OWQ- WATERSHED ASSESSMENT & PLANNING BRANCH
IDEM/OWQ/WAPB/WS
VIRTUAL FILE CABINET INDEX FORM

Program: Watershed

Document Type: Report

*Document Date: 6/30/1986

*Security: Public

Project Name: Indiana 305(b) Report 1984-85

*Report Type 305B/Integrated

Fiscal Year: No Selection

HUC Code: 00000000 Statewide

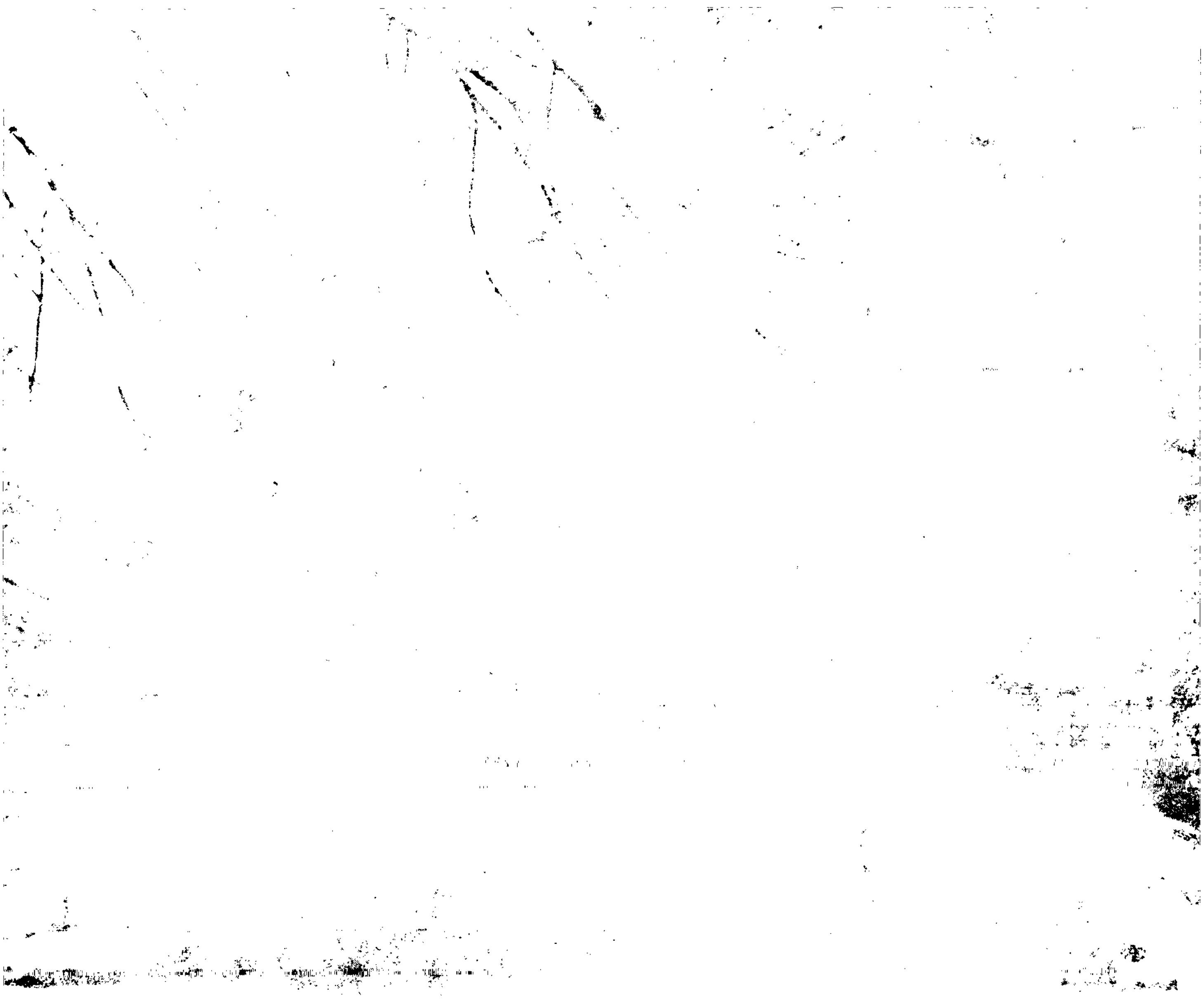
Contract #:

County: No Selection

Cross Reference ID:

Comments: Indiana 1984-85 Integrated Report (305(b) Report and 303(d) List of Impaired Waterbodies)

Redaction Reference ID:



INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

1984-85 305(b) REPORT

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EXECUTIVE SUMMARY

The 1984-85 305(b) Report is organized into four sections, and Indiana's activities in each area are summarized or discussed as follows:

1. Surface Water Quality - This section includes 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; and a summary of the surface water quality in each of the major river basins.

2. Water Pollution Control Program - The discussion of Indiana's water pollution control program is directed at 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 the monitoring programs Indiana uses to obtain necessary water quality data.

3. Groundwater Quality - This section describes Indiana's groundwater resource, areas of potential contamination and Indiana's efforts to protect its resource including Indiana's groundwater monitoring program.

4. Special Concerns and Recommendations - This section highlights Indiana's special concerns and includes recommendations for future actions by the state and federal governments.

There are an estimated 90,000 miles of rivers and streams in Indiana and about 560 publicly-owned lakes and reservoirs with a combined surface area of some 92,800 acres. There are also 100,000 acres of other wetlands remaining in the state. In addition, Indiana controls 154,000 acres of Lake Michigan. The Department of Environmental Management (DEM) has responsibility for protecting the quality of all of these waters.

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, this was reduced to 0.4%; and this percentage was only 0.04% in 1985. In 1972, there were no advanced wastewater treatment (AT) plants. In 1982, 18% of the population was served by AT plants, and in 1985, 45% of the population was served by AT plants.

Since 1972, Indiana has received over 1.1 billion dollars in federal construction grant monies and has spent over 130 million dollars in state money and 180 million dollars in local matching funds for new or upgraded treatment plants and sewer systems. There is no precise information on the amount of money spent for industrial waste treatment or control, but there were 159 claims for more than $803,676,180 in tax exemptions for industrial wastewater treatment or control facilities in 1985.

As a result, our data indicate that since 1972, water quality has been improved in at least 1,000 stream miles, and only about 200 miles of waterways have significant water quality problems remaining. Since 1972, no new stream miles have been degraded.

Several rivers, lakes, and streams were surveyed for toxic substances during this time period in addition to the CORE station sampling regularly done. Sediment, fish, wastewater effluents and, in some cases, sludge samples were collected in the Wabash River Basin, the East Fork of White River Basin, the St. Joseph River Basin in Elkhart and St. Joseph counties and in 14 lakes and reservoirs. Wastewater effluent and sediment samples from these streams, rivers, lakes, and reservoirs do not indicate widespread pollution by toxic substances. Few sediment or wastewater effluent samples contained levels of these substances which would be of concern. Concentrations of organic toxic substances in stream sediments, other than PCBs, could seldom be linked to specific wastewater effluent sources. On the other hand, metals found in "concentrations of concern" often were associated with effluents containing high metals concentrations or with dischargers with a history of problems with metals. At most of the localities where unacceptable levels of toxic substances were found, remedial actions have been initiated or completed.

Fish populations downstream from nearly all of the major municipal and industrial wastewater treatment facilities have substantially improved in recent years. However, in some areas, chlordane and/or PCBs have accumulated in fish tissue in excess of FDA action levels. This has prompted the issuance of consumption advisories for fish taken from several stream or river areas and Lake Michigan. No dieldrin concentrations exceeding FDA action levels were found in the most recent fish tissue samples. Where tissue contamination has been traced to a specific source or sources, corrective action has been initiated.

The availability and ambient quality of groundwater from the unconsolidated and bedrock aquifer system in the state are generally adequate for most of the current demands for potable supply, industry, and agriculture. Shallow aquifers in settings of surficial sands and gravels and thin cover over bedrock are relatively more vulnerable and are where most of the sites of groundwater contamination occur. Indiana will be developing a groundwater protection strategy to address the important issues regarding groundwater. Local efforts in counties where groundwater protection is most vital can be important.

I. INTRODUCTION

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. Most of these economic pursuits in some way depend on or affect Indiana's water resources. Also, much of the wastes produced by Indiana's 5.5 million inhabitants is ultimately discharged to Indiana's waterways after receiving some form of treatment.

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 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 the turn of the century, the extent of the water resource remains essentially the same. Of the estimated 90,000 total miles of waterways in Indiana, only about 45,000 miles of streams and rivers are large enough to support aquatic life throughout most of the year. 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. For purposes of this report, waterways in Indiana have been divided into one of seven water basins.

Indiana has approximately 560 publicly owned lakes, ponds, and reservoirs under 5000 acres in size, with a total area of approximately 76,800 acres. There are two reservoirs over 5000 acres in size with a total area of about 16,000 acres. Indiana's publicly owned lakes, ponds and reservoirs have a gross storage capacity of around 606 billion gallons. Indiana also controls 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 remnant 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. They also serve as sediment and nutrient traps and provide flood control. 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 100,000 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 in 1984-85.

II. SURFACE WATER QUALITY

Current 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 support aquatic life throughout the year. The rest are normally pooled or dry, especially in the summer. A vast majority of these small streams receive no 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 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 approximately 1000 stream miles, and there remain only about 200 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 and middle West Fork of White River, the East Fork of White River, the Wabash River, the Maumee River, the Muscatatuck River, the Grand Calumet River, and numerous smaller streams. In the 1984-1985 reporting period, the most serious remaining problems were in the Little Calumet and Grand Calumet River basins in Lake County and Trail Creek at Michigan City.

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). 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 were monitored monthly from 1981 to 1983 for coliform bacteria, only about 20% regularly met the standard for partial-body contact. In 1984 and 1985 more than 40% of these stations were able to meet the recreational use designation. 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 municipalities that have combined sewer overflows. Also, while standards are not always met, the maximum and average values for fecal coliform concentrations have dropped dramatically at most stations in recent years.

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. The current indicators of bacterial water quality are less than ideal, and more effective but practical methods for bacteriological assessment are being sought. EPA has recently drafted new bacteriological criteria using E. coli and/or Enterococcus as indicator organisms rather than fecal coliform bacteria.

Indiana has approximately 560 public lakes and reservoirs less than 5,000 acres in size and 2 reservoirs greater than 5,000 acres in size. These lake groups total approximately 77,000 acres and 16,000 acres, respectively. Since 1970, nearly all of these lakes have been sampled for various limnological parameters. Data obtained in the early 1970s were used to develop the Indiana Lake Classification System and Management Plan. In this document, all of Indiana's lakes which had been surveyed were grouped into four "classes," based on their trophic state, and further divided into seven "management groups." These management groups were formed using cluster analysis based on lake size, mean depth, and Eutrophication Index Values. The Eutrophication Index, explained in more detail in the Lake Classification System and Management Plan, is basically an index developed utilizing the limnological data collected in the lake.

During 1985, Indiana Lake Classification System and Management Plan was revised and updated. Most limnological data gaps were filled, and new data were added. Additional natural and man-made lakes were assigned to appropriate management plan groups. With the completion of this revision, nearly all of Indiana's public lakes have been assigned to one of four trophic classifications and to one of seven management groups.

In the classical sense, there may be no lakes in Indiana which would be considered oligotrophic, and probably no more than 10% of all lakes would be considered mesotrophic. The majority would be considered eutrophic. Indiana has classified its lakes into four classes, with Class I lakes being the least eutrophic, or best in terms of water quality, and Class IV being oxbows and remnant lakes which are most eutrophic and support extensive populations of weeds and algae. A more complete description of these four classes can be found in the Indiana Lake Classification System and Management Plan.

Table 1 shows the number and acreage of Indiana lakes and reservoirs in each of the four classes. Both of Indiana's larger reservoirs (over 5,000 acres) would be classified as Class I lakes. Of the total acreage of lakes and reservoirs less than 5,000 acres in size, approximately 44% would be in Class I, 40% in Class II, 13% in Class III, and 3% in Class IV.

Class I and II lakes almost never have water quality problems and designated uses are never impaired. Class III lakes may support periodic algal blooms or excessive weed growths, but designated uses are seldom impaired (less than 10% of the time). Chemical control is often used in these lakes to control weeds and algae when these do appear to be problems. Many Class IV lakes would be considered to only partially support their designated uses due to excessive weed or algae growth a significant amount of the time.

Table 1. Classification of Indiana lakes and reservoirs.

Lake Size	Class	Number	Acres
over 5,000 acres	I	2	16,000
under 5,000 acres	I	117	31,180
	II	206	28,623
	III	111	9,190
	IV	118	2,448
Total		554	87,441

All of Indiana's lakes and reservoirs are designated for fishable and swimmable uses. Our data indicate that very few designated swimming areas in lakes were closed due to high bacterial counts in the 1984-85 period. Those closures that did occur could be traced to upsets in sewage treatment plant operations or spills and were short-term occurrences (1-2 days).

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. These wetlands may provide spawning areas for some fish, 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.

Because of their demonstrated ability to act as sediment traps and as filters for contaminants and excessive nutrients, the protection of these wetlands is of vital importance to the water quality of Indiana's streams, rivers and lakes. The authority to protect wetlands is inherent in Sections 7 and 8 of Indiana Stream Pollution Control Law

IC 1971, 13-1-3 and portions of regulation 330 IAC 1-1. During the next review and revision of 330 IAC 1-1, Indiana will explore the possibility of adding a reference to wetlands in the definition of waters of the state. Additional protection of wetlands is provided through the 404 environmental review and 401 certification process and early environmental coordination of proposed construction processes not requiring 401 certification.

Since January 1984 the State of Indiana has received approximately 120 Public Notices from the U.S. Army Corps of Engineers regarding Water Quality Certification under Section 401 of the Federal Clean Water Act. Approximately 10% would have involved the filling of wetlands and, of those, 90% were denied. Unfortunately, Indiana's wetlands are still disappearing and being altered at a significant rate as they are illegally drained and filled for agricultural and residential development. The greatest potential for further wetland protection in Indiana lies in educating the public to the requirements of the 404 environmental review and 401 certification process and of the contribution to better water quality and wildlife habitat provided by wetlands.

Indiana's largest body of water is the 154,000 acres of Lake Michigan in northwestern Indiana. These waters, bordering 43 miles of shoreline, are used extensively for sport and commercial fishing, swimming and boating, and both potable and industrial water supply. The only use of these waters which has occasionally been impaired in the past is whole-body contact (swimming). In 1972, an estimated 5 miles of Lake Michigan beachfront were closed because of high bacterial counts. No Indiana beaches have been closed recently, and water quality along all of the shoreline has improved. However, there is a lakewide fish consumption advisory for certain species due to high concentrations of chlordane, dieldrin, DDT, and PCBs.

Since 1979, we have evaluated at least 58 dischargers on headwater streams which are having a moderate to severe impact on downstream uses. If there is an assumed average of 2 miles of impaired uses at each site, a total of 116 stream miles would be impaired. Construction grants have been issued to 10 of these dischargers since 1982, and this should improve approximately 20 miles of stream.

The current status of water quality for recreational and aquatic life uses in Indiana based on Fixed Water Quality Monitoring Network data is shown in Table 2. The status of a body of water is determined based on the criteria outlined in Table 3. Figures 1 and 2 are maps of Indiana showing the major waterways and the degree to which each meets established use designations.

Fixed Station Water Quality Monitoring Network data from 1981 to 1983 and 1984 to 1985 were reviewed to determine the five most common parameters responsible for substandard water quality (Table 4). These parameters were identified by determining the number of exceedances of Indiana water quality standards or EPA recommended criteria. The most noticeable change in water quality was a 22.8 percent increase in the number of stations being able to meet the recreational use designation based on fecal coliform bacteria counts.

Table 2. Current status of rivers and streams monitored by the Fixed Station Water Quality Monitoring Network.

	Recreational Uses		Aquatic Life Uses	
	1981-1983	1984-1985	1981-1983	1984-1985
Number of stream miles assessed	2,055	2,100	2,055	2,100
Number of stream miles supported	885	1,146	1,849	1,952
Number of stream miles partially supported	405	467	97	108
Number of stream miles not supported	765	487	109	40

The same data used to determine the most common problem parameters revealed that 70 of the 86 stations from 1981 to 1983 and 52 of the 87 stations from 1984 to 1985 did not fully support their designated use(s) (water identified previously as partially supporting or not supporting their uses). The relative causes of use impairment at these stations were assessed by reviewing the type of water quality problem(s) and local discharger(s). The 5 following pollution source categories were used to describe the statewide sources of pollution on Indiana rivers and streams:

1. Nonsupport Caused by Industrial Sources
2. Nonsupport Caused by Municipal Sources
3. Nonsupport Caused by Combined Sewer Overflows
4. Nonsupport Caused by Nonpoint Sources
5. Nonsupport Caused by Unknown Sources

Figure 3 indicates the extent to which each pollution source category is responsible for designated uses not being fully supported in both the 1981-1983 and 1984-85 periods. From Figure 3 it can readily be seen that the relative contributions of each pollution source have not drastically changed from the 1981-1983 period to the 1984-1985 period.

Table 3. Criteria for evaluating the support of a designated use

SUPPORT OF DESIGNATED USE	BACTERIOLOGICAL AND CHEMICAL INFORMATION	DIRECT OBSERVATION/ PROFESSIONAL JUDGEMENT
Waters support designated use Minor/no impairment of uses	Standard is exceeded in 0 -10% of the analyses and the mean measured value is less than the standard	Direct observation shows that the designated use is supported, or professional judgement indicates that there is no reason for the use not to be supported
Waters partially support designated use Moderate--some interference with designated uses	Standard is exceeded in 11 -25% of the analyses and the mean measured value does not violate the standard; or standard is exceeded 0 -10% of analyses and mean measured value exceeds the standard	Direct observation shows that the use exists in the waterbody but professional judgement suggests the use is not supported at a maximum level (e.g. citizen complaints on record or fisherman success rates declining).
Waters do not support designated uses Severe--designated uses are precluded	Standard is exceeded in more than 25% of analyses and mean measured value meets the standard; or standard is exceeded in 11-24% of analyses and mean measured value exceeds the standard	Direct observations show overt signs of obvious use impairment (e.g. severe or frequent fish kills), or provide no evidence that the use exists. Professional judgement suggests that the use cannot be supported due to known or suspected water quality impacts.

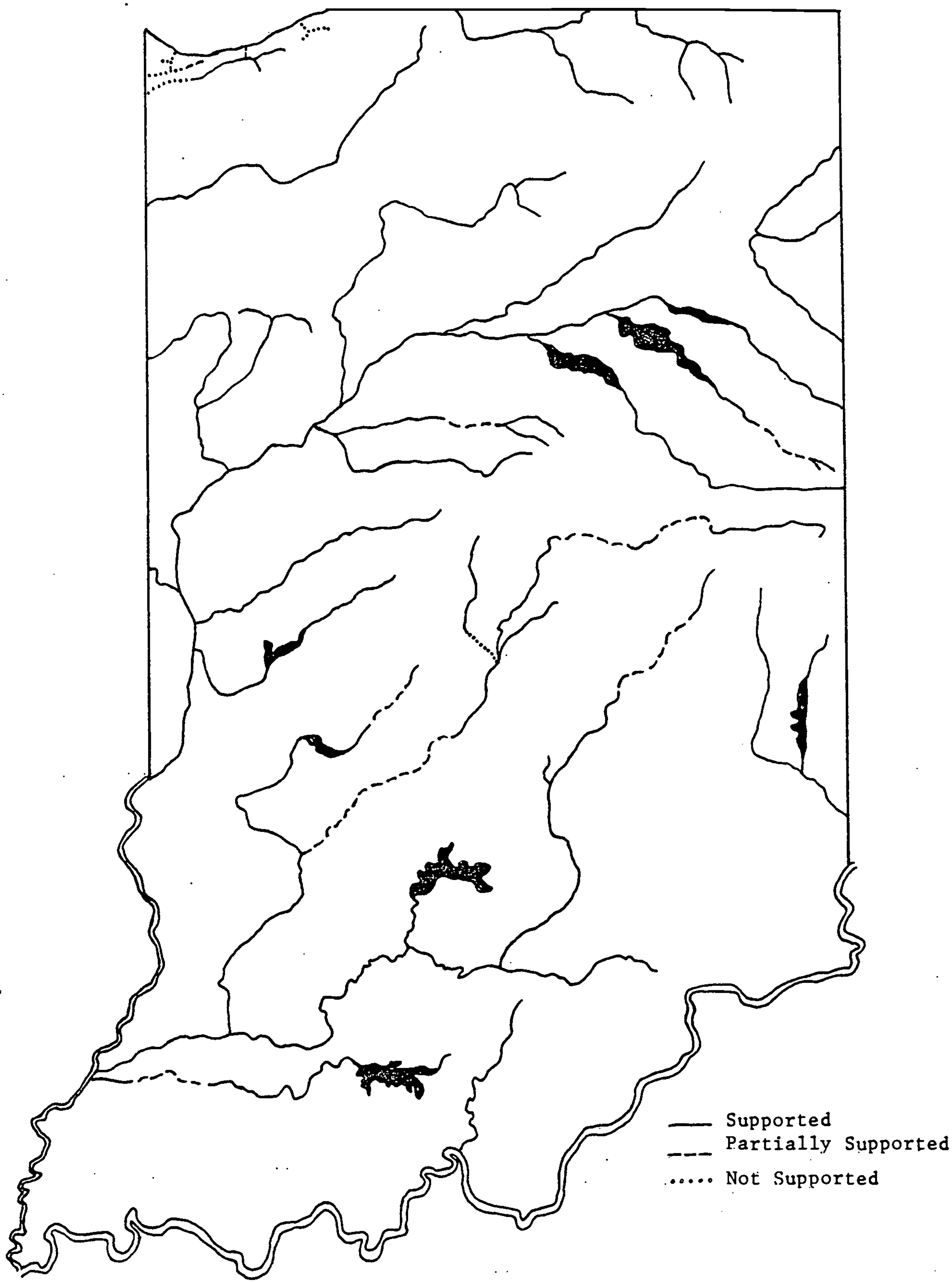


Figure 1. Major waterways in Indiana indicating designated aquatic life uses being supported, not supported or only partially supported in 1984-85.

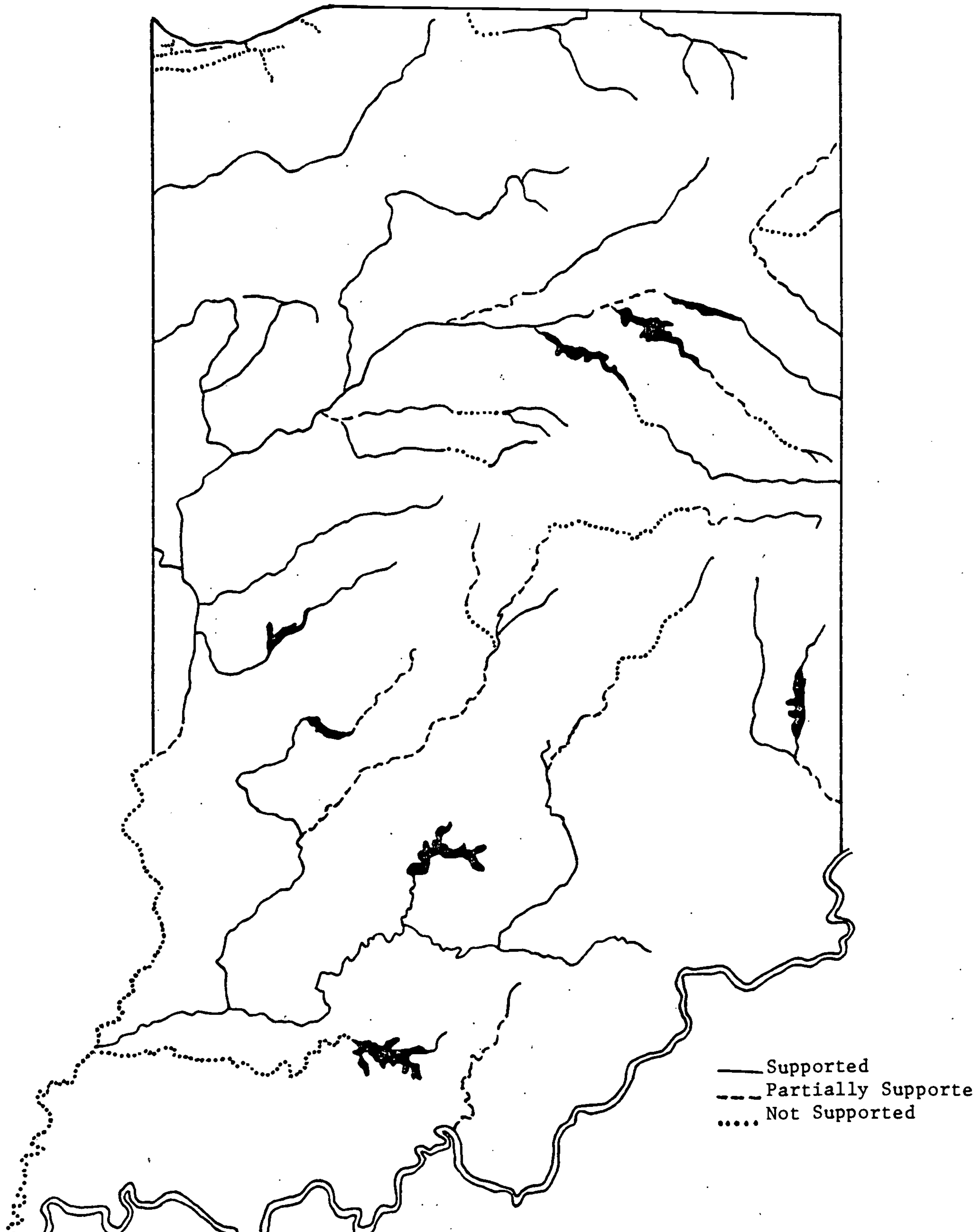


Figure 2. Major Waterways in Indiana indicating designated recreational uses being supported, not supported or only partially supported in 1984-85.

Table 4. The five parameters most responsible for nonsupport at Indiana's Fixed Station Water Quality Monitoring Network stations.

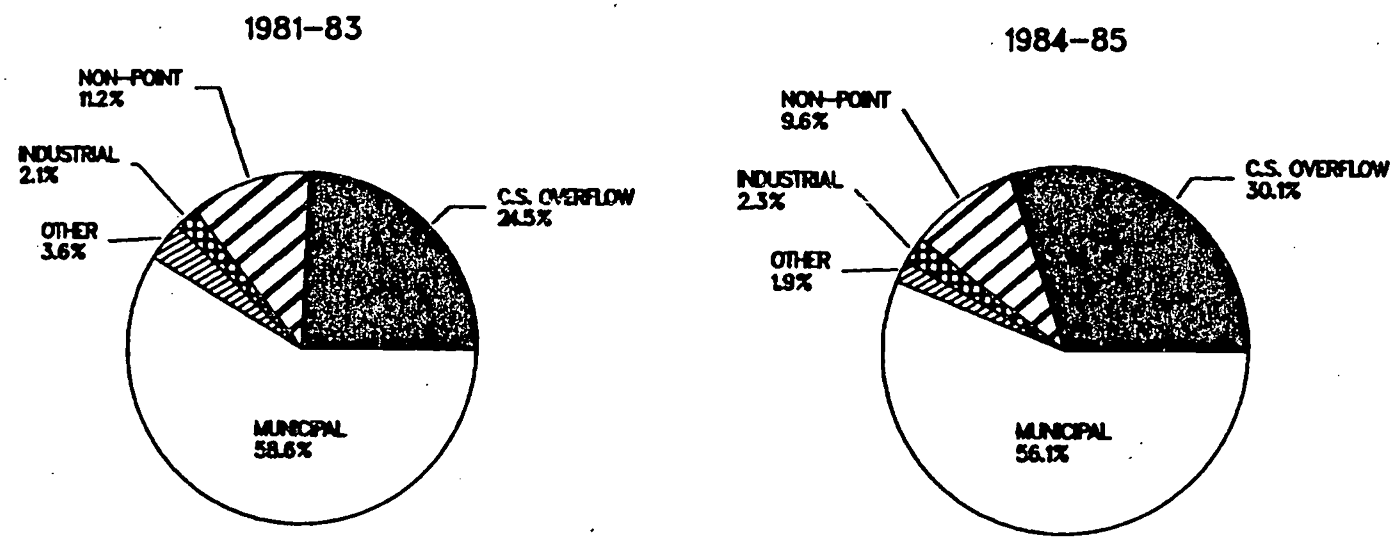
Parameter	1981-1983 Number of Stations Not Supported	1984-1985 Number of Stations Not Supported
Fecal coliform	69	50
Ammonia (total and unionized)	17	15
Dissolved oxygen	8	10
Metals	4	5
Cyanide	1	2
Total Number of Stations Assessed	86	87

Municipal dischargers account for more than one-half of the number of stream miles which do not fully support their designated uses. Low dissolved oxygen, elevated ammonia, and high fecal coliform bacteria concentrations are the primary problems associated with these discharges. Combined sewer overflow problems can be connected to high fecal coliform and low dissolved oxygen concentrations that occur following periods of intense rainfall. Industrial discharges and nonpoint runoff account for the remaining areas with poor water quality. Low dissolved oxygen, pH changes, elevated temperatures and toxic substances (such as metals and cyanide) 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 contribute nutrients, cause turbidity and pH changes, and may contain pesticides and heavy metals. One other area of concern is water quality problems associated with oilfield brines, even though this is largely restricted to the southwest corner of the state.

It should be noted that combined sewer overflows and municipal problems comprise over 80 percent of the nonsupport designations. Hopefully, with the increase in the number of AT plants and proposed sewer separations, these sources of pollution will decrease.

Data from the Fixed Station Water Quality Monitoring Network were compiled for fecal coliform, biochemical oxygen demand (BOD) and unionized ammonia in an effort to statistically describe water quality trends. Comparisons of the 19 stream CORE stations during three different time periods (1975-80, 1981-83, and 1984-85) were made for each of the three parameters using t-tests. The stream CORE stations were selected because they are intended to be indicative of general statewide waterway conditions, have established, unchanged locations and sufficient databases.

Figure 3. Causes of waterways not fully supporting their designated uses.



Fecal coliform, BOD, and unionized ammonia are not the only parameters that could be used to indicate water quality trends in Indiana. The decision to perform statistical trend analyses on only three parameters was primarily based on the fact that laboratory detection limits and quality assurance for these parameters have not changed since 1975. For instance, the detection limit for copper, prior to 1979, was 20 ug/l, far above the current detection limit of 4 ug/l. This change in detection limits could lead to the misinterpretation of data comparisons between different time periods.

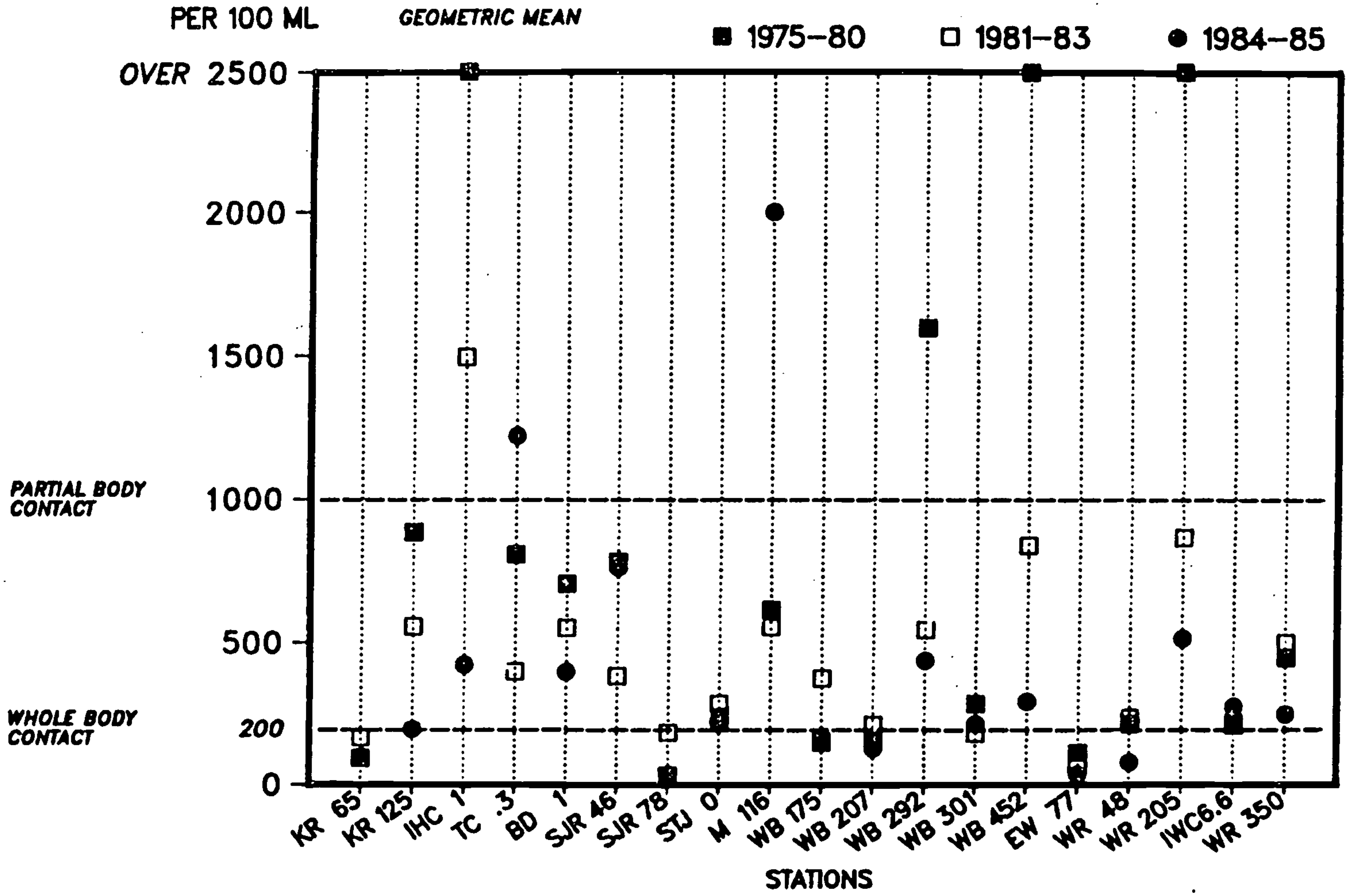
In this trend analysis, nondetectable and actual measured concentrations were used in all comparisons. Nondetectable values were designated as minimum detectable values for computations. For example, a BOD value of less than 1.0 mg/l was included in a calculation as 1.0 mg/l. Since the majority of values used in the calculations are actual reported values, overestimation of concentrations was not expected to be a large factor in the data interpretations.

Data were analyzed using the SAS program PROC t-test. Statistics collected included sample size, arithmetic or geometric mean, standard deviation, standard error, minimum value, t-statistic, confidence limit, and P-value. P-values less than 0.05 were considered significant.

The direct examination for specific pathogens in water is too costly, time consuming, and unwieldy for routine investigations. Instead, water is examined for an indicator of fecal contamination. When such an indicator is found in significant numbers, it is assumed that the water is potentially dangerous. In recent years, public health agencies have used fecal coliform bacteria as the indicator of fecal contamination. Inasmuch as fecal coliform concentrations in streams may be influenced by factors other than waste discharge, such as agricultural and urban runoff, a great deal of care must be used in interpreting bacteriological data.

The geometric mean fecal coliform concentration ranges at all 19 CORE stations were 36-6,388/100 ml in 1975-80, 70-1,494/100 ml in 1981-83 and 39-1,221/100 ml in 1984-85. Five stations (SJR-46, WB-452, WR-205, IHC-1, and WB-292) showed significant improvements from the 1975-80 period to the 1981-83 period. An additional 3 stations (KR-125, EW-77, and WR-48) exhibited significant decreases from the 1975-80 to 1984-85 reporting periods. From Figure 4 it can be seen that 17 of the 19 CORE stations met the partial body contact standard in 1984-85, compared to 15 of 19 in 1975-80. During the same period, seven stations (KR-65, KR-125, WB-175, WB-207, EW-77, WR-48, and SJR-78) met the whole-body contact standard (Figure 4), compared to five stations (KR-65, SJR-78, WB-175, WB-202, and EW-77) meeting this level in the 1975-80 reporting period. (The locations of these stations are shown in Table 32.) The greatest improvements, based on geometric mean concentrations, were in the Indiana Harbor Ship Canal, Wabash River below Lafayette, White River near Winchester, White River below Indianapolis and Wabash River near Geneva. Hopefully, the 1986-87 reporting period will provide adequate statistical evidence to document expected improvements due to completed and proposed wastewater treatment plant improvements and CSO control projects.

Figure 4. Fecal coliform concentrations (geometric mean) at the 19 CORE stations for the periods 1975–80, 1981–83, and 1984–85.



The biochemical oxygen demand (BOD) of a stream or waste effluent is the amount of oxygen required for the biological breakdown of organic material under aerobic conditions. The BOD test is very important in determining the strength of polluting substances and the degree of self-purification that has occurred in a stream below the point of waste discharge.

Domestic sewage and some industrial wastes contain high concentrations of organic material which is readily broken down by microorganisms. If environmental conditions are suitable, populations of microorganisms involved in this process increase rapidly and establish a demand for oxygen for respiration (BOD). The BOD of a stream is highest immediately below the point where organic materials are discharged and decreases downstream in proportion to the extent of decomposition of the organic material by microorganisms. In addition to waste effluents, organic material from soil erosion, and the remains of aquatic plants and animals contribute to the BOD of a stream.

In the 1981-83 reporting period, 5 stations (IHC-1, SJR-78, SJR-46, WB-292, and EW-77) had significant decreases in BOD levels from the previous five years (1975-80) of data. A comparison of the 1975-80 and 1984-85 reporting periods showed that only four stations (BD-1, IHC-1, SJR-46, and WR-205) had significantly declining BOD levels. The only continued statistically significant decrease in BOD was observed at IHC-1 on the Indiana Harbor Ship Canal.

Table 5 shows water quality at Indiana's CORE stations relative to BOD levels as described by Hynes (3). Although BOD levels at few stations have demonstrated statistically significant changes, levels at most have already reached concentrations typically classified as "clean" to "fairly clean." As many of these BOD values are at or approach background levels, statistically significant changes would be difficult, if not impossible to achieve.

Ammonia is a natural constituent of both surface and groundwaters. It can result from the decomposition of organic matter including plant remains and is a common constituent of domestic wastewaters and certain industrial wastes.

Table 5. Water quality relative to BOD_5 levels at 19 of Indiana's CORE stations.

Water Quality and BOD_5 Concentration*	(mg/1)	No of CORE Stations 1975-80	1981-83	1984-85
Very clean	1.0	0	0	2
Clean	2.0	5	7	5
Fairly clean	3.0	11	10	10
Doubtful	5.0	2	1	2
Bad	10.0	1	1	0
Mean BOD_5 values (mg/1)		3.46	3.10	2.87

*From Hynes (3).

Dissolved oxygen is consumed during the biochemical oxidation of ammonia to nitrite and nitrate. This nitrogenous oxygen demand (NOD) is generally exerted in the receiving stream unless ammonia removal takes place as part of the wastewater treatment process.

Ammonia has also been shown to be toxic to fish and other aquatic life. The toxic component of ammonia is the unionized portion which increases with pH. Ammonia toxicity also increases with a decrease in dissolved oxygen and at temperature extremes.

Indiana's water quality standards for unionized ammonia are intended to protect freshwater aquatic life under a wide range of environmental conditions. In developing wasteload allocations for ammonia, both the NOD and the possible toxic effect are considered.

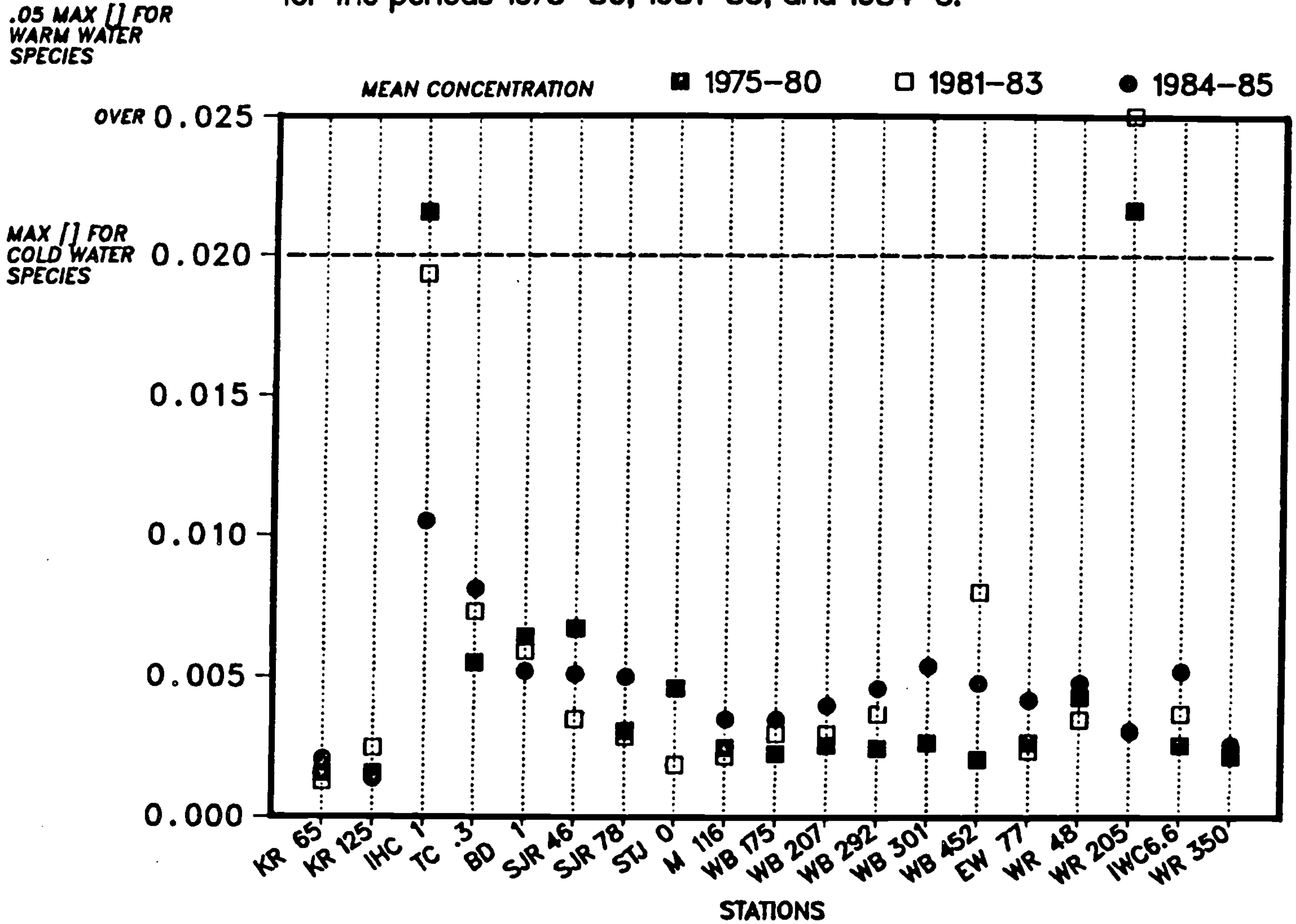
Although occasional water quality violations for unionized ammonia have been observed, mean concentrations at the 19 CORE stations are below the recommended criteria and/or state standards. No stations had mean concentrations above the maximum allowable unionized ammonia concentrations of 0.05 mg/l for warm water species in any of the sampling periods (Figure 5). In fact, all stations in the 1984-85 sampling period had mean concentrations below the maximum allowable unionized ammonia concentration of 0.02 mg/l for cold water species. Statistically significant decreases in unionized ammonia concentrations have been observed in the Indiana Harbor Ship Canal (IHC) and White River below Indianapolis.

Statistically significant increases in unionized ammonia concentrations occurred in the Indianapolis Water Canal (IWC-6.6), the Wabash River near Geneva (WB-452), and above Lafayette (WB-301) from the 1975-80 to 1984-85 reporting periods. Even though significant increases in mean values were observed at these three stations, all mean values remained below 0.01 mg/l, which is quite acceptable.

All three water quality indicators analyzed in this study showed significant improvement at the IHC station (IHC-1) and the station on the White River below Indianapolis (WR-205). Improved wastewater treatment at the Southport and Belmont STPs in Indianapolis and throughout the Grand Calumet River/IHC system are responsible for the improvements. With good maintenance and operation of the Indianapolis STPs and implementation of the Grand Calumet River/IHC Master Plan, these improvements in water quality should continue.

In the summer of 1985, fourteen Indiana lakes and reservoirs were sampled as part of a toxics monitoring program which involved the collection of fish and sediment for analysis. At the same time, limnological testing and sampling was conducted on these lakes and reservoirs to determine their current general condition, to gather data for comparison to surveys that were done 10 to 12 years ago, and to provide baseline data for future comparisons.

Figure 5. Unionized ammonia concentrations at the 19 CORE stations for the periods 1975–80, 1981–83, and 1984–5.



When limnological data collected in 1985 were compared to data obtained in 1973 and 1975 on the same lakes, it was found that conditions of several had improved. All of the lakes and reservoirs remained in the trophic class in which they were originally placed, but many study lakes moved upwards within that class and therefore rank a little better today than they did in 1973 and 1975. Lakes that do not receive municipal discharges generally remained at about the same trophic level and ranking order as they were in the early seventies.

Lakes that receive municipal discharges by way of tributaries showed a trend toward improvement of lake conditions in 1985. This is extremely encouraging since these lakes and reservoirs often age dramatically in a ten to fifteen-year period and sometimes show a worsening of lake conditions and/or of use impairment.

Figure 6 compares the Eutrophication Index Values (EIV) for 11 lakes and reservoirs surveyed in 1985 with EIVs from the mid-1970s (lower EIVs indicate a less eutrophic condition). Most lakes and reservoirs had 1985 EIVs very similar to the 1970s values, with only slight increases or decreases. However, two waterbodies, Monroe Reservoir and Versailles Lake, had rather substantial drops in the EIV between the two periods. Both of these waterbodies receive treated municipal wastewater through tributaries.

Phosphorus concentrations are indicative of a lake's trophic status because phosphorus is the essential nutrient for algal growth which is most often limiting. Figure 7 shows epilimnal phosphorus values for 12 lakes sampled in 1985 as compared to epilimnal phosphorus values in these lakes when they were sampled in the mid-1970s. Sampling occurred at nearly the same time (mid-summer) each year. Of the 12 lakes, only one showed an increase in epilimnal phosphorus values in 1985 as compared to the previous sampling date. Although caution must be used when comparing these data utilizing only one set of samples from each of two different times, the fact that nearly all these lakes showed the same trend (some to a greater extent than others) does at least indicate that phosphorus levels in these lakes have not increased to any extent over this 10-12 year period and may actually have decreased. Figure 8, showing water column average total phosphorus data from ten lakes with comparable measurements from the two time periods, tends to support these same conclusions. Seven of these ten lakes had water column average phosphorus values either the same or less than the earlier samples, and two showed only slightly increased values. The two samples from Mississinewa Reservoir differed in that one sample (Dam) showed slightly increased phosphorus levels and the other (Pearson Mill) showed decreased phosphorus levels. As most of Indiana's lakes and reservoirs are phosphorus limited, reductions of phosphorus in these lakes should slow the eutrophication process.

There are several reasons why phosphorus levels in a number of Indiana lakes and reservoirs may have decreased over this 10-12 year period. One is the enactment of a phosphate detergent ban by Indiana in 1971 (that became fully effective in 1973). This law limits the phosphorus content in laundry detergents to 0.5% or less. Indiana also requires phosphorus removal for any discharge containing 10 pounds or

Figure 6. Eutrophication Index Values for 11 lakes and reservoirs sampled in the mid-1970s and in 1985.

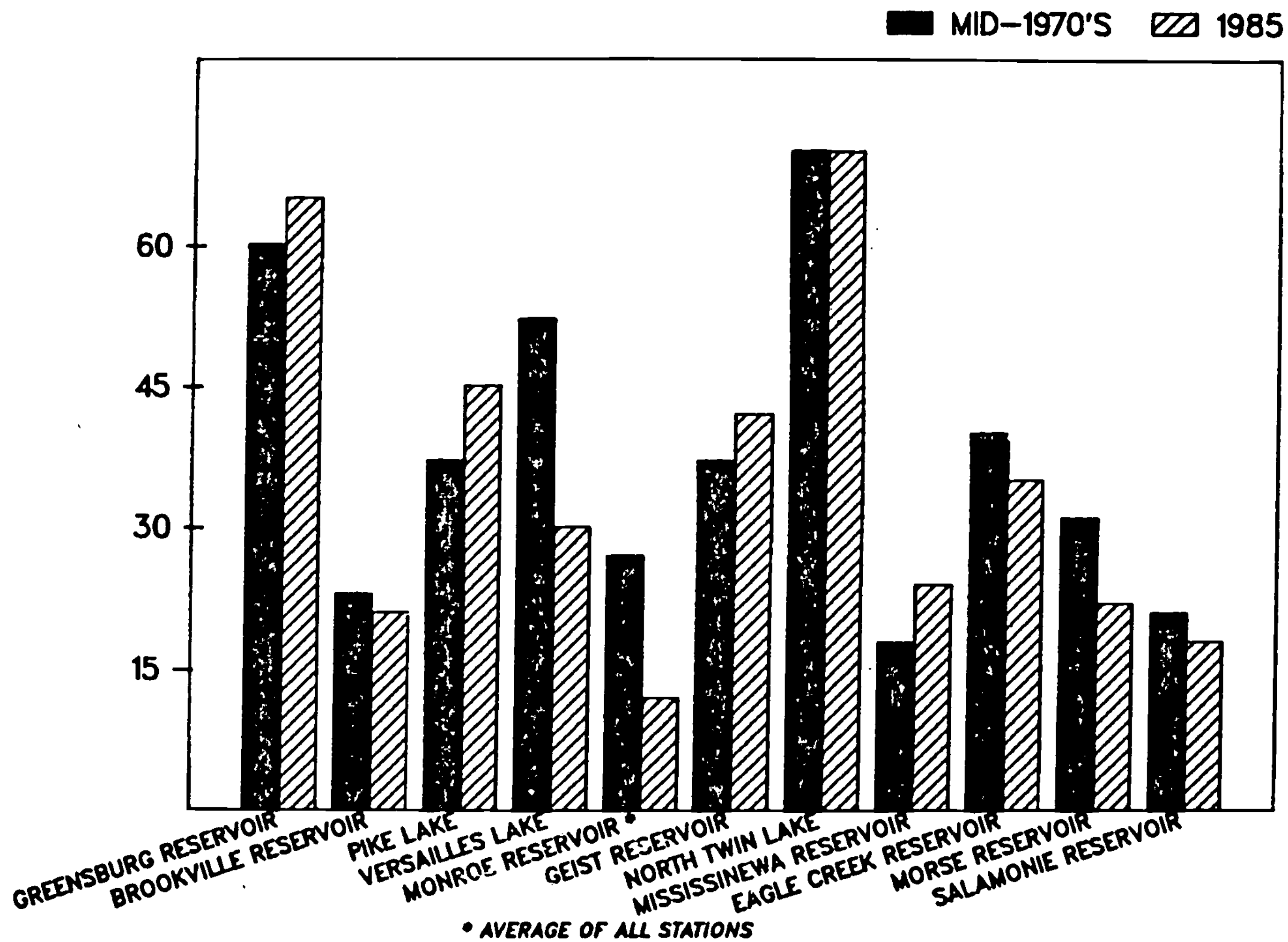


Figure 7. Epilimnal total phosphorus concentrations* for 12 lakes and reservoirs sampled in the mid–1970s and in 1985.

** PALESTINE LAKE IS A WATER COLUMN AVERAGE FIGURE*

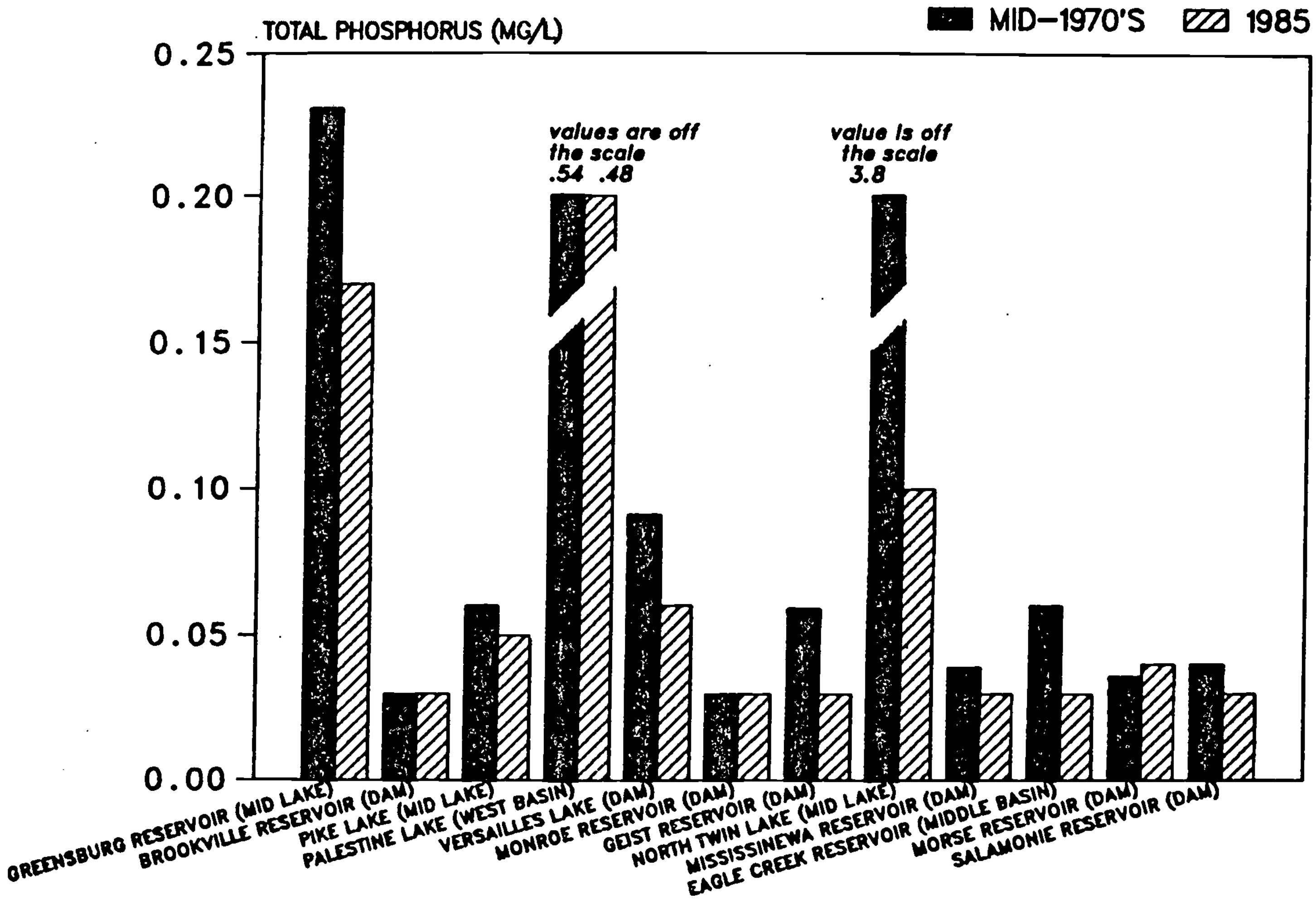
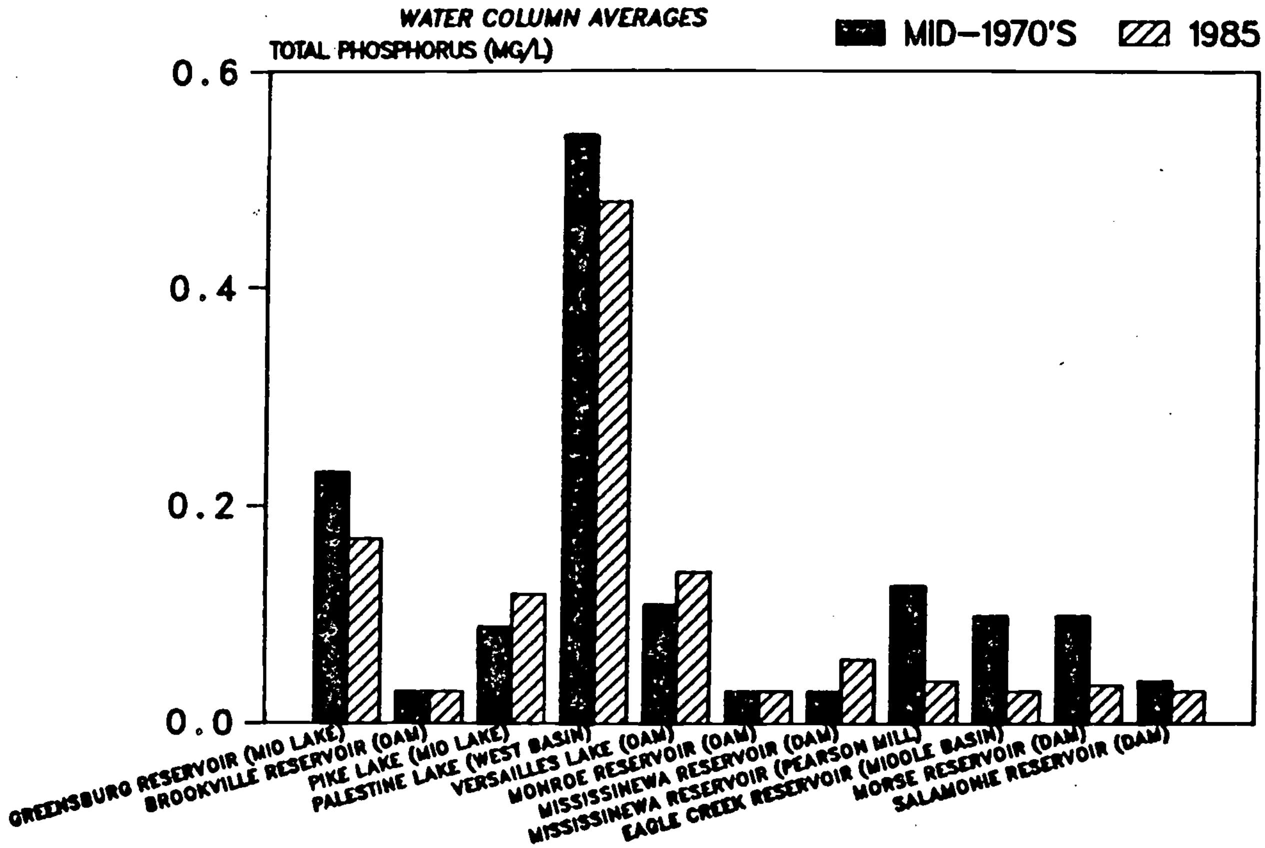


Figure 8. Water column average total phosphorus concentrations for 10 lakes and reservoirs sampled in the mid-1970s and in 1985.



more of total phosphorus where this discharge is located: in the Lake Michigan or Lake Erie basins; on a tributary within 40 miles upstream of the lake or reservoir; or on a lake or reservoir. The agency may also require phosphorus removal irrespective of the amount of phosphorus in the discharge if it is determined that phosphorus reduction is needed to protect downstream water uses or to meet water quality standards. Additionally, enforcement of the Confined Feeding Control law and land application regulations have reduced phosphorus loadings to lakes and reservoirs from these activities.

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; and 3) toxic materials in the water could 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 contaminated water supplies or 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 associated 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 1984-85 (and earlier in some cases) to discover the scope of the toxic problem and the causes and possible solutions to these problems.

River and Stream Studies

Monitoring for toxic materials in fish flesh at 19 Indiana CORE network stations (Figure 9) 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 four times during the six-year period.

At each station, an attempt was made to collect two samples of "bottom feeding" 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. Parameters for which the fish are analyzed are shown in Table 6.

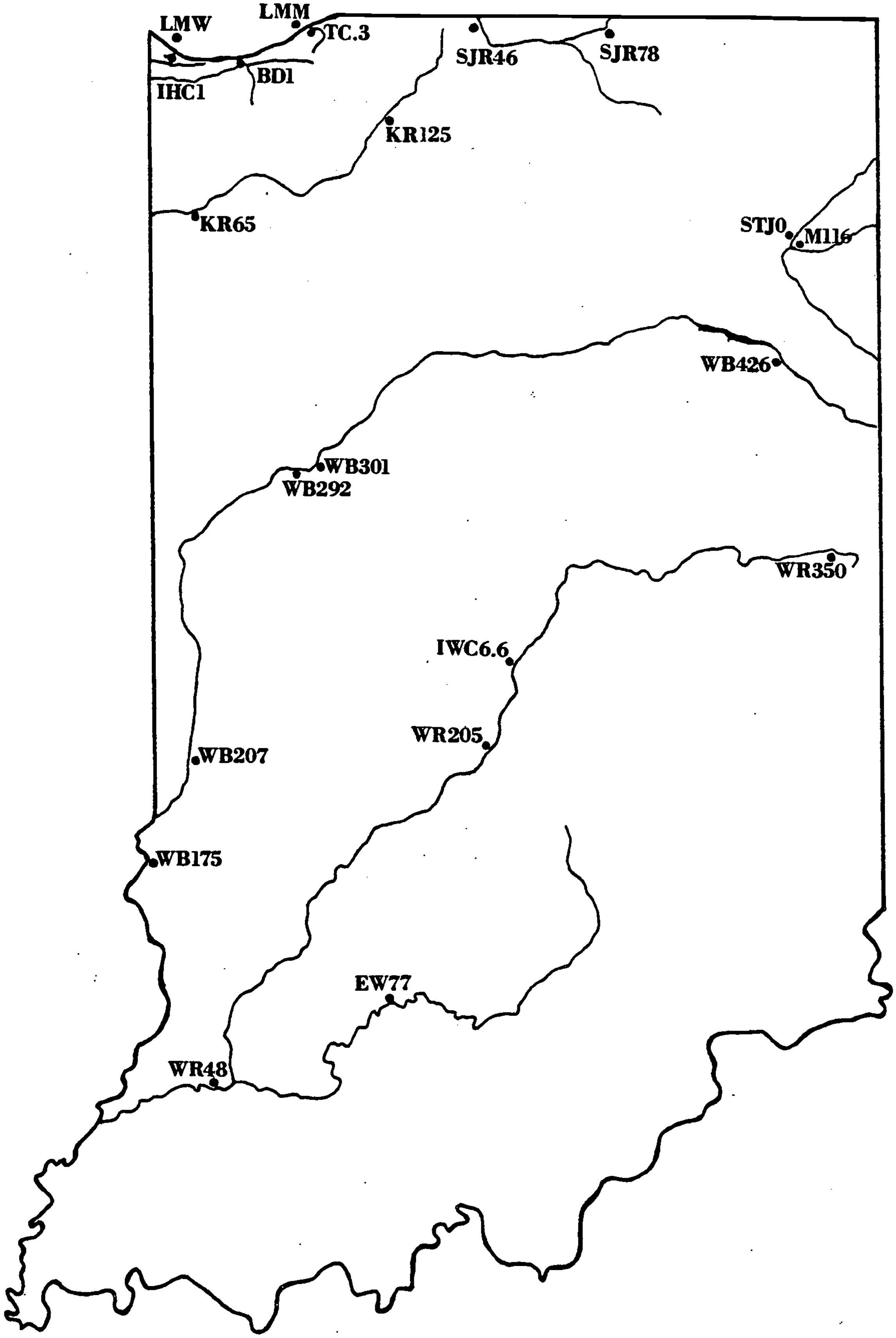


Figure 9. Location of Indiana's CORE monitoring stations.

A summary of the fish flesh data collected at Indiana's CORE stations (excluding the Lake Michigan stations) in the periods 1979-82 and 1983-84 is shown in Table 7. Of the various toxic parameters for which these samples are analyzed, only three (chlordane, PCBs, and dieldrin) have been found in quantities which exceeded FDA action levels. The number and percent of the samples from each CORE station which exceeded the FDA action levels of these three compounds in samples collected in the 1979-82 period and the 1983-84 period are shown in Table 7. Only one set of samples was collected in the the 1983-84 period and three sets of samples were collected in the period from 1979 to 1982. Thus, comparisons between the two periods are somewhat tenuous as the 1983-84 data are based on fewer samples.

The United States Food and Drug Administration (FDA) lowered the action level for PCBs from 5.0 ppm to 2.0 ppm in August 1984. Thus, fish collected in 1983-84, were evaluated using the 2.0 ppm action level whereas fish collected in 1979-82 were originally evaluated using the 5.0 ppm action level. With this change in the PCB action level, a greater percentage of exceedances was found in the samples collected in the 1983-84 period, and these exceedances occurred at more localities (Table 7). Comparisons of the 1979-82 PCB data with the 1983-84 PCB data using the 2.0 ppm action level indicate that, in general, localities that had PCB exceedances in 1983-84 would have had exceedances in 1979-82 at the 2.0 ppm level (Table 7, columns 5 and 7). Two exceptions seem to be: 1) the Wabash River above Lafayette which shows no PCB exceedances in the 1983-84 samples but would have had 4 (44%) exceedances in the 1979-82 samples; and 2) the Maumee River at Fort Wayne which has 2 of 3 1983-84 samples above 2.0 ppm but no 1979-82 samples exceeding that level.

The location of fish samples exceeding FDA action levels for PCBs in 1983-84 can be somewhat correlated with known (or suspected) PCB sources. In 1983, Wea Creek, a tributary to the Wabash River below Lafayette, and Elliot Ditch, a tributary to Wea Creek, were found to contain PCB contaminated fish and sediment. This tributary could be a source of PCB contamination seen in fish collected from the Wabash River below Lafayette. The source of the PCB contamination of Elliot Ditch and Wea Creek has been determined to be the ALCOA discharge in Lafayette, although the PCBs appear to be of nonpoint source origin on the ALCOA property and not from their manufacturing processes. The state and ALCOA are working to determine and eliminate this PCB source. Additionally, sediment samples collected in the Wabash River just downstream of Olin Corporation near Covington as part of the toxics monitoring program (Figure 13) contain rather high concentrations of PCBs (240 ug/kg). As yet, the source(s) of this contamination is unknown, but additional sampling is planned. The PCB Aroclor found in these sediments is different than the Aroclor found in Wea Creek and Elliot Ditch.

Table 6. 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,p,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

Contamination of fish with PCBs in the West Fork of White River above Indianapolis (station IWC-6.6) is probably the result of PCB contamination originating in a tributary of the West Fork of White River near Noblesville. Again, this source seems to be of nonpoint origin, but occurs in the discharge of the Firestone Plant near Noblesville. The state and the company have finalized a plan to monitor and hopefully eliminate this PCB source.

Contamination of fish with PCBs in the East Fork of White River is undoubtedly associated with the PCB problems in the Bloomington and Bedford area. Westinghouse, the old Bloomington STP, and several landfills in the Bloomington area have been known PCB sources for several years. General Motors' Central Foundry near Bedford has also had problems with PCBs. Most of these sources discharge into East Fork of White River tributaries upstream of the monitoring station at Williams. Fish contaminated with PCBs have been found in most of the tributaries into which these facilities discharge as well as in the East Fork of White River upstream of the monitoring station at Williams. Remedial actions are in progress at all of these possible sources of PCBs.

Specific sources of PCBs which might be related to the PCB contaminated fish in the Grand Calumet River-Indiana Harbor Ship Canal area, the Maumee River below Fort Wayne, and the St. Joseph River below South Bend are not as readily known. Given the highly industrialized nature of the area, the long-term accumulation of sediments known to contain PCBs and other toxic substances, and the presence of many old

Table 7. Fish flesh samples collected at CORE stations in 1979-82 and 1983-84 showing pollutants of concern (PCBs, Total Chlordane, and Dieldrin) and the exceedances of FDA action levels for these pollutants. Samples are of whole fish.

Locality	Total No. Samples 1979-82	No. (%) Exceeding FDA action levels (1979-82)				No. Samples 1983-84	No. (%) Exceeding FDA action levels (1983-84)			No. (%) Exceeding FDA action levels for PCBs** (1979-84)
		PCBs*	Chlordane	Dieldrin	PCBs**		PCBs**	Chlordane	Dieldrin	
Wabash River at Bluffton (WB-426)	9	0	2 (22)	0	0	2	0	0	0	0
Wabash River above Lafayette (WB-301)	9	0	4 (44)	3 (33)	4 (44)	3	0	2 (67)	0	4 (25)
Wabash River below Lafayette (WB-292)	7	0	1 (14)	3 (43)	1 (14)	3	2 (67)	1 (33)	0	3 (30)
Wabash River above Terre Haute (WB-207)	7	0	2 (29)	4 (57)	1 (14)	3	1 (33)	1 (33)	0	2 (20)
Wabash River below Terre Haute (WB-175)	9	0	4 (44)	5 (56)	0	3	0	1 (33)	0	0
White River at Winchester (WR-350)	9	0	3 (33)	0	0	2	0	1 (50)	0	0
White River at Indianapolis Water Canal (IWC-6.6)	9	3 (33)	3 (33)	2 (22)	8 (89)	4	4 (100)	2 (50)	0	12 (92)
White River at Henderson Ford (WR-205)	8	0	8 (100)	0	5 (63)	3	3 (100)	3 (100)	0	8 (73)
East Fork White River at Williams (EW-77)	11	4 (36)	5 (45)	3 (27)	8 (73)	3	3 (100)	2 (67)	0	11 (79)
White River at Petersburg (WR-48)	8	0	4 (50)	0	0	3	0	2 (67)	0	0
Kankakee River at Kingsbury (KR-125)	9	0	0	0	0	3	0	0	0	0
Kankakee River at Ind.-Ill. State Line (KR-65)	9	0	1 (11)	0	0	3	0	0	0	0
Indiana Harbor Ship Canal (IHC-1)	3	1 (33)	1 (33)	0	2 (67)	1	1 (100)	0	0	3 (75)
Burns Ditch (BD-1)	6	0	0	0	0	2	0	0	0	0

Table 7. (Cont'd.)

Locality	Total No. Samples 1979-82	No. (%) Exceeding FDA action levels (1979-82) PCBs*	Chlordane	Dieldrin	PCBs**	No. Samples 1983-84	No. (%) Exceeding FDA action levels (1983-84) PCBs**	Chlordane	Dieldrin	No. (%) Exceeding FDA action levels for PCBs** (1979-84)
Trail Creek (TC-0.3)	5	0	0	0	0	2	0	1 (50)	0	0
St. Joseph River at Bristol (SJR-78)	8	0	0	0	0	3	0	0	0	0
St. Joseph River below South Bend (SJR-46)	9	0	2 (22)	0	4 (44)	3	3 (100)	1 (33)	0	7 (58)
St. Joseph River at Fort Wayne (STJ-0)	9	0	0	0	0	3	0	0	0	0
Maumee River at Fort Wayne (M-116)	9	0	0	0	0	3	2 (67)	0	0	2 (17)

*PCBs at 5.0 ppm action level
**PCBs at 2.0 ppm action level (August 20, 1984)

landfills near the stream, it is not at all surprising that fish from the Grand Calumet River-Indiana Harbor Canal area contain levels of PCBs above the 2.0 ppm FDA action level, although specific sources have not been identified to date. A fish and sediment survey conducted in the summer of 1985 on the St. Joseph River in the Elkhart, Mishawaka, and South Bend area revealed higher than expected PCB levels in the sediment of several tributaries but none in the main stem. The state is now trying to determine possible past and/or present sources of these PCBs. Several old landfills along the Maumee River near Fort Wayne are being investigated as possible PCB sources.

Chlordane appears to be a widespread fish contaminant problem, especially in streams in the southern two-thirds of the state. However, point sources for chlordane have not been identified even though several of these rivers and streams have been surveyed rather extensively. Sediment surveys done on the West Fork of White River and its tributaries in 1981, the East Fork of White River and its tributaries in 1983, and the middle Wabash River in 1984 showed almost no detectable levels of chlordane ($\geq$0.20 ug/l) in these sediments. No chlordane concentrations above this level were found in the East Fork of White River or the middle Wabash River. Only samples collected at Henderson Ford below Indianapolis and near Washington had values above this detection level in the West Fork of White River. A total of 57 sludge and effluent samples were collected from municipal and industrial discharges to the East Fork of White River, the middle Wabash River, and their tributaries in the 1983 and 1984 surveys. Only 4 sludge samples and no effluent samples had chlordane concentrations above detection levels (50 ug/l and 0.5 ug/l, respectively). Thus, it does not appear that chlordane is entering these rivers and streams from point sources.

One bright spot in the fish contamination picture is the drastic reduction in the number of fish samples exceeding the FDA action level for dieldrin (0.3 mg/kg) in the 1983-84 samples when compared to the prior years (Table 7). Dieldrin contamination in fish was rather widespread in the Wabash River and also found, to a lesser extent, in the White River in the 1979-82 reporting period. In the 1983-84 period, no fish samples were collected from any station which exceeded the FDA action levels for dieldrin. If this trend continues over the next sampling period, it would appear that dieldrin contamination no longer will be a problem in Indiana fish.

In 57 sludge and effluent samples collected in 1983 and 1984 from municipal and industrial dischargers to the East Fork of White River and the middle Wabash River, no dieldrin concentrations above the detection limit (0.05 ug/l) were found in the effluent samples, and only one sludge sample had detectable amounts of dieldrin. Sediments collected in these same rivers showed several samples above the detection limits of 1.0 ug/kg, but only 3 above 10 ug/kg, all in the East Fork of White River or its tributaries. Sediment samples collected in the West Fork of White river and its tributaries in 1981 showed no values above 10 ug/kg. Thus, dieldrin appears not to be entering these streams from point sources and, in fact, is probably no longer being contributed by nonpoint sources in significant amounts.

Both dieldrin and chlordane have been banned from general agricultural use, dieldrin in 1974 and chlordane in 1980. Dieldrin concentrations appear to be dropping in fish flesh, but chlordane values still exceed FDA action levels. As rather extensive sampling does not indicate point sources for these substances nor do high sediment concentrations appear to be present, fish tissue concentrations of these substances may reflect the difference in post-exposure times. It is anticipated that chlordane values in fish flesh will show the same declines in the next few years that are found in dieldrin values now.

In 1984, Union City was completing its sewage treatment plant (STP) expansion under the construction grants program and had requested permission to dispose of the sludge in an anaerobic digester and Imhoff tank by land application. One of the requirements for the land application permit was that the sludge had to be analyzed. As a result of these analyses, high concentrations of PCBs were found in the sludge in these two tanks. These holding tanks were subsequently removed from service and isolated from the rest of the treatment processes occurring at the plant. Consequently, in November 1984, a fish and sediment survey was conducted in the Little Mississinewa and Mississinewa rivers near Union City to determine whether PCBs had been released to the environment.

Analytical results of the fish and sediment samples collected in these streams are shown in Table 8. Sediment samples from the Little Mississinewa River at Westinghouse Road had undetectable PCB concentrations, but a sample taken approximately 1,500 feet downstream in a city park had a PCB concentration of 40 mg/kg, which is among the highest recorded in the state. The city park station is upstream of the Union City STP outfall. Concentrations gradually decreased downstream, and no PCBs were detected in Mississinewa River sediment. Thus, although PCBs were found in the Union City STP sludge and in sediments downstream from the STP discharge, there were obviously other significant sources of PCBs upstream.

Certain metals (chromium, copper, lead, nickel, and zinc) were also present in high concentrations in the city park sample (Table 8). Measured concentrations here were up to 100 times higher than upstream samples. These concentrations also gradually decreased downstream, and metals concentrations in the Mississinewa River sediment approached normal levels.

All of the fish collected in the area violated the FDA action level (2 mg/kg) for PCBs (Table 8). Even fish collected upstream from all known sources were above this level. Migration of fish from contaminated areas downstream could easily account for this finding as the upstream fish sampling location is only about 1500 feet upstream of the location of the heavily contaminated sediments found in the city park. Because this upstream sampling location is only about four miles from the extreme headwaters of the Little Mississinewa River, it is likely that fish in the entire river may be contaminated with PCBs.

Table 8. Fish and sediment collections from Little Mississenewa and Mississenewa rivers near Union City, Randolph County, in November 1984 (Concentrations in mg/kg).

	Sediment							Whole Fish	
Locations	Chromium	Copper	Lead	Nickel	Zinc	PCBs	Chlordane	PCBs	Chlordane
Little Mississinewa River 1.2 miles above STP (Westinghouse Rd.)	10	15	9.2	11	55	< 0.05	< 0.05	11.9*	0.10
Little Mississinewa River 1.0 mile above STP (City Park)	360	1800	160	1100	970	40	< 4	____	____
Little Mississinewa River 1.0 miles below STP (CR 400 N)	540	790	190	350	630	8.4	< 0.84	____	____
Little Mississinewa River 4.0 miles below STP (CR 700 N)	87	120	18	94	110	3.1	< 0.31	11.3*	0.14
Mississinewa River 0.5 miles below confluence with Little Mississinewa R. (CR 700 E)	26	39	8.1	110	58	0.25	< 0.5	5.2*	0.37*

(Arsenic, cadmium, iron, manganese, and mercury were also analyzed, but no elevated concentrations were noted in any sample).

*Exceeds FDA action level

Fish collected from the Mississinewa River one-half mile below the confluence of the Little Mississinewa River also violated the action level for PCBs as well as the action level (0.3 mg/kg) for chlordane (Table 8). Fish samples collected in the Little Mississinewa River did not exceed the chlordane action level, so chlordane contamination does not appear to be extensive in this stream. This is supported by the sediment samples, which showed no positive values for chlordane in any sample. Chlordane violations occur in fish from several streams in Indiana and do not appear to be directly associated with point sources.

At the present time, negotiations are underway between the state, the city, U.S. EPA, and three industries in Union City to determine who will pay the clean up costs for the contaminated sludge in the STP. Since the contaminated units are not currently in use, the immediate threat of further PCB contamination from this source has been eliminated. Studies are continuing to try to determine the sources of the PCB contamination upstream of the STP in the Little Mississinewa River.

In late 1982, at the request of the Indiana State Board of Health (ISBH), the Aluminum Company of America (ALCOA) contracted to have a PCB survey conducted on Elliot Ditch and Wea Creek near Lafayette in Tippecanoe County. Results of this survey indicated that sediments, fish and, to some extent, water samples collected downstream of their discharge in Elliot Ditch and in Wea Creek were contaminated with PCBs. A subsequent ISBH study on fish and sediment in Elliot Ditch and Wea Creek in 1983 substantiated these earlier findings by ALCOA.

Extensive studies by ALCOA indicate that the PCB contamination is not associated with current manufacturing processes and is related to nonpoint sources on their property. The state and ALCOA have worked together to reduce PCB loadings to these streams, and a second study at the same locations on Elliot Ditch and Wea Creek by ALCOA in 1984 indicated that PCB levels in fish and water appear to be decreasing. However, sediment core samples showed levels similar to those found in the 1982 study. ALCOA feels that the older PCB contaminated sediments are being covered by less contaminated sediments. They believe this is slowing the transfer of PCBs from sediments to the fish although the PCBs still show up in sediment core samples. The feasibility and desirability of removing sediments from Elliot Ditch is still under study.

The state and ALCOA signed a consent decree in January 1985 which requires ALCOA to meet NPDES permit limits of 1 ppb PCBs at their discharge point to Elliot Ditch. ALCOA has installed additional treatment facilities and currently can meet the 1 ppb PCB limit except during wet weather events. The consent decree also contains a schedule to bring ALCOA into compliance with the 1 ppb PCB limit at all times by May 1988. ALCOA is required to submit progress reports every three months and to conduct additional studies if necessary.

In a general sediment survey of the West Fork of White River and its tributaries in 1981, high PCB levels were found in Stoney Creek sediments (8.7 mg/kg). This prompted on investigation of potential PCB sources in the Stoney Creek drainage system. In 1983, Firestone Industrial Rubber Company in Noblesville found PCBs in the sediment of Wilson Ditch (a tributary of Stoney Creek into which Firestone discharges) below their discharge. Subsequent sediment sampling by Firestone indicated the highest PCB levels in sediment (2,900 mg/kg as Aroclor 1248) above their permitted outfall to Wilson Ditch but downstream from a roof drain from Plant #1. Firestone subsequently agreed to institute a program of sampling to establish the location of the highest contamination levels, to search for and eliminate the PCB sources, and to address any contamination of Wilson Ditch. The state limited the concentration of PCBs from any source to 1 ppb (based on technology to remove PCBs from a contaminated source) and stipulated that the contaminated sediments in Wilson Ditch would need to be addressed as levels and locations were determined. The state was very concerned about this PCB source as fish from the West Fork of White River at Broad Ripple near Indianapolis showed high PCB levels (above FDA action levels) and no other upstream source was known.

Fish and sediment sampling done by the state in October and December of 1984 revealed high levels of PCBs in the sediment from Wilson Ditch (13.0 mg/kg to 19 mg/kg) and in fish (8.1 mg/kg, 16.8 mg/kg) and sediments (10.0 mg/kg) collected downstream of Wilson Ditch in Stoney Creek (a tributary to the West Fork of White River). Sediment samples collected upstream of Wilson Ditch in Stoney Creek and upstream of Stoney Creek in the West Fork of White River had levels of PCBs below detection levels, and fish samples from these areas had PCB values well below FDA action levels. These results indicated that Wilson Ditch was probably the major source of PCB contamination in this area, and is probably responsible for the fish tissue contamination at Broad Ripple near Indianapolis. A fish consumption advisory has been issued for Wilson Ditch, Stoney Creek downstream from Wilson Ditch, and the West Fork of White River from below Noblesville to Martinsville (60 stream miles) due to high PCB levels in fish.

At a May 1985 meeting with the state, Firestone agreed to initiate a sampling program on the plant #1 roof drain discharge during rainfall events. The maximum PCB concentration in the runoff water was to be limited to 1 ppb prior to dilution in Wilson Ditch. Sampling conducted by Firestone on the roof drain during the last six months of 1985 revealed PCB concentrations as high as 12 ppb during some rainfall events. Thus, further action is needed by the company (and possibly the state) to reduce these levels to the 1 ppb level.

The company has also completed a sediment survey of that portion of Wilson Ditch on their property to determine the locations of PCB contamination. The remedial action necessary to eliminate these sediment "hot spots" has yet to be determined. It is expected that this source of PCB contamination will soon be eliminated.

In the early 1970s, significant PCB contamination was discovered in the sludge and effluent from the Winston-Thomas Sewage Treatment facility in Bloomington. The source of these PCBs was determined to be the Westinghouse Corporation discharge to the sewage treatment facility. Subsequent sampling of several streams in the area revealed high concentrations of PCBs in fish and sediment from these streams mainly due to the discharge from the sewage treatment plant and leaching of PCBs from several landfills where Westinghouse had disposed of old capacitors and other PCB containing wastes. Fish consumption advisories were issued for several streams in the area. In June of 1982, a new wastewater treatment facility was completed south of Bloomington at Dillman Road, and the Winston-Thomas facility was closed. Details of these events were presented in the 1982-83 305(b) report.

On August 22, 1985, after years of negotiating, the U.S. EPA, the State of Indiana, the Monroe County Health Department, the City of Bloomington, and the Westinghouse Corporation signed a consent decree which prescribes clean-up and disposal of waste contaminated areas. Westinghouse will build an incinerator to safely incinerate these PCB containing wastes.

Stream excavation and sediment hydrovacuuming are scheduled to occur between May and September 1986. Those streams involved include the entire length of Conard's branch (a tributary of Richland Creek) and portions of Richland Creek, Stout Creek, Clear Creek, and Salt Creek. Removed sediment will be taken to an interim storage facility until it can be burned at the solid waste incinerator.

Soil, solid waste, and other material will be removed from five landfills--Neal's Landfill, Neal's Dump, Lemon Lane Landfill, Bennett's Dump, and the Anderson Road Landfill--and the interim storage facility (formerly the Winston-Thomas STP) and incinerated. Stream sediment will be monitored both before and after closure of these landfills to locate any contaminated sediments which may be released from the landfill during soil removal. Further sediment hydrovacuuming would be required if significant amounts of contaminated soil have eroded into the streams.

Ash from the incinerator will be landfilled in accordance with the requirements of the law. An estimated 650,000 cubic yards of material will be incinerated within (a maximum of) 15 years from the date on which Westinghouse receives all required permits to begin incineration.

Additionally, General Motors Central Foundry near Bedford was found to have high PCB levels in its discharge to Pleasant Run, a tributary of Salt Creek. These PCBs had accumulated in fish tissue to the extent that fish consumption advisories were issued for Pleasant Run, Salt Creek and portions of the East Fork of White River (see 1982-83 305(b) report). Central Foundry has added additional treatment consisting of carbon filtration and now regularly meets their NPDES limit of 0.001 mg/l PCBs. Hopefully, the elimination of the Bloomington PCB discharge, the clean up of the landfills and stream sediment, and the control of the General Motors PCB discharge will correct the PCB problem in this area. However, additional problems with high phenol and BOD concentrations in the discharge from the General Motors Central Foundry facility have been found, and the state is currently involved in enforcement proceedings involving these parameters.

In 1983-84, extensive surveys for priority pollutants were conducted in the East Fork of the White River and Wabash River basins. The screening in these two basins was designed to identify the occurrence and concentrations of the priority pollutants and to help identify their sources. Samples of wastewater treatment plant effluents, sludges, and stream sediments were collected and analyzed for 136 priority pollutants (Table 9). The priority pollutants list consists of 13 metals, cyanide, aroclors of polychlorinated biphenyls (PCBs), and 115 organic compounds (halogenated volatile organics, nonhalogenated volatile organics, base/neutral fractions, phenols, organochlorine pesticides, and aromatic volatile organics).

Samples of sediment were collected from a total of 36 stream stations in the East Fork of the White River basin (Figure 10), and from 25 stream stations in the Wabash River basin (Figure 11). These stream stations were located to bracket the significant dischargers. Thirty-nine effluents (two dischargers had two outfalls) and 22 sludge samples were collected from dischargers in the same areas in 1984-85. Effluent samples consisted of 24 hour composites while sludge samples were single grabs. Fish were also collected at the sediment sampling stations for fish flesh contaminant studies. However, laboratory analyses are not yet completed on the fish samples.

Table 10 indicates those organic priority pollutants detected in 10% or more of the samples. Of these, only chloroform, bis(2-ethylhexyl)phthalate, lindane, total PCBs, and 1,1,1-trichloroethane were detected in each sample type (effluents, sludges, and sediments). However, with the exception of PCBs at certain sites, very little correlation was found between the occurrence of the organic pollutants in stream sediments and their occurrence in effluents and sludges. Therefore, the source of organic pollutants in the sediment could not usually be traced to particular wastewater discharges. One reason for this may have been that some of the effluents and sludges were sampled up to two years after the sediment samples were collected.

Dieldrin did not appear to be elevated in samples of sediment from either basin. Highest concentrations observed were in the Greensburg area (21-31 ug/kg at Stations 22, 24, and 25) and further investigation may be necessary here. Dieldrin was detected in lower concentrations in most of the other sediment samples collected from both basins (Tables 11 and 12 and Figures 12 and 13).

DDT and DDT metabolites (DDD and DDE) were detected in samples of sediment from several stations the East Fork of the White River Basin (Table 11). The highest levels were from sediment samples upstream of Columbus in the Flatrock River, downstream of Medora in the East Fork of the White River, and upstream of the Bloomington South STP in Clear Creek. Only one station on the Wabash River had detectable concentrations of DDT metabolites in the sediment (Table 12).

Table 9. List of priority pollutants.

METALS

Antimony
Arsenic
Beryllium
Cadmium
Chromium
Copper
Cyanide
Lead
Mercury
Nickel
Selenium
Silver
Thallium
Zinc

HALOGENATED VOL. ORGANICS

Methylene Chloride
1,1-Dichloroethylene
1,1-Dichloroethane
Chloroform
Carbon Tetrachloride
1,2-Dichloropropane
Trichloroethylene
1,1,2-Trichloroethane
Dibromochloromethane
Tetachloroethylene
Chlorobenzene
Trichlorofluoromethane
Trans-1,2-Dichloroethylene
1,2-Dichloroethane
1,1,1-Trichloroethene
Bromodichloromethane
Trans-1,3-Dichloropropane
CIS-1,3-Dichloropropene
Bromoform
1,1,2,2-Tetrachloroethane
2-Chloro-Ethylvinylether

NONHALOGENATED VOL. ORGANICS

Methyl Ethyl Ketone (MEK)
Methyl Isobutyl Ketone (MIBK)

AROMATIC VOL. ORGANICS

Benzene
Toluene
Ethyl Benzene
Xylenes

BASE/NEUTRAL FRACTION

Bis(2-Chloroethyl)Ether
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
n-Nitroso-n-Dipropylamine
Nitrobenzene
Hexachloroethane
Isophorone
Bis(2-Chloroethoxy)Methane
1,2,4-Trichlorobenzene
Naphthalene
Hexachlorobutadiene
Hexachlorocyclopentadiene
2-Chloronaphthalene
2,6-Dinitrotoluene
Dimethylphthalate
Acenaphthalene
Acenaphthene
2,4-Dinitrotoluene
Diethylphthlate
Fluorene
N-Nitrosodiphenylamine
4-Bromophenylphenylether
Hexachlorobenzene
Phenanthrence
Anthracene
Di-N-Butylphthlate
Fluoranthene
Pyrene
Butylbenzylphthalate
Benzo(A)anthracene
Chrysene
Bis(2-ethlylhexyl)Phthalate
Di-N-Octylphthalate
Benzo(A)Pyrene
Benzidine
3,3-Dichlorobenzidine
4-Chlorophenylphenylether
Bis(2-Chloroisopropyl)Ether
N-Nitrosodimethylamine
Pentachloroanisole
Benzo(b)Fluoranthene
Benzo(k)Fluoranthene
Benzo(gni)Perylene
Dibenzo (a,h)Anthracene
Indeno(1,2,3-cd)Pyrene
Aniline
Benzyl Alcohol
4-Chloroaniline
2-Methylnaphthalene
3-Nitroaniline
Dibenzofuran
4-Nitroaniline
2-Nitroaniline

PHENOLS

Phenol
2-Chlorophenol
2-Nitrophenol
2,4-Dimethylphenol
2,4-Dichlorophenol
p-Chloro-m-Cresol
2,4,6-Trichlorophenol
4-Nitrophenol
4,6-Dinitro-O-Cresol
Pentachlorophenol
2,4-Dinitrophenol
Benzoic Acid
o-Cresol
p-Cresol
2,4,5-Trichlorphenol

ORGANOCHLORINE PESTICIDES

Alpha-BHC
Beta-BHC
Gamma-BHC (Lindane)
Delta-BHC
Heptachlor
Heptachlor Epoxide
Aldrin
Endosulfan I
p,p'(4,4') DDE
p,p'(4,4')DDD
p,p'(4,4') DDT
Dieldrin
Endrin
Endosulfan II
Endosulfan Sulfate
Methoxychlor
Chlordane
Toxaphene
Endrin Aldehyde

PCBs

PCB-1221
PCB-1232
PCB-1016
PCB-1242
PCB-1248
PCB-1254
PCB-1260

Figure 10. Sediment and fish collection sites in the East Fork of the White River Basin, 1983-84.

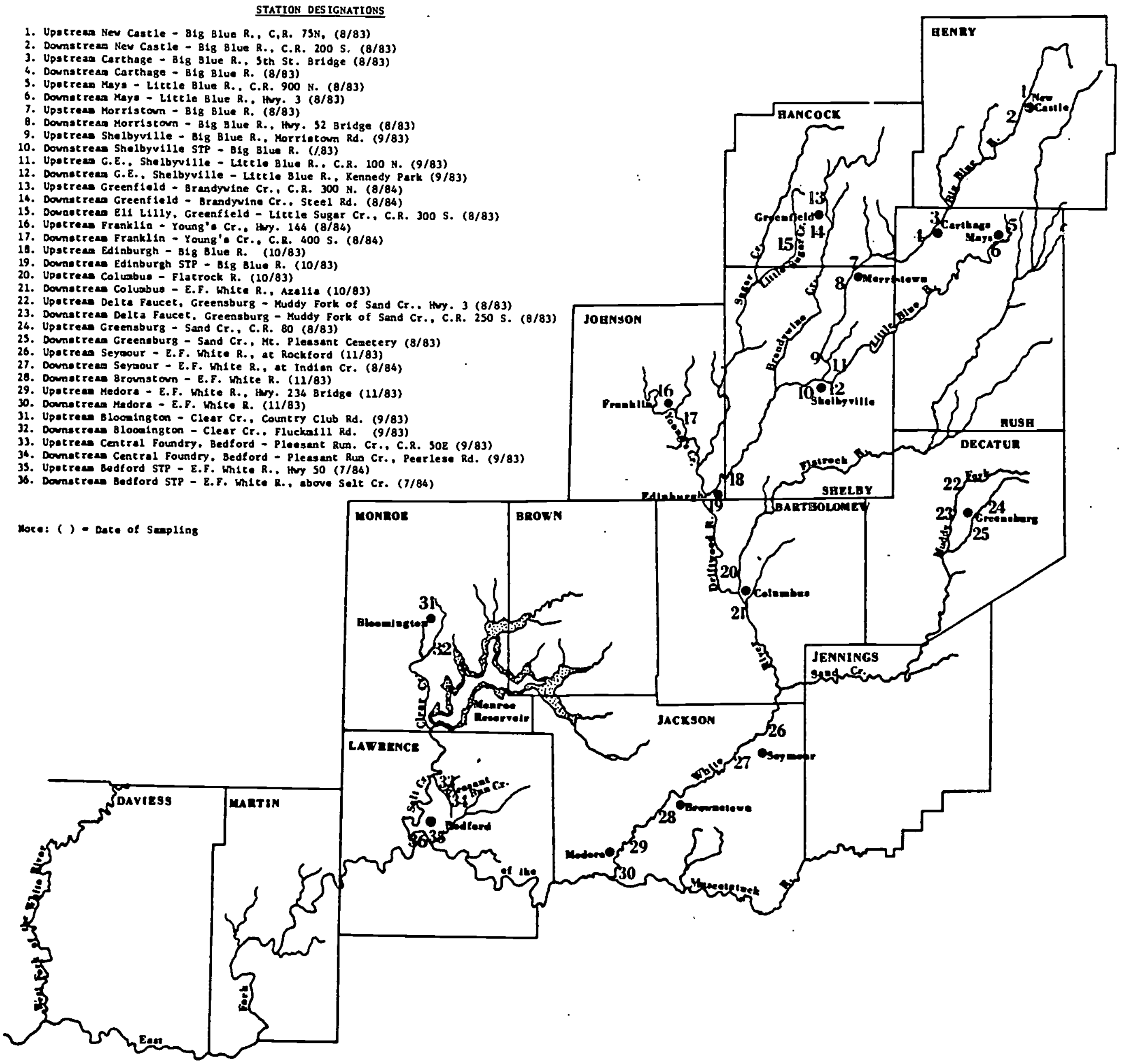


Figure 11. Sediment and fish collection sites in the Wabash River Basin, 1983-84.

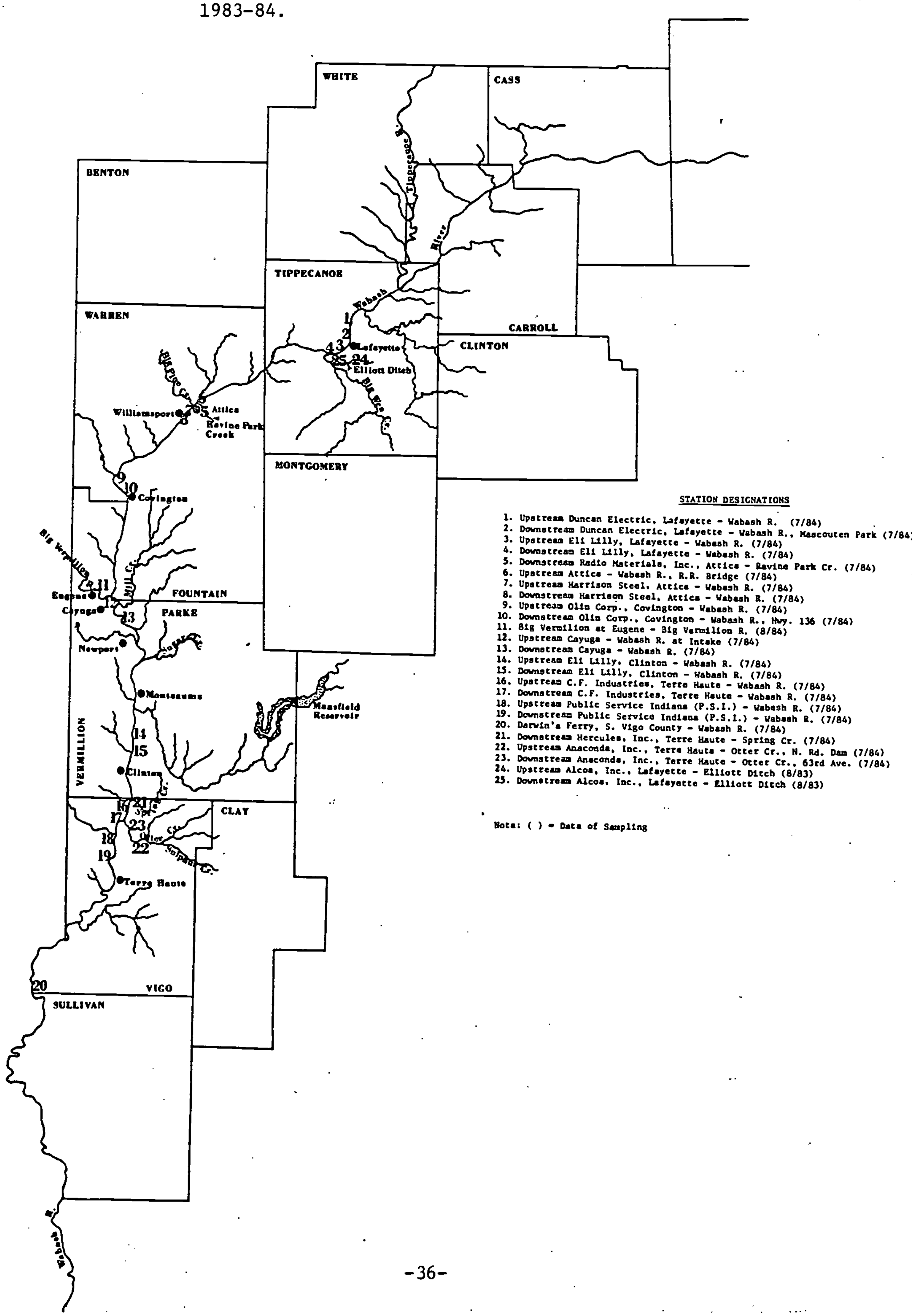


Table 10. Organic priority pollutants occurring in ten percent or more of the samples of either effluent, sludge, or sediment from the East Fork of the White River and Wabash River basins.

	Effluent		Sludge		Sediment	
Compound	Percent Occurrence*	Conc. Range ug/l	Percent Occurrence*	Conc. Range (ug/kg)	Percent Occurrence*	Conc. Range (ug/kg)
Chloroform	38 (39)	1.3 - 38.0	5 (19)	1.0 - 2.4	8 (61)	1,300 - 2,700
Trichloroethylene	18 (39)	1.0 - 36.0	5 (19)	0.01 - 1.10	0 (61)	N.D.+
1,1,1-Trichloro-ethane	10 (39)	2.3 - 6.5	5 (19)	0.1 - 6.6	16 (61)	1,300 - 11,000
Bis(2-ethylhexyl) phthalate	15 (39)	360.0 - 2,600	29 (21)	8.0 - 64.0	2 (61)	3.5 - 17,000.0
Phenol	3 (39)	10.0 - 14.0	14 (21)	3.7 - 6,200.0	0 (61)	N.D.
Gamma-BHC (lindane)	13 (39)	0.03 - 0.16	5 (22)	1.0 - 11.0	13 (61)	0.3 - 3.7
Total PCB	3 (39)	0.1 - 2.0	14 (22)	240.0 - 750,000	44 (61)	15.0 - 2900.0
Dibromochloromethane	13 (39)	1.5 - 7.4	0 (19)	N.D.	0 (61)	N.D.
Bromodichloromethane	15 (39)	1.3 - 8.4	0 (19)	N.D.	0 (61)	N.D.
Acetone	23 (13)	52.0 - 180.0	0 (4)	N.D.	0 (61)	N.D.
Methylene Chloride	13 (39)	7.0 - 63.0	0 (19)	N.D.	3 (61)	12,000 - 58,000
p,p' - DDE	0 (39)	N.D.	10 (22)	6.2 - 30.0	10 (61)	2.3 - 35.0
Dieldrin	0 (39)	N.D.	5 (22)	5.0 - 11.1	49 (61)	1.4 - 31.0
Heptachlor epoxide	0 (39)	N.D.	10 (22)	2.0 - 14.0	2 (61)	2.0 - 12.0
Chlordane	0 (30)	N.D.	18 (22)	110.0 - 550.0	0 (61)	N.D.
Di-N-Butylphthalate	0 (39)	N.D.	10 (21)	3.6 - 63.0	2 (61)	8.0 - 26,000
Phenanthrene	0 (39)	N.D.	10 (21)	2.0 - 7.0	0 (61)	N.D.

*Number in parentheses indicates the number of samples analyzed.
+N.D. - No Detection

Table 11. Detectable concentrations of organic priority pollutants in sediment from the East Fork of the White River Basin

East Fork of the White River

Station #	Station	Toxic Parameter	Concentration (ppb) (ug/kg)
1	Big Blue River, Upstream New Castle	N.D.+	
2	Big Blue River, Downstream New Castle	Dieldrin	8.9
		PCB-1260	49.0
3	Big Blue River, Upstream Carthage	Dieldrin	2.0
4	Big Blue River, Downstream Carthage	Heptachlor	5.7
		Heptachlor Epoxide	12.0
		pp' (4,4') DDE	9.2
		pp' (4,4') DDD	3.0
		pp' (4,4') DDT	5.0
		Dieldrin	3.0
5	Little Blue River, Upstream Mays	N.D.	
6	Little Blue River, Downstream Mays	N.D.	
7	Big Blue River, Upstream Morristown	Gamma-BHC (Lindane)	0.5
8	Big Blue River, Downstream Morristown	N.D.	
9	Big Blue River, Upstream Shelbyville	N.D.	
10	Big Blue River, Downstream Shelbyville	N.D.	
11	Little Blue River, Upstream G.E.-Shelbyville*	Dieldrin	4.4
12	Little Blue River, Downstream G.E.-Shelbyville	N.D.	
13	Brandywine Creek, Upstream Greenfield	N.D.	
14	Brandywine Creek, Downstream Greenfield	Cyanide	11,000.0
15	Little Sugar Creek, Downstream Eli Lilly, Greenfield	N.D.	
16	Young's Creek, Upstream Franklin	Cyanide	23,500.0
17	Young's Creek, Downstream Franklin	N.D.	
18	Big Blue River, Upstream Edinburgh	PCB-1260	24.0
		PCB-1242	35.0
		Dieldrin	1.4
		Gamma BHC (Lindane)	0.3
19	Big Blue River, Downstream Edinburgh	PCB-1260	38.0
		PCB-1242	29.0
20	Flatrock River, Upstream Columbus	Chloroform	2,700.0
		1,1,1-Trichloroethane	11,000.0
		p,p' (4,4') DDE	13.0
		p,p' (4,4') DDD	51.0
		p,p' (4,4') DDT	29.0
		Dieldrin	8.0
21	E.F.W.R., Downstream Columbus	Chloroform	2,000.0
		1,1,1-Trichloroethane	8,600.0
		Dieldrin	5.0
22	Muddy Fork of Sand Cr., Upstream Delta Faucet Co.	Dieldrin	26.0
		Gamma BHC (Lindane)	3.0
		1,1,1-Trichloroethane	2,400.0
23	Muddy Fork of Sand Cr., Downstream Delta Faucet Co.	Dieldrin	9.4
		Aldrin	7.8
		Gamma-BHC (Lindane)	0.4

Table 11. Continued

Station #	Station	Toxic Parameter	Concentration (ppb) (ug/kg)
24	Sand Creek, Upstream Greensburg	Dieldrin	21.0
		p,p' (4,4') DDE	2.3
		Gamma-BHC (Lindane)	3.7
		1,1,1-Trichloroethane	2,400.0
25	Sand Creek, Downstream Greensburg	Dieldrin	31.0
		Gamma-BHC (Lindane)	0.5
		Di-N-Butylphthalate	26,000.0
		1,1,1-Trichloroethane	1,300.0
26	E.F.W.R., Upstream Seymour	1,1,1-Trichloroethane	1,800.0
		Dieldrin	8.7
27	E.F.W.R., Downstream Seymour	N.D.	
28	E.F.W.R., Downstream Brownstown	Dieldrin	4.2
29	E.F.W.R., Upstream Medora	Chloroform	1,300.0
		1,1,1-Trichloroethane	3,700.0
		Dieldrin	4.7
30	E.F.W.R., Downstream Medora	Chloroform	1,500.0
		1,1,1-Trichloroethane	6,400.0
		p,p' (4,4') DDE	35.0
		Dieldrin	4.4
31	Clear Creek, Upstream Bloomington STP	PCB-1242	1,000.0
		p,p'(4,4') DDD	28.0
		p,p(4,4') DDE	9.3
		Dieldrin	5.5
		Gamma-BHC (Lindane)	0.3
		1,1,1-Trichloroethane	1,900.0
32	Clear Creek, Downstream Bloomington South STP	PCB-1242	440.0
		p,p'(4,4') DDD	2.9
		p,p'(4,4') DDE	4.9
33	Pleasant Run Creek, Upstream G.M. Central Foundry Bedford	N.D.	
34	Pleasant Run Creek, Downstream Central Foundry, Bedford	PCB-1242	1,900.0
35	E.F.W.R., Upstream Bedford	Delta-BHC	37.0
36	E.F.W.R., Downstream Bedford	N.D.	

+N.D. = No detection of Organic Priority Pollutants.
*G.E. is now AnaMag/Wellman Thermal.

Table 12. Detectable concentrations of organic priority pollutants in sediment from the Wabash River Basin

Station #	Station	Toxic Parameter	Concentration (ppb) (ug/kg)
Wabash River Basin			
1	Wabash River, Upstream Duncan Electric*	Dieldrin	1.7
2	Wabash River, Downstream Duncan Electric	Dieldrin	2.4
		PCB-1254	45.0
3	Wabash River, Upstream Eli Lilly, Lafayette	bis(2-Ethylhexyl) Phthalate	17,000.0
		Dieldrin	1.2
4	Wabash River, Downstream Eli Lilly, Lafayette	Gamma-BHC (Lindane)	0.9
		Dieldrin	2.9
		PCB-1254	23.0
5	Ravine Park Cr., Downstream Radio Materials, Attica	Dieldrin	4.4
		PCB-1254	310.0
6	Wabash River, Upstream Attica	Dieldrin	3.6
		PCB-1254	67.0
7	Wabash River, Upstream Harrison Steel, Attica	Dieldrin	1.7
		PCB-1254	30.0
8	Wabash River, Downstream Harrison Steel, Attica	Methylene Chloride	12,000.0
		1,1,1-Trichloroethane	1,200.0
		PCB-1254	42.0
9	Wabash River, Upstream Olin Corp., Covington	Dieldrin	1.7
		PCB-1254	16.0
10	Wabash River, Downstream Olin Corp., Covington	pp'(4,4') DDD	5.7
		PCB-1254	240.0
11	Big Vermilion River, Eugene	N.D.+	
12	Wabash River, Upstream Cayuga	Dieldrin	1.7
		PCB-1254	21.0
13	Wabash River, Downstream Cayuga	PCB-1254	28.0
14	Wabash River, Upstream Eli Lilly, Clinton	Dieldrin	1.4
		PCB-1254	18.0
15	Wabash River, Downstream Eli Lilly, Clinton	Dieldrin	1.4
		PCB-1254	15.0
16	Wabash River, Upstream C.F. Industries, Terre Haute	Dieldrin	1.7
		PCB-1254	24.0

Table 12. Continued

Station #	Station	Toxic Parameter	Concentration (ppb) (ug/kg)
17	Wabash River, Downstream C.F. Industries, T.H.	N.D.	
18	Wabash River, Upstream PSI (Wabash)	Dieldrin	3.6
		PCB-1254	26.0
19	Wabash River, Downstream PSI (Wabash)	PCB-1254	30.0
20	Wabash River, Darwin's Ferry, S. Vigo County	PCB-1254	50.0
21	Spring Creek, Downstream Hercules, Terre Haute	Methylene Chloride	58,000.0
		Chloroform	1,700.0
		PCB-1254	33.0
22	Otter Creek, Upstream Anaconda, Inc., Terre Haute	1,2-Dichloroethane	1,500.0
		PCB-1254	18.0
23	Otter Creek, Downstream Anaconda, Inc., Terre Haute	PCB-1254	45.0
24	Elliott Ditch, Upstream Alcoa, Lafayette	Trichlorofluoromethane	3,000.0
		Trans-1,2-Dichloroethylene	1,100.0
		Dieldrin	3.9
		PCB-1254	22.0
25	Elliott Ditch, Downstream Alcoa, Lafayette	PCB-1242	2900.0

+N.D. = No Detection of Organic Priority Pollutants.
*Duncan Electric Company is now Landis Gyr, Inc.

Figure 12. Dieldrin and total PCB concentrations in sediments from the Big Blue River and East Fork of White River from New Castle to just below the Bedford STP.

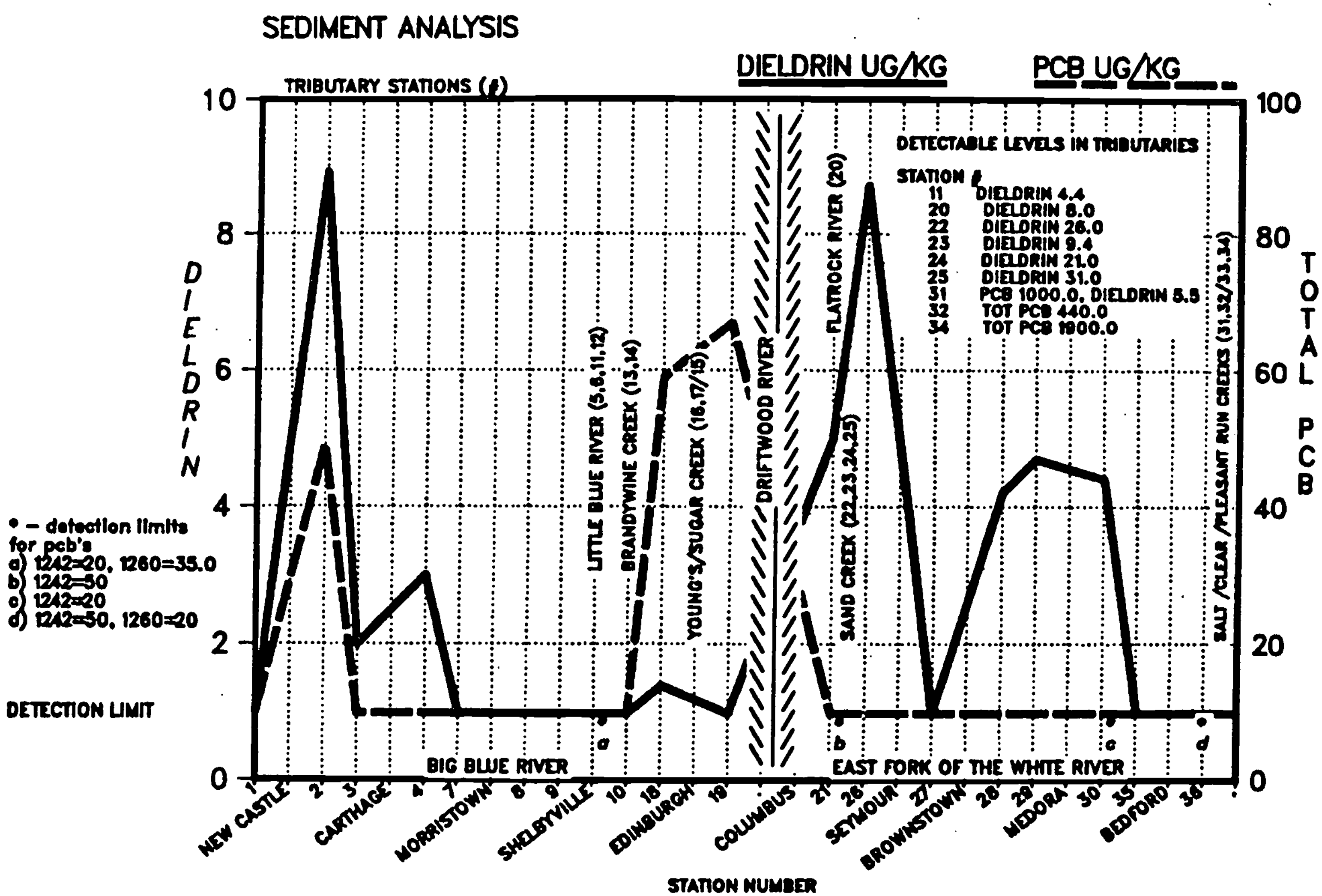
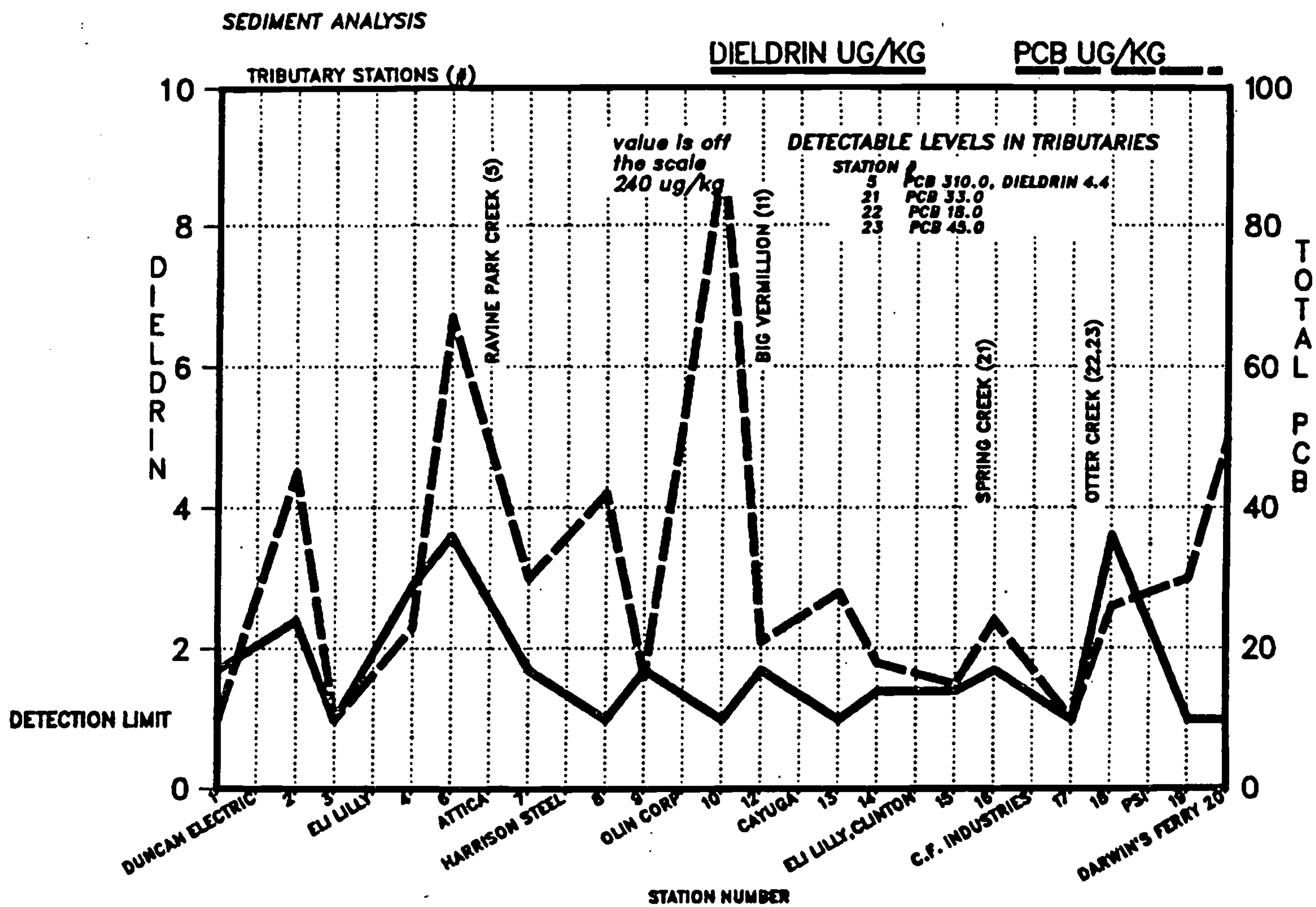


Figure 13. Dieldrin and total PCB concentrations in sediments from the mainstem of the Wabash River from Lafayette to 25 miles south of Terre Haute.



Levels of dieldrin, DDT, and DDT metabolites were not found in any effluent samples. Therefore, their presence in samples of stream sediment can best be explained as the result of their extensive use on agricultural crops in the past. Both dieldrin and DDT have been banned from agricultural use in the United States, but these pesticides are quite persistent and may remain in the environment for a long time. Another potential source would be leaching from landfills.

Chlordane was not detected in any effluent or sediment samples from either the East Fork of the White River Basin or the Wabash River Basin (sediment detection limit 10 ug/kg). It was detected in three sludge samples from sewage treatment facilities in concentrations ranging from 110-550 ug/kg. It is probable that if the chlordane detection level would have been lower for sediment samples, it would have been detected in some places. Chlordane has been detected as a fish contaminant exceeding FDA action levels in several areas of the state. Although widely used in the past, chlordane was banned from use in 1980 except for subterranean termite control. It is believed that the present problem with fish tissue contamination is largely related to past agricultural usage.

The results of the analyses of sediment samples collected from the East Fork of the White River Basin for total PCBs are shown in Figure 12. For the most part PCB levels were below the minimum detection limits in Big Blue River and East Fork of the White River mainstem sediment samples. The highest concentrations observed were downstream of New Castle and upstream and downstream of Edinburgh in the Big Blue River, although none was detected in either the effluent or sludge of wastewater treatment plants in these areas. The significance of these values may become more apparent when the fish tissue analyses for PCBs has been completed.

Samples of sediment from tributaries to the East Fork of the White River where PCBs were at elevated levels included Pleasant Run Creek (Station 34) in Lawrence County and Clear Creek (stations 31 and 32) in Monroe County (Table 11). The elevated PCB levels in Clear Creek originated from the old Bloomington sewer system, which received wastewater from Westinghouse Corporation. The elevated PCB levels in Pleasant Run Creek sediment have been linked to higher than acceptable levels of PCBs in the effluent from General Motors Central Foundry near Bedford. This source is now being controlled with carbon filtration. Additional actions taken to correct these problems are discussed elsewhere in this report. PCB concentrations exceeding FDA action levels have been found in fish tissue samples, collected in other studies, from Clear Creek, Salt Creek, and the East Fork of the White River from Salt Creek to Williams Dam.

PCB concentrations in samples of sediment from the Wabash River (Figure 13) were above minimum detection levels at all sampling stations on the Wabash River except for those located upstream of Landis and Gyr (Duncan Electric) in Lafayette (Station 1), upstream of Eli Lilly in Lafayette (Station 3), and downstream of CF Industries north of Terre Haute (Station 17). PCB concentrations in Wabash River sediment ranged from 15.0 ug/kg to 240 ug/kg. The 240 ug/kg level was found in

Wabash River sediment below Olin Corporation (Station 10), a plastics manufacturer near Covington. Olin Corporation has contracted a consultant to set up a sampling program to determine if the PCBs originated at their facility. A fish consumption advisory is in effect for the mainstem of the Wabash River from Lafayette to Darwin's Ferry in southern Vigo County (Station 20) because of elevated PCB and chlordane levels in fish tissue.

A fish consumption advisory has also been issued for Elliott Ditch and Wea Creek, a tributary of the Wabash River below Lafayette in Tippecanoe County. Samples of sediment taken from Elliott Ditch (a tributary to Wea Creek) downstream of the ALCOA Company plant (Station 25) in 1983 contained highly elevated levels of PCBs (Table 12). Analysis of sludge and effluent from Alcoa disclosed PCB levels at 25,000 ug/kg in the sludge, but PCBs were not detected in the effluent during this survey. The state and ALCOA have entered into a consent decree which will virtually eliminate this PCB source by May 1988.

A PCB concentration of 310 ug/kg was found in samples of sediment from Ravine Park Creek, in Attica, which is a tributary of the Wabash River. The samples were collected downstream of Radio Materials, Inc. (Station 5), a manufacturer of ceramic capacitors which discharges to a county ditch that flows into the Ravine Park Creek. Radio Materials, Inc., has used PCB related materials (PBBs or polybrominated biphenyls) in their manufacturing, but the discharge is non-contact cooling water. No PCBs were detected in the Company's effluent, but sludge samples were not collected. Further investigations need to be conducted at this site.

Detectable concentrations of PCB have also been found in samples of sediment from stations in Otter Creek (Stations 22 and 23) upstream and downstream of Anaconda, Inc., (an aluminum sheeting producer), and in Spring Creek (Station 21) (Table 12) downstream of Hercules, Inc. (a manufacturer of polypropylene plastic film and containers). However, no PCBs were detected in either industry's effluent or sludge samples.

Several other organic priority pollutants were detected in samples of sediment (Tables 11 and 12), but, as of this writing, there are few criteria by which to interpret the significance of these levels. The U.S. EPA is currently working to establish sediment criteria or guidelines for many of these substances.

Detectable concentrations of the organic priority pollutants in effluent samples were compared to U.S. EPA water quality criteria for human health and/or for aquatic life (Table 13). Of those organic priority pollutants which have these criteria, only 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, endosulfan, tetrachloroethylene, 1,2-dichloroethane, gamma-BHC (lindane), and diethylphthalate were found in any effluent at concentrations which exceeded either the human health criteria and/or the aquatic life criteria values. Most concentrations for these pollutants were considered low (approaching minimum detection limits) and were only

Table 13. Dischargers which had detectable concentrations of organic priority pollutants in their effluent greater than the human health and/or aquatic life water quality criteria (U.S. EPA).

Priority Pollutant	Discharger	Effluent Conc. (ug/l)	Human Health Criteria (ug/l)	Chronic Toxicity Criteria (ug/l)
1,1,2-Trichlorethane	Lafayette STP	12.0	0.6 [1]	9400
1,1,2,2-Tetrachlorethane	Lafayette STP	5.5	0.17 [1]	2400
Endosulfan	Lafayette STP	0.11	74.0 [2]	0.056
Endosulfan	Greenfield STP	0.1	74.0 [2]	0.056
Gamma-BHC (Lindane)	Greenfield	0.1	0.0092 [1]	0.08
Gamma-BHC (Lindane)	Endinburgh STP	0.1	0.0092 [1]	0.08
Gamma-BHC (Lindane)	Greensburg STP	0.11	0.0092 [1]	0.08
Tetrachloroethylene	Bedford STP	3.3	0.80 [1]	840
Tetrachloroethylene	Eli Lilly, Lafayette	2.4	0.80 [1]	840
1,2-Dichloroethane	Eli Lilly, Lafayette	4.1	0.94 [1]	20,000
Diethylphthalate	Anaconda, Inc., Terre Haute	630.0	350,000 [2]	3.0

(1) Human Health Criteria based on the ingestion of contaminated water and contaminated organisms resulting in the incremental increase in cancer risk estimated at 10^{-6}.

(2) Protection of Human Health from the toxic properties of the priority pollutant through water and contaminated aquatic organisms.

slightly above criteria values (which apply to lakes and streams, not effluents). In most cases, once the effluent has mixed with the receiving stream, the pollutant concentration will be substantially lower than the criteria limits and probably not detectable. These effluent concentrations, therefore, would not appear to pose any water quality problems.

Metals, and even some organic compounds, are present in varying amounts in all sediments. As with the organic priority pollutants, no metals standards or criteria have been developed for stream sediment to which the concentrations found in this study can be compared. Table 14 lists metal concentrations from sediment sampling stations thought to show substantially increased values downstream compared to upstream (4-5 times) or to be unusually high when compared to other values in the respective basins.

An evaluation of these concentrations indicate that there was a substantial (5-15 times) increase in metals levels in samples of sediment from the Big Blue River downstream of New Castle (Table 14). Downstream values for chromium, copper, lead, nickel and zinc appeared much higher than values found at most other stations in the East Fork of the White River Basin.

Table 14. Concentrations of metals and cyanide in sediment from upstream-downstream sampling stations where there is a substantial difference (4-5x increase) or an elevated concentration exists.

	Element	Upstream Concentration (ug/kg)	Downstream Concentration (ug/kg)
New Castle, Big Blue R.	T. Chromium	13,000	190,000
	Copper	10,000	54,000
	Lead	9,600	79,000
	Nickel	8,000	94,000
	Zinc	40,000	210,000
Mays, Little Blue R.	Lead	5,400	25,000
	Nickel	6,600	80,000
	Selenium	210	850
	Zinc	25,000	110,000
Greenfield, Brandywine Cr.	Cyanide	N.D.*	11,000
	Zinc	72,000	380,000
Franklin, Young's Cr.	Cyanide	23,500	N.D.
Greensburg, Sand Cr.	Nickel	4,000	26,000
	Zinc	18,000	130,000
Bloomington South STP, Clear Creek	Lead	220,000	46,000

*Not Detectable

There are two steel industries in New Castle (Allegheny Ludlum Steel and Ingersoll Steel) that are possible contributors of potentially toxic metals to the Big Blue River. Effluent samples from both industries showed high nickel concentrations (Table 15). Ingersoll Steel (now named Avesta, Inc.) has had many NPDES permit violations for metals in the last few years. Allegheny Ludlum has also had repeated NPDES permit violations for metals including hexavalent and total chromium and nickel. Recent bioassays on the Allegheny effluent showed high toxicity to Daphnia magna, probably due to high levels of these metals. Stream studies have revealed a lower macroinvertebrate community diversity downstream of the Allegheny Ludlum Steel Company outfalls than upstream. During fish collections in 1983, an unusually low number of species were observed, and there was a lower catch rate than would be expected for the quality of habitat present downstream of New Castle. The state is working with these companies to resolve these problems.

Other locations in the East Fork of the White River basin in which there were substantial increases (4-5 times) in metals concentrations in downstream sediment samples compared to upstream locations include the Little Blue River at Mays, Brandywine Creek at

Table 15. Potentially toxic effluent concentrations (ug/l) of metals and cyanide.

Discharger	Chromium	Copper	Nickel	Zinc	Cyanide
Allegheny Ludlum Steel, New Castle	--	--	1200	--	--
Ingersoll Steel New Castle	--	--	7600*	--	--
American Heat Treat, Mays	--	97	960*	--	--
DHW Products, Morristown	1200*	1100*	990*	--	--
Greenfield STP	--	--	--	950	--
Delta Faucet, Greensburg	--	--	--	--	600*
ITT, Medora	3600*	120	760*	--	--
Inland Container, Newport	--	--	--	--	160

* = Violation of NPDES discharge limits

Greenfield, and Sand Creek at Greensburg (Table 14). At each of these locations, there was an upstream discharger with effluent concentrations in violation of their NPDES discharge limits or at potentially toxic levels (Table 15). In addition, the Greensburg STP receives wastewaters high in metals, and frequent bypassing causes these untreated wastes to be discharged directly to Sand Creek.

Two locations showed elevated levels of pollutants at the "upstream" sampling sites (Table 14). Sediment concentrations of cyanide were much higher in Young's Creek upstream of Franklin than at the downstream site. At present, the source(s) of this cyanide is unknown, and further investigation may be needed here. At Bloomington, lead levels at the upstream site (220,000 ug/kg) may have been elevated above downstream areas by a CSO outfall near the upstream sampling location.

In the Wabash River Basin metals in the sediment appeared to be rather consistent between all sampling stations with no values significantly elevated from the others. Further evaluation will be made when U.S. EPA criteria and guidelines are established for the evaluation of sediment samples.

In the summer and fall of 1984, fish flesh samples were collected at eight sites in Indiana in conjunction with the National

Table 16. Results of dioxin (TCDD) monitoring of fish flesh at eight Tier 7 sites in Indiana in 1984.

Location	Species	Type of Sample	Percent Fat	TCDD (parts per trillion)
Grand Calumet River (East Branch)	carp	whole fish	10	8.0
Mississinewa River at Matthews	smallmouth bass	whole fish	1.4	2.0
	smallmouth bass	fillet	0.0	ND*
	carp	whole fish	4.4	1.0
	carp	whole fish	0.0	ND
Wabash River at Black Rock	carp	whole fish	8.9	1.4
	carp	fillet	0.0	ND
Wabash River at Darwin	carp	whole fish	--	ND
Wabash River at New Harmony	carp	whole fish	10.0	2
	carp	fillet	0.0	ND
	white crappie	whole fish	0.0	ND
White River at Petersburg	carp	whole fish	0.0	ND
Ohio River at Uniontown	carp	whole fish	6.0	3.4
Ohio River at Westport, KY	carp	whole fish	8.2	5.2
	sauger	whole fish	2.5	2.1

*ND = not detected.

Dioxin Study conducted by U.S. EPA. All fish flesh collection sites in Indiana were considered Tier 7 sites, where contamination is unlikely. Sample locations, species collected, and 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin or TCDD) concentrations are shown in Table 16. Whole fish samples were analyzed first, and, if detectable amounts of TCDD were found, fillet samples were analyzed if available. These results represent analyses completed as of December 13, 1985.

Although small amounts of TCDD were found in some whole fish samples collected, these values were well below the U.S. FDA guidelines of 25 and 50 parts per trillion (ppt). Fillet samples analyzed from these locations contained no detectable amounts of TCDD.

The Indiana Department of Natural Resources requested TCDD analysis of some fish tissue from the South Bend and Bristol areas of the St. Joseph River in Indiana. This was in response to a report that fish collected farther downstream in the St. Joseph River in Michigan did contain significant amounts of TCDD. Fish samples collected from the St. Joseph River in 1982 by ISBH personnel were analyzed for TCDD under contract with Wright State University. Species analyzed included smallmouth bass, rock bass, and several redhorse sucker species. No detectable levels of TCDD were found in these samples. From these results and the results of the National Dioxin Study, it would appear that TCDD contamination is not a problem in Indiana waters or fish.

Lake Studies

Numerous limnological surveys have been done on Indiana lakes by this agency in the past. In 1985, staff again collected limnological data from several lakes and, simultaneously, sampled fish and sediment for toxic substances. Lakes were selected to be sampled for a variety of reasons: proximity to a landfill, potential contamination from agricultural or forest land or known pollution sources in the watershed, or a high degree of recreational use. Since many of these reservoirs are used extensively for fishing, it is also important to monitor fish tissue contamination. The selected lakes are listed in Table 17 and their locations are shown in Figure 14.

In 1985, six lakes and eight reservoirs (Table 17) were sampled for toxic substances in fish flesh and sediments, and for nutrients and phytoplankton. Limnological data collected included depth profiles of pH, dissolved oxygen, temperature, conductivity, Secchi disc readings, and light transmission.

Although no criteria are presently established for sediments, for comparative purposes staff have calculated a mean and maximum for "background" sites (those with no known point sources of pollution) for the most common parameters (metals, PCBs, and some pesticides). Generally, the maximum background concentration is about an order of magnitude greater than the mean background concentration. Therefore, for purposes of this study, if the sampled concentration is ten (or more) times the mean background concentration, it is considered to be of concern.

Forty parameters were analyzed in each of 28 sediment samples, and 32 parameters are being analyzed in each of 30 fish samples (Table 18). All of the 1,120 sediment analyses have been completed, and only 11 detectable concentrations of toxic organic substances and three metals with "concentrations of concern" (in 6 different lakes) were found (Table 19). Fish flesh analyses are expected to be completed in June 1986.

Palestine Lake is the only lake in this group which appears to need some immediate attention (Table 19). The PCB Aroclor 1254 concentration was 3800 ppb in the West Basin near the edge of the cattail bed at the mouth of Williamson Ditch. The concentrations of chromium, cadmium, and zinc in the West Basin of this two-lobed lake are 100 to 1000 times greater than mean background concentrations for these metals, but no metals "concentrations of concern" were found in the East Basin. The origin of the PCBs is still undetermined, but the metals appear to have come from Warsaw Black Oxide, an electroplating industry in Burket which discharges to Williamson Ditch.

Table 17. Waterbodies in the 1985 and 1986 lake and rêservoir toxics monitoring program.

Waterbody Number	Waterbody	Acreage	Location
1	*Monroe Reservoir	10,750	Monroe County
2	Lake Lemon	1,650	Brown/Monroe Counties
3	*North Twin Lake	10	Monroe County
4	Yellowwood Lake	133	Brown County
5	*King Lake	19	Fulton County
6	*Palestine Lake	232	Kosciusko County
7	*Pike Lake	203	Kosciusko County
8	Dogwood Lake	1,300	Daviess County
9	*Eagle Creek Reservoir	1,500	Marion County
10	*Mississinewa Reservoir	3,180	Miami/Wabash Counties
11	*Brookville Reservoir	5,260	Franklin/Union Counties
12	Lake Shafer	1,291	White County
13	Lake Freeman	1,547	Carroll County
14	Huntington Reservoir	900	Huntington County
15	*Salamonie Reservoir	2,860	Wabash/Huntington Counties
16	Cataract Reservoir	1,400	Putnam County
17	Mansfield Reservoir	2,060	Parke County
18	Bischoff Reservoir	200	Ripley County
19	*Versailles Lake	230	Ripley County
20	Hamilton Lake	802	Steuben County
21	Wolf Lake	385	Lake County
22	*Lake George (Hobart)	270	Lake County
23	Crooked Lake	802	Steuben County
24	*Morse Reservoir	1,463	Hamilton County
25	*Geist Reservoir	1,800	Marion County
26	Deam Lake	195	Clark County
27	Patoka Reservoir	2,010	Dubois/Orange/Crawford Counties
28	*Greensburg Reservoir	23	Decatur County

*Sampling completed in 1985.

Although the sediment samples collected in the other lakes have lower concentrations, results of the fish flesh analyses, yet to be completed, may disclose problems in some of these lakes. The state plans to do similar sampling at 14 additional lakes in 1986 (Table 17).

Bioassay Program

Bioassays are conducted by the state to screen wastewaters for potentially toxic effects. During 1984-85, 36 static acute bioassays were conducted on both industrial and municipal wastewaters. The zooplankter Daphnia magna was used as the test organism in all cases. A summary of the results is shown in Table 20. Little or no toxicity was observed in 24 of the tests (67%). Further testing will be required by the state on those effluents which had significant acute toxicity. In

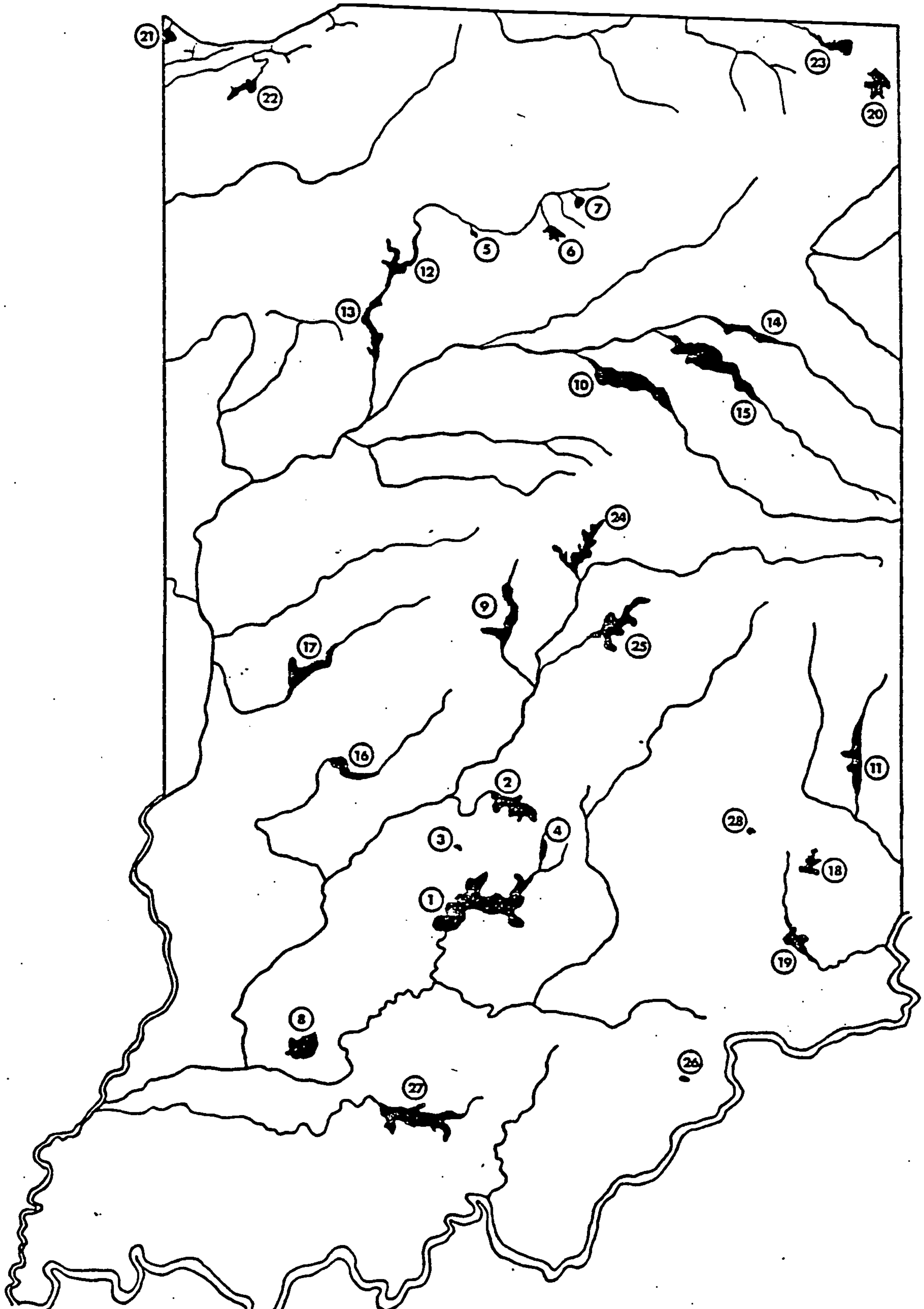


Figure 14. Location of Indiana's lake and reservoir toxic monitoring stations for 1985-86. (Numbers refer to lakes and reservoirs listed in Table 17.)

Table 18. Parameters list for the 1985 and 1986 lake and reservoir toxics monitoring program.

Metals	Sediment	Fish
Antimony	X	
Arsenic	X	X
Beryllium	X	
Cadmium	X	X
Chromium	X	X
Copper	X	X
Cyanide	X	
Lead	X	X
Mercury	X	X
Nickel	X	
Selenium	X	
Silver	X	
Thallium	X	
Zinc	X	
Organochlorine Pesticides		
Alpha-BHC	X	X
Beta-BHC	X	X
Gamma-BHC (Lindane)	X	X
Delta-BHC	X	X
Heptachlor	X	X
Heptachlor Epoxide	X	X
Aldrin	X	X
Endosulfan I	X	X
pp' (4,4') DDE	X	X
Dieldrin	X	X
Endrin	X	X
pp' (4,4') DDD	X	X
Endosulfan II	X	X
pp' (4,4') DDT	X	X
Endosulfan Sulfate	X	X
Methoxychlor	X	X
Chlordane	X	X
Toxaphene	X	X
Endrin Aldehyde	X	X
PCBs		
PCB-1221	X	X
PCB-1232	X	X
PCB-1016	X	X
PCB-1242	X	X
PCB-1248	X	X
PCB-1254	X	X
PCB-1260	X	X
Total	40	32

Table 19. Detectable concentrations of toxic organic substances and metals "concentrations of concern" in sediments from Indiana lakes and reservoirs sampled in 1985.

Waterbody	Parameter	Lake Sediment Concentration (ppb)	Mean Background Concentration* (ppb)	Maximum Background Concentration (ppb)
Morse Reservoir (South Basin)	Dieldrin	8.0	3.0	46
Morse Reservoir (North Basin)	Dieldrin	5.0	3.0	46
Geist Reservoir (N.E. Basin)	PCB-1254	180.0	12.0	250
Geist Reservoir (Dam)	PCB-1254	160.0	12.0	250
Lake George-Hobart (Dam)	PP' (4,4')DDE	17.0	2.0**	69**
Lake George-Hobart (Dam)	PP' (4,4")DDD	16.0		
Lake George-Hobart (Upstream of RR)	PCB-1254	140.0	12.0	250
Pike Lake (near landfill)	PCB-1254	200.0	12.0	250
Pike Lake (mouth of Deed's Creek)	PCB-1254	80.0	12.0	250
Greensburg Reservoir	PCB-1254	190.0	12.0	250
Palestine Lake (West Basin)	PCB-1254	3800.0	12.0	250
Palestine Lake (West Basin)	Cadmium	430,000.0	440.0	10,000
Palestine Lake (West Basin)	Chromium	1,300,000.0	14,100.0	143,000
Palestine Lake (West Basin)	Zinc	7,800,000.0	35,300.0	255,000

*Calculated from data collected statewide from locations with no known point sources of pollution.
**Total DDT

Table 20. Results of bioassays conducted in 1984-85.

Discharge	Receiving Stream	LC_{50} (% effluent)	Observed Toxicants
GCI, Huntertown	Willow Creek	5.6%	copper lead nickel
Dana Corporation Fort Wayne	Neuhaus Ditch	no toxicity	--
USS Lead East Chicago	Grand Calumet River	no toxicity	--
Eli Lilly Clinton	Wabash River	56%	copper? zinc?
Rostone Lafayette	Elliott Ditch	56%	copper zinc 2-ethythexyl phthalate
Essex Columbia City	Cook Ditch	no toxicity	--
Hercules Terre Haute	Spring Creek	no toxicity	--
Anaconda Terre Haute	Otter Creek	25%	oil and grease
Columbus STP	E. F. White River	56%	chlorine
Duncan Electric Lafayette	Wabash River	no toxicity	--
Keene Products (CTS) Middlebury	Mather Ditch	56%	nickel
Plymouth STP	Yellow River	no toxicity	--
Conrail Elkhart	Crawford Ditch	25%	oil and grease?
GMC Central Foundry Bedford	Bailey Branch	13%	copper?
Pfizer Terre Haute	Jordan Creek	no toxicity	--
Laketon Refining Laketon	Flack Ditch	5.6%	copper oil and grease

Roll Coater Kingsbury	Travis Ditch	9%	copper oil and grease
Sheller Globe Union City	Little Mississinewa River	no toxicity	
Midstates Steel and Wire Crawfordsville	Whitlock Springs	3.2%	copper? precipitants
Conrail Avon	Salem Creek	no toxicity	--
Wabash STP	Wabash River	no toxicity	--
Enginuity Albany	Halfway Creek	4.2%	zinc
Rieke Corporation Auburn	tributary to Cedar Creek	no toxicity	--
South Bend STP	St. Joseph River	no toxicity	--
Warsaw STP	Walnut Creek	no toxicity	--
Bridgeport Brass Indianapolis	Eagle Creek	25%	copper
Speedway STP	Eagle Creek	no toxicity	--
George Moser Leather New Albany	Ohio River	no toxicity	--
Olin Corporation Covington	Wabash River	no toxicity	--
Inland Container Newport	Wabash River	no toxicity	--
R. R. Donnelly Warsaw	J. Maisch Ditch	no toxicity	--
Colgate Palmolive Clarksville	Ohio River	100%	surfactants? copper?
U.S. Steel Gary	Grand Calumet	no toxicity	--
Inland Steel East Chicago	Indiana Harbor Canal	14%	chlorine cyanide?
Ingersoll Steel New Castle	Big Blue River	14%	chlorine nickel?
Allegheny Ludlum Steel New Castle	Big Blue River	18%	nickel

some cases, this testing is in the form of additional bioassays. In others, chemical analysis of the effluent for a wide range of toxic substances is required. If toxicity is observed in conjunction with an NPDES permit violation, the results are used as evidence in enforcement cases.

A particularly interesting result of the bioassays is that none of the six municipal sewage treatment facilities tested to date has shown any significant acute toxicity. All six facilities tested had industrial inputs to the sewer system. Industrial pretreatment programs have probably helped considerably to reduce potentially toxic discharges from these facilities.

Fish Consumption Advisories

Approximately 465 stream miles and all of Indiana's portion of Lake Michigan (241 sq. miles) are affected by fish consumption advisories. Table 21 lists the Indiana waters affected by such advisories, the dates the advisories were issued, the pollutants of concern in these waters, the fish species affected, and the scope of the advisories.

In most cases, these fish consumption advisories are based on whole fish data, because this is the only type of data available. As specified by EPA, whole fish are collected for analysis for Indiana's CORE program, and laboratory constraints do not allow for many additional fillet samples to be analyzed. In order to adequately inform the public as to the potential risks of consuming fish from certain areas, fish consumption advisories are issued when these whole fish data show contaminant values in excess of FDA action levels, even though these action levels are based on edible portions of fish (fillets). Most of the pollutants of concern are concentrated in the fat of the fish; our studies have shown that skinning and filleting fish and removing any excess fat before cooking can substantially reduce (20%-50%) contaminant levels in these fish. Cooking fish in such a way as to allow fats and oils to drip away from the fish (broiling, barbecuing, baking on a rack) can further reduce the level of contaminants to which consumers are exposed. The State Board of Health recommends that all fish caught in Indiana waters be skinned and filleted before consumption.

The pollutants of concern (PCBs and pesticides) for fish in Indiana waters are persistent substances that, for the most part, are no longer used to any extent in agriculture or industry. The persistent nature of these substances has made them available to the aquatic life over a long period of time and they have bioconcentrated in the fish to levels which sometimes exceed the FDA action levels. Specific sources of PCBs along streams with fish that have high PCB concentrations have been identified in several instances (see Toxic Pollutants Section), but no such sources of chlordane or dieldrin (pesticides) have been found. Corrective actions are being taken at localities where PCB sources have been found. Since these substances are no longer being used to any extent and known sources are being controlled, it is expected that fish contamination problems will decrease with time. This may be occurring

Table 21. Current Indiana fish consumption advisories.

River, Stream or Lake	Date Issued	Pollutants of Concern	Fish Species Involved	Scope of Advisory
Richland Creek in Monroe, Owen and Greene counties	1983	PCBs	all	No more than 1 meal (½ lb.) per week. Child-bearing age women and children should not eat any fish
Clear and Salt Creeks in Monroe and Lawrence counties	1983	PCBs	all	Same as for Richland Creek
East Fork of White River from Bedford to Williams Dam	1983	PCBs	all	Same as for Richland Creek
Elliot Ditch and Wea Creek in Tippecanoe County	1983	PCBs	all	No fish should be eaten
East Fork White River below Williams Dam in Lawrence County	1985	PCBs and Chlordane	catfish	No catfish should be eaten
Wabash River from just north of Lafayette to Darwin, Illinois	1985	PCBs and Chlordane	all	Carp should not be eaten. All others should be limited to 1 meal (½ lb.) per week. Child-bearing age women and children should not eat any fish.
West Fork of White River from Noblesville downstream to Broad Ripple	1985	PCBs	all	Do not consume fish from these areas
West Fork of White River from Broad Ripple downstream to Martinsville	1985	PCBs and Chlordane	all	Do not consume fish from these areas
West Fork of White River from Martinsville downstream to Petersburg	1985	PCBs and Chlordane	all	No more than 1 meal (½ lb.) per week. Child-bearing age women and children should not eat any fish.
West fork of White River at Petersburg	1985	Chlordane	carp	Carp should not be eaten
Stoney Creek downstream from Wilson Ditch south of Noblesville	1985	PCBs	all	Do not consume fish from these areas
Little Mississinewa River near Union City	1985	PCBs	all	Do not consume fish from this river.
Mississinewa River - 1 mile above and below confluence of Little Mississinewa River	1985	PCBs and Chlordane	all	Do not consume fish from this area
St. Joseph River downstream of South Bend	1985	PCBs and Chlordane	carp smallmouth bass redhorse suckers	Do not consume carp from this area. Smallmouth bass and redhorse suckers should not be eaten more than once/week (½ lb.) Child-bearing age women and children should not consume any fish from this area.
Maumee River below Fort Wayne	1985	PCBs	all	Fish prepared and consumed as skinless fillets should be within acceptable limits. Child-bearing age women and children should not consume fish from this area.
Lake Michigan (Joint Lake Michigan Fish Consumption Advisory)	1985	PCBs, Chlordane Dieldrin, DDT	yellow perch, smelt, coho, rainbow trout, lake trout 20"	Fish in this group pose lowest risk. FDA action levels met at least 90% of time.
			chinook 25" lake trout 20"-25"	One or more contaminants above FDA action levels in at least 50% of fish tested. Consume no more than 1 meal/wk. (½ lb.). Child-bearing age women and children should not consume.
			brown trout, lake trout over 25", carp	No one should consume these species

already with the pesticide dieldrin which was present in fish from several streams at levels exceeding FDA action levels in the period before 1984. Dieldrin did not exceed FDA action levels in any fish samples collected in 1984-85 (Table 7). Existing fish consumption advisories will remain in effect until subsequent sampling indicates that there are no longer problems in these areas.

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 is usually evidence of severe water quality problems and may indicate the long-term loss of use of the affected waters for a fishery.

A fish kill can result from the accidental or intentional spill 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 pollutants.

The number of reported fish kills has decreased slightly since the 1982-83 reporting period (59 down to 53) and remains greatly reduced over the 1980-81 reporting period (106). However, as depicted in Figure 15, 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 and to reporting requirements of 330 IAC 1-6 which became effective in 1974.

Thirty-nine percent (21) of the fish kills in 1984 and 1985 were caused by the release of some agriculturally related material (Figure 16). Spills of fertilizer related products were the number one cause of fish kills (18%) (10 fish kills), followed by animal waste (16%) (8). Approximately 5% (3) of the kills resulted from the release of pesticides.

The distribution of fish kills on a month-by-month basis is shown in Figure 17. 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 1984-85, a total of 1,183 reported spill incidents resulted in the release of 16.9 million gallons and 175 tons of material. The types of materials spilled are shown in Table 22. The release of petroleum products accounted for the largest number of incidents (529), followed by miscellaneous chemicals with about half that number. Miscellaneous materials, with a relatively small number of spills, had the greatest volume with 15.2 million gallons of liquid (mostly municipal sewage) and 58 tons of dry materials.

Figure 15. The number of major fish kills by year 1960–1985.

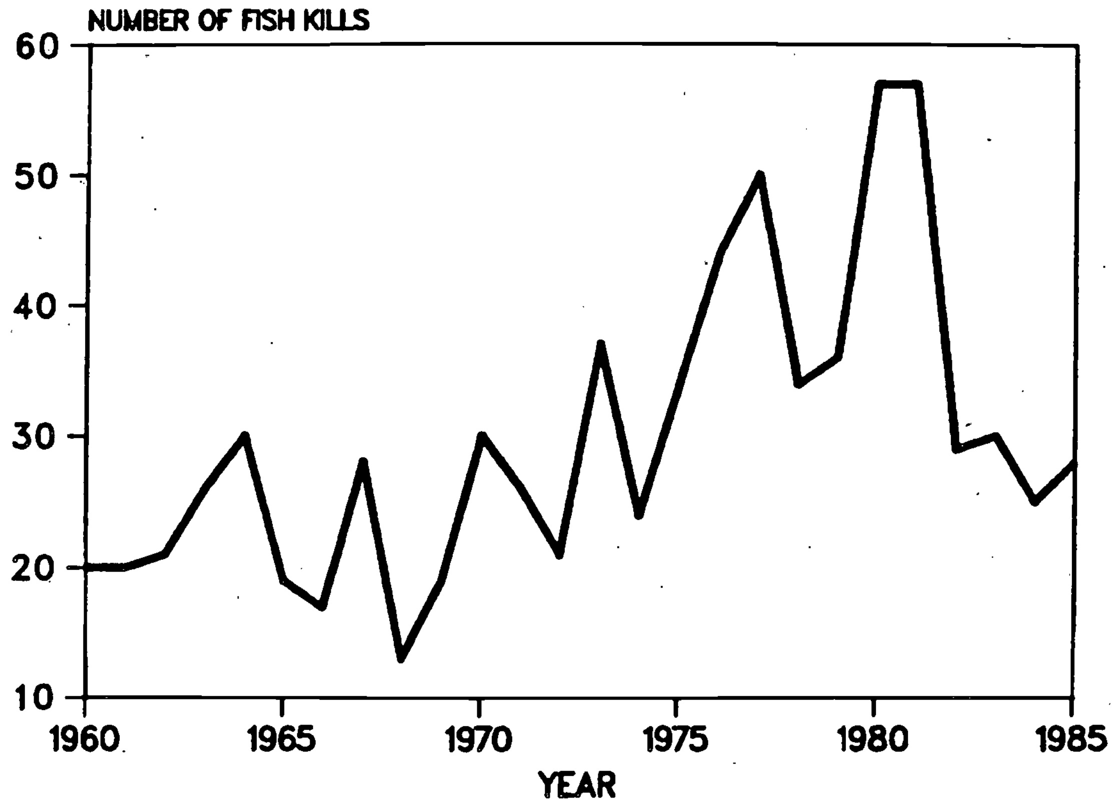


Figure 16. Fish kills by category 1984–1985.

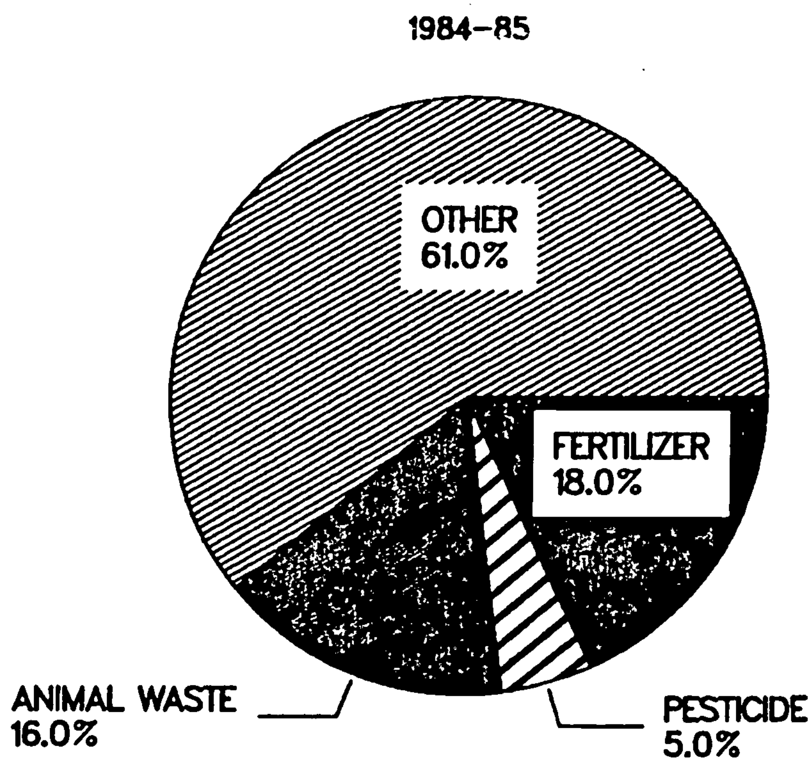


Figure 17. Total fish kills by month 1960–1985.

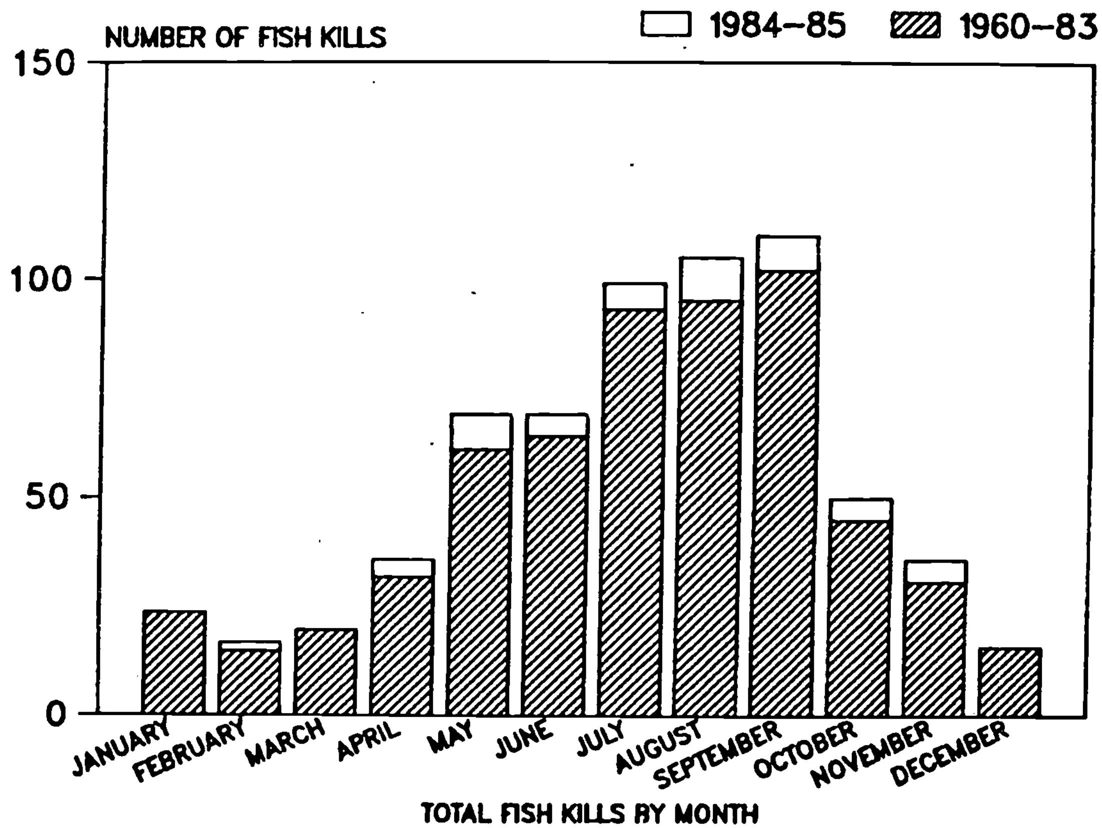


Table 22. Types of materials spilled in 1984-1985.

	No. of Incidents	Percent of Incidents	Amount	Percent Recovery
1. Petroleum Products	529	45	0.5 million gal. 16.8 tons	42 98
2. Miscellaneous Chemicals	270	23	0.2 million gal. 29.7 tons	36 33
3. Agricultural Related Prod.	162	14	0.9 million gal. 34.7 tons	6 20
4. Food Products	22	2	38,132 gallons 6 tons	51 100
5. Acids or Bases	92	7	357,000 gallons 29.8 tons	36 14
6. Miscellaneous Materials	108	9	15.2 million gallons 58 tons	0.8 85
Total	1183	100	16.9 million gallons 175 tons	

Table 23. Sources of materials spilled in 1984-1985.

	No. of Incidents	Percent of Incidents	Amount	Percent Recovery
1. Industrial	380	33	519,174 gallons 26.6 tons	39 22
2. Transportation	337	28	306,894 gallons 120 tons	36 72
3. Commercial	168	14	116,940 gallons 1.6 tons	37 85
4. Agricultural	116	10	818,748 gallons 26.8 tons	6 3
5. Semi-Public, Municipal STP	63	5	15.2 million gallons	0.0
6. Unknown, Other, Individual	119	10	74,000 gallons	22
Total	1183	100	16.9 million gallons 175 tons	

The sources of materials spilled were broken down into six categories (Table 23). The industrial related grouping accounted for the largest number of reported incidents with 380. These were identified as spills where the loss was from sources involved in manufacturing or mining. The semi-public 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 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 24). Equipment malfunction accounted for nearly half of all spills (43.7%), with transportation accidents and employee error the next largest categories. Intentional discharge, vandalism, miscellaneous and unknown categories combined accounted for only 20% 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 24. Causative circumstances of spills of oil, hazardous and objectionable materials.

	No. of Incidents	Percent
1. Equipment	518	43.7
2. Transportation	198	16.7
3. Employee Error	223	18.8
4. Miscellaneous	66	5.5
5. Intentional Discharge	56	4.9
6. Vandalism	26	2.2
7. Unknown	96	8.2
Total	1183	100

During 1984-85, 1,183 spills of oil, hazardous, and/or objectionable substances were reported. Of these, 643 incidents (54% of the total) were reported by the responsible party as required. The remaining 540 spills were reported by other governmental agencies and/or private citizens. An awareness 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 1984-85 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 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 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, the chance of a successful operation is greatly increased. Experience has demonstrated that if time is lost in the cleanup initiation, resultant cost for cleanup will increase, and the success rate will decrease. Immediate cleanup is therefore of optimum importance.

During 1984-85, 836 (71%) of the reported incidents had either complete or partial cleanup. This represents a 13% increase over the 1982-83 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 1984-85, water quality violations resulted from 224 (19%) of the 1183 reported incidents. Twenty-four percent of the incidents which caused water quality violations resulted in a fish kill. Sixty-two percent of the reported incidents did not involve a water quality violation because the lost material did not reach waters of the state.

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 43 miles of shoreline and 241 square miles, about 1% of the total surface area.

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 18). 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 Indiana 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 via a tributary. In addition, a number of industries also use the lake as a raw water resource. Lake Michigan and its contiguous harbor areas have been designated 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 1,653 analyses were conducted on water samples collected from Lake Michigan as part of the Fixed Station Water Quality Monitoring Network Program during 1984 and 1985. These data showed a greater than 40% decrease in the percentage of total water quality standards violations when compared to 1982-1983 data. The most noticeable decreases in violations were for mercury, phenols, and phosphorus. There are occasional violations of standards for chlorides and cadmium. From this analysis, it appears that designated uses (in 330 IAC 2-1) are being supported.

Water quality in Lake Michigan does vary in the Indiana portion. Concentrations of mercury and phenols in the nearshore zone reflect the wastewater and tributary contributions from the watershed. The highest values consistently appear near the Indiana Harbor Ship Canal. High levels of chlorides in the contiguous harbor, and low dissolved oxygen and high unionized ammonia values on Trail Creek, may also be responsible for some of the chemical variability in the lake.

Tissue from some species of fish in Lake Michigan have contained concentrations of contaminants in excess of FDA action levels since testing began in the early 1970s. Fish are collected for metals, pesticide and PCB analysis in the fall each year by the Indiana Department of Natural Resources (IDNR) and analyzed by the ISBH. PCBs are a problem, with values in excess of the Food and Drug Administration (FDA) guideline of 2.0 ppm. Chlordane is also found in excess of the FDA guideline of 0.3 ppm. A revised fish consumption advisory for fishermen and consumers of these fish is issued each spring.

Figure 18. Lake Michigan Drainage Basin.

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 at 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 Regulation 330 IAC 2-4 (Natural Spawning, Rearing or Imprinting Areas; Migration Routes for Salmonid Fishes). This particular regulation was revised in late 1985. 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. In 1984, Michigan City received a grant award of over 18 million dollars for projects that will eliminate most 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. Dissolved oxygen violations in the lower reaches of the creek occurred nearly 40% of the time according to 1984-1985 ISBH Fixed Station Water Quality Monitoring data. Fecal coliform bacteria criteria were violated more than 50% of the time, and violations of un-ionized ammonia standards occurred 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" temperatures. Heavy rain causes bypassing of raw and partially treated sewage to the stream at the sewage treatment facility as well as from combined sewer overflows. The Michigan City Sanitary District is planning to plug CSOs and to build a storage basin for stormwater, which will reduce the amount of sewage entering Trail Creek CSOs. The city is also increasing the capacity of the STP to handle larger volumes of wastewater, which will reduce the frequency of bypassing.

Fish kills due to low dissolved oxygen, high temperature, and/or ammonia have occurred regularly in the past. An ISBH CORE monitoring survey found few fish (only 7 species) in the lower reach of Trail Creek in the fall of 1984. Salmonids attempting to migrate through this area must subject themselves, for short periods, to conditions that are detrimental to this type of fishery. The Lake Michigan Basin provides 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.

Biological sampling in Trail Creek has been conducted since 1979. Hester-Dendy macroinvertebrate samples collected at the Franklin Street bridge near the stream mouth have indicated a community dominated by pollution tolerant chironomid larvae and oligochaetes. Limited numbers of native fish have been obtained in the lower reach of Trail Creek. Of the native fish tissue samples tested, only one sample exceeded an FDA action level (chlordane, in 1984).

The Little Calumet River flows through Lake and Porter counties in northwest Indiana. This 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 the wastershed, they appear to be more concentrated here, with little time for the stream to recover from individual pollution sources.

A portion of the West Branch of the Little Calumet River drains to Lake Michigan via Burns Ditch while a flow divide near Griffith directs a portion of the flow into Illinois, and eventually the Illinois River. The west branch is covered by 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 into Illinois includes Hart Ditch.

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 station LCR-13 occurred approximately 50% of the time from 1981 to 1985. The 1984-1985 data show a larger percentage of violations than do the 1981-1983 data. A similar pattern for unionized ammonia violations occurred in the same period. Violations of the fecal coliform bacteria standard occurred approximately 90% of time from 1981-1985. Water quality problems are expected to decrease once sewage treatment facility upgrading at Schererville and Dyer are complete. However, CSOs from Hammond and Munster may continue to degrade water quality.

Schererville, which had previously been denied funding, received a $6,697,800 grant to upgrade and expand its plant from 2.0 mgd to 3.5 mgd and to provide nitrification. Upgrading of the Schererville sewage treatment facility began in mid-1985. Completion of the 3.5 mgd activated sludge plant is expected in 1987. Improvements in the plant effluent should alleviate problems which inhibit aquatic life in the receiving streams.

The Dyer sewage treatment facility completed the addition of filters to its activated sludge plant. Even though the new facilities are now in operation, NPDES permit limits are not being met 40% of the time. Problems associated with plant construction have been outlined and will be corrected.

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 by Regulation 330 IAC 2-4 for salmonid migration, or for rearing and imprinting of salmonids.

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. A recent fish kill near South Haven has yet to be linked to any direct source. Advanced waste treatment, including nitrification and dechlorination, was completed in 1985 at the facility, and should help alleviate many problems. Control of combined sewer overflows was required.

The Crown Point sewage treatment facility has been meeting it's NPDES limits for several years. The most recent sampling inspection indicated both low BOD and suspended solids in the effluent. Improved water quality in Beaver Dam Ditch and Deep River is attributable to the past improvements of this advanced treatment plant.

Hobart received $11,181,675 to provide improved wastewater treatment by regionalization with Gary which should be completed by early 1987. The elimination of the discharge is expected to improve water quality in Deep River.

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 it is 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 (80-100 mgd) cooling water discharge that enters the river upstream of its confluence with Salt Creek. It appears that this warmer water may inhibit salmonid migration in the late summer and fall, possibly diverting some fish up Salt Creek. Bethlehem Steel contracted with a consultant to conduct thermal avoidance studies in 1984 and 1985, but data from these studies were inconclusive. Bethlehem Steel believes that the temperature exceedances found are a direct result of the increased lake water intake temperature.

Midwest Steel discharges wastewater to Burns Ditch. Inspection reports and compliance surveys of this facility all indicate that Midwest Steel is meeting its NPDES permit limits and having little or no 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, 1982, and 1984. The number of genera has increased from 10 in 1979 to 17 in 1984. Along with this increase in diversity, the numbers of organisms have increased and more of these organisms are pollution intolerant. Chironomid larvae were the dominant organisms found.

Carp have been collected from Burns Ditch in 1979, 1980, 1982, and 1984 for fish flesh analysis for toxic substances. No violations of FDA action levels were found.

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 just west of Indianapolis Boulevard. 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. 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 contributed to this designation. Regulation 330 IAC 2-2 was revised in 1985 and no longer includes the partial-body contact designation. Due to the presence of high concentrations of toxic substances in the sediment and areas of sediment deposition up to 20 feet deep, the state did not wish to encourage partial-body contact activities in these areas. The fecal coliform bacteria standard to protect for partial-body contact was retained, however.

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, but have been reduced. Dissolved oxygen, chlorides, ammonia, phosphorus, and fecal coliform are parameters for which standards are most commonly violated.

Three major sewage treatment plants, Gary, Hammond, and East Chicago discharge to the Grand Calumet River. All three municipalities are involved in some type of enforcement action by the state and U.S. EPA. Hammond and East Chicago are scheduled to receive construction grant funding in FY '86.

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 was to address the inadequate sludge disposal methods employed by the Sanitary District. Leaching of material from the District's sludge storage lagoons to the Grand Calumet River was alleged. A 5.8 million dollar sludge dewatering facility is now under construction, and is scheduled to be completed by mid-1986. Also, construction of a nitrification facility must begin by May 1987 and be in full operation by July 1988.

The City of East Chicago and the East Chicago Sanitary District have entered into a Consent Decree with the State of Indiana, U.S. EPA, and the State of Illinois. The Consent Decree established a fixed date schedule that requires the POTW to be in compliance with new NPDES permit limits by April 1989.

The City of Gary and the Gary Sanitary District have entered into a Consent Decree 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 response to a request for enforcement initiated by the State of Indiana concerning inadequate sludge storage and possible leaching of material from their lagoon to the Grand Calumet River, Gary was awarded a $8,861,315 construction grant for sludge handling facilities in FY '85.

Recently constructed additions to the Gary sewage treatment facility have resulted in water quality improvements in the Grand Calumet River. Fixed Station Water Quality Monitoring Network data from 1984 and 1985 indicate that both ammonia and fecal coliform violations have decreased from almost 50 percent to approximately 30 percent, and that phosphorus and cyanide violations are almost nonexistent.

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 impacts 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 degradation of the waterway. These inputs are not only from point sources, but include ship traffic in the IHC, parking lot runoff, etc.

Although the water quality is far from being desirable, it is showing improvements. A gross comparison of biological observations yielded the same improving trend. Resident fish populations are evident (carp, goldfish, golden shiner, fathead minnow, central mudminnow, black bullhead and green sunfish were observed in 1985), and even some salmonids stray up the river in autumn. Macroinvertebrate communities has increased from 1 genus in 1978 to 11 genera in 1984. Bryozoans have become very abundant, and the appearance of some odonates and gastropods has been observed. The bird life along the stream is abundant (mallards, wood ducks, kingfishers, herring gulls, green heron, red-tail hawk, sparrow hawk, red-wing blackbird, and many small migrants were observed in 1984). These observations could be due to both better treatment of wastewater as well as a reduction in wastewater discharged to the river from the steel mills in the most recent years.

Fish flesh sampling for toxics in the IHC-GCR system has been done every other year since 1980. Samples from 1982 and 1984 exceeded FDA action levels for PCBs. Only one large carp collected in 1982 exceeded the FDA action level for chlordane. A revised fish consumption advisory for 1986 is expected to include the IHC-GCR system.

The Grand Calumet River Master Plan calls for programs which will focus U.S. EPA and State of Indiana water quality control efforts on problems related to these streams. These programs include best available technology permit development, waste load allocations, pretreatment program development, and compliance actions (both municipal and industrial). Longer-term investigations to evaluate the effectiveness of existing and new control programs for enhancing water quality conditions in the IHC-GCR system will be conducted. Implementation of step two (intensive biological sampling) of the Master Plan is expected to start in 1986.

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. Although the river segment in Indiana is less than 40 miles long, the Indiana drainage basin covers 1,778 square miles and six counties. Water quality data from fixed water quality monitoring stations at Bristol and South Bend show few violations of water quality standards. However, occasional fish kills (2000 fish in 1983 at Mishawaka and 400 fish in 1984 at Elkhart) indicate that some problems still exist. An additional fixed water quality monitoring station will be located between Bristol and South Bend near the Twin Branch fish hatchery.

Regulation 330 IAC 2-4 was revised in 1985 to include the St. Joseph River from the Twin Branch Dam to the Indiana-Michigan state line. Through a cooperative effort between Indiana and Michigan, fish ladders are being built at dams in South Bend (to be completed in 1986), Mishawaka (to be completed in 1987) and in Michigan. A new cold water hatchery is in operation at Mishawaka, Indiana. The salmonid stocking program and the removal of migration barriers will enable trout and salmon to move up the river to Mishawaka from Lake Michigan. These projects will hopefully produce a salmonid fishery in the St. Joseph River.

The addition of new aerators, clarifiers, and sludge handling capability to the Elkhart sewage treatment facility is nearly complete. The facility is currently meeting all of its NPDES limits, even though it is not scheduled to be fully complete until December 1986.

In order to obtain data for modeling, wasteload allocation, permitting, and construction grant purposes due to the new salmonid designation, an intensive survey of the St. Joseph River from Bristol to the state line below South Bend was conducted in August 1985. Data collected at 40 sites revealed that, for the most part, standards in Regulation 330 IAC 2-4 could be supported. Another intensive survey has been scheduled for 1986.

Biological studies indicate diverse macroinvertebrate and fish communities at Bristol and South Bend. Analysis of fish flesh for toxic substances has shown that some fish violate the FDA action levels for PCBs and chlordane below South Bend. An ISBH fish consumption advisory is in effect for certain species below South Bend.

A sediment survey for metals, pesticides, and PCBs took place in late 1985. Values from four stations on the main stem of the St. Joseph River were all below detection limits, but PCBs (up to 17,000 ppb) were found near the mouth of five of its tributaries. These sites are currently under investigation.

The Pigeon River in LaGrange County located in northeastern Indiana enters the St. Joseph River in Michigan. A fixed water quality monitoring station was placed on this put-and-take trout stream at the request of the Indiana Department of Natural Resources. Insufficient data have been collected so far to determine if poor returns on stocking can be attributed to poor water quality.

Maumee River Basin

The Maumee River Basin is located in the northeastern portion of Indiana and drains parts of Adams, Allen, DeKalb, Noble, and Wells counties (Figure 19). The drainage area in Indiana is approximately 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 at 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 and empties into Lake Erie. The $Q_{7,10}$, as measured at New Haven, is 70 cfs. This basin is covered under Regulation 330 IAC 1-1. In the 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 River in Allen County. The balance of the basin is designated for warm water aquatic life and partial-body contact. The Fixed Station Water Quality Monitoring Network in the basin includes two stations on the St. Mary's River (STM-33 and STM-12), one on the St. Joseph River (STJ-0) and three on the Maumee River (M-116, M-110, and M-95).

The headwaters of the St. Mary's River originate in Ohio. Although no major cities are located in this area, several small Ohio towns have affected the water quality in the past. Phosphorus values in the St. Mary's are consistently among the highest found in the state, except for those located just below point source dischargers. The Ohio problems, coupled with the absence of a phosphorus detergent ban in that state, have adversely impacted water quality of the St. Mary's River before it enters Indiana. However, fixed water quality monitoring station STM-33, located just inside Indiana on the St. Mary's River, has had a decrease in fecal coliform violations of state water quality standards from 32% in the 1982-83 monitoring period to 6% in the 1984-85 period. Unionized ammonia standards were violated 6% of the time for the 1984-85 period compared with 0% during the 1982-83 period. These waters have also shown an increase in cyanide violations from 0% to 6%. No dissolved oxygen or mercury violations have been recorded since the 1982-83 monitoring period during which there were 4% for each.

The drainage area for the St. Mary's River is used heavily for agriculture, and suspended solids in the St. Mary's and the Maumee rivers are high. Only one major municipal sewage treatment plant, Decatur (2.8 mgd capacity), is located on the St. Mary's River. Fecal coliform violations of state standards have substantially decreased (from 32% to 12%) since 1982-83 downstream of this STP. A fish kill was reported in September of 1984 in the St. Mary's, probably due to lift station problems at the facility. In May of 1984, the Allen County Regional Sewer District received a construction grant award of $1,446,710 for constructing sewers and a waste stabilization pond for Hoagland and sewers for Arcola.

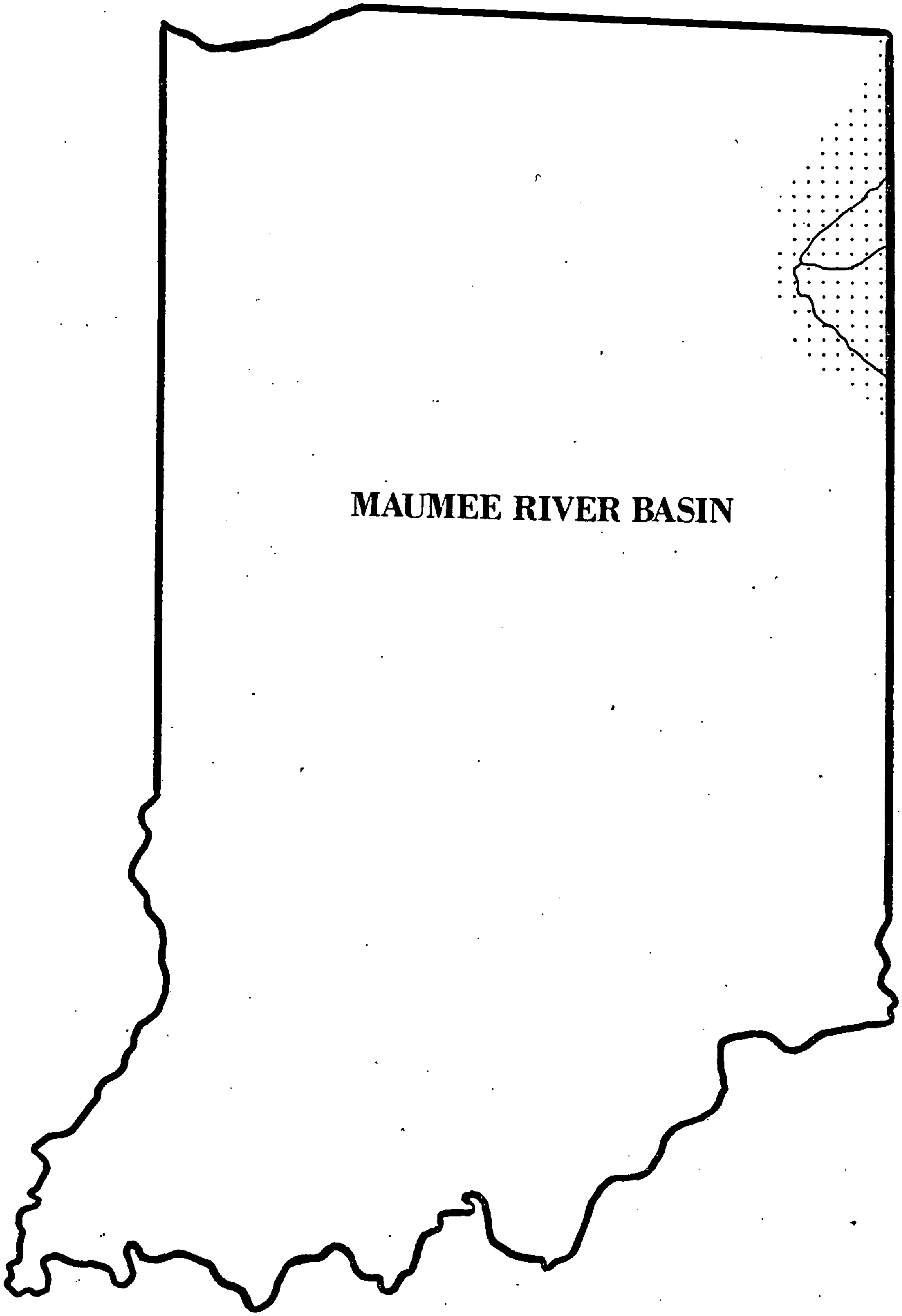


Figure 19. Maumee River Drainage Basin.

Central Soya, also a major contributor of phosphorus to the basin, is a soybean processing plant in Decatur, Indiana that discharges into the St. Mary's River. A newly revised permit has been proposed for Central Soya based on the 90% removal requirement of Regulation 330 IAC 5-10. The proposed permit will allow a maximum daily phosphorus discharge of 175 pounds per day. Currently, Central Soya is meeting phosphorus removal requirements.

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 fixed water quality monitoring station (STJ-0) near the mouth in Fort Wayne, appears good from data collected. Fecal coliform bacteria concentrations exceeded the whole-body contact water quality standard about 50% of the time during the recreational season in the 1984-85 monitoring period, but there were no fecal coliform bacteria violations during the non-recreational season when the partial-body contact standard applies. Also, average fecal coliform concentrations have decreased over 50% since the 1982-83 monitoring period. Grabill, Indiana, located along the St. Joseph River, has recently received a construction grant of $246,297 for regionalization with Fort Wayne. Removal of this discharge to the river should improve water quality even more.

The St. Joseph 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 dissolved oxygen depletion beneath the extended ice cover.

Cedar Creek is an important tributary to the St. Joseph River entering just below Cedarville Reservoir. 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 some partial bypassing in "dry weather." The plant was expanded to a 3.0 mgd capacity in 1984. An additional expansion and sewer separation project is scheduled for 1986.

A number of industrial dischargers are also found in this watershed, with one of the most notable being Kitchen Quip in Waterloo, a kitchen utensils manufacturing plant. In the past, the company has had a number of NPDES permit violations, but none since 1981. This is probably due to Kitchen Quip's plating line decreasing its operation to only a few days per month. Their treatment system currently appears to be operating satisfactorily, but no recent biological surveys of this reach of Cedar Creek have been done.

GCI, Inc., formerly Gridcraft Corporation, in Huntertown has also had a history of wastewater problems. This printed circuit board manufacturing facility discharges to a branch of Willow Creek, a tributary of Cedar Creek. In the past, the plant effluent has not been treated sufficiently before it leaves the site and has severely impacted the receiving water and sediment. A March 1984 compliance survey indicated a number of metals (copper, lead, and nickel) violations in the final effluent. In addition, high levels of total chromium (0.045%) copper (2.5%), iron (2.2%), lead (1.0%), tin (3.0%), and silver (0.025%) were found in sediments immediately below the outfall. The stream bottom was a light blue color, indicating the presence of high concentrations of these metals. A 1985 Notice of Violation was issued for noncompliance of NPDES permit limits for copper (daily maximum) ammonia, and HSL (octylphenoxypolyethoxyethanol).

A Daphnia magna 48-hour toxicity bioassay included in this survey was stopped after seventeen 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.

A Consent Decree between the Stream Pollution Control Board and GCI, Inc., was signed in October of 1984 requiring GCI to limit HSL, an oily compound used during the soldering of printed circuits which has caused foaming in their effluent, and to dredge the Willow Creek stream bed for 200 feet downstream from the point of discharge to remove the contaminated sediment. Also, GCI will be required to connect to the Huntertown sewer system which is combining its wastewater into the larger volume of the Fort Wayne waste treatment system. Construction of the Huntertown to Fort Wayne connection is scheduled for 1986. This should eliminate the noncompliance problems GCI has had and improve water quality in Willow Creek and Cedar Creek.

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. The receiving stream is Hindman Ditch which connects to Bear Creek, a tributary of the St. Joseph River. Biological oxygen demand and suspended solids are treated in an aerated lagoon system. In the past, 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. An investigation of the receiving ditch by ISBH staff showed the water to be dark and odorous, and found extensive sludge deposits below the treatment lagoon discharge point. Hindman Ditch is small, and Sechler supplies most, if not all, of the flow during portions of the year. The wastewater treatment facility was expanded in 1983 by the addition of a 1.8 million gallon storage lagoon, and the primary lagoon was cleaned of accumulated sludge. In 1984, the aeration capacities of the lagoons were increased. These changes should alleviate water quality problems in Hindman Ditch occurring from this facility. To date, no water quality problems have been noted in Bear Creek.

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 AT, phosphorus removal facilities, and storm water retention ponds. The effluent from the plant is of good quality and is causing little or no degradation of the

Maumee River. In fact, fecal coliform violations at fixed water quality monitoring station M-110, six miles downstream of the STP, showed a drop from 42% to 26% since the 1982-83 monitoring period. Unionized ammonia violations did not occur in the 1984-85 monitoring period. However, the STP was sent an Order of Compliance in September 1985 for violation of total suspended solids limits in their discharge. This was speculated to be due, in part, to algal blooms in the holding ponds before release. An algicide will be used to control these blooms.

Sewage problems still exist in the Fort Wayne area with 47 combined sewer overflows (CSO) discharging to the Maumee River from its point of origin to New Haven. This problem is currently being addressed. Fort Wayne received $996,525 for CSO separation work in fiscal year 1984.

The metropolitan Fort Wayne area includes a number of industries. The most concentrated area is the east side where an industrial complex is located. Rea Magnet Wire, Phelps Dodge, and ITT-Aerospace/Optical Division are all permitted to discharge to the Maumee River or to small tributaries. Gladieux Refinery, and Falstaff Brewing Company wastewaters now go to the Fort Wayne STP.

Comparison of data from the fixed water quality monitoring station (M-116) upstream of the Fort Wayne sewage treatment facility and industrial complex with the downstream station in New Haven (M-110) showed little differences. No unionized ammonia violations of state water quality standards were recorded for either station during the 1984-85 monitoring period. However, station M-116, upstream of the STP, showed an increase in fecal coliform bacteria violations from 30% to 53% since the 1981-83 period. Station M-110, downstream of the STP, showed a decrease in fecal coliform bacteria violations in the same period. Oil and grease violations were not found for either station in 1984-85. There were violations of nickel water quality criteria 5% of the time at M-116, and a cyanide violation (from one grab) at M-110. The 1984-85 data from monitoring station M-95, located near Woodburn just before the Maumee enters Ohio, showed good water quality with a decrease in fecal coliform violations in the 1984-85 period (6%) compared to the 1982-83 monitoring period (36%). However, there were total chromium violations of state water quality criteria 6% of the time here.

The relatively high phosphorus values in the Maumee River come from the St. Joseph and St. Mary's watersheds. Values continue to remain about the same, averaging approximately 0.23 mg/l for the Maumee River. However, state water quality standards, with the possible exception of fecal coliform standards, are being met in almost all cases for the whole basin. It can be concluded that the aquatic life uses of the Maumee River basin are being attained, and recreational uses are partially attained.

Biological surveys in the basin since 1979 have included collections of fish tissue for toxic analysis at monitoring station STJ-0 (mouth of St. Joseph River) and the Maumee River downstream from the Fort Wayne sewage treatment facility discharge (between M-116 and M-110). Tissue samples collected in 1984 in the Maumee River contained

PCBs in excess of Federal Food and Drug Administration action levels. A limited fish consumption advisory for the Maumee River has been issued. The fish community otherwise 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.

Macroinvertebrate studies at monitoring stations STJ-0 and M-95, in 1984, indicated fair water quality. The numbers and kinds of macroinvertebrates present were not radically different from those previously found there. Therefore, there appears to be no obvious water quality degradation problems at either station.

The soil conservation demonstration project sponsored by the U.S. EPA Great Lakes National Program Office includes the Maumee drainage basin in Indiana. The objective of the project is 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. The 1984 project expanded to approximately 3,200 acres of test plots in six northeastern Indiana counties. Data from the project since 1982 have continued to indicate that no till farming and "Best Management Practices" (BMP) could benefit water quality by reducing nutrient and sediment loading and be economically advantageous for farmers in many instances. The number of people interested in no-till farming and BMP is increasing.

Kankakee River Basin

The Kankakee River Basin (Figure 20) 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, and even at low summer flows only about 3% of the flow in the Kankakee River where it leaves Indiana is composed of treated wastewater.

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 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

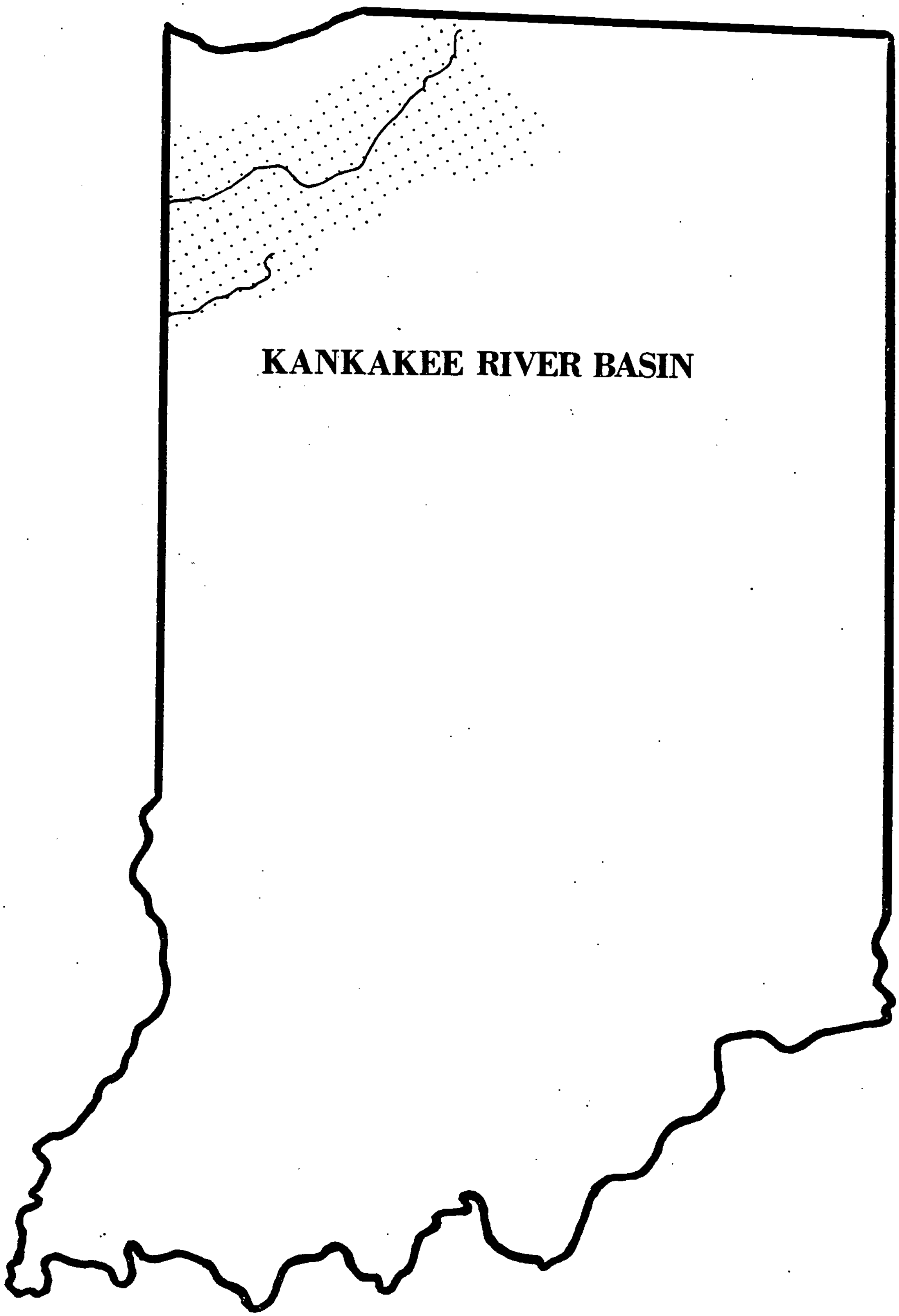


Figure 20. Kankakee River Drainage Basin.

caddisflies, whose larval stage is completely aquatic and is an important fish food. Parts of the river are used frequently for canoeing, and there are two commercial canoe liveries on the Kankakee. Most of the streams in the basin are designated to support warmwater fisheries, although the Little Kankakee (LaPorte County), Crooked Creek (Porter County) and Potato Creek (St. Joseph County) are put-and-take trout streams and designated to support coldwater fisheries. Newly designated limited use streams in the basin include portions of ditches downstream from the Kentland and Lakeville sewage treatment plants. All streams in the Kankakee basin must meet water quality standards for partial-body contact recreation.

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, since no violations of water quality criteria were observed at either location during 1984 and 1985. In addition, both sites also met the coliform bacteria criteria for partial-body contact at all times. This represents a considerable improvement in water quality since during the 1982-83 period the criteria were exceeded 4% of the time at KR-65 and 17% of the time at KR-125.

Recent biomonitoring activities in the Kankakee Basin included fish collection for tissue analysis and macroinvertebrate sampling. No fish kills were reported in the Kankakee River basin during 1984-85. Fish tissue analysis revealed that metals, PCB, and pesticide levels in fish from the Kankakee remain among the lowest in the state and are well below the concentrations affecting human health. Macroinvertebrate sampling also confirmed that water quality continues to be excellent in the Kankakee mainstem.

One site in the Kankakee basin was recently identified as being a potential source of dioxin contamination. The D. H. and R. Company in the Kingsbury Industrial Park blended the herbicide silvex between 1976 and 1979. Dioxin is a potential by-product of silvex production. However, extensive soil sampling by U.S. EPA on the company's property in 1984 revealed no traces of dioxin on the grounds. Therefore, the risk of any dioxin contamination in the Kankakee River from this source is extremely low.

Several improvements in the water quality of Kankakee River tributaries have been made since 1983. New sewage treatment plants were completed at Walkerton and Kingsford Heights. The Walkerton facility is completely new and consistently meets its NPDES permit limits. Water quality in Pine Creek is undoubtedly improved with the completion of this project. The original Kingsford Heights sewage treatment plant was constructed in the early 1940s. Although it still worked reasonably well, parts were wearing out and permit limitations were occasionally violated. The new facility produces an excellent effluent and has resulted in improvements of water quality in Porter Ditch.

Improved conditions have also been noted downstream from the Hebron sewage treatment plant and the Westville Oil Company in Westville. Hebron installed pumps in 1983 to recycle their wastewater and the average BOD loading to Cobb Creek has decreased 50% since then.

The facility still cannot meet its NPDES limits, however. The Westville Oil Company recycles used oils and had a history of oil spills to Crumpacker Ditch in the Crooked Creek watershed. Some of these oils were contaminated with PCBs, and PCBs were detected in stream sediments in 1978. In 1983, the company installed a new treatment system and dredged the stream bed to remove residual oil. Recent inspections revealed vastly improved conditions there, and self-monitoring reports indicated general compliance with discharge limitations.

Several municipal dischargers in the Kankakee Basin still do not meet their NPDES limits. These include the sewage treatment plants at LaPorte, Plymouth, Remington, New Carlisle, Westville, Lowell, and Hebron. Steps are being taken to improve these situations. LaPorte and Plymouth have received federal construction grants of 5.8 and 5.1 million dollars, respectively, to upgrade their treatment plants. These are the two largest cities in the Kankakee Basin and together account for about 75% of the total wastewater flow in the watershed. Upgrading of these facilities is expected to greatly improve local water quality in the basin. The Town of Lowell, which also treats sewage from Cedar Lake, has recently been fined $20,000 and must, by Consent Decree, design a management strategy to eliminate raw sewage bypasses into Cedar Creek. The Town must also complete construction of ammonia-removal facilities by 1988.

Industrial facilities which require improved wastewater treatment include Roll Coater at Kingsbury and Capital Products at Kentland. A recent bioassay of effluent from Roll Coater indicated a potentially serious toxicity problem. The company is frequently violating its oil and grease discharge limitations and the observed toxicity may be related to this problem. The Capitol Products discharge began in 1983 and the company immediately began having problems with high ammonia and nitrate concentrations in the effluent. Enforcement proceedings against both companies have been started in an attempt to bring the facilities back into compliance.

Wabash River Basin

The Wabash River Basin provides drainage for approximately 33,000 square miles of the surface area of Indiana, Illinois, and Ohio. The greatest portion of the basin is in Indiana, where it drains two-thirds of the state's surface area (Figure 21). 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 (C.O.E.) 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.

Regulation 330 IAC 1-1 establishes the water quality standards for the Wabash River Basin. In general, the river and its tributaries are designated for partial-body contact recreation and maintenance of a

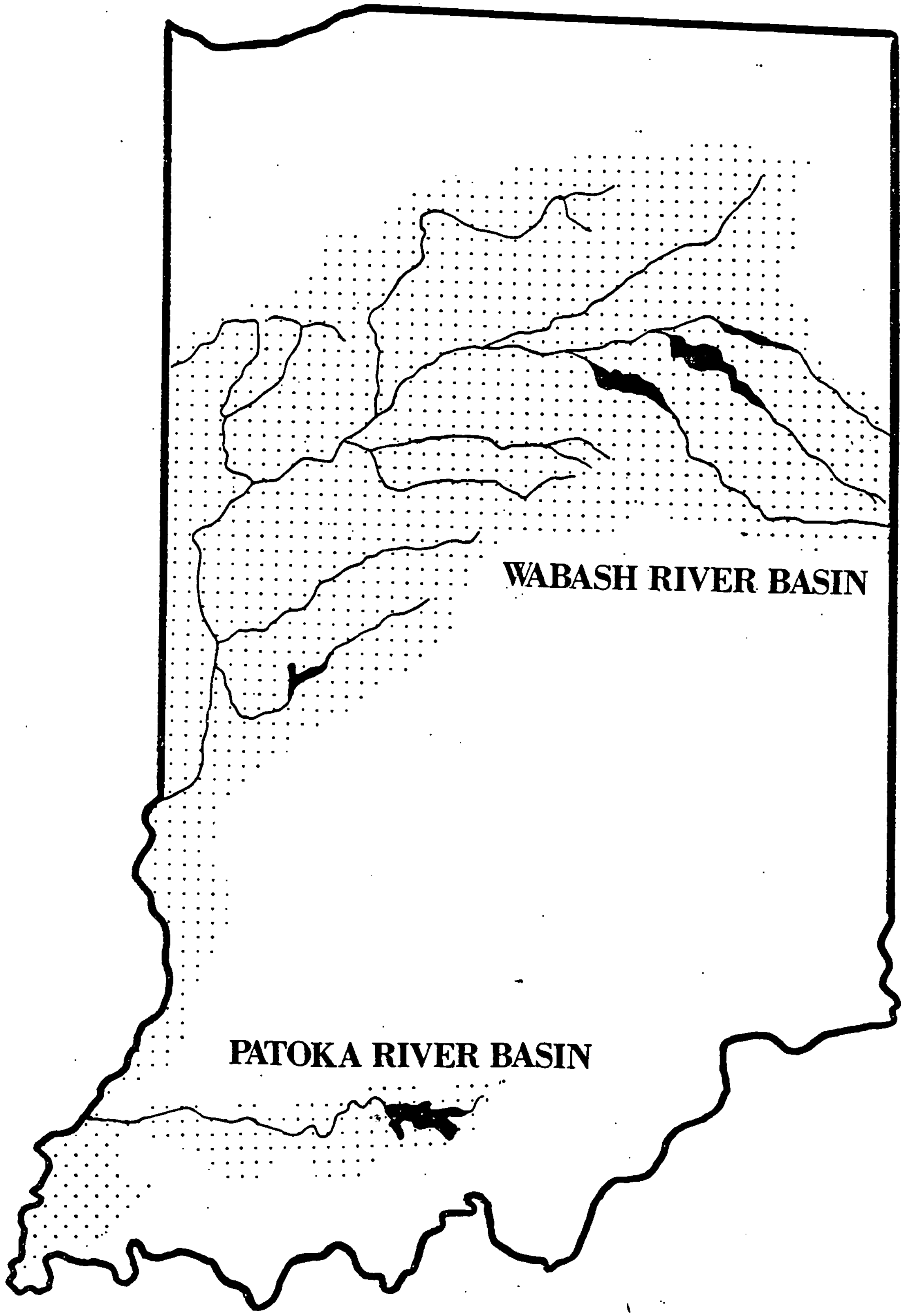


Figure 21. Wabash and Patoka River Drainage Basins.

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 designated for either "limited" or "exceptional" use and are subject to a wider range of limitations. Because 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. Eight of the ten streams designated 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. Waters in the basin receive a diversity of wastes from municipal sewage treatment facilities, cropland runoff, chemical manufacturing facilities, steam-electric power plants, steel processing plants, and coal mines. (Figure 22 shows the relationship of the state's coal producing area to the basin, and Table 25 shows the number of stream miles in the watershed affected by mine drainage). The combined impact which oxygen demanding waste waters and heated effluent 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. As a result, appropriate discharge limitations are being incorporated into NPDES permits upon their renewal.

Of the variety of factors affecting the streams in this basin, one which is often overlooked is the combined effect of confined feedlots which are concentrated in several of the northern counties. In general, well operated swine, poultry, veal, 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 land application of the wastes can result in the runoff of biodegradable matter which can rapidly consume oxygen in the receiving stream. Fish kills frequently result from such actions.

It is impossible to assess the total effect 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 impact in some areas is substantial. 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 can be washed into nearby streams during heavy rains and produce some effect.

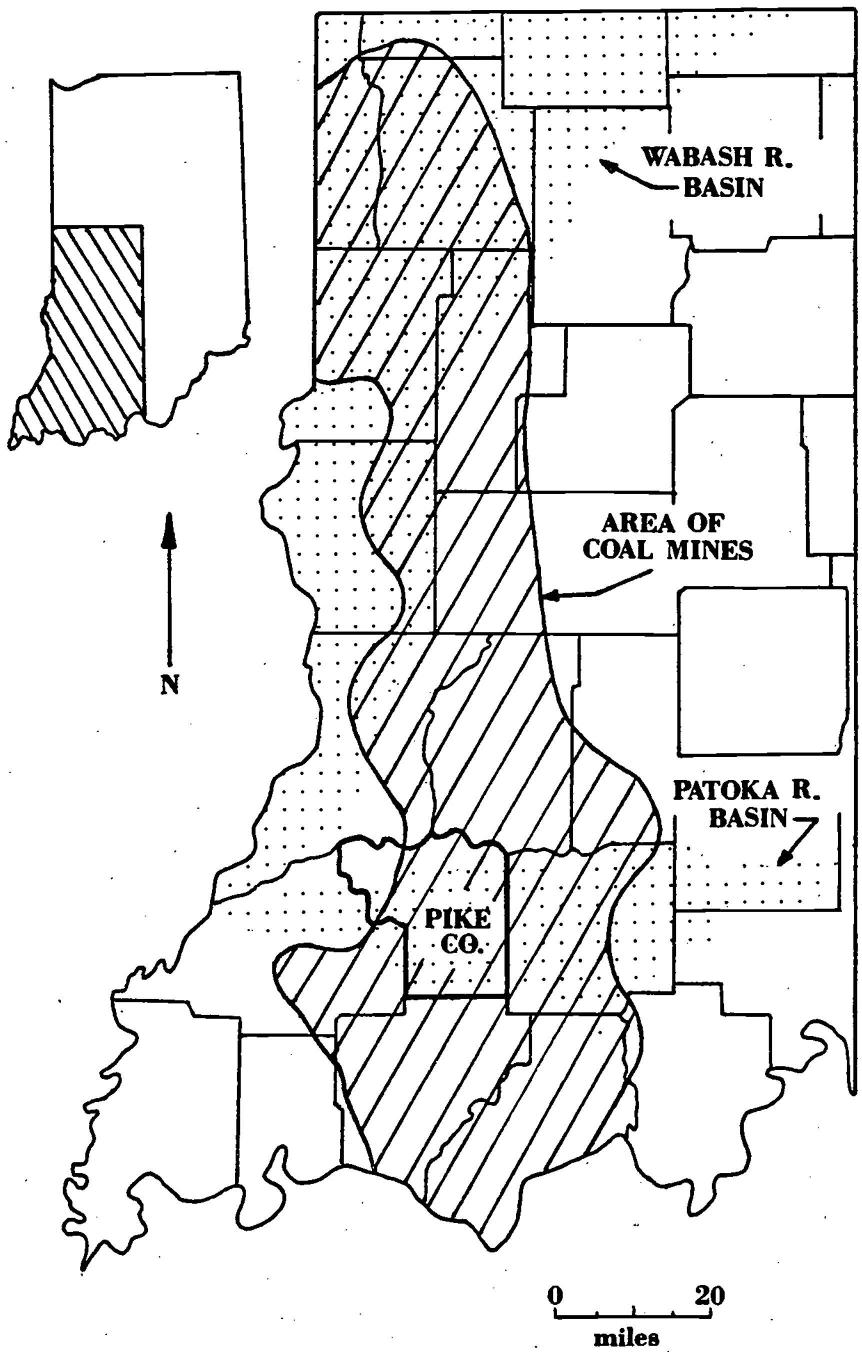


Figure 22. The southwest portion of Indiana showing the area of coal mining activity in the state.

Table 25. Portions of Wabash River and Patoka River watersheds affected by acid mine drainage (AMD) (from Derelict Lands of Indiana--1978, Indiana Department of Natural Resources).

Patoka River and Tributaries	Miles of Stream Impacted
Wheeler Creek	2
Honey Creek	0.5
Rough Creek	4
Durham Ditch	6
Enos Stream	0.5
Houchin Ditch	4
Unnamed Tributary	1.5
Unnamed Tributary	3
Unnamed Tributary	5
Unnamed Tributary	2.5
Main Trunk South Fork Patoka River	17
Stone Coe Creek	2.5
Flat Creek	5
Sugar Creek	2
Unnamed Tributary	0.5
Barren Ditch	3
Mill Creek	2.5
Unnamed Tributary	2
Hog Branch	2.5
Beadens Creek	2
Deep Mine drainage	2
Patoka River Mainstem	45
Wabash River & Tributaries	
Big Branch	3
Kettle Creek	2
Unnamed Tributary	0.5
Sulphur Creek	6.5
Big Branch	1
Buttermilk Creek	5
Mud Creek	6.5
Busseron Creek	23
Brouilletts Creek - Vermillion County	2
Honey Creek-Vigo County	26
Otter Creek-Vigo and Clay counties	10.5
Raccoon Creek-Parke County	.5
South Fork Smalls Creek-Knox County	8
Sugar Creek-Vigo County	9
Turman Creek-Vigo and Sullivan counties	3
Unnamed Tributaries to Wabash River-Vermillion and Vigo counties	1.5
Greene-Sullivan Lake #29-Sullivan County	141.5 Acres

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 at river mile (R.M.) 465.6, and then through parts of four Indiana counties to become 900 acre Huntington Reservoir, with its dam at R.M. 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, which include 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 general water quality, despite wet weather bypassing of the municipal sewage treatment plant.

Downstream from Huntington Reservoir the river is joined by the Little River, which receives the Roann lagoon system discharges. An electroplater in the town has discontinued its wastewater discharge to Cow Creek (a Little River tributary) and has re-directed the pretreated waste to the Roann sanitary collection system. Although this added contribution has not resulted in effluent violations, a potential concern is the accumulation of heavy metals in the town's sludge.

Further downstream, the Little River passes through the City of Huntington. Although the city's advanced wastewater treatment (AT) facility discharges a high quality effluent to the Wabash River mainstem, combined sewers continue to overflow into the Little River. Approximately 10 miles downstream from Huntington, the Town of Andrews operates a 0.35 mgd treatment facility which was constructed in 1984. Prior to that time, only primary treatment was provided; now, however, the new facility produces an effluent comparable to that provided by advanced waste treatment.

The Salamonie River is the first major tributary of 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 activated 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.

Approximately 10 miles downstream from Portland, combined sewer overflows from the Montpelier wastewater collection system discharge to the river. The discharge from the wastewater treatment plant appears to be satisfactory. Fifteen miles further downstream, the Town of Warren contributes well treated wastewater to the flow in the Salamonie. During wet weather, though, the severely overloaded combined sewers overflow into the river and a large volume of raw sewage bypasses the treatment plant.

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 seem to be having no appreciable effect on the stream.

The City of Wabash operates parallel treatment plants which discharge at Mile 387 directly to the Wabash River. One of the plants was constructed primarily to serve a cardboard container manufacturer. Overloading of the collection and treatment systems results in combined sewer overflows, bypasses, and even discharge of mixed liquor. The state, city and industry are currently working to solve this problem.

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. Following plant expansion, a study was conducted to evaluate impacts of the city's combined sewer overflows on the river. The evaluation indicated that there would be some oxygen depletion in the river as a result of the CSOs and that water quality standards violations might occur 3 percent of the time. Assessment of fecal coliform bacteria was complicated by an unidentified upstream source, but bacterial levels did not seem to increase appreciably downstream from the discharge points. 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 violations of water quality standards. The river and reservoir are therefore generally able to meet the uses for which they are designated.

As part of a national dioxin (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin) monitoring survey, fish were collected in 1984 from the Mississinewa River near Matthews (R.M. 57), as well as from several other stations around the state. Low levels of dioxin were found in samples of carp and smallmouth bass. In the fall of 1985, fish samples from Mississinewa Reservoir were submitted to EPA for analysis to determine the validity of those first results, but as of this writing analyses are not completed.

The Little Mississinewa River receives various wastewaters from the Union City sewage treatment plant and area industries before flowing into the Mississinewa. Within the past two years, the city has been trying to determine the source of high levels of PCBs which have accumulated in the STP's sludge. In addition, the state is continuing to investigate the situation since sediments downstream from the STP are heavily contaminated, and the levels of PCBs in the fish exceed the federal Food and Drug Administration's action level for consumption by humans. A fish consumption advisory was issued in 1985 for the Little Mississinewa River and a portion of the Mississinewa River.

The Eel River, which joins the Wabash at R.M. 354 in Logansport, and its tributaries drain portions of seven counties. This river system receives effluent from four older municipal sewage treatment facilities as well as a number of industries and semipublic facilities. In addition, the Town of Denver began operation of a totally new wastewater collection and treatment system in mid-1984 which has eliminated previous wastewater problems attributable to inadequate septic systems.

Water quality overall is adequate to sustain a notable smallmouth bass fishery, although recent studies have shown a decline in that population over a ten-year period. Since there has been a general improvement in the degree of treatment provided by municipal STPs in the watershed for the same time period and the fish flourished in "more polluted" waters, it does not seem likely that the STP discharges could be responsible for the decline of the smallmouth. Conventional monitoring has not revealed any obvious water quality problems, even though there are still some known sources of inadequately treated wastewater, such as Columbia City, where an estimated 30-40 percent of the STP influent is almost continually bypassed without treatment. The North Manchester wastewater treatment plant, which is 20 miles downstream, becomes hydraulically overloaded following precipitation events and a portion of the raw inflow is bypassed; eight combined sewers also overflow to the river.

The Town of Churubusco, which discharges to Johnson Drain (a tributary of the Eel River's headwaters) is a potential problem because it does not adequately treat its wastewaters. Established ammonia limitations are not attained by the treated waste stream, and during wet weather, infiltration and inflow (I & I) to the collection system result in bypassing of the plant and combined sewer overflows. Early in the spring of 1986, PCB contamination was found in sludge at the Churubusco STP. The source of this contamination appeared to be the BRC Injected Rubber Products site previously owned by Dana Corporation. Meetings of the state with the city, BRC Injected Rubber and Dana Corporation in April 1986 resulted in formulation of a plan to clean up this contamination.

The South Whitley sewage system is also afflicted by severe I & I, and bypassing and combined sewer overflows are a problem there, too. Further study would be required to assess any possible individual or cumulative impacts of such wet weather waste flows on the bass population. Other potential causes of the decline of the fishery could be related to nonpoint source pollutants such as pesticides or sediments carried by runoff from agricultural areas.

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.

Kosciusko County, in which a large portion of the river's headwaters originate, has been the object of an innovative wetland preservation project in the past two years. Conceived by the E.P.A., the "Advance Identification of Disposal Sites" (AIDS) program arose in response to dredge and fill proposals permitted by the Army Corps of Engineers' Section 404 process. The AIDS program was devised as a means of pre-identifying major open water and wetland sites which would be unacceptable as fill areas. The loss of some sites not identified would also be a concern to environmentalists. Direct participants in the program included the E.P.A., this agency, the U.S. Fish and Wildlife Service, the C.O.E., and Kosciusko County conservationists. The general public was informed of the process and comments were solicited. The result of the effort was the designation of one suitable disposal site as well as 15 unacceptable areas.

Water quality in the Tippecanoe River and its tributaries is typically satisfactory, and the quality of the fishery is quite high. State record sauger, walleye, and white bass have all been caught in the river.

Treatment at the Warsaw STP, which discharges to Walnut Creek (a tributary of the river), has been gradually but notably improved over the past few years. The pretreatment program which has been implemented to decrease undesirable industrial discharges to the wastewater treatment system has helped to bring toxic components of the waste stream under control. Although different metals are still present in the STP discharge, their levels are such that the effluent has been shown to be nontoxic to <u>Daphnia magna</u> in a 48-hour static bioassay; the STP otherwise also produces a quality effluent, although it is subjected to extraneous infiltration from the area's high groundwater table.

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 localized water quality problems in the tributaries. Three areas in the watershed which have caused concern in the recent past are Pike Lake in Warsaw, which drains through Lones Ditch to the Tippecanoe River; Deeds Creek, which receives wastewater from the Pierceton area and flows into Pike Lake; and Palestine Lake, which drains through Trimble Creek to the Tippecanoe.

Pike Lake and Palestine Lake were two of several from which fish and sediment samples were collected in 1985. Although other contaminants were not detected, PCBs were found in two Pike Lake sediment samples in detectable quantities, and may warrant further evaluation; fish samples have not yet been analyzed, but it is possible that they may also be contaminated by the PCBs. Fish sampling several years ago revealed the presence of heavy metals in fish collected from the West Basin of Palestine Lake, but not the East Basin. Williamson Ditch, which flows into the West Basin, receives wastewater from an electroplater in Burket. Sediment sampling in 1985 confirmed the presence of high levels of heavy metals in the West Basin, and a PCB concentration of 3.8 parts per million. Fish flesh analyses, when finalized, will help determine the severity of the problem, but these concentrations are of concern.

In 1985, another electroplater, in Pierceton, was required to remove metals contaminated sludges and sediments from Deeds Creek downstream from the wastewater outfall. In order to prevent further such discharges, the facility is in the process of upgrading its treatment equipment.

Mill Creek, which flows into the Tippecanoe River at Mile 56.8, receives effluent from new waste stabilization lagoons constructed in 1984/85 by the Town of Kewanna; inadequate septic systems have now been eliminated. In contrast is the overloaded condition of the Rochester STP which discharges to a different Mill Creek approximately 40 miles upstream on the Tippecanoe. Inadequately treated wastewater discharged from this facility has impaired designated uses of the creek.

Several miles downstream on the Tippecanoe, at Mile 64.0, the Town of Winamac has begun expansion of its treatment facilities to alleviate hydraulic problems which cause unacceptable discharges at times. 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 there is the wet-weather bypasses which enter Lake Freeman from Monticello municipal sewers.

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 pollution events are generally attributable to improper disposal of the accumulated 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. Improvements in the Kokomo sewage treatment facility have resulted in a high quality effluent and higher water quality downstream. Improved waste treatment at several area industries has also contributed to better 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 from Kokomo.

Comparisons of data from 1974 to 1976 with that from 1984 and 1985 show that concentrations of unionized ammonia, fecal coliform bacteria, copper, and zinc have dramatically decreased while dissolved oxygen concentration have increased. Violations of state water quality standards, which were once 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 improve still more.

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. 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 "State Resource Waters" which "...shall be maintained in their present high quality without degradation." Unfortunately, in August 1985, a massive fish kill occurred in the South Fork of Wildcat Creek. The unidentified agent responsible apparently entered the stream in the Frankfort area and killed virtually every fish for approximately 15 miles. The total of 61,000 dead fish included many thousands of sizeable gamefish.

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 reach which has been the object of an extensive sampling and computer analysis program designed to resolve disagreements between the State of Indiana and the major industrial dischargers regarding effluent limitations. The necessary data were collected and a consultant was employed by the Mid-Wabash Industrial Consortium to develop 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 in the past. Prior to the mid-1970s, poorly treated wastewater 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. Dr. James Gammon (pers. comm.) of DePauw University, in a not yet released study of the 1984-85 fish populations of the Middle Wabash River, has indicated that a significant increase has been observed in the quantities and species diversity of fish since 1973. This change became particularly evident in 1984, and even more so in 1985 when twice as many fish were collected as the previous year.

The Lafayette sewage treatment facility has been upgraded and expanded since 1976 and now discharges a highly treated effluent. An enforcement action brought by U.S. EPA against Lafayette for their failure to develop an acceptable pretreatment program in the required timeframe has recently been resolved, and Lafayette now has an approved program which it is currently implementing. Most industrial dischargers have also improved their treatment processes, and water quality in this reach of the river has improved. Fish collections made since 1979 in conjunction with the CORE program at the station below Lafayette (WB-292) have also indicated that the fish community is improving in this reach, which supports Gammon's findings. 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 station samples from areas where water quality is relatively good.

Macroinvertebrate data from Hester-Dendy (artificial substrate) samples from this station (since 1979) are generally comparable to the samples collected upstream from Lafayette and indicate relatively good water quality. However, some pollution intolerant species are less abundant at this downstream location.

A more significant 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 in this discharge have accumulated in fish and sediment in the streams and have rendered the fish unsuitable for consumption. The state and the responsible industry are continuing to work together to remedy the situation; PCBs are still found at levels greater than 1 ppb in stormwater runoff from the facility.

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." In March 1984 a fixed water quality monitoring station was established at State Road 55 near Pine Village to measure the water quality of Big Pine Creek just upstream of the "Exceptional Use" reach. Indications of unpermitted sanitary discharge, perhaps from septic tanks, had been noted in the area, but data collected at this station indicate good water quality. The stream flows into the Wabash River near Attica.

Approximately seven miles downstream from Big Pine Creek's confluence, the Wabash River is joined by Bear Creek which, along with two of its tributaries, is another "Exceptional Use" stream. One of those tributaries has eroded away the sandstone bedrock to form "Portland Arch," which is located in an area now designated as a nature preserve.

Coal Creek joins the Wabash River at Mile 255.4. One of its tributaries, the East Fork, receives the wastewater discharge from Waynetown's extended aeration facility. A biological survey in 1985 disclosed that the discharge is adversely affecting the receiving stream, which supports a smallmouth bass fishery upstream. Aquatic life was absent for several hundred yards downstream from the outfall, despite acceptable dissolved oxygen concentrations, indicating possible chlorine or ammonia toxicity.

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 River (2) 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, Illinois area is compounded downstream by lateral erosion.

Approximately 5 miles downstream from the Big Vermilion River confluence, the 1,075 megawatt Public Service Indiana (PSI) Cayuga electrical generating station utilizes the Wabash river for once-through cooling. The potential effect of the plant is a concern because a major portion of the river's flow may be withdrawn for cooling purposes. Obviously, such a situation could have a disastrous impact on the aquatic biota in the river bend between the intake and discharge, as this part of the river could be essentially dewatered.

More controversy arises from the more usual, day-to-day operations of the plant and the 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 cooling water intake. The issues would be much simpler to resolve if it were not for the fact that the oxygen-retaining capability of the river is already limited by the increased temperature. Intensive survey data have revealed that a significant oxygen "sag" occurs in the section of the river between Cayuga and Montezuma. The exact cause of the depletion has not yet been ascertained, but it is related to a combination of factors, including a rather high sediment oxygen demand. Downstream from this reach, 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 significant industrial and municipal discharges of oxygen-consuming substances at various points along the river as far downstream as Terre Haute. The NPDES permits reissued to PSI in September 1985 for both power plants required, among other things, the installation of closed cycle cooling. This would eliminate the heated water discharge and substantially reduce the impingement and entrainment effects of the cooling water intakes. PSI has challenged these requirements.

Sugar Creek, the next major tributary downstream, enters the Wabash from the east. Overall, water quality in the stream'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 Thorntown, where illegal sewer connections have been eliminated to bring the town's discharge into compliance with NPDES permit limits. Improvement has also been noted downstream at Darlington and Crawfordsville. 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 (2), 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 stream from agricultural fields. They found the stream'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 stream's quality is good and it is an important recreational resource for "...thousands of campers, canoeists, and fishermen."

Indian Creek is an "Exceptional Use" tributary which joins Sugar Creek at Mile 24.95. Along with its tributary, Clifty Creek (also designated for "Exceptional Use"), the stream has formed dramatic 100 foot high ridges ("backbones") within the confines of the Pine Hills Nature Preserve. Water quality in these streams has been historically good.

Big Raccoon Creek, the next Wabash River tributary of significant size, is dammed approximately halfway down its length to form 2,070 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 Town of Ladoga's old 0.25 mgd trickling filter plant continues to discharge an undisinfected effluent to the stream, approximately 20 miles upstream from the reservoir. This plant, which serves a population of about 1,150, has not had a disinfection system and has yet to secure funds for construction of such facilities.

At R.M. 230, the Wabash River receives wastewater from the 1.0 mgd Clinton STP. In addition, extensive combined sewer overflows and bypassed raw sewage resulting from stormwater inflow and inadequate sewers enter the river. As the river flows downstream through Terre Haute it receives treated wastewaters from the municipal sewage treatment facility and industrial dischargers. Coal Creek, which enters upstream, and Sugar Creek, which joins the Wabash downstream from Terre Haute, contribute acid mine drainage to the river. Biological data collected at CORE stations indicate that certain fish species are absent or numerically depressed both above and below Terre Haute, at least during the summer and fall. This section of the river is the third (after the Lafayette and Montezuma areas) where the fish community seems to be adversely affected by human activity. Macroinvertebrate samples collected in Terre Haute and downstream at Darwin, Illinois are similar to each other, and, on the basis of the lack of intolerant species, indicate only "fair" water quality.

Terre Haute is currently involved in an enforcement action with U.S. EPA due to their failure to develop an acceptable pretreatment program in the required timeframe. The city has now developed an approvable program, and it is expected to be implemented in the summer of 1986. However, the enforcement action has yet to be resolved. The implementation of this program should result in a better quality sludge and effluent from the wastewater treatment plant and reduce the impact of the effluent on the river.

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. 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 20 miles downstream from Terre Haute, the river receives cooling water from the 420 megawatt Indiana & Michigan (I&M) Breed generating station and then, after 10 more miles, from an electrical generating plant at Hutsonville, Illinois. Turman Creek, which flows into the Wabash at about the same point, is the receiving stream for the Farmersburg STP. Although the plant operates adequately, wet weather infiltration and inflow of the relatively new sewer system causes hydraulic overloading of the plant, which results in bypassing that has proved detrimental to the creek. There is little, if any, effect on the Wabash River. Ten miles further downstream, 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 the Hoosier Energy 980 mw power plant, also serves as a fishing lake. The Indiana Department of Natural Resources stocked the completed reservoir with a mixture of game fish and manages the reservoir for sport fishing. Plant operation began in 1982, and studies to determine how the heated water from the plant is affecting the fishery are continuing.

The next major downstream tributary of the Wabash River 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. Discharges from these mines are generally in compliance with their NPDES permit limits. However, there are also abandoned mining operations in the area. 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 affected by drainage from an abandoned strip mine and supports almost no aquatic life for most of its length. The Indiana Department of Natural Resources will begin activities in the spring of 1986 designed to reclaim the mine waste area which is contaminating the creek. 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 significant impact on the water quality of the Wabash. There are, however, wet weather combined sewer overflows to City Ditch which present a persistent problem. 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 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. The Patoka River, 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 22). 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. (Table 25 shows the number of stream miles affected by mine drainage.)

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 water must be filtered through carbon and subjected 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 to compensate for evaporative losses.

For the remaining 80 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 and possibly some problems associated with oil production.

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 23). The major tributaries to this river 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 in the West Fork of White River Basin 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 enforcement of 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 has resulted in similar water quality improvements downstream of Indianapolis.

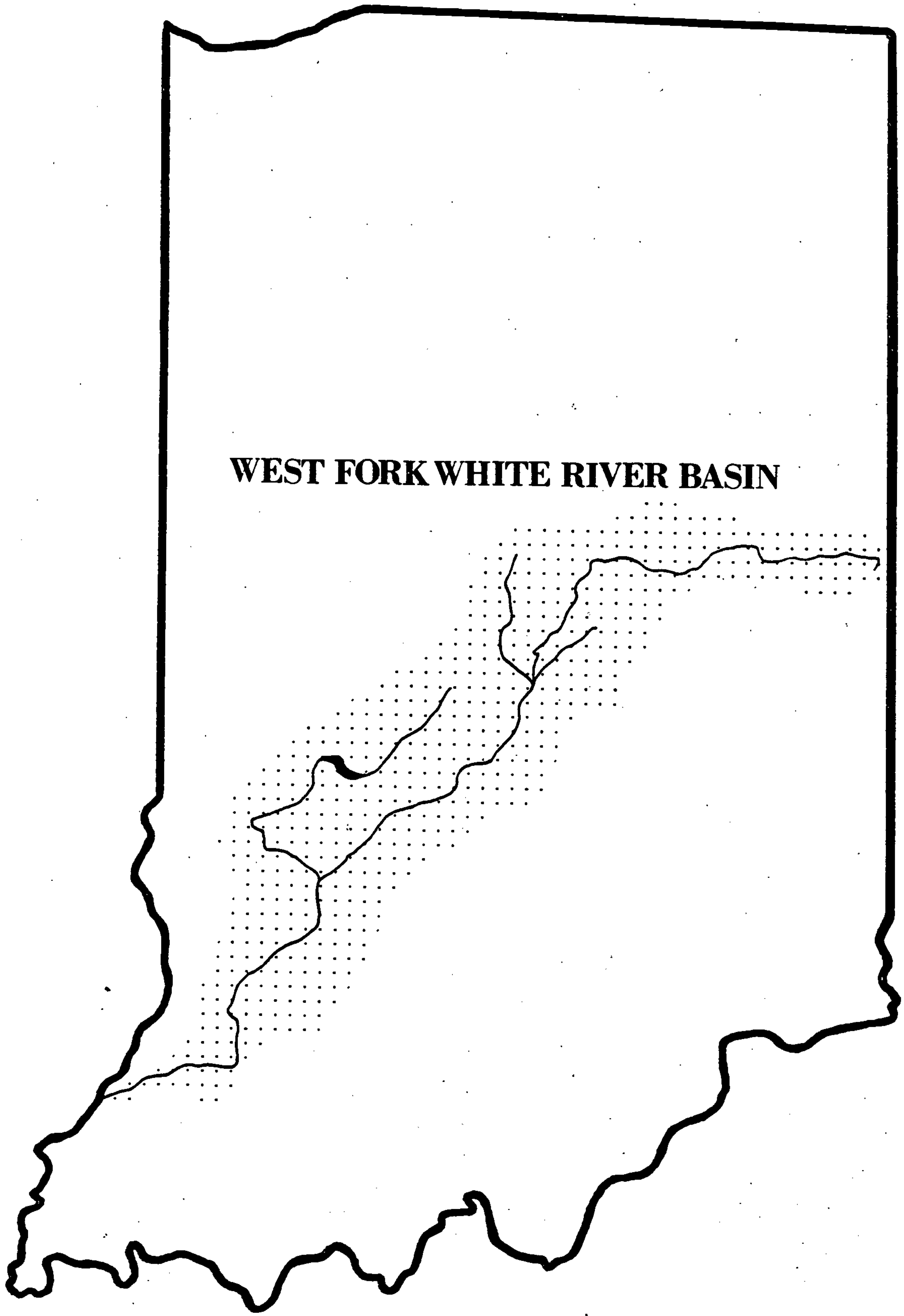


Figure 23. West Fork White River Drainage Basin.

Fixed water quality station WR-350 is located on the West Fork of White River upstream of Winchester. The standard for fecal coliform bacteria has been violated at this station in about 20% of the samples from 1978 to 1983. No violations of the standard were found from 1983 to 1985.

Station WR-350 is also a CORE station. Collections of fish and aquatic invertebrates show that the water quality is good at this station. At least 15 species of fish have been collected including bass, sunfish, grass pickerel, darters, and several kinds of minnows. Artificial substrate samples yielded several genera of clean water aquatic insects.

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 few other water quality violations have occurred here in recent years, and water quality is sufficient to support the designated uses of the West Fork of White River at this locality. From 1981 to 1983 the fecal coliform, total chromium, and phenol standards were exceeded in less than 10% of the samples. In 1984 and 1985 there were no total chromium nor phenol violations, but the fecal coliform standard was exceeded in about 17% of the samples. An excellent smallmouth bass fishery is reported to exist in the West Fork of White River within the northern city limits of Muncie.

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. Muncie currently has additional sewage treatment facilities under construction with an estimated completion date of May 1986.

Although improvements in water quality were seen when comparisons were made between 1981-83 data and data collected before 1981, there have been no substantial changes since 1983. Unionized ammonia values in excess of the standards have not been found since 1981. However, dissolved oxygen violations still occur about 10% of the time and fecal coliform violations still are found about 30% of the time. Additional improvements in water quality are expected after Muncie completes construction of the additional advanced treatment facilities which must be operational by May 1986, according to a consent decree recently signed with U.S. EPA. As part of the consent decree, the Muncie Sanitary District also agreed to pay a $75,000 fine for water quality violations that have occurred since 1981.

Although fish kills have occurred frequently in the reach of the White River below Muncie in the past, the frequency of these kills has been greatly reduced since the mid-1970s, and improved water quality has permitted healthy, diverse fish populations to develop in this portion of the river. Unfortunately, periodic fish kills still occur, and in September 1985 a large kill involving more than 60,000 fish occurred in a reach of the river extending downstream from Muncie approximately five miles. Killed were significant numbers of smallmouth bass, largemouth bass, rock bass and other centrarchids as well as suckers, carp, darters and minnow species. The fish kill was caused by low dissolved oxygen concentrations resulting from combined sewer overflows following 0.8 inches of rain. Although EPA turned down funding for a CSO project for Muncie, the state and the city are currently negotiating a consent decree to address these CSO problems. Once these problems are addressed and solved, the periodic fish kills should be largely eliminated and a permanent, high quality fish community should thrive in this reach of the river.

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. The plant is in compliance with current NPDES permit limits, however, excess NH_3 in the final effluent has been reported recently.

Water quality station WR-295 is located in Anderson upstream from the Anderson STP discharge. The data show few water quality problems with the West Fork of White River in this segment except for fecal coliform bacteria. The fecal coliform standard was exceeded in about 19% of the samples from 1981 to the present. Combined sewer overflows may be one reason for these violations.

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. Although partial body contact recreational uses would appear to be only partially supported at this station due to violations of fecal coliform standards (20%-30%) in samples taken since 1983, aquatic life uses are supported in this reach of the river.

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. Water quality in Pipe Creek seems to be improving, based on a decrease in fish kill reports.

The small communities of Atlanta, Sheridan, Arcadia, and Cicero in Hamilton County and Tipton (in Tipton County) all have sewage treatment facilities that discharge upstream from or directly 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. Sheridan has sewer expansion under construction, and the STP is also being upgraded. The plant's final effluent has improved considerably in quality.

Morse Reservoir is a highly eutrophic body of water, 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 flows to the West Fork of White River.

Fish and sediment were collected from Morse Reservoir as part of the 1985 toxics program. The fish samples are still being analyzed at this time. Sediment samples contained detectable levels of the pesticide dieldrin, but these levels were at or only slightly above background levels.

Limnological measurements made during 1985 were compared with results of the 1973 National Eutrophication Survey of Morse Reservoir and an ISBH survey of 1975. This comparisons show that Morse Reservoir has improved in some parameters since the early 1970s. Total nitrogen decreased in all parts of the reservoir and total phosphorus decreased in the middle basin. The reservoir's water was clearer in 1985 than in 1973, and algal numbers were much lower. Dominance had shifted from blue green species in 1973 to diatoms in 1985. Lake conditions usually become worse as an impoundment ages and it becomes more eutrophic. Morse Reservoir appeared much better in 1985 than in 1973, and its number of eutrophy points fell from 31 to 22.

Noblesville, Westfield, Carmel, and Fishers are other towns and municipalities 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 scheduled for expansion. The hook-up is scheduled for completion in April of 1986. Construction to expand Carmel's STP to 8.0 mgd is scheduled to start in July of 1986 and is expected to be completed in January of 1988. The sewage treatment facilities of Noblesville and Fishers are reported to be consistently in compliance with NPDES permit limits.

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 identified as the Firestone Company in Noblesville. The company has recently completed a PCB study of Stoney Creek in an effort to determine the extent of the problem and the proper cleanup procedures to implement. The company and the state are working on procedures for cleaning up sediment hotspots in the creek.

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. Several fishing outings on the West Fork of White River in Indianapolis were arranged for Indianapolis area children in the summer of 1985.

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 mg/l. 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 during the 1981-83 period was only 4,300/100 ml. In 1984 and 1985 the fecal coliform standard was exceeded in 11% of the samples, and the highest value found was 2,300/100 ml. There were no violations of any other standard.

The fixed water quality monitoring station IWC 6.6 is located at the point where the Indianapolis Water 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 1981-83 period no water quality problems other than three fecal coliform violations were found, and these violations had greatly decreased (high value 5,100/100 ml). In 1984 and 1985, there was only one violation of the standard for fecal coliform (2,900/100 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 problems.

The Broad Ripple station (IWC 6.6) is also a CORE station monitored for 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 including several species of suckers, several species of centrarchids (bass and sunfish), catfish, and minnows also exists at this locality. However, fish tissue samples which have been analyzed for toxic substances show that chlordane and PCBs exceed the FDA action levels in some fish at this locality.

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 old Washington Street bridge after flowing underground for several hundred feet. 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 even though the State Board of Health has included this water body in a fish consumption advisory. 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 despite the fish consumption advisory that has been issued for fish caught between Noblesville and Martinsville. A catch and release program is being promoted by certain sportfishing groups that fish the river.

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.

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 problems with 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 constructed 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 for this area.

The fixed water quality monitoring station on Eagle Creek at Zionsville (EC-21) reflects water quality upstream of Eagle Creek Reservoir. Since 1980, only occasional fecal coliform standards violations (about 10% of the samples) have occurred here, and the stream in this reach should support its designated recreational and aquatic life uses.

Eagle Creek Reservoir is a heavily used water supply and recreational impoundment. It is bounded by the large Eagle Creek Park and has a beach and exclusive residential areas around its shoreline. Thousands of bank and boat fishermen use the reservoir, although it is not known as a particularly good fishery.

Fish and sediment samples were taken from Eagle Creek Reservoir in 1985 to be analyzed for toxics. The fish samples are still being analyzed, and results of sediment analyses revealed no values for toxic pollutants that were of concern.

Limnological measurements were also made throughout the main basins of the reservoir in 1985. These limnological results, when compared with survey results of 1975 and 1978 indicate that some conditions have improved, and that no lake uses are impaired. Total phosphorus showed a decline is some basins of the reservoir, and algal counts have also declined. Dominance appears to have shifted from blue green algae species to diatoms.

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 implementing these practices. These efforts have helped reduce sediment and nutrient loadings to the reservoir.

Eagle Creek flows southeast from Eagle Creek Reservoir to its confluence with the West Fork of White River about 1.5 miles downstream of Raymond Street in south Indianapolis. In this reach, the Speedway sewage treatment facility discharges to Eagle Creek. The facility was constructed in 1955 and upgraded in 1972. However, additional operational improvements and upgrading have occurred since 1972 which have improved the condition of Eagle Creek downstream of the discharge. The substrate in this area is clean sand and gravel, and there are no objectionable deposits of sludge or Sphaerotilus growth. Dissolved oxygen levels are high enough to support aquatic life and eliminate objectionable odors.

A biological study of Eagle Creek was conducted in the fall of 1985 to help determine if more stringent permit limits were needed for dischargers to this stream. The study indicated that moderately diverse benthic communities of aquatic invertebrates exist in Eagle Creek. The communities are adversely affected in the immediate vicinity of the Speedway STP discharge, but soon recover, only to be further impacted in downstream segments by industrial outfalls, which seriously degrade the aquatic community all the way to the stream mouth.

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, lower Eagle Creek has received the effluent from the Speedway sewage treatment facility and three industrial discharges. 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. From 1981 to 1983, concentrations of copper and fecal coliforms were reduced (maximum values of 120 ug/l and 54,000/100 ml, respectively), but the frequency of values above satisfactory levels remained about the same--48% for copper and 37% for fecal coliforms. No dissolved oxygen violations were found. In 1984 and 1985, only one copper sample (5%) exceeded 43 ug/l, but fecal coliform violations still occurred in about 35% of the samples.

Unionized ammonia concentrations still appear to be a problem at this station. Data collected since 1981 from this fixed water quality monitoring station indicate that 20% to 60% of the samples collected each year have unionized ammonia concentrations greater than 0.05 mg/l. Although high ammonia values are found in the industrial discharges, much of the problem does not originate with the industries. Groundwater from wells used as a raw water source for their plant processes contains high levels of ammonia (20-50 mg/l). The state and the industries are now negotiating ammonia limits for these facilities. 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 (one municipal and three industrial dischargers) in order to prevent toxicity to aquatic life and meet dissolved oxygen requirements during low flow periods. The economic impacts of these ammonia removal requirements are still being evaluated.

Fall Creek, another tributary which joins the West Fork of White River in Marion County, originates from several headwater streams in Madison and Henry counties. Until recently, Fall Creek and its tributaries received wastes from Middletown, Markleville, Pendleton, the Pendleton Reformatory, Fortville and, periodically, the Brookside Corporation before it entered Geist Reservoir in Hamilton and Marion counties. In November of 1985, Pendleton regionalized into the Fall Creek Regional Waste District which also serves the Town of Ingalls and the Pendleton Reformatory. This will help reduce the nutrient loading to Fall Creek and Geist Reservoir since phosphorus removal will be required.

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. In 1985, fish and sediment were collected from Geist Reservoir for the toxics program. The fish tissue is still being analyzed, and sediment analyses revealed that only PCB concentrations (160-180 mg/kg) were slightly above background levels.

Limnological studies were also conducted on Geist Reservoir in 1985. When the results were compared with the results of the EPA National Eutrophication Survey (NES) of 1973, it was found that Geist Reservoir has apparently not aged as rapidly as was anticipated. Total phosphorus levels of epilimnal waters had declined in the dam pool and the middle basins. Water column total phosphorus concentrations remained about the same, but nitrogen and ammonia levels had declined throughout the reservoir. Algal numbers were not excessive and diatoms were usually dominant over blue-green algal species. No lake uses were impaired.

These recent data support the continuance of a trend first seen when data collected from Geist Reservoir in 1963-64 were compared to the 1973 NES data. This comparison showed that substantial phosphorus load reduction had occurred over this period even though the sewered municipal population increased by roughly 50% during that time. These reductions were attributed to nonpoint source controls and the Indiana phosphate detergent ban. Although the population in this area has continued to grow, these previous actions plus the phosphorus removal requirements at the various municipal wastewater treatment plants have worked to slow the eutrophication process in Geist Reservoir over this time period.

Downstream from Geist Reservoir, Fall Creek flows southwest 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 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. Since 1981, few violations of water quality standards have been found at this station. Fecal coliform exceeded the standard in about 20% of the 1981-83 samples, but, in 1984-85 samples, only one sample (6%) was above the fecal coliform standard. Recent connections of the Fort Harrison and Lawrence sewage treatment facilities to Indianapolis have helped improve conditions in Fall Creek.

The extensive amount of nonpoint urban runoff from Indianapolis' streets, parking lots, rooftops, and crowded dwelling places at times contribute to the degradation of Fall Creek. However, considerable progress has been made in the last few years in eliminating some combined sewer overflows and illegal discharges, and this has helped improve the water quality in Fall Creek.

Pogue's Run, which discharges to the West Fork of White River in the Indianapolis 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. The majority of the outfalls are storm sewers which discharge rainwater and snowmelt water. Stormwater 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 pollutants 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 in Marion County 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. In the past, the West Fork of White River downstream of the Indianapolis sewage treatment plants could not adequately assimilate the treated wastewater 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 found downstream of the sewage treatment facilities. 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, seven extensive fish kills occurred in the river in the Indianapolis area and one extended downstream as far as 150 miles. Since 1981, only one minor fish kill has occurred.

The West Fork of White River has the natural characteristics necessary to support a well-rounded warm water fishery. However, fishing, except for carp, was relatively poor immediately downstream of Indianapolis. Boating, canoeing, and camping along the river were not 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. However, combined sewer overflows may periodically degrade the water quality of the West Fork White River until extensive corrections are made.

The fixed water quality monitoring station at Henderson Ford (WR-205) reflects river water quality a short distance below Indianapolis. Comparisons of data for several water quality parameters collected in 1981-83 (before completion of the new Indianapolis sewage treatment plants) and in 1984-85 (after completion of the plants) show some definite improvements. In the 1981-83 period, unionized ammonia violations occurred about 20% of the time, dissolved oxygen violations occurred about 10% of the time, and fecal coliform violations occurred about 40% of the time. In the 1984-85 period, no unionized ammonia or dissolved oxygen violations were found, and fecal coliform violations decreased to 15%. Unionized ammonia values now average less than 0.005 mg/l (compared to 0.037 mg/l in 1981-83), average dissolved oxygen values have increased to almost 10 mg/l (from 7.5 mg/l in 1981-83), and average fecal coliform concentrations are less than 2000/100 ml (6600/100 ml in 1981-83).

The station at Henderson Ford (WR-205) is also a CORE station and biological data are collected here. 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 and PCBs exceed FDA action levels in the fish sampled. Macroinvertebrate samples collected at this station have been dominated by pollution-tolerant midge larvae, and the diversity has been low. In 1985 samples, 7 species of fish were collected at Henderson Ford, the most numerous being carp and channel catfish. The macroinvertebrate sample was slightly more diverse than the 1983 sample, and preliminary information on macroinvertebrate data collected by the United States Geological Survey as part of a "before and after" study indicates rather significant improvements in the macroinvertebrate community in this reach of the river since the new treatment plants have been in operation. As yet, no extensive studies of fish populations have been done since the new plants began operation, but improvements in the fish community are also expected to be seen.

The water quality at the fixed water quality monitoring stations at Centerton (WR-197), Paragon (WR-185), and Spencer (WR-166) on the West Fork of White River show the same trends as the station at Henderson Ford (WR-205). The 1984-85 data indicate that water quality standards violations for dissolved oxygen and unionized ammonia are almost non-existent, and fecal coliform violations occur in 20% or less of the samples collected. Average fecal coliform concentrations are less than half of the 1981-83 levels.

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 before it joins the West Fork of White River near Centerton.

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. Both Mooresville and Danville are in the process of upgrading their wastewater treatment facilities.

The East Fork of White Lick Creek originates in a heavily settled and industrialized area in western Marion County and flows south to its confluence with White Lick Creek near Mooresville. The stream has good fish habitat and high potential for recreational use.

The East Fork of White Lick Creek 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. Quemetco has installed an ion-exchange treatment facility which has decreased metals concentrations. Quemetco's current permit is under adjudication, and a consent decree is being negotiated.

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 sewer 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.

The fish and other aquatic life of White Lick Creek were assessed in the segment of the stream nearest to its confluence with West Fork of White River in 1984. Both the fish and macroinvertebrate communities were diverse and indicated water quality was usually good in White Lick Creek when it entered the West Fork of White River.

The Eel River, which enters the West Fork of White River near Worthington, 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.

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 unionized 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.

Thus, 1984-85 data collected since the new Indianapolis sewage treatment facilities have become operational indicate that the entire portion of the West Fork of the White River below Indianapolis supports the designated aquatic life use and partially supports the designated recreational use. It should be noted, however, that the entire West Fork of the White River from Noblesville down to Petersburg (about 220 river miles) is currently affected by some type of fish consumption advisory. In this area, the pollutants found in fish tissue in excess of FDA action levels are chlordane and PCBs.

The West Fork of White River is joined by the East Fork of White River just upstream of Petersburg in Pike County. 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 discharges. At these times, fish populations may leave certain parts of the river. These occasional high temperatures are being addressed in the new proposed NPDES permits for these plants.

The Petersburg 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 include 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 normally 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 generally good water quality and are typical of medium to large 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 well operations and active and abandoned strip mines.

East Fork of White River Basin

The East Fork of White River drains about 5,600 square miles of southern Indiana (Figure 24). Roughly 15,000 miles of streams are included in the basin. Sugar Creek, Big Blue River, Driftwood River, Flatrock River, the Muscatatuck River, and Salt Creek are the river's major tributaries. The largest cities in the watershed (populations greater than 15,000) are Columbus, Seymour, Bloomington, New Castle, Shelbyville, and Bedford.

The topography of this basin ranges from flat to rugged as it crosses seven of southern Indiana's eight physiographic regions. The basin also 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 of White River Basin have been minimal.

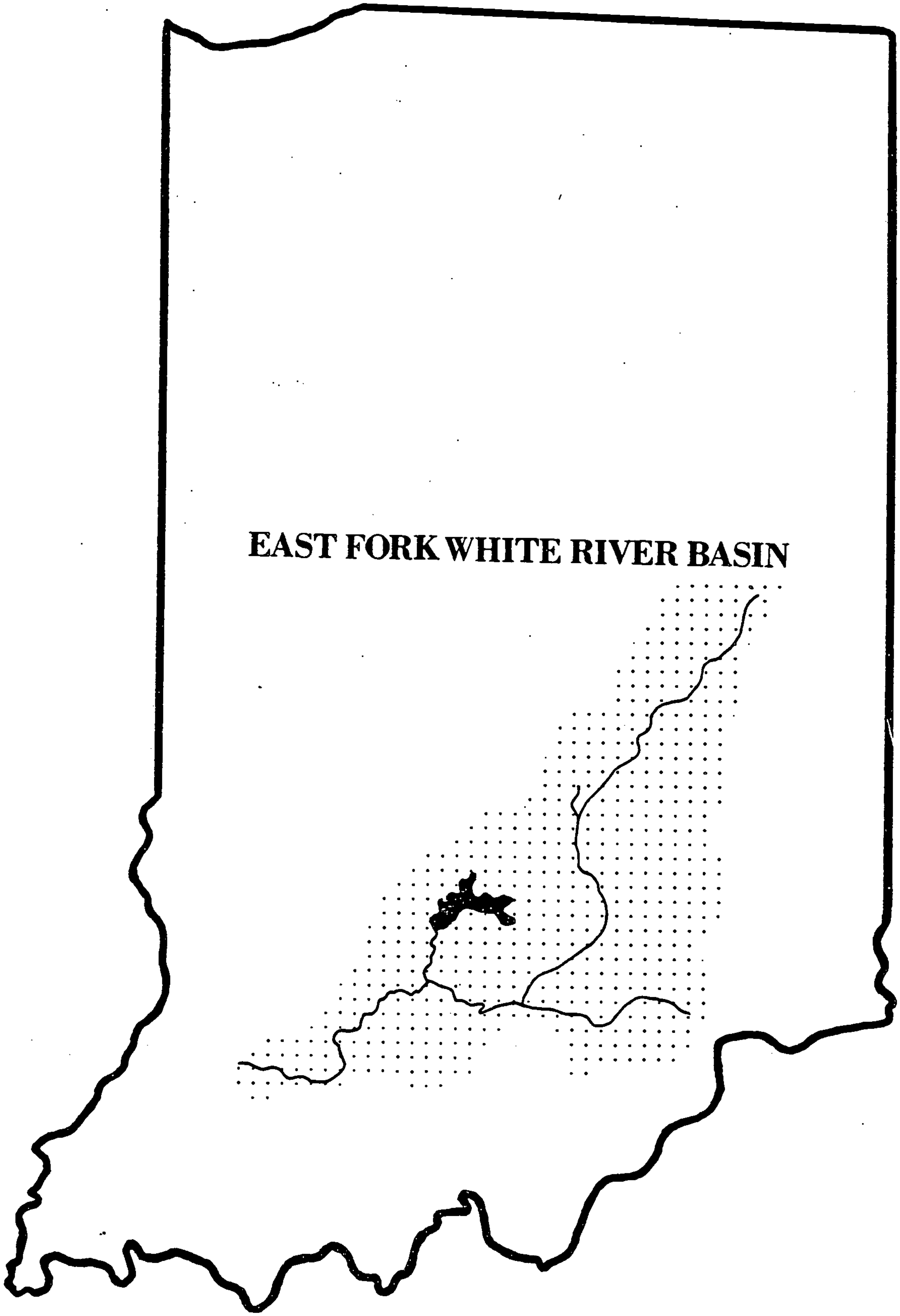


Figure 24. East Fork White River Drainage Basin.

The East Fork of White River has always been an important sport fishery. State records for flathead catfish, freshwater drum, rock bass, flier, sucker, and smallmouth bass have all come from this river or one of its tributaries. The reputation of the river to support large fish continues to be justified, as the state records for sucker and smallmouth bass were set in 1984 and 1985. An important fresh water mussel fishery also exists in the lower portion of the river. The shells of certain mussels are used in the cultured pearl industry and are commercially valuable.

There are drinking water supply intakes on the East Fork of White River at Bedford, Mitchell, and Seymour. Surface water supplies for drinking are also found at Paoli, West Baden, Bloomington, Westport, North Vernon, and Scottsburg on various tributaries of the river. Therefore, the water in this basin must meet the raw water standards for potable water supply at the municipal intakes.

The river and several of its tributaries are popular canoeing streams. The 1983 Indiana Canoeing Guide prepared by the Department of Natural Resources lists the Driftwood, Flatrock, and Muscatatuck rivers as especially good for this sport. At least one commercial canoe livery operates within the basin. Like most other Indiana Streams, the river is designated for partial-body contact recreation and must meet bacterial standards for this use as well.

The Lost River and many of its tributaries in Orange and Martin counties have recently been designated for exceptional use. This designation should help preserve the exceptional water quality in the watershed and help protect several unusual aquatic animals, including blind cavefish, which inhabit the river. Several streams in the basin have recently been designated for limited use, based on their lack of habitat to support a diverse fishery. These include Plasterers Creek at Loogootee, portions of Brewer's Ditch at Whiteland, and portions of Ackerman Branch and Mill Creek at Jasper.

There are eight fixed water quality monitoring stations in the basin. Water quality is suitable for aquatic life at seven of the stations but is partially impaired by chromium violations at the Big Blue River station downstream from New Castle (BL-64). Use of the water for partial-body contact recreation is also impaired at this site (43% of the 1984-85 samples exceed the standard), as well as at station BL-0.1 on the Big Blue River near Edinburgh (14% of the 1984-85 samples exceed the standard). Water quality is generally satisfactory as a raw water source for potable water supply at all of the drinking water intakes on the East Fork of White River and its tributaries.

Besides the normal chemical monitoring of water quality, several biomonitoring studies were recently conducted in the basin. In 1983, the state collected fish, mussels, and sediments from 32 locations in the East Fork and some of its tributaries to measure levels of metals, pesticides, PCBs, and other toxicants. Apparently healthy aquatic communities were observed at most locations and levels of toxicants in sediment were near normal or "background" concentrations. Exceptions occurred at three locations: Clear Creek near Bloomington, Pleasant Run near Bedford, and Big Blue River near New Castle. The first two sites had fairly good fish communities but sediments were still somewhat contaminated with PCBs from industrial sources identified in the 1970s. The site near New Castle had noticeably depressed fish populations and the sediments showed elevated levels of certain metals. Bioassays indicate that the steel mills in New Castle are the probable sources of this impairment. Thus, biological monitoring confirmed the impairment predicted by the fixed water quality monitoring station samples at BL-64, as previously discussed.

Fish and macroinvertebrates were also collected from the CORE site on the East Fork of White River immediately below Williams Dam in 1985. Regular biomonitoring has occurred at this site since 1979. The macroinvertebrate sample was extremely diverse and many pollution intolerant species were present, indicating excellent water quality. The fish population also appeared to be healthy. Analysis of fish for metals, PCBs, and pesticides has not yet been completed for this most recent sample, but samples taken in 1983 indicated that consumption of fish from this area should be limited because of chlordane and PCB contamination (see Table 7).

Five fish kills were investigated in the East Fork of White River basin in 1984 and 1985. Over 6,700 fish were involved in one of the kills. Agricultural practices, including manure, herbicide, and fertilizer handling were responsible for all of the fish kills. No point source wastewater discharges were involved.

Several recent improvements in water quality have been noted in this basin. During 1984 and 1985, three of the eight monitoring stations had no violations of the fecal coliform bacteria standards for recreational uses. Previously, all of the stations had at least occasional violations. Also, there were no violations of dissolved oxygen, oil and grease, or cyanide criteria in the last two years. All of these criteria were violated occasionally at one or more sites between 1981-83. Therefore, although water quality was already fairly good in the basin, improvements continue to be made at locations where new or upgraded sewage treatment facilities have been put into operation. A new treatment plant at New Palestine in Hancock County began operation in 1985 and reportedly produces an excellent effluent. This facility should correct one water quality problem that existed in the upper Sugar Creek area. Upgrading of the sewage treatment plant at Morristown in Shelby County was completed in 1984. This facility seldom met its NPDES discharge limits prior to the completion of the new project. Now, the average BOD concentration of the effluent has been reduced by half and the plant regularly meets its limits. Consequent improvements in water quality of the Big Blue River is expected because of better sewage treatment at Morristown.

Water quality problems continue to exist in streams with inadequately treated wastewater discharges. Municipal sewage treatment plant effluents at Loogootee, Brownstown, Orleans, and Paoli are among the worst of these discharges, providing little more than primary treatment and continuously violating their discharge permits. Municipal facilities at Greensburg, Mitchell, North Vernon, and Nashville often meet permit limits but chronic combined sewer overflows, leaking sewers, or failing lift stations frequently allow untreated sewage to reach streams and cause water quality violations.

Malfunctions at a lift station at Greensburg have often caused fish kills in nearby Greensburg Reservoir, a 23 acre state-owned lake west of the city. Frequent discharges of untreated sewage have also contributed to rapid nutrient enrichment and caused the lake to be among the most eutrophic in the state. Sediments collected from the lake bottom in 1985 showed the lake to have slightly elevated concentrations of copper, nickel, and PCBs. Fish were also collected to monitor the concentrations of these substances in the flesh, but analysis is not yet complete.

Bioassays of industrial effluents have shown that at least one discharge in the basin may have a potentially toxic effect on aquatic communities. Allegheny Ludlum Steel in New Castle has a wastewater discharge to the Big Blue River. This company has frequent violations of its discharge permit for various metals, and several recent bioassays of their effluent confirm that these violations can have a toxic effect on aquatic life. At least partial responsibility for use impairment at the fixed water quality monitoring station on the Big Blue River (BL-64) can be traced to this effluent. The company is working with the state to eliminate frequent upsets which cause the wastewater treatment system to fail, resulting in water quality standards violations.

Another concern in the East Fork of White River basin is the continued fish consumption advisory issued for 75 miles of streams in Monroe, Lawrence, and Greene counties. PCB contamination in these areas was discovered in the 1970s and originated from several industrial sources. Richland Creek, Clear Creek, Salt Creek below the Monroe Reservoir dam, and the East Fork of White River from Bedford to Williams Dam all have fish with PCB concentrations in excess of FDA action levels. The state recommends that preschool children and women of child bearing age should avoid eating fish from these areas. All other persons should eat no more than one meal per week of these fish. Catfish from the area immediately below Williams Dam should not be eaten by anyone.

Several recent measures have been taken to reduce or eliminate PCBs in area streams. Westinghouse Corporation in Bloomington completed construction of an activated carbon filter system to eliminate PCBs leaching from Neal's Landfill into Richland Creek. Westinghouse has also agreed to hydrovacuum stream sediments at 5 sites identified by the state in 1984 as having PCB concentrations greater than 0.5 parts per million. Monitoring of stream sediments in late 1984 showed that PCB concentrations are 2 to 4 times less than they were at the same sites in 1983 and 9 to 17 times less than they were in 1980. This is not surprising since the source(s) of contamination seems to have been largely eliminated.

In 1985 the state also collected fish and sediments from five sites in Monroe Reservoir and one site in North Twin Lake to check for possible PCB contamination. Although fish flesh analysis is not yet complete, no detectable amounts of PCBs were measured in any of the lake sediments. Apparently, no appreciable PCB contamination exists in these two waterbodies.

Funding for increased wastewater treatment became available to several communities in the basin in 1984 and 1985. EPA construction grants of 1.1 to 1.3 million dollars have recently been awarded to Paoli, Westport, and Crothersville to upgrade their sewage treatment systems. In addition, Nashville and Brownstown received grants and loans totalling 1.3 and 2.5 million dollars, respectively, from the Indiana Department of Commerce and FHA to improve their sewage treatment plants. Plans for the Nashville facility were received and approved in 1985 and construction is scheduled to begin in the spring of 1986. Construction at Brownstown is scheduled to be completed in 1987. All of these facilities have regularly violated their discharge permits, and the upgraded facilities should result in improved downstream water quality.

The Ohio River Basin

The long standing boundary dispute between Indiana and Kentucky concluded in early November 1985 when the Supreme Court ratified the boundary agreement. Indiana now owns a minimum of 100 feet into the river and up to half the river width in some locations. All islands were retained by Kentucky. Indiana's special sport fishing regulations for the Ohio River are now in effect. On November 27, 1985, an interim agreement regarding license reciprocity was signed with Kentucky. Indiana's next step will be to promulgate special commercial fishing regulations for the Ohio River. Legislation has previously been passed which creates an Ohio River commercial fishing license based on Kentucky's fees. The same legislation also stipulates that Indiana's commercial fishing regulations must "conform" with Kentucky's.

The Ohio River and its Indiana tributaries drain approximately 5,800 square miles in Indiana (Figure 25). 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 a large portion 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, which forms the southern boundary of Indiana from about mile points 491.5 to 848.0, is done by the Ohio River Valley Water Sanitation Commission (ORSANCO), a consortium composed of eight states, six of which border the Ohio River mainstream. 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 Department of Environmental Management (DEM) personnel conduct compliance surveys and other water quality monitoring activities on Indiana facilities and water bodies that discharge to the Ohio River.

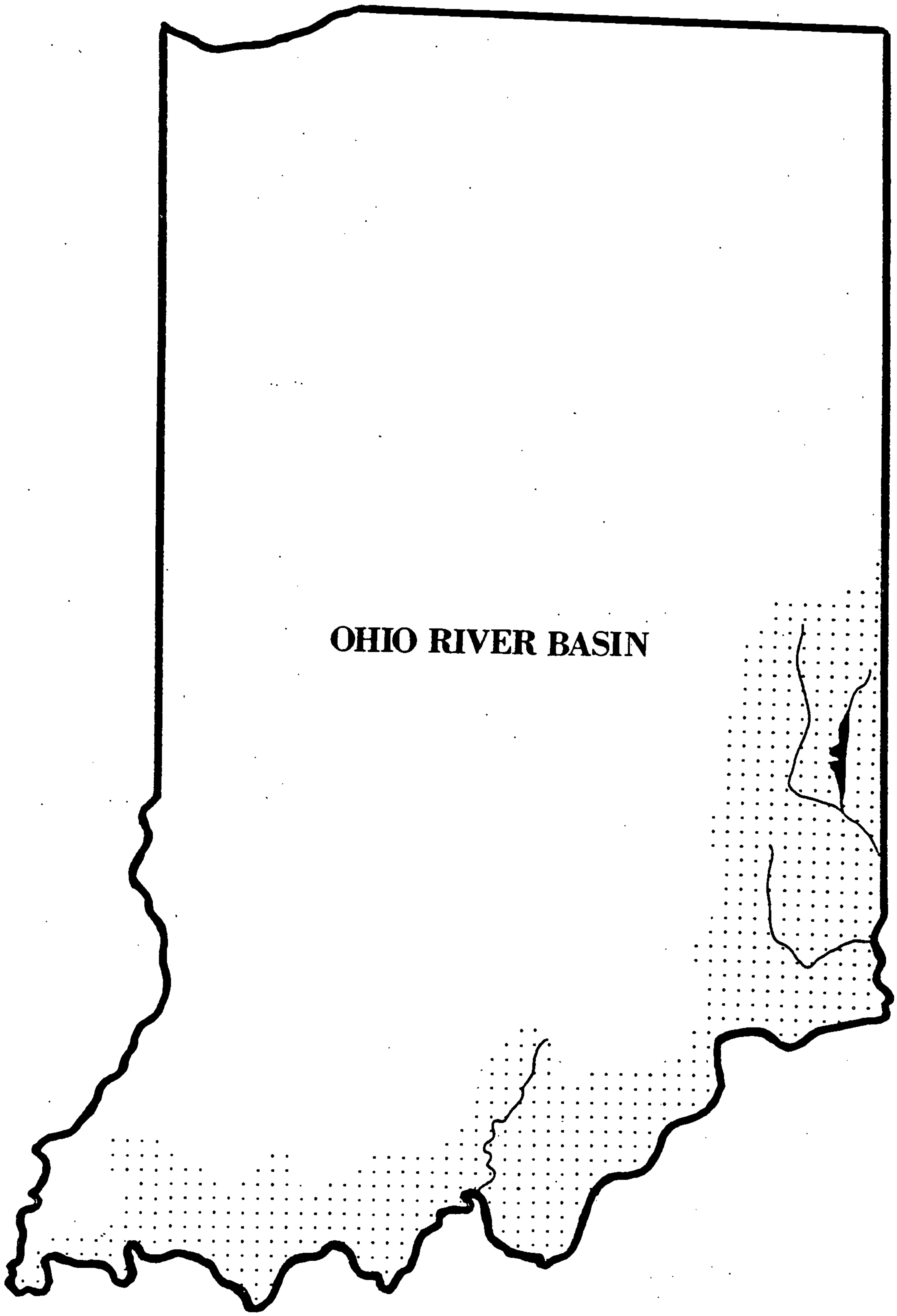


Figure 25. Ohio River Drainage Basin.

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.

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 the embayments and inflowing streams are excellent fish habitat.

A brief summary of the information contained in a draft executive summary of ORSANCO's 1984-85 305(b) report is provided below. More detailed information on the Ohio River can be found in the 1984-85 ORSANCO 305(b) report.

ORSANCO data from the portion of the Ohio River which forms the southern boundary of Indiana indicate that, in general, the stream criteria for aquatic life and recreation are exceeded approximately 10% of the time, and the criteria for public water supply are exceeded 10-25% of the time. The major problems occur with dissolved oxygen, phenolics, PCBs, fecal coliforms, mercury, cyanide, solids/turbidity, algae, and certain organic compounds. These problems come from municipal, industrial, nonpoint, and unknown sources.

When all segments of the river are considered, it may appear that the ratings for support of designated uses may indicate degraded water quality. ORSANCO feels that this is mainly due to the more stringent criteria recently adopted by ORSANCO for temperature, dissolved oxygen, copper, and zinc. Also, the lowering of the FDA action level for PCBs in fish flesh from 5.0 ppm to 2.0 ppm has increased the incidence of exceedances of PCB action levels in fish.

Special concerns of ORSANCO for the Ohio River would include the manufacture and transport of organic chemicals and other hazardous substances in the Ohio Valley together with the use of the river as a public water supply; the need for improvements to municipal wastewater treatment facilities; the effects of nonpoint sources of pollution; and the emergence of hydroelectric generators at each of the irrigation dams. ORSANCO feels these problems will require substantial commitments of resources now and in the future.

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 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.

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 found, 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 have shown only occasional violations of the fecal coliform standard (15-20%) in the past. These violations were not large and remained about the same in the periods 1976 to 1983. In 1984 and 1985, there were only two fecal coliform standard violations. There were no other standards violations.

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.

Fish and sediment were taken from three areas of Brookville Reservoir for toxics analyses during 1985. The fish samples are currently being processed, but sediment samples contained no toxic substances in amounts above what would be considered background levels.

Limnological studies were also conducted on the deepest basin of the reservoir in 1985. These studies indicated that the reservoir is in good condition when compared with similar tests conducted 10 years ago. Phosphorus levels were less than 0.03 mg/l in all sections of the reservoir that were tested. Plankton numbers were relatively low and diatoms were dominant. Brookville Reservoir is a deep, moderately eutrophic reservoir and dissolved oxygen in the summer of 1985 fell to 5.0 mg/l at about 20 feet and to 0.0 mg/l at 30 feet. No reservoir uses were impaired.

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 below 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 maximum 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 in magnitude 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 in its headwater segments.

One of the two sewage treatment facilities at Versailles discharges to Laughery Creek; the other discharges to Graham Creek. The plant which discharges to Laughery Creek is inadequate and has caused water quality problems downstream in Laughery Creek. Versailles has received Step I grant money. 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. The project should be completed in March of 1988.

Fish and sediment were collected from Versailles Reservoir for toxics analysis in the summer of 1985. The fish samples are still being processed, but sediment results indicate there are no concentrations of pollutants which would be of concern. Limnological tests and observations of the reservoir revealed that the impoundment was in good condition and had not aged excessively during the last 10 years. No uses of the reservoir are impaired.

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. Indian-Kentuck Creek in Jefferson County reportedly receives no discharges. Recent biological surveys by DEM biologists revealed that the fish and other aquatic life of the stream were in superior condition.

The Sellersburg and Clarksville North sewage treatment facilities both discharge to Silver Creek. Both plants have received funding to be expanded and/or upgraded in order to adequately protect Silver Creek. At present, Clarksville has two sewage treatment facilities. The north plant discharges to Silver Creek and the south plant discharges to Cane Branch. The facility plan calls for the construction of a new sewage treatment facility which will discharge directly to the Ohio River and eliminate both the north and south plant discharges. When these plans are realized, the conditions in Silver Creek and Cane Branch will improve. The project is scheduled for completion in September 1987.

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. This addition will also improve the water quality in Silver Creek.

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. 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.

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.

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, and the entire reach of the Blue River from the junction of the West and Middle Forks downstream to the Ohio River, as well as a portion of the South Fork of the Blue River, were designated as "Exceptional Use" streams in 1985.

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 regularly occurred 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 the upgrading in 1976, and water quality now appears to be satisfactory. During a biological survey in the summer of 1984, the aquatic life directly downstream of the Salem STP discharge was in good condition. Several longear sunfish were observed spawning a few feet downstream of the outfall.

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 also 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 water quality standards violations in the past, 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. However, in 1984 and 1985 no water quality standards were violated at Station BLW-53.

The Blue River is the home of several of Indiana's unique, threatened and/or endangered animal species. This is the only stream system 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 (Etheostoma maculatum), 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 Anderson River and its tributaries drain parts of Perry, Spencer, and Dubois counties. For the most part, 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). In the past, Cypress Creek periodically received acid mine drainage from unreclaimed strip mines in its watershed. However, a project sponsored by the Indiana Department of Natural Resources should result in these being reclaimed in 1986. The Boonville sewage treatment facility was also impacting the stream, producing high BOD, fecal coliform, and ammonia levels in the creek. Boonville is ranked #1 on the PPL, and has received grant monies from the Indiana Department of Commerce to provide for local share funding of the Federal Construction Grant Program. The city is currently conducting the facility planning process which is expected to lead to funding of the project during 1986. The communities of Chandler, which discharges to Little Pigeon Creek, and Darmstadt, which is going to regionalize with Evansville, received construction grant awards in 1985 and 1984, respectively.

Pigeon Creek and its tributaries drain portions of Warrick, Vanderburgh 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 affect the water quality, which is marginal at best in this area.

A survey of the fishes of Posey County by Kozel, et al. (5) 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.

III. WATER POLLUTION CONTROL PROGRAM

Point Source Control Program

The point source control program in Indiana primarily involves discharges from municipal or industrial wastewater treatment 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. 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.

Municipal Facilities

Table 26 depicts the changes in the degree of wastewater treatment provided by municipal facilities in Indiana in the period from 1972 to 1985. 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 only by secondary treatment 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 1985, almost one-half of the population was being served by these types of systems. Of the 38 percent of the population not served by municipal wastewater 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.

Table 26. Changes in degree of wastewater treatment provided by municipal facilities to the population of Indiana in the period 1972-1985.

	1972	1982	1985
Population size	5,195,392	5,490,129	5,499,000
No municipal treatment	40%	40%	38%
Primary treatment	6%	0.4%	0.04%
Secondary treatment	54%	41%	17%
Advanced treatment	0%	18%	45%

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 <u>if innovative or alternative technology was employed</u>. 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 95-217) 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 reverted to only 55 percent. These amendments also stressed utilization of innovative or alternative technologies.

Since 1972, Indiana has received over 1.1 billion dollars in federal construction grants money and has spent over 130 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 180 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 for their design. Grants for construction are Step 3 projects: Grants which include both design and construction in one phase are called Step 2 and 3 projects. Table 27 shows the number of construction grants projects awarded and completed from 1984 through 1985. Table 28 shows the number of new plants built for communities that previously had no plants and the number of grant awards for new plants in towns currently without plants.

Table 27. Construction grants projects awarded and physically completed from 1984 through 1985.

	Projects Awarded	Projects Physically Completed
Step 1*	--	--
Step 2*	--	--
Step 3	12	22
Step 2 & 3	17	6
Total	29	28

*Step 1 and 2 awards have been discontinued.

Table 28. Physical completions and new grant awards in Indiana in 1984-85. (Includes only locations that did not previously have sewage treatment facilities.)

	Minor Treatment Facilities (less than 1 MGD)	Major Treatment Facilities
Number Completed	3	0
Number New Awards	6	0
Number in Compliance*	100%	100%
Number Completed on Priority Water Bodies	0	0
Number New Awards on Priority Water Bodies	3	0
Federal Grant Amounts	1.49 million dollars	0

*Compliance is anticipated for the plants with new grants 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 amount 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 1978-1985 by Indiana industries are shown in Table 29. This amount has more than doubled in this time period.

Table 29. The number of tax exemption claims and the total dollars claimed by Indiana industries for wastewater treatment facilities from 1978 to 1985.

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
1984	145	797,153,029
1985	159	803,676,180

In the past, industrial wastewaters have caused water quality problems even though they were discharged to a municipal sewage treatment facility. These wastes 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, some of these pollutants can pass through a wastewater treatment facility and remain 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 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 programs.

Indiana has identified 51 municipalities that need to have direct control of their industrial users (IUs). Only three of these have yet to receive EPA/state approval of their program plan. Also, there are approximately 70 IUs that discharge into smaller municipal sewage plants that will be controlled directly by the state. The state has already issued about 30 industrial waste pretreatment permits, and another 30 permits have been drafted and are waiting to be public noticed or issued.

Compliance And Enforcement

In order to assure compliance with NPDES permit limits for 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 report forms, data collected during compliance sampling inspections conducted by DEM staff, water quality monitoring survey data, bioassay data and other information which may be available. 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, formal enforcement hearings and, if necessary, judicial proceedings. Table 30 shows the number and kinds of enforcement actions taken by the state between January 1981 and December 1985.

Table 30. Enforcement actions taken from January 1981 through December 1985 against municipal and nonmunicipal facilities in significant noncompliance.

	1981	1982	1983	1984	1985	Total
Total Number of Facilities	1,019*	1,019	1,019	1,019	1,019	1,019
Number of Pre-Administrative Hearings	200	127	140	160	170	677
Number of Administrative Actions	38	63	42	67	71	281
Number of Judicial Actions	6	5	29	10	6	56

*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 considerations.

In addition to compliance tracking, which focuses on significant noncompliance at all types of facilities, the Municipal Compliance Strategy (MCS) has been implemented to achieve maximum municipal compliance by July 1, 1988. This is 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 independent of outside financial assistance.

Nonpoint Source Control Program

Traditionally, nonpoint source (NPS) pollution has not been perceived as a major problem in Indiana. Available resources have been utilized to eliminate more readily recognized and technologically eradicable point source problems. Now, however, with those point source discharges having been largely brought under control, nonpoint source pollution has become a more prominent issue.

Existing nonpoint source problems and programs, are as follows:

1. Chemical contaminants, particularly pesticides and PCBs, are detectable in fish and sediments at points scattered throughout the state. Fish in many areas have accumulated some of the pollutants in concentrations that make them "unsafe for consumption." The sources of the contaminants are difficult to identify, but evidence seems to indicate that past use of some persistent pesticides (such as chlordane) on agricultural lands is to blame. Some rather obvious PCB sources have been identified as the cause of localized problems, but fish contamination is too widespread to be attributed only to those few specific sites identified to date. Runoff from urban and industrialized areas is a potential source of pollutants which warrants further investigation as well. Our efforts toward addressing the problem, to date, have included analyses of fish tissue and sediment samples as part of ongoing toxics monitoring surveys of particular watersheds and lakes.

2. Nutrients, particularly phosphorus, which enter streams increase eutrophication rates of downstream impoundments and lakes. Since agricultural fertilizers are a major source of nutrients, (as well as are some soils, themselves) it is important that runoff from fertilized croplands be minimized. A variety of programs have been in place for several years to address the phosphorus issue, not only within the state, but also at the national and international levels, where Great Lakes (i.e., Lake Erie) protection is a concern. In Indiana, phosphorus loadings have been decreased by implementation of the Phosphate Detergent Ban, installation of phosphorus removal equipment by industries and at POTWs, and through improved agricultural practices.

Within the past few years, relatively large-scale implementation of agricultural conservation tillage practices in the United States' portion of the Lake Erie watershed has, along with other remedial programs, resulted in a remarkable decrease in the phosphorus loading to the lake. EPA's Great Lakes National Program Office was largely responsible for providing needed impetus through the Lake Erie Conservation Tillage Demonstration Projects which it directed and helped fund.

Target phosphorus loadings which were jointly agreed upon by the United States and Canada called for Indiana to reduce its phosphorus discharge to Lake Erie by 90 metric tons per year, for four years beginning in 1985. Earlier state legislation and regulations had curbed point source phosphorus discharges from municipalities, industries, and animal feedlots, so it was determined that any additional significant decreases would have to result from control of non-point source contributors. The U.S. Department of Agriculture, local Soil and Water Conservation Districts, and the Cooperative Extension Service, then, in cooperation with EPA, have encouraged and assisted farmers in the implementation of Best Management Practices (BMPs), including conservation tillage, which decrease soil erosion and sedimentation. Based on data compiled by the Conservation Tillage Information Center, the calculated result of the efforts was a 106 metric ton reduction for 1985--16 tons in excess of the target value for the year. In addition, a calculated excess reduction of 14 tons per year by Maumee River watershed municipalities in Indiana raised the total to 120 tons for the year (a reduction of 30 tons more than was required by the agreement).

3. A related issue, sedimentation and turbidity resulting from erosion, is attributable, in part, to farming practices. Sedimentation and siltation can destroy benthic habitat in streams, fill in reservoirs, and otherwise adversely affect water quality. A number of the agriculturally oriented agencies mentioned previously have been working for many years to decrease cropland erosion, and the Department of Environmental Management (DEM) has initiated efforts to become more closely involved in their programs so that we can cooperatively resolve such issues.

   Significant erosion can also occur at construction sites where nonpoint source loadings of sediment can be 500 times greater per unit area than from agricultural operations. Although state legislation had been proposed in the past, there is currently no law which specifically addresses this problem. Various boards and agencies have the general authority to control site runoff, but exercise of specific control has been very limited and, to date, there has been no extensive staff effort directed at the issue.

In December 1985, a Governor's Task Force submitted its final report entitled "T by 2000: An Accelerated Program to Reduce Soil Erosion and Sedimentation in Indiana", which "...contains recommendations for public and private sector actions... necessary to protect the state's soil resource for future generations." In the report, it was recommended that a statewide program be implemented to decrease erosion, and that a new division be created within the Indiana Department of Natural Resources (IDNR) to administer the program. In addition, it was recommended that financial assistance should be provided to help accomplish the necessary goals. Legislation to establish this program was enacted in the 1986 session of the Indiana General Assembly.

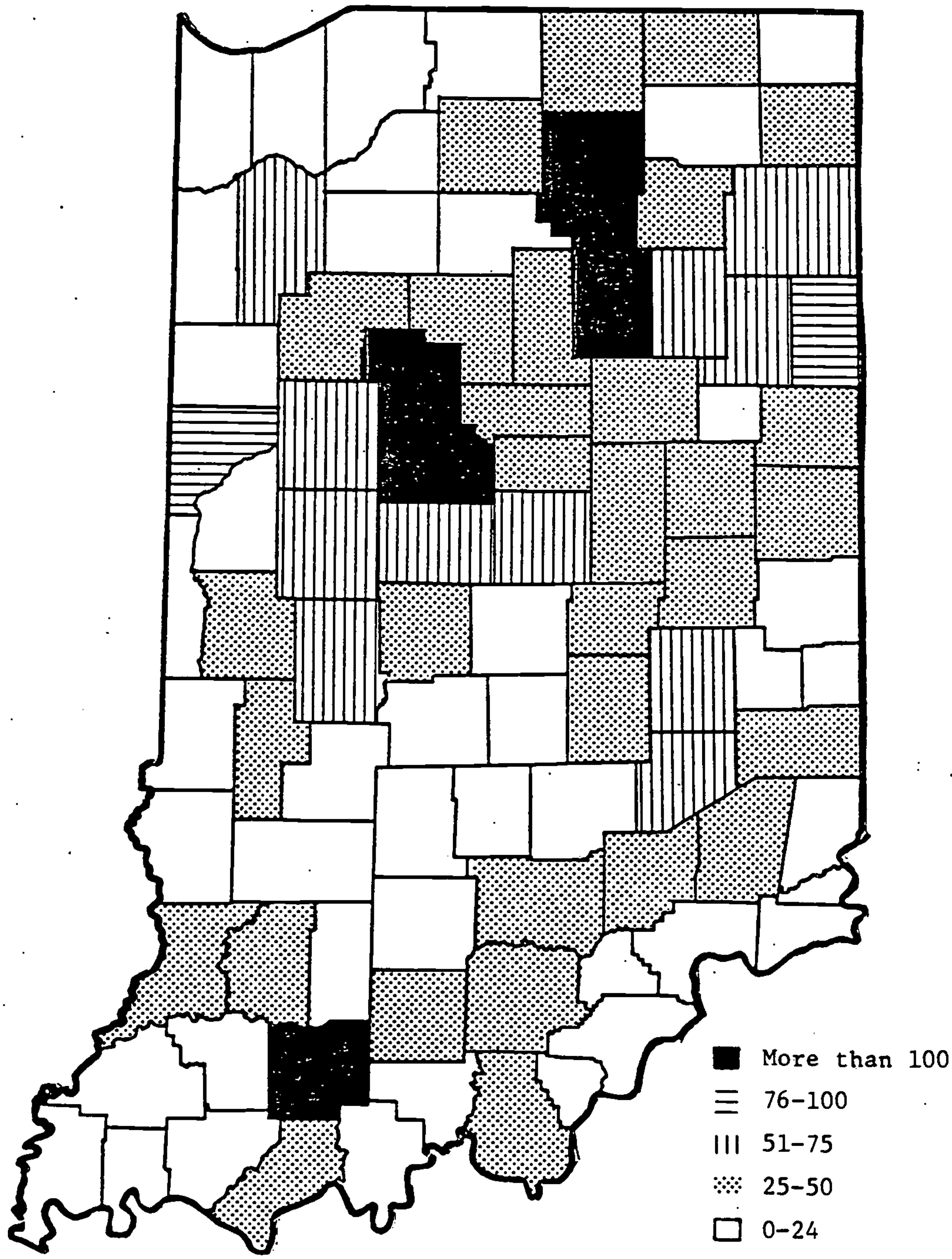
4. Although not strictly a NPS issue, combined sewer overflows (CSO) can produce water quality problems which are generally not addressed as point source problems. Traditional dogma has relegated them to a position of relative unimportance, because of the dilution provided the untreated sewage by stormwater. It is recognized, however, that the stormwater includes the previously mentioned industrial and urban runoff which can contribute other pollutants to the receiving stream, in addition to the untreated sewage. Investigators have found the impacts extremely difficult to quantify, and any serious efforts in that direction would be expensive and resource intensive. Acknowledgement of potential impacts has led to funding of some sewer separation projects which have removed sanitary wastes from storm sewers. In larger municipalities, though, the cost of such projects might be considered prohibitive.

   One readily quantifiable CSO impact which has been observed all too often is the massive fish kills that can result from storm events which occur while the receiving stream is at low flow and little dilution is provided.

5. Concentrated animal feeding operations pose a potential for serious water quality degradation (Figure 26). Although generally regulated by the State Confined Feeding Control Law of 1971, the facilities, if not properly operated, can allow tremendous quantities of biodegradable wastes to escape into surface waters. There were six reported incidents in 1984 involving discharge of waste to streams from confined feeding operations and 12 in 1985, many of which degraded the water sufficiently to cause fish kills. Although the causes of the release of the waste vary, a large percentage are documented as being intentional; some operators are multiple offenders, which suggests that penalties may not be sufficiently stringent to dissuade violations.

6. County drainage boards are authorized to maintain "legal drains" and provide for necessary drainage of adjacent land. Unfortunately, this is often accomplished with little or no regard for environmental concerns. Some projects, which have

Figure 26. Number of confined feeding operations registered with the Department of Environmental Management per county.



eradicated miles of aquatic wildlife habitat, otherwise degraded water quality, and significantly increased erosion, have been carried out unnecessarily, or for the benefit of only a few acres of marginal cropland. This agency's authority to protect water quality, and IDNR's power to protect fish and other aquatic life, has been limited by the perceived preemptive authority of the state drainage laws.

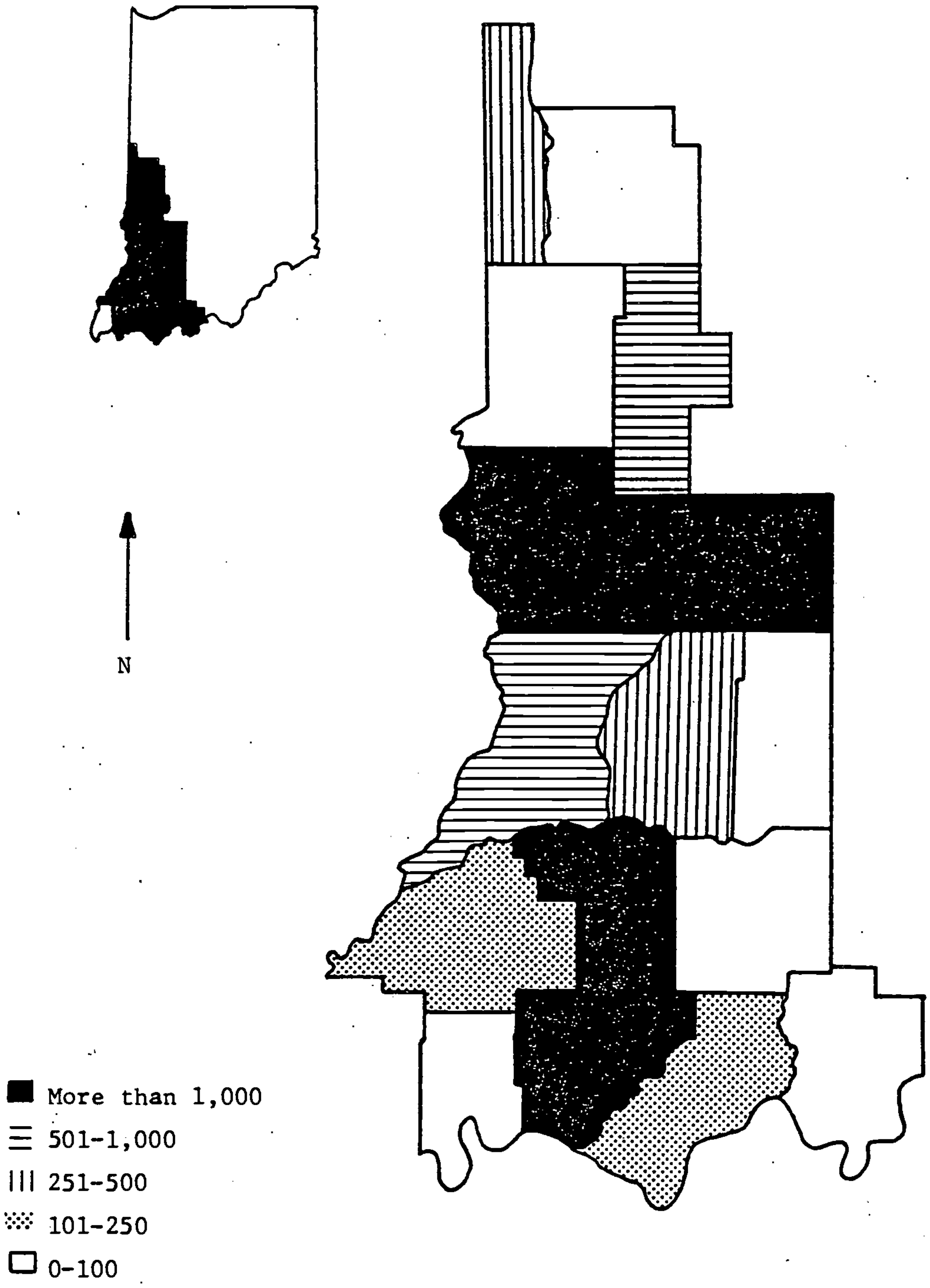
Section 404 of the Clean Water Act, which is administered by the Corps of Engineers (C.O.E.), allows some opportunity for control of environmentally unacceptable dredging practices, since certification of a project must be granted by the state water pollution control agency before the C.O.E. can issue a permit. The provisions of the laws and regulations are such, however, that some rather extensive activities can be conducted without a C.O.E. permit.

7. Landfills, dumps and other disposal sites, although sometimes NPS problems, are regulated by EPA and the DEM. Some abandoned and improperly designed or operated sites are causing downstream water, sediment, and fish contamination--and may be a threat to groundwater. In some instances, such as with certain abandoned dumps in the Bloomington area which harbor PCB laden capacitors, the company which generated the pollutants has agreed to finance a cleanup of the sites. More often, though, cleanup of such areas will be dependent upon governmental funding, such as that provided by the Superfund program, and will undoubtedly require many years to accomplish.

8. Abandoned, unreclaimed surface coal mines have contaminated and destroyed many miles of streams in the past (Figure 27). The Indiana Department of Natural Resources (IDNR) Division of Reclamation is involved in utilizing limited funds to reclaim these sites and eliminate damaging runoff, but this is another problem which will not be resolved for several years. As of September 1985, only 18 of the 43 abandoned mine land sites producing acid mine drainage have been subjected to some form of reclamation work which has corrected water quality problems. Five more sites are to be reclaimed in FY 1986, but the future of those remaining is uncertain, since funding provided by the federal government may diminish.

   To date, no formal program has been established to assess the streams involved and determine the extent of their recovery following reclamation work. Streams which have received heavy silt and/or coal fine loads may require several years to cleanse themselves and return to a natural state, since reclamation work focuses on the actual mine site and does not address stream restoration.

Figure 27. Acres of derelict land per county in southwestern Indiana associated with mining activities.



9. Residual wastes such as municipal and industrial sludges often contain contaminants which make it necessary for disposal to be regulated. If disposal is to be by land application, necessary approvals must first be provided by the DEM. Permission is based upon contaminant levels and quantity of acreage available for disposal. These wastes provide a potential for diffuse pollution of surface waters if improperly applied and allowed to be transported to streams by precipitation runoff. Groundwater contamination is also a concern. The relatively few documented problems are attributable to over-application, and little information is available regarding quantitative impacts.

Monitoring Programs

Fixed Station Water Quality Monitoring 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. Since 1957, the program has been expanded until, in 1985, 94 stations were included. Of these, 85 were sampled once a month, and nine were sampled quarterly.

Physical, chemical, and bacteriological analyses are made on samples collected from all 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 31. Not all of these parameters are measured on samples collected at all stations.

The Fixed Station Water Quality Monitoring 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 obtain background data on certain types of wastes, such as sewage, industrial wastes, and radioactive materials, and to detect critical changes.

Table 31. Analyses conducted at Indiana's Fixed Water Quality Monitoring Network 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)	Selenium
Copper as Cu (total recoverable)	Silica as SiO_2
Cyanide (total) as Cn	Silver as Ag
Dissolved Iron	Sodium as Na
Dissolved Oxygen (DO)	Suspended Residue (nonfilterable reside)
Fecal Streptococcus Group	Volatile Suspended Matter
Fluoride as F	Total Residue
Hardness as $CaCO_3$	Dissolved Residue (filterable residue)
Iron as Fe (total)	Specific Conductance as micromhos/cm
Lead as Pb (total recoverable)	Sulfate as SO_4
Magnesium as $MgCO_3$	Total Organic Carbon (TOC)
Manganese as Mn (total)	Turbidity as NTU
Mercury as Hg	Zinc as Zn (total recoverable)

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

6. To compile data necessary to support enforcement actions intended to preserve streams for all beneficial uses.

In the fall of 1985, a comprehensive review of the network was conducted. Changes in sampling locations and parametric coverage were based on the following:

1. Existing and/or recommended water quality standards.

2. Monitoring requirements established by the Department of Environmental Management (DEM) or by EPA.

3. The maintenance of data bases for essential parameters.

4. The ability to obtain representative samples at convenient locations.

5. A review of water quality trends and standards violations between 1979 and 1985.

The number of sampling stations for 1986 has been increased to 105. Of the 105 stations, 90 are sampled once each month, and 15 are sampled quarterly. These stations and their descriptions are listed in Table 32 and shown in Figures 28 and 29.

Physical, chemical, and bacteriological analyses are made on samples from all 105 of the stations, but an extensive review of necessary parameter coverage at each station will result in a 16 percent reduction in water chemistry laboratory workload. Phytoplankton will now be analyzed at 41 stations, with emphasis on interstate and algal dominated waters. Radiological analyses remain at the 23 stations that were sampled in 1985.

Toxics Monitoring Programs

Regular monitoring of toxic substances is conducted by the Department of Environmental Management (DEM) through analysis of fish tissue samples collected at the 21 CORE sampling stations (Figure 9). 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 and process this number of fish tissue samples, the CORE stations were divided into two groups in 1981, which are sampled on alternate years.

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 U.S. EPA 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 6.

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 each station 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 the nature of water quality problems originating in these areas.

Water is routinely sampled for a limited number of toxic parameters (mostly metals) at the fixed water quality monitoring stations. Effluents from discharges known or suspected to contain toxic materials are analyzed for these materials when compliance sampling is conducted at these localities. In addition, 48-hour static bioassays using Daphnia magna as the test organism are conducted on effluents from all major dischargers. During 1984-85, 36 static acute bioassays were conducted.

Table 32. Indiana's Fixed Station Water Quality Monitoring Network (1986).

STATION	NAME	LAT/LONG	LOCATION
BD-1(C)	Burns Ditch at Portage	41 37 20.5/87 10 34.4	Midwest Steel Truck Bridge, Portage
BD-2E	Burns Ditch at Portage	41 36 45/87 10 25	State Highway 249 Bridge (Chrisman Road
BD-3W	Burns Ditch at Portage	41 36 9.3/87 11 37	Portage Boat Yard Dock, Portage
BL-.7 (BL-.1)(Q)	Big Blue River at Edinburg	39 21 29/85 59 01	U.S. Highway 31 Bridge, Edinburg
BL-64 (BL-61)(Q)	Big Blue River near Spiceland	39 52 25/85 26 20	County Road 450S Bridge
BLW-57 (BLW-53)(Q)	Blue River, West Fork-Fredericksburg	38 26 02/86 11 31	U.S. Highway 150, Fredericksburg
EC-1	Eagle Creek at Indianapolis	39 44 11/86 11 48	Raymond Street, East of State Hwy. 67
EC-7	Eagle Creek at Speedway	39 46 41/86/15 02	Lynhurst Bridge near W. 10th Street
EC-21	Eagle Creek at Zionsville	39 54 37/86 17 08	State Highway 100, S. of Zionsville
EEL-1(Q)	Eel River at Worthington	39 07 26/86 58 10	S.R. 67 Bridge, Worthington
ELL-7	Eel River near Logansport	40 46 55/86 15 50	C.R. 125N Bridge, NE of Logansport
ELL-41	Eel River near Roann	40 56 53/85 53 28	S.R. 15 NE of Roann
ER-.3	Elkhart River at Elkhart	41 41 16/85 58 18	East Jackson Street Bridge, Elkhart
EW-1	East Fork, White River-Petersburg	38 32 22/87 13 22	S.R. 57 Bridge NE of Petersburg
EW-79 (EW-77)(C)	East Fork, White River-Williams	38 48 07/86 38 44	County Road South of State Highway 450
EW-94	East Fork, White River-Bedford	38 49 33/86 30 47	U.S. Highway 50 Bridge, S. of Bedford
EW-168 (EW-167)	East Fork, White River-Seymour	38 59 12/85 53 56	Seymour Waterworks Intake
EW-239	East Fork, White River-Columbus	39 12 02/85 55 35	S.R. 46 Bridge, Columbus
FC-.6	Fall Creek-Indianapolis	39 46 54/86 10 36	Stadium Drive Bridge, Indianapolis
FC-7	Fall Creek-Indianapolis	39 50 05/86 07 19	Keystone Avenue near Water Intake
CGR-34	Grand Calumet River-Hammond	41 37 12/87 30 31	Hohman Avenue Bridge at Hammond
GCR-37	Grand Calumet River-East Chicago	41 36 50/87 27 41.4	Bridge on Kennedy Avenue, E. Chicago
GCR-42	Grand Calumet-Gary	41 36 33/87 22 20	Bridge Street Bridge, Gary
IHC-0	Indiana Harbor Canal at E. Chicago	41 40 23/87 26 25	At Mouth of Ship Canal
IHC-2 (IHC-1)(C)	Indiana Harbor Canal at E. Chicago	41 39 18/87 27 33	Bridge on Dickey Road, E. Chicago

Table 32 (cont'd)

STATION	NAME	LAT/LONG	LOCATION
IHC-3S	Indiana Harbor Canal at E. Chicago	41 38 22/87 28 16	Bridge on Columbus Drive, E. Chicago
IHC-3W	Indiana Harbor Canal at E. Chicago	41 38 48/87 28 51	Bridge on Indianapolis Blvd., E. Chicago
IWC-9 (IWC-6.6)(C)	Indianapolis Waterway Canal at Indianapolis	39 52 07/86 08 30	Confluence of Canal and White River
KR-68 (KR-65)(C)	Kankakee River at Shelby	41 10 57/87 20 26	S.R. 55 Bridge, 1 Mile South of Shelby
KR-118 (KR-125)(C)	Kankakee River-Kingsbury Wildlife	41 28 39/86 36 16	U.S. 6 Bridge, S. of Kingsbury Wildlife
LCR-13	Little Calumet River at Hammond	41 34 39/87 31 19	Hohman Avenue Bridge, Hammond
LCR-39	Little Calumet River-Porter	41 37 04/87 07 32	S.R. 149, S. of U.S. Hwy. 12, NW of Porter
LM-EC	Lake Michigan at East Chicago	41 39 09/87 26 17	Raw Water, East Chicago Waterworks
LM-G	Lake Michigan at Gary	41 38 58/87 20 32	Raw Water, Gary Waterworks
LM-H	Lake Michigan at Hammond	41 42 00/87 29 00	Raw Water, Hammond Waterworks
LM-M(C)	Lake Michigan at Michigan City	41 44 07/86 54 00	Raw Water, Michigan City Waterworks
LM-W(C)	Lake Michigan at Whiting	41 40 45/87 29 17	Raw Water, Whiting Waterworks
M-114 (M-95)	Maumee River at Woodburn	41 10 11/84 50 57	S.R. 101 Bridge, 3 Miles N. of Woodburn
M-129 (M-110)(C)	Maumee River at New Haven	41 05 06/85 01 14	Landin Road, .5 Mile North of New Haven
MC-18 (MC-17)(Q)	Mill Creek at Devore	39 26 00/86 45 47	U.S. Highway 231 Bridge, Near Devore
MC-35(Q)	Mill Creek at Stilesville	39 38 12/86 38 25	U.S. Highway 40 Bridge at Stilesville
MS-1	Mississinewa River at Peru	40 45 14/86 01 23	State Highway 124, East of Peru
MS-28	Mississinewa River at Jalapa	40 37 32/85 43 52	Izaak Walton Lodge
MS-36 (MS-35)	Mississinewa River at Marion	40 34 34/85 39 34	Highland Avenue Bridge, Marion
MS-99 (MS-100)	Mississinewa River at Ridgeville	40 16 48/84 59 43	County Road 134E, 2 Miles East of City
MU-20 (MU-25)	Muscatatuck River near Austin	38 45 46/85 56 11	S.R. 39 Bridge West of Austin
P-35 (P-33)(Q)	Patoka River near Oakland City	38 22 57/87 20 00	Miller Rd. Bridge, 2 Miles W. of S.R. 57 Bridge
P-76(Q)	Patoka River at Jasper	38 19 40/86 57 59	County Road West of State Highway 45

Table 32 (cont'd)

STATION	NAME	LAT/LONG	LOCATION
PC-21(Q)	Big Pine Creek, Pine Village	40 25 19/87 20 30	S.R. 55 Bridge, Pine Village
PGN-37	Pigeon River, Mongo	41 42 00/85 21 08	S.R. 3 Bridge, Mongo
S-0	Salamonie River-Largo	40 49 46.5/85 43 06	Division Road, near Largo
S-25	Salamonie River-Lancaster	40 43 45/85 30 26	C.R. 300W, S. of Lancaster
S-71	Salamonie River-Portland	40 25 42/85 02 17	106 South Road Bridge, Portland
SC-25 (SC-30)	Sugar Creek at Shades State Park	39 56 46/87 03 33	S.R. 234 Bridge, above Shades State Park
SGR-1(Q)	Sugar Creek at Edinburg	39 21 39/85 59 51	Road to Atterbury from Edinburg
SJR-51 (SJR-46)(C)	St. Joseph River at South Bend	41 44 40/86 16 22	Auten Road Bridge, South Bend
SJR-64	St. Joseph River at Mishawaka	41 40 16.5/86 09 08	Petro Park Bridge, Mishawaka
SJR-87 (SJR-76)(C)	St. Joseph River at Bristol	41 43 20/85 49 03	County Road through Bristol
SLC-1	Salt Creek, Portage	41 35 59/87 08 43	U.S. Hwy. 20 Bridge, Portage
SLC-17 (SLC-12)	Salt Creek near Valparaiso	41 29 56/87 08 29	S.R. 130 Bridge, Below Sewage Treatment Plant
SLT-12 (SLT-11)	Salt Creek near Oolitic	38 53 18/86 30 31	State Highway 37 Bridge
STJ-.5 (STJ-0)(C)	St. Joseph River at Fort Wayne	41 45 21.5/85 07 42	Tennessee Street Bridge
STM-.2(C)	St. Mary's River at Fort Wayne	41 05 01/85 08 07	Spy Run Bridge over St. Mary's
STM-11 (STM-12)	St. Mary's River at Fort Wayne	40 59 17/85 06 01	Anthony Blvd. Bridge, S. of Hwy. 27-33
STM-37 (STM-33)	St. Mary's River at Pleasant Mills	40 46 45/84 50 32	S.R. 101 Bridge, N. of Pleasant Mill
TC-.5 (TC-.3)(C)	Trail Creek at Michigan City	41 43 21/86 54 16	Franklin Street Bridge, Michigan City
TC-1	Trail Creek at Michigan City	41 43 18/86 53 49	U.S. Hwy. 12 Bridge, Michigan City
TC-2	Trail Creek at Michigan City	41 43 21/86 52 32	Bridge Upstream STP at Krueger Park
TR-9 (TR-6)	Tippecanoe River near Delphi	40 35 40/86 46 14	S.R. 18 Bridge, 5 Miles West of Delphi
TR-107	Tippecanoe River near Rochester	41 06 21/86 13 12	U.S. 31 Bridge, North of Rochester
V-.8	Vermillion River at Cayuga	39 57 40/87 27 07	State Highway 63 Bridge, Cayuga
WB-52(C)	Wabash River at New Harmony	38 07 52/85 56 33	U.S. Hwy. 460 Bridge, New Harmony
WB-130 (WB-128)	Wabash River at Vincennes	38 42 26/87 31 09	U.S. Hwy. 50 Bridge, NW Edge of Vincennes

Table 32 (cont'd)

STATION	NAME	LAT/LONG	LOCATION
WB-183 (WB-175)(C)	Wabash River, West of Fairbanks	39 13 39/87 34 21	I&M Breed Generating Station
WB-218 (WB-207)(C)	Wabash River near Terre Haute	39 30 24/87 24 50	Ft. Harrison Boat Club
WB-230 (WC-219)	Wabash River at Clinton	39 39 26/87 23 42	S.R. 163 Bridge at Clinton
WB-240 (WB-228)	Wabash River at Montezuma	39 47 33/87 22 26	U.S. Hwy. 36 Bridge, W. Edge of Montezuma
WB-256 (WB-245)	Wabash River at Cayuga	39 50 08/87 25 11	State Highway 234 Bridge, Cayuga
WB-303 (WB-292)(C)	Wabash River near Lafayette	40 24 43/87 02 11	Granville Bridge, SW of Lafayette on Road 700W
WB-316(C)	Wabash River north of Lafayette	40 25 10/86 53 50	S.R. 225 (East St.) Bridge, Battleground
WB-347 (WB 336)	Wabash River at Georgetown	40 44 19/86 30 10	C.R. 675, West of Georgetown
WB-370 (WB 360)	Wabash River at Peru	40 44 32/86 05 48	Business U.S. Highway 31 Bridge, Peru
WB-402 (WB 390)	Wabash River at Andrews	40 52 08/85 36 06	S.R. 105 Bridge, North of Andrews
WB-409 (WB-399)	Wabash River at Huntington	40 50 19/85 29 53	Huntington Waterworks
WB-420 (WB-409)	Wabash River at Markle	40 49 26/85 20 22	State Highway 3 Bridge
WB-452	Wabash River at Geneva	40 37 00/84 57 15	U.S. 27 Bridge, 1.5 Miles N. of Geneva
WC-3 (WC-1)	Wildcat Creek at Lafayette	40 27 12/86 51 05	S.R. 25 Bridge, NE of Lafayette
WC-60 (WC-63)	Wildcat Creek at Kokomo	40 28 26/86 11 02	County Road 300W, 1 Mile W. of Kokomo
WC-66 (WC-69)	Wildcat Creek at Kokomo	40 29 10/86 06 37	U.S. Highway 31 Bypass Bridge
WCS-34(Q)	Wildcat Creek, South Fork-Frankfort	40 18 59/86 32 48	Hwy. 38-39 Bridge N.W. of Frankfort
WHE-27(Q)	East Fork, Whitewater River-Abington	39 43 57/84 57 35	Abington Pike Rd. Bridge, E. Edge of Abington
WHW-22(Q)	West Fork, Whitewater River, Cedar Grove	39 21 12/85 56 36	S.R. 1 Bridge, Cedar Grove
WLSL	Wolf Lake at Hammond	41 39 42/87 31 30	Culvert, S. Edge of Dike W. of Calumet Ave.
WR-19(Q)	West Fork White River at Hazelton	38 29 24/87 33 00	S.R. 56 Bridge, Hazelton
WR-46 (WR-48)(C)	West Fork White River at Petersburg	38 30 42/87 17 16	State Highway 61 Bridge, Petersburg

Table 32 (cont'd)

STATION	NAME	LAT/LONG	LOCATION
WR-81 (WR-80)	West Fork White River at Edwardsport	38 42 42/87 14 26	S.R. 358 Bridge, 1 Mile Below PWR Gen. Station
WR-162 (WR-166)	West Fork White River at Spencer	39 17 16/86 44 45	S.R. 43 & 46 Bridge, S. Edge of Spencer
WR-192	West Fork White River, Martinsville	39 26 02/86 26 55	S.R. 39 Bridge West of Martinsville
WR-210(C)	West Fork White River at Waverly	39 33 35/86 16 28	S.R. 144 Bridge, Waverly
WR-248 (WR-249)	West Fork White River at Nora	39 54 35/86 06 19	State Highway 100 Bridge, E. of Nora
WR-279 (WR-280)	West Fork White River, Perkinsville	40 08 30/85 52 48	State Highway 13 Bridge
WR-293 (WR-295)	West Fork White River at Anderson	40 06 22/85 40 22	10th Street at Waterworks
WR-309 (WR-310)	West Fork White River at Yorktown	40 10 42/85 29 40	County Road Bridge, N. of Yorktown H.S.
WR-319	West Fork White River at Muncie	40 10 41/85 20 32	Memorial Drive, East Edge of Muncie
WR-348 (WR-350)(C)	West Fork White River, Winchester	40 10 56/85 58 10	At U.S. 24 Bridge, East of Winchester

(C) CORE Station
(Q) Quarterly Sampling Station

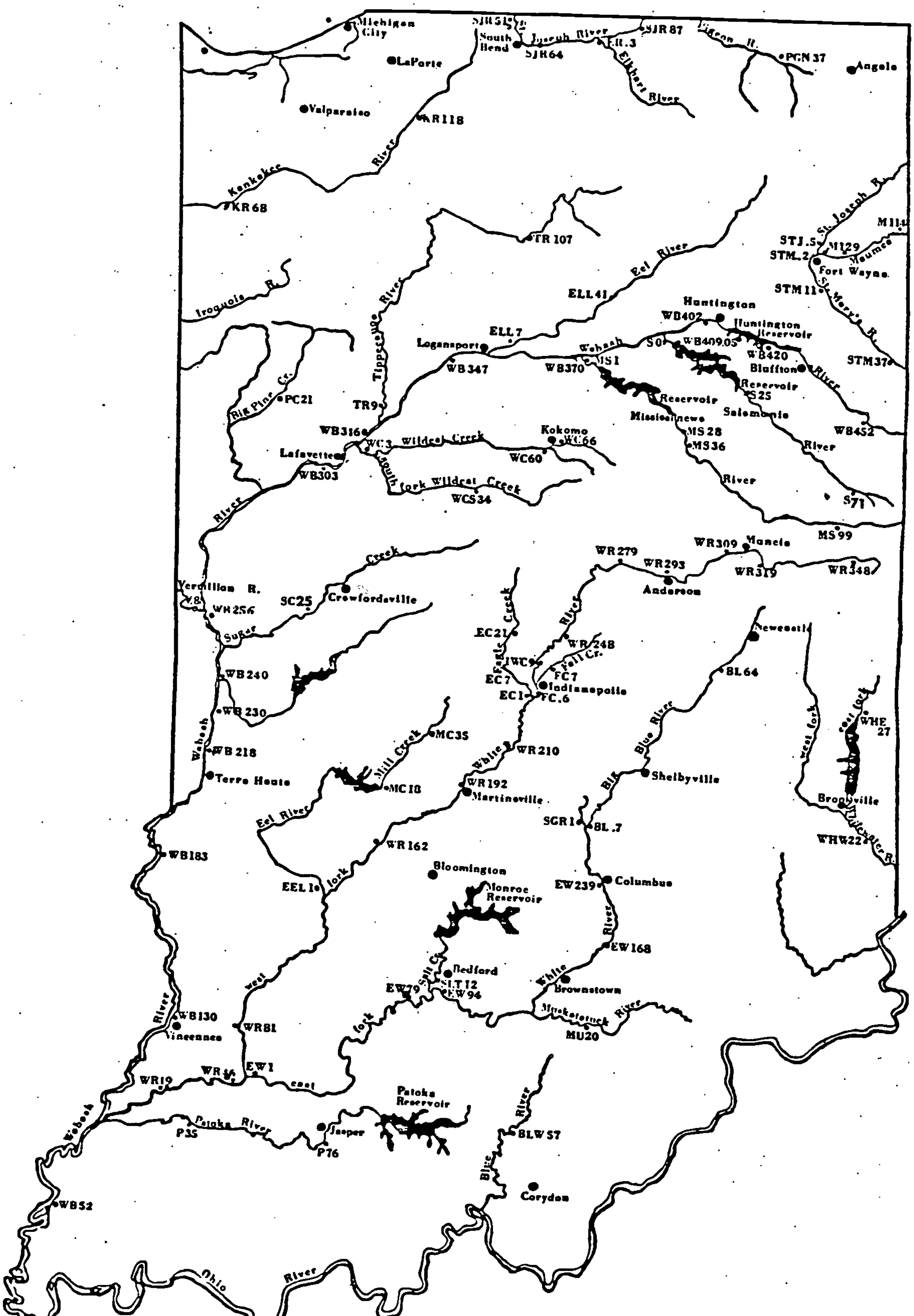


Figure 28. Location of stations in Indiana's Fixed Station Water Quality Monitoring Network, 1986.

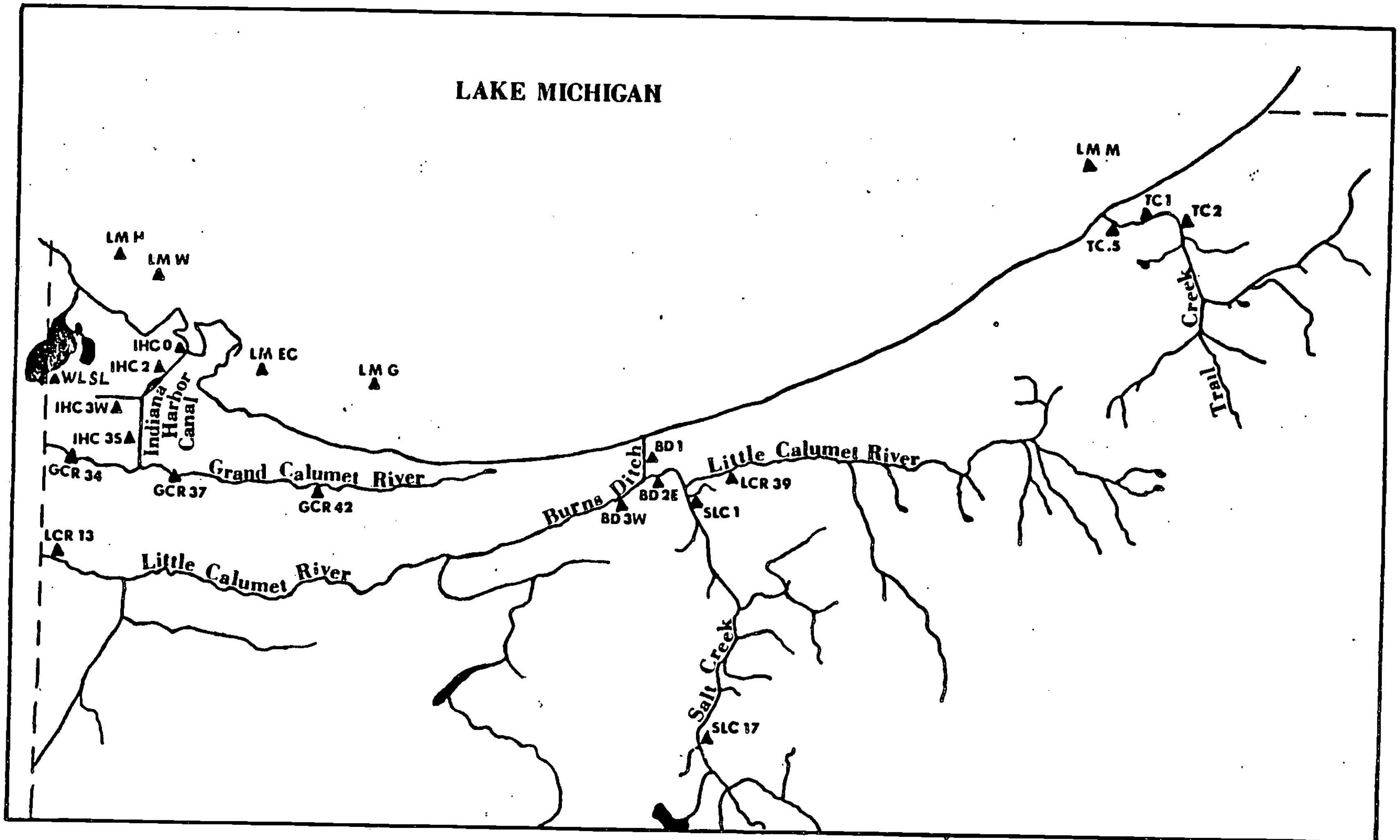


Figure 29. Location of stations in Indiana's Fixed Station Water Quality Monitoring Network (1986) in the Lake Michigan area.

In addition to the more routine monitoring, special studies of fish, sediment, and, in some cases, water are conducted to monitor for toxic substances. Such studies on portions of the East and West Forks of the White River, the Wabash River, and the St. Joseph River have recently been completed. Samples of fish tissue and sediment have been collected from several smaller streams and from lakes and reservoirs in response to known or suspected problems with toxic substances. Additional lakes and reservoirs will be sampled in 1986.

Biological Monitoring

Biological monitoring involves sampling for fish, aquatic invertebrates, plankton, bacteria, and conducting bioassay work. Some of these programs were discussed in the Toxic Monitoring Programs Section and will not be discussed further here.

In addition to those fish collected and analyzed for toxic substances, data as to numbers and kinds of all fish observed are recorded during sampling. This provides qualitative information as to the composition of the fish community at these stations. These data can then be compared to data obtained in previous years or from other studies to give some indication of how the fish community is reacting to changes in water quality. Similar data on the aquatic invertebrate community is obtained by the identification and enumeration of organisms collected on Hester Dendy samplers.

Routine monitoring of fecal coliform bacteria is done at all 94 fixed water quality monitoring stations. Very high numbers of these organisms usually indicate inadequate sewage treatment, feedlot contamination, or areas where combined sewer overflows may be causing problems upstream. Bacteriological samples are also collected as part of surveys or inspections at wastewater treatment facilities.

Phytoplankton samples have been collected at 18 of the 94 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. Because of increasing concerns about nutrient loads in interstate waters and potential problems with algal dominated waters (primarily in the middle Wabash River and West Fork of the White River), the phytoplankton sampling network is being increased to 41 stations for the 1986 monitoring schedule.

Primary productivity studies are also part of the biological monitoring program. These are not done on a routine basis, but are used to provide information for full scale models and wasteload allocations when needed and in conjunction with special lake studies. A primary productivity study was conducted on the St. Joseph River near South Bend in 1985 as part of an intensive survey. This study will be repeated in 1986. 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 full scale models for wasteload allocations.

Considerable biological monitoring has been done in conjunction with the construction grants program. Some 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 might be. The state has established a "Limited Use" designation for some of these streams. Although all uses other than aquatic life are protected, water quality standards for such streams are not quite as high as those for streams designated for "General Use". At the same time, waters which provide unusual aquatic habitat, which are an integral feature of an area of exceptional natural beauty or character, or support unique assemblages of aquatic organisms may be classified for "Exceptional Use."

Each year Habitat and Use Attainability 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 describes all existing and potential stream uses that the stream can physically support with an advanced degree of treatment.

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 Water Pollution Control Board to support a recommended change in the official stream use designation. The report will also be made part of the official record of the public hearing that is held to consider changing the official use designation in the water quality standards. In 1984-85, Habitat and Use Attainability Studies were conducted on 49 streams.

A revised regulation (330 IAC 1-1) containing 34 stream reaches (77 stream miles) designated for "Limited Use" and 11 designated for "Exceptional Use" (181 stream miles) was fully promulgated in 1985. It is expected that some additional stream reaches will be examined for inclusion in these use categories during the next two years.

Intensive Survey Program

Intensive water quality surveys are conducted according to a priority established by the Agency 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 proposed sites for 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.

An intensive segment survey consists of 24-hour sampling of all significant dischargers, the receiving stream, and flowing tributaries within the stream 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 phytoplankton populations are also included. Intensive surveys of this type may involve the collection of data along as much as 150 miles of stream. Data from at least two intensive surveys are normally required for model calibration and verification. Intensive surveys conducted during the summers of 1984 and 1985 are listed in Table 33.

Table 33. Intensive segment surveys, 1984-1985.

Segment No.	Segment Name
71	Upper Blue River
80	Upper Flat Rock River
79	Blue River
72	Flat Rock River
8	St. Joseph River

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 that will result from various degrees of wastewater treatment. Minimum instream water quality data are required, but the physical data required are the same as for the more complex models. These usually include a five mile stream reach survey. Tables 34 and 35 list the simplified modeling surveys that were conducted during 1984 and 1985, respectively.

Intensive Survey Abstracts

St. Joseph River

Michigan and Indiana are cooperatively working to establish and maintain a salmonid fishery in the St. Joseph River. A hatchery has been constructed near Mishawaka and fish ladders over the hydro-electric dams have been built or are in the planning stages. The St. Joseph river from below the I & M Twin Branch dam in Mishawaka to the state line below South Bend has been upgraded to a migration route for salmonids under Regulation 330 IAC 2-4 "Water Quality Standards for Natural Spawning, Rearing and Imprinting Areas; and Migration Routes for Salmonid Fishes." The standard requires a minimum dissolved oxygen (DO) concentration of 5.0 mg/l at any time and 6.0 mg/l during migration periods; minimal heat addition; pH range of 6.0 to 9.0 su; and limits on

Table 34. Simplified steady state modeling surveys - 1984.

Municipality	Receiving Stream
Bloomington North STP	Bean Blossom Creek
Bluffton	Wabash River
Churubusco STP	Churubusco Drain
Connersville STP	West Fork Whitewater River
Dupont STP	Bear Creek
Ferdinand STP	Holey Run
Franklin STP	Young's Creek
Georgetown	Georgetown Creek
Greensburg STP	Gas Creek
Hagerstown STP	West Fork Whitewater River
Hartford City STP	Big Lick Creek
La Fontaine STP	Grant Creek
La Grange STP	Fly Creek
Oldenburg STP	Harvey Branch
Princeton STP	Richland Creek
Shelbyville STP	Big Blue River
Turkey Creek RSD	Tributary to Cromwell Ditch
Van Buren STP	Big Black Creek
Windfall STP	Round Prairie Ditch

Table 35. Simplified steady state modeling surveys - 1985.

Municipality	Receiving Stream
Berne STP	Habegger Ditch
Bluffton STP	Wabash River
Chrisney STP	Tributary to Little Pigeon Creek
Clarks Hill STP	Tributary to Anderson Ditch
Claypool	Tributary to Ring Ditch
Clayton STP	Mud Creek
Demotte STP	Evers Ditch
Fountain City	Nolands Fork
Fowler STP	Humbert Ditch
Geneva STP	Loblolly Creek
Goodland	Tributary to Hunters Ditch
Huntingburg STP	Ditch to Huntley Creek
Lake Dalecarlia	Cedar Creek
Linton STP	Beehunters Ditch
Montgomery STP	Tributary to South Fork Prairie Creek
New Market STP	Rattlesnake Creek
Oldenburg STP	Harvey Branch
Pierceton STP	Deeds Creek
Pittsboro STP	West Fork White Lick Creek
Rensselaer STP	Iroquois River
Shirley STP	Smith Ditch
Waveland	Little Raccoon Creek
Waynetown STP	East Fork Cool Creek
Whitestown STP	Jackson Run

oil, turbidity, settleable solids, color, floating material, radioactive material, toxic substances, fecal coliform, and plant nutrients.

Some public concern has been expressed that the river could not meet those standards. To address those concerns, it became apparent that water quality surveys were needed to provide data for modeling and, if necessary, wasteload allocations at the four STPs - Bristol, Elkhart, Mishawaka, and South Bend, and the Uniroyal Plastics facility in Mishawaka. Water quality surveys to acquire data needed for these wasteload allocation were planned for 1985 and 1986. The 1985 surveys were completed on July 29-August 2 and August 4-9.

Fish collection for toxic organic analyses was completed in 1985 concurrent with the water quality surveys. The 1985 survey emphasis was to assess the mainstem water quality, and the major tributaries were only sampled near their mouths.

River flow was monitored in Indiana at the Elkhart USGS stream gage, and at gages in Mottville, Michigan, located about four miles upstream of Bristol, and in Niles, Michigan, downstream of South Bend. At the Elkhart gage, flows averaged 1.8 and 2.0 times the $Q_{7,10}$ (818 cfs), respectively, for the two weeks of the surveys. Rain brought the river up in the second week.

General stream water quality appeared good. The mean dissolved oxygen in the main river stem at 31 collection sites was 8.1 mg/l. The average of the daily low DO's was 7.3 mg/l, well above the standard. Temperatures during the 24-hour sampling period ranged between 20°-25° C. The pH generally ranged from 7.5-8.9 su. Thermal stratification of the reservoir pools was not readily apparent, but the oxygen and pH profiles did show some stratification. Algal cell counts show total mixing throughout the strata, and concentrations were high enough to inhibit light penetration and, therefore, limit oxygen production in the deeper water. Ammonia, phosphorous, BOD, and nearly all other parameters were low and below levels that would be of concern.

The effluents from all four sewage treatment plants were within the limits of their NPDES permits. However, primary bypassing occurred for a short period at South Bend. Only cooling water, about 7.5 mgd, was discharged at the Uniroyal Plastics plant. The South Bend STP discharge was causing the only noticeable effect on the stream quality. The dissolved oxygen concentration was slightly lower at two stream sites downstream of the discharge than at other stations, but still above the standard. Sediment oxygen demand measurements were highest here as well. The South Bend STP has experienced more operational problems than Elkhart and Mishawaka. Elkhart has finished upgrading their facility, and the effluent looked very good. Mishawaka's effluent was also clear. The St. Joseph River will be surveyed again in 1986 to gather more data for modeling purposes.

West Fork Whitewater River

On August 14-15, September 6-7, 1984, and September 17-18, 1985, intensive surveys were conducted on the West Fork Whitewater

River. These surveys were designed to bracket the City of Connersville and provide information on effects of the Connersville wastewater treatment plant on water quality for a wasteload allocation study.

Twenty-four hour composite water quality samples were collected at five stream stations. The wastewater treatment plant's influent and effluent were also sampled. Field tests for dissolved oxygen, pH, and temperature were conducted, and time-of-travel, flow, and sediment oxygen demand were measured at selected sites.

The seven-day, ten-year low flow is projected at 48 cfs at the USGS gaging station near Alpine, Indiana. During the August and September 1984 surveys, the 24-hour mean values at this gage were 139 cfs and 110 cfs, respectively. During the 1985 survey a reading of 96 cfs for a 24-hour mean value was obtained, and the 24-hour flow measured at the Connersville Plant was averaged at 10 cfs.

Analytical results of the water quality samples taken showed little degradation of the river, and the Connersville wastewater treatment plant effluent was within its permit limits. During the 1985 survey, when stream flows were the lowest of the three surveys, water quality characteristics represent conditions when stream flow was two times $Q_{7,10}$. At this time, the final effluent C-BOD_5 was 1.9; the long term C-BOD_{20} was 2.0. At the last downstream station, the C-BOD_{20} was 1.5, and no significant nitrification was noted in the river. A small dissolved oxygen sag was noted which was partly attributable to the wastewater treatment plant, although the dissolved oxygen in the stream did not fall below 6.9 at any time during the 24-hour period. This was the lowest D.O. recorded on all three surveys. In-stream temperatures averaged 17°C.

During the 1985 survey, the time-of-travel of West Fork Whitewater River averaged 0.79 feet per second for the 7.38 (river) mile reach which was surveyed. Sediment oxygen demand was very low.

The overall water quality of the West Fork Whitewater River in the past few years has been very good. The Indiana Department of Natural Resources rated this area high for aquatic habitat value. These surveys support previous evaluations.

Bluffton STP and the Wabash River

On September 20-21, 1984, and September 12-13, 1985, intensive surveys of the Wabash River were conducted at Bluffton. The surveys were designed to supply information for a modeling and wasteload allocation study for the Bluffton wastewater treatment plant.

The drainage area for the Wabash River at Bluffton is 532 square miles. The $Q_{7,10}$ is 5.10 cfs, and the average flow is 387 cfs. The Bluffton treatment plant has a design flow of 2.6 MGD, but the average flow for 1984 was only 1.7 MGD. During the survey the STP flows were 1.57 MGD (2.43 cfs) for 1984 and 1.64 MGD (2.54 cfs) for 1985. Upstream flows were 9.3 cfs, for 1984 and 15.0 cfs for 1985.

During the surveys, eight stream sampling locations for water quality were evenly distributed along approximately nine miles of the Wabash River as it winds through and downstream from Bluffton. Samples were collected as composites for a 24-hour period. The following field data were also compiled: stream flow, slope, sediment oxygen demand, time of travel, temperature, pH, and dissolved oxygen. Temperature, pH, and dissolved oxygen were well within the limits of the applicable water quality standards during the surveys.

The Bluffton STP was sampled for various parameters in addition to those listed in the NPDES permit. The facility was clean and well maintained, and the effluent met NPDES permit limits and conditions.

During these surveys (September 1984 and 1985) the quality of both the Bluffton STP effluent and the Wabash River was generally good. Only a few marginal fecal coliform bacteria counts were found (2,600 was the highest, in 1985).

IV. GROUNDWATER QUALITY

Overview-The Resource

Groundwater in Indiana occurs in both unconsolidated and bedrock aquifer systems that can yield potable water in sufficient quantity to serve as a source of supply. The most productive aquifers are associated with glacially derived outwash sand and gravel deposits that occur in the major river valleys. Large diameter wells in these areas can produce up to 2000 gallons per minute. Other good unconsolidated aquifers are found in the thick, inter-till sand and gravel deposits of central and northern Indiana. The withdrawal potential for properly constructed wells there ranges from 400 to 2000 gallons per minute. The major bedrock aquifers include the Pennsylvanian age sandstones of southwest Indiana, Mississippian age limestones in the south central area, Devonian age limestone and dolomite units across the northern and mid-sections, and Silurian age limestones and dolomites in the north and central portions of the state. Well yields of the important bedrock aquifers can vary from 20 to 600 gallons per minute.

The ambient groundwater quality throughout Indiana is variable and dependent on the aquifer system, geologic setting, and depth of the formation. On a general basis, the incidence of mineralized or even saline groundwater increases rapidly at bedrock depths below 300 feet. The chemical quality of the potable water is adequate to meet the basic needs for household, municipal, industrial, and irrigation uses. However, the waters are normally very hard, exceeding 180 parts per million (ppm) hardness in a range from 100 ppm to over 600 ppm across the state. Other constituents of importance to natural water quality are iron, manganese, sulfate, fluoride, and hydrogen-sulfide. Most of Indiana's groundwater contains over the 0.3 ppm aesthetic threshold for iron. Manganese concentrations are often a nuisance associated with iron, but are lowest along the Wabash and Whitewater Rivers and in Mississippian age limestone aquifers. Sulfate levels are dependent on the geologic deposits. Concentrations exceeding 600 ppm have been noted in northeastern Indiana, and Harrison, Orange, Vermillion and Lake counties. Hydrogen-sulfide is present in the groundwater of sizeable areas in the northwestern region underlain by limestone bedrock. Even small concentrations can be objectionable to domestic water users.

Nearly 59% of the state's population uses groundwater for drinking water purposes. There are 426 public water systems, utilizing some 1,775 individual waterwells, that are directly dependent on groundwater for their supplies. About half of the population served by public water supplies use groundwater (4). The distribution of public water supply wells by county is depicted in Figure 30. Approximately a half-million homes have private wells for their water supply and their number may increase by as much as 44% by the year 2000 (1). The 1980 census data for private wells per county is shown in Figure 31. Groundwater also services the needs of Indiana's economy. Industry uses an average 602 million gallons per day, irrigation consumes 106 million gallons per day and livestock depends on an average of 44 million gallons per day (1).

Areas Susceptible to Groundwater Contamination

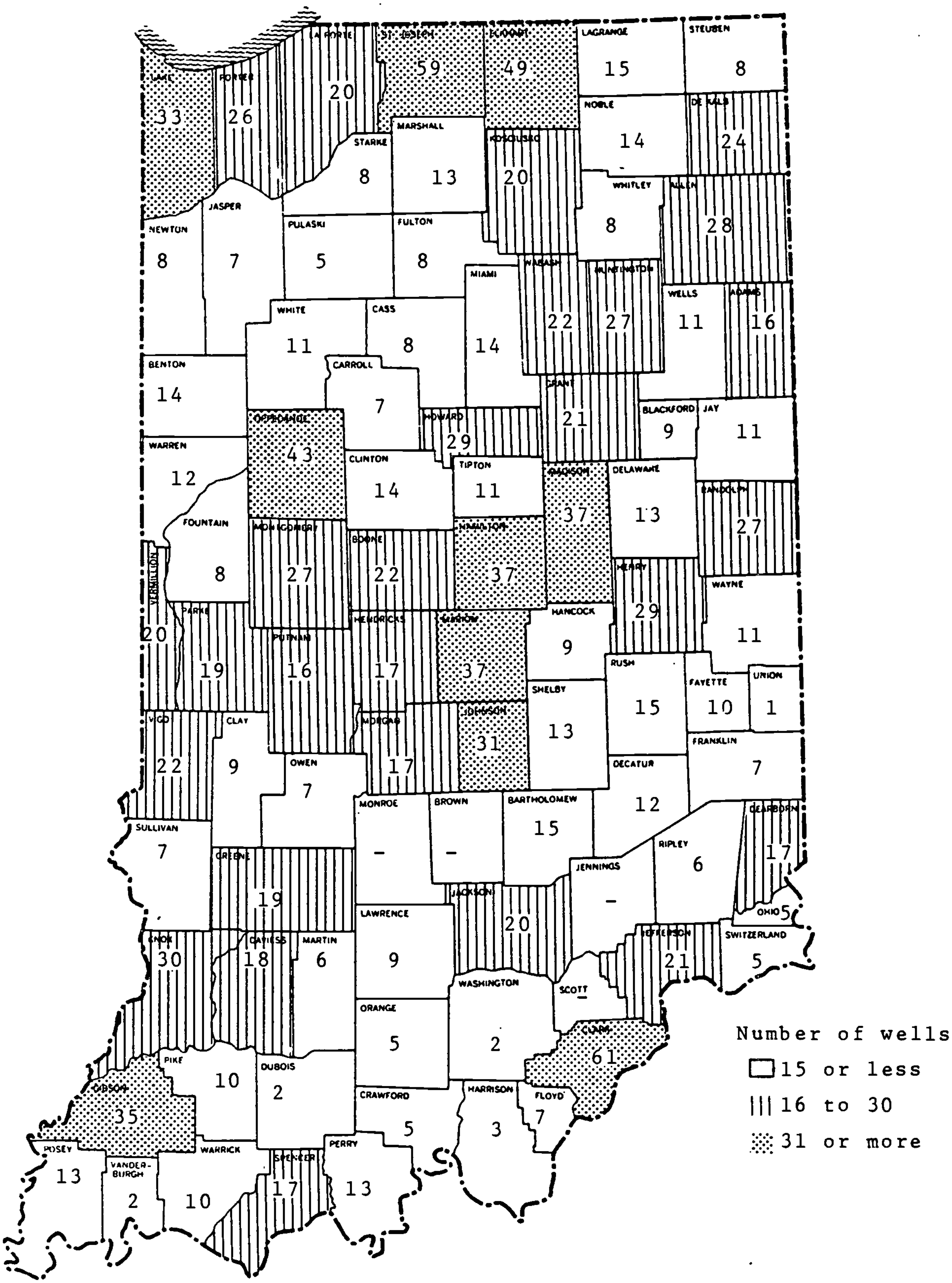
Certain geologic settings can be considered to be more vulnerable or susceptible to groundwater contamination than others. Potential surface-located, or shallow, buried sources of hazardous chemicals in these settings have a greater likelihood of impacting groundwater because the geologic material is more porous, permeable, and less capable of retarding the vertical and horizontal migration of these chemicals. Areas that are relatively most susceptible to groundwater contamination are (a) those with surficial glacial deposits of sand and/or gravel in valley-trains, outwash plains, kames, eskers, dunes, and beaches, and (b) those with less than about 50 feet of unconsolidated material overlying the bedrock. These areas in Indiana are shown in Figure 32.

As can be seen graphically in subsequent figures using the susceptible areas basemap, about 60% of the sites of groundwater and waterwell contamination occur in the sand and gravel surficial geologies and about 45% occur in areas with thin cover over the bedrock.

Man's Impacts on Groundwater Quality

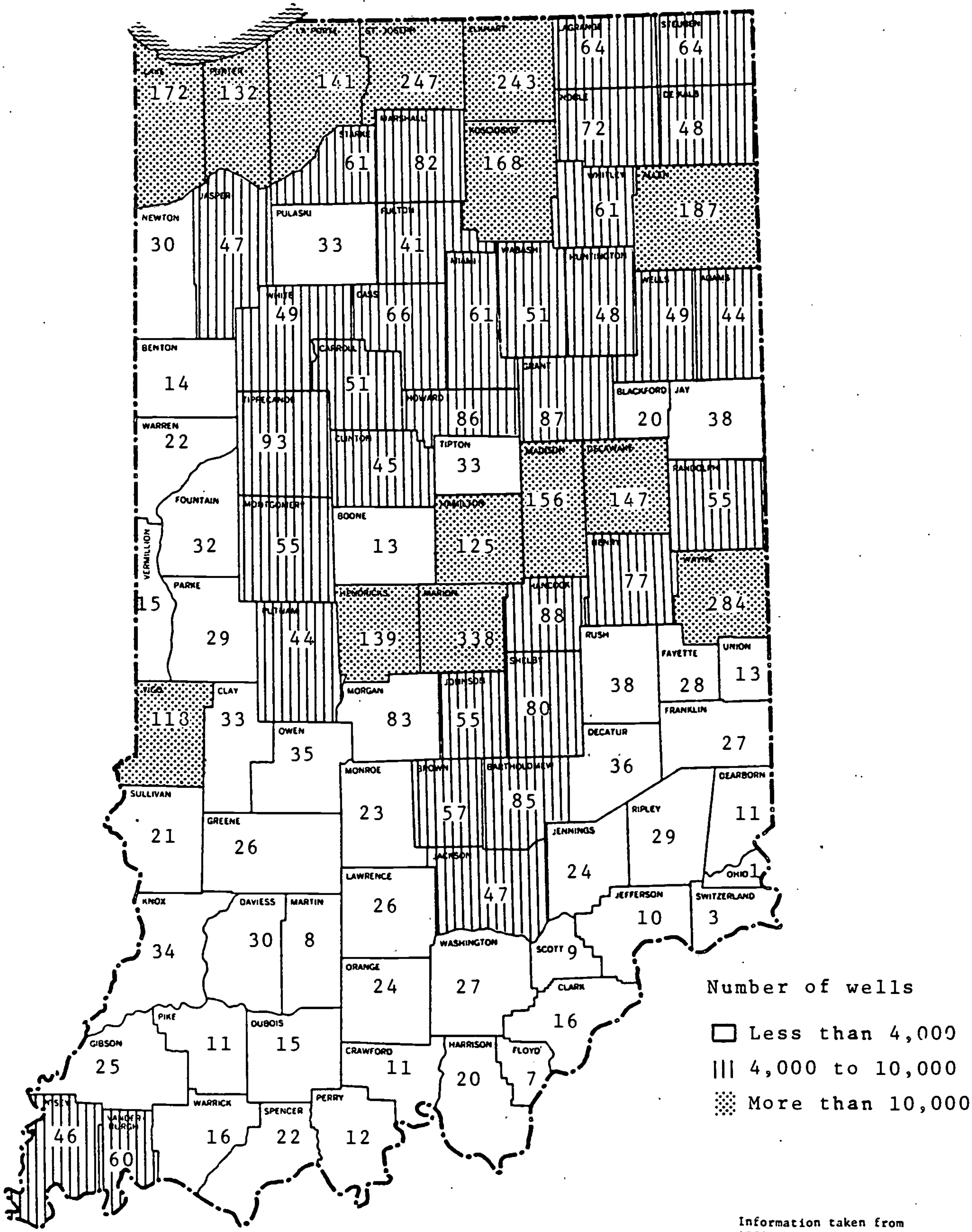
Over the past 20 years, and most notably the past 5 years, nearly 400 separate wells were documented to have been contaminated in Indiana. (Contamination means a public drinking water standard, proposed standard or health protection guidance level was exceeded in a wellwater sample.) The locations of these wells are shown in Figure 33. Seventy-two percent were residential waterwells, 17 percent were public wells, 19 percent were at industrial or commercial facilities, and 8 percent served a transient public at restaurants, schools, etc. The depth of the affected wells is generally 65-75 feet. The source of the contamination, when identified, was generally very close to the affected well, averaging from 400-1000 feet

Figure 30. Number of public water supply wells per county.



Information provided by
Indiana State Board of
Health Public Water
Supply Division

Figure 31. Number of private water wells per county (in hundreds of wells)



Information taken from
1980 Census on Population
and Housing for Indiana,
U.S. Dept. of Commerce,
listing number of drilled and
dug wells per county

Figure 32. Areas susceptible to groundwater contamination.

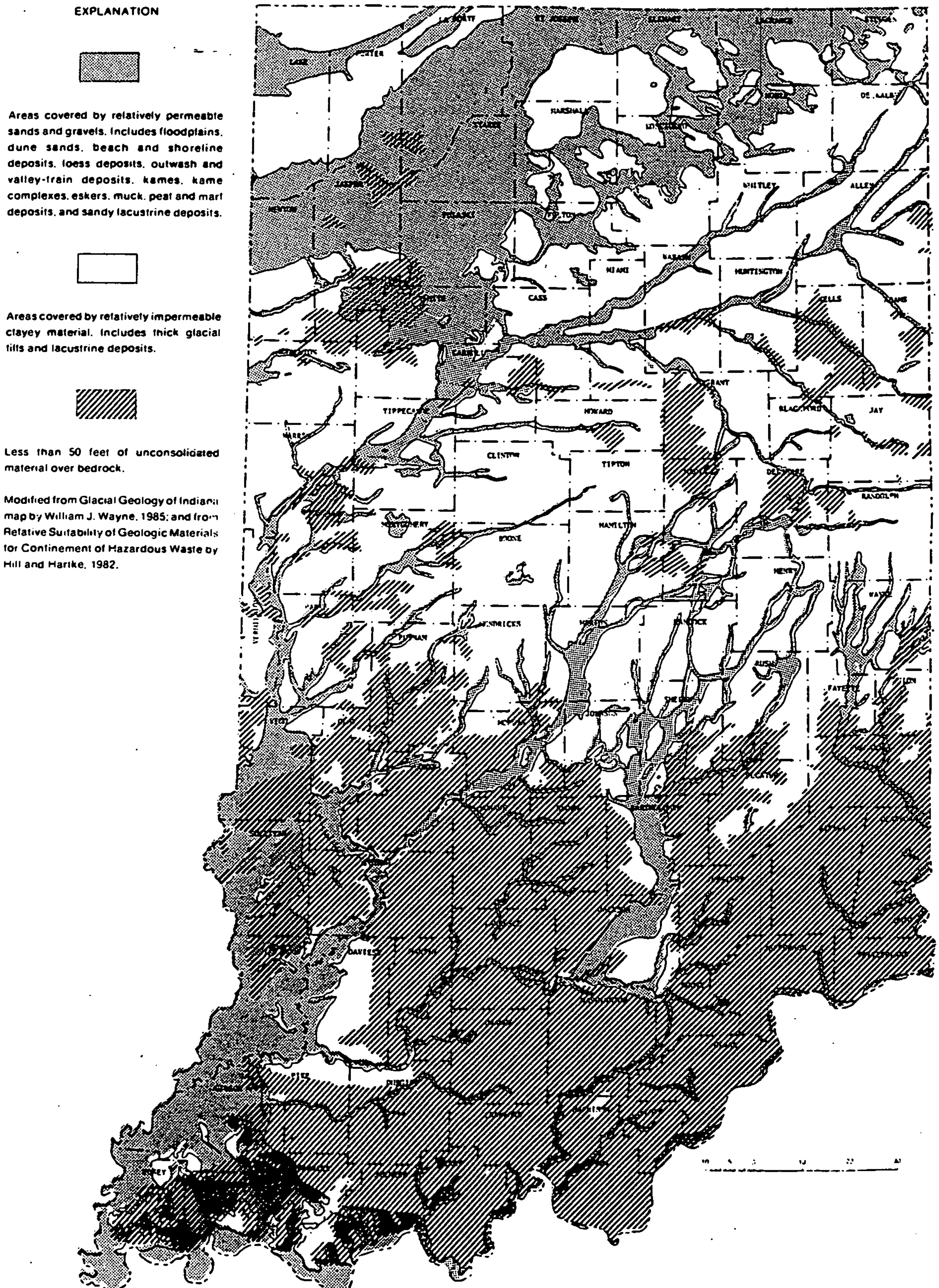


Figure 33. Sites of water well contamination.

EXPLANATION

Areas covered by relatively permeable sands and gravels. Includes floodplains, dune sands, beach and shoreline deposits, loess deposits, outwash and valley-train deposits, kames, kame complexes, eskers, muck, peat and marl deposits, and sandy lacustrine deposits.

Areas covered by relatively impermeable clayey material. Includes thick glacial tills and lacustrine deposits.

Less than 50 feet of unconsolidated material over bedrock.

Modified from Glacial Geology of Indiana map by William J. Wayne, 1985; and from Relative Suitability of Geologic Materials for Confinement of Hazardous Waste by Hill and Hartke, 1982.

Number of individual water wells contaminated per site

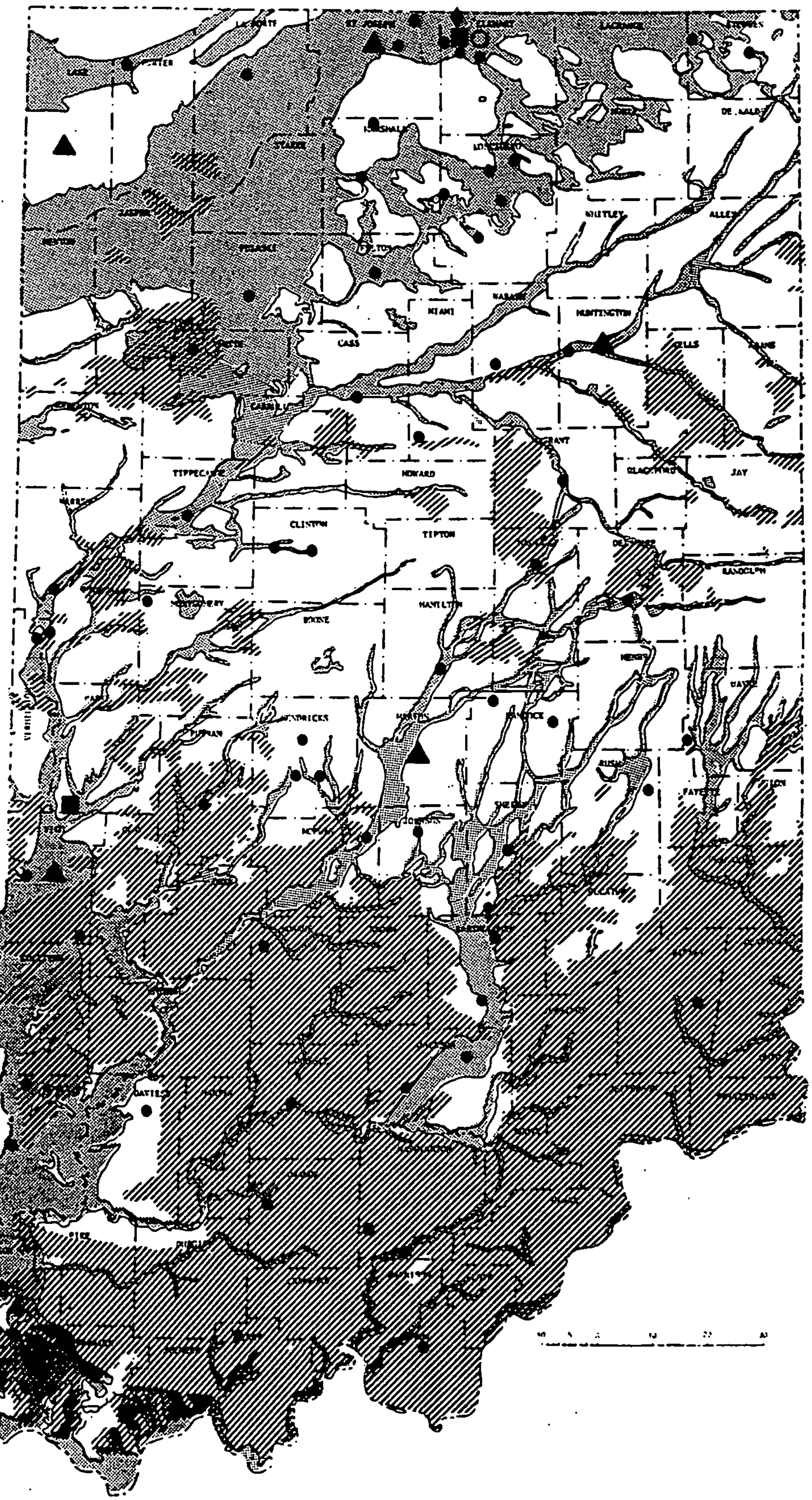
● 1 - 10

▲ 11 - 25

■ 26 - 50

◆ 51 - 100

○ 101 -



away. In over half of the incidents, there was a potential risk to human health of chronic or acute toxicity from consumption of the contaminated groundwater, based on the reported concentrations. Alternate water supplies or water treatment were used in most of the cases, while a cleanup of the contamination also occurred in about a fourth of the incidents.

Growing concern over the possible presence of synthetic organic chemicals in groundwater used for public supplies resulted in several nation-wide reconnaissance surveys by the U.S. EPA. Since 1981, the U.S. EPA, Region V, Office of Drinking Water has been conducting a survey for 26 volatile organic chemicals, with a design to sample every public groundwater supply in the state serving over 25 customers. As of March 31, 1986, they report that 1,198 of the 1,774 public water supply wells in Indiana have been sampled. In 96 wells, detectable levels of at least one chemical occurred. The location of these wells is shown in Figure 34. In 47 of the wells, the identified chemicals posed an increased lifetime cancer risk for over 650,000 persons. As of December 31, 1985, 15 of these public wells had been permanently or temporarily abandoned due to contamination detected by the survey. Four water supplies were using treatment systems to remove the contaminants, and one of the affected wellfields was being addressed by the Superfund program. For the remaining wells, the water utilities were advised to continue monitoring the water quality. In a number of cases, blending the water from several wells has produced a finished water for the customers with non-detectable chemical contaminants.

Groundwater Protection Programs

Indiana's groundwater management and protection programs reside in the Department of Environmental Management, the Department of Natural Resources, and the State Board of Health. In addition, federal programs supervising public water supplies and underground injection control under the Safe Drinking Water Act are administered in Indiana by the U.S. EPA.

The Department of Environmental Management regulates hazardous and solid waste management as well as wastewater treatment and discharge. The federally funded groundwater protection program is located in this agency. The Department of Natural Resources collects information on groundwater availability, use, and ambient quality. They protect the rights of small water users from effects of large water withdrawals through legislation passed in 1985. The State Board of Health administers the program for public water supplies.

Indiana is developing a groundwater protection policy through the efforts of an interagency work group. A public comment and review period will follow the issuance of the draft policy. This formal statement of goals and objectives is expected to be final by the summer of 1986. A groundwater protection strategy, which identifies substantive issues and formulates action plans to resolve short and long-term problems regarding groundwater protection, is planned for

Figure 34. Public water supply wells with detectable organic chemicals.

EXPLANATION

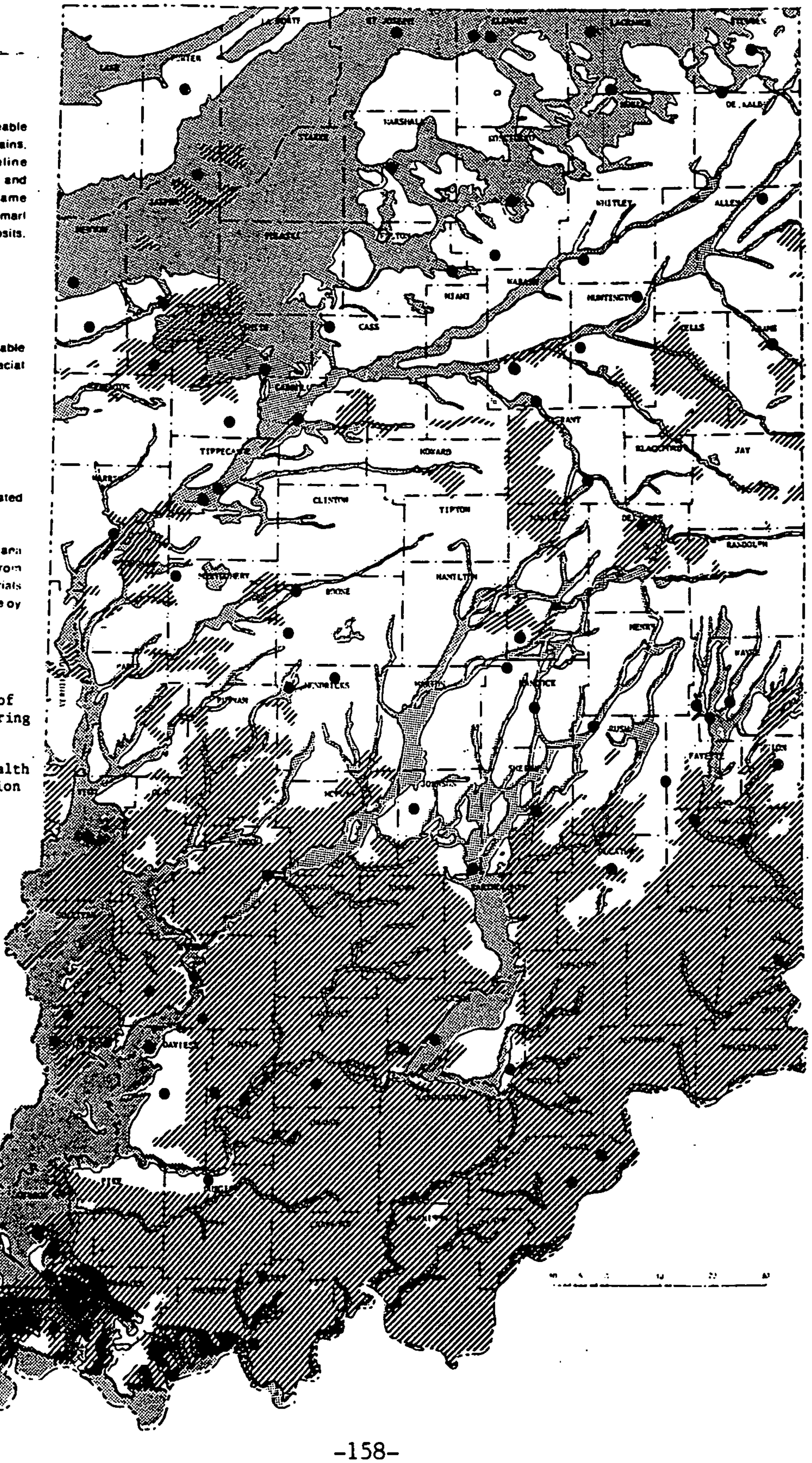
Areas covered by relatively permeable sands and gravels. Includes floodplains, dune sands, beach and shoreline deposits, loess deposits, outwash and valley-train deposits, kames, kame complexes, eskers, muck, peat and marl deposits, and sandy lacustrine deposits.

Areas covered by relatively impermeable clayey material. Includes thick glacial tills and lacustrine deposits.

Less than 50 feet of unconsolidated material over bedrock

Modified from Glacial Geology of Indiana map by William J. Wayne, 1985; and from Relative Suitability of Geologic Materials for Confinement of Hazardous Waste by Hill and Hartke, 1982.

Information taken from
U.S. EPA Region V Office of
Drinking Water VOC Monitoring
Survey Quarterly Reports
1981-1986 as provided by
Indiana State Board of Health
Public Water Supply Division



development later in 1986. Several interagency work groups in the state have been involved in laying the groundwork for the protection strategy by addressing topics of data management, water information exchange, priority groundwaters, and groundwater monitoring.

At least two of the county health departments in the state have established groundwater protection programs. Marion County, where Indianapolis is located, has passed ordinances banning drywells for wastewater disposal, requiring salt piles to be covered, and forcing new wastewater lagoons to be lined. The Marion County Health Department is also conducting private well sampling and performing an underground storage tank inventory. The Elkhart County Health Department is actively involved with over 20 sites of groundwater contamination in the city of Elkhart. They have embarked on an intense educational program in the business and civic community to promote awareness of the groundwater resource. An advisory board of business leaders in Elkhart is working with the health department to develop groundwater protection ordinances.

Groundwater Quality

Major Sources of Contamination

Groundwater quality may be altered by a variety of man's activities. The U.S. Congress Office of Technology Assessment in Protecting the Nation's Groundwater From Contamination (October 1984) lists 33 discrete, potential, man-induced sources among broad categories of waste disposal, waste treatment, surface impoundments, injection wells, raw materials storage and handling, and wells or boreholes.

Information regarding sites and sources of groundwater contamination is based principally on analysis of samples from public or private waterwells or from monitoring wells. Claims related to responsible sources are not yet possible for sites where groundwater data has not been collected.

"Contamination" means concentrations of chemicals in excess of public drinking water standards, proposed standards or health protection guidance from the U.S. EPA. Documented sites of groundwater contamination, with their associated sources have been summarized from available records of several state agencies: the Board of Health, the Department of Environmental Management and the Department of Natural Resources. From this information, 146 independent locations have been identified (Figure 35.) In 29 of these cases (19%) the source of the contamination has not been confirmed. Table 36 provides information regarding the remaining 117 locations.

Figure 35. Sites of documented groundwater contamination.

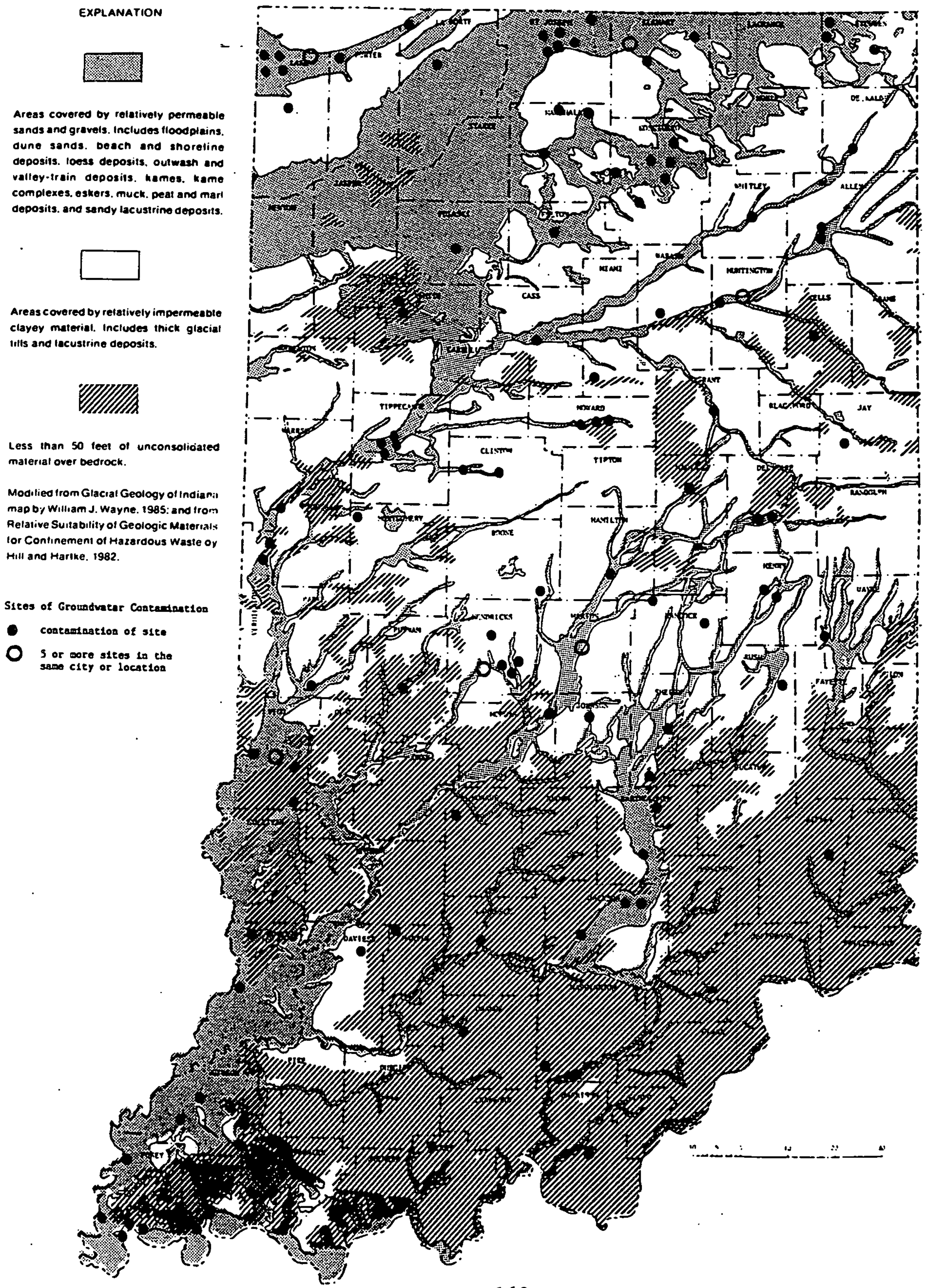


Table 36. Sources of groundwater contamination at 117 Indiana sites. (In some cases, more than one source was involved, so column totals are not relevant.)

Source	No. Sites	Percent of Total
Hazardous material spills	38	32.5
Underground storage tank systems	29	24.8
Solid and hazardous waste disposal	29	24.8
Above-ground storage of materials	22	18.8
Pits, ponds, and lagoons	18	15.4

Hazardous Material Spills: According to information derived from records at the Indiana Office for Environmental Emergency Response, about 36% of all spills occur at industrial facilities involved with storage and handling of hazardous materials. Transportation accidents account for 21% of the losses,and commercial operations experience 14% of the events. Agricultural chemical facilities and transportation pipelines attribute 8% each. The average ratio of material reported to be recovered in a spill event is only 15%. That which is not subject to volatilization or adsorption may be capable of affecting groundwater. At 26 of the sites where spills contaminated groundwater, a significant release of chemicals was reported. Long-term, minor losses were the cause at 12 of the sites.

Underground storage tank systems: Chronic leaks and sudden releases from buried tanks and piping have resulted in the contamination of groundwaters mainly with gasoline, heating, oil, or diesel fuel. A few were due to faulty residential heating oil tanks, and several incidents involved chlorinated solvents.

Solid and hazardous waste disposal: Improper waste disposal at 11 Indiana sites on the Superfund National Priorities List has resulted in documented groundwater contamination and extensive cleanup activities. Downgradient monitoring wells at 6 hazardous waste treatment, storage, and disposal facilities regulated under RCRA have shown groundwater contamination that may require corrective action. Sanitary landfills have contributed to 6 cases of off-site contamination, due to problems with construction or operation. An additional 6 cases can be traced to waste disposal practices that allowed groundwater to be affected.

Above-ground storage of materials: At seven of the locations, uncovered road deicing salt storage piles have affected groundwater quality. Fourteen other sites involved releases from above-ground storage tanks, and one was due to leaching from a waste pile.

Pits, ponds, and lagoons: At 12 hazardous waste treatment storage and disposal facilities regulated under RCRA, monitoring wells downgradient of waste storage impoundments have revealed groundwater contamination that may require corrective action. At the remaining locations, salt, nitrogen, or hazardous waste was the contaminant leaked from the lagoon or pit into the groundwater.

Other sources: In addition to the sources previously discussed, a number of others are less frequently noted, but are documented in the records. These include: disposal wells, transportation pipelines, improperly constructed or abandoned wells, and septic systems.

Contaminating Substances

Various chemicals have been detected through analysis of water samples from public or private waterwells, or monitoring wells, at the sites of groundwater contamination previously discussed. Where the concentration of a chemical exceeds a U.S. EPA primary or secondary public drinking water standard, proposed standard, or health protection guidance for drinking water, contamination was considered to be present. In summarizing the information from available state agency records covering the past 20 years, the following categories of contaminants were documented for the sites mentioned in the previous section. A statistical cross tabulation with sources was not performed, but contaminants involved, are presented in Table 37 and discussed below.

Table 37. Substances contaminating groundwaters at 146 sites. (Multiple contaminants were present at some sites, so column totals are not relevant.)

Chemical Category	#Sites	Percent of Total
Volatile organic chemicals	71	48
Petroleum and petroleum products	37	25
Metals and heavy metals	27	18
Chlorides and salts	18	12
Nitrates	12	8

Volatile Organic Chemicals: Halogenated, non-halogenated, and aromatic volatile organic chemical compounds (VOCs) are included in this category. At 46 of the sites, the primary compounds were chlorinated VOCs, most notably trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethylene, and 1,1-dichloroethane. Concentrations ranged from 5 parts per billion to 500 parts per million at the various sites. At 25 of the locations, aromatic VOCs were present, typically benzene and toluene. In all but two of these instances, dissolved motor fuels were considered to be the source of the chemicals. Other compounds often associated with the dissolved fuels include ethylbenzene, xylenes, methyl isobutyl ketone, methyl ethyl ketone, and 1,2-dichloroethane. The chlorinated VOCs were associated with hazardous waste disposal, hazardous materials spills, and most of the cases where the source had not been identified. The aromatic VOCs were linked to leaking underground storage tank systems and petroleum fuel spills. In only a few cases, the aromatics were traced to improper disposal or spills of solvents.

Petroleum and petroleum products: This category includes crude oil, gasoline, fuel oil, diesel fuel, and petroleum distillate solvents such as naptha. At 23 of the sites, leaking underground storage tank systems had released motor fuels or heating oil. In four of the cases, petroleum based solvents were released from buried storage systems. Four other sites involved crude oil present in private water wells. The remaining locations can be attributed to spills from storage, handling, or transportation accidents.

Metals or heavy metals: Typical inorganic analytical parameters for RCRA-imposed groundwater monitoring at hazardous waste treatment, storage, and disposal facilities, and at sites under investigation or correction through Superfund include a list of metals addressed by the public drinking water standards. These are arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, iron, manganese, copper, and zinc. At many downgradient monitoring wells at RCRA sites, iron and manganese levels are greatly elevated. Other metals that typically exceed standards for drinking water at most of the contamination sites are arsenic, lead, and chromium. There are only a few cases where high levels of metals were found in private water wells. Most of the sites involve monitoring wells. Natural water quality conditions associated with highly mineralized waters or outcrops of black, bituminous bedrock can also evidence high levels of arsenic, lead, iron, and manganese. Natural groundwater quality problems are not included in this summary, however.

Chlorides and salts: Concentrations of chlorides (expressed as total chlorine) in excess of the secondary public drinking water standard of 250 parts per million can exhibit objectionable taste in drinking water, particularly at levels of about 500 parts per million or greater. Because cases of naturally high amounts of chlorides in groundwater are not included in this report, all of the sites listed here are public or private waterwells impacted by point sources. Elevated levels of sodium, in excess of 150 parts per million, are typically found in conjunction with elevated chlorides. The majority of the sites are due to leaching from uncovered storage piles of road deicing salt. The rest are associated with crude oil exploration and production activities through brine disposal pits, brine disposal wells, and improperly abandoned testholes.

Nitrates: Nitrates expressed as total nitrogen corresponds to a public drinking water standard of 10 parts per million for protection of infants under six months of age who might be exposed. Due to the screening criteria used to define contamination, sites where nitrate concentrations exceed this standard are included. Most of these locations involve private waterwells near nitrogen fertilizer manufacturing or storage facilities, or near spills of nitrogen fertilizer. In two cases, the source of the elevated nitrogen was not identified.

Other Contaminants: Total coliform bacteria counts are routinely used as indicators of bacterial contamination of wellwater samples. Such tests are also useful as an index for the integrity of well installation. Although thousands of such samples are analyzed each year with some yielding unsatisfactory results, these have not been included in this report. Two historical incidents where multiple private wells in a housing development were apparently impacted by neighboring septic systems, were documented by coliform bacteria tests, and these cases are included.

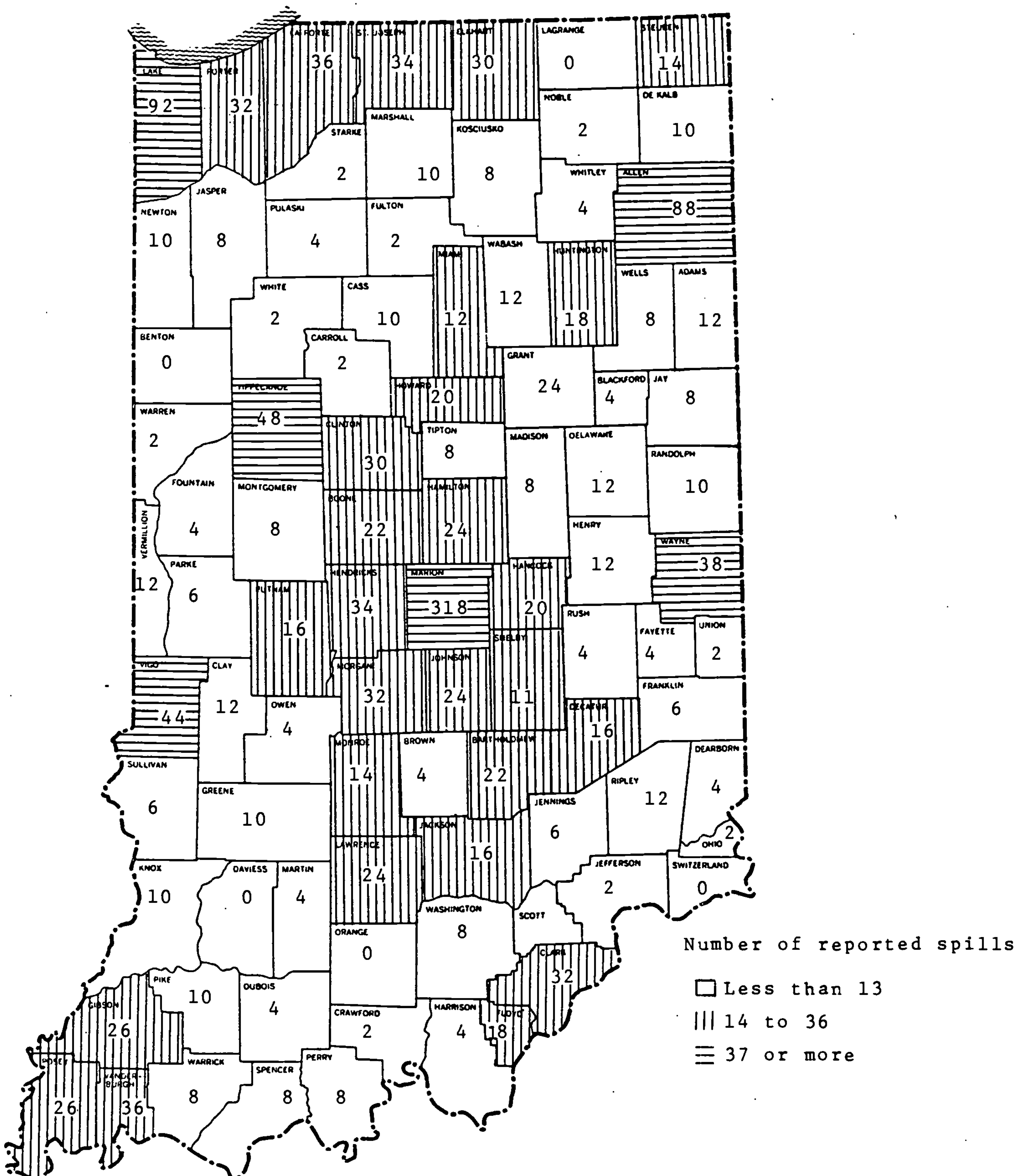
Other chemicals that have a less frequent appearance among the total were found in waterwells. Three involved spilled herbicides, three were from insecticide injection for termite treatment, and one was due to spills of phenols.

Geographic Areas of Concern

The concept that some areas are relatively more susceptible to groundwater contamination than others, as discussed earlier in the report, provides a first order screening of geographic areas of concern for groundwater protection. The magnitude of current and potential water use, the location of known sites of contamination, and the presence of potential sources of contamination are additional screening criteria. The use of county boundaries is admittedly an artificial demarcation when compared to the natural boundaries of a groundwater basin. A groundwater basin includes the areas of recharge, conveyance, and discharge of the groundwater and thus focuses on a more complete hydrologic system. However, much currently available information is most easily sorted on a county basis. For purposes of this general discussion, county lines will be used.

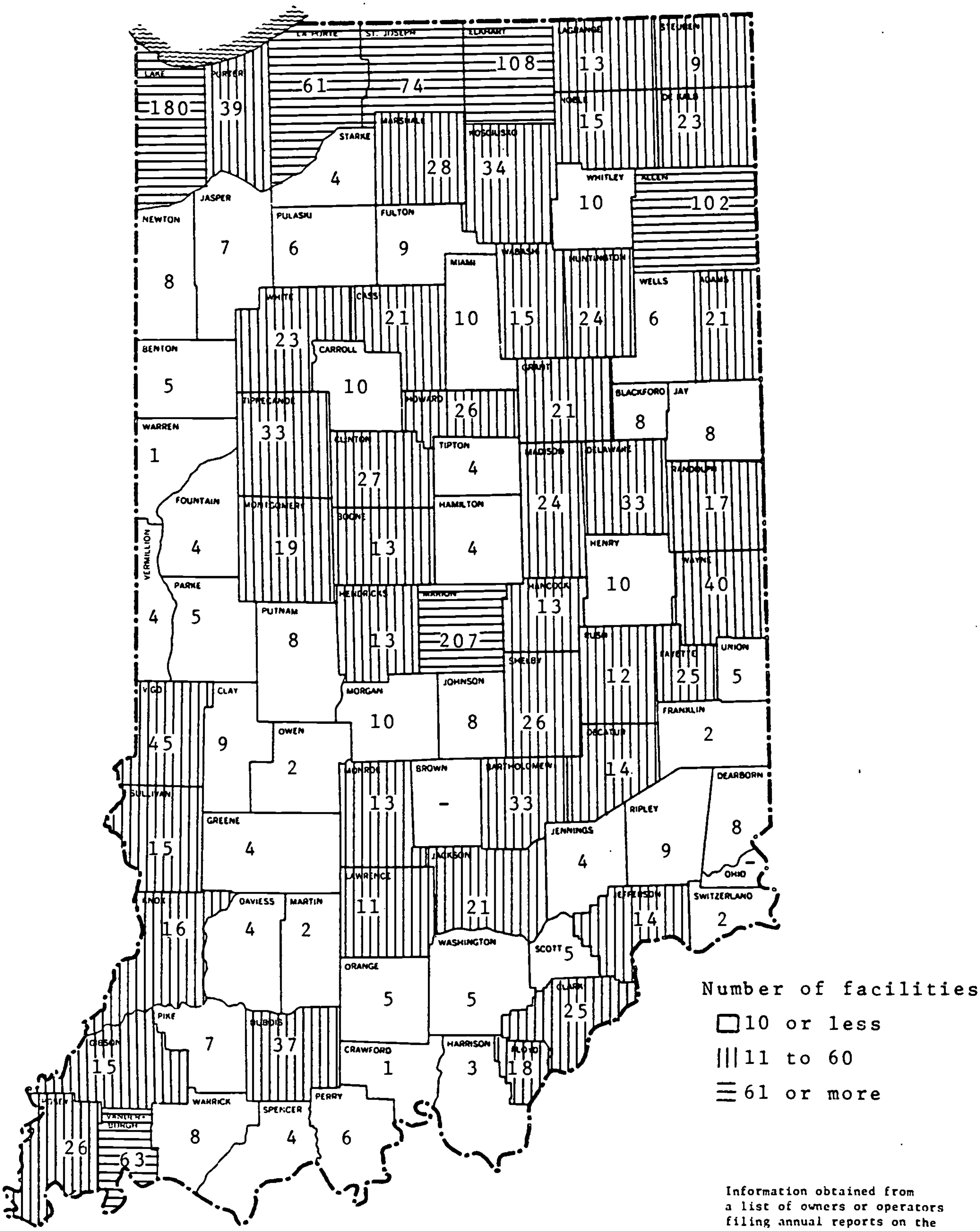
A rank order of numbers of public and private waterwells is used to describe groundwater use. Groundwater quality is viewed by the number of groundwater contamination sites, and the number of contaminated waterwells per county (Figures 34 and 35). The leading sources of contamination listed in this report, hazardous material spills and solid or hazardous water disposal, can also be described by a rank order list by county. It includes: the number of hazardous materials spills since January 1, 1985, the number of hazardous waste generator, treatment, storage, and disposal facilities, the number of abandoned hazardous waste disposal sites on the Superfund inventory list, and the number of sanitary landfills (Figures 36, 37, and 38, respectively).

Figure 36. Reported spills of hazardous materials per county.



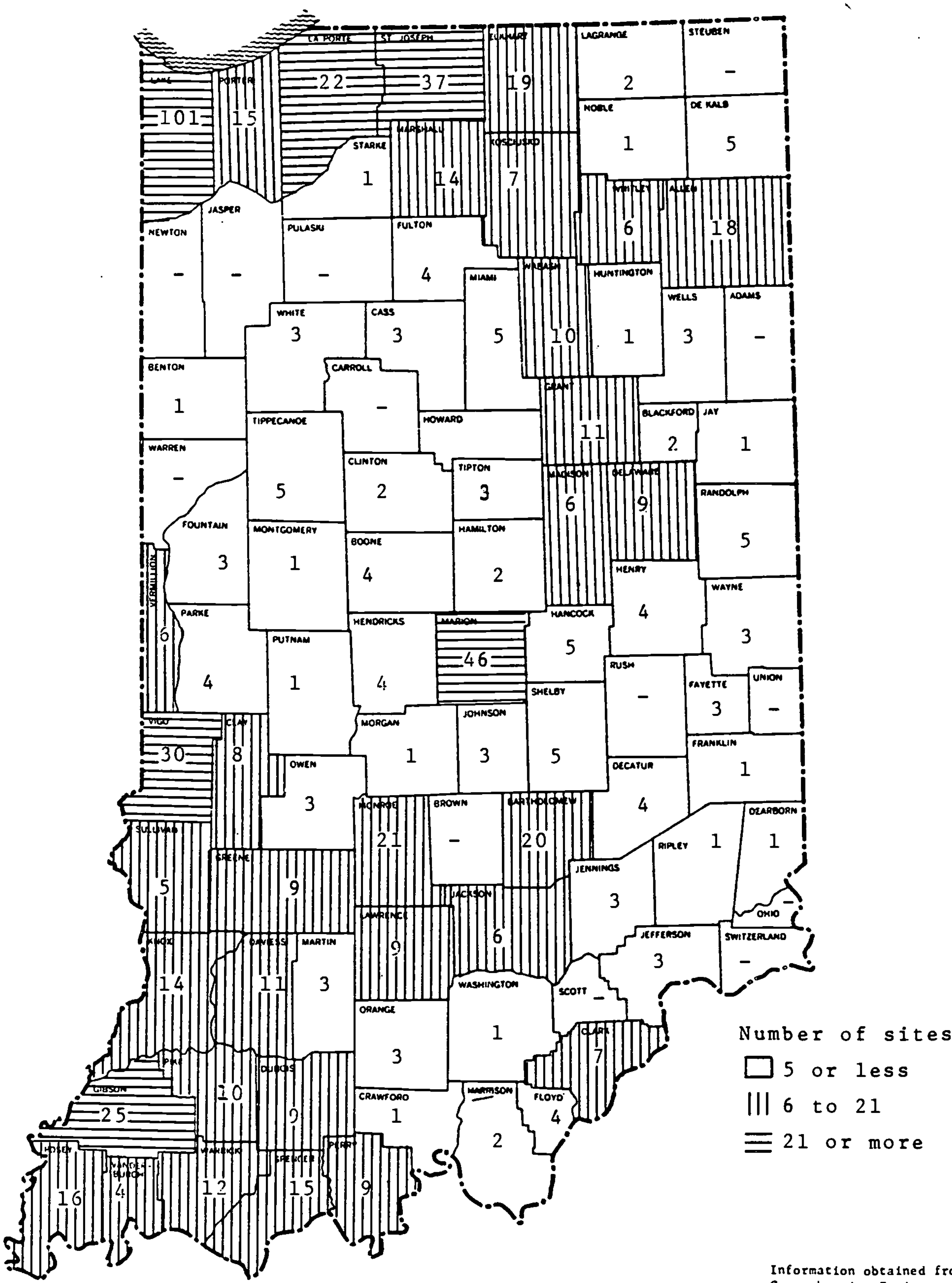
Information obtained from
computer index of spills
reported to the Indiana
Office of Environmental
Emergency Response
January 1, 1985 through April 30, 1986

Figure 37. Number of hazardous waste facilities per county. (Generators and treatment storage disposal sites).



Information obtained from a list of owners or operators filing annual reports on the generation of over 1000 kilograms per month of per month of hazardous waste. List provided by the Indiana Dept. of Environmental Management, 1985.

Figure 38. Number of abandoned waste disposal sites per county.



Information obtained from the
Comprehensive Environmental
Responsibility & Liability
Inventory System List for Indiana
provided by the Indiana Dept.
of Environmental Management
Office of Waste Management

In general, the information on groundwater use and quality, and sources of contamination, tends to reflect the distribution of population and industry among the state's major cities, as reflected in county rankings (Table 38). The areas of concern are located near major rivers and highly productive groundwater resources. In such areas, there is an association among the prevalence of industry, spills, and groundwater or waterwell contamination.

The geographic areas of concern therefore, include the following counties: Elkhart, Marion, Lake, St. Joseph, Vigo, Tippecanoe, Laporte, Kosciusko, Allen, Wayne and Porter. This is not meant to place less importance on specific problems or needs in other cities or counties, but merely to indicate areas where groundwater protection may be the most needed. The U.S. EPA and Indiana Department of Environmental Management are addressing this need in Lake County through the development of a comprehensive environmental action plan which includes extensive studies of surface and groundwaters in the Grand Calumet River Basin. In Elkhart and Marion Counties, aggressive groundwater protection activities are implemented by the county health departments. Similarly, other county health departments are strengthening their capabilities to respond to environmental issues, including groundwater protection. Efforts at federal, state, and local levels are providing the broad base for prevention, detection, and correction of groundwater contamination, particularly in the geographic areas of concern in Indiana.

V. SPECIAL STATE CONCERNS AND RECOMMENDATIONS

Although the discharge of inadequately treated "conventional" pollutants (BOD, ammonia, solids, etc.) in the past often resulted in highly visible evidence of water pollution, much has been done in the last ten years to greatly reduce or eliminate these problems. This includes the construction of an increasing number of advance wastewater treatment plants; the implementation of a Municipal Compliance Strategy (MCS) which will require all municipalities to be in compliance with water quality standards by 1988, regardless of the availability of construction grant funding; and the implementation of an operator training and assistance program to help assure better operation of these wastewater treatment facilities.

In 1985, Indiana revised the water quality standards for salmonid waters (330 IAC 2-4) to include that portion of the St. Joseph River from the Twin Branch Dam in Mishawaka downstream to the Indiana-Michigan state line. Specific criteria for several toxic pollutants were also added to this regulation. The Indiana Department of Natural Resources has already begun stocking salmonids in this river, and fish passages are expected to be completed at all dams (both in Michigan and Indiana) between Mishawaka and Lake Michigan by 1987. These more stringent water quality standards are required to protect the salmonid fishery which should be established in the St. Joseph River.

Table 38. Information summary for county groundwater protection needs.

County	Number of Public Waterwells	Number of Private Waterwells	Number of Groundwater Contamination Sites	Number of Contaminated Waterwells	Number of Hazardous Material Spills 1985-86	Number of Hazardous Waste Facilities	Number of Abandoned Hazardous Waste Sites	Number of Sanitary Landfills
Elkhart	49	24,300	23	229	32	108	19	3
Marion	37	33,800	6	7	318	207	46	4
Lake	33	17,200	10	22	92	180	101	9
St. Joseph	59	24,700	6	23	34	74	37	2
Vigo	22	11,800	11	46	44	45	30	4
Tippecanoe	43	9,300	4	8	48	33	5	2
Laporte	20	14,100	2	1	36	61	22	1
Kosciusko	20	16,800	6	11	8	34	7	3
Allen	28	18,700	2	0	88	102	18	3
Wayne	11	28,400	1	1	38	40	3	2
Porter	26	13,200	1	2	32	39	15	2

Indiana also revised the water quality standards (330 IAC 2-2) for the Grand Calumet River-Indiana Harbor Ship Canal in 1985. More stringent criteria for several parameters were adopted for that portion of the river system flowing to Lake Michigan. This should eventually reduce the amounts of several pollutants reaching the lake from this tributary. The Lake Michigan regulation (330 IAC 2-1) is currently being reviewed by the state and U.S. EPA and will be revised to include appropriate criteria for toxic substances.

Indiana has also done considerable work with toxic substances over the last two years. Rather intensive fish, sediment, and effluent surveys were conducted on the East Fork of White River, the Mid-Wabash River, and the St. Joseph River basins to assess possible toxic pollutant problems in these streams. Other surveys involving fish and sediment were conducted in response to suspected problems with toxics on several other streams.

The state has also developed a Groundwater Program to deal with current and potential groundwater contamination problems. Although this program is still in the developmental stages, it has already been involved in the investigation of several highly publicized problems.

Thus, while the state has acted to address many of the concerns and problems mentioned in the 1982-83 305(b) report, some of these remain to be resolved and additional ones have arisen. Some of these concerns will be briefly discussed below.

One of the major concerns that has yet to be completely resolved is the lack of laboratory capacity to adequately handle the number of sediment, fish, and water samples needed to fully address the toxics problems in the state. Salary adjustments for many laboratory personnel were made in 1985, and this may help the state attract and/or retain qualified laboratory personnel in the future. However, lack of additional equipment needed to analyze these toxic samples and the need for more highly trained personnel to operate it still prevents the expansion of the state's toxic monitoring programs to some extent.

Another problem is the lack of toxics criteria for sediments. The state has collected considerable sediment data on toxic substances, but there are essentially no criteria or guidelines available which allow the state to assess the potential environmental effects of these substances in stream sediments. The state does not presently have the personnel to develop these criteria and has requested the U.S. EPA to develop sediment criteria or guidelines for toxic substances.

Along those same lines, additional FDA action levels or U.S. EPA criteria for contaminants in fish flesh need to be developed for many of the other priority pollutants. The state has collected a considerable number of fish tissue samples which have been analyzed for many of the priority pollutants, but little is known concerning health effects caused by most of these substances in fish tissue.

It also appears that U.S. EPA is planning to place more emphasis on the inclusion of human health criteria numbers in the water quality standards. These criteria are based on the increased cancer risks that would result from consuming aquatic organisms and/or water from lakes, rivers, and streams. Federal guidelines on the selection of appropriate risk levels are needed, especially for interstate waters and the Great Lakes.

U.S. EPA is also requiring states to develop implementation strategies for the anti-degradation policies and narrative toxics criteria in their water quality standards. Indiana would like to see U.S. EPA take the lead in assuring that all states in the Region (and nation) develop similar anti-degradation policies and implement these in similar ways. Problems could arise if it appears that substantially different anti-degradation policies and implementation strategies are adopted by neighboring states and are approved by U.S. EPA. Indiana would also like to see U.S. EPA develop more specific guidance on how to implement the narrative toxics criteria ("free from" provisions) in water quality standards. Indiana presently does not have the staff nor resources to do extensive toxic criteria development. Hopefully, the state will be able to employ a toxicologist which will solve some of these problems.

Another area of concern is the Grand Calumet River-Indiana Harbor Ship Canal (GCR/IHR) in northwest Indiana. This is an International Joint Commission Area of Concern and considerable time and resources will continue to be focused on this area by both the federal government and the state to implement recommendations of the "Master Plan for Improving Water Quality in the Grand Calumet River/Indiana Harbor Canal" and the Remedial Action Plan for this Area of Concern. The state and U.S. EPA are developing plans to make in-depth studies of water, air, and land pollution problems in the GCR/IHC watershed. Problems that will be addressed include: in-place polluted sediment, leaching from landfills and sludge lagoons, groundwater contamination, disposal of dredged sediments, groundwater-surface water interactions, nonpoint runoff, combined sewer overflows, atmospheric deposition, and effluent toxicity. These problems are very complex, and it will require considerable cooperation between various federal, state, and local agencies and much time to resolve them.

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