town is in a rapidly developing area that has little heavy industry on its sewer system. The sewage treatment facility discharges to East Grassy Creek. About 0.35 mile downstream of the facility's discharge, East Grassy Creek joins Grassy Creek which flows south and, after it is joined by a few small tributaries, eventually becomes Youngs Creek.

East Grassy Creek has a reported $Q_{7,10}$ of 0.0 cfs upstream of the sewage treatment facility. However, there are a few permanent pools in the upstream segment that provide enough habitat to support a limited recreational fishery and habitat for other aquatic life. Downstream of the facility, a large percentage of the flow in East Grassy Creek is final effluent from the plant discharge. Obviously, the quality of East Grassy Creek and Grassy Creek is greatly influenced by the quality of the effluent from the New Whiteland sewage treatment facility, and any significant change in the effluent should produce corresponding changes in the stream.

In the late 1960s and early 1970s, the New Whiteland sewage treatment facility was hydraulically overloaded and not adequately maintained and operated. During a fish kill investigation in August of 1969, it was found that two of the six aerators were out of operation in the activated sludge units, and these units and the final settling tank were septic. In an attempt to get the plant operating properly, the operator was pumping the activated sludge out onto the plant grounds, and the sludge was also running into the stream.

The receiving streams were dark colored and septic, and the fish kill extended for three to four miles downstream. At this time, the New Whiteland sewage treatment facility was receiving flows of about 0.300 mgd, well in excess of the designed capacity of 0.200 mgd. Attempts to get the plant operating properly were largely unsuccessful.

A biological and chemical survey conducted in 1970 disclosed that East Grassy Creek was severely depressed biologically downstream from the point of discharge. The stream was discolored, odors and sludge deposits were present and sewage fungus was abundant. Twenty-six genera of macroinvertebrates were found upstream and only nine pollution-tolerant genera were found downstream. Fish were found upstream of the discharge, but none were found downstream.

As a result of these findings, a Stream Pollution Control Board enforcement action was initiated, and in 1972, the New Whiteland sewage treatment facility was expanded and upgraded. The capacity was increased from 0.200 mgd to 0.450 mgd, and the plant was converted from an activated sludge facility to an extended aeration facility with a microstrainer. Following a period of operational problems after the improvements were made, the facility appeared to be meeting its NPDES permit limits.

Table 20 shows that the results from samples collected upstream, downstream and at the facility outfall both before (1970) and after (1979) the plant

Table 20. Results of surveys done before (1970) and after (1979) plant expansion at New Whiteland, Indiana.

	Before (1970)			After (1979)		
	Upstream	Plant Effluent	Downstream	Upstream	Plant Effluent	Downstream
BOD_5 (mg/l)	3.6	81	43	—	1.0	1.2
Suspended Solids (mg/l)	7	130	62	—	11.0	22.0
Fecal Coliform (#/100N)	700	—	28,000	—	10	360
Dissolved Oxygen (mg/l)(min)	4.1	—	3.3	10.0	6.9	7.8
Residual Chlorine	—	—	—	0.0	3.4	1.5

was expanded and upgraded. Values for BOD_5, suspended solids and fecal coliform bacteria were greatly reduced in downstream samples taken in 1979 when compared to 1970 data. Minimum dissolved oxygen values downstream in 1979 were double those in 1970. However, residual chlorine values in the effluent and downstream samples taken in 1979 were quite high, apparently due to equipment problems and/or problems in regulating chlorine dosage by plant operators.

"Values for BOD_5, suspended solids and fecal coliform bacteria were greatly reduced in downstream samples taken in 1979 when compared to 1970 data."

The 1979 survey indicated that criteria for most chemical parameters and fecal coliform bacteria were being met. However, residual chlorine was still detectable in East Grassy Creek about 0.5 mile downstream of the New Whiteland sewage treatment facility discharge. Stream conditions indicated some deleterious effects of high residual chlorine concentrations, and few fish or aquatic invertebrates were found in this section. Recorded observations indicated that aquatic plant life was also abnormally sparse here, although "normal" populations existed upstream of the discharge and further downstream in Youngs Creek. The water in the stream was extremely clear, and no sewage odors or sludge deposits were evident.

Eight species of fish (266 individuals) were collected from East Grassy Creek upstream of the facility in 15 minutes by using a back pack DC electrofishing unit. Creek chubs and stonerollers were the most common fish, but 25 green sunfish, 3 longear sunfish, and 22 common white suckers were present in the collection. Fifteen minutes of shocking in East Grassy Creek just downstream of the facility outfall produced only two green sunfish. These fish may have been chased into the area by the upstream activity, as no other fish were collected or seen after an extended search.

Fifteen minutes of fish shocking in Youngs Creek about 3.0 miles downstream of the sewage treatment facility discharge produced 208 individuals representing 16 species. Orangethroat darters and bluntnose minnows were the most numerous. However, 18 bluegills, 5 longear sunfish, 4 common white suckers and 2 yellow bullheads were collected. These species are valued by small stream fishermen.

Twenty minutes were spent collecting aquatic invertebrates at each station by hand picking microhabitats and sifting marginal vegetation with a net. A total of 34 individuals representing 7 taxa were found in East Grassy Creek just upstream of the New Whiteland sewage treatment facility discharge. The most numerous organisms were isopods. The only organism found downstream of the discharge in 20 minutes of searching was one crayfish. A total of 36 individuals representing 8 taxa was found in Grassy Creek just downstream of the confluence with East Grassy Creek. The most numerous organisms were isopods which made up over half of the organisms collected.

At the station on Youngs Creek about 3.0 miles downstream of the discharge, 87 aquatic organisms representing 12 taxa were collected. The most numerous invertebrates were mayfly lavae (Stenonema interpunctatum) midge larvae (Tendipes sp.), damselfly larvae and adult amphipods.

The fish and invertebrates collected at the Youngs Creek station indicated that the community was much more diverse than aquatic communities found at the other stations. This is probably due to the larger volume of flow, more favorable habitat and reduced residual chlorine content of the waters.

In November of 1979, a letter from the Enforcement and Operations Branch, ISBH, to the superintendent of the New Whiteland sewage treatment facility explained that while the New Whiteland plant was generally accomplishing an excellent degree of treatment for BOD_5 and suspended solids, the excessive chlorine was preventing the establishment of an aquatic community in East Grassy Creek. The letter recommended that adjustments be made on the chlorine dosage. The New Whiteland NPDES premit provides for a maximum residual chlorine of 1.0 mg/l.

A brief observation of East Grassy Creek in October of 1983 during extended low flow conditions indicated that the stream's aquatic life is still depressed to some extent by residual chlorine. Minnows were found in moderate numbers both upstream and downstream of the New Whiteland sewage treatment facility discharge, and filamentous green algae and watercress were found in small amounts. However, the benthic organisms were restricted to amphipods and isopods upstream of the discharge and no organisms were found immediately downstream. Periphyton was also abnormally sparse downstream of the discharge. The stream was very pleasant aesthetically with clear waters and an extremely clean, sandy bottom. East Grassy Creek is no longer a health hazard and is a very pleasant stream even immediately below the sewage treatment facility outfall. However, there are apparently still adjustments to be made with the excess chlorine concentrations in the plant effluent before the aquatic life of the watercourse can reach its full potential. Once these adjustments are made and lower chlorine residuals maintained, East Grassy Creek should provide excellent habitat for aquatic life. Grassy Creek will also provide area youths with a recreational fishery not often found in a heavily developed area.

"Once these adjustments are made and lower chlorine residuals maintained, East Grassy Creek should provide excellent habitat for aquatic life."

Fort Wayne (Maumee River)

The Maumee River is formed by the confluence of the St. Mary's River and St. Joseph River within the City of Fort Wayne in Allen County. Writings by early naturalists in the late 1700s described the Maumee River as teeming with fish including muskellunge, largemouth bass, smallmouth bass, northern pike and walleye. These early writers described spearing the fish easily and killing others with clubs and stones. They reported that, on some days, up to a thousand could be taken with hook and line from the Maumee River near the old Fort Wayne. In the early and mid-1800s, dams were built on the upper Maumee tributaries, land was cleared for farming and the area became more industrialized with slaughterhouses and breweries built along the river. The dams blocked spawning migrations for many of the fish, and the farms and industry created pollution which made its way to the river. Consequently, the fishery in the Maumee River began to decline.

The first scientific studies of the fish of the Maumee River in the Fort Wayne area were conducted in 1894 and 1895. Fish were collected by seining river stations in the segment of the Maumee between the present site of the Fort Wayne sewage treatment facility and New Haven. Seining is generally better for collecting small species of fish inhabiting shallow water. However, a few representatives of all game fish species present should have been captured by repeated collections. In all, forty-eight species of fish were collected, but no northern pike, muskellunge, walleye, largemouth bass or smallmouth bass were found. Only a few years before this study, the species were apparently quite numerous in the watershed. Only five species considered as sport or game species were present in the collections.

By 1930, Fort Wayne was a city with approximately 115,000 people and several large industries. Many were probably discharging wastewater to the Maumee River either directly or via the municipal sewers, and the quality of the river continued to deteriorate.

In 1941, Dr. Gerking of Indiana University conducted a survey of the Maumee River using methods similar to those used in 1894 and 1895. Gerking had a collection station on the east edge of Fort Wayne and also near the S.R. 101 bridge close to the Ohio-Indiana State Line. Only 23 fish species were found at the two stations combined. Fourteen of these species had not been present in the 1894-1895 collections, and 25 species that had been found in the early study were missing, indicating a significant change in habitat quality. Although five species of game fish were found at each of Gerking's stations, only the largemouth bass represented game species that were formerly common.

In the 20 years between Gerking's work and the early 1960s, water pollution problems became so severe that the Maumee River was devoid of all but the most tolerant aquatic life. In August of 1964, 2,000-3,000 shad, suckers, carp, and bullhead catfish were killed when dissolved oxygen was depleted by raw and inadequately treated sewage bypassed from the sewage treatment facility following a heavy rain. However, no fish, living or dead, were observed for seven miles downstream of the Fort Wayne sewage treatment facility. In the eighth mile downstream of the discharge, dead fish and some stressed living fish were found. The kill continued to a point near the state line. At miles 7 and 8 downstream of the plant, crayfish were seen on the banks of the Maumee—none were in the water.

In August of 1970, 11,000 fish died because of low dissolved oxygen concentrations in the Maumee between the sewage treatment facility at Fort Wayne and the Ohio-Indiana State Line. The kill was composed mainly of carp, bullhead catfish, and shad. Crayfish were again found climbing from the river onto the banks. A few channel catfish and suckers were found at the downstream end near the state line. The conservation officer investigating the kill stated that no "game fish" could live in the Maumee River, and that similar "rough fish" kills had occurred seven years in a row. Since the officer felt that no one was doing anything about the problem, he had not reported any kills since 1964.

In 1977, the Indiana Department of Natural Resources (IDNR) conducted a fish population study of the Maumee River at New Haven. Electrofishing equipment, which often excludes the smaller darters and minnows, was used. For this reason, the IDNR results cannot be realistically compared to the 1894-1895 or 1941 studies. However, the number of game fish species found during the IDNR study compared favorably to the number in the two earlier studies. No walleye, pike or smallmouth bass were found.

The Indiana State Board of Health (ISBH) collects fish from the Maumee River as part of the ongoing CORE program. Electrofishing methods were used to take fish from just downstream of the Fort Wayne sewage treatment facility in 1979, 1980, and 1982. In 1982, a collection was also made at the Indiana-Ohio State Line.

The 1979 ISBH collection contained seven species of sport fish. The collection included significant numbers of smallmouth bass and northern pike. The 1894-1895 and 1941 collections contained only five sport fish species and did not contain smallmouth bass or northern pike.

"The 1979 ISBH collection contained seven species of sport fish. The collection included significant numbers of smallmouth bass and northern pike."

In 1980, nine species of sport fish were found in the ISBH collection. Good populations of smallmouth bass and northern pike were present again, and these were found in several size ranges. Walleye were also collected during the 1980 trip. Walleye were not present in any previous collections.

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The station immediately below the Fort Wayne sewage treatment facility was sampled in 1982 following a combined sewer overflow (CSO) related fish kill. Although the sample contained eight species of sport fish, smallmouth bass, walleye, northern pike, and white crappie were not collected. However, largemouth bass were present, and pumpkinseed sunfish, an ammonia sensitive species, were taken for the first time.

It was of special interest to the ISBH biologists to note the large numbers of well-conditioned northern pike and the varying size ranges of these fish. It was also very encouraging when fine walleye were taken in 1980. All of the fish taken in the 1979, 1980, and 1982 studies appeared to be very healthy specimens. Fish did not avoid the Fort Wayne sewage treatment facility discharge area, and several species were taken directly from the turbulent discharge mixing zone. None of the fish collected in the river by ISBH biologists contained metals or pesticides in concentrations potentially harmful for human consumption.

"None of the fish collected in the river by ISBH biologists contained metals or pesticides in concentrations potentially harmful for human consumption."

It is obvious that the fishery in the Fort Wayne segment of the Maumee River has dramatically improved in recent years, and is actually better than it was at the turn of the century. In order to understand what caused the changes in the water quality of the Maumee that was necessary to produce these desired changes in the fish populations, we can examine the records of the Indiana Stream Pollution Control Board (ISPCB).

"It is obvious that the fishery in the Fort Wayne segment of the Maumee River has dramatically improved in recent years, and is actually better than it was at the turn of the century."

1. In 1941, a 24 mgd activated sludge sewage treatment facility was placed in operation in Fort Wayne.

2. In 1959, the sewage flow to the sewage treatment facility had reached 22.6 mgd. This same year the ISBH approved plans for a 32 mgd plant.

3. In 1961, a package sewage treatment facility was approved to treat wastewater discharging to Spy Run until an interceptor could be extended into the area later in 1962. Spy Run is a tributary to the Maumee.

4. In 1965, the east end sanitary sewer was approved to pick up waste from the Parrot Packing Company, three subdivisions, and several industries that had been contributing to the pollution of the Maumee River.

5. In 1967, an engineering study indicated that 69% of the population of Fort Wayne was served by combined sewers. It was found that there were 27 combined sewer overflows to the Maumee River, interceptor sewer overflows and bypassing at the sewage treatment facility. It was estimated that 3.17 million pounds of BOD per year were being contributed to the Maumee River by Fort Wayne. A plan was devised to reduce this contribution by at least 60%. This was to be accomplished by constructing three tertiary lagoons at the facility.

6. In 1970, the ISBH approved plans to connect the Diversified Utilities sewage treatment facility to the Fort Wayne facility.

7. In 1971, final plans were approved for combined sewer overflow interceptors.

8. In 1974, approval was given for the expansion of the Fort Wayne sewage treatment facility from 32 mgd to 60 mgd, construction of storm water retention ponds and terminal lagoons for advanced treatment.

9. The new Fort Wayne facility was completed in 1979.

In summary, the City of Fort Wayne has constructed over 135 miles of sanitary sewers, 36 miles of storm sewers, stormwater retention ponds, and an advanced wastewater treatment facility with phosphorus and ammonia removal since the early 1970s. All of these efforts have contributed to the remarkable improvements in Maumee River water quality in recent years.

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Data from ISBH 24-hour surveys of 1974 and 1975 and annual average self-monitoring data since 1976 reflect the improvements of the Fort Wayne sewage treatment facility final effluent (Table 21). An examination of the ISBH Fixed Water Quality Monitoring Station records from 1975 to 1983 revealed that there have been no recorded violations of the state standards for dissolved oxygen at either the Maumee River station at New Haven or the Maumee River station near the Indiana-Ohio State Line.

Table 21. Data from Fort Wayne sewage treatment facility for the years 1974 to 1983. (Values in mg/l)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
BOD_5	22.0	24.0	9.3	7.8	8.7	2.1	2.3	2.3	5.4	3.9
Suspended Solids	16.0	40.0	9.0	11.2	13.3	3.7	3.7	3.8	6.3	4.3
Total Ammonia	11.5	14.0	—	4.0	2.1	0.47	—	0.35	1.11	1.38

There has been only one recorded fish kill in the Maumee River downstream of Fort Wayne since 1977. This fish kill occurred in 1982 due to combined sewer overflows during a storm event. As a result, the discharged wastes caused a depletion of the dissolved oxygen concentration of the river a short distance downstream of the sewage treatment facility. More than 3,000 channel catfish, largemouth bass, northern pike, carp, and shad were killed. Self-monitoring records indicate that dissolved oxygen concentrations often go below state standards immediately below the treatment facility following combined sewer overflows. If these combined sewer overflows can be controlled, the Maumee River below Fort Wayne should have no water pollution problems which would prevent the establishment and maintenance of an excellent urban sport fishery.

"If these combined sewer overflows can be controlled, the Maumee River below Fort Wayne should have no water pollution problems which would prevent the establishment and maintenance of an excellent urban sport fishery."

Kokomo and Frankfort (North and South Forks of Wildcat Creek)

The lower stretches of the North and South Forks of Wildcat Creek in Tippecanoe and Carroll counties are part of the Indiana Natural, Scenic, and Recreational Rivers System. Both are relatively unaltered streams with forested banks and are popular with canoeists. Indiana water quality regulations specifically designate them as State Resource Waters to protect their present high quality. However, the headwaters of both streams have been chronically polluted in the past. As the following histories illustrate, water quality in the headwaters of the North and South Forks has improved greatly in recent years.

Downstream from Kokomo, the North Fork was in poor condition for a long time. Nine fish kills, attributed to pollution sources in Kokomo, have been documented since 1961. A study in 1966 disclosed that sludgeworms and midge larvae, indicative of polluted waters, were dominant for about 15 miles below the city. Samples collected in 1978 showed no benthic organisms downstream. The problem was twofold: inadequately treated sewage from the municipal treatment facility and the discharge of high concentrations of metals by at least nine industries. The metals discharged to the sewer system adversely affected the sewage treatment process. Dissolved oxygen concentrations in the stream dropped below state standards 15% of the time. Un-ionized ammonia was present in potentially toxic amounts 29% of the time. Also, some of the industries discharged metals directly to the stream itself. Copper and zinc were present in potentially toxic amounts 17% and 9% of the time, respectively. Aquatic life sensitive to such conditions could not exist downstream from Kokomo.

Construction of advanced sewage treatment facilities in 1977, together with improved pretreatment of metals from Kokomo industries discharging to municipal sewers, has resulted in major improvements of water quality in the North Fork of Wildcat Creek. The improvements began in 1979, the first full year of operation of the treatment plant. Since then, no dissolved oxygen or ammonia standards violations have been found downstream. Zinc, lead, and copper concentrations have been halved, and a single high copper measurement has been the only metals problem observed. Recent fish surveys of the stream show that populations still have not returned to normal, but additional improvement in the quality of industrial discharges should result in the improvement of the fishery below Kokomo.

"Construction of advanced sewage treatment facilities in 1977, together with improved pretreatment of metals from Kokomo industries discharging to municipal sewers, has resulted in major improvements of water quality in the North Fork of Wildcat Creek."

Similar, though less extensive, problems existed on the South Fork of Wildcat Creek below Frankfort. Sludgeworms and snails dominated the benthic community for five miles downstream in 1966. Three fish kills involving 1,500 to 3,000 fish each occurred between 1967 and 1976. Two of these were related to poorly treated sewage. Before 1980, dissolved oxygen concentrations below state standards were measured several times, but local conservation officers said the situation was chronic. The Frankfort sewage treatment facility was hydraulically overloaded and could not handle the volume of wastes it received. The problem was especially bad each year in late summer when a tomato canning company began discharging organic wastes to the treatment plant. Poorly treated wastes passed through the system to the South Fork of Wildcat Creek. Intense bacterial action consumed most of the oxygen in the water and made the establishment of a normal stream community impossible much of the time. In addition to the adverse effects on aquatic life, fecal coliform bacteria levels were above standards for partial-body contact 58% of the time.

In 1981, an expanded sewage treatment facility with advanced waste treatment capabilities was completed in Frankfort at a cost of 17.6 million dollars. No low dissolved oxygen concentrations have been observed since then, and average ammonia levels have decreased by one-third. Such conditions are much more favorable to the establishment of a normal stream community than the chronically polluted waters present before 1981. Also, the South Fork of Wildcat Creek below Frankfort is now one of the few places in the state where fecal coliform bacteria standards for partial-body contact have not been violated recently. This much improved water quality in the headwaters of the South Fork should have a beneficial effect on the recreational use of the officially designated State Resource Waters further downstream.

"In 1981, an expanded sewage treatment facility with advanced waste treatment capabilities was completed in Frankfort at a cost of 17.6 million dollars. No low dissolved oxygen concentrations have been observed since then, and average ammonia levels have decreased by one-third."

It should be noted that the ammonia removal occurring at Frankfort is only occurring because of increased detention due to a hydraulic underload. As hydraulic loading approaches the designed capacity, ammonia removal facilities may be required to maintain the improved water quality.

Morgan Packing Company (Muscatatuck River)

Another long stream segment with remarkably improved water quality is the lower Muscatatuck River in southern Indiana. The lower 30 miles of this river form the boundary between Jackson, Scott, and Washington counties. The Morgan Packing Company at Austin discharges to the Muscatatuck and was responsible for numerous water quality violations and fish kills during the 1950s, 1960s, and 1970s. Decomposition of cannery wastes, generated during vegetable canning operations at the company, created a large bacterial demand for oxygen in the river and a buildup of sludge on the river bottom. This frequently caused oxygen concentrations to fall below levels required to support fish and other aquatic animals, especially during hot weather and low stream flow. Fish would be killed or driven from the area when dissolved oxygen decreased. As conditions improved, fish recolonized the area, only to be killed or driven out again by another period of deoxygenated water.

The extent of pollution problems in the lower Muscatatuck River was shown in biological surveys of the river in 1961 and 1970. In both years, sludgeworms were present in enormous numbers below the company's outfall. These organisms are one of the few truly aquatic animals to thrive where oxygen levels are very low most of the time. During both surveys, the presence of black, putrid water was noted at various points. Pieces of floating vegetables were abundant in the river. During the 1970 survey, hundreds of crayfish were observed along the river banks as they tried to crawl out of the polluted waters. Pollution-tolerant organisms predominated for 30 miles below the outfall. Only near the river's juncture with the East Fork of White River had a normal, cleanwater community returned.

"At least four fish kills occurred between 1961 and 1970. Three of these killed fish along the entire 35 miles of the lower Muscatatuck. In 1970, about 10,000 fish were killed as oxygen concentrations fell to near zero from the Morgan Packing Company outfall to the river's mouth."

At least four fish kills occurred between 1961 and 1970. Three of these killed fish along the entire 35 miles of the lower Muscatatuck. In 1970, about 10,000 fish were killed as oxygen concentrations fell to near zero from the Morgan Packing Company outfall to the river's mouth.

As recently as the 1975 to 1980 period, state water quality standards for dissolved oxygen were violated 8% of the time at a monitoring station 10 miles below the outfall. In 1979, the company completed construction of two aerated lagoons and a large holding lagoon to provide more complete treatment of their wastewater. Most of the waste decomposition which had once occurred in the river and depleted it of oxygen is now carried out more rapidly in these treatment lagoons before the wastewater is discharged.

Since 1980, only one violation of the state dissolved oxygen standard has occurred at the downstream monitoring station, and this violation was minor. The aeration capacity of this slow, meandering river is quite low, and natural dissolved oxygen concentrations are somewhat lower than in most other streams in the state.

"Since 1980, only one violation of the state dissolved oxygen standard has occurred at the downstream monitoring station, and this violation was minor."

Aquatic invertebrate samples were collected from the river 10 miles below the Morgan Packing Company discharge in 1983. During previous biological surveys, the only aquatic organisms present here were a few leeches, isopods, and pollution-tolerant midges. Now the diversity of life has greatly increased and pollution-intolerant mayflies are the dominant organism. Local fisherman report that large catfish are occasionally taken from the river at this location, and spotted bass, crappie, sunfish, and other gamefish are also taken by sportsmen. No fish kills have occurred in recent years. Apparently, the lower 35 miles of the Muscatatuck River have once again become a healthy aquatic resource.

"Apparently, the lower 35 miles of the Muscatatuck River have once again become a healthy aquatic resource."

Nonpoint Source Control Program

Nonpoint source pollution in the State of Indiana has been judged to be relatively unimportant in relation to other types of pollution with respect to impact on water quality and aquatic life. Sediment, per se, is not seen to be a significant water quality problem except in a few isolated instances. Phosphorus enriched sediment may pose an additional nutrient load to lakes, but most natural lakes in the state are in the northern flatlands where erosion rates are minimal. In addition, some lakes are also impacted by more readily available nutrients from septic tanks to some extent. It is often quite difficult and expensive to control these septic tank nutrient sources, and probably even more difficult and expensive to effectively control nonpoint sources of sediment borne nutrients. Since several federal and county agencies (the U.S. Department of Agriculture, the Soil Conservation Service, and the county Cooperative Extension Service) are involved with agricultural programs designed to promote soil conservation, the state has chosen not to become involved with sediment control programs at this time.

"Sediment, per se, is not seen to be a significant water quality problem except in a few isolated instances."

Recent fish sampling surveys in conjunction with the CORE program and other toxics monitoring programs have shown that fish in several Indiana rivers are contaminated by chlordane and dieldrin (pesticides). It appears that these substances most probably entered the streams on eroded soil particles from farmland on which these pesticides have been applied. However, EPA banned the use of these chemicals for agricultural purposes several years ago. The state needs to determine if soil erosion is still a significant source of these contaminants and if reducing erosion can be effective in eliminating fish contamination. If this is found to be the case, new sediment control programs may need to be proposed.

Table 22 provides a summary of our assessment of the severity and extent of nonpoint source contributions to Indiana waterways and the primary pollutant parameters. Table 23 lists the existing and recommended nonpoint source control programs in the state and, where possible, the estimated state administrative costs.

Studies of record on the water quality impacts of urban runoff fail to document either any serious, long-lasting water quality impacts or any cost-effective means for reducing pollutants loadings from this source. Control programs consist of providing structures to direct runoff to sewers where possible. This may lead to further water quality problems if storm sewers and sanitary sewers are combined. Heavy runoff may produce combined sewer overflows which often have quite deleterious effects on water quality.

Table 22. Severity and extent of nonpoint source contributions

TYPE OF NPS	EXTENT	SEVERITY	PRIMARY PARAMETERS
Urban	L	I	C,M,SS
Agriculture (irrigated)	N/A	N/A	N/A
Agriculture (nonirrigated)	M- W	I	SS,T,N,P
Animal wastes	L	I- S	C,OD,N
Silviculture	L	I	SS
Mining	L	I- S	SS,O*
Construction	L	I	SS
Hydrologic modification	L	I	SS,O**
Saltwater intrusion	N/A	N/A	N/A
Residual Waste /Landfill	L	I	M,N,O***

---EXTENT---

W = widespread (50% or more of the State's waters are affected)
M = moderate (25% to 50% of the State's waters are affected)
L = localized (less than 25% of the State's waters are affected)

--SEVERITY---

S = severe (des. use is impaired)
M = moderate (des. use is not precluded, partial support)
I = minor (des. use is almost always supported)

--PRIMARY PARAMETERS--

C = coliforms
LF = low flow
M = metals
N = nutrients
OD = oxygen demand
P = pesticides/herbicides
S = salinity
SS = suspended solids
T = turbidity
O = other (please specify)

O* -pH; O** -Loss of habitat and shade; O*** -Synthetic organics

Table 23. Existing and recommended nonpoint source control programs and estimated state administrative costs.

TYPE OF NONPOINT SOURCE	TYPE OF CONTROL PROGRAM		COSTS (OPTIONAL) ($1,000)	
	EXISTING	RECOMMENDED	CURRENT YR.	NEEDED
Urban	S			
Agriculture (irrigated)	N/A			
Agriculture (nonirrigated)				
Animal wastes	R		60	+ 90
Silviculture	N/A			
Mining	R			
Construction	R,E			
Hydrological modifications	R			
Saltwater intrusions	N/A			
Residual Waste/Landfill	R		2,800	+ 3,000

- - TYPE OF CONTROL PROGRAM

S = structural/public works
E = education
T = tech. assistance
F = financial incentives
R = regulation
O = other

Animal wastes from confined feeding operations have been controlled by regulation since 1971 and are treated as point sources. These wastes are confined and subsequently land applied. Problems from animal wastes usually arise from accidental (or deliberate) release of the confined wastes from holding areas and from the inappropriate application of these wastes to farmland. The severity of these incidents range from minor to severe depending on how much waste entered the stream, the stream flow at the time, etc.

Silviculture is a limited activity in the state and is not believed to cause any significant water quality problems. No state control programs exist.

Nonpoint source problems from active coal mines are controlled by state and federal regulations, and problems caused by these mines are minor. There are a few instances in the state where acid mine drainage from older, abandoned mines is causing severe water quality problems, but control of these problems is very difficult and often prohibitively expensive. The Indiana Department of Natural Resources (IDNR) has plans for and is implementing restorative measures for some of these abandoned mines.

Mineral mining (rock, sand, and gravel) requires a state permit for discharges. Sedimentation basins are required, and suspended solids limits are placed in the discharge permit.

Sediment from construction projects is only partially controlled but, in general, appears to pose no discernible, long-term water quality problems due to the limited amount of land under construction and the relatively short time the surface is bare. Road and bridge construction projects funded by the Indiana Department of Highways have erosion and sediment control measures incorporated into the bidding specifications. Also, the Indiana State Board of Health (ISBH) must review and certify (under Section 401 of the Clean Water Act) construction permits which require federal approval for dredging or filling in waterways and wetlands. Ascertaining possible adverse effects on water quality is part of this review.

Hydraulic modifications (dams and channelization) are subject to approval by the IDNR. To the extent that drainage purposes can be met, they require practices that minimize the impact on aquatic life. If dredging or filling of waterways or wetlands is involved, ISBH also reviews and certifies these projects (see above paragraph).

Residual wastes and landfills are subject to state regulations designed to prohibit adverse water quality impact. When designed, built, and operated properly, these nonpoint sources seldom affect surface water quality. In a few instances, leaching of hazardous materials from landfills has caused some water quality problems, but these problems are usually quickly addressed. While there is more to do in both these areas, programs do exist to further control water quality problems from these sources.

Monitoring Programs

Fixed Water Quality Monitoring Station Network

In April 1957, the Indiana State Board of Health established 49 sites for the biweekly collection of samples for physical, chemical, and bacteriological analysis. Ten of the stations were sampled for radiological analysis. Since 1957, various changes and improvements have been made, and at the present time, 92 stations are included in the program. Of the 92 stations, 81 are sampled once each month, and 11 are sampled quarterly. These stations and their descriptions are listed in Table 24 and shown in Figures 18 and 19.

Physical, chemical, and bacteriological analyses are made on samples collected from all 92 of the stations, plankton analysis from 18 and radiological analyses from 23. A list of the parameters for which analyses are made is given in Table 25. Not all of these parameters are sampled at each station.

In many instances, stations are located upstream and downstream of suspected sources of pollution. Stations were established at bridges whenever possible and practical for convenience and to permit sampling in the stream channel. Approximately 2,055 stream miles are regularly monitored by this program.

The Fixed Water Quality Monitoring Station Network was established to provide basic information which would reveal pollution trends and provide water quality data for the many existing and potential users of surface water in Indiana. The monitoring program has these specific objectives:

1. To determine chemical, physical, bacteriological, and biological characteristics of Indiana's waters under changing conditions.

2. To indicate, when possible, the sources of pollution entering a stream.

3. To compile data for future pollution abatement activities.

4. To determine background data on certain types of wastes, such as sewage, chlorides, and radioactive materials, and to detect critical changes.

5. To obtain data useful for municipal, industrial, agricultural, and recreational users.

6. To procure data useful and necessary for securing public action toward the preservation of streams for all beneficial uses.

STATION DESCRIPTIONS

Table 24. Indiana's Fixed Water Quality Monitoring Stations (1983).

STATION	NAME	LOCATION
BD0	Burns Ditch at Portage	Midwest Steel Catwalk
BD1	Burns Ditch at Portage	Midwest Steel Truck Bridge, Portage
BD2E	Burns Ditch at Portage	State Highway 249 Bridge (Chrisman Road)
BD3W	Burns Ditch at Portage	Portage Boat Yard Dock, Portage
BL.1	Big Blue River at Edinburg	U.S. Highway 31 Bridge, Edinburg
BL61	Big Blue River near Spiceland	County Road 450S Bridge
BLW 53	Blue River, West Fork-Fredericksburg	U.S. Highway 150, Fredericksburg
EC1	Eagle Creek at Indianapolis	Raymond Street, East of State Hwy. 67
EC21	Eagle Creek at Zionsville	State Highway 100, South of Zionsville
ELL7	Eel River Near Logansport	C.R. 125N Bridge, NE of Logansport
ER.3	Elkhart River at Elkhart	East Jackson Street Bridge, Elkhart
EW1	East Fork, White River - Petersburg	S.R. 57 Bridge NE of Petersburg
EW77	East Fork, White River - Williams	County Road South of State Highway 450
EW94	East Fork, White River - Bedford	U.S. Highway 50 Bridge, South of Bedford
EW 157	East Fork, White River - Seymour	Seymour Waterworks Intake
FC7	Fall Creek - Indianapolis	Keystone Avenue Near Water Intake
GCR 34	Grand Calumet River - Hammond	Hohman Avenue Bridge at Hammond
GCR 37	Grand Calumet River - East Chicago	Bridge on Kennedy Avenue, East Chicago
GCR 41	Grand Calumet River - Gary	Bridge on U.S. Highway 12, Gary
IHC0	Indiana Harbor Canal at East Chicago	At Mouth of Ship Canal
IHC1	Indiana Harbor Canal at East Chicago	Bridge on Dickey Road, East Chicago
IHC 35	Indiana Harbor Canal at East Chicago	Bridge on Columbus Drive., East Chicago
IHC 3W	Indiana Harbor Canal at East Chicago	Bridge on Indianapolis Blvd., East Chicago
IWC6.6	Indianapolis Waterway Canal at Indianapolis	Confluence of Canal and White River
KR65	Kankakee River at Shelby	S.R. 55 Bridge, 1 Mile South of Shelby
KR 125	Kankakee River - Kingsbury Wildlife	U.S. 6 Bridge, South of Kingsbury Wildlife
LCR 13	Little Calumet River at Hammond	Hohman Avenue Bridge, Hammond

Table 24. (Cont.)

STATION	NAME	LOCATION
LCR 39	Little Calumet River - Porter	S.R. 149, South of U.S. Hwy. 12, NW of Porter
LMEC	Lake Michigan at East Chicago	Raw Water, East Chicago Waterworks
LMG	Lake Michigan at Gary	Raw Water, Gary Waterworks
LMH	Lake Michigan at Hammond	Raw Water, Hammond Waterworks
LMM	Lake Michigan at Michigan City	Raw Water, Michigan City Waterworks
LMW	Lake Michigan at Whiting	Raw Water, Whiting Waterworks
M95	Maumee River at Woodburn	S.R. 101 Bridge, 3 Miles North of Woodburn
M110	Maumee River at New Haven	Landin Road, .5 Mile North of New Haven
M116	Maumee River at Fort Wayne	Anthony Blvd. Bridge, Fort Wayne
MC17	Mill Creek at Devore	U.S. Highway 231 Bridge, Near Devore
MC35	Mill Creek at Stilesville	U.S. Highway 40 Bridge at Stilesville
MS1	Mississinewa River at Peru	State Highway 124, East of Peru
MS28	Mississinewa River at Jalapa	Izaak Walton Lodge
MS35	Mississinewa River at Marion	Highland Avenue Bridge, Marion
MS 100	Mississinewa River at Ridgeville	County Road 134E, 2 Miles East of City
MU25	Muscatatuck River near Austin	S.R. 39 Bridge West of Austin
P33	Patoka River near Oakland City	Miller Rd. Bridge, 2 Miles W. of S.R. 57 Bridge
P76	Patoka River at Jasper	County Road West of State Highway 45
S0	Salamonie River - Largo	Division Road, Near Lagro
S75	Salamonie River at Portland	S.R. 67 Bridge 2 Miles SW of Portland
SC30	Sugar Creek at Shades State Park	S.R. 234 Bridge, Above Shades State Park
SJR 46	St. Joseph River at South Bend	Auten Road Bridge, South Bend
SJR 76	St. Joseph River at Bristol	County Road Through Bristol
SLC 12	Salt Creek near Valparaiso	S.R. 130 Bridge, Below Sewage Treatment Plant
SLT 11	Salt Creek near Oolitic	State Highway 37 Bridge
STJ0	St. Joseph River at Fort Wayne	Tennessee Street Bridge
STM 12	St. Mary's River at Fort Wayne	Anthony Blvd. Bridge, South of Hwy. 27-33
STM 33	St. Mary's River at Pleasant Mills	S.R. 101 Bridge, North of Pleasant Mill
TC.3	Trail Creek at Michigan City	Franklin Street Bridge, Michigan City
TC1	Trail Creek at Michigan City	U.S. Hwy. 12 Bridge, Michigan City
TR6	Tippecanoe River near Delphi	S.R. 18 Bridge, 5 Miles West of Delphi
V.8	Vermillion River at Cayuga	State Highway 63 Bridge, Cayuga

Table 24. (Cont.)

STATION	NAME	LOCATION
WB 128	Wabash River at Vincennes	U.S. Hwy. 50 Bridge, NW Edge of Vincennes
WB 175	Wabash River, West of Fairbanks	I&M Breed Generating Station
WB 207	Wabash River near Terre Haute	Ft. Harrison Boat Club
WB 219	Wabash River at Clinton	S.R. 163 Bridge at Clinton
WB 228	Wabash River at Montezuma	U.S. Hwy. 36 Bridge, West Edge of Montezuma
WB 245	Wabash River at Cayuga	State Highway 234 Bridge, Cayuga
WB 292	Wabash River near Lafayette	Granville Bridge, SW of Lafayette on Rd. 700W
WB 301	Wabash River at Lafayette	U.S. Hwy. 26 Bridge, W. Edge of Lafayette
WB 336	Wabash River at Georgetown	C.R. 675, West of Georgetown
WB 360	Wabash River at Peru	Business U.S. Highway 31 Bridge, Peru
WB 390	Wabash River at Andrews	S.R. 105 Bridge, North of Andrews
WB 399	Wabash River at Huntington	Huntington Waterworks
WB 409	Wabash River at Markle	State Highway 3 Bridge
WB 452	Wabash River at Geneva	U.S. 27 Bridge, 1.5 Miles N. of Geneva
WC1	Wildcat Creek at Lafayette	S.R. 25 Bridge, NE of Lafayette
WC63	Wildcat Creek at Kokomo	County Road 300W, 1 Mile W. of Kokomo
WC69	Wildcat Creek at Kokomo	U.S. Highway 31 Bypass Bridge
WCS 35	Wildcat Creek, South Fork - Frankfort	State Highway 75 Bridge, Frankfort
WHE 27	East Fork, Whitewater River - Abington	Abington Pike Rd. Bridge, E. Edge of Abington
WHW 24	West Fork, Whitewater River - Brookville	Blue Creek Rd. Bridge, South of Brookville
WLSL	Wolf Lake at Hammond	Culvert, S. Edge of Dike W. of Calumet Avenue
WR48	White River at Petersburg	State Highway 61 Bridge, Petersburg
WR80	White River at Edwardsport	S.R. 358 Bridge, 1 Mile Below PWR Gen. Station
WR 166	White River at Spencer	S.R. 43 & 46 Bridge, South Edge of Spencer
WR 185	White River at Paragon	C.R. 700 West, 2 Miles South of Paragon
WR 197	White River at Centerton	IPALCO Generating Station
WR 205	White River at Centerton	Henderson Ford Bridge, West of S.R. 37
WR 249	White River at Nora	State Highway 100 Bridge, East of Nora
WR 280	White River at Perkinsville	State Highway 13 Bridge
WR 295	White River at Anderson	10th Street at Waterworks
WR 310	White River at Yorktown	County Road Bridge, North of Yorktown H.S.
WR 319	White River at Muncie	Memorial Drive, East Edge of Muncie
WR 350	White River near Winchester	At U.S. 24 Bridge, East of Winchester

Figure 18. Location of Indiana's Fixed Water Quality Monitoring Stations.

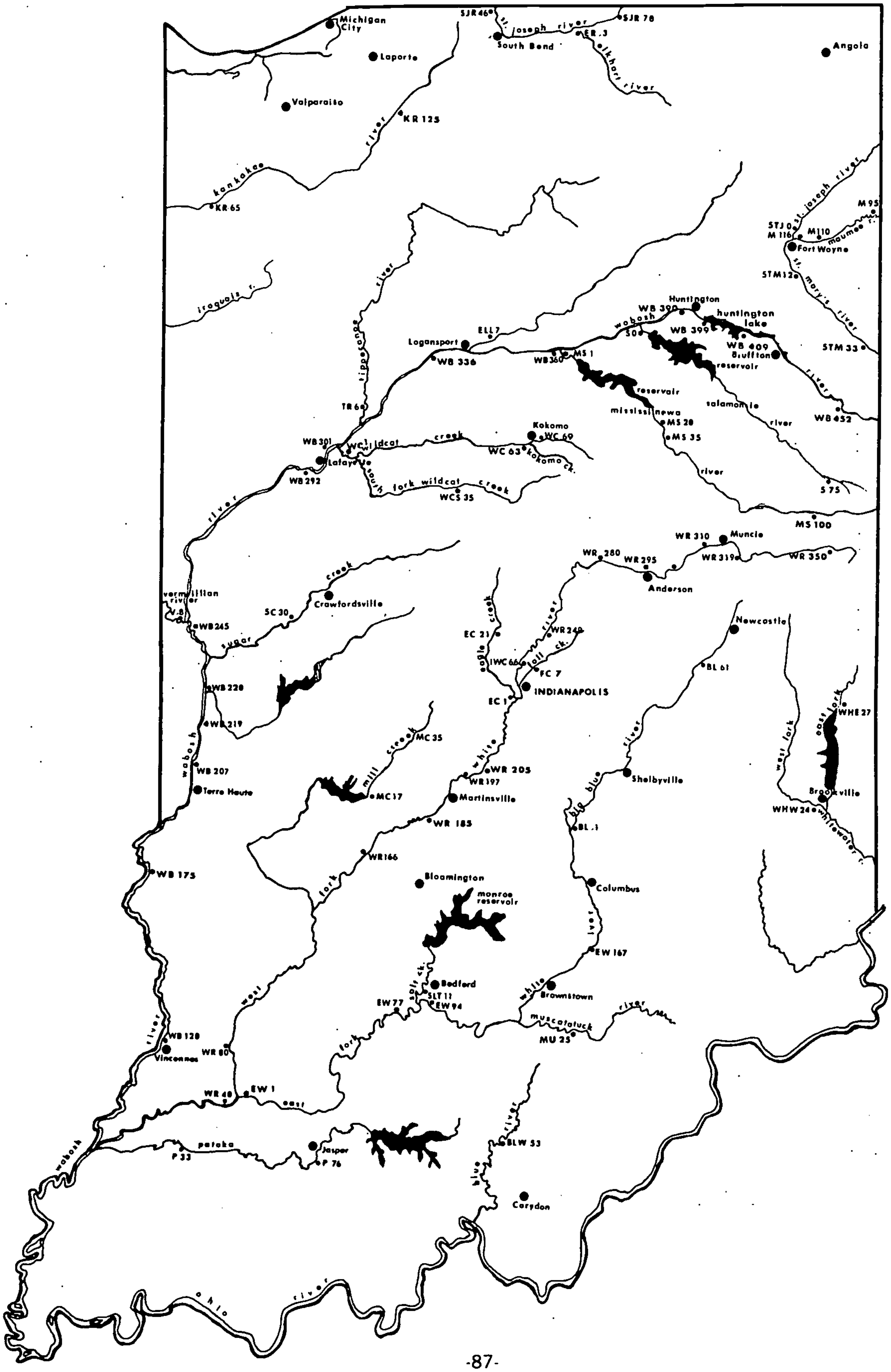

Figure 19. Location of Indiana's Fixed Water Quality Monitoring Stations - Lake Michigan Region.

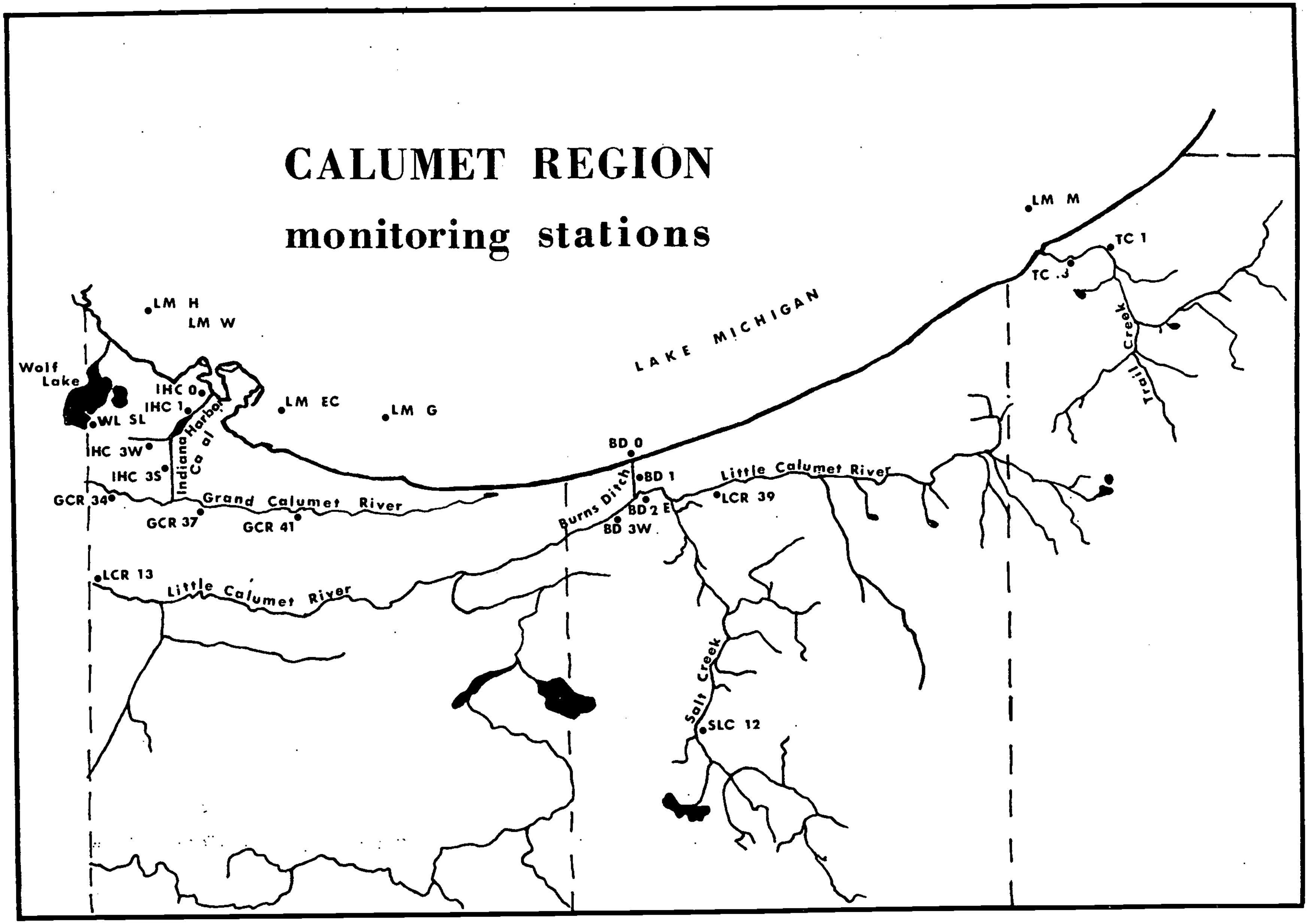

Table 25. Analyses conducted at Indiana's Fixed Water Quality Monitoring Stations. (Not all parameters are sampled and analyzed at each station.)

Alkalinity (total)	Nickel as Ni (total recoverable)
Ammonia as NH_3-N	Nitrate + Nitrite as N
Arsenic as As (total)	Nitrogen, TKN (total)
Biochemical Oxygen Demand (BOD)	Threshold Odor (number)
Calcium as $CaCO_3$	Oil and Grease
Chemical Oxygen Demand (COD)	Polychlorinated biphenyls (PCBs)
Cadmium as Cd	pH
Chloride as Cl	Phenol
Chromium as Cr_{+6} (hexavalent)	Phosphorus as P (total)
Chromium as Cr (total)	Phthalates
Coliform fecal (per 100 ml)	Potassium as K
Coliform total (per 100 ml)	Silica as SiO_2
Copper as Cu (total recoverable)	Sodium as Na
Cyanide (total) as Cn	Suspended Residue (nonfilterable reside)
Dissolved Oxygen (DO)	Volatile Suspended Matter
Fecal Streptococcus Group	Total Residue
Fluoride as F	Dissolved Residue (filterable residue)
Hardness as $CaCO_3$	Specific Conductance as micromhos/cm
Iron as Fe (total)	Sulfate as SO_4
Lead as Pb (total recoverable)	Total Organic Carbon (TOC)
Magnesium as $MgCO_3$	Turbidity as NTU
Manganese as Mn (total)	Zinc as Zn (total recoverable)
Mercury as Hg	

Toxics Monitoring Program

Regular monitoring of toxic substances is conducted by the Division of Water Pollution Control through sample analysis of fish tissue samples collected at the 21 "CORE" sampling stations (Figure 2). Division of Water Pollution Control personnel sample 19 of these stations and the Department of Natural Resources samples the Lake Michigan stations located at Michigan City and East Chicago. In 1979 and 1980, the first two years of the monitoring program, all stations were sampled. However, due to the amount of time required to collect the samples and the amount of laboratory time required to process this number of fish tissue samples, the "CORE" stations were divided into two groups in 1981. One group is sampled one year and the other group the next.

Three sets of fish samples (5 fish each, if possible) are collected at each station. Whole fish samples are submitted to the laboratory for analysis to satisfy the requirement of the Basic Water Monitoring Program. In addition, fillet samples have been collected at some stations so comparisons can be made between "edible portion" and "whole fish" samples. A list of the parameters for which the fish samples are analyzed is shown in Table 2.

Monitoring for aquatic invertebrates also is done at these "CORE" stations. Approximately 4-6 weeks before the fish sampling occurs, three Hester-Dendy samplers are set at the "CORE" station localities to be sampled that year. At the time of the fish sampling, these samplers are retrieved, and the organisms collected, preserved, and identified to the lowest possible or practical taxon and counted. Differences in kinds and/or numbers of organisms between samples set upstream and downstream of major discharge areas may indicate water quality problems originating in these areas.

Water is routinely monitored for a limited number of toxic parameters (mostly metals) at the Fixed Water Quality Monitoring Stations (Figure 18). Also, effluents from discharges known or suspected to contain toxic materials are analyzed for these materials when compliance sampling is conducted or other samples are collected at these localities. In addition, 48-hour static bioassays using Daphnia magna are done on effluents from all major dischargers. In the last three years, 23 static bioassays have been done. Of these, 78% showed no toxic effects or were only slightly toxic. One onsite flow-through bioassay has been done. This was a 96-hour test using fathead minnows (Pimephales promelas) with effluent from a metal plating firm. No toxicity was found. Also, one static 96-hour bioassay using fathead minnows (Pimephales promelas) has been done on a metal plating firm. The LC_{50} for this bioassay was 42% effluent.

"In the last three years, 23 static bioassays have been done. Of these, 78% showed no toxic effects or were only slightly toxic."

In addition to the more regular monitoring for toxic substances in fish tissue and water, special studies of fish, sediment and, in some cases, water contaminated by toxic substances are done. Fish and/or sediment surveys of both the East and West Forks of White River have recently been completed, and a similar study of the middle portion of the Wabash River is planned for 1984. Samples of fish tissue and/or sediment have been collected from several smaller streams and a few lakes in the last few years for toxic analysis, mostly in response to known or suspected problems in a particular stream or lake.

Biological Monitoring Program

Biological monitoring involves sampling for fish, aquatic invertebrates, plankton, bacteria, special biological studies, and bioassay work. Many of these programs were discussed in the Toxic Monitoring Programs section and will not be discussed further here. This section will discuss biological studies not directly related to toxic materials.

In addition to those fish collected and analzed for toxic substances, data as to numbers and kinds of all fish observed are taken. This information provides qualitative data as to the composition of the fish community at these stations. These data can then be compared to data obtained from previous years or from other studies to give some indications as to what is occurring at that locality in the part of the fish community amenable to our sampling apparatus (D.C. electrofishing). Similar data on the aquatic invertebrate community is obtained by the identification and enumeration of organisms collected on the Hester-Dendy samplers.

Routine monitoring of coliform bacteria is done at all 92 Fixed Water Quality Monitoring Stations. Water designated for whole-body contact recreation must meet more stringent coliform bacteria requirements than water designated for other uses. Very high numbers of these organisms usually indicate inadequate sewage treatment or areas where combined sewer overflows may be causing problems. Also, bacteriological samples are collected as part of surveys or inspections at wastewater treatment facilities.

Plankton samples are collected routinely at 18 of the 92 Fixed Water Quality Monitoring Stations. These samples are preserved in the field and later identified and counted. These data provide information on plankton population trends.

Primary productivity studies are also part of the biological monitoring program. Although not done on a routine basis, several of these studies have been done over the past 2-3 years, mostly to provide information for wasteload allocation models. Primary productivity studies were conducted in 1981, 1982, and 1983 on the Wabash River between Lafayette and Merom; in 1983 on Trail Creek near Michigan City; and in 1983 on the East Fork of the White River between Columbus and Azalia. These studies provide information on the rates of algal photosynthesis and respiration in the river, lake or stream. These rates are then utilized as part of wasteload allocation models.

Considerable biological monitoring has been done in the past 2-3 years on small streams in conjunction with the construction grants program. Some headwater streams are incapable of supporting diverse communities of fish and other aquatic life during much of the year simply because there is not enough water, food or suitable habitat present to support them, no matter how high the water quality. Therefore, the state has established a "limited use" designation for certain headwater streams. Water quality standards for such streams are not quite as high as those for streams designated for maintenance of well balanced fish communities and aquatic life ("general use").

Each year, habitat evaluation studies are conducted to determine the existing and/or potential uses that various stream reaches will support. In scheduling and conducting these surveys, priority is given to those stream reaches where it appears that a discharger to a headwater stream will be required to provide advanced wastewater treatment in order to meet general use criteria.

During the study, a checklist which includes detailed information regarding the physical, chemical, and biological nature of the stream, as well as a description of riparian land use, is completed. This information is used to prepare a habitat evaluation report which is presented to the agency's AT (Advanced Treatment) Committee for review and approval.

If the habitat evaluation study indicates that the use designation for a particular stream or stream reach should be changed, the habitat evaluation report is presented to the Indiana Stream Pollution Control Board to support the recommended change. The report will also be made part of the official record of the public hearing that is held to consider changing the stream use designation in the water quality standards.

Since 1979, habitat evaluations were conducted on 164 headwater streams. Of these, 91 had at least a small stretch that could be recommended for limited use designation. Of the total number of evaluations, 133 were on streams receiving municipal discharges, and 31 were on streams receiving industrial discharges.

A revised regulation (330 IAC 1-1) containing 18 stream reaches designated for limited use was fully promulgated at the beginning of 1984. It is expected that additional stream reaches will be designated for limited use during the next two years.

Intensive Survey Program

An intensive survey consists of 24-hour sampling of all significant dischargers, receiving streams, and flowing tributaries within the stream reach or segment being studied. In addition to chemical and bacteriological testing, flow, stream slope, reaeration capacity, and other physical factors are measured during these surveys. In many instances, measurements of sediment oxygen demand, phytosynthesis/respiration rates, chlorophyll a, depth of light penetration, and plankton counts are also included.

Intensive Water Quality Studies for stream modeling are conducted according to a priority established by the state water monitoring committee. Data obtained from these studies are used in support of various activities including the preparation of stream models and wasteload allocations, basin plans, nonpoint source evaluation, and for compliance monitoring. Data are also provided for NPDES permit reissuance, for determining extent of compliance with existing water quality standards, to demonstrate cause and effect relationships, and for evaluating potential sites for future wastewater treatment facilities. These surveys also surface violations of NPDES permit limits or conditions and help determine the ability of a stream to support the designated uses.

Data from at least two intensive surveys are normally required for model calibration and verification. However, for those isolated municipalities on low flow streams or ditches a simplified modeling approach was developed which utilizes an application of the modified Streeter-Phelps equation to predict dissolved oxygen concentrations. Minimum instream water quality data are required, but the physical data required are the same as for the more complex models. Tables 26, 27, 28 and 29 list the intensive surveys that were conducted during FY 1982 and FY 1983.

Intensive segment surveys are conducted in much the same manner as the modeling surveys. However, all streams and dischargers in a designated stream segment are included. No true segment surveys were conducted during the last two fiscal years, but several are planned for this and next (Tables 30 and 31).

Intensive Survey Abstracts

1. Mid-Wabash Comprehensive Survey

During the summers of 1981 and 1982, a comprehensive survey was conducted on a 147-mile reach of the Wabash River between Lafayette (MP 312) and Merom (MP 164.8). This survey was conducted in cooperation with the USGS, Purdue University, DePauw University, representatives of the Mid-Wabash Industrial Consortium, and Dr. Donald J. O'Conner and John St. John of HydroQual, Inc. These data were required for mathematical modeling needed to equitably allocate wasteloads to the various municipal and industrial dischargers along the reach of the river in question.

Parameters measured included sediment oxygen demand, biochemical oxygen demand, temperature, diurnal dissolved oxygen fluctuations, chlorophyll a, primary productivity, light extinction coefficients, time of travel, reaeration capacity, cross-sectional area, river flow, and various chemical consituents both in the river and tributaries. Significant discharges to the river were also sampled during the survey.

In September 1983, the Indiana State Board of Health (ISBH) found particularly low dissolved oxygen conditions occurring in the lower end of the Covington reach of the Wabash River in the vicinity of Sugar Creek. These observations were initially made during a period when river flow was quite low, on the order of one and a half times the minimum seven day, ten year value. Consequently, the state conducted several water quality surveys of the river from September 8 through September 30, 1983. These surveys extended through the entire length of the middle Wabash River but focused on the zone from the Vermilion River to the USGS gage at Terre Haute. Results from these surveys confirmed the existence of a substantial depression of dissolved oxygen centering in the vicinity of Sugar Creek. Dissolved oxygen values as low as 2.0 mg/l were observed near this location. The data collected from these surveys, as well as data collected from a 1977 survey which disclosed similar conditions, are being used to supplement and refine HydroQual's mathematical model, which was developed following the 1981 and 1982 surveys.

2. Trail Creek, Michigan City

Trail Creek is maintained as a salmonid fishery stream by the Indiana Department of Natural Resources and is protected by Stream Pollution Control Board Regulation 330 IAC 2-4 "Water Quality Standards for Natural Spawning, Rearing or Imprinting Areas; Migration Routes for Salmonid Fishes." The standard requires a minimum dissolved oxygen (D.O.) concentration of 5.0 mg/l at all times except during migration periods when minimum D.O. is 6.0 mg/l. A wasteload allocation was needed to determine the degree of treatment required at the Michigan City wastewater treatment facility and the extent of control of combined sewer overflows (CSO) and raw sewage bypassing needed to meet the standards in Trail Creek.

Water quality downstream of the sewage treatment facility outfall indicated that D.O. ranges from 2.0 to 4.0 mg/l near the bottom and between 4.0 and 5.0 mg/l in the upper layer of the stream during summer months. Trail Creek upstream of the sewage treatment facility is a typically flowing stream, but from the treatment facility downstream to the lake, water movement is sluggish and pooled throughout. The Michigan City sewage treatment facility is hydraulically overloaded most of the time, resulting in frequent bypassing. Also, small rain events cause major combined sewer overflows. Solids from the bypasses and CSO's settle out in the slow moving stream, resulting in sediment buildup that in some places becomes anaerobic.

A steady state water quality model and wasteload allocation has been developed for Michigan City. The model was calibrated and verified using the data collected during three intensive surveys: June 23, 1981, June 28 and August 4, 1983. Chlorides, solids, nitrogen, and dissolved oxygen data for each survey were analyzed in the calibration and verification of the model. Stratification was checked by measuring flow direction, D.O. and temperatures. Time of travel was measured in the August 4, 1983, survey when the stream flow was the lowest. Chlorophyll a, primary productivity, light extinction coefficients, and cross-sectional area were also measured. In addition, sediment oxygen demand was measured at several locations.

The analysis shows that the major sources of oxygen depletion are the sediment oxygen demand (SOD) and the carbonaceous biochemical oxygen demand (CBOD) waste inputs. Each of these components deplete the oxygen by about 1.5 to 2.5 mg/l.

Michigan City is expected to receive construction grants funds in 1984 for expansion and upgrading of their plant, including sand filters. They will be required to supersaturate their effluent (13.5 mg/l D.O.) in June, July, August, and September and to minimize combined sewer overflows by retaining up to a three month storm event with no bypassing. These improvements should greatly improve water quality in Trail Creek.

3. West Fork White River

A low flow study of the West Fork of White River began on August 24-26 and was finished September 6 and 7, 1983. Grab samples were collected from Winchester to Muncie; 24-hour composite samples were collected in the vicinity of Muncie, Anderson, and Strawtown; and grab samples were collected from the north side of Indianapolis to Spencer. In all, approximately 143 miles were surveyed. Flows recorded at all USGS gages ranged from 1½ to 3 times the $Q_{7,10}$ values, respectively. The purpose of this survey was to give a general view of the water quality of White River during a low-flow period. Many of the major municipal wastewater treatment facilities discharging directly to the river in this stretch have recently been renovated or are in the process of being upgraded. Some have historically had severe operational problems.

Water quality in the Winchester to Muncie reach of the river was good. At Muncie, the sewage treatment facility effluent nearly tripled downstream river flow. A slight dissolved oxygen sag was found downstream, but water quality appeared good and standards were met. Sludge handling problems, however, resulted in a high sediment oxygen demand in the pooled area below the outfall.

In Anderson, flow in White River was nearly 3 times the $Q_{7,10}$. Field observations indicated that an algae bloom was occurring during the survey. High water temperature, varying pH values, and wide diurnal dissolved oxygen fluctuations indicated a significant degree of photosynthetic activity, particularly downstream of the facility discharge. Dissolved oxygen values ranged from 17.5 to 3.7 mg/l over the 24-hour period. With the exception of ammonia-N (13.0 mg/l), the Anderson plant was producing excellent effluent. Laboratory analysis indicate that the ammonia discharge contributes significantly to downstream BOD_5 values. The total BOD_5 at downstream stations was generally two times the CBOD values.

In the Indianapolis area, high fecal coliform counts were found in Fall Creek near the White River confluence (52,000/100 mg/l), at Harding Street above the Belmont sewage treatment facility (100,000/100 ml) and at Southport Road upstream from the mixing zone with the Southport sewage treatment facility effluent (180,000/100 ml) on September 7, 1983. The effluents from the two facilities had no detectable fecal coliform concentrations. It is obvious that these high concentrations were due to combined sewer overflows following an area rain on September 6. Dissolved oxygen concentration at the I-465 South bridge below Indianapolis was 2.5 mg/l at 11:00 a.m. The Belmont plant effluent D.O. was 5.9 mg/l, and the Southport plant D.O. was 11.0 mg/l. Ammonia from the facilities has been reduced significantly because of the improvement of these plants (Belmont NH_3-N =.1, Southport NH_3-N = 3 mg/l). Overall water quality for this portion of the White River has vastly improved and should improve more when sewage treatment facility renovations have been completed and the city has gained better control of their CSO problems.

4. East Fork White River

On July 12-13 and August 9-10, 1983, an intensive survey was conducted on the reach of the East Fork of White River between Columbus and the Azalia bridge (12 river miles). The purpose of the survey was to gather data to develop a model and wasteload allocation for the Columbus sewage treatment facility. The sewage treatment facility normally receives a significant waste loading from Stadler Meat Packing Plant in Columbus, but the plant was not operating at the time of the survey. Thus, data collected reflect the loadings to the river without the meat packing plant loadings.

Twenty-four hour composite samples were collected at 13 sites on the East Fork of White River, at the Columbus sewage treatment facility and from three tributaries (Haw Creek, Clifty Creek, and Little Sand Creek). Sediment oxygen demand (SOD) was measured at six river sites. Primary productivity, chlorophyll a, and algae counts were measured at three sites. These were upstream of Columbus, below Haw Creek, and at the Azalia bridge. Flows during the August 9-10 survey were less than twice the $Q_{7,10}$ flow.

These data, along with the predicted additional loading from Stadler Meat Packing to the sewage treatment facility, are incorporated in a wasteload allocation for this reach of the East Fork of White River. Data collected on these surveys should also allow for the determination of NPDES permit limits for Stadler Meat Packing which would protect the water quality in the East Fork of White River should they propose to discharge directly to the river rather than to the Columbus sewage treatment facility. This possiblilty has been raised in correspondence from representatives of Stadler Meat Packing.

5. Walnut Creek and Tippecanoe River (Warsaw sewage treatment facility).

Walnut Creek, the receiving stream for the Warsaw sewage treatment facility, is a tributary of the Tippecanoe River. Walnut Creek was sampled in August 1979 and September 1981 in order to prepare a model and wasteload allocation for the stream. In September 1983, flows in Walnut Creek fell to the $Q_{7,10}$ level. This provided an opportunity to obtain data from the sewage treatment facility and the receiving stream to test the model and, if necessary, correct the coefficients in the wasteload allocation. These data are presently being reviewed.

At present, the sewage treatment facility is achieving 92-97% removal of BOD and suspended solids, but ammonia loadings are moderately high. The effluent, which usually has a low dissolved oxygen concentration, is discharged into Walnut Creek, a slow moving stream which is heavily shaded. There are problems of virtually no physical reaeration and large accumulations of solids and debris which produce a large sediment oxygen demand. These factors contribute to substandard dissolved oxygen concentrations in Walnut Creek.

Walnut Creek flows into the Tippecanoe River, a high quality stream being considered by the Indiana Department of Natural Resources for inclusion in its Natural, Scenic, and Recreational River System. Data from this low flow survey should provide the necessary information to verify (or modify) the existing model and wasteload allocation. After this is completed, we will know if the existing water quality standards for Walnut Creek are attainable.

Table 26. Simplified steady state modeling surveys (Priority Water Bodies List-1982).

Municipality	Receiving Stream
Albany STP	Mississinewa River
Bloomington North STP	Stout Creek
Brazil STP	Birch Creek
Brookston STP	Moots Creek
Bruceville	Smalls Creek
Columbia City STP	Blue River
Dale STP	Ballard Creek
Ft. Branch STP	West Fork Pigeon Creek
Goodland	Hunter Ditch
Haubstadt STP	West Fork Pigeon Creek
Holton	Otter Creek
Hymera STP	Sulphur Creek
Jasper-Mill Creek	Mill Creek
Markleville	Lick Creek
Mooreland STP	Flatrock River
New Palestine	Sugar Creek
Orleans STP	Sinkhole to Lost River
Otterbein STP	Otterbein Ditch
Oxford STP	Lagoon Ditch
Remington STP	Carpenter Creek
Sanborn	Hill Ditch
Sellersburg STP	Silver Creek
Shakamak State Park STP	Branch Creek
Sullivan STP	Buck Creek
Versailles STP	Laughery Creek

Table 27. Intensive stream reach surveys - 1982.

Segment	
30	Walnut Creek and Tippecanoe River at Warsaw
4	Trail Creek at Michigan City
57	Eagle Creek at Indianapolis
43,44,45, 49,51	Wabash River and Tributaries from Lafayette to Merom

Table 28. Simplified steady state modeling surveys (Priority Water Bodies List-1983).

Municipality	Receiving Stream
Albion STP	Croft Ditch
Albany STP	Mississinewa River
Auburn STP	Cedar Creek
Avilla STP	King Lake Ditch
Bloomington North STP	Beanblossom Creek
Brazil STP	Birch Creek
Bunker Hill STP	Pipe Creek
Chandler STP	Strollberg Ditch
Cloverdale STP	Rabbit Run
Dunkirk STP	Dunkirk Drain
Ellettsville STP	Jack's Defeat Creek
Elnora STP	Tributary Vertees Ditch
Fountain City	Noland's Fork Whitewater River
Gas City STP	Mississinewa River
Grabill STP	Haifley Ditch
Grissom AFB STP	Pipe Creek
Hymera STP	Sulphur Creek
Jasper STP	Patoka River
Jonesboro STP	Back Creek
Lebanon STP	Prairie Creek
Liberty STP	Silver Creek
Loogootte STP	Tributary to Friend's Creek
Lynn STP	Mud Creek
Marion STP	Mississinewa River
Michigan City STP	Trail Creek
Milan STP	Branch, South Hogan Creek
Mitchell STP	Rock Lick Branch
North Vernon STP	Vernon Fork, Muscatatuck River
Osgood STP	Tributary, Laughery Creek
Ossian STP	Eight-Mile Creek
Portland STP	Salamonie River
Shelburn STP	Kettle Creek
Shirley STP	Six-Mile Ditch
Wakarusa STP	Baugo Creek
Westville STP	Forbes Ditch

Table 29. Intensive stream reach surveys - 1983.

Segment No.	
4	Trail Creek at Michigan City
43, 44, 45	Wabash River and Tributaries from
49, 51	Lafayette to Merom
38, 39	Salamonie River, Upper and Lower

Table 30. Proposed stream reach or modeling surveys from Priority Water Bodies list.

Municipality	Receiving Stream
Waveland-Russellville	Little Raccoon Creek
Georgetown	Georgetown Creek
LaGrange	Fly Creek
Ferdinand	Holey Run
Morgantown	Indian Creek
Medora	Hinderlander Ditch
Churubusco	Churubusco Branch
Dupont	Bear Creek
Van Buren	Big Black Creek
Oldenburg	Harvey Branch
Ft. Branch	West Fork Pidgeon Creek
Royal Center	Fredericks Ditch
Bluffton	Wabash River
LaFontaine	Grant Creek
Montgomery	South Fork Prairie Creek
Milltown	Trib. to Blue River
New Pekin	South Fork Blue River
Argos	Myer Ditch
Bloomington North STP	Bean Blossom Creek
North Judson	Pine Creek
Connersville	West Fork Whitewater River
Hartford City	Lick Creek
Lowell	Cedar Creek
Moores Hill	Whitaker Creek
Rensselear	Iroquois River
Roachdale	Clines Creek
Roanoke	Little Wabash River
New Market	Rattlesnake Creek
Hagerstown	West Fort Whitewater
Princeton	Richland Creek
Walton	Phillips Ditch
Clayton	Mud Creek
Waldron CD	Conns Creek
Linton	Beehunter Ditch
Windfall City	Round Prairie Creek
Pittsboro	West Branch White Lick Creek

Table 31. Intensive segment surveys FY 84 & FY 85.

Segment No.	Segment Name
71	Upper Blue River
72	Flat Rock River
73	Youngs Creek
74	East Fork White River-Clifty Creek
75	Upper Salt Creek
76	East Fork-Vernon Fork Muscatatuck River
77	Lost River
78	Sugar Creek
79	Blue River
80	Upper Flat Rock River
81	Flat Rock-Driftwood Rivers
82	Sand Creek
83	Muscatatuck River
84	East Fork White River (Jonesville to Williams Dam)
85	East Fork White River (Below Williams Dam)

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