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INDIANA

STREAM POLLUTION CONTROL BOARD

1980-1981 Status of
Water Quality Report
for the
State of Indiana *

* This Report has been prepared in accordance with requirements of Section 305 (b) of the Clean Water Act of 1977, as amended.

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1980-1981 Status of Water Quality Report

for the

State of Indiana

By

Planning Section
Division of Water Pollution Control
Indiana State Board of Health
June 1980

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I. Executive Summary

In accordance with Section 305(b) of the Clean Water Act of 1977, as amended (PL 92-217), the State of Indiana hereby submits its 1980-81 Status of Water Quality Report. The intent and purpose of this report is twofold; to examine and quantify the ability of Indiana streams to attain water quality standards as prescribed by either the Indiana Stream Pollution Control Board (SPCB) or the U.S. EPA, and secondly, to transmit its findings and recommendations for Indiana's 208 Water Quality Management Plan.

The methodology employed in this year's report utilizes the capabilities of the National Water Quality Information System, commonly referred to as STORET. This federal information STO-rage and RET-rieval system is used for the compilation of data from Indiana's Fixed Station Monitoring Program. This program includes approximately 100 stations located on major streams and waterways across the State. Data extracted for analysis between 1974-1978 include fundamental water quality parameters such as temperature (^oC.), dissolved oxygen (D.O.), nitrates/nitrites (NO_2 + NO_3), the five-day Biochemical Oxygen Demand (BOD_5), pH factors, total ammonia calculated as un-ionized ammonia (NH_3), fecal coliform bacteria, and numerous toxic and heavy metals. Once the raw data was retrieved and verified, additional STORET programs were executed to determine if parameters were meeting water quality standards, and the general trends of their concentrations over a five-year period.

The specific programs implemented for this assessment were:

1. A RET-rieval program to supply raw water quality data for all Fixed Station Monitors in Indiana.

2. A STAND-ard program indicating to what degree each water quality parameter violated SPCB standards and/or criteria accepted for general instream water quality.

3. A PLOT program which plotted all parameter data over time (1974-1978).

Rather than providing a regional assessment, this report will assess water quality by basin. Data from each Fixed Water Quality Monitoring Station along the main stem of primary streams was compiled to determine the aggregate improvement or degradation each stream demonstrates. Particular emphasis was placed on locating stream monitors on each side of major cities and towns. Therefore, a before-and-after effect could be derived to determine the impact of each municipality on water quality. Secondary, or tributary streams were also monitored for a five-year period. It should be noted however that not every stream had a monitor located along its path. This is not to imply that water quality problems are non-existent, but merely to recognize that fewer water quality problems exist in these areas than in urban-industrial environments. Some streams had very limited data available due to either the location of new sampling stations and new parameter monitoring, or the discontinuance of specific parameter sampling found no longer to be a critical limiting factor. In these instances, the total period of record was extracted for analysis.

The development of this report has been a cooperative effort of numerous agencies. An additional source of information was provided by each Designated 208 Water Quality Management Agency. It appeared that a more clear and accurate water quality assessment would be more reliable if other opinions were solicited. Therefore, because Section 208 of the Act requires each designated agency to assess its water quality, their combined input assisted in identifying problem areas of pollution.

The Indiana Stream Pollution Control Board (SPCB) has been delegated the authority to protect the integrity of all instream water uses, and has promulgated several standards that are aimed to this end. These include:

Article 1

330 IAC 1-1-1 et seq., Rule 1; "Water Quality Standards for All Waters Within the State of Indiana," 1977.

Article 2

330 IAC 2-1-1 et seq., Rule 1; "Water Quality Standards for Lake Michigan and Contiguous Harbor Areas," 1978.

330 IAC 2-2-1 et seq., Rule 2; "Water Quality Standards for The Grand Calumet River and the Indiana Harbor Ship Canal," 1978.

330 IAC 2-3-1 et seq., Rule 3; "Water Quality Standards for Wolf Lake," 1978.

330 IAC 2-4-1 et seq., Rule 4; "Water Quality Standards for Natural, Spawning, Rearing, or Imprinting Areas, and for Migration Routes for Salmonid Fishes," 1978.

Guidelines On Ammonia Reductions for Protection of Warm Water Fish.

Article 1, Rule 1, is a regulation that, in addition to establishing minimum treatment requirements and nondegredation policies applicable to all waters, establishes water quality standards applicable to all waters of the State of Indiana except where otherwise specified by the Stream Pollution Control Board through other standards.

The nondegradation policies of the State are applicable to all waters of the State, especially those designated as an outstanding Natural or State resource, and those streams incorporated by the Indiana Department of Natural Resources into the Natural, Scenic, and Recreational Rivers System. Such designation includes:

1. Blue River from U.S. 150 in Fredricksburg, downstream 45.5 river miles to river mile 11.5. This designated stream flows through portions of Washington, Harrison, and Crawford Counties.

2. Cedar Creek from river mile 13.7 to its confluence with the St. Joseph River. Cedar Creek flows through portions of DeKalb and Allen Counties.

This designation and related classifications may be foregone if the Stream Pollution Control Board, after appropriate consideration to public participation and government coordination, determines that limited degradation is justifiable on the basis of necessary economic or social factors, and will not become injurious or interfere with any beneficial instream uses.

Basically, four (4) uses have been determined by the Stream Pollution Control Board for all waters of the State. These include recreation, aquatic life, industrial/domestic use (as a surface water intake), and agricultural uses. However, only the recreational, aquatic life, and water supply criteria, (where applicable) will be assessed.

All lakes and reservoirs, the St. Joseph River in Elkhart and St. Joseph Counties, the St. Joseph River in Allen County, the Wabash River where forming the common boundary with Illinois, the Whitewater River after its confluence with the East Fork of the Whitewater River, the Ohio River, and any stream reach incorporated into the Natural, Scenic, and Recreational River System are designated for whole-body contact recreation. All other streams are classified for partial-body contact recreation.

Whole-body contact recreation is limited to the months of April through October, inclusive. The remainder of the year, these streams will be subject to criteria for partial-body contact recreation. The bacterial quality for whole-body contact at any point outside the mixing zone requires that the fecal coliform content (MPN or MF) shall not exceed 200 organisms per 100 milliliters (200/100 ml.) of water as a geometric mean based on not less than five samples per month, nor 400/100 ml. in more than one sample during the month. Conversely, the bacterial quality for partial-body contact outside the mixing zone requires that the fecal coliform bacteria content (MPN or MF) shall not exceed 1000/100 ml. as a geometric mean based on not less than five samples per month; nor exceed 2000/100 ml. in more than one sample.

Waters of the State designated for aquatic life must be capable of supporting a well-balanced, warmwater fish community; except that, all waters, where the natural temperatures will permit, will be capable of supporting put-and-take trout fishing, and, where now possible, the natural reproduction of trout and salmon. The criteria for maintaining minimum water quality for aquatic life generally considers not only the unpalatable flavor and offensive odor of fish but also limits toxic substances to 1/10 of the 96-hour median lethal concentration (LC_{50}). No pH values will be permitted below 6.0 nor above 9.0 except where attributed to photosynthetic activity.

In addition to this general standard, other standards have been established to ensure the maintenance of a well-balanced, warmwater fish community, and cold water fish communities. For a warmwater fish community, concentrations of dissolved oxygen (D.O.) shall average at least 5.0 milligrams per liter of water (mg/l) per calendar day and shall not be less than 4.0 mg/l at any time. Water temperature shall not exceed certain maximum limits. For the Ohio River, these temperature constraints range from 10.0° C. in January to 31.7° C. in July and August. In the St. Joseph River, a tributary to Lake Michigan, these maximum temperatures range from 10.0° C. from December through February to 29.4° C. from June through September. Other maximum temperatures for Indiana streams range from 10.0° C. in January and February to 32.2° C. from June through September. For specific monthly maximum temperature limits, please consult the standard.

Article 2, Rule 1, is a regulation establishing water quality standards for Indiana's portion of Lake Michigan and its Contiguous Harbor Areas, i.e., the Inner Harbor, Gary Harbor, and Burns Harbor. Section 3 of this regulation defines three water uses in this area. The uses include: recreation, aquatic life, domestic potable water supples, and industrial water supplies.

In addition to a toxic substance limitation of 1/10 of the 96-hour median lethal concentration (LC_{50}) for the most ecologically sensitive organism, temperature standards for Lake Michigan and Contiguous Harbor Areas dictate that maximum monthly temperatures not exceed certain prescribed limits. These limits range between 7.0° C. from January through March to 26.5° C. from July through September.

Table 1
Lake Michigan/Harbor Area Water Quality Standards

Parameter	Harbor Areas	Lake Michigan
D.O. (mg/l)	7.0	7.0
pH	7.5-8.5	7.5-8.5
*Unionized Ammonia (mg/l)	0.10/0.03	0.05/0.02
*Chlorides (mg/l)	20.0/15.0	20.0/15.0
*Sulfates (mg/l)	50.0/26.0	50.0/26/0
*Dissolved Iron (mg/l)	0.30/0.15	0.30/0.15
*Phenols (ug/l)	3.0/1.0	3.0/1.0
*Total Phosphorus (mg/l)	0.04/0.03	0.04/0.03
Cyanide (mg/l)	0.01	0.01
Cadmium (ug/l)	10.0	10.0
Arsenic (ug/l)	50.0	50.0
Total Chromium (ug/l)	50.0	50.0
Lead (ug/l)	50.0	50.0
Total Mercury (ug/l)	0.05	0.05
PCBs (ug/l)	0.001	0.001

*Daily Maximum/Monthly Average

Article 2, Rule 2, is another regulation for the Great Lakes Region. Its standards apply to the Grand Calumet River and the Indiana Harbor Ship Canal. Because of the extensive urban-industrial environment, the flow of these two watercourses is comprised predominately of treated wastewaters and wastewaters of nonpoint source origin, such as stormwater overflow. Due to these factors, the unnatural character of these stream beds and the recognition that even if all wastewaters discharged into these streams are provided the best available technology for treatment, they may not be capable, at all times, of sustaining a well-balanced fish community, the Stream Pollution Control Board has classified these streams for use as partial-body contact recreation, for limited aquatic life and for use as a industrial water supply.

In addition to limiting toxic substance concentrations to 1/10 of the 96-hour median lethal concentration (LC_{50}) and pH values to a minimum of 6.0 and a maximum of 9.0, the minimum water quality standards for these waterways specify that dissolved oxygen concentrations shall not be less than 4.0 milligrams per liter (mg/l). Water temperature is not to exceed 15.6° C. from December through March, nor exceed 30.6° C. in the summer months of July and August. Recreational criteria for partial-body contact recreation requires that the fecal coliform bacteria content (MPN or MF) shall not exceed a geometric mean of 1000 organisms per 100 milliliters of water (1000/100 ml) nor exceed 2000/100 ml. in more than 10% of the samples, except during periods of storm water runoff. The filterable residue or total dissolved solids shall not exceed 500 mg/l at anytime.

The chemical constituents of the Grant Calumet River and the Indiana Harbor Ship Canal should be held to the levels denoted in Table 2.

Table 2
Grand Calumet River/Indiana Harbor Ship Canal
Chemical Concentration Standards

Constituent	Concentration
Total Ammonia Nitrogen	1.5 mg/l
Cyanide	0.1 mg/l
Fluoride	1.3 mg/l
Iron (dissolved)	0.3 mg/l
Phenol	0.01 mg/l
Total Mercury	0.5 ug/l
PCBs	0.001 ug/l

Two of the remaining standards, chlorides and sulfates, are limited so as to guarantee the potential for domestic potable water supplies. Specifically, the total chloride content shall not average more than 40 mg/l during any 12-month period nor exceed 125 mg/l at any time. The total sulfate content shall not exceed an annual average of more than 75 mg/l nor exceed 225 mg/l at any time.

The total phosphorus limitation specifies that the phosphorus concentration shall not exceed 0.10 mg/l at any time except in waters flowing westward into Illinois. Oil or similar materials shall not be present in such quantities that they will produce a visible film on the water surface, coat the banks or bottom of the streams or in any way be toxic or harmful to fish and any other aquatic life. To fulfill this criterion, the total oil concentration shall not exceed 10.0 mg/l.

Article 2, Rule 3, is a regulation establishing water quality standards for Wolf Lake and Wolf Lake Channel. This standard requires that the water quality of the lake and its channel be designated for whole-body contact recreation and of sufficient quality that they be able to support a well-balanced warmwater fish community.

To maintain the recreational potential for whole-body contact recreation, the fecal coliform content (either MPN or MF) shall not exceed 200 organisms per 100 milliliters of water (200/100 ml.) as a geometric mean based on not less than five samples; nor exceed 400/100 ml. in more than 10% of the samples. In addition to limiting toxic substance concentrations to 1/10 of the 96-hour mean lethal concentration (LC_{50}), the following minimum water quality standards for fish and aquatic life shall apply.

No pH values below 6.5 nor above 8.5 may be tolerated, except for those excursions above 8.5 that are correlated with photosynthetic activity. Oil shall not be present in such quantities that will produce a visible film on the water surface, coat the banks and bottom of the lake or be toxic to fish or aquatic life. Un-ionized ammonia, cyanide and total phosphorus will be limited to daily concentrations not to exceed 0.02 mg/l, 0.01 mg/l, and 0.04 mg/l, respectively. The concentrations of dissolved oxygen shall average at least 5.0 mg/l per day and shall not fall below 4.0 mg/l at any time, except that lower values associated with depth may be tolerated if caused by natural conditions. Temperature standards and criteria have been established for Wolf Lake or Wolf Lake Channel. Generally, the temperature of the waters of Wolf Lake shall not exceed 29.4^{o} C. during the summer nor 15.5^{o} C. during the period from October through March, inclusive. Secondly, at any place in Wolf Lake Channel, the receiving water shall not be more than 2.4^{o} C. above the existing natural water temperature of the lake. The temperature of Wolf Lake Channel at its mouth shall not be more than 1.5^{o} C. above the natural temperature of the lake.

Article 2, Rule 4, is a standard established for the protection of the natural salmonid spawning, rearing, and imprinting areas in the State. The standard also provides for the protection of migration routes of salmonid fishes. The Indiana Department of Natural Resources has designated four areas in the State as natural spawning areas or rearing and imprinting areas for salmonid fishes. These include:

1. Trail Creek and tributaries upstream of U.S. Highway 35.

2. Little Calumet River and tributaries upstream (easterly) of the Wagner Road Bridge. The Wagner Road Bridge is located downstream of Chesterton at the southeast corner of the southwest quarter, Section 26, T37N, R6W, in Porter County, Indiana.

3. Kintzele Ditch (Black Ditch) from Beverly Drive downstream to Lake Michigan.

4. Salt Creek above its confluence with the Little Calumet River.

Within these areas, water quality standards are stringent. Specifically, temperature criterion indicates that <u>no heat shall be added</u> to any part of these stream reaches. In addition, the concentrations of dissolved oxygen (D.O.) shall not be less than 6.0 at any time or at any place. During the spawning season or during periods of rearing or imprinting, the D.O. shall not fall below 7.0 mg/l at any time or at any place. These critical periods usually occur twice a year; once in the fall and again in the spring. The Department of Natural Resources usually anticipate these times to occur between March 15 through June 30 and again from August 1 through approximately December 1.

Other standards applicable to rearing and imprinting areas indicate that no pH values below 6.0 nor above 8.5 may be tolerated. This excludes any daily fluctuations correlated with photosynthetic activity. Concentrations of toxic substances in these streams are subject to those maximum limits specified in the U.S. EPA Administrator's Quality Criteria for Water 1976 for the protection of sensitive aquatic life.

To maintain acceptable recreational standards, the fecal coliform bacteria content (MPN or MF) shall not exceed a geometric mean of 200 organisms per 100 milliliters of water (200/100 ml.) nor exceed 400/100 ml. in more than 10% of the samples.

Salmon migration routes also exist in two streams within this area; Trail Creek from Highway 35 downstream to Lake Michigan and the Little Calumet River from Wagner Road Bridge downstream to Lake Michigan via Burns Ditch. Migration periods occur twice a year, once in the spring from mid-March through June and again in the fall from the beginning of August through the beginning of December. During these periods, the dissolved oxygen (D.O.) concentration shall not fall below 6.0 mg/l at any time or any place. At other times during the year, dissolved oxygen must average at least 6.0 mg/l during any 24-hour period and not fall below 5.0 mg/l at any time. The maximum temperature shall not exceed 52.2^{o} C. at any time or any place during migration periods nor exceed 67.26^{o} C. at any time. No pH values below 6.5 nor above 8.5 will be tolerated with an exception for photosynthetic activity.

Another principal concern is the quality of the Ohio River. Not unlike the Lake Michigan Basin, which is also an international water, the Ohio is an interstate river system subject to multi-state jurisdiction. In 1948 an interstate compact, signed by not only Indiana, but also Illinois, Kentucky, Ohio, New York, Pennsylvania, Virginia, and West Virginia, established the Ohio River Valley Water Sanitation Commission (ORSANCO) and committed the signatory states to carry out the policies of the Commission. Article I of the Ohio River Valley Water Sanitation Compact pledges each member state, including Indiana, to place and maintain the waters in the basin "in satisfactory and sanitary condition" available for use as a public and industrial water supply after reasonable treatment, suitable for recreational usage, capable of maintaining fish and other aquatic life, free from unsightly or malodorous nuisances due to flooding solids or sludge deposits, and adaptable to such other uses as may be legitimate.

One such policy of the Commission is the "Stream Quality Criteria and Minimum Conditions for the Main-Stem of the Ohio River." Accordingly, the minimum conditions applicable to all waters at all places and at all times specify that water must be free from: 1) substances that will settle to form putrescent or otherwise objectionable sludge deposits, 2) floating debris, oil, or scum which may be unsightly or deleterious, 3) materials producing color, odor, or other conditions which create a nuisance, and 4) substances which are toxic to human, animal, plant or aquatic life.

Other specifications require that at no time shall the dissolved oxygen concentration be less than 4.0 mg/l any place outside the mixing zone and shall average at least 5.0 mg/l per calendar day.

The Stream Pollution Control Board (SPCB) has also adopted ORSANCO's recommended instream temperature criteria. As such the maximum temperature shall not exceed 5° F., above the natural temperature. In addition, the allowable maximum temperature during a month shall not exceed:

Month	Temperature	Month	Temperature
January	50° F.	July	89° F.
February	50° F.	August	89° F.
March	60° F.	September	87° F.
April	70° F.	October	78° F.
May	80° F.	November	70° F.
June	87° F.	December	57° F.

Some variance is granted from the above table in that temperature shall not exceed these limits during more than 1% of the hours in the 12-month period ending with any month, but at no time shall it exceed those limits by more than 3° F.

In addition, the pH factor shall not fall below 6.0 nor rise above 9.0; except those fluctuations above 9.0 which are correlated with natural photosynthetic activity. In addition to pH, un-ionized ammonia shall be calculated with the corresponding concentration of total ammonia and temperature. At no time should un-ionized ammonia exceed 0.05 mg/l.

Although ORSANCO recommends limiting toxic substances to one-tenth of the 96-hour tolerance limit (LC_{50}), it also proposes some additional guidelines for toxic substance control. First, if maximum values, established through verified laboratory tests, are exceeded through natural instream characteristics, than those natural occurring values shall be the threshold concentration. Secondly, if synergistic toxic effects can occur as a result of not only a discharge, but also natural occurrences, the limitations for that discharge should be determined using standard bioassay techniques for the effluent and the receiving stream. Lastly, for those pollutants, such as PCBs, which are known or thought to have potential for bioaccumulation and are also below quantifiable levels (0.1 ug/l), the total body weight concentration shall indicate a need for further action using bioassay monitoring of fish flesh to determine a potential toxic threshold. As in the case of PCBs, a body burden level exceeding 2.0 ug/l shall be cause for additional investigation.

ORSANCO has also recommended other maximum concentrations for several other chemicals including:

Constituent	Maximum Limit	Constituent	Max. Limit
Arsenic	0.05 mg/l	Lead (filterable)	50.0 ug/l
Barium	1.0 mg/l	Nitrate-N & Nitrate-N	10.0 mg/l
Cadmium	0.01 mg/l	Nitrate-N	1.0 mg/l
Chlorides	250.0 mg/l	Phenols	10.0 ug/l
Chromium (hex)	0.05 mg/l	Selenium	0.01 mg/l
Copper	0.1 mg/l X 96 hr. LC_{50}	Silver	0.05 mg/l
Cyanide	25.0 ug/l	Sulfate	250.0 mg/l
Fluoride	1.0 mg/l	Zinc	0.1 mg/l X 96 hr. LC_{50}

Total Mercury - 0.05 ug/gram (total body burden)
Unfiltered Mercury - 0.2 ug/l

As fulfillment for whole-body contact recreation the commission recommends that the fecal coliform concentrations (either MPN or MF) shall not exceed 200/100 ml. as a monthly geometric mean based on not less than five samples per month; nor exceed 400/100 ml. in more than 10% of the samples taken in one month. This recreational standard is applicable only during the designated recreation season of April through October, inclusive. Other coliform standards have been adopted for those municipalities which utilize the Ohio River as a source of water supply. These municipalities include the Cities of Evansville, Mt. Vernon, and New Albany. Therefore, the fecal coliform content (MPN or MF) to maintain a potable water supply, should not exceed 2,000/100 ml. as a monthly geometric mean based on not less than five samples per month. In addition, the dissolved solids, as recommended, should not exceed 500 mg/l as a monthly average value nor exceed 750 mg/l at anytime.

The final criteria from the Stream Pollution Control Board are the guidelines it has established on "Ammonia Reduction for the Protection of Warm Water Fish." The staff's recommendation, as approved by the Stream Pollution Control Board, states that the ammonia criterion for the protection of warm water fish should be 0.05 mg/l un-ionized ammonia. This criterion would be equivalent to a total ammonia concentration of 2.8 mg/l at a pH of 7.5 and a temperature of 25^{o} C.

Other parameter criteria which have been utilized for this water quality assessment have either been taken from the U.S. EPA, Quality Criteria for Water, 1976 and/or from The California State Water Resources Control Board's, Water Quality Criteria, 1963.

II. Status of Water Quality

Lake Michigan Basin

General Assessment:

The water quality within the Lake Michigan Basin is probably the most difficult to accurately evaluate. In conjunction with its urban environment, many State and Federal water quality standards must be taken into consideration, i.e., Lake Michigan Standards, Grand Calumet River and the Harbor Canal Standards, sensitive cold water environments, and the U.S. EPA Standards.

Generally, the water quality of Lake Michigan is found to be in compliance with applicable water quality standards, although one of the main problems continues to be high levels of phenol constituents. Most inland rivers and streams appear to support designated uses, but in some instances, such as within the Grand Calumet River, the influx of toxic waste material significantly reduces the stream's capacity to attain acceptable water quality.

Technical Assessment:

The Lake Michigan Basin lies in extreme northwestern Indiana. Its waters encompass not only Lake Michigan, but also the principal streams of the Grand Calumet River, the Little Calumet River and Salt Creek. Several streams also drain directly into Lake Michigan. These tributaries include the Indiana Harbor Ship Canal, Burns Ditch, and Trail Creek. All of the stream segments have been classified as "water quality" areas. Therefore, it is anticipated that a majority are not currently meeting water quality standards even after the application of applicable effluent limitations.

The water quality of Lake Michigan is gauged through water samples taken from several Fixed Station Water Quality Monitors located at municipal water supply intakes. Cities that utilize Lake Michigan as a potable water supply source include East Chicago, Gary, Hammond, Whiting, and Michigan City.

Collectively, the dissolved oxygen concentrations at each municipal intake are generally well above State standards. The larger violations have occurred at Michigan City with a 13% violation rate over a five-year period. This still represents 87% compliance over a five-year period (1974-1978). It may, therefore, be concluded that although sporadic violations do occur, sufficient dissolved oxygen is present to support fish and aquatic life.

Because of their acceptable concentrations, other parameters also promote the maintenance of a well-balanced lake environment. The State limits the amount of un-ionized ammonia to 0.05 mg/l as a daily maximum. At no time has this critical level been exceeded. Both temperature and pH are two of the major variables determining the amount of un-ionized ammonia present. Although temperature did not exceed its monthly maximum limits, pH did show variation between its high and low limits from 21%-34% of the time at each survey location. But these changes were not severe enough to significantly alter the amount of un-ionized ammonia.

Table 3 illustrates that there may be four (4) potential limiting factors preventing Lake Michigan from attaining compliance with water quality standards.

Table 3
Lake Michigan Water Quality Violations
(% of Total Samples)

	Phenols	Phosphorus	Cyanide	Oil/Grease
East Chicago	74%	37%	20%	25%
Gary	73%	31%	27%	19%
Hammond	63%	49%	14%	25%
Whiting	77%	42%	21%	30%
Michigan City	59%	45%	18%	19%
Limit	3.0 ug/l	0.04 mg/l	0.01 mg/l	10.0 mg/l

State standards require that concentrations of phenols be limited to a daily maximum of 3.0 ug/l and 1.0 ug/l as a monthly average. From 1974-1978, the concentration of phenols averaged 4.9 ug/l at each water intake location on Lake Michigan. This averages approximately 31% compliance at each location. It appears that more violations occurred between 1977-1978 than in earlier years of the survey period.

Excessive total phosphorus concentrations also affect the biological quality of Lake Michigan. As State regulations prescribe, total phosphorus concentrations within Lake Michigan should not exceed a daily maximum of 0.04 mg/l or 0.03 mg/l as a monthly average. Analysis of data indicate this daily limit is generally exceeded 40% of the time. Over a five-year period this parameter average 0.09 mg/l per year.

Cyanide concentrations have also been noted to be above State limitations. The Stream Pollution Control Board limits total in-lake cyanide to 0.01 mg/l at anytime. Although violations are periodically recorded at each location, some improvement is indicated. Collectively, most violations were identified early within the survey period and supported by the fact that total cyanide concentrations have averaged near 0.01 mg/l for the entire five-year period, some instream reductions have occurred.

The recreational potential for the open waters of Lake Michigan was found to be very high. Occasionally, at the Whiting and Michigan City water intakes, coliform bacteria concentrations exceeded State limits. These instances were very uncommon and the total effect was not considered detrimental to the lake's recreational potential.

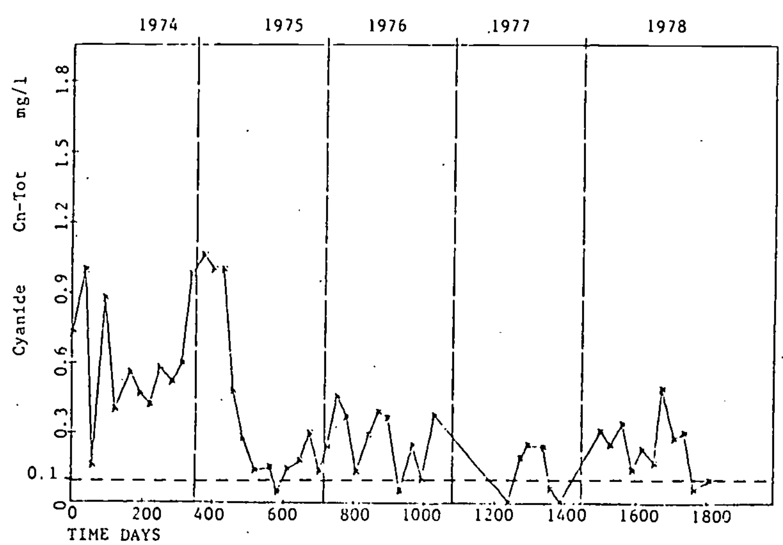
There are several streams within the Lake Michigan Basin discharging directly to the surface water of Lake Michigan. These waterways include, but are not limited to, the Indiana Harbor Ship Canal, Burns Ditch and Trail Creek.

The Indiana Harbor Ship Canal is a man-made waterway that connects the Grand Calumet River to Lake Michigan. Because of the heavy industrialization of the area, the water quality of the Indiana Harbor

Ship Canal has been significantly impaired. In at least 44% of the surveys (1974-1978), the dissolved oxygen concentrations have been found to violate State standards. The most severe case is illustrated by a small western inlet of the Canal that complies with dissolved oxygen standards only 40% of the time. Considering the complex urban-industrial environment and the persistent limited flow of the waterway, it is not surprising that dissolved oxygen concentrations are commonly below standard. Between its upstream and downstream monitoring stations, the Indiana Harbor Ship Canal has measured a 1% reduction of available dissolved oxygen between its junction with the Grand Calumet River and its Lake Michigan confluence.

The two most frequently violated standards of the Indiana Harbor Ship Canal were, therefore, total ammonia and polychlorinated biphenols (PCBs). At three of the four stations the total ammonia standard was violated in every instance and recorded only a 24% compliance rate at the mouth of the Canal. In addition, the five-year average is approximately 2.8 mg/l over State standards. The toxic pollutant of greatest concern in the Indiana Harbor Canal is probably PCBs. Although limited data is available, every measurement taken between 1974-1976 presumably exceeded State limitations. Specifically, PCB concentrations ranged between less than 0.01 ug/l to 0.04 ug/l at each location surveyed.

Figure 1 ; 1974-1978
Total Cyanide Concentrations, (mg/l)
Indiana Harbor Canal at East Chicago



As Figure 1 illustrates, concentrations of cyanide were also found at some locations with the higher levels reported to occur at the farthest upstream monitor. In this instance, the State limitation of 0.1 mg/l was met 15% of the time. Over a five-year period, total cyanide was measured at a mean value of 0.36 mg/l. (72% over State regulations). Some reductions have been made near the mouth of the Canal. This monitor has recorded a 74% compliance rate with State standards which amounts to an overall 0.20 mg/l reduction between upstream and downstream stations.

Total phosphorus concentrations discharged to Lake Michigan from the Indiana Harbor Canal is quite low. During a five-year period results of analysis have shown 76% compliance with standard requirements. But measurements of total phosphorus from monitoring stations further upstream have averaged a 90% rate of violation for the same period of time. Therefore, an overall improvement can be denoted as this stream flows toward Lake Michigan. As an average, a total phosphorus reduction of 1.0 mg/l has been realized from 1974-1978 between these monitoring points.

Coliform bacteria concentrations indicated very poor recreational potential for the Indiana Harbor Ship Canal. Generally, the upstream monitors record poorer bacterial quality than those downstream. In particular, upstream samples indicate only a 66% compliance rate for a five-year period with measurements averaging near 16,700 organism per 100 milliliters. Therefore, even though measurable improvement in the bacterial quality occurs prior to its discharge to Lake Michigan, the Indiana Harbor Ship Canal's recreational potential is also limited by several other causal factors resulting from its urban flow pattern.

The remaining two streams draining directly into Lake Michigan are Burns Ditch and Trail Creek. These streams are unique in that they are cold water environments capable of supporting put-and-take trout fishing. These streams serve as migration routes and are also used for the rearing and imprinting of salmonid fishes. The other cold water streams include Salt Creek, Kintzele Ditch, and the Little Calumet River from the Wagner Road Bridge downstream to Lake Michigan via Burns Ditch.

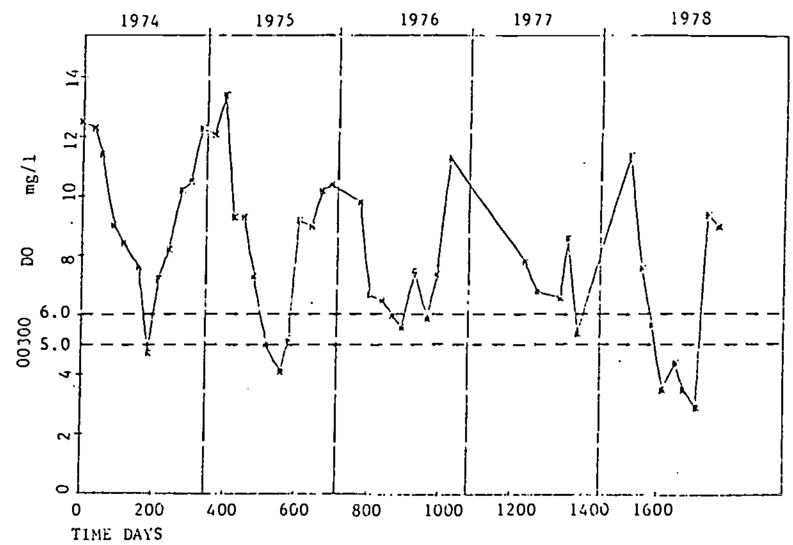
Trail Creek (7_Q10=20 cfs), is located in LaPorte County, Indiana, and flows northward to its confluence with Lake Michigan near Michigan City, Indiana. The State of Indiana has located two stream monitors to evaluate water quality; one downstream from the Michigan City Wastewater Treatment Facility and another prior to its Lake Michigan confluence.

Data indicate that the annual dissolved oxygen concentrations have complied with State water quality standards 87% of the time (between 1974-1978) prior to discharging to Lake Michigan. But at comparable times during the year, 22% more violations have been recorded at the other station below Michigan City's wastewater treatment plant. In these instances, dissolved oxygen concentrations in Trail Creek fall below 4.0 mg/l, primarily due to poor physical stream flow conditions and due to the impact of municipal waste.

Periods of fish migration are the most critical times when sufficient oxygen must be present for salmon and trout. The State Department of Natural Resources anticipates a bi-annual period for these occurrences; from mid-March through June and again from August through the first of December.

Water quality data indicate that Trail Creek meets minimum dissolved oxygen standards only 65% of the time (between 1977-1978) downstream from Michigan City's Wastewater Treatment facility. During designated periods of migration, this point on Trail Creek complies with the minimum requirement of 6.0 mg/l of dissolved oxygen in only 60% of the samples. Figure 2 indicates better water quality at the mouth of Trail Creek where 6.0 mg/l of dissolved oxygen is sustained approximately 74% of the time. Dissolved oxygen values at this location comply with the prescribed minimum concentration of 5.0 mg/l 87% of the time. It may be concluded that while Trail Creek annually averages a dissolved oxygen concentration near 7.2 mg/l, migrational patterns may at times be partially impaired immediately downstream from the Michigan City Wastewater Treatment Facility. The City has been issued a Step 1 grant award for facility planning. The State anticipates that upon completion of advance waste treatment and ammonia removal water quality problems should be significantly reduced. This will improve potential for salmonid migration in Trail Creek.

Figure 2 ; 1974-1978
Dissolved Oxygen Concentrations (mg/l)
Trail Creek at Michigan City



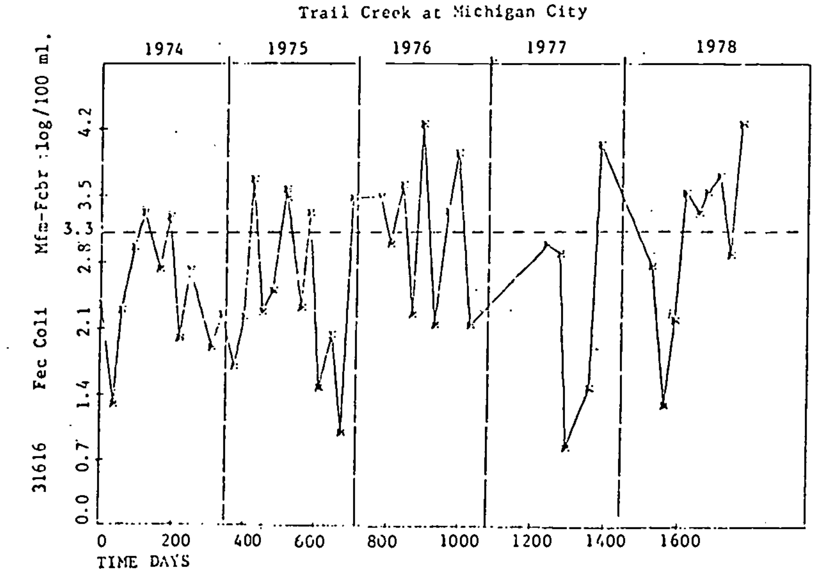
Another potential limiting factor is temperature. At least one sample from each migration period indicates that temperature exceeded its 21° C. limitation. Although a small temperature increase has been denoted, it is not significant enough to preclude Trail Creek's potential as a cold water environment for salmon and/or trout. Most temperature violations have been associated with summer low-flow periods when temperature reaches its peak level.

The most serious documented problem on Trail Creek is cyanide contamination. Each monitoring station has averaged only 44% compliance with the U.S. EPA criterion. Prior to its Lake Michigan confluence, Trail Creek exceeded 5.0 ug/l of cyanide in 33% of the cases as compared to 60% immediately downstream from Michigan City treatment facility during 1977-1978. Total cyanide concentrations were found to average 7.0 ug/l and 11.0 ug/l, respectively, at each monitoring location.

Some problems may be associated with un-ionized ammonia and oil and grease. The U.S. EPA has determined that un-ionized ammonia at concentrations greater than 0.02 mg/l may be a threshold level for fish and aquatic life, especially in cold water environments. Since this level is approached only sporadically, un-ionized ammonia does not appear to affect Trail Creek. Oil and grease was reported to exceed 10.0 mg/l in 25% of the 1977 samples. A majority of these cases occurred during critical periods when cold water streams are utilized as migration routes. Although the mean concentration for the survey period, ending in 1977, averaged 8.0 mg/l, violations ranged from 10.2 mg/l to 19.5 mg/l. Therefore, excessive amounts of oil and grease posed problems for migration during these critical periods.

Trail Creek is also designated for partial-body contact recreation. Instream bacterial quality should not exceed 2,000 organisms per 100 milliliters of water (log = 3.3). On an average, this coliform bacteria standard is met in only 64% of the measurements on Trail Creek. Mean averages do indicate a more severe problem immediately downstream from Michigan City as indicated in Figure 3. Comparatively, fecal coliform bacteria concentrations have averaged almost 5,700/100 ml. (log = 3.7) at this point in contrast to a almost 2,300/100 ml. (log = 3.4) at the mouth of Trail Creek. Until corrective measures are implemented at the Michigan City Wastewater Treatment facility, the recreational potential in Trail Creek will continue to be periodically impaired.

Figure 3 ; 1974-1978
Fecal Coliform Concentrations (log/100 ml.)
Trail Creek at Michigan City



Burns Ditch is part of the salmon migration route originating in the upper reaches of the Little Calumet River near the Wagner Road Bridge in Porter County. The U.S. Geological Survey has measured a seven-day, once-in-ten-year low flow of 18 cubic feet per second on the Little Calumet River prior to its junction with Burns Ditch. At Porter, Indiana, data from the State's Fixed Station Monitor indicate an excellent environment for fish and aquatic life. Overall, dissolved oxygen has demonstrated 95% compliance with daily minimum standards over a five-year period. At this point the mean dissolved oxygen of the Little Calumet River averages 9.0 mg/l even during designated migration periods.

The upper reaches of the Little Calumet River are also designated for partial-body contact recreation. Coliform bacteria therefore should not exceed 2,000 organisms per 100 milliliters of water (2,000/100 ml.). Data indicate that even though the five-year mean is 2,400/100 ml., instream quality has complied with State standards approximately 77% of the time. Generally, violations have ranged from 20/100 ml. to 4,877/100 ml. over State limitations.

The Little Calumet River joins Burns Ditch near East Gary, Indiana, and flows to Lake Michigan. The main channel of Burns Ditch reflects the water quality of the combined flows of its east and west branches, however, only the main channel and the east branch of Burns Ditch are subject to standards applicable to cold water streams.

Dissolved oxygen concentrations are usually high in Burns Ditch and have not violated State minimum standards in more than 8% of the samples. Overall dissolved oxygen concentrations have averaged 8.5 mg/l for a five-year period. Dissolved oxygen has been present in sufficient quantities during the critical periods of salmonid migration. The only major parameters that may prove prohibitive to fish and aquatic life are cyanide and oil and grease. Data indicate that total cyanide concentrations have complied with the U.S. EPA criterion only 65% of the time between 1974-1978. Throughout this period, the mean concentrations have averaged 9.0 ug/l or 4.0 ug/l above Federal standards, with violations ranging from 6.0 ug/l to a high 85.0 ug/l above criterion. Therefore, no overall improvement can be denoted. Prior to discontinuing its sampling in 1977, oil and grease concentrations were found to exceed the recommended instream criteria of 10.0 mg/l in 26% of the samples. While the mean average remained at a concentration of 8.0 mg/l, recorded violations ranged from 11.0 mg/l to 26.0 mg/l and occurred solely during critical migration, rearing, or imprinting periods.

Some areas of Burns Ditch are able to meet instream recreation standards between 65% and 79% of the time. Data indicate that upstream coliform concentrations have averaged 1,033/100 ml., while downstream, only one mile from Lake Michigan, bacterial concentrations were approaching 2,600 organisms per 100 milliliters. Therefore, an overall 31% increase of coliform bacteria impacts Burns Ditch prior to its Lake Michigan confluence. It is apparent that recurrent bacterial problems, especially in the main channel of Burns Ditch, are major factors prohibiting attainment of water quality standards.

The western branch of Burns Ditch is not designated as a cold water stream, and therefore, is subject to less stringent State standards. State standards require that, in these waters, a minimum dissolved oxygen concentration of 4.0 mg/l must be maintained. Data indicate that no values have fallen below this limit between 1974-1978.

Several other water constituent values have violated either State Water Quality Standards and/or U.S. EPA water quality criteria. Concentrations of phenols violate the U.S. EPA criterion in 85% of the samples. A Federal criterion of 1.0 microgram per liter (ug/l) has been established to protect against the tainting of fish flesh. Generally, the mean concentration of phenols is reported to be 3.8 ug/l for a five-year period with an average violation of 4.3 ug/l per year. Cyanide concentrations also prohibit attainment of water quality criteria. Although the U.S. EPA has limited total instream cyanide to 5.0 micrograms per liter (ug/l), records reveal that the mean annual concentration is 8.0 ug/l, with only 55% compliance over a five-year period. The total range of violations are between 6.0 ug/l and 85.0 ug/l, with the average violation approximating 16.0 ug/l.

Concentrations of iron, which violated recommended criterion 42% of the time over a five-year period, is another problem of concern. In some freshwater environments iron concentrations above 1.0 milligram per liter (mg/l) may be a critical level for fish and other aquatic life. Although the mean annual iron concentration is reported to approach this limit, the average violation reported was 1.5 mg/l with concentrations as high as 3.0 mg/l during 1974-1978.

Oil and grease were also measured constituents in the west branch of Burns Ditch. Oil and grease have exceeded desirable concentrations in 30% of the samples. However, vast improvement has been realized. Prior to 1976, oil and grease was a significant water quality problem often exceeding the recommended 10.0 mg/l. Excessive concentrations of oil and grease usually ranged between 11.0 mg/l to 30.0 mg/l. However, reductions in these concentrations have occurred, and present concentrations rarely exceed 10.0 mg/l.

Mercury has also sustained measurable reductions. Prior to 1976 total instream mercury concentrations violated the U.S. EPA criterion approximately 43% of the time. Violations generally ranged between 0.20 ug/l to 1.60 ug/l. Recently, however, recorded mercury concentrations have not exceeded 0.10 ug/l at anytime. In addition only 53% of the coliform bacteria complied with standards applicable for partial-body contact recreation in the west branch of Burns Ditch. As an average, the five-year coliform bacteria concentration is near 35,000 organisms per 100 milliliters (35,000/100 ml.) with violations ranging from 100/100 ml. to 38,000/100 ml. over State recreational standards.

The remaining cold water stream in the Lake Michigan Basin to be discussed is Salt Creek located in Porter County, Indiana. The headwaters of Salt Creek originate in a marshy area in central Porter County. Its southerly flow, measured at a seven-day, once-in-ten-year low flow of 19 cubic feet per second, joins the Little Calumet River near McCool, Indiana. The only major impact this stream receives is from the Valparaiso Wastewater Treatment Facility.

The water quality of Salt Creek has been evaluated through data compiled from temperature, dissolved oxygen, oil and grease, un-ionized ammonia and fecal coliform bacteria measurements. According to State standards, no heat shall be added. However, between 1974-1978 mean annual temperatures increased approximately 28%. The largest gain was reported in 1976-1977 during which time temperature increased approximately 2^{o} C. The overall dissolved oxygen concentration of Salt Creek demonstrates a 86% compliance with the 6.0 mg/l minimum requirement. State standards require that dissolved oxygen concentrations must be at least 7.0 mg/l during spawning periods. This standard was violated approximately 38% of the time. Only two violations were correlated with excessive bacterial concentrations or the large biochemical oxygen demand of the stream.

Oil and grease were also found to be potential water quality problems. Prior to mid-1977, oil and grease failed to meet acceptable concentrations 26% of the time. Since that time, however, an overall reduction has been realized. In the last survey year, lower concentrations have been recorded which have averaged only 1.7 mg/l. Therefore, a net 21% reduction has been achieved between the annual mean concentration of 8.1 mg/l and the present concentrations of oil and grease.

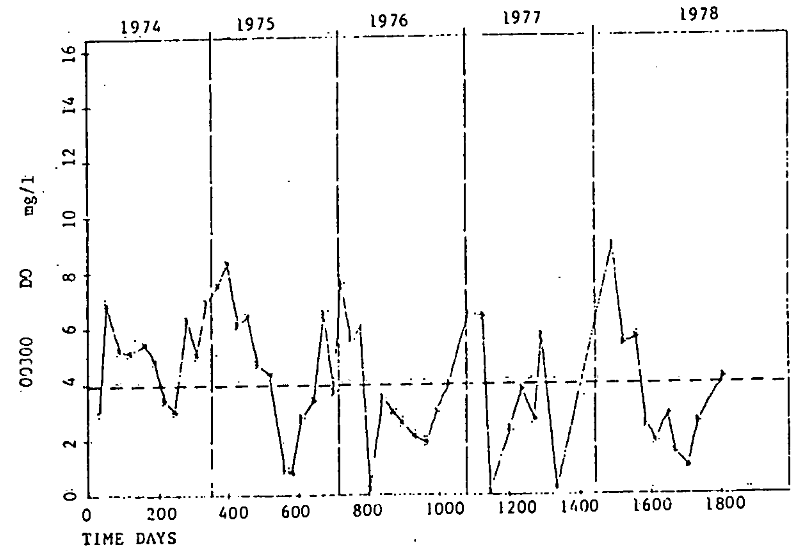
The recreational standards for partial-body contact have been met only 38% of the time. In the most recent two years of record, bacterial limits were exceeded 66% of the time. But conditions seem to be improving since bacterial measurements made during the earlier years of the survey period indicate 15% less coliform bacteria than more recent measurements.

Within the Lake Michigan Basin, there are two major streams flowing across the Indiana and Illinois state line. The first stream is the Grand Calumet River. It originates in the eastern portion of Lake County, Indiana, and flows through one of the largest urban-industrial environments of the United States prior to leaving the State west of Hammond, Indiana.

The first monitoring site on the Grand Calumet River is located at the Industrial Highway in Gary, Indiana. No dissolved oxygen measurements made between 1974-1978 violated State requirements. Overall, dissolved oxygen values maintained a five-year mean concentration of 7.6 mg/l. But this does not offset other limiting factors which pose a detriment to the environment. In particular, the total ammonia concentration exceeded instream limitations in 98% of the surveys. Between 1974-1978 the mean total ammonia at this point averaged 3.0 mg/l, or double the maximum allowable concentration required by state standards. Other parameters also exhibiting critical levels include cyanide and phenols--both demonstrating only 10% compliance during a five-year period.

The recreational potential is also very poor. Standards require that coliform bacteria counts are not to exceed 2,000 organisms per 100 milliliters (2,000/100 ml.) in more than 10% of the samples. This excludes periods after storm events. When applying this standard, data reveal violations in 57% of the samples between 1974-1978. Therefore, the coliform bacteria standard for recreational waters is exceeded approximately half of the time. The mean coliform concentration during this period was 48,000/100 ml.

Figure 4 ; 1974-1978
Dissolved Oxygen Concentrations (mg/1)
Grand Calumet River at Hammond



As denoted in Figure 4, a significant change in overall water quality is noticed at the final monitoring station downstream from Hammond, Indiana. In particular the combined pollutional impact on the Grand Calumet River has resulted in dissolved oxygen concentrations that comply with standards only half of the time. Although the five-year mean concentration is marginally over standards, when compared to upstream conditions an overall 46% reduction of available dissolved oxygen has occurred.

As Table 4 depicts, total ammonia concentrations are still a severe limiting factor for the Grand Calumet River.

Table 4
Grand Calumet River
Water Quality Violations
(% of Total Samples)
1974-1978

	Standard	Hammond	E. Chicago	Gary
Total Ammonia	1.5 mg/l	91%	98%	98%
Cyanide	0.1 mg/l	9%	89%	93%
Phenols	0.01 mg/l	70%	76%	89%
Chlorides	125.0 mg/l	30%	0%	0%
Sulfates	225.0 mg/l	11%	0%	0%
Oil/Grease	10.0 mg/l	46%	28%	36%

In addition, even though overall phenols violations have been reduced by 18%, only 30% of the samples are in compliance with State standards. The most significant reduction is in total cyanide. As the flow of the Grand Calumet River enters Illinois, total cyanide concentrations demonstrate a 91% compliance with Indiana requirements. Specifically, when comparing five-year mean averages recorded at the Gary and Hammond monitors, a 99% reduction of total in-stream cyanide has been achieved. The recreational potential of the Grand Calumet River is very poor and exhibits only 38% compliance with State coliform bacteria limitations. Between 1974-1978, mean coliform concentrations have averaged more than 25,000/100 ml. over State standards.

The last stream considered in this evaluation is the Little Calumet River. As previously discussed, the upper reaches of this waterway have been designated as a cold water stream potentially capable of supporting put-and-take trout fishing and salmonid migration. Below Burns Ditch, however, the Little Calumet River is subject to the water quality standards promulgated for all warmwater streams in Indiana.

As the Little Calumet River flows through this region, at an average flow of 16.5 cubic feet per second, several parameters such as phenols, cyanide, un-ionized ammonia, and iron significantly retard its ability to maintain acceptable water quality. For instance, dissolved oxygen levels are below minimum daily requirements approximately 40% of the time. These violations have not been limited to low flow periods, since only 30% have been recorded during the summer.

The most serious limiting factor for fish and aquatic life are phenol constituents which have exceeded the U.S. EPA criterion 86% of the time over a five-year period. At least 50% of the time, the phenols level exceeded 6.0 micrograms per liter (ug/l), and averaged 7.7 ug/l between 1974-1978. Iron concentrations have also exceeded the acceptable criterion 73% of the time. In 33 samples the average violation was reported to be 2.2 mg/l.

Other parameters exceeding Federal criteria for fish and aquatic life are cyanide and mercury. Each has exceeded the U.S. EPA standard an average of 56% and 40% of time, respectively. In 31 samples, cyanide concentrations averaged 0.04 mg/l, and in 19 samples mercury concentrations averaged 0.07 mg/l. The State proposed guideline for un-ionized ammonia (0.05 mg/l) in warmwater environments has been exceeded approximately 50% of the time. Although these constituents are not the major limiting factors existing in the Little Calumet River, their concentrations do preclude attainment of State guidelines for warmwater fish and aquatic life.

The potential for partial-body contact recreation is practically nonexistent since coliform bacteria counts are in compliance with State standards less than 20% of the time. In 44 samples, coliform bacteria averaged 67,000 organisms per 100 milliliters (67,000/100 ml.) with no trend toward improvement.

The only lake gauge within the Lake Michigan Basin, other than those recording water quality measurements in Lake Michigan, is located on Wolf Lake in Lake County, Indiana. Specific water quality limitations have been designated for Wolf Lake because it borders the Indiana and Illinois state line. Generally, the water quality of Wolf Lake can be described as good. No temperature violations have been recorded. Dissolved oxygen measurements have shown values above required daily limits in 96% of the samples.

Total phosphorus samples from Wolf Lake frequently exceeded State standards. According to State limitations, total phosphorus should not exceed 0.04 mg/l. However, data indicate this value was exceeded in 70% of the samples. In 32 instances, total phosphorus was reported to have a mean violation of 0.13 mg/l.

The St. Joseph River Basin

General Assessment:

The St. Joseph River has been designated for two (2) instream uses, fish and aquatic life and recreation. Dissolved oxygen concentrations are adequate to maintain fish and aquatic life. The once high cyanide levels have been reduced during this survey period and are no longer perceived as a limiting factor. However, the St. Joseph River does have problems maintaining desirable bacterial levels for full recreational benefits from April through October, inclusive. The remaining months, where standards for partial-body contact recreation apply, demonstrate less severe bacterial concentrations and better instream compliance.

The major tributary stream--the Elkhart River, also maintains sufficient water quality for fish and aquatic life. However, much like the St. Joseph River, coliform bacteria concentrations periodically rise above State limitations.

Technical Assessment:

The St. Joseph River Basin is located in the far north-northeastern portion of Indiana and comprises portions of Planning and Development Regions 2, 3A, and 3B. The major streams influencing drainage patterns in this area include the St. Joseph River, the Elkhart River, and Pigeon Creek in LaGrange County. The largest stream, exhibiting a seven-day, once-in-ten-year low-flow of 760 cubic feet per second, is the St. Joseph River. Its headwaters originate within the State of Michigan, and it flows south entering Indiana north of the Bristol planning area in Region 2. A circular flow pattern is formed when the St. Joseph abruptly turns north at South Bend and returns to Michigan. The major tributary to this stream is the Elkhart River joining the St. Joseph River near Elkhart, Indiana.

The water quality of the St. Joseph River is monitored at three locations within Indiana. The first Fixed Station Monitor is located at Bristol, Indiana, the second at Osceola, and the last near South Bend which monitors the stream's characteristics prior to flowing back into Michigan. Data indicates good levels of dissolved oxygen in the St. Joseph River. The stations at Bristol and South Bend show a five-year mean dissolved oxygen average of 10.7 mg/l. At no time during the period between 1974-1978 did dissolved oxygen decline below minimum State standards. Another parameter which maintains acceptable levels for a good aquatic environment is un-ionized ammonia. Proposed guidelines have established that a critical level for warmwater fish is approached when instream un-ionized ammonia attains a concentration of 0.05 mg/l. In only one instance in 1977 was this critical level surpassed (0.09 mg/l), and occurred within the South Bend planning area.

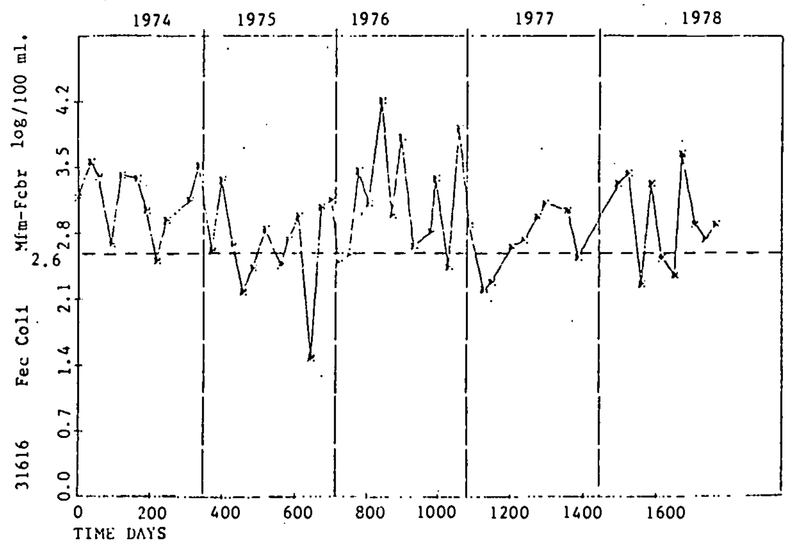
Some improvement has been noted for instream cyanide concentrations. Prior to 1977, cyanide levels near South Bend, Indiana, were reported to exceed the U.S. EPA standards in 59% of the samples. Because of control measures to deter its input into the environment, cyanide concentrations have exhibited 90% compliance with Federal standards between 1977-1978.

During the same time period cyanide levels further upstream near Bristol were achieving a poor 45% compliance until 1977. Violations have been reduced to where present conditions have complied with Federal standards in more than 80% of the samples.

Almost the opposite trend has been recorded for instream mercury in the St. Joseph River. From 1974-1978, total mercury at South Bend has been reported to comply with Federal standards in 73% of the measurements. Prior to the spring of 1976, mercury appeared to be a significant limiting factor for fish and aquatic life by averaging only 62% compliance and a mean average concentration of 0.30 mg/l. Attention was brought to this problem, and subsequently instream concentrations were reduced to conform with Federal regulations. In 1978, evidence again indicated a trend toward noncompliance with Federal standards. While averaging 0.30 ug/l, mercury has complied with Federal standards in only 45% of the samples. Similar problems were in evidence upstream, but control measures brought total mercury concentrations into an 88% compliance at the Bristol monitoring station. Since 1978 mercury has averaged 0.20 ug/l and has demonstrated only 15% noncompliance with Federal standards.

As an interstate river system, the St. Joseph River has been designated for whole-body contact recreation. Therefore, State regulations require that fecal coliform concentrations should not exceed 400 organisms per 100 milliliters (400/100 ml.) in more than one sample per month during the period April through October. For the remainder of the year (January-March and November-December) the fecal coliform concentration should not exceed 2,000/100 ml. in more than one sample per month. As illustrated in Figure 5, data indicates that between 1974-1978 the coliform bacteria requirements for whole-body contact recreation at South Bend have complied with State standards in only 15% of the measurements taken from April through October of each year. During this period, the mean coliform levels averaged 1,400/100 ml. over State limitations. Further upstream at Bristol, coliform bacteria has exhibited a 92% compliance rate during this same period. Violations of whole-body contact limitations have averaged 24,550/100 ml. but are limited to only two samples. The general range of coliform bacteria not violating State limitations are between 10/100 ml. to 330/100 ml. Therefore, even though the St. Joseph River maintains good whole-body contact recreation, the bacterial contamination within the South Bend area significantly retards this stream use as the St. Joseph River flows back into Michigan.

Figure 5 ; 1974-1978
Fecal Coliform Concentrations (log/100 ml.)*
St. Joseph River at South Bend



*400/100 ml.= 2.6
2000/100 ml.= 3.3

The Elkhart River (7Q10 = 76 cfs) is the only major tributary to the St. Joseph River. Its headwaters originate in the glacial lake areas near Waldron Lake in Region 3B. It traverses a north-northwestern direction through Region 2 to its confluence with the St. Joseph River at Elkhart, Indiana.

The water quality of the Elkhart River is very good. Data indicate that no parameter is prohibitive in attaining standards for fish and aquatic life. However, the bacterial quality does show problems in maintaining recreational standards. Specifically, the Elkhart River is required to meet standards applicable for partial-body contact recreation. But data collected, prior to its St. Joseph River confluence, indicate coliform concentrations are in compliance in 63% of the samples. In 21 measurements, the fecal coliform levels have ranged between 2,100/100 ml. to a maximum of 24,000/100 ml. Collectively, coliform bacteria has averaged 2,283/100 ml. between 1974-1978.

The Kankakee River Basin

General Assessment:

The water quality of the Kankakee River is good. The river is an excellent habitat for wildlife, fish, and other aquatic life as well as a superior recreational resource. The only limiting factor within this stream has been an undefined source of mercury near its headwaters. Although the extent of this concentration is not severe enough to warrant a toxic threshold, its presence should be locationally defined and remedial efforts implemented.

Technical Assessment:

The Kankakee River Basin, lying directly south of the Lake Michigan Basin, drains approximately 3,101 square miles within portions of Indiana Planning and Development Regions 2, 1A, and 4. Principal streams located within this basin include the Kankakee River, the Iroquois River, Yellow River, and Cedar Creek. However, the most extensive water quality data available is for the Kankakee River. All other streams are presumed to have sufficient water quality to support their designated uses and adequately comply with State and Federal water quality standards.

The headwaters of the Kankakee River originate from a marsh located near South Bend, Indiana. Its flow is directed in a south-southwest direction into Illinois where it ultimately discharges to the Illinois River. Flow measurements indicate that its annual seven-day, once-in-ten-year low flow is 24 cubic feet per second at LaPorte County, but further downstream at Shelby, Indiana, the flow of the Kankakee River increases by 94% to 403 cubic feet per second as an annual seven-day, once-in-ten-year low flow.

Water quality data from the headwaters area of the Kankakee River is very limited. The State initiated its continuous sampling program south of the State Fish and Wildlife area near Kingsbury, Indiana, in 1978 and therefore, data is currently limited to only one year of measurement. There appear to be very few problems in the headwaters region of the Kankakee River. Dissolved oxygen concentrations are well above State standards. Annually, dissolved oxygen has averaged 8.0 mg/l and at no time declined below 6.4 mg/l. The only significant limiting factor is mercury contamination from an undetermined source. The U.S. EPA criterion specifies that mercury concentrations should not exceed 0.05 micrograms per liter (ug/l). Data indicates this Federal criterion has been complied with only 30% of the time. At this location, mercury concentrations have averaged 0.26 ug/l with a mean violation of 0.33 ug/l. Excessive levels of mercury are extremely hazardous to all forms of life.

Similar water quality conditions appear further downstream on the Kankakee River at Shelby, Indiana. Dissolved oxygen concentrations are well above State minimum standards. Throughout the one-year survey period, dissolved oxygen was measured at an average of 8.3 mg/l, and did not fall below 6.4 mg/l. Un-ionized ammonia did not approach the critical 0.05 mg/l threshold as proposed by State guidelines. The maximum concentration for this parameter during 1978 was 0.005 mg/l.

Excessive mercury concentrations also appear at this downstream location. In particular, the Kankakee River at Shelby has complied with the Federal mercury criterion in only 30% of the surveys. The largest concentration of 0.6 ug/l was reported during June 1978 or 83% higher than Federal limitations. Collectively, mercury concentrations averaged 0.26 ug/l during 1978.

Coliform bacteria concentrations remained within State standards in 80% of the surveys. In a total of 10 samples taken, only two were found in excess of 2,000 organisms per 100 milliliter of water (2,000/100 ml.), with a mean violation of 2,750/100 ml. Therefore the Kankakee River sustains adequate water quality to support its recreational uses.

The Maumee River Basin

General Assessment:

From a dissolved oxygen standpoint, each major river within this basin complies with State Water Quality Standards for fish and aquatic life. Some other constituents may have been detrimental for such uses. High concentrations of copper, cyanide, and mercury may have been definite limiting factors within this area. Much improvement has been demonstrated to indicate some instream improvements are being made. In at least two streams, the potential for partial-body contact recreation meets applicable recreation criteria. Standards for whole-body contact recreation are not always met in the St. Joseph River.

Technical Assessment:

The Maumee River Basin is located in the north-northeastern portion of Indiana, and includes not only the Maumee River, but also the St. Joseph River and the St. Mary's River which join to form the Maumee River at Fort Wayne. The Maumee River takes an eastly flow through Allen County into the State of Ohio. The Maumee River, with a 7Q10 of 58 cubic feet per second (cfs) in Indiana, is ultimately discharged to Lake Erie at Toledo, Ohio. Within Indiana, the State Board of Health has located three (3) Fixed Station Water Quality Monitoring Stations on the Maumee River at Fort Wayne, New Haven, and Woodburn, Indiana.

Between 1974-1978, the Maumee River at Fort Wayne has maintained very good dissolved oxygen levels. Averaging 9.9 mg/l during this period, no levels have violated either the State's minimum standard or the average daily requirement. The extent to which these standards are violated are somewhat limited and occur further downstream from Fort Wayne. Specifically, only 7% of the total samples surveyed indicate that dissolved oxygen declined below the 5.0 mg/l daily average requirement, and were usually associated with periods of summer low flow. At no time did these levels decline below 4.0 mg/l. Therefore, it may be concluded that adequate dissolved oxygen is present to support a divergent fish and aquatic life environment.

As a potential oxygen consuming parameter, un-ionized ammonia does not appear to be a significant limiting factor in the Maumee River. The only location which approached the States 0.05 mg/l critical threshold level was in the New Haven planning area. In 1974, an average concentration of 0.08 mg/l was recorded, but subsequent measurements through 1978 indicate a net 90% reduction has been achieved. This is supported by two facts: first, no concentrations greater than 0.006 mg/l were measured in 1978, on the Maumee River at New Haven, and second, other stations further downstream in the Woodburn area have measured significantly lower un-ionized concentrations in 1978 than in previous years of the survey period.

Several parameters have difficulty in attaining either desirable concentrations or State/Federal Water Quality Standards. These problem constituents include: copper, cyanide, mercury, and oil and grease.

In some aquatic species, copper constituents may become a limiting factor when approaching levels greater than 20.0 ug/l. At New Haven, the Maumee River has exceeded this criterion in 48% of the measurements, and has averaged 40.0 ug/l between 1977-1978. Some trends towards improvement have been evidenced. In particular, the Maumee River at Woodburn has denoted a 69% compliance rate with this criterion while sustaining a 20.0 ug/l average. By comparison, total copper concentrations have averaged 32.0 ug/l, or a 20% reduction from that reported upstream.

Secondly, total cyanide concentrations have exceeded Federal standards. The most cyanide, between 1974-1978, appears to have been found in the Woodburn area. At this point, mean cyanide levels have averaged near 8.0 ug/l and have only complied with the U.S. EPA standards in 55% of the samples. Prior to 1976, it was not uncommon for total cyanide concentrations to range between 5.0 ug/l to 9.0 ug/l. The remaining two-year period, cyanide has averaged only 3.0 ug/l, and exceeded Federal guidelines in 10% of the samples. Therefore, present cyanide concentrations pose no detriment to fish and aquatic life.

Some portions of the Maumee River also have problems in sustaining acceptable mercury concentrations. At Fort Wayne and at Woodburn, mercury levels have only been in compliance with the U.S. EPA criterion in 74% and 66% of the samples, respectively. At each location, violations have come in spurts. At the beginning of each survey period (1974), mercury was found to be very acceptable. Then, for some undefined reason, the concentrations began to rise with violations ranging between .20 ug/l to .80 ug/l. As a potential problem, total mercury was again brought into compliance in mid-1976 through 1977, but again, current mercury levels are becoming a problem in the Maumee River. At both locations during 1978, mercury values have averaged 0.30 ug/l, with violations ranging between 0.80 to 1.3 ug/l of total mercury. Presently, instream surveys completed for the third quarter of 1979 indicate that only in the Fort Wayne area are average mercury concentrations recorded in excess of Federal standards.

The last water constituent having a detrimental affect upon the aquatic community is oil and grease. Data indicate that between 1974-1978, oil and grease values in the Maumee River at Fort Wayne have exceeded 10.0 mg/l 25% of the time. However, some strides toward improvement have been realized, since no concentrations greater than 10.0 mg/l have been recorded in more than one and one-half years.

The recreation potential for the Maumee River is found suitable for partial-body contact recreation between 75%-85% of the time. Data indicate that for the majority of time within a one year period, coliform bacteria can be found at concentrations not greater than 2,000 organisms per 100 milliliters of water (2,000/100 ml.). A 31% net reduction of bacteria is noted between Fort Wayne and Woodburn planning areas during this five-year period. Thus, evidence indicates that recreation potential may increase as the Maumee River flows through Indiana and into Ohio.

The St. Mary's River is one of two major tributary streams of the Maumee River. Flow records indicate that prior to its discharge to the Maumee River, the St. Mary's River seven-day, once-in-ten-year low flow is 8.1 cubic feet per second.

Water quality data compiled from Indiana Fixed Station Monitoring at Fort Wayne indicates good dissolved oxygen levels are being attained. Specifically, between 1974-1978, dissolved oxygen is maintaining 94% to 98% compliance with daily average requirements and with minimum standards. Throughout this period, average concentrations were measured at 9.2 mg/l. In addition, an overall 11% increase of available dissolved oxygen has been realized between 1974-1978. As an oxygen consuming agent, un-ionized ammonia has not handicapped the water quality of the St. Mary's River. At no time has un-ionized ammonia exceeded the States proposed 0.05 mg/l critical level for warm water fish and aquatic life.

Presently, the only parameter potentially inhibiting fish and aquatic life is total iron concentrations. The U.S. EPA believes that instream iron in excess of 1.0 mg/l may be injurious to aquatic life. Periodic sampling in 1977 indicates this criterion to be above standards in 43% of the samples. For the most part, total iron concentrations have recorded a mean average of 1.8 mg/l between 1977-1978.

The bacterial quality of the St. Mary's River demonstrates an 85% compliance with State recreation standards for partial-body contact. Most violations in excess of 2,000 organisms per 100 milliliters of water (2,000/100 ml.) occurred prior to 1976, with an average concentration of 1,991/100 ml. Much improvement has been realized in recent years, especially between 1976-1978. During this three-year period, only one sample exceeded State standards, with overall bacterial concentrations averaging 325/100 ml. On an annual basis, a 70% reduction of coliform bacteria has been recorded for the St. Mary's River at Fort Wayne.

The St. Joseph River is also a contributing stream to the Maumee River. It enters Indiana near Newville, Indiana, in DeKalb County, and flows southwest into the Cedarville Reservoir. The ultimate seven-day, once-in-ten-year low flow of 23 cubic feet per second to the Maumee River is a combination of dischargers from this Reservoir and the several smaller tributary streams of the St. Joseph River. Water quality is very good for fish and aquatic life. The dissolved oxygen concentrations maintain levels well above State requirements. Over a five-year period, dissolved oxygen has sustained a 9.9 mg/l average, and has not fallen below the 4.0 mg/l minimum requirement at anytime.

The only instream use demonstrating compliance problems is the recreation potential of the St. Joseph River. According to State standards, the St. Joseph River is to maintain suitable bacterial quality for whole-body contact recreation between the months of April through October, inclusively. Data indicate that during these designated months, the coliform bacteria (fecal) meets State standards only 42% of the time. Instream coliform bacteria has averaged 692 organisms per 100 milliliters (692/100 ml.) between 1974-1978.

The Wabash River Basin

General Assessment:

The water quality of the Wabash River can generally be described as attaining the State's Water Quality Standards. Dissolved oxygen concentrations are high enough to maintain a well-balanced fish community in most areas of the waterway. Urban discharges within the Region 5 and Region 4 planning areas create a slight downstream dissolved oxygen sag. The extent of this pollution is not severe enough to preclude the stream's recovery rate. Each year there is a general net reduction in coliform counts, but, as in the case of dissolved oxygen concentrations, the bacterial quality increases downstream of the Region 4 and 5 planning areas.

The tributary streams generally comply with water quality standards, but also suffer from many localized pollution problems. The most severely impacted stream within the Wabash River Basin is probably Wildcat Creek. As a result of the pollution impact of discharge from the City of Kokomo, Wildcat Creek shows increases in concentrations of some toxic parameters. Completion of the City's upgraded wastewater facility should result in extensive water quality improvement in the stream.

Technical Assessment:

The major drainage area within Indiana is the Wabash River Basin. In conjunction with its associated sub-basin areas of the East Fork and the West Fork of the White River, the Wabash River system drains approximately three-fourths of the land area in the State.

The Wabash River enters Indiana just south of the Maumee River Basin in Jay County, Indiana. Within Indiana, its flow is directed over 400 miles from a 40-mile north-northwestern course to Huntington, Indiana, thence in a westerly course of almost 51 miles through Logansport in Region 5, thence in a south-southwest course for over 80 miles through portions of Region 4 to Covington, and finally in a southerly direction to its confluence with the Ohio River in Region 13B. Flow measurements recorded by the U.S. Geological Survey indicate that the Wabash River increases its flow from an annual seven-day, once-in-ten-year low flow of 1.5 cubic feet per second (cfs) at New Corydon to over 2,170 cubic feet per second at Mt. Carmel, Illinois. The total base flow is supplemented through eight major tributary streams including:

1.	Salamonie River	(7Q10 = 20 cfs)
2.	Mississinewa River	(7Q10 = 20 cfs)
3.	Eel River	(7Q10 = 91 cfs)
4.	Tippecanoe River	(7Q10 = 190 cfs)
5.	Wildcat Creek	(7Q10 = 47 cfs)
6.	Sugar Creek	(7Q10 = 21 cfs)
7.	White River (East and West Forks)	(7Q10 = 700 cfs)
8.	Patoka River	(7Q10 = 20 cfs)

The State has designated the Wabash River to sustain sufficient water quality for not only fish and aquatic life, but also for partial-body contact recreation, except for that portion where the Wabash River forms the Indiana-Illinois common boundary. Where this interstate boundary exists, water quality is required to meet applicable standards for whole-body contact recreation. The State requires that dissolved oxygen shall not decline lower than 4.0 mg/l at any time, nor decline lower than an average of 5.0 mg/l per calendar day. Overall, very few violations of the State's minimum standard have been recorded. Noncompliance is generally limited to only minimum daily requirements.

Table 5
Annual Dissolved Oxygen Concentrations (mg/l)
Wabash River; 1974-1978

Location	1974	1975	1976	1977	1978
Bluffton	9.5	8.4	11.8	7.4	8.4
Markle	10.2	9.5	10.7	8.4	9.4
Huntington	10.9	9.7	11.3	9.0	8.6
Andrews	--	--	--	8.4	8.2
Wabash	11.2	9.5	11.4	9.4	--
Peru	11.1	10.1	11.5	9.8	9.8
Logansport	12.0	10.4	12.5	11.2	11.2
Georgetown	--	--	--	10.2	10.2
Lafayette	10.5	9.4	10.0	10.3	10.3
Granville Bridge	10.5	9.4	10.0	10.3	10.3
Cayuga	11.2	9.8	11.0	9.8	11.4
Montezuma	10.7	9.8	11.0	9.6	10.7
Clinton	--	--	--	9.2	10.5
Terre Haute	10.0	9.4	10.9	9.6	10.3
Vincennes	10.2	9.4	9.7	10.7	11.0
Net Change	+7.0%	+12%	-18%	+45%	+31%

Between 1974-1978, as Table 5 indicates, the dissolved oxygen concentrations for the Wabash River steadily increase as the river progresses through the State. Only in 1976 was an overall reduction reported between Bluffton and the Vincennes planning areas. In this instance, an average annual dissolved oxygen depletion of 2.0 mg/l occurred in the Wabash River. Since this time, an estimated annual 3% increase of dissolved oxygen has been recorded between 1977-1978. Table 5 also indicates that each monitoring station location upstream from Cayuga, Indiana, has demonstrated some loss of available dissolved oxygen between from 1974-1978. The more severe depletions occur between Huntington and Logansport, Indiana, where over a five-year period, an average 2.0 mg/l reduction of available dissolved oxygen has occurred. Prior to 1978, it appears that the incremented increase of dissolved oxygen is offset by the impact from waste dischargers of the Logansport and Lafayette areas. Data suggest that an average 12% dissolved oxygen reduction occurs between the Logansport and Granville Bridge Water Quality Monitoring Stations. Not until 1978 is this pattern somewhat stabilized to the point of continuing a incremented gain downstream to the Ohio River.

Dissolved oxygen values have increased between 1974-1978 at the majority of monitoring stations on the Wabash River as it flows through Indiana. Even though sporadic violations of the State's average 5.0 mg/l daily requirement are recorded above the City of Wabash, Indiana, no values have declined lower than 4.0 mg/l at anytime along its course.

Some parameters, such as cyanide, copper, mercury, lead, and iron, show increases in concentration in localized areas. These could be a potential limiting factor to fish and aquatic life if allowed to persist for any length of time. In particular, two locations on the Wabash River have recorded notable mercury levels that may cause instability in the aquatic community. In the first case, the Wabash River at Georgetown, in Region 5, has complied with Federal mercury standards in only 57% of the measurements between 1977-1978. During this two-year period, mercury concentrations have averaged 0.20 ug/l in 21 samples. In 1978, only 36% of the samples registered permissible concentrations with the remaining 64% ranging between 0.20 ug/l to 0.60 ug/l. It should be noted that sampling completed for the third quarter of 1979 indicates only two values above 0.10 ug/l. Therefore, it appears that concentrations have again declined to acceptable levels. The second case occurs immediately downstream from the Wabash River Generating Station near Terre Haute, Indiana. Although data at this point are limited to 1978, mercury concentrations represented only 30% compliance with Federal criterion. In a total of 11 samples taken at this point, mercury levels averaged 0.34 ug/l with violations ranging between 0.20 ug/l to 1.0 ug/l. Throughout 1978 all measured mercury concentrations at not only these locations on the Wabash River, but at all Fixed Water Quality Monitoring Stations on the Wabash River recorded high mercury levels. Subsequent measurements sampled in 1979 indicate that many of these 1978 problem areas are once again within compliance with water quality standards. Therefore, it has yet been determined why the 1978 measurements proved questionable.

Two localities on the Wabash River also indicate the presence of cyanide as an instream water constituent. Federal standards limit total instream cyanide to 5.0 ug/l for freshwater aquatic life. Below Lafayette, the Wabash River demonstrates an 82% compliance between 1977-1978. Although only four violations were recorded, ranging between 8.0 ug/l to 35.0 ug/l. The extent of this pollution was significant enough to raise the annual mean to 2.0 ug/l. Similar tendencies are reported at Clinton, Indiana, where two years of data has determined 14% noncompliance with a mean cyanide concentration of 3.0 ug/l. The three samples found at excessive levels averaged 12.0 ug/l during this period.

The State further requires the water to meet certain bacterial standards that will allow the stream to support partial-body contact recreation. This designation is applicable for the Wabash River upstream from Terre Haute, Indiana. That portion of the river forming the boundary with Illinois must meet more stringent instream conditions to sustain whole-body recreational potential, especially during the months of April through October.

Table 6; Wabash River
Fecal Coliform Bacteria Levels (#/100 ml.) and Annual Compliance Percentages

Location	1974	Compliance	1975	Compliance	1976	Compliance	1977	Compliance	1978	Compliance
Bluffton	972	83%	2,456	83%	529	91%	410	91%	506	75%
Markle	1,782	82%	761	100%	454	100%	27,562	82%	6,057	67%
Huntington	714	91%	639	92%	86	100%	2,830	91%	393	88%
Andrews	--	--	--	--	--	--	10,234	55%	1,885	50%
Wabash	2,066	84%	1,905	59%	1,371	73%	5,457	84%	--	--
Peru	872	92%	1,574	67%	485	100%	2,638	90%	1,046	87%
Logansport	478	92%	1,207	83%	167	100%	569	90%	875	82%
Georgetown	--	--	--	--	--	--	1,464	67%	1,535	82%
Lafayette	686	92%	1,178	84%	792	92%	838	89%	2,799	82%
Granville Bridge	2,497	42%	7,772	42%	28,019	19%	2,993	50%	4,542	82%
Cayuga	490	100%	1,113	91%	1,171	83%	177	100%	266	100%
Montezuma	386	92%	1,616	92%	599	85%	170	100%	359	88%
Clinton	--	--	--	--	--	--	230	100%	348	100%
Terre Haute	809	92%	966	92%	327	100%	351	100%	266	100%
*Vincennes	959	67%	810	67%	100	91%	1,015	50%	417	82%
Net Change	-1%		-67%		-81%		+147%		-17%	

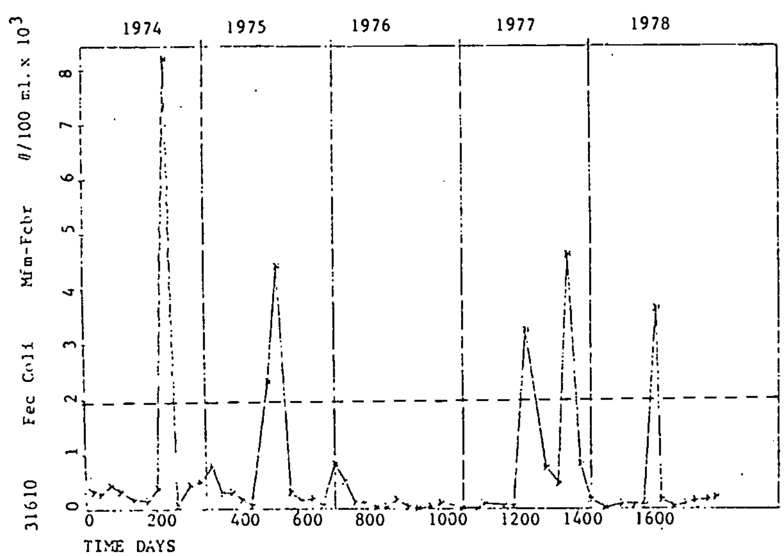
*Whole-body contact recreation.

Table 6 illustrates that, as of 1978, most portions of the Wabash River, with exception of Andrews, Markle, and Bluffton planning areas, now comply with State recreation standards more than 80% of the year. During 1978, these planning areas were not found in compliance with regulations and exceeding 2,000 coliform bacteria per 100 milliliters between a three to six month period. At Bluffton, even though an average 48% reduction of coliform bacteria has been achieved between 1974-1978, the occurrence of violations is more frequent than in previous years. Because of probable sewer bypassing near Markle, Indiana, excessive coliform bacteria concentrations have obviously raised the annual average. Some problems still exist, however, since samples taken during four months in 1978 resulted in bacteria levels in excess of State standards.

That portion of the Wabash River capable of most frequently meeting partial-body contact recreation coliform standards is that portion between Cayuga and a point immediately downstream from Terre Haute. During this period, coliform bacteria standards were met an average of 11 months per year. In contrast, the Wabash River southwest of Lafayette exhibited the most limited recreation potential prior to 1976, due to bacterial contamination. There was an average 82% increase in coliform bacteria between 1974-1978. Bacterialogical surveys indicated that water quality standards were barely being achieved for six months per year.

The Vincennes planning area must maintain water quality suitable for whole-body contact recreation. Figure 6 indicates that the Wabash River, near Vincennes, is presently complying with standards 82% of the time during the designated recreation period. Much of the time between 1974-1978, relatively moderate coliform concentrations existed. A reduction of total coliform bacteria levels occurs as the Wabash River flows through the State. In 1978, a 17% reduction was achieved in bacterial concentrations between the Bluffton and Vincennes planning areas. Although this is not as significant as those levels reached in 1975 and 1976, there are signs of continued improvement.

Figure 6 ; 1974-1978
Fecal Coliform Concentrations (#/100 ml.x 10^3)
Wabash River at Vincennes



The Salamonie River is the first major stream to augment the flow of the Wabash River. Its headwaters lie north of Portland, Indiana, in Region 6, and drain northwest to the Salamonie Reservoir. At this point, the annual seven-day, once-in-ten-year low flow is 7.0 cubic feet per second.

Prior to its discharge to the Salamonie Reservoir, stream conditions are relatively good. At Lancaster, Indiana, the Salamonie River has maintained a five-year dissolved oxygen mean concentration in excess of 10.0 mg/l. At no time between 1974-1978 has dissolved oxygen declined below 5.0 mg/l. On an annual basis, a marginal 18% increase of total dissolved oxygen has been recorded. In comparison with stations further upstream, dissolved oxygen concentrations at Lancaster have shown an average increase of 20% per year or 2.0 mg/l annually.

Cyanide concentrations have shown a substantial reduction at the Lancaster station. Prior to 1976, total cyanide concentrations in the Salamonie River at Lancaster averaged 54% noncompliance with Federal standards. In 1974 and 1975, annual cyanide levels averaged 14.0 ug/l and 7.0 ug/l, respectively, but in the following two-year period, cyanide was reduced to concentrations acceptable to the U.S. EPA. Specifically, the 5.0 ug/l Federal standard has received 86% compliance prior to 1978 when monitoring for this parameter was discontinued. Since average cyanide concentrations were found to be 2.0 ug/l below Federal limitations between 1976-1977, conditions for fish and aquatic life appear to be improving. In conjunction with diminishing cyanide concentrations, the increased availability of dissolved oxygen may result in a more diverse aquatic community within the Salamonie River.

The upstream planning areas of the Salamonie River are also in compliance with State recreation standards. Upstream of the Salamonie Reservoir, coliform bacteria counts were found to comply with the state standards 85% to 87% of the time between 1974-1978. In addition to declining bacterial levels, other significant improvements in water quality have been recorded between stations at Lancaster and Montpelier. At Lagro, Indiana, coliform bacteria concentrations demonstrate a 98% compliance with State requirements. Dissolved oxygen concentrations have averaged 11.0 mg/l for a five-year period. No serious un-ionized ammonia problems have been recorded. Fish and aquatic life habitats are therefore enhanced.

The Mississinewa River, enters Indiana from Parke County, Ohio and flows to the Wabash River via the Mississinewa Reservoir. Fixed Water Quality Monitoring Stations upstream from the Reservoir indicate fairly good water quality. Dissolved oxygen concentrations have maintained levels well above standards and have averaged 9.0 mg/l for a five-year period with no recorded levels declining below 5.0 mg/l.

Possibly the only parameter attaining levels detrimental to fish and aquatic life during this period was oil and grease. Prior to 1976, oil and grease concentrations were found to exceed 10.0 mg/l in 35% of the measurements. During this time, 12 samples from the Mississinewa River were reported to have reached levels ranging from 11.0 mg/l to 29.0 mg/l. Since this date however, only two samples have been found above 9.0 mg/l. Similar patterns have been recorded upstream at Jalapa, Indiana, where oil and grease appears to be diminishing toward more acceptable levels.

Some problems do exist upstream from the Mississinewa Reservoir, in maintaining a high recreation potential. At Marion, coliform bacteria concentrations comply with State standards in 67% of the samples. This complies with instream requirements on an average of eight months a year. In addition, since data collected between 1974-1978 indicate a 35% decrease from 2,517/100 ml. to 1,633/100 ml. in 1978. Therefore some improvement has been realized.

The regulated 20 cubic feet per second flow discharged from the Mississinewa Reservoir is of excellent quality. Indiana's Fixed Station Monitoring site located one-mile upstream from the Wabash River confluence shows no parameters harmful to fish and aquatic life. Dissolved oxygen concentrations usually do not fall below 6.5 mg/l, and over a five-year period, have averaged 11.2 mg/l. Un-ionized ammonia levels have not approached the State's 0.05 mg/l critical level. Of the 56 coliform bacteria measurements taken, only two have been found to exceed 2,000 organisms per 100 milliliters of water. Therefore, with a 98% compliance record, the Mississinewa River downstream from the Reservoir meets all applicable standards for partial-body contact recreation.

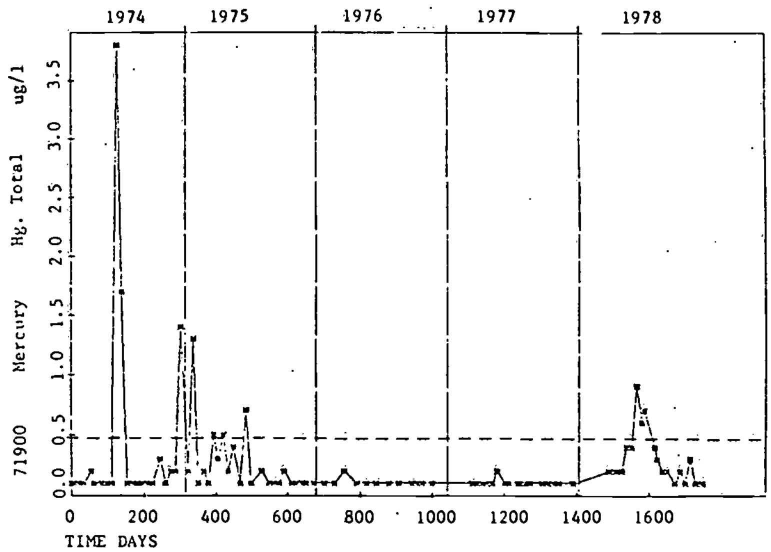
The next significant stream to contribute flow to the Wabash River is the Eel River. In addition to the designated uses of fish and aquatic life and partial-body contact recreation, Eel River is also utilized as a water supply for the City of Logansport. Data indicate that coliform bacteria limitations meet State standards in 75% of the samples taken. In five instances, total coliform bacteria was found at levels exceeding 5,000 organisms per 100 milliliters of water. In all probability, this limits bacteria violations to only those periods associated with summer low flow. The only potential limiting factor in this area is possibly thermal inputs discharged from the Logansport City Electric Company. Past violations of Indiana's temperature standards have necessitated the City to conduct a Thermal Demonstration Project to determine the effects of heated discharges on fish and aquatic life. This study is presently under staff review.

The most severely impacted stream within the Wabash River Basin is probably Wildcat Creek. Its headwaters originate in the northeastern portion of Tipton County and flow in a westerly direction through Howard and Carroll Counties to its Wabash River confluence at Lafayette, Indiana. Data indicates that discharges from the City of Kokomo significantly degrade a stretch of Wildcat Creek.

Upstream from Kokomo, Wildcat Creek generally complies with State Water Quality standards. Only two parameters, mercury and oil and grease constituents, may partially impair fish and aquatic life. Dissolved oxygen has averaged well above State minimum standards, and in only one instance has violated average daily requirements. In addition, un-ionized ammonia concentrations have only approached the State's 0.05 mg/l threshold level in 1974. Since this time, the largest recorded un-ionized ammonia concentration was 0.01 mg/l in 1976. Steady ammonia reductions have been recorded throughout this five-year period upstream from Kokomo.

As previously mentioned, total mercury concentrations may be one limiting factor to fish and aquatic life in Wildcat Creek. Upstream from Kokomo, Federal standards have been exceeded in 37% of the surveys, with values averaging 0.26 ug/l between 1974-1978 (see Figure 7). A majority of these violations have been recorded in only two periods between 1974-1975, and again during 1978. In the interim, total mercury concentrations have averaged 0.10 ug/l with a 92% compliance rate. During these periods, total mercury has averaged 0.42 ug/l and 0.32 ug/l, respectively, but subsequent sampling conducted in 1979 indicated no concentrations greater than 0.20 ug/l.

Figure 7 ; 1974-1978
Total Mercury Concentrations (ug/l)
Wildcat Creek at Kokomo



Oil and grease concentrations have exhibited similar tendencies, except that no values after mid-1977, have been recorded greater than 8.2 mg/l. The highest concentrations occurred in 1975, when violations ranged between 12.0 mg/l and 28.0 mg/l and averaged 12.6 mg/l for the year. With a 25% annual reduction of oil and grease concentrations that may have limited instream uses in the past, the stream is presently recovering and meeting criterion.

The recreational potential for Wildcat Creek upstream from Kokomo is very good. Bacterial standards for partial-body contact recreation are met in 99% of the surveys between 1974-1978 with a mean average of 224 organisms per 100 milliliters.

Downstream from Kokomo, an entirely different story unfolds. Data indicate that dissolved oxygen concentrations are in compliance with minimum standards in only 81% of the surveys and comply with average daily requirements in 71% of the surveys. Therefore, although dissolved oxygen usually falls below 4.0 mg/l during summer low flow periods, the minimum 5.0 mg/l daily requirement is found to decline below standards on an average of three additional months a year. As Table 7 depicts, annual dissolved oxygen has averaged as follows:

Table 7
Annual Dissolved Oxygen Concentrations (mg/l)
Wildcat Creek at Kokomo; 1974-1978

	Upstream	Downstream	Net Change
1974	11.1 mg/l	8.5 mg/l	-23%
1975	10.6 mg/l	7.5 mg/l	-24%
1976	9.1 mg/l	5.5 mg/l	-40%
1977	10.1 mg/l	7.5 mg/l	-25%
1978	8.7 mg/l	7.3 mg/l	-16%

The impact of the City of Kokomo is evident. Each year between 1974-1978 has recorded a net reduction from 16% to 40% of available dissolved oxygen downstream from Kokomo. In addition, yearly comparisons also indicate a moderate decline of dissolved oxygen at each station during 1978, as compared to the annual concentrations recorded in 1974.

However, even though the dissolved oxygen content of Wildcat Creek is sufficient for fish and aquatic life, data demonstrates that concentrations of un-ionized ammonia, oil and grease, and other limiting agents cause moderate reductions of available dissolved oxygen downstream of urban and industrial dischargers.

During this same period, un-ionized ammonia exceeded the State's 0.05 mg/l threshold level in 22% of the measurements. Although the majority of these critical levels were recorded in 1974, there is strong evidence supporting the fact that occasional increases in un-ionized ammonia have elevated annual concentrations to twice that concentration reported in 1974. Occasionally in 1978, un-ionized ammonia levels increased beyond the critical stage by 0.05 mg/l. Secondly, there had appeared to be a notable increase of oil and grease constituents below Kokomo. Between 1974-1978 oil and grease concentrations exceeded 10.0 mg/l in only 28% of the samples, but generally excursions were limited to summer low flow. The more serious concentrations were recorded during 1975 when annual measurements indicated oil and grease concentrations averaged 13.6 mg/l. Since this time, although downstream sampling still indicates an increased loading being contributed to Wildcat Creek, data indicates an 83% reduction of measurable oil and grease constituents at the station downstream from Kokomo.

Other parameters measured in Wildcat Creek, such as cyanide, copper, and mercury, may also deter its uses for fish and aquatic life. As Table 8 indicates, much higher levels of cyanide are reported downstream

Table 8
Annual Total Cyanide Concentrations (ug/l)
Wildcat Creek at Kokomo; 1974-1978

	Upstream	Downstream	Net Change
1974	14.0 ug/l	78.0 ug/l	+457%
1975	19.0 ug/l	80.0 ug/l	+321%
1976	4.0 ug/l	15.0 ug/l	+295%
1977	2.0 ug/l	18.0 ug/l	+800%
1978	2.0 ug/l	5.0 ug/l	+150%

from Kokomo. Specifically, 79% more violations during this five-year period were found to exceed Federal standards below Kokomo, with values ranging between 7.0 ug/l to 182.0 ug/l. However, even though cyanide demonstrates higher concentrations as a result of discharges at Kokomo, Indiana, significant reductions have been made over a five-year period indicating measurable instream improvement.

Mercury has also found generally to be reducing since 1974. Collectively each Fixed Station Water Quality Monitor, above and below the City of Kokomo has complied with Federal standards in only 64% of the measurements. During each year prior to 1978, each monitor sustained an annual 18% reduction of total mercury, but within the fifth year demonstrated noncompliance resulted in the annual concentrations to exceed 0.13 ug/l upstream and 0.24 ug/l downstream from Kokomo. However, between these stations, 29% less mercury has been recorded below the municipality.

Significant reductions of total copper in Wildcat Creek has been recorded between 1974-1978. As Table 9 illustrates, discharges from the area had increased the copper loadings of Wildcat Creek to a unstable annual concentration of 80.0 ug/l. But between this time a 75% reduction has been recorded to sustain a concentration near equilibrium.

Table 9
Total Copper Concentrations (ug/l)
Wildcat Creek at Kokomo; 1974-1978

	Upstream	Downstream	Net Change
1974	20.0	80.0	+300%
1975	20.0	50.0	+150%
1976	20.0	50.0	+150%
1977	20.0	30.0	+ 50%
1978	21.0	20.0	0

Until 1978 when concentrations declined to acceptable levels, copper was found in compliance 30% of the time with violations ranging from 30.0 ug/l to 210.0 ug/l.

Data generally indicate improving instream quality for fish and aquatic life. But the potential for partial-body contact recreation is severely limited, especially downstream from the City of Kokomo. At this point, coliform bacteria counts have exceeded State standards in 63% of the samples between 1974-1978, as compared to a 1% violation rate at a station upstream of Kokomo. As Table 10 illustrates, a large increase in bacterial counts is produced by the Kokomo area. Throughout the five-year survey period, mean coliform bacteria concentrations have

Table 10
Fecal Coliform Concentrations
(#/100 ml.)
Wildcat Creek at Kokomo

	Upstream	Downstream	Net Change
1974	221	10,471	+ 4,000%
1975	230	41,947	+18,000%
1976	271	23,206	+10,000%
1977	164	18,119	+10,000%
1978	313	14,926	+ 4,600%

averaged 22,641 organisms per 100 milliliters (22,641/100 ml.) downstream from Kokomo. Therefore, it is assumed that present conditions below Kokomo preclude Wildcat Creek from recreational use.

The next tributary stream is the Tippecanoe River. It originates near Warsaw, Indiana, in Kosciusko County, and flows south-southwest to Lake Shafer in White County. From Lake Shafer, the Tippecanoe River continues its southerly flow to its confluence with the Wabash River near Delphi, Indiana, in Region 4. Since water quality monitoring was discontinued at Delphi in 1970, and not resumed again until 1976, data from the State's Fixed Station monitoring records are very limited. However, since 1976, dissolved oxygen concentrations have averaged 10.3 mg/l and have not declined below 5.0 mg/l at anytime. In addition, the recreation potential is also good. Over a three-year period coliform bacteria concentrations have averaged 76 organisms per 100 milliliters (76/100 ml.), and at no time have fecal coliform counts exceeded 600/100 ml.

Sugar Creek is of particular importance since the Department of Natural Resources has proposed its designation into Indiana's Natural, Scenic and Recreational Streams. The stream originates in southwestern Tipton County and flows in a southerly direction through the City of Crawfordsville to its confluence with the Wabash River in Parke County. Prior to its confluence, Sugar Creek has an estimated seven-day, once-in-ten-year low flow of 21 cubic feet per second. Data obtained from Indiana's Fixed Station Monitoring station downstream from Crawfordsville indicate good water quality for fish and aquatic life. Dissolved oxygen has a five-year mean concentration of 11.4 mg/l. At no time have levels fallen below 5.0 mg/l. In fact, even during summer low flow periods, dissolved oxygen concentrations have been 3.0 mg/l above State minimum requirements. Good water quality is also reflected by the low concentrations of un-ionized ammonia. No measurement taken between 1974-1978 indicated that the State's 0.05 mg/l threshold level was approached. In fact, the largest concentration (0.02 mg/l) of un-ionized ammonia on record occurred in 1974. Since that time, marginal reductions have been achieved to further enhance water quality for fish and other aquatic life.

As part of the State's Natural, Scenic, and Recreational River System, Sugar Creek would be required to maintain a suitable bacterial quality to sustain whole-body contact recreation. Therefore, coliform concentrations must not exceed more than 400/100 ml. during the months April-October of each year. The remainder of the year bacteria should be consistent with State regulations for partial-body contact recreation. During each April through October period, coliform bacteria has complied with these standards in 62% of the samples between 1974-1978 while averaging no more than 975/100 ml. The remainder of the time Sugar Creek recorded 93% compliance with partial-body contact requirements. Therefore, the bacterial quality seems fairly good, but there are problems in attaining full recreation potential.

The final stream to contribute major flow to the Wabash River is the Patoka River. The stream originates in the western portion of Washington County, in Region 14, and flows west to the Patoka Reservoir near Jasper, Indiana. From the Reservoir, the Patoka River continues its westerly flow to its confluence with the Wabash River near Patoka, Indiana, in Region 13B.

Indiana has established two Fixed Station Water Quality Monitoring Stations on the Patoka River. The first is located immediately downstream from Jasper, Indiana, and the second 33 miles upstream from the Wabash River near Oakland City in Gibson County. Both stations indicate a five-year average dissolved oxygen concentration of 7.3 mg/l. However, Table 11 illustrates a reduction of average dissolved oxygen at each station from 1974 to 1978 had occurred. However, data does indicate that

Table 11
Dissolved Oxygen Concentrations (mg/l)
Patoka River; 1974-1978

	Jasper	Oakland City	Net Change
1974	7.7 mg/l	7.8 mg/l	+ 1.3%
1975	7.6 mg/l	7.9 mg/l	+ 3.8%
1976	7.2 mg/l	7.0 mg/l	- 2.8%
1977	7.0 mg/l	7.2 mg/l	+ 2.7%
1978	6.0 mg/l	6.8 mg/l	+11.8

but with exception of 1976, each year sustains an increase of dissolved oxygen levels in the Patoka River. Particular attention should focus on the upstream areas near Jasper, where dissolved oxygen concentrations failed to maintain average daily requirements 33% of the time. A majority of these instances, however, were recorded during summer low-flow periods.

Total iron concentrations may be more of a critical factor for fish and aquatic life, especially in upstream areas of the Patoka River. Between 1974-1978, iron concentrations exceeded desirable levels in approximately 26% of the surveys, averaging 22.0 mg/l. Excursions from this pattern ranged between a low of 3.4 mg/l to a high of 8.3 mg/l in 1974. An overall 44% reduction of total iron has been realized during this time.

Downstream from Jasper, cyanide may impair fish and aquatic life to a greater degree. At this point cyanide concentrations have complied with Federal standards 62% of the time. Prior to discontinuing sampling in 1977, cyanide concentrations averaged 22.0 ug/l with the more severe violations occurring in 1974. Between 1974 and 1977, however, cyanide concentrations have been reduced by over 85%.

The bacterial quality of the upstream portions of the Patoka River appear to be lower than in other areas. Near Jasper, standards for partial-body contact recreation are met in only 58% of the surveys with a mean concentration of 2,036/100 ml. Downstream, near Oakland City a slight 11% improvement has occurred, with coliform bacteria concentrations during this same period of time averaging 1,803/100 ml.

Table 12 illustrates that as the Patoka River progresses downstream, a reduction of coliform bacteria occurs. However, because of low compliance with continuing state standards, the bacterial quality in the vicinity of Jasper precludes stream uses for recreation much of the time.

Table 12
Fecal Coliform Levels (#/100 ml.) and Annual Compliance
Patoka River

	Jasper	Compliance	Oakland City	Compliance	Net Change
1974	3,496	33%	1,868	45%	-65%
1975	6,238	54%	1,192	90%	-80%
1976	800	92%	168	92%	-77%
1977	31,807	55%	3,155	78%	-28%
1978	1,684	55%	375	80%	-70%

In conclusion, it would appear that significant operational problems exist in the Jasper planning area, but data indicates that the bacterial quality of the Patoka River improves enough to meet partial-body contact recreational criteria before joining the Wabash River.

West Fork White River Basin

General Assessment:

The general water quality of the West Fork White River is good except for certain reaches downstream of metropolitan areas. As a result of discharges from the Muncie, Anderson, and Indianapolis metropolitan planning areas, degradation occurs that significantly affects the stream as far downstream as the Spencer area. A notable decrease of annual dissolved oxygen concentrations and corresponding increase of coliform bacteria occur downstream from each of these municipalities. Concentrations of parameters such as phenols, mercury, cyanide, and copper, although demonstrating a decrease over the past five-years, are still persistent water quality problems in some areas of the West Fork of White River.

Technical Assessment:

The West Fork of White River is the second largest drainage area in the State of Indiana. The West Fork of White River flows approximately 350 miles through Indiana prior to its confluence with the Wabash River near East Mt. Carmel, Indiana, in Region 13B. Originating east of Winchester, Indiana, White River flows west approximately 85 miles through the Muncie-Anderson planning areas. Near Noblesville, Indiana, in Region 8, the West Fork of White River shifts to a south-southwest course for almost 190 miles through Indianapolis and Martinsville to a point south of Washington, Indiana, (Region 13A) where it joins the East Fork of White River. At Petersburg, Indiana, only 48 miles upstream from the Wabash River, the seven-day, once-in-ten-year low flow is estimated near 700 cubic feet per second (cfs).

In this basin, only a few Fixed Station Water Quality Monitoring stations are located on tributary streams of the West Fork White River. According to the U.S. Geological Survey these streams and their seven-day, once-in-ten-year low flow are: Fall Creek (20 cfs), Eagle Creek (20 cfs), Walnut and Mill Creek southwest of Indianapolis (0.5 cfs and 0.8 cfs, respectively) and the Eel River (18 cfs).

A total of twelve (12) Fixed station Water Quality Monitoring stations are located on the West Fork of White River in Indiana. As indicated in Table 13, dissolved oxygen concentrations at each of these locations generally declined between 1974-1978. Except for 1978, the West Fork of White River has sustained a net increase of total dissolved oxygen. There are two areas that significantly impact and cause depletion of the available dissolved oxygen in White River. These areas include the Muncie-Anderson metropolitan districts and the City of Indianapolis. Monitoring stations downstream of these districts, with the exception of 1976-1977, have annually recorded less dissolved oxygen than stations located upstream from the districts. The most extensive oxygen loss occurred in 1978 where 1.4 mg/l was lost or 14% between Perkinsville and Winchester, Indiana. Waste discharges from the City of Indianapolis produced an annual 2.6 mg/l loss of dissolved oxygen in the West Fork of White River between 1974-1978. The stream approaches complete recovery several miles downstream in the Spencer area where, as Figure 8 illustrates, no dissolved oxygen concentrations fall below daily average standards.

Figure 8 ; 1974-1978
Dissolved Oxygen Concentrations, (mg/l)
West Fork of White River at Spencer

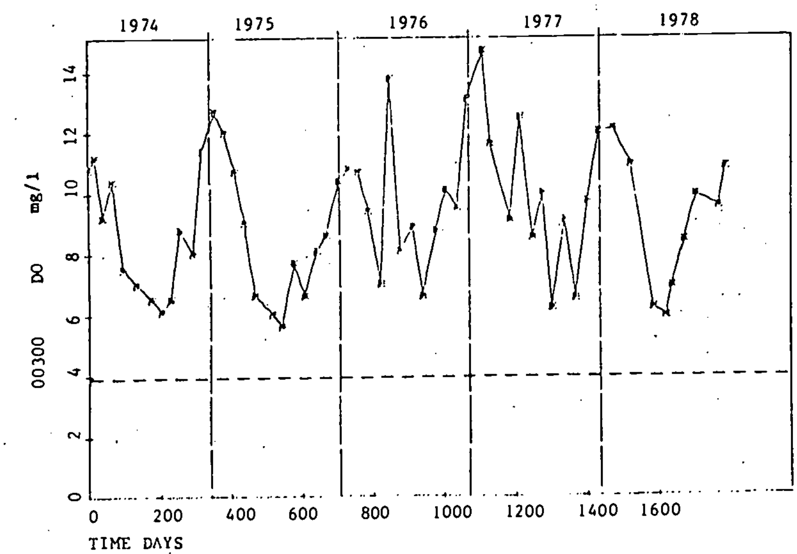


Table 13
Annual Dissolved Oxygen Levels (mg/l)
West Fork of White River; 1974-1978

Location	1974	1975	1976	1977	1978
Winchester	9.0	8.4	7.3	8.1	9.8
Muncie	10.4	9.7	10.1	9.9	9.2
Yorktown	8.3	7.5	8.2	7.6	7.6
Daleville	9.3	8.4	9.8	9.0	8.3
Anderson	10.4	9.8	11.6	10.7	9.3
Perkinsville	8.9	8.1	9.3	8.1	8.4
Nora	9.8	9.5	10.5	9.6	10.2
Centerton	7.5	7.9	6.6	7.2	7.2
Martinsville	8.2	8.7	7.8	8.4	7.3
Spencer	8.6	8.7	9.7	10.0	8.5
Edwardsport	10.1	10.4	10.7	10.0	9.0
Petersburg	9.4	9.4	10.2	9.6	9.4
Net Change	+4%	+12%	+40%	+18%	-4%

Regardless of the impact of municipal discharges on White River, there is sufficient dissolved oxygen within the stream to support aquatic life. Periodically, data show violations of daily required dissolved oxygen averages, but levels seldom fall below 4.0 mg/l.

Other than dissolved oxygen, which generally poses no problem in maintaining minimum standards, there are some instream constituents that may adversely affect fish and other aquatic life. Monitoring stations upstream from Indianapolos indicate high concentrations of cyanide, mercury, phenols, and un-ionized ammonia.

Cyanide concentrations above Indianapolis, over a five-year period, have complied with Federal standards between 55%-68% of the time. A majority of the higher levels occurred primarily early in the survey period (1974). In comparison with 1978 concentrations, significant reductions have been realized. Specifically, each sample location recorded a net cyanide loss ranging from 67% to 99% from that reported in 1974. Mercury is another parameter exhibiting remarkable reductions since 1974. Over this five-year period, total concentrations of mercury have averaged between 0.1 ug/l at Winchester to 0.3 ug/l at Perkinsville, Indiana. Data indicate that for some undefined reason, mercury significantly increased in 1978. But the validity of these measurements becomes questionable since information compiled for three quarters of 1979 indicate a net decrease of almost 80% from levels reported in 1974.

Phenol concentrations are the most persistent and prohibitive parameter for this segment of White River. The U.S. EPA maintains a 1.0 ug/l limit to protect against the tainting of fish flesh. Data indicate that two stations between Anderson and Muncie complied with this instream standard in only 11% and 21% of the measurements. At Yorktown, immediately below Muncie, phenol concentrations have demonstrated 100% violation in 16 samples taken. Collectively, average concentrations recorded between 1974-1978 ranged between 5.4 ug/l and 4.5 ug/l of total phenols at the Anderson and Muncie monitoring stations, respectively. Although no definite linear relationship can be denoted, high levels indicate no instream reduction of phenols is being achieved. The only fixed station water quality monitoring station which denotes un-ionized ammonia concentrations approaching the State's 0.05 mg/l critical level is located at Yorktown, Indiana. Although no measurement has exceeded this threshold, several samples in 1977 indicated un-ionized ammonia at .04 mg/l. An overall reduction has been realized between 1974-1978. In several instances un-ionized ammonia in 1974 reached probable toxic levels between 0.07 mg/l to 0.4 mg/l. However, 1978 data indicated no concentration has exceeded 0.02 mg/l at anytime. Therefore, a possible 90% reduction has been demonstrated within this five-year period.

Possibly the only other instream constituent which may be injurious to fish and other aquatic life is total copper. Generally, concentrations of copper greater than 20.0 ug/l are thought to be toxic to some forms of aquatic life. While most water quality stations upstream from Indianapolis record copper concentrations which comply with the criterion 89% of the time, noncompliance occurs at Perkinsville, Indiana, just below the City of Anderson. Specifically, as a general instream standard, 20.0 ug/l has been exceeded in 58% of the samples. In 32 of the 55 samples total copper at this location was found to be between 30.0 ug/l to 270.0 ug/l during a five-year period with a mean concentration of 42.0 ug/l.

As the West Fork of White River enters the Region 8 planning area, some recovery is demonstrated. Cyanide, mercury, and copper still appear to be persistent, although both cyanide and mercury concentrations have been significantly reduced. By the end of 1977, when sampling was discontinued, cyanide and mercury had achieved a 99% and 38% instream reduction, respectively. There have been marginal increases of total copper concentrations. During the period of 1974-1978 a 19% increase was realized between an annual average concentration of 26.0 ug/l in 1974 and a 31.0 ug/l average in 1977.

Through comparison of data compiled for several Fixed Station Water Quality Stations below Indianapolis to that data from above the metropolitan area, the impact of Indianapolis can be readily identified. There are several parameters such as cyanide, mercury, un-ionized ammonia, and phenols that, over a five-year period, were present in concentrations that often exceeded water quality requirements.

Total cyanide concentrations decreased 73% below Indianapolis. Between 1974-1978 cyanide concentrations have averaged 17.0 ug/l downstream of Indianapolis as compared to 64.0 ug/l at Nora; but the downstream Indianapolis station still complies with Federal standards in only 27% of the measurements. The extent of this noncompliance masks the overall 85% reduction of total cyanide which has occurred below Indianapolis.

According to the data, similar trends have been recorded for mercury levels below Indianapolis. Between 1974-1978, total mercury recorded upstream of Indianapolis increased 76% from an annual concentration of 0.25 ug/l to 0.44 ug/l. Below Indianapolis, 22 measurements exceeded the U.S. EPA standards to indicate a 59% compliance record. However, upon comparison with mercury data compiled in 1979, an apparent 33% reduction has been achieved.

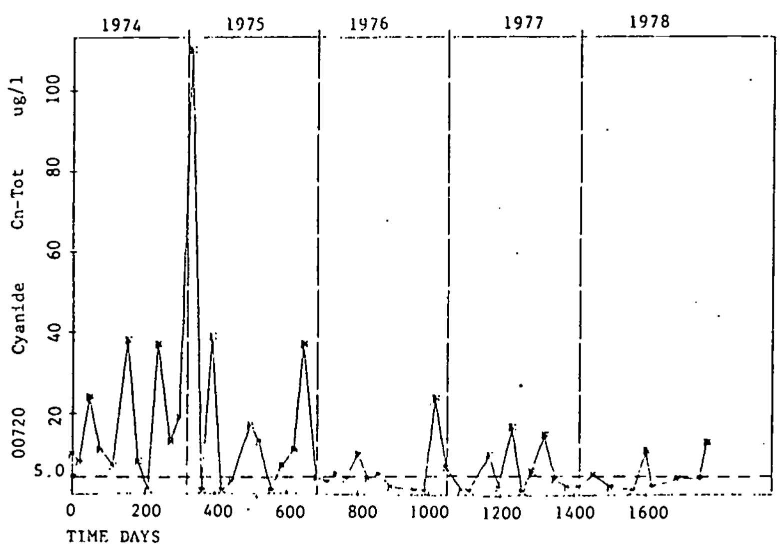
Although total copper, as a five-year average, still exceeds 20.0 ug/l by 3.0 ug/l, its total concentration has been reduced by 8% as the West Fork of White River flows through Indianapolis. Of 55 measurements taken at Centerton, 24% exceeded this general criterion by an average of 16.0 ug/l. Specifically, copper concentrations at Centerton have been reduced by 39% over a five-year period and present concentrations approach the desirable 20.0 ug/l instream concentration.

The most serious problem for the West Fork of White River is probably excessive phenol concentrations recorded downstream from Indianapolis. Specifically, two stations within Region 8 indicate phenol concentrations averaging 7.2 ug/l in 1978 with no measurement in compliance with Federal standards. When considering the severity of this problem in the upstream planning areas, it is apparent that a considerable phenol problem exists for the majority of the West Fork of White River.

A reduction in un-ionized ammonia was identified below Indianapolis within the 1974-1978 survey period. However, the impact of Indianapolis is again apparent. Upstream from Indianapolis, no measurement indicates concentrations approaching the State's 0.05 mg/l threshold level for aquatic life. But downstream near Centerton, approximately 30% of the samples exceeded the States critical level. Although a majority of these excursions were recorded in 1974, years preceeding 1978 exhibited at least one deviation each year above this prohibitive level.

Below the Region 8 planning area, only three Fixed Station Water Quality Monitoring stations record White River's characteristics prior to its confluence with the Wabash River. These are at Spencer in Owen County, at Edwardsport in Knox County, and downstream from the East Fork White River-West Fork White River confluence, at Petersburg, Indiana, in Pike County. According to the data, possibly the only limiting factor for aquatic life is total cyanide. The more excessive instream concentrations exist in the Spencer planning area where, as Figure 9 indicates, cyanide values conformed to Federal standards in only 51% of the measurements and averaged 11.0 ug/l between 1974-1978. While violations of this standard still occurred in 1978, there was a net 67% reduction of cyanide, from a 1974 annual average of 16.0 ug/l to 5.0 ug/l in 1978. At Petersburg, cyanide concentrations within White River comply with Federal requirements in 73% of the measurements with a five-year average mean of 33.0 ug/l. However, approximately 32% more cyanide has been eliminated at this location than at Spencer. Therefore, it may be concluded that although cyanide had, in the past, been considered a significant limiting factor for aquatic life, remedial action has resulted in significant total instream reductions.

Figure 9; 1974-1978
Total Cyanide Concentrations (ug/l)
West Fork of White River at Spencer



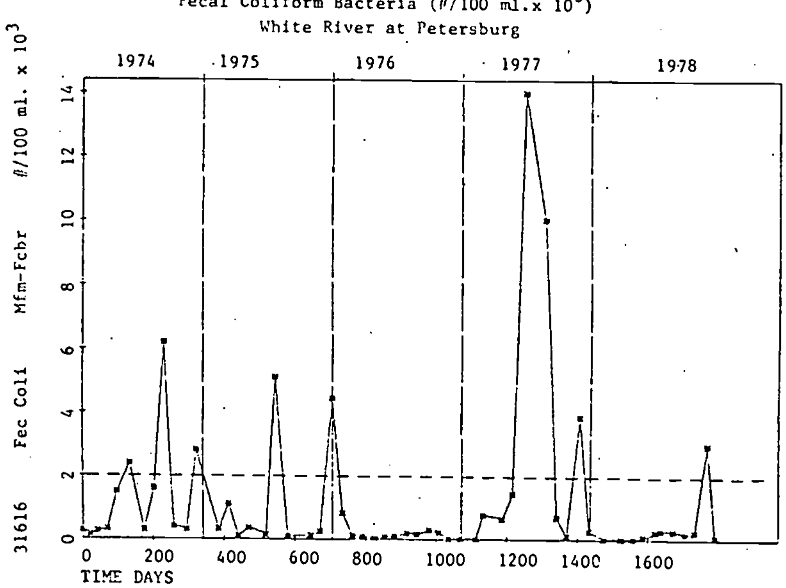
The remaining designated use for the West Fork of White River is partial-body recreation as defined by State coliform bacteria standards. Throughout this five-year period, excessively high coliform concentrations existed below Muncie and Indianapolis. As Table 14 illustrates, the Water Quality Monitoring stations below Muncie and Indianapolis have recorded lower compliance rates than any other stations on the West Fork White River. In addition, 1978 appears to be the year of least compliance with State recreational standards as evidenced by only 23% compliance below Muncie and 19% compliance below Indianapolis. Overall, as the West Fork of White River flows to the Wabash River confluence, a 52%-96% reduction of coliform bacteria was realized between 1974-1978.

Table 14
West Fork of White River
Annual Fecal Coliform Bacteria (#/100 1)

Location	1974	Compliance	1975	Compliance	1976	Compliance	1977	Compliance	1978	Compliance
Winchester	25,104	75%	2,468	67%	3,982	82%	2,192	50%	1,286	75%
Muncie	658	82%	659	92%	550	91%	709	100%	1,891	75%
Yorktown	49,401	25%	12,711	33%	5,568	58%	3,700	67%	9,933	23%
Daleville	3,767	33%	5,054	50%	1,112	83%	2,520	70%	6,412	00
Anderson	10,416	25%	22,702	33%	3,305	97%	2,795	80%	5,351	63%
Perkinsville	1,484	75%	802	92%	1,879	83%	934	80%	2,029	78%
Nora	1,301	75%	1,225	83%	402	92%	1,173	89%	852	82%
Centerton	3,427	58%	1,610	75%	577	92%	1,964	89%	6,984	19%
Martinsville	1,782	67%	1,599	75%	590	82%	1,505	70%	4,846	40%
Spencer	1,596	75%	2,962	75%	597	92%	2,070	70%	943	78%
Edwardsport	1,677	83%	802	92%	149	100%	972	90%	343	100%
Petersburg	1,368	75%	1,192	80%	168	100%	3,155	70%	375	91%
Net Change	-95%		-52%		-96%		+44%		-71%	

Only in 1977 was an increase of 963 organisms per 100 ml. recorded between the headwaters region and the last survey point at Petersburg. But as Figure 10 depicts, the overall bacterial quality is generally sufficient to not preclude recreational uses at Petersburg. Therefore, although two points far exceeded State standards, the general potential for partial body contact recreation in the West Fork of White River is relatively good.

Figure 10; 1974-1978
Fecal Coliform Bacteria (#/100 ml.x 10^3)
White River at Petersburg



As previously indicated, there are only a few major streams augmenting the West Fork of White River as it flows through the State. The first of these streams is Eagle Creek which joins White River at Indianapolis. The headwaters of Eagle Creek originate in Boone County and flow in a southern direction to Eagle Creek Reservoir in Marion County. Its discharge from this multi-purpose impoundment continues its flow to White River.

Above the reservoir, there is sufficient dissolved oxygen to support aquatic life. At no time have recorded dissolved oxygen concentrations fallen below either average daily requirements or minimum State standards. Through this survey period, dissolved oxygen maintained an average concentration of 10.4 mg/l. However, cyanide concentrations may have had an adverse effect upon the aquatic environment. Cyanide concentrations complied with Federal standards in 62% of the measurements. Although this constituent averaged 42.0 ug/l during this period, a substantial reduction has been achieved. By comparison, total instream cyanide was reduced 98% from an average annual level of 65.0 ug/l in 1974 to 1.0 ug/l in early 1978 when monitoring was discontinued. The bacterial quality above the reservoir is also very good. Between 1974-1978, fecal coliform bacteria counts complied with standards in 91% of the measurements. In five samples, coliform bacteria were found to exceed 2,000 organisms per 100 milliliters, with peaks between 2,200/100 ml. and 34,000/100 ml. Usually, bacterial levels measured near 1,210/100 ml.

Prior to its confluence with White River, Eagle Creek sustained measurable degradation. Dissolved oxygen, while still maintaining levels above state standards, averaged 9.1 mg/l during this five-year period. In addition, although no levels fell below minimum standards, two samples were found below average daily requirements. Presently, the only prohibitive instream constituent is copper. Between 1974-1978, copper values complied with the 20.0 ug/l criterion in only 22% of the measurements and averaged 160.0 ug/l. Although an 88% reduction has been recorded in this portion of Eagle Creek, the total copper criterion is still exceeded 55% of the time in 1978. Cyanide is also found to be a water quality problem in this area. The Federal standard of 5.0 ug/l has been exceeded in 46% of the samples taken between 1974-1978 and averaged 14.0 ug/l over this period. Although a 98% reduction has been achieved during this period, the frequency of violations between 1977-1978 (22%) justifies further sampling of this parameter downstream from Eagle Creek Reservoir.

The stream's capacity to attain partial-body contact recreational standards is also fair. Between 1974-1978, coliform bacteria concentrations exceeded 2,000 organism per 100 milliliters in only 24% of the measurements. Of particular concern is the 1978 measurements which violated instream limitations 64% of the time ranging from 7,300/100 ml. to 540,000/100 ml. On an annual basis, the potential for partial-body contact recreation below Eagle Creek Reservoir is declining.

Another stream that augments White River's flow within Marion County is Fall Creek. It originates in the southwestern portion of Madison County and flows into Geist Reservoir at the Marion-Hamilton County line. After its regulated discharge, the stream continues its southerly flow to White River. The quality of water discharged from the

Geist Reservoir maintains high levels of dissolved oxygen. At no time have concentrations fallen below the minimum 4.0 mg/l limit and generally levels above 9.0 mg/l have been maintained. As is the case for Eagle Creek, there are several constituents that may inhibit the aquatic life of Fall Creek below Geist Reservoir. Between the latter part of 1974 and early 1978, when sampling was discontinued, phenol concentrations exceeded the U.S. EPA, 1.0 ug/l limit in 75% of the cases. During this period, the average phenol concentration was 3.7 ug/l with violations ranging from 2.0 ug/l to 10.0 ug/l. Mercury also appears to be a problem in this portion of Fall Creek. During almost a four-year period, total mercury averaged 0.20 ug/l and violated Federal standards 40% of the time. Although data for 1978 alone indicated an average mercury concentration of 0.20 ug/l, concentrations as high as 0.50 ug/l have been recorded. Unlike other areas of the State where these measurements are questionable, data compiled for 1979 are more positive and indicate similar violations. Therefore, mercury concentrations for this portion of Fall Creek are considered high and surveillance should continue.

Below the Reservoir, Fall Creek maintains very good bacterial quality. In a total of 71 samples only 15% exceeded the State standards. Therefore, since coliform counts indicate 85% compliance during this period, Fall Creek appears to maintain sufficient bacterial quality to support partial-body contact recreation.

The remaining stream for which data is available is Mill Creek in Putnam County. It originates north of Stilesville, Indiana, and flows south-southwest to Cataract Lake. Data from Indiana's Fixed Station Monitoring stations at Devore and Stilesville indicate dissolved oxygen concentrations have maintained acceptable limits. Therefore, dissolved oxygen appears sufficient to support aquatic life. However, the bacterial quality at times, does not comply with standards. During most instances violations were limited to summer low-flow periods.

East Fork White River

General Assessment:

The water quality of the East Fork White River is improving. Sufficient dissolved oxygen is present to support a divergent aquatic community. Several factors create localized pollution problems. However, many of these local problems are being resolved.

Technical Assessment:

The East Fork of White River is located in south central Indiana and orignates at the confluence of the Driftwood and Flatrock Rivers north of Columbus, Indiana. Its estimated 190-mile course takes a southerly direction for about 20 miles to Seymour where, for the remainder of its journey, the river takes a westerly direction to its confluence with the West Fork of White River near Petersburg, Indiana.

Table 15
Dissolved Oxygen Concentrations (mg/l)
East Fork White River; 1974-1978

	Seymour	Compliance	Bedford	Compliance	Williams	Compliance	Net Change
1974	9.8	100%	8.8	100%	9.5	100%	-3%
1975	10.9	100%	8.6	97%	9.9	100%	-9%
1976	10.0	92%	9.3	82%	9.8	100%	-2%
1977	9.3	91%	9.1	100%	9.5	100%	+2%
1978	10.1	100%	9.4	100%	10.1	100%	-1%

As Table 15 indicates, the dissolved oxygen concentrations are high and rarely fall below State minimum standards. At each survey location, a net increase of available dissolved oxygen has been recorded between 1974-1978. As the East Fork of White River flows through Indiana, dissolved oxygen concentrations fall slightly, but the extent of this decline is minimal and dissolved oxygen values have averaged approximately 10.0 mg/l over a five-year period.

The only potential limiting factor demonstrated for the East Fork White River is the concentrations of total copper found upstream of Seymour. In some instances, copper concentrations exceeding 20.0 ug/l may become a critical factor for fish and aquatic life. According to data, this parameter has complied with general instream limitations in 67% of the samples taken between 1974-1978. Although the average five-year concentration measured 197.0 ug/l, an overall 94% reduction has been realized during this period to indicate improvement in water quality.

One possible source of pollution within the Seymour planning area is the Seymour Recycling Corporation. This facility has been identified by the U.S. EPA as one of the most serious hazardous waste disposal areas in the nation. As of April 1978, the Corporation estimated that there were 42,000 drums and over 500,000 gallons of hazardous waste in bulk storage within the site. Materials involved include reclaimable solvents, acid and caustic wastes, cyanide, laboratory chemicals, pesticides, still bottoms, enamels, and a vague category of waste classified as "set-up." In October 1978, a hydrogeological study was conducted to determine the potential for groundwater contamination at the site. It was concluded that pollutants could migrate to significant depths within the soil profile. The prevalent soil type in this vicinity is the Ayrshire series characterized by soils of slow to moderately rapid conductivities. More recently, however, Seymour Recycling has been ordered by the State and Federal environmental authorities to clean up its site and remove all cyanide. Inspections have revealed poor management and operation practices which have resulted in ruptured barrels and miscellaneous spillage pooling on the surface of the site. Subsequent investigation has led to a massive clean up effort by an Ohio chemical firm to remove all damaged containers and retard any surface runoff into nearby tributaries of the East Fork of White River.

Further downstream at Williams, total instream cyanide has exceeded Federal standards in 31% of the measurements taken between 1974-1978. Average concentrations during this period are reported to be 6.0 ug/l. This is 1.0 ug/l over the U.S. EPA criterion for freshwater aquatic life. Higher concentrations persisted early in the survey period, but since this time, a 93% reduction has been realized.

Table 16
Fecal Coliform Bacteria (#/100 ml)
and Annual Compliance
East Fork White River; 1974-1978

	Seymour	Compliance	Bedford	Compliance	Williams	Compliance	Net Change
1974	514	100%	1,482	92%	568	100%	+10%
1975	1,152	75%	625	100%	760	93%	-34%
1976	193	100%	132	100%	105	100%	-46%
1977	1,451	90%	1,571	78%	474	90%	-67%
1978	476	92%	623	100%	505	90%	+12%

The bacterial quality of East Fork of White River meets state standards on most occasions. As Table 16 depicts, the coliform bacteria concentrations have never fallen below 75% compliance during any year. Except for a 12% and 10% increase of coliform bacteria between Seymour and Williams in 1978 and 1974, respectively, each year showed reductions of instream bacteria concentrations. Therefore, it may be considered that bacterial quality is improving.

Three municipalities adjacent to the East Fork of White River utilize its flow as a potable water supply. State standards require that, as a monthly average, total coliform bacteria shall not exceed 5,000/100 ml., nor exceed this number in more than 20% of the samples examined during any month. Data indicate that between each survey point, State standards were met between 72% to 79% of the time from 1974-1978. During this period mean concentrations of coliform bacteria did not exceed 7,000/100 ml., but rather ranged between 4,477/100 ml. to 6,963/100 ml. Data also indicate a marginal reduction of total coliform bacteria in the East Fork of White River as it flows downstream, and an overall reduction at each survey point throughout this five-year period. Therefore, it seems that the East Fork of White River is an acceptable water supply source for the communities of Seymour, Bedford, and Mitchell since total coliform violations do not frequently occur.

The Big Blue River orignates north of New Castle, Indiana, in Henry County and flows southwest through Rush and Shelby County to its confluence with Sugar Creek near Edinburg. At Shelbyville the seven-day, once-in-ten year low flow is measured at 0.5 cubic feet per second.

The State Board of Health has located two Fixed Monitoring Stations along this stream. The first is located near Spiceland, below the City of New Castle. This area of the basin, designated as a "water quality" segment, suggestions that present water quality is not meeting standards, and is not expected to meet standards even after the application of effluent limitations. Data indicate the river is good habitat for fish and other aquatic life. Dissolved oxygen concentrations met minimum standards in 97% of the measurements while averaging 8.5 mg/l. In only one instance was un-ionized ammonia found approaching the States critical threshold level. Cyanide was found to possibly be a major limiting factor for fish and aquatic life. Within this three-year period (1976-1978), total cyanide has complied with federal standards 77% of the samples. Although the average concentration was 3.8 ug/l, seven violations were recorded ranging between 6.0 ug/l to 19.0 ug/l.

The bacterial quality of Big Blue River is usually good. Specifically, the State's standard for partial-body contact recreation was met 84% of the time in a three-year period. Average bacterial levels exceeding 2,000/100 ml. have ranged from 2,800/100 ml. to 70,000/100 ml. However, minor coliform problems were recorded in 1978 to indicate a 30% violation rate. Further attention is necessary to ensure that additional degradation is prevented.

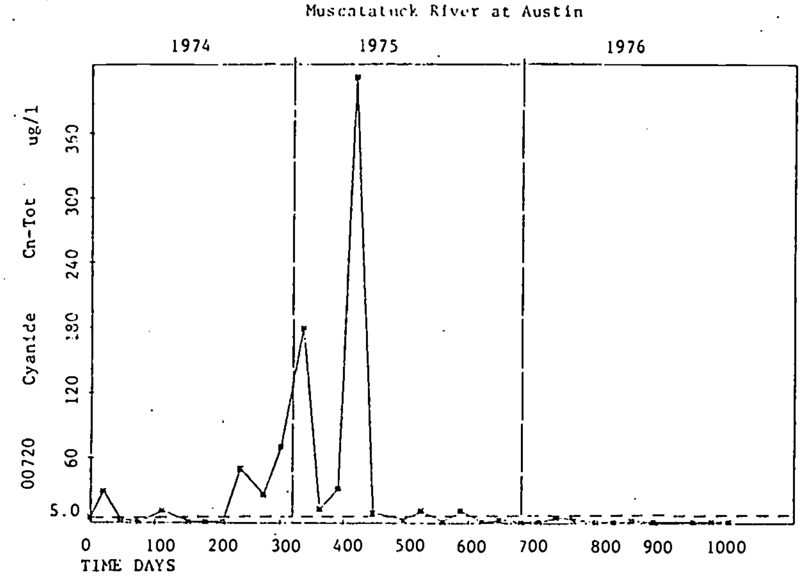
The second monitoring station is located immediately upstream from the Big Blue River confluence at Edinburg. Data at this location also indicate generally good water quality. Between 1974-1978, dissolved oxygen concentrations have maintained average levels near 10.0 mg/l, and at no time has it declined below State minimum requirements. Although the overall results of bacterial sampling indicate 70% compliance, the majority of the violations occurred early in the survey period. Between 1974-1978, analysis of 20 samples revealed that 56% exceeded the coliform bateria limit of 2,000 per 100 milliliters and averaged 3,264/100 ml. Since this time, instream conditions have improved enough to meet partial-body contact recreation standards in 88% of the measurements.

The second tributary to impact and supplement the flow of the East Fork of White River is the Muscatatuck River. It originates in western Jefferson County and flows west to its confluence with the East Fork of White River near the Washington-Lawrence County line. Near Austin, the seven-day, once-in-ten-year low flow is estimated to be 0.5 cubic feet per second.

Water quality data collected at this location indicate good water quality for fish and aquatic life and for partial-body contact recreation. Between 1974-1978, average dissolved oxygen concentrations maintained levels between 7.4 mg/l to 8.3 mg/l. Although average daily standards (5.0 mg/l) for this parameter were violated about 20% of the time, minimum standards were met in 100% of the samples.

Cyanide concentrations in the Muscatatuck River reportedly exceeded U.S. EPA standards in 36% of the samples. However, as Figure 11 graphically displays, a recorded 97% reduction, which occurred between 1975-1976. Therefore, cyanide levels attained compliance with Federal standards and sampling was discontinued. Similar trends were recorded for oil and grease concentrations which averaged 6.7 mg/l for a five-year period and attained acceptable concentrations 75% of the time. There were some problems in 1975 when levels averaged 11.3 mg/l. However, an 88% reduction by 1978, to an average 1.4 mg/l concentration, indicates that oil and grease no longer significantly affects fish and other aquatic life.

Figure 11: 1974-1976
Total Cyanide Concentration (ug/l)
Muscatatuck River at Austin



During this period, coliform bacteria counts sustained 83% to 88% compliance with State Water Quality Standards. Average concentrations were recorded near 1,150/100 ml. Therefore, the coliform bacteria standard for partial-body contact recreation was generally exceeded only two months of any given year, and limited violations to summer low-flow periods.

Salt Creek is the final stream within this basin where the State Board of Health maintains a Water Quality Monitoring Station. The flow of Salt Creek orignates from the regulated discharge of Monroe Reservoir, and its principle direction of flow is southwest through Lawrence County. Near Peerless, Indiana, the U.S. Geological Survey estimates that the annual seven-day, once-in-ten-year low-flow is 1.3 cubic feet per second.

At Oolitic, the State Board of Health monitoring station data from Salt Creek indicate generally good water quality. In a five-year period, dissolved oxygen concentrations maintained levels well above State minimum standards. This is evidenced through 98% compliance with the States 4.0 mg/l minimum requirement. A marginal 12% reduction of available dissolved oxygen occurred during this period. In 1974, the annual average was reported to be 9.5 mg/l, but in 1978, the annual average deteriorated to 8.3 mg/l.

In Salt Creek no recorded pH measurements have fallen below 6.2 or risen above 8.3. No critical levels of nitrate/nitrites, chlorides, or sulfates were recorded that inhibited Salt Creek's use as an industrial or public water supply. Dissolved oxygen levels have been sufficient to support aquatic life. No recorded levels of un-ionized ammonia have exceeded state standards. In a five-year period State coliform bacteria standards were violated in 27% of the measurements while averaging 662 organisms/100 ml.

The most serious water quality problem affecting aquatic life and the human population is the presence of polychlorinated biphenols (PCBs) in the Bloomington and Bedford areas of Clear Creek. Past investigations revealed that concentrations of PCBs exceeding 1.0 ug/l were present. The discontinued use of PCBs in the Bloomington area, has resulted in lower instream levels, but investigations within the Bedford planning area have indicated a rise of PCB concentrations at some stream locations.

Whitewater River Basin

General Assessment:

Both branches of the Whitewater River support diverse species of fish and aquatic life. Dissolved oxygen concentrations fell below minimum requirements only once in the West Fork of the Whitewater River. No parameter concentrations were recorded that were toxic to fish and aquatic life. The bacterial quality is higher in the East Fork. The West Fork of the Whitewater River does not regularly comply with the bacteriological standards for recreational waters.

Technical Assessment:

The final river basin for this Statewide water quality assessment is the Whitewater River Basin in Planning and Development Region 9. The main stem of the Whitewater River is formed by the confluence of its East Fork and West Fork near Brookville, Indiana. From this point, the Whitewater River flows southeast prior to leaving the State in northeastern Dearborn County. At its confluent point the Whitewater River has a measured seven-day, once-in-ten-year low flow of 86 cubic feet per second.

The West Fork of the Whitewater River originates in southwestern Randolph County in Region 6 and flows south to its confluence with the East Fork at Brookville, Indiana. Water quality data indicate a very good environment for fish and aquatic life. Over a three-year period (1976-1978), dissolved oxygen concentrations averaged 10.5 mg/l, with only one measurement below minimum State standards.

The West Fork of the Whitewater River is presently under consideration for inclusion in the State's Natural, Scenic, and Recreational River System. If the stream is included in the System, bacterial quality must be high enough to permit support whole-body contact recreation. Measurements taken between April through October indicate very poor potential for meeting whole-body contact recreation standards. Past records indicate zero compliance with this instream standard. Although improvement has occurred, present coliform bacteria concentrations preclude this stream for use for whole-body contact recreation. Its present use for partial-body contact complies with State Standards in 62% of the samples in a three-year period. During this time coliform bacteria averaged 3,665/100 ml.

The East Fork of the Whitewater River originates north of Richmond, Indiana, and flows south into Brookville Reservoir. The regulated discharge from this impoundment travels only a short distance until its confluence with the West Fork of the Whitewater River. The data indicate that a very good quality of water is being discharged to Brookville Reservoir. Dissolved oxygen concentrations were at no time below either average daily requirements or minimum State standards. Over a three-year period, dissolved oxygen averaged approximately 10.0 mg/l. Upstream of the reservoir, the East Fork of the Whitewater

River is designated for partial-body contact recreation. Data indicate that the State standard of 2,000 coliform organisms per 100 milliliters is met 87% of the time. Coliform bacteria concentrations usually averaged in the range of 1,033/100 ml.

The Whitewater River, therefore, demonstrates sufficient water quality to support its present designated uses.

The Ohio River*

The Ohio River forms the southern boundary of the State of Indiana and drains the lower tier of Indiana Counties which accounts for 1% of the State's areas. None of the waters or the stream beds of the Ohio River are considered to be part of the State of Indiana. The Commonwealth of Kentucky, however, claims all of the stream bed to the high water mark on the Indiana shore. Indiana asserts that the boundary is the low water mark as it existed on the northerly side of the Ohio River in 1792. For this reason no fixed water quality monitoring stations have been established by the State of Indiana along the Ohio River; however, fixed station monitoring has been conducted by the Ohio River Valley Water Sanitation Commission (ORSANCO) in conjunction with the Commonwealth of Kentucky.

This boundary dispute has been a long standing controversy not only between Indiana and Kentucky, but also among Ohio, Virginia, and Kentucky. These disputes have recently been brought before the U.S. Supreme Court. In the case of the State of Ohio vs. Commonwealth of Kentucky, the Court has ruled that the common boundary between these states is the low-water mark on the northerly side of the Ohio River as it existed in 1792 (the date Kentucky was granted Statehood) and that the boundary is not the low-water mark as it exists today.

In the case of Indiana vs. Kentucky, the Supreme Court has summarily adopted its Special Master's (mediator) Second Report. By this adoption, the Supreme Court has also determined (by analogy to the Ohio decision) that the common boundary between Indiana and Kentucky is also the 1792 low-water mark. However, now the States are expected to determine what the actual physical boundary was as it existed in 1792. Various issues still remain as to how this physical determination can be made. For instance one consideration which must be addressed is the extent to which the low-water mark has been altered as a result of the construction of dams and locks by the U.S. Corps of Engineers.

This issue as well as other procedural issues will be heard in evidentiary hearings by the Court's appointed Special Master.

Information contained within ORSANCO's 305(b) Report for the State of Indiana indicates that dissolved oxygen is frequently found not in compliance from a point below Cincinnati to Cannelton, Indiana. This covers approximately 230.0 River Miles on the Ohio River. High concentrations, exceeding State standards, of fecal coliform bacteria have also been found between these points. In the past these large concentrations have been to the extent to issue advisories by Indiana and Kentucky against the recreational use of the river. Probable causes of these high levels of coliform bacteria include inadequately treated sewage, combined sewer overflow, and urban runoff. When waste treatment facilities at Cincinnati and Louisville are fully completed and operational these water quality problems should substantially be reduced.

*Taken from the Ohio River Valley Water Sanitation Commissions's, Assessment of Water Quality Conditions, Ohio River Mainstem 1978 and 1979, April 1980.

Other water quality problems, defined by ORSANCO include high mercury concentrations, exceeding criteria at most points along the Ohio River. In addition, phenolic constituents are also perceived as a critical factor for not only the upper portions, but also in 279.0 River Miles from the Kanawha River in Ohio to the Kentucky River at Ohio River Mile 545.8. This encompasses almost 56.0 River Miles from Lawrenceburg, Indiana, to the extreme southwestern boundary of Switzerland County adjacent to the Ohio River. Lastly, cyanide was also measured at locations from the source of the river near Pittsburg downstream to Louisville. However, the cyanide criterion was only exceeded in the first 200 miles. Probable sources of this contaminant are from industrial discharges, especially steel industries, on the upper reaches of the Ohio River.

Lake Classification Program

General Assessment

Discussions of lake associated problems traditionally deal with lake degradation resulting from cultural pollution and premature aging. Inputs of organic materials and nutrients from municipal, semi-public, and industrial sources; confined feeding operations; agricultural sedimentation and septic tanks all have the potential for accelerating the eutrophication process in lakes. Not only have these sources caused primary detrimental effects on lakes, often harming fish and aquatic life and producing conditions sometimes hazardous to public health, but they have also contributed to a more long-term problem of eutrophication. Excessive organic loadings result in the reduction of the amount of dissolved oxygen available to fish and other aquatic organisms. Excessive nutrient loadings, especially of phosphorus, stimulate the growth of algae. This often triggers a series of longer biochemical processes which also reduce the dissolved oxygen concentration in lakes. The continuing, accelerated growth, death, decomposition and sedimentation of plant material physically decreases the depth of most lakes. The long-term overproduction of plant life and ultimate reduction of lake volume form the basis of accelerated lake eutrophication.

The State has actively sought pollution control measures for lakes for many years. Point source discharges are being controlled through enforcement of Stream Pollution Control Board Water Quality Standards. Confined feeding operations are being monitored through the Confined Feeding Control Law. Agricultural sedimentation and erosion, will be controlled through implementation of the State's Agricultural Nonpoint Source Strategy. The only potential source that appears to lack effective State-wide control is that from lake-side septic systems. Although the nutrient loading may have been somewhat diminished through the phosphate detergent ban, the input from this type of pollutant still occurs at some locations. One possible reason is that enforcement of the State's on-lot disposal regulation, 410 IAC 6-8, is at the local level. Many places cannot meet the requirements of this regulation generally because of soil limitations, lot sizes, and other factors.

BonHomme's Index

In accordance with Section 314(a)(i) of the Clean Water Act of 1977 as amended, the State, using the BonHomme's Index, has completed its trophic classification of all publicly owned fresh water lakes. The BonHomme Index is a unique trophic index classifying lakes using a system of eutrophy points ranging from 0 to 75. Each lake or reservoir is given a total point count. The higher the point count, the more eutrophic the lake. Generally, points were generated from a compilation of various parameters including: total phosphorus, soluble phosphorus, organic nitrogen, dissolved oxygen (percent saturation at five feet and percent of the measured water column with at least 0.1 ppm dissolved oxygen), light penetration and transmission, and total plankton per milliliter. As it stands, the number of known natural lakes (404) and man-made impoundments (150) which have been classified totals 554 with a surface area of approximately 87,533 acres. The new Patoka Reservoir has not been included. In addition, there are several new, small watershed project impoundments constructed under PL 83-566. Because of their number and undetermined locations, many of these have not been surveyed.

Lakes and man-made impoundments will fall into one of four categories. Class I lakes, covering approximately 47,180 acres within the State, rarely support extensive populations of weeds and/or algae and are usually without a chemical control program. Their existing lake uses become significantly impaired only under unusual environmental conditions. These lakes usually exhibit the highest degree of water quality with an index ranging from 0-25 eutrophy points, and are the least eutrophic. Class II lakes, with an index ranging from 26-50 points, demonstrate a medium quality of water and cover about 28,615 acres in Indiana. These lakes, without a chemical control program, frequently support extensive weed and/or algae growth, but seldom to the extent that one or more of the existing lake uses are significantly impaired. Lakes of the lowest quality (Class III), always support extensive populations of weeds and/or algae which frequently impair one or more of the existing lake uses unless chemical waste control programs are utilized. Class III lakes total 9,190 acres and have a point count ranging between 51-75 (advanced eutrophic).

Class IV lakes consist of small remnant lakes and river flood plain lakes. Remnant or marsh lakes have reached an advanced eutrohpic state. Because of their small surface area and/or dissimilarity of characteristics they cannot be realistically ranked with the larger, deeper lakes in Indiana. These marsh lakes are essentially all that remain of the deep basins of large lakes that have gradually filled in through the eutrohpication process. River floodplain lakes, oxbows, and washouts are formed when large rivers, such as the White River and the Wabash River, overflow their banks and cut new channels. They are characteristically rich in phosphorus and nitrogen and they often appear very turbid. During the weather the turbidity is often caused by the rooting behavior of large populations of carp. Plankton blooms also cause the water to be discolored.

Class IV lakes, totalling approximately 2,448 acres in Indiana, demonstrate similarities in that both are used by man for hunting, fishing, and trapping, and often provide a wildlife refuge and a natural wetland. To date, the marginal areas of most remnant and floodplain lakes remain undeveloped. The marshy characteristics of the shorelines often limit development of more intensive land uses. Without a chemical control program, these lakes always support extensive populations of weeds and/or algae, however, the existing lake uses are not usually impaired.

Water Quality Management

In the initial planning for Water Quality Management, the State has developed, through contractual arrangements with Ball State University, a Classification and Management Plan for all publicly owned lakes and reservoirs. Based upon a cluster analysis, this plan has identified seven (7) major lake groupings. Each group contains lakes morphometrically and trophically similar to each other.

The cluster analysis utilized three variables: a) lake size (acres), b) mean depth (ft.), and c) BonHomme's Index. Each of these variables is interrelated in evaluating a lake and selecting a cost-efficient management strategy. This cluster technique produced groups of lakes having similar characteristics in terms of the three variables used. Since the type of restoration techniques or management strategy will depend on the lake size, depth, and eutrophic condition, certain restoration techniques will be more appropriate for use on certain of the groups than on others. For example, large lakes require different management or restoration strategies than small ones. Deep lakes require different strategies than shallow lakes. More eutrohpic ones (nutrient rich) require different strategies than those that are nutrient poor. A list of the lakes in their various clusters is shown in Table A-2 located in the Appendix.

As a result of this clustering concept, Indiana lakes have been classified into seven groupings:

<u>Group I</u> lakes are characterized by their large surface area and relatively good water quality. Although no restoration techniques are recommended, the primary management strategy would be to curb nutrient input from the immediate shoreline, and also from the entire watershed.

<u>Group II</u> lakes have been characterized in three subgroups. Groups IIA and IIB contain some of the best examples of undisturbed natural lakes in the state. The major strategy for these impoundments should be to maintain and protect present water quality. Group IIC, however, differs in that some degradation of water quality has occurred. Strategy for these lakes may encompass management of nutrient inputs and, in some instances, nutrient inactivation and/or selective discharge may be advised.

<u>Group III</u> consists of large shallow bodies of water that exhibit eutrohpic characteristics. Although many of these may be naturally eutrophic, the primary concern should be to prevent further degradation by curbing nutrient input. In more severe cases, possible restoration by macrophyte harvesting and sediment consolidation could be instituted.

<u>Group IV</u> lakes probably contain the majority of problem lakes in the state. Most of these impoundments have such severe water quality problems that recreational use is often impaired. Because specific restoration techniques are area and depth dependent, these lakes have been divided into four (4) subgroups. Although restoration is a major priority, the emphasis on nutrient abatement programs will provide an initial step towards long-range improvement.

<u>Group V</u> lakes consist of shallow lakes, both natural and man-made, that demonstrate high water quality. Management should stress maintenance of present conditions. Because of shallow depths, the degree of protection needed should possibly be greater than those for Groups IIA and IIB.

Group VI lakes demonstrate moderate to advanced eutrohpication relative to their intermediate size and mean depths. Although the main management strategy will be to limit nutrient inputs, in some cases selected restoration techniques may be applicable.

Group VII lakes are somewhat similar to Group VI but are shallower. Because of their lower mean depths, a wider range of restoration techniques may be considered. Water quality problems are not usually severe enough to warrant any restoration procedures other than management of nutrient inputs.

State Strategy

The ongoing State point source regulatory control programs, and the implementation of the State's Agricultural Nonpoint Source Control Strategy, both provide a mechanism for the continued protection of lakes. During FY 80-94, the State will increase study efforts in the Clean Lakes Program for the purpose of making certain lakes eligible for Section 314 renovation work. Two weaknesses in the program exist: (1) the inability to control shoreline septic disposal systems, and (2) the lack of sufficient funding to provide State and/or a local match for large-scale restoration projects. To maintain and restore the integrity of Indiana lakes, the Stream Pollution Control Board will continue its efforts for point source control programs, confined feeding operations and its implementation of the State's Agricultural Nonpoint Source Control Strategy. Also, the State will pursue the utilization of recommended actions for Group IV lakes. To this end, the State will solicit funding appropriations to encourage and finance the restoration of candidate lake projects. Secondly, lake assessment data and the Basic Limnological Primer will be disseminated to lake property owners and other interested groups to advise them of lake problems, restoration techniques and control measures. Implementation of the restoration or control measures will be based on the local level. Any proposed alternative must be found to be cost-effective and environmentally sound. Lastly, the State will make a comprehensive investigation of all studies relative to septic tank alternatives or system improvements such as chemical addition. If found to be cost-effective, these alternatives will be pursued for implementation.

Investigations of Oil, Hazardous Material and Objectionable Material Spillage

Summary of Materials Spilled

During 1979, 338 recorded spill incidents resulted in the discharge of 345 materials or approximately 891,000 gallons. On several occasions more than one kind of material was lost during a spill incident. The materials spilled were grouped into six (6) categories and then summarized according to: the number of spills within that category; the percentage of that category of the total materials spilled (345); the amount of liquid material spilled (if determined); and that percentage of the total volume of material spilled (891,000 gallons). Similar summaries were constructed for each respective year between 1976-1978.

In addition, petroleum products accounted for 177 spill incidents or 51% of the total number of spills in 1979. The volume of this spillage exceeded 528,800 gallons or 59% of the estimated 891,000 total gallons spilled. With 46 reported incidents, gasoline accounted for not only the greatest number of spills, but with an estimated 290,000 gallons lost, also represented the largest volume of petroleum products spilled. During 1976, 1977 and 1978, petroleum products represented 56%, 64% and 55% of the products spilled. In addition, during 1977-1978, these products accounted for 32% and 49%, respectively, of the total volume spilled. Therefore, although petroleum spill incidents decreased slightly in 1979, the volume of material released rose by 10% between 1978-1979.

With 72 reported incidents, agricultural-related materials accounted for 21% of the materials spilled and totalled approximately 168,000 gallons of material spilled. This represented 19% of the total volume spilled and the second largest volume of material spilled. The largest volume of material identified in this category was fertilizer, although the spillage of animal waste also represented a large volume of the agricultural-related material spilled. However, the difficulty of determining the volume spilled precluded recording of volume figures.

The miscellaneous chemicals category included an array of organic and inorganic compounds spilled during 1979. A total of 30 materials were spilled, representing 9% of the total number of spills recorded during the year. The miscellaneous chemical category accounted for the third largest volume of material spilled, approximately 123,000 gallons or 14% of the total volume. Several of the materials spilled involved very toxic or reactive materials. (Inwood, Marshall County--train derailment, November 9, 1979, Indianapolis--train derailment, December 17, 1979.)

Acids and bases accounted for 25 recorded spills or 7% of the total. Included in this category were several significant spills involving toxic and very reactive material. Acids and bases by volume only account for 7% of the total volume spilled. Acid and base spilled during 1976, 1977, and 1978 represented 10%, 5% and 3%, respectively, of the materials spilled.

The remaining two categories were food products and miscellaneous materials. Together they accounted for 12% of the materials spilled.

Sources of Materials Spilled

Spills investigated in Indiana during 1979 were divided into five classifications according to source. This classification was enlarged during 1978 to better identify the source of materials spilled. The new fifth classification identifies spills originating from commercial enterprises. Before 1978, spills originating from commercial sources were included with the other four categories.

Transportation-related spills accounted for 108 of the 338 reported spills or 32% of the spills occurring in Indiana during 1979. Transportation-related spills were divided into four categories:

Trucks	Pipelines
Railroads	Ships and Barges

This division differs slightly over previous years with the inclusion of pipelines as a transportation-related spill source instead of being identified as a separate source. Even with the inclusion of spills originating from pipelines, the percent of spills originating from transportation sources declined in 1979 over 1977 and 1978.

Transportation-related spills were those spills originating from sources involved in the transportation of materials and people. The spilled substance may have been the material transported or the fuel powering that mode of transportation. These spills may have resulted from accidents, equipment malfunctions, vandalism, employee error, and other reasons, but involved the discharge of material from a mode of transportation or the discharge of material from the maintenance or storage area serving the mode of transportation.

Industrial-related spills accounted for 103 of the 338 recorded spills or 31% of the spills occurring in Indiana during 1979. This represented an increase of 19 spills over 1978, but a slight decrease in the percent of spills originating from industrial sources.

Spills identified as industrial-related spills were those incidents in which materials were lost from sources involved in the manufacturing or mining of materials. These materials may have involved raw products awaiting processing or finished products ready for distribution to industrial or wholesale users. Spills involving both a transportation mode and industrial mode were classified according to where the material originated and what mode had control. For example, if a material was lost while loading a transport truck from an industrial source, it was identified as an industrial-related spill. If the material was lost while being unloaded at an industrial source, it was identified as a transportation-related spill. However, if it was determined that while loading, the transportation mode was obviously responsible, the spill was then identified as a transportation-related spill. Likewise, if it was determined that while unloading, the industrial mode was obviously responsible, the spill was then identified as an industrial-related spill.

Agricultural-related spills accounted for 35 of the 338 incidents or 10% of the spills recorded during 1979. This represents a significant increase in the number of incidents over 1978 and a 4% increase of spills during 1979 over 1978.

Agricultural spills were identified as those spills which occurred from sources involved in the actual production of agricultural products from commonly identified farms.

Spills from commerical sources accounted for 54 of the 338 recorded incidents or 16% of spills during 1979. The category was newly defined during 1978. Commercially-related spills increased from 41 to 54 incidents during 1979 over 1978.

Most spill incidents currently identified as commercially-related spills were grouped with miscellaneous and unknown spills during earlier years, or in some cases, identified with the three other categories. Commercially-related spills were so identified when the material lost originated from businesses involved with the wholesale or retail handling of a product.

Miscellaneous and unknown spills accounted for 38 incidents during 1979. These incidents were grouped in the final category when they could not be identified as belonging to the other four categories.

Circumstance of Spills

During 1979, 338 spills of oil, hazardous, or objectionable substances were recorded in Indiana. Each spill incident was identified according to source and then grouped into five categories. In addition, each spill incident was examined as to the circumstances or reason the spill occurred. In many cases, the spills resulted from several different factors, but an attempt was made to determine the one significant factor as the major circumstance for the spill's occurrence. Seven separate categories were identified as factors responsible for the recorded spills during the year:

- Equipment Malfunctions
- Employee Error
- Transportation Accidents
- Vandalism
- Intentional Discharge
- Miscellaneous Circumstances
- Unknowns

Equipment malfunction accounted for the greatest number of recorded spills during 1979. Forty-three percent, or 147 spills attributed to equipment malfunctions, resulted when equipment failed to operate as intended. The failures may have been attributed to poor design or construction, improper maintenance, equipment damage not attributable to vandalism, employee error, or transportation-related accidents.

Eighty spill incidents, or 24% of the spills in 1979, were identified as resulting from employee error. Such spills were identified when persons, employed or authorized by a responsible party, made an erroneous decision that precipitated the spill. A bad decision may have been made when a person did not perform a task as directed, per-formed a task without proper explanation, or just exercised bad judgment while utilizing existing information. Employee error may have also contributed to spills that have been identified as equipment malfunction or transportation accidents.

Transportation accidents accounted for 47 incidents, or 14%, of the recorded spills for the year. These spills included incidents involving railroads, trucks, ships, and barges when these vehicles collided with another vehicle, object, or otherwise deviated from their intended path of transit.

Thirteen spills resulting from vandalism accounted for 4% of the spills during 1979. These spills occurred when unauthorized person(s) inflicted damage to equipment, or altered equipment such that material was lost.

Intentional acts of discharging materials to the waters of the State accounted for 6% of the spills in 1979. On 21 occasions, person(s) were identified as knowingly discharging material that subsequently entered or threatened to enter the waters of the State.

On ten occasions, spill incidents could not be grouped with any of the preceding classifications. Consequently, these ten incidents, 3% of all spills, were grouped as miscellaneous spills.

On 20 occasions, the circumstances for the spill incidents could not be identified due to lack of information. This represented 6% of the spills recorded in 1979.

Response to Oil and Hazardous Materials Spills--1979

Indiana Administrative Code 330 IAC 1-6 requires the notification to the Stream Pollution Control Board or its representatives of all spills of oil, hazardous and/or objectionable substances that enter or threaten to enter the waters of the State. Prompt containment, recovery and neutralization of the threatening substance is also required by this Rule. The Rule further requires that the organization or persons responsibile for the spill make the notification. This obligation to report is not deemed fulfilled if the report was made to some other State, local, or Federal agency.

During 1979, 338 spills of oil, hazardous and/or objectionable substances were recorded. Of these, 171 incidents, or 51% of the total, were properly reported. The remaining 167 incidents were not reported by the responsible party, but were reported to the Board by representatives of other governmental agencies and/or private citizens. A modest state-wide education program has been launched to familiarize State and local governmental agencies, industries, businesses, appropriate associations, and interested citizens with the provisions of the Rule. It is anticipated that this program will result in improved compliance.

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

Spill cleanup success depends on several critical factors, including the nature of the material involved, the time elapsed between the spill event and cleanup initiation, the expertise of the cleanup personnel, methodology employed, topographical characteristic of the spill site, and climatic conditions. When immediate action is taken to contain and cleanup a spill, it greatly increases the chance of a successful operation. Experience has demonstrated that, if hours or even minutes are lost, the operation will be more costly and there will be a more limited chance of success. If oil is contained at the spill site, it is normally much easier and less costly to cleanup than if it were spread over miles of stream. Immediate action taken to remove a pool of toxic substance from the ground is much less expensive and safer for the environment and the public than delayed action taken to recover the material from the groundwater.

Two serious incidents involving hazardous material spills occurred in Indiana during 1979 which contaminated the groundwater. On November 9, 1979, a Conrail train derailed in Marshall County spilling over 120,000 gallons of chemicals from 24 tank cars. The sandy soils of the area allowed the materials to enter the aquifer and contaminate the groundwater. It appears that the cleanup operation will continue well into 1980. The contaminated soil was removed and the contaminated groundwater was pumped from the aquifer for treatment. In another instance, on December 19, 1979, reported vandalism resulted in the loss of approximately 20,000 gallons of 28% liquid nitrogen fertilizer at a fertilizer distribution station in Noble County. A portion of the fertilizer was recovered from the surface of the ground, but a large portion of the fertilizer contaminated the underlying aquifer. Contaminated soil was again removed and the groundwater was pumped from the aquifer. In both cases, the spilled materials contaminated the groundwater and threatened the water supply of nearby residents.

Many caustic solutions in water may be neutralized. Non-soluble, lighter than water materials may be skimmed from the water surface. Nonsoluble, heavier than water materials may be pumped up from the stream bed, but materials like liquid fertilizer, soluble organics or various toxic materials may require the use of extraordinary recovery methods that might include activated carbon filters, chemical treatment, aeration or other such measures.

During 1979, 195 successful or partially successful cleanup operations were initiated. On several occasions, the lack of knowledge of appropriate cleanup techniques prevented the responsible party from initiating a successful operation. Such situations clearly demonstrate the necessity of the spill reporting requirements. If the responsible party is not aware of appropriate containment and cleanup methods, assistance can be provided by the staff.

The environmental impact of a spill is significantly influenced by the speed and success of cleanup operations. During 1979, water quality violations resulted from 183 of the incidents cited. Forty-two of these resulted in significant fish kills. Ninety-eight incidents resulted in no water quality violations being detected. Most of these latter incidents involved spills where the material lost did not enter the waters of the State, but were confined to the immediate spill site and immediately cleaned up. Due to a lack of adequate information, no determinations of the extent of water quality violations could be made for the remaining 57 incidents.

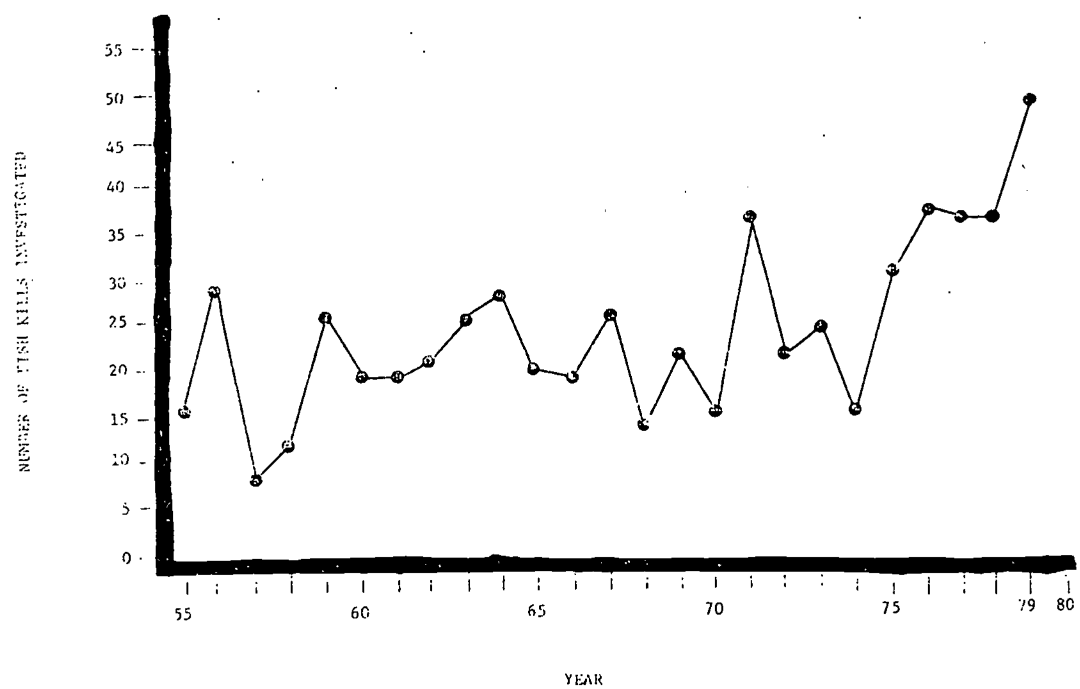
Fish Kill Report

A diverse healthy fish population is considered an indication of good water quality. Bodies of fresh water exhibiting such quality are utilized by society to serve its needs for public water supplies, water sources for domestic animals, areas for recreational activities, and sources of water for industrial use. The sudden appearance of many dead and dying fish resulting from the poisoning or degradation of an aquatic environment can arouse serious public concern. The sudden appearance of dead and dying fish can quickly signal the temporary or possible long-term loss of the use of the affected waters.

Fish kills can result from the accidental or intentional discharge of toxic or oxygen-demanding materials into an aquatic environment. Fish kills can also occur downstream of continuous industrial and municipal discharges when unusual circumstances such as equipment failure or spillage of toxic or oxygen-demanding materials may cause the facility to discharge a lethal effluent. It might be noted that fish kills in waters of continuous poor water quality may go unnoticed since these areas do not normally support a significant fish population or serve as a recreation site.

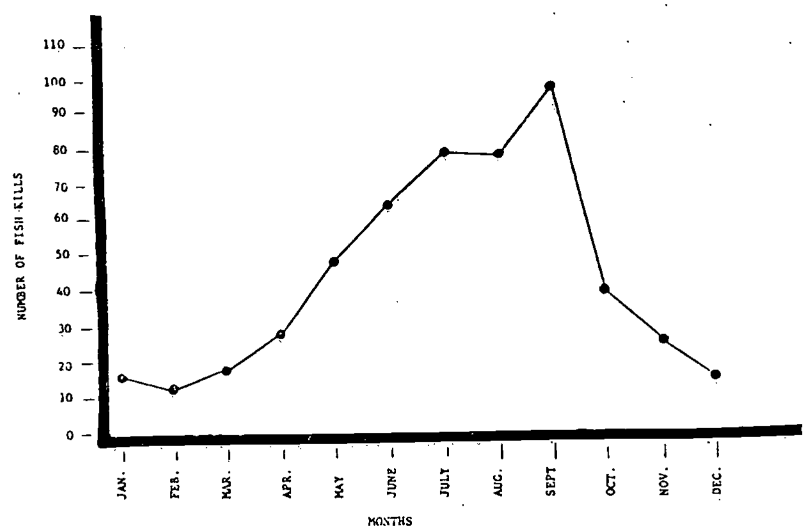
It has been noted that climactic conditions often influence the number of fish kills that occur each year. A relationship appears to exist between the amount of rainfall and fish kills. Figure 12 graphically presents the number of fish kills that have occurred in the past 24 years. As an example, the number of documented fish kills was low for the years 1957, 1968 and 1974. These were years of high rainfall.

Figure 12
NUMBER OF FISH KILL INVESTIGATIONS
VS
YEAR (1955-1979)



Conversely, the number of fish kills were significantly higher during the low precipitation years of 1956, 1964, 1971, 1976, and 1977. During 1978 and 1979, years of high rainfall, the number of investigated fish kills was also high. This may be due to increased public awareness of the need to report fish kills to the Indiana State Board of Health. Figure 13 points out that fish kills occur most often during summer and fall months of the year. These months normally have the least amount of rainfall. Fish kills resulting from suffocation due to ice cover were not included. Such instances are not normally related to pollution problems.

Figure 13
CUMULATIVE MONTHLY DISTRIBUTION
OF FISH KILLS 1960-1979



Tables A-7 and A-8 in the Appendix presents documented sources of the pollutants responsible for investigated fish kills in 1979. It is apparent that agricultural activities were responsible for the greatest number of fish kills in Indiana during 1979. Fifty percent of the documented incidents were found to be agriculturally related. Twelve incidents involved the loss of liquid fertilizer, pesticides, and animal waste from storage facilities on farms in the State. The loss of animal wastes as run-off from farm fields caused an additional twelve incidents. Businesses involved in the manufacture, transport, and distribution of agri-chemicals were determined responsible for additional fish kills resulting from agri-chemical spillage.

Table 17
SUMMARY OF FISH KILL CAUSES
1960-1979

	Percentage of Total Kills	
SEWAGE SOURCES (107)		21
GENERAL (55)	11	
INDUSTRIAL WASTE (17)	3	
COMBINED SEWER OVERFLOW AND BYPASSING (35)	7	
INDUSTRIAL SOURCES (163)		31
GENERAL (58)	11	
CYANIDE (9)	2	
CANNERIES (27)	5	
OIL (27)	5	
PACKING PLANTS (2)	1	
AGRICULTURAL PLANTS (40)	8	
AGRICULTURAL RELATED (111)		21
ANIMAL WASTES (71)	14	
SILAGE (6)	1	
PESTICIDES (11)	2	
FERTILIZER (19)	4	
OTHERS (4)	1	
WATER TREATMENT PLANTS SOURCES (4)		1
INDIVIDUAL (9)		2
NATURAL CAUSES (24)		4
UNDETERMINED SOURCES (102)		20

Table 17 presents the data in a slightly different format for the years 1960 to the present. Table A-9 in the Appendix illustrates the changing pattern of sources identified as responsible for fish kills. Sewage and industrial sources accounted for a significant percentage of the documented fish kills in earlier years while kills resulting from identified agricultural sources accounted for a minor, but increasing, percentage of the incidents.

At this point, the dramatic increase of agriculture related fish kills corresponds to an increase in the use of agri-chemicals and confined feeding lots. Fish kills often occurred as a result of a sudden discharge of toxic or oxygen-demanding materials normally associated with agri-chemicals and animal waste.

Effects of the 1971 Phosphate Detergent Law

During its 1971 session, the Indiana General Assembly enacted a Phosphate Detergent Law (IC 1971, 13-1-5.5) which made it unlawful, after January 1, 1972, to use, sell or otherwise dispose of laundry detergents containing more than 8.7% phosphorus by weight into the waters of the State. This law was subsequently amended during the 1972 session to make it unlawful, after January 1, 1973, to sell, use or otherwise dispose of laundry detergents containing more than 0.0% phosphorus by weight into waters of the State. The law was amended a second time during the 1973 session to allow for trace concentrations (not to exceed 0.5% by weight) that might be incidental to manufacturing.

No new programs were initiated by the staff which were specifically designed to determine the effects of the State's phosphorus laundry detergent ban on the waters of Indiana (in Indiana streams and lakes and the biological changes which may have resulted from any reduction achieved). Trends have been determined by comparing pre and post phosphate ban data resulting from 24-hour surveys of municipal sewage treatment plants, the Statewide Fixed Station Monitoring Program, and the Lake Studies Program.

In 1971 through 1978 the staff conducted a large number of 24-hour surveys of municipal sewage treatment plants. Total phosphorus determinations were routinely made for samples collected during these surveys. Trends were determined by comparing the concentration (mg/l) of phosphorus in the raw influent of the treatment plants surveyed each year. A comparison of pounds per capita per day indicated variations in annual average concentrations which might be due to changes in the average amount of infiltration of groundwater or storm water during the respective survey periods.

In 1971 analysis for total phosphorus concentrations were made on grab samples collected on a bi-weekly basis from 58 fixed water quality monitoring stations located on major streams throughout the State. Total phosphorus analyses were made on samples collected from 55 water quality monitoring stations sampled during 1972 and 1973. During the period of 1974 through 1978 most fixed stations were sampled on a monthly basis. However, the number of stations on which phosphorus was analyzed was increased to 85 stations.

It is recognized that it is probably not statistically correct to attempt to determine trends on the basis of the results of analysis of one to two samples per month from a given stream station. However, when a state-wide average is obtained on the basis of the results of more than 100 separate analyses per month for 1971-1973, and 85 samples per month for 1974, 1975, 1976, 1977, and 1978, a resonable comparison can be made. On the basis of average pounds/capita/day, it appears that there has been about a 60% reduction of phosphorus in raw sewage during the 1971-1978 period. During the same period there has been a higher average reduction in pounds/capita/day phosphorus in sewage treatment plant effluents.

On the data available at this time, it is impossible to determine precisely the extent to which stream phosphorus loadings have been reduced as a result of the phosphorus detergent law. Nevertheless, it is apparent that during the 1971-1978 period there has been a significant reduction in stream phosphorus loadings, possibly in the neighborhood of 25 to 30% (on the pounds basis) statewide.

During August and September 1976 statewide total phosphorus concentrations attained questionably high values which greatly distorted the yearly average. Low flow conditions, and hence a low dilution factor for effluent discharges, initially appeared to be a plausible explanation for this phenomenon. A closer look at the flow data, however, revealed that low flow conditions extended from July through December. This would tend to rule out low flow as a possible reason for the apparent increase in phosphorus during only these two months.

Another explanation is the possibility of an error either in the sample collection or laboratory analysis of the sample. A review of the quality control procedures practiced by field and laboratory personnel did not reveal any discernable abnormalities. However, it seems highly unlikely and statistically improbable (according to International Joint Commission officials) to attain the high levels of phosphorus found in Lake Michigan (2.0 mg/l, East Chicago station, August) during this period. Data collected from the lake by other agencies at this time did not indicate similarly high levels. For this reason, we are placing all of the August and September 1976 Water Quality Data in a questionable status, to be viewed with the said facts in mind.

The peak of phosphorus in November 1976 reflects the effects of a single value of 14.0 mg/l in the Grand Calumet River. Eliminating this single sample would drop the monthly average to 0.44 mg/l, a more expected value. High phosphorus values at this station are not too uncommon, denoting the chronic problems that exist in this watershed. However, the 14.0 mg/l value is unusually high.

No programs were specifically initiated to determine the effects of the phosphorus detergent ban on the water quality of Indiana lakes. This fact, coupled with the paucity of pre-ban data available, has made it extremely difficult to establish trends based on before and after comparisons. However, lakes such as Long Lake in Steuben County, that receive substantial amounts of treated sewage and combined sewer overflow, have experienced significant reductions in phosphorus levels. Since treatment plants in some of these lake watersheds have recently been upgraded to provide phosphorus removal, all of these reductions cannot be solely attributed to the phosphorus detergent ban. However, the phosphorus detergent ban has probably contributed considerably to the phosphorus reduction.

In the case of other lakes which receive smaller amounts of treated sewage or septic tank effluent, reductions in average phosphorus levels have not been quite as obvious. This is not surprising since it may be several years before the effects of the phosphorus detergent ban can be measured and fully evaluated. It is unrealistic to assume that dramatic changes in lake quality would be immediately evident in every case.

A significant decrease in the phosphorus concentrations in the south end of Lake Michigan has been noted by the U.S. EPA. That agency has attributed this reduction to the Indiana phosphorus detergent ban. Recent information indicates that this downward trend is continuing.

III. Nonpoint Source Pollution

Nonpoint Source Pollution

Nonpoint source pollution differs from point source pollution in two distinct ways: it does not occur from a definable source such as a pipe, ditch, or outfall, and nonpoint pollution are most severe at times of the year when seasonal rains may carry pollutants to water courses. Point sources are more critical during stream low-flow conditions.

Nonpoint source pollution in Indiana occurs from a variety of sources and in varying degrees. In the State's Five Year Strategy (FY 80-84) for Water Quality Management Planning, the Stream Pollution Control Board (SPCB) has noted that the priorities are agriculture and residual waste. No direct efforts will be focused on mining nonpoint source since reclamation plans developed through the Department of Natural Resources have met the intent of Section 208 of the Clean Water Act of 1977, as amended.

Agricultural Nonpoint Source

Indiana is primarily an agricultural state, and therefore, the potential for nonpoint pollution generated from agricultural activities is large. Generally, the potential polluting substances considered are sediment, phosphorus, nutrients, organic matter, pesticides, herbicides, and pathogenic bacteria from animals.

In an effort to quantify agricultural nonpoint pollution, the State, as part of its 208 Water Quality Management Planning contracted with Indiana's State Soil and Water Conservation Committee (SWCC). The total scope of services included identifying the erosion potential of each soil association using the Universal Soil Loss Equation (USLE), assigning an annual erosion potential to each soil association based upon fallow land conditions; estimating gross erosion on a tons per acre per year basis utilizing such factors as type of agricultural land use, differences in crop intensities, and management practices, and lastly to develop a list of best management practices (BMPs).

The SWCC assessment divided the amount of potential soil loss into four categories, low, medium, high, and very high. The Low erosion areas (0-30 tons/acre/year), are relatively level although moderately rolling topography can be found. The medium erosion areas, (31-80 tons/acre/year) may occur on moderately sloping topography, some level lands and most often on small areas of strongly sloping soils. The agricultural land uses of cropland, pastureland, and woodland vary widely in these areas throughout the State. The high erosion areas (81-350 tons/acre/year), present severe erosion hazards on very sloping lands that are bare and left exposed for long periods of time. However, much of this land is protected by grassland and woodland uses and generally not in a fallow state. Areas with a very high soil loss range of 350 tons/acre/year or more are the most serious erosion hazards if not maintained with good protective cover. These areas are very steep sloping and are predominately forest lands in southern Indiana. Many of these southern regions have adequate cover, and sound conservation practices protect the land from excessive erosion. Therefore, in proportion to other areas, the potential erosion assessment does not imply that the steeper sloping southern districts are losing more soil to erosion than the northern flatter portions of the State.

Gross erosion is an estimate of soil loss that is occurring under current land use conditions. To estimate gross erosion, three factors were taken into consideration: vegetative cover, erosion control practices, and land management. Current land uses were determined utilizing the 1968 Conservation Needs Inventory from the Soil Conseration Service (SCS), and further refined with input by various local agencies and the local erosion assessment committee meetings in each PDR. Upon completion of this inventory, the following soil loss ranges were established for gross erosion:

Gross Erosion	Soil Loss (Tons/Acre/Year)
Low	0 - 4.9
Medium	5.0 - 9.9
High	10.0 - 14.9
Very High	15.0 plus

In the Appendix, Table A-10 provides a compilation of regional potential and gross erosion estimates as calculated by the State Soil and Water Conservation Committee utilizing the USLE. Please note that at this time erosion estimates for Regions 1A, 6, 7, and part of Region 2 were not complete and therefore excluded.

It is assumed that areas having higher amounts of erosion are most likely to have greater sediment problems in their waterways. It is possible, as indicated within the Regional Erosion Estimates, to have differing ranges between gross and potential soil loss mostly because of the intensity of land use and management practices. For instance, data contained in Table 18, from Region 4, indicate it is highly possible for several soil associations, which are characteristically loamy and silty soils in glacial till, to have a high potential erosion factor (L5-L7). However, when land use characteristics such as intensity and erosion control practices are considered, these soil associations will have a medium or low gross erosion factor.

Table 18
Region 4 Erosion Assessment (tons/acre/yr)

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	2.9	Low
B2	Maumee-Gilford-Sebewa	6.0	Low	1.2	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	3.0	Low
E2	Elston-Shipshe-Warsaw	16.0	Low	3.3	Low
E3	Oshtemo-Fox	21.0	Low	3.8	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.3	Medium

Table 18 (Cont'd)

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
F2	Plainfield-Maumee-Oshtemo	11.0	Low	4.7	Low
I1	Ragsdale-Raub	14.0	Low	4.3	Low
I2	Sable-Ipava	14.0	Low	4.1	Low
I3	Fincastle-Ragsdale	20.0	Low	5.4	Medium
I4	Reesville-Ragsdale	26.0	Low	6.6	Medium
J1	Brookston-Ordell-Corwin	11.0	Low	3.4	Low
J2	Crosier-Brookston	24.0	Low	4.5	Low
J3	Crosby-Brookston	18.0	Low	3.7	Low
L1	Parr-Brookston	22.0	Low	5.6	Medium
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	4.4	Low
L4	Miami-Crosby-Brookston	62.0	Medium	7.6	Medium
L5	Miami-Hennepin-Crosby	161.0	High	9.2	Medium
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	9.0	Medium
L7	Russell-Hennepin-Fincastle	235.0	High	4.3	Low

Overall the majority of land in Indiana has generally a low to medium gross erosion factor. Only a few areas demonstrate a high to very high annual soil loss.

Specifically, according to the gross erosion estimates, some areas located within Regions 13A, 13B, 14, 15, and 9 have very high soil loss. In Region 9, two soils appear to have a high to very high gross erosion loss which may affect streams within the Whitewater drainage basin. The Cincinnati-Rossmoyne (04) Association, characterized by a sloping well-drained topography and silty-soils with fragipans, average an annual soil loss of 13.5 tons/acre/year. Similarily, the Edin-Switzerland (R3) soil association has a very high soil loss averaging 40.5 tons/per acre/per year.

As Table 19 indicates, Region 13B is another planning area possibly having a high sediment accumulation in some of its area streams.

Table 19
Region 13B Erosion Estimate (tons/acre/yr)

	Soil Association	Potential Erosion	P-Rating	Gross Erosion	G-Rating
A3	Sloan-Ross-Vincennes-Zipp	14.0	Low	3.8	Low
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	3.4	Low
D2	Patton-Lyles-Henshaw	15.0	Low	5.0	Medium
D3	Zipp-Markland-McGary	50.0	Medium	5.8	Medium

Table 19 (Cont'd)

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
G	Princeton-Bloomfield-Ayrshine	76.0	Medium	9.1	Medium
H	Alford	169.0	High	16.9	Very High
I4	Reesville-Ragsdale	26.0	Low	6.4	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	10.9	High
N2	Weinbach-Wheeling	32.0	Medium	7.7	Medium
01	Hosmer	143.0	High	10.7	High
02	Zanesville-Wellston-Tilsit	307.0	High	11.3	High

Only the Alford soil association has a very high gross erosion rating (16.9 t/a/yr), and is characterized by sloping well drained soil in loess. Although most streams impacted by this soil loss are intermittent in nature, some lands of high soil loss are located adjacent to both the Wabash River and the Ohio River.

As noted in the above table, there are three soil associations having a high rating of gross erosion. These include; the Bartle-Peoga-Dubois soils characterized by their nearly level terrain, poorly drained character with fragipans, and the Hosmer soils and the Zanesville-Wellston-Tilsit soil association characterized by its sloping, well drained features. Collectively, these soils compose approximately one-half of the land area in Region 13B and collectively have an estimated average annual soil loss of 11.0 tons/acre. Potentially impacted streams may include Cypress Creek and smaller tributaries. The remaining soils in Region 13B have a low to medium soil loss ranging from a low of 3.4 tons/acre/year to 7.7 tons/acre/year.

The majority of Region 15, as reported in Table 20, has a moderate erosion problem. The majority of its land area is rated as having a medium classification with annual soil loss ranging from 6.1 tons/acre to 8.4 tons/acre. Some of its western portions, particularly in the southwestern area near Eureka in Spencer County, have soils with a high to very high gross erosion.

Table 20
Region 15 Erosion Assessment (tons/acre/yr)

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	2.9	Low
D3	Zipp-Markland-McGay	50.0	Medium	6.1	Medium
H	Alford	169.0	High	16.8	Very High
N1	Bartle-Peoga-Dubois	70.0	Medium	6.8	Medium
N2	Weinbach-Wheeling	32.0	Low	6.5	Medium
01	Hosmer	143.0	High	11.9	High
02	Zanesville-Wellston-Tilsit	307.0	High	10.7	High

Table 20 (Cont'd)

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
P	Wellston-Zanesville-Berks	457.0	Very High	8.4	Medium
Q1	Crider-Bedford-Lawrence	181.0	High	7.7	Medium
Q2	Crider-Hagerstown-Bedford	213.0	High	6.6	Medium
Q3	Crider-Baxter-Corydon	235.0	High	8.4	Medium

The small area within the Alford soil association is rated as very high in erosion potential, averaging 16.8 tons/acre/year. Although no major stream is impacted, several small tributary streams to the Ohio River may possibly be affected. The western half of Spencer County and the southwestern portion of Dubois County have been identified as areas with high erosion loss soils. This area includes the Hosmer and the Zanesville-Wellston-Tilsit soil associations. Although no major waterways are affected, there are several intermittent streams which may be impacted adversely.

Region 13A appears to have much of its soil in the high to very high range. As Table 21 depicts, nearly half of the associations range from 10.5 tons/acre/year to 14.5 tons/acre/year.

Table 21
Region 13A Erosion Assessment (tons/acre/yr)

	Soil Association	Potential Erosion	P-Rating	Gross Erosion	G-Rating
A3	Sloam-Ross-Vincennes	14.5	Low	4.5	Low
A4	Wheeling-Huntington-Lindsdale	26.0	Low	3.7	Low
C3	Lyles-Cyrshine-Princeton	12.0	Low	4.1	Low
D2	Patton-Lyles-Henshaw	15.0	Low	3.5	Low
E2	Elston-Shipshe-Warsaw	76.0	Low	4.8	Low
G	Alford	169.0	High	10.8	High
H	Princeton-Bloomfield-Cyrshine	76.0	High	6.7	Medium
I4	Reesville-Ragsdale	26.0	Low	5.7	Medium
I5	Iva-Vigo	28.0	Low	5.2	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	6.1	Medium
O1	Hosmer	143.0	High	2.9	High
O3	Cincinnati-Vigo-Iva	279.0	High	0.5	High
P	Wellston-Zanesville-Berks	457.0	Very High	12.1	High
P1	Crider-Bedford-Lawrence	181.0	High	11.9	High
Q2	Crider-Hagerstown-Bedford	213.0	High	13.0	High
Q3	Crider-Baxter-Corydon	235.0	High	14.5	High
R1	Berks-Gelpen-Weikert	469.0	Very High	4.6	Low
R2	Corydon-Weikert-Berks	669.0	Very High	12.5	High

Streams that may be affected in this area include Indiana Creek, located in Martin County, portions of Lost River and Sugar Creek in Daviess County as well as Lake Greenwood in Martin County.

It is thought much of this sediment loss within these southern regions is a result of the erosion of the gullies which frequently make up the topographic setting of southern Indiana. The remaining portion of Indiana is reported as not having large amounts of sediment loss from erosion. Probably because of the geographic and geologic characteristics, erosion that does occur may stem from sheet, wind, and/or rill erosion. Generally, the northern portions of the State range from a low value of 0.5 tons/acre/year to a medium loss of 9.9 tons/acre/year. No comprehensive study has been made to determine the total sediment load throughout the State.

Several conclusions can be noted from this assessment. First, sediment is not the only nonpoint pollution, and not all sediment produced is a water pollutant. Much of this sediment, resulting from runoff, will be deposited on land and not impact streams. In addition, no tolerable soil loss limits have been set. Therefore, it is not known what an acceptable soil loss value is.

To curb sediment loss many farmers have already instituted certain management practices. This voluntary action is in their own best interest because common knowledge dictates that loss of productive topsoil will ultimately lead to reduced productivity and a lower economic return from the land. For example, certain types of tillage practices around the contour of land is a basic "best management practice" (BMP). The accepted definition of BMP's is according to the SWCC:

> An alternative combination of land use, conservation practices, and management techniques which, when applied to a unit of land, will result in the opportunity for a reasonable economic return within acceptable environmental standard."

Best management practices have been divided into four categories: Tillage and Residue Management, Vegetative Planting, and Improvements, Structural Erosion Control, and Water Management Conservation Cropping. Proposed BMPs were rated as to their need and suitability in each Region by IDNR's Erosion Assessment Committee. As Table 22 depicts, several of the southern planning regions rated certain practices as more highly suitable than did their northern counterparts. For instance, the southern regions rated a high suitability and need for establishing grasses and legumes, and maintaining the stand for a definite number of years as part of the planting rotation schedule. Except for the extreme north-eastern regions, this BMP was rated as moderately suitable for the needs of the northern areas. Contour plowing was also moderately suitable for southern regions, but obviously of little value in the level northern glacial regions.

Conversely, some management practices, such as the use of wind breaks, which are well suited for northern Indiana, are of little use because of their natural abundance in southern Indiana. All across the State, each region rated the practice of crop residue management as being one of the most needed and suitable as well as grassed waterways, conservation cropping, green manue crops, and critical area planting.

TABLE 22

REGIONAL SUITABILITY & NEED OF BEST MANAGEMENT PRACTICES*

RATING: H = HIGH, M = MEDIUM, L = LOW

BMP/PDR	1B	2	3A	3B	4	5	6	9	10	11	12	13A	13B	14	15
A1. Access Road Protection	L	L	L	L	L	L	L	M	M	M	L	M	L	M	M
2. Diversion	M	H	M	L	M	L	M	M	H	H	M	H	H	H	H
3. Firebreak	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
4. Grade Stabilization/Water Control Structures	M	H	M	M	H	H	M	H	M	H	H	H	H	M	M
5. Grassed Waterway	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
6. Irrigation Water Management	L	M	M	L	L	L	L	L	L	L	L	L	L	L	L
7. Land Grading and Shaping	L	M	L	M	L	L	M	M	L	M	M	M	L	M	M
8. Pond	L	M	M	M	M	L	M	M	H	M	M	H	M	M	M
9. Sediment Basin or Trap	L	M	M	M	M	M	M	M	M	M	M	H	M	M	M
10. Streambank Protection	M	M	M	H	M	M	M	M	M	M	H	H	M	M	H
11. Terraces	M	M	M	M	M	M	M	M	M	M	M	H	H	H	H
B1. Conservation Cropping	H	H	H	H	M	H	H	H	H	H	H	H	H	H	H
2. Conservation Tillage	H	M	H	M	M	H	M	H	H	H	M	H	H	H	M
3. Contour Farming	L	L	M	L	L	L	L	M	H	M	M	M	M	H	M
4. Crop Residue Management	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
5. Mulching	M	L	M	M	L	M	M	M	M	M	M	M	M	M	M
6. Plow-Planting	M	L	L	L	L	L	L	M	M	M	M	M	L	M	L
7. Spring Plowing	M	H	M	M	M	M	M	H	M	H	M	M	M	M	H
8. Stripcropping	L	L	L	M	L	L	L	M	M	L	M	M	L	M	M
C1. Cover and/or Green Manure Crops	H	H	H	H	M	M	M	H	H	H	H	H	H	H	H
2. Critical Area Planting	H	H	H	H	M	M	H	H	H	H	H	H	M	H	H
3. Grass Strips	M	M	M	H	M	M	M	M	H	H	M	H	M	M	M
4. Grasses and Legumes in Rotation	M	M	H	H	M	M	M	M	H	H	M	H	H	H	H
5. Livestock Exclusion and Fencing	M	H	L	M	M	M	M	M	H	M	M	H	M	M	M
6. Pasture and Hayland Planting and Management	M	H	H	M	M	M	M	H	H	H	M	H	M	H	H
7. Recreation-Wildlife Area Planting & Management	M	M	M	M	M	L	L	M	M	M	M	M	L	M	M
8. Tree and Shrub Planting	H	H	M	M	M	M	M	M	M	M	M	M	L	M	M
9. Windbreaks	H	H	M	M	M	M	M	L	L	L	L	M	L	L	L
10. Woodland Improved Harvesting and Timber Stand Improvement	M	H	M	M	M	M	M	M	M	H	M	M	M	M	M

*This rating was done by members of the Erosion Assessment Committee in attendance at the third of a series of four meetings. It is not to be regarded as a statistical accurate sampling of landowners and landusers in each PDR.

Agricultural Conservation Program

To aid local landowners in instituting best management practices, several on-going programs (State and Federal) have been established to institute remedial measures to control agricultural nonpoint pollution through the prioritization of critical areas. Two such programs are the Agricultural Conservation Program (ACP) and the Rural Clean Water Program (RCWP).

Under the Soil Conservation and Domestic Allotment Act of 1934 and Title X of the Agricultural Consumer Protection Act of 1973, provisions were made to cost-share, through the ACP, with farmers to install conservation practices on their land. Conservation practices are classified yearly in regards to effectiveness and need with cost-share levels up to 90% for high priority practices. This determination is made from a coordinated effort by the local Soil Conseration Service (SCS), the Soil and Water Conservation Districts (SWCDs), County Extension Service and other local assessment groups. Although the ACP is limited to agricultural producers, it is very flexible in its options by offering annual agreements, three to five year long-term agreements, pooling agreements with multiple producers, and special projects developed at the local level and funded through a State reserve.

Cost-share levels are geared toward problem solving although particular emphasis will be placed upon coordinating State and county programs with Section 208 nonpoint pollution abatement plans and practice needs. Table 23 specifies those best management practices which will be used to control erosion and sedimentation from agricultural lands through the ACP.

Table 23
Agricultural Conservation Program's Best Management Practices
Soil Loss from Water and Wind Erosion
*High Priority

- *SL1 Permanent Cover Established
- SL2 Permanent Cover Improvement
- *SL3 Stripcropping System
- *SL4 Terrace Systems
- *SL5 Diversions
- SL6 Grazing and Protection
- *SL7 Windbreak Establishment
- SL8 Cropland Cover
- SL9 Conservation Tillage
- *SL10 Permanent Cover for Critical Areas

Water Conservation Problems

- WC1 Impoundment Reserves

Water Quality Problems

- WP1 Retention Structures
- WP2 Stream Protection
- WP3 Sod Waterways
- WP4 Animal Waste Control Facilities

Forestry Conservation Practices

*FR1 Tree Plantations
*FR2 Tree Stand Improvements

Wildlife Habitat Conservation

WL1 Permanent Habitat
WL2 Shallow Waterways for Water Fowl

Local Soil and Water Conservation

SP Special Conservation Practices

Funding for projects through the Agricultural Conservation Program has been received for a total of 19 counties in Indiana including:

Blackford	Knox	Spencer
Crawford	Lake	Tipton
Dubois	Madison	Vigo
Fulton	Miami	Wells
Hancock	Noble	Whitley
Jasper	Porter	
Jennings	St. Joseph	

These areas will collectively receive an estimated $225,000 in 1979 ACP funding to establish best management practices on agricultural land. In addition, Allen County, Indiana, will received approximately $75,000 in 1979 funding for 12 ACP projects commonly known as "Dirty Baker's Dozen."

Model Implementation Plan

To initiate a BMP nonpoint pollution demonstration project, the U.S. Environmental Protection Agency (U.S. EPA) and the U.S. Department of Agricultural (USDA) have agreed to work together in developing a "Model Implementation Project" (MIP) for water quality management, using accelerated USDA and EPA program activities.

In Indiana, the Indiana Heartland's Coordinating Commissions' (IHCC) Eagle Creek Watershed and the Stott's Creek Watershed have been nominated for the MIP for the following reason:

1. The Heartland area closely represents the full range of erosion potentials in the State, and is typical of the agricultural practices utilized in the Midwest.

2. The proposed project identifies two critical nonpoint source areas within the region.

3. IHCC has a well-developed committee structure, local contacts, and adequate staffing.

To provide an incentive for local landowner acceptance, the cost-share rates, as established by the State Development Group, averaged higher than the State applied levels. A maximum cost-share of $2,500 per landowner was established with a $10,000 ceiling per producer and agreements where one or more farmers cooperate in a joint effort on a designated practice for water quality improvement.

Tables 24a and 24b represents cost-share rates for the MIP area:

Table 24a

AGRICULTURAL "BEST MANAGEMENT PRACTICES"
FOR THE REDUCTION OF SEDIMENT RELATED POLLUTANTS
Estimated Cost-Share Funding Needs By BMP's For
Eagle Creek Reservoir Watershed

CROP MANAGEMENT PRACTICES	BMP'S NEEDED	COST PER UNIT	PERCENT COST-SHARE	TOTAL COST-SHARE FUNDS NEED
A. Crop Residue Management	14,283	$ 3.00	--	--
B. Chisel Plowing (Fall)	14,028	7.00	--	--
C. Cover Crops	4,756	6.00	--	--
D. Minimum Tillage	15,227	10.00	--	--
E. No Till Planting	299	7.00	--	--
WATER TRANSPORT PRACTICES				
A. Contour Farming	198	5.00	--	--
B. Directional Contouring[1]	7,606	--	--	--
C. Parallel Terraces (300'/AC)	131,956	1.50	75%	$148,450.51
D. Diversions	7,640	.75	75%	4,297.51
E. Grass Waterways	95	800.00	75%	57,000.00
F. Erosion Control Structures	--	--	--	--
1. Drop Spillway	72	2,000.00	75%	108,000.00
2. Pipe Inlets	94	1,000.00	75%	70,500.00
G. Ditchbank Seeding	57,931	.15	75%	6,517.25
LAND MANAGEMENT PRACTICES				
A. Crop Rotations (with sod)	529			
B. Critical Area Plantings	203	300.00	75%	45,675.00
C. Stream Border Plantings	11,240	.28	75%	2,360.40
D. Pasture Plantings	313	75.00	75%	17,606.25
E. Tree Plantings	14	100.00	75%	1,050.00
F. Wildlife Habitat Plantings	79	50.00	75%	2,962.50
G. Conservation Pond	5	3,000.00	25%	3,750.00
H. Fencing (Livestock Exclusion)	15,198	1.25	75%	14,248.13
I. Animal Waste Systems	7	10,000.00	25%	17,500.00
TOTAL ACRES OF CROPLAND NEEDING TREATMENT:	33,358	TOTAL COST-SHARE FUNDS NEEDED:		$499,917.55

Table 24b

AGRICULTURAL "BEST MANAGEMENT PRACTICES"
FOR THE REDUCTION OF SEDIMENT RELATED POLLUTANTS
Estimated Cost-Share Funding Needs By BMP's For
Stotts Creek

CROP MANAGEMENT PRACTICES	BMP'S NEEDED	COST PER UNIT	PERCENT COST-SHARE	TOTAL COST-SHARE FUNDS NEED
A. Crop Residue Management	7,175	$ 3.00	--	--
B. Chisel Plowing (Fall)	2,251	7.00	--	--
C. Cover Crops	731	6.00	--	--
D. Minimum Tillage	5,745	10.00	--	--
E. No Till Planting	648	7.00	--	--
WATER TRANSPORT PRACTICES				
A. Contour Farming	451	5.00	--	--
B. Directional Contouring[1]	2,724	--	--	--
C. Parallel Terraces (300'/AC)	87,377	1.50	75%	$98,299.13
D. Diversions	11,405	.75	75%	6,415.31
E. Grass Waterways	53	800.00	75%	31,800.00
F. Erosion Control Structures				
1. Drop Spillway	24	2,000.00	75%	36,000.00
2. Pipe Inlets	48	1,000.00	75%	36,000.00
G. Ditchbank Seeding	14,507	.15	75%	1,632.04
LAND MANAGEMENT PRACTICES				
A. Crop Rotations (with sod)	852	--	--	--
B. Critical Area Plantings	327	300.00	75%	73,575.00
C. Stream Border Plantings	11,990	.28	75%	2,517.90
D. Pasture Plantings	188	75.00	75%	10,575.00
E. Tree Plantings	24	100.00	75%	1,800.00
F. Wildlife Habitat Plantings	212	50.00	75%	7,950.00
G. Conservation Pond	8	3,000.00	25%	6,000.00
H. Fencing (Livestock Exclus.)	52,390	1.25	75%	49,115.63
I. Animal Waste Systems		10,000.00	25%	
TOTAL ACRES OF CROPLAND NEEDING TREATMENT:	13,531	TOTAL COST-SHARE FUNDS NEEDED:		$361.680.00

To date, the initial work in the MIP area has been an inventory of land uses and aquatic life, and the establishment of monitoring and sampling stations throughout the MIP area to collect background data and to measure the effects of installed BMPs.

Rural Clean Water Program: (RCWP)

Section 35 of the Clean Water Act of 1977 (Public Law 95-217) ammends Section 208 of the Federal Water Pollution Control Act (Public Law 92-500) by adding a new implementing subsection (j) entitled "Agricultural Cost Sharing." This subsection enables the Secretary of Agriculture, upon concurrence of the Administrator of the U.S. EPA to establish a program and enter into long-term agreements of not less than five years and no more than ten years for technical and cost-sharing assistance to eligible rural land owners and operators for the purpose of installing and maintaining best management practices to control nonpoint source pollution. This program is to be applicable to only those states and designated areas which have an approved agricultural portion of a 208 Water Quality Management Plan.

Once U.S. EPA approves the State's 208 Water Quality Management Plan, the program may begin to receive a maximum cost-share of 50% material per participant, not to exceed $50,000 each. Nationally Congress has appropriated $50 million to carry out an experimental Rural Clean Water Program in FY 1980.

The procedural steps for RCWP funding indicates a very lengthy process, especially since the RCWP, still in its infancy, is awaiting U.S. EPA approval of agricultural portions of the States 208 Water Quality Management Plan. Upon certification, the Stream Pollution Control Board (SPCB) will assemble both State and Areawide Agricultural 208 Water Quality Management Plans and in conjunction with the State Rural Clean Water Coordinating Committee (SRCWCC) will prepare a strategy and apply it toward selection of initial priority projects.

The next step in the funding process encompasses formulating a Local Rural Clean Water Committee which, in addition to identifying local projects and priorities, will hold public meetings and prepare preapplications for review by the SPCB. A formal review process then begins through public meetings conducted by SPCB and the SRCWCC in addition to formal A-95 review by State and Regional Clearinghouses. Based upon these comments the SPCB will make its final preapplications review and determine final priorities and modifications.

At this point the SPCB will prepare a formal application which will consist of the following elements:

1. A summary of the proposed action,

2. Definition and description of the project area,

3. A statement on the severity of erosion and pollution problems incurred,

4. Cost and schedule of implementation,

5. A statement of benefits anticipated from the proposed action, and

6. The administration and accountability of local support.

Subsequently, the formal application will again receive formal review as described above, and forwarded to the Governor. Upon certification by the Governor, the application will be forwarded to the Administrator of the Soil Conservation Service who, upon concurrence with the Administrator of U.S. EPA, will select national priorities and delegate funding to selected projects.

State Strategy

In its State Agricultural Nonpoint Source Control Strategy, the Indiana Stream Pollution Control Board (SPCB) has identified sediment-bound phosphorus as the main agricultural nonpoint source pollutant contributing to documented water quality problems not being adequately controlled by current programs. Though specific impacts on aquatic life and the environment have not been quantified to the extent desirable, it appears that the best agricultural nonpoint strategy is one which targets existing programs and resources in each county to those cropland areas experiencing excessive erosion to reduce sediment and sediment bound phosphorus into streams and lakes/reservoirs; more closely monitor nitrate concentrations at public surface water intakes and, where concentrations approach or exceed 10.0 milligrams per liter, to study whether or not control of fertilizer application on land is warranted.

Because the critical gross erosion has been identified through the State's Water Quality Management Plan, adequate expertise is available through local Soil and Water Conservation Districts and the Soil Conservation Service to further refine gross erosion rates to a smaller scale and identify farms experiencing the most severe erosion as well as those delivering the greatest sediment load to a waterway. Therefore, the strategy will utilize the resources of these management agencies to induce the application of best management practices to the most severely impacted areas of the State. Given the long-term nature of such programs and the historical county based institutional arrangements, this approach will achieve the same statewide results within the same time frame without continually moving personnel and disrupting the development of human relationships vital for a successful voluntary program.

When the Rural Clean Water Program (RCWP) is fully funded, project areas must be prioritized and funded in accordance with priority ranking and funding availability. Since the two pollutants identified for control are sediment-bound phosphorus and sediment, two priority systems will be utilized: one for sediment-bound phosphorus, and its impact on lakes and reservoirs as measured by their tropic status, and one for sediment inputs into streams as measured by gross erosion estimates.

Project areas will be identified on the following basis. Those watersheds draining into lakes and/or reservoirs will be listed and ranked according to a combination of the potential nutrients input and the lakes trophic status. In the case of streams and waterways, their watersheds will be broken down to approximately 220,000 acres or less and ranked relative to the gross erosion factor of the watershed.

For those areas of the state which submit applications for cost-share monies appropriated through the RCWP, a priority will be emphasized for those eligible areas which have either watersheds draining into lakes and reservoirs and/or watersheds of 220,000 acres or less. Ranking and prioritization will be through a combination of factors encompassing not only the trophic status of surface impoundments but also the gross erosion potential of the entire watersheds. In turn, those project areas which meet these criteria will be nominated to the Rural Clean Water Program for funding eligibility.

Solid Waste Disposal

The practice of solid waste disposal has for many years been regarded as only an urban problem spilling over into the rural community. As a result, an evolved philosphy of out-of-sight, out-of-mind became justification for the ultimate disposal of solid waste. This precept is no longer prevelent because waste disposal has, in some instances, been improperly handled, poorly managed, and subsequently is back in the public mind. Therefore, the purpose of this assessment is not to address the solid waste problem relative to amounts of a total waste tonnage generated, but rather to determine which activities may adversely impact the State's water resources.

Basically, there are two types of solid waste disposal practices; the area method and the trench method. The area disposal method can best be described as the deposition of refuse on land in which a mounding affect is given. Conversely, the trench method is different in that refuse is deposited in excavated areas. In both methods daily cover is applied which aids in the sound management of a properly located site. However, with poor siting a landfill operation may potentially impact not only groundwater resources but also surface water by contamination from leachate transmitted through local groundwater aquifers.

Generally, there are three ways in which water resources may become degraded from poorly located solid waste facilities. These impacts include: depositing refuse directly into saturated soil or surface water, precipitation infiltrating into the refuse, and surface water runoff. The latter occurrence usually stems from poor grading and seeding to the inadequate application of cover. The former two, however, are very dependent on not only the soil cover, but also on the soils permeability which collectively determine the rate of infiltration and attenuation. Permeable soils will permit rapid movement of leachate and generally will allow the contaminants to filter into the water table. Less permeable soils, such as clay will retard leachate migration and often restrict it to the immediate disposal area. Generally, when disposed refuse comes into contact with the water table, a lateral movement of leachate will occur paralleling the slope of the water table. The gradient of the water table is usually reflected by the slope of the land surface tilting to the stream valley where the groundwater is ultimately discharged as supplemental surface flow.

Within Indiana there are approximately 146 permitted sanitary landfills. Of this total 68% (99) meet State geologic criteria; 77% (76) of this total must conform to additional specific management and operation practices prescribed by the Stream Pollution Control Board. As listed in Table 25, a total of 17% (25) do not meet state criteria and therefore, are unacceptable sanitary landfill operations. Lastly, 15% (22) do not have enough information to quantifiably determine their environmental suitability.

Table 25
Unacceptable Sanitary Landfill Operations
Under Phase-Out Plan
*In Litigation

	Disposal Sites	County	Region
* 1	Dis-Pos-All Dump	LaPorte	2
* 2	East Gary (Lake Station) Dump	Lake	1A
3	Franklin County Landfill	Franklin	9
4	Fulton County Landfill	Fulton	5
* 5	Gary Disposal Dump	Lake	1A
* 6	Gary Land Development Corporation	Lake	1A
7	Industrial Disposal Dump	Lake	1A
* 8	Lane Restoration	Marion	8
9	Lawrence County Landfill	Lawrence	13A
10	Lawrenceburg City Landfill	Dearborn	12
11	Miller Landfill	White	4
12	Crawfordsville Landfill	Montgomery	4
13	New Paris Landfill	Elkhart	2
14	Petersville Gravel Pit	Bartholomew	11
15	Seymour Recylcing	Jackson	11
16	Runyon Landfill	Carroll	4
17	Segal Landfill	White	4
18	Spidel Landfill	LaGrange	3A
19	Starke Landfill	Starke	1B
20	Superior Waste Landfill	St. Joseph	2
*21	Warsaw City Landfill	Koscuisko	2
*22	United Refuse Landfill	Allen	3B
23	Warren County Landfill	Warren	4
*24	Tippecanoe County Landfill	Tippecanoe	4
25	Franklin City Landfill	Johnson	8

Region 1A

One of the more landfill dense areas of the State is Lake County in Region 1A. Presently, four (4) disposal areas have been classified as geologically unsuitable. The East Gary (Lake Station) Dump is one that is presumed to be contributing leachate to Deep River and may be an immediate threat to local groundwater and surface water resources. In its proximity to the Deep River, this landfill is located on the north bank and because of highly permeable cover material leachate generation is very probable. In addition, a swamp located on the site has been used for refuse disposal. Based upon staff observation, it is presumed that this swamp is hydraulically linked to Deep River. In several instances leachate laden waste had been noticed welling up from the river floor adjacent to the landfill property. This reinforces the conclusion that a good portion of this operation is linked hydraulically to the Deep River.

The Gary Land Development Corporation also operates a disposal site in the Lake County area. The site itself is located approximately 10 feet from the Grand Calumet River and is reported to be within the stream's 100-year flood elevation. One of the State's major concerns is that leachate, rather than being transported to a wastewater treatment facility, is being discharged directly to the Grand Calumet River. Lab analysis has indicated that significant amounts of heavy metals and oils were being discharged from this site. Therefore, as an unauthorized discharger, this facility is a major factor prohibiting the Grand Calumet River from attaining water quality standards. Presently, the owners of the Gary Land Development Corporation have applied for an NPDES permit which will establish effluent limitation for their discharge.

Lastly, the Industrial Disposal Landfill is also located along the Grand Calumet River. Because of soil characteristics and its geologic environment, this site has also been classified as an unacceptable landfill and presently has no permit authorizing its operation. Types of waste which may be accepted at this site include foundry sand, woods, plastics, and steel slag, which not being totally innocuous to the environment, have produced leachate when coming into contact with the shallow groundwater resources. In addition, as a totally unacceptable cover agent, sand has been used as a cover material in the past. This operational practice greatly accentuates the possibility of leachate generation since sand is characteristically a very good conductor for lateral movement.

Region 2

Several landfills located in Region 2 have been located in geologically poor areas. The New Paris Landfill in Elkhart County is one that is unacceptable because of the threat it presents to local groundwater resources. The ease of infiltration through the sandy-silt and silty-sand cover and the permeable materials beneath the refuse probably results in accelerated leachate generation and migration to the water table. Upon reaching the saturated zone, the leachate most likely flows laterally northward or north-eastward according to local aquifer hydraulics. Leachate has been observed in the past to be leaving the property through a culvert discharging to a marsh area east of the landfill site.

Superior Waste Landfill, another geologically unsuitable operation, is located in St. Joseph County. The major concern is that sand and gravel deposits, the principal aquifer water source, maybe in direct contact with the refuse or separated by thin layers of slowly permeable silty material within low depressional areas on the property. Leachate generation has been documented and could be further aggravated if silty-sand and fine gravel material is applied as cover.

The Warsaw City Landfill, located in Kosciusko County has been issued its final operating permit by the Stream Pollution Control Board. Although the type of refuse received at this site is limited to paper, street refuse, and cans, as such, it is at times being deposited in unapproved filling areas. By November 1, 1980, all closure proceedings should be completed, including final grading and seeding.

Lastly, LaPorte County serves as the present location of the Dis-Pos-All Dump. Staff reports indicate, in addition to its unfavorable geologic setting, other alleged violations have occurred including the acceptance of unauthorized hazardous waste, general poor operation of their facility and lack of adequate cover material. Periodic inspections have revealed the use of foundry sand, a highly permeable material, as a covering agent. This could promote rapid leachate generation and movement which could impact the quality of Trail Creek, which is located adjacent to the landfill. Presently, the Stream Pollution Control Board has ordered this site to be closed and covered.

Regions 3A and 3B

The northeastern portion of the State has two sanitary landfills which may adversely affect the environment. The Spidel Landfill, located in LaGrange County of Region 3A, has been determined to be unacceptable because of its potential deleterious impact upon local groundwater resources. Although all shallow deposits were found unsaturated, their high hydraulic conductivities may still allow a significant amount of leachate migration within the subsurface strata. In addition, the use of sand as a cover agent poses an additional possibility for leachate generation through the refuse.

The second landfill is United Refuse located in Allen County, Indiana. Because this landfill is sited within the 100-year flood elevation of the St. Mary's, Maumee, and St. Joseph Rivers it has been classified as located within an unacceptable geologic environment. On April 18, 1978, the Stream Pollution Control Board (SPCB) denied renewal of its operating permit for not only failure to submit required well monitoring reports, but also for alleged filling within an unapproved area. Because of the flood area location, any area which is proposed to be used for refuse disposal must receive approval from the Department of Natural Resources and concurrence from the State Board of Health.

Region 4

The Region 4 planning area is the largest area of the State which possesses unacceptable landfill operations. Specifically, the Miller Sanitary Landfill is located within an extremely poor geologic environment. Potential groundwater contamination is presumed to be great because of the existing permeable surficial materials and the probability of recharge to a widely used bedrock aquifer. Also the Segal Landfill in White County is located within an area which is characterized by very permeable surficial material. Because of the high localized water table, this landfill has been determined to be within an unfavorable environment.

The remaining landfills which have been sited in questionable geologic environments are located in Montgomery, Warren, Tippecanoe, and Carroll Counties of Region 4.

The Runyon Landfill in Carroll County has been slated for eventual closure. Because of thick permeable granular zones beneath the site and the possibility of direct hydraulic contact with local surface water systems, this site has been classified as an unacceptable operation. In addition, generation of excessive leachate may occur as the result of the poor characteristics of sand, sandy-silt and gravel used as a cover agent. Any leachate which is produced may eventually be discharged to the Wabash River via Burnett's Creek.

Also scheduled for closure in 1983 is the Warren County Landfill. Unacceptable conditions exist which create limiting factors for this area to be used for disposal purposes. Specifically, the high permeability of weathered material overlying gray till in conjunction with high groundwater tables allow water to infiltrate the refuse and possibly flow through the trenches unchecked.

Finally, the Tippecanoe Sanitary Landfill has been denied renewal of its operating permit. Several factors led to this determination. The major concern is that the present site is within the 100-year flood elevation of the Wabash River and Wildcat Creek. Other indicators such as the degree of saturation below the site and at shallow depths supported this denial.

Region 8

Region 8 has two sanitary landfills in central Indiana currently sited within questionable locations. Located in Johnson County, the Franklin City Landfill is geologically unacceptable for several reasons. First, the eastern portion of this site is subject to periodic flooding from Buckhart Creek. Secondly, there exist saturated zones of granular material in close proximity to the surface. When this fact is considered, in addition the inadequate barrier of silt-clay material which separates refuse from more permeable soils, it becomes a good probability that shallow groundwater resources may become contaminated with leachate.

A more severe problem, however, may exist with Lane Restoration in Marion County, Indiana. The landfill itself is located approximately one-half mile south of White Lick Creek. A water filled borrow pit is located on the west end of the property and is utilized for the disposal of pickling liquor. The residual itself is not disposed of until it has supposedly been neutralized with lime and incorporated with flyash to improve the consistency of the waste.

Originally, the Stream Pollution Control Board approved the disposal of this waste as an experimental demonstration. One year later monitoring wells were established on site and in 1978 it was concluded by staff that some groundwater impairment had occurred. Subsequently, the Stream Pollution Control Board concluded that the landfill operation was the source of contaminants and disapproved continued use of the site for disposal. Presently, an appeal of this administrative ruling is pending.

Regions 9 and 12

There are two landfills in eastern Indiana, in Region 9 and Region 12 which pose severe limitation as disposal facilities. The Franklin County Landfill in Region 9 is an unacceptable operation due to saturated zones of granular material located close to the surface. In addition, water cannot run off and is forced to percolate into the refuse. Lastly, the thin layer of silty-clay used to separate groundwater from the refuse is not sufficient to retard leachate. Therefore, when leachate occurs it is a distinct possibility that groundwater contamination occurs.

The Lawrenceburg City Landfill located in Region 12 also violates several fundamental disposal principles and should not be allowed to continue. Its geologic setting is characterized by an abundance of sand and gravel deposits and a meager clay thickness beneath the site make groundwater contamination a distinct possibility. Secondly, a portion of this site is located within the Ohio River floodplain. Flooding frequently occurs and when the refuse becomes saturated, leachate generation may be inevitable.

Lastly, staff records indicate that permeable fly-ash, sawdust and woodchips have in the past been used as a cover material. This is an extremely poor practice and increases the likelihood of water infiltration into the disposal refuse.

Region 11

Optimum conditions for pollution of groundwater aquifers exist where the water table is at or near the land surface, subjecting the waste to direct contact with water. Such conditions usually exist in abandoned reservoirs and gravel pits that penetrate the groundwater reservoir. These same conditions exist to a certain degree in the aforementioned landfills which have pits, ponds, and/or lagoons, and marshes on location utilized for refuse disposal. Although some efforts to curtail leachate movement through artificial liners have been initiated, their success is very limited and marginal. These conditions are especially relevant at Petersville Gravel Pit in Bartholomew County, which is generally thought to be unacceptable for any type of waste disposal. It is highly probable that because of the shallowness of saturated sand and gravel deposits, pollution, when it occurs, is ultimately discharged to Clifty Creek located at the northern margin of the landfill property.

One possible source of pollution within the Seymour planning area is the Seymour Recycling Corporation. This facility has been denoted by the U.S. EPA as one of the most severe hazardous waste facilities in the nation. As of April 1978 the Corporation estimated that there were 42,000 drums and 500,000 gallons of hazardous waste in bulk storage within the site. Materials involved include such substances as reclaimable solvents, acid and caustic wastes, cyanide, laboratory chemicals, pesticides, still bottoms, enamels, and a vague category of waste classified as "set-ups." In October 1978 a hydrogeological study was conducted to determine the potential for groundwater contamination at the site. It was concluded that pollutants could migrate to significant depths within the soil profile. The prevalent soil type in this vicinity is the Ayrshire series characterized by soils of slow to moderately rapid conductivities. More recently, however, Seymour Recycling has been ordered by the State and Federal environmental authorities to clean up its site and remove all cyanide. In addition, as a result of poor management and operation many inspections have revealed ruptured barrels and miscellaneous spillage pooling on the surface of the site. Subsequent investigation has led to a massive clean up effort by an Ohio chemical firm to remove all damaged containers and retard any surface runoff into nearby tributaries of the East Fork of the White River.

Region 13A

Geologically, possibly the poorest landfill site is the Lawrence County Landfill in Region 13A. The highly permeable material into which the refuse is placed allows water to percolate freely through the refuse, generate leachate, and flow downward to enter the groundwater system within the bedrock. Some leachate, however, may be diverted westward in the surficial cover by the influence of the tight residual clay zone. Because groundwater in Karst systems moves rapidly, pollutants may become dispersed over a wide area in a short period of time than if normal geologic conditions prevailed, and filtration and attenuation may be neglible. It may, however, be argued that the dilution of leachate may occur much more efficiently in such a system as described in Lawrence County.

State Strategy

It is policy of the Stream Pollution Control Board (75-1) that a sanitary landfill should be developed in the most environmentally acceptable property in the area it is to serve. The Stream Pollution Control Board (SPCB) will discourage the development of plans for sanitary landfills in gravel pits, floodplains, swamps, areas with shallow static water levels and in earth materials of coarse grain size. Emphasis must be placed on scientific selection of a site which is environmentally suited for sanitary landfill operation in its natural restored state.

In keeping with this policy, the State has initiated a Landfill Phase-Out Strategy for all landfills which are not geologically acceptable and which are not currently under litigation by the Stream Pollution Control Board (SPCB). It is the objective of this strategy to schedule the closure of landfills posing real or potential threats to groundwater resources, while simultaneously providing responsible parties with sufficient time to relocate their facilities within acceptable geologic regimes. Also, the strategy will allow responsible parties sufficient time to demonstrate the feasibility of employing environmental safeguards as alternatives to site closures. Such safety measures may include, but not limited to, artificial liners, leachate collection/treatment systems, and any other modifications in design or operation improving the environmental soundness of a site. These measures must be demonstrated to be effective and feasible to implement.

Generally, after review and examination of well logs, published data, and site-specific information provided within our files and field inspections, the landfill will be issued its final operating permit at the time of their next renewal. This procedure will provide two to four years to locate and prepare another landfill site in a more suitable environment.

In addition, pursuant to the proposed 208 Water Quality Management Plan, the State will pursue enabling legislation for:

1. Adequate control over land disposal of wastewater treatment sludge, industrial on-site waste disposal, and off-site or land application control over agricultural waste.

2. Elimination of illegal dumping.

3. Control over the storage of hazardous waste in barrels, pits, ponds, or lagoons.

4. An effective reporting and monitoring system of land disposal of wastes.

5. Long-term control of land use on abandoned disposal sites.

6. Resolution of siting problems.

Other activities will include utilizing Resource Recovery and Conservation Act (RCRA) funding to evaluate effectiveness of approved sites and operational practices. Also, in conjunction with other Divisions within the Bureau of Engineering, a single plan will be developed to incorporate all federal requirements of the RCRA, CWA, and SDWA pertaining to ultimate disposal and groundwater protection. Lastly, a process will be established for selected cases whereby staff can require that adequate measures be taken, including the installation of monitoring wells, in order to prove groundwater contamination.

The 1980 Indiana General Assembly has taken a positive step toward sound management of hazardous waste through its 1980 enabling legislation. Specifically, the Environmental Management Law is amended to empower the Environmental Management Board to regulate and require the safe and proper transportation, treatment, storage and disposal of hazardous waste generated in or brought into the State of Indiana. Whenever possible, any regulations the Environmental Management Board may promulgate should allow for variation in the State with regard to population density, climate, and geology. Any facility which is issued a permit of operation must establish its financial and technical capability to contain and control any emergency condition which may occur such as spillage and groundwater contamination. Finally, to ensure proper safeguards, a restrictive convenant must be filed prior to allowing the operation of the sanitary landfill for the disposal of hazardous waste. Such a convenant ensures that the Environmental Management Board shall review all future land use zoning of the facility following closure at the end of the landfill's life. Therefore, no building, drilling, and/or construction may take place without proper authorization of the State.

IV. Social and Economic Impacts

Social and Economic Impacts

An essential part of any cost-effective pollution abatement program is consideration given to the social and economic factors of water quality. This is of particular importance for Indiana since a vital source of revenue can be generated from improvement in water quality in conjunction with an expanded outdoor recreation program for water related activities. In its 1979 Indiana Outdoor Recreation Plan, the Department of Natural Resources (IDNR) recognized the importance of Indiana's rivers and streams. Accordingly it identifies that two of the more frequently utilized water activities are fishing and swimming. The IDNR estimates that for every 100 participants, 42 utilize the State's resources for fishing and another 38 for swimming. Other activities such as boating, waterskiing, and canoeing represent another 25, 9, and 8 participants, respectively.

Of all outdoor recreation activities, fishing and swimming rank as the third and fourth most popular statewide. But in 16 of the 18 planning regions, both of these pastimes were ranked no lower than third. Therefore, as a potential economic return, both these activities represent a viable revenue source for 3/4 of the State.

Water oriented recreation offers good potential for the development of tourism within Indiana. Although not totally dependent upon water-related recreation, tourism is thought to be a billion dollar industry within Indiana. Some estimates, however, perceive outdoor recreation to generate almost $6.0 million annually. As a result of increased leisure time and high cost of fuel, the State's vital water resources will have an increased demand placed upon it. Consequently, residents of Indiana as well as populations of neighboring states, will be forced to utilize this time near their homes.

A report entitled, "Economic Potential of Tourism" by the Indiana State Department of Commerce indicates that much of the water recreation attractions are located in the northeastern planning regions, which collectively have several hundred natural and man-made lakes. Data obtained from this report conclude these regions top the list for total sales tax collections ($0.33/capita) from tourist attractions. Although this amount is not totally derived from water-related recreation, the abundance of water resources in northeast Indiana is a direct contributing factor.

Southern Indiana is also rapidly expanding its tourist market and outdoor recreation potential. Three multi-purpose reservoirs are located within close proximity to three major metropolitan areas. Collectively, Monroe Reservoir, Brookville Reservoir, and Patoka Reservoir have the potential to attract over 3.3 million people from the Indianapolis, Louisville, and Evansville planning areas. Upon completion of the Patoka Reservoir, receipts stemming from its annual hunting and fishing activities are estimated in the range of $121,000 per year. In addition, the U.S. Army Corps of Engineers estimates that with an annual visitation of 1.5 million people, the total benefit derived may be close to $1.0 million per year.

Although this example represents estimates and projections, the potential benefits of water recreation is apparent. If the State of Indiana continues to strive for improved water quality, the revenue generated will reflect the enhancement of the State's water resources.

Substantial state funds are required to control and eliminate pollution affecting our lakes, streams, and waterways. Since 1972 the State has processed over 400 construction grant awards totalling in excess of $1.0 billion. Of this total, approximately $270 million has been allocated for the planning, design and construction of new wastewater treatment facilities. The remainder has generally been utilized for the expansion and upgrading of existing municipal facilities. However, this accounts for only that funding which has been obligated. In addition, one must also consider what level of funding is needed and what level will actually be available to meet the goals and objectives of the Clean Water Act.

In their 1978 Needs Survey; Cost Estimates for the Construction of Publicly-Owned Wastewater Treatment Facilities, the U.S. EPA and the State of Indiana estimate that $4.2 billion is required to attain the 1983 Federal mandates. Since 1976, when the last needs assessment was completed, the State of Indiana anticipated an increase of almost $612 million dollars in funds required to meet the Federal objectives, which presently represents only 4% of the total national need.

These funds are anticipated to be allocated not only for the planning, design and construction of new wastewater treatment facilities to meet secondary and advanced levels of treatment, but also for correction of excessive inflow/infiltration problems, major rehabilitation of existing sewage systems, construction of new collection and interceptors, the control of combined sewer overflows (CSOs), and for the control and treatment of stormwaters.

The amount of funds needed for the construction of treatment facilities to meet secondary and/or advanced waste treatment requirements is estimated to be in the neighborhood of $583.0 million. A majority of these funds are needed for treatment costs in areas where water quality standards dictate a need for the removal of such constituents as ammonia and/or phosphorus, etc. Only $46 million is anticipated to be obligated to further facilities in attaining the "Best Practicable Treatment" available, in a cost-efficient manner.

A combined need of $52.0 million has been estimated for not only the correction of infiltration and inflow, but also for the major rehabilitation of infrastructure found to be unsound. This work usually is determined to be outside the scope of general operation and maintenance. However, the correction of infiltration and inflow problems within a system will possibly require almost double the allocation required for rehabilitation. The individual cost needs have been reported to be almost $16.0 million for rehabilitation and $36.5 million for infiltration and inflow. Although the total need for rehabilitation work has declined by almost $50.0 million and inflow/infiltration by $172.0 million, some of these funds crossed over into identified combined sewer overflow needs.

The largest required need, as reported by the State of Indiana and the U.S. EPA, is for the structural control of combined sewer overflows. Basically, between 1976-1978, the funds required for this need have increased by $1.5 billion to bring the 1978 needs to almost $3.0 billion. This represents approximately 11% of the total need nation-wide. Funds will be utilized for facilities to prevent and control periodic bypassing of untreated wastes. It will not include costs for the handling of stormwaters in separate storm and drainage systems.

Collectively a total cost of $651.0 million is needed for the construction of not only new collection systems, but also new interceptor sewers. Individually, the new collection systems are anticipated to alleviate pollution caused by raw sewage discharges, septic tank seepage, etc., with total estimated cost in the range of $340.0 million. The amount needed for new interceptor lines for transferring sewage to a centralized treatment facility is estimated near $311.0 million.

The estimated funds required for the treatment and control of stormwaters is in the realm of $1.6 billion, according to the 1978 assessment. These funds, if appropriated, will be utilized by urban areas to prevent stormwater runoff from being channeled through sanitary sewers. It will not include the removal of toxic substances.

From this assessment it is evident that much work is still necessary for attainment of the goals and objectives of the Clean Water Act. When considering the total funds necessary, the cost for the citizens of Indiana will be approximately $733 per capita by the year 2000. But in light of several factors, this amount will probably not be attained. Within the State's five-year planning period (1980-85) only $686.0 million will be available for abatement of municipal wastewater pollution. Total funding available will incrementally increase from $93.0 million in FY 1980 to a possible $136.0 million available in FY 1985.

V. Analysis and Recommendations

Analysis and Recommendations

Throughout this report efforts were directed toward assessing Indiana's water quality relative to the extent that Federal and State Water Quality Standards are being attained, and the degree that these waterway's are capable of sustaining their designated uses.

Several conclusions are evident. First, dissolved oxygen concentrations in most waters of Indiana are sufficient to support fish and other aquatic life. As a general rule, the primary streams within each of the nine (9) river basins maintain oxygen levels well above the State minimum 4.0 mg/l standard. The smaller streams are usually the problem waterways. In many instances, these waterways are incapable of meeting average daily requirements, but usually only as the result of severe pollution, do they fail to meet minimum standards. In some instances, oxygen deficiencies may be attributed to low stream flow characteristics that are accentuated during dry summer periods. One surprising fact has been noted. Although major streams had few problems in sustaining adequate dissolved oxygen concentrations, each monitoring station usually recorded a net loss of available oxygen during the 1974-1978 survey period.

Several streams of the State have been found to contain significant concentrations of heavy metals and toxics that may inhibit stream uses. In addition to certain streams of the Great Lakes Basin, the West Fork of White River exhibits several water quality problems. In several cases documented concentrations of mercury, phenols, and cyanide have often exceeded Federal standards. Substantial enforcement action has reduced mercury concentrations to current acceptable levels, but cyanide and phenols, although they have sustained significant instream reductions, are, in some instances, still in excess of Federal Standards.

Organic toxics are also a localized pollution problem. These parameters are harmful not only to fish and other aquatic life, but also pose a threat to human health since they persist and have a cumulative effect. The most notable of these constituents in streams within the Lake Michigan Basin and Clear Creek of the East Fork of White River Basin is polychlorinated biphenols (PCB's). Although samples from the rivers of the Great Lakes Basin still indicate that PCB's are at critical levels, the Ninth Annual Report of the Council on Environmental Quality reported decreases in PCB levels in Lake Michigan Coho Salmon for the first time since monitoring began five years ago. This toxic material is still prevelent in other areas of the State. Minor reductions may be occurring in Clear Creek, but some inspections still indicate high levels in the aquatic environment.

One of the most widespread water quality problems is the bacterial pollution affecting streams and waterways. Bacterial concentrations may be introduced into waterways from a variety of sources, i.e., sewage bypassing, combined sewer overflow, agricultural runoff (feedlots), and septic tank seepage. The more persistent violations were found within the St. Joseph River Basin, the Maumee River Basin, and the West Fork of White River. In each instance, general reductions have been recorded at each Fixed Water Quality Monitoring station.

As additional municipal and industrial wastewater treatment facilities are placed in operation, additional improvement in water quality is anticipated. To date, approximately $270 million has been allocated for the planning, design, and construction of new municipal wastewater treatment facilities. In addition, a supplemental $730 million has also been proportioned for plant expansion and improvement to bring treatment facilities into compliance with federal mandates. The remaining municipalities, on the municipal project list, await funding on 392 projects. Numerous other entities not yet having a priority rank have an estimated $4.2 billion total need to attain the 1983 goals of the Clean Water Act. When put into perspective, it is evident that current funding levels (through 1978) for the construction and improvement of municipal wastewater treatment facilities will preclude the States attainment of these Federal directives. This is not to say that the Federal mandates of "restoring the biological integrity of the nations waters" are not achievable. The goals are unrealistic in the sense that other pollution sources, such as nonpoint sources, and combined sewer overflows, have necessitated a redirection of planning to cope with these new problem elements.

Besides funding deficiencies, there are elements within existing programs that also deter this possibility. It is not unusual for a town or community to initiate an EPA Step 1 planning grant, but because of so-called "red-tape," to still be without adequate wastewater treatment three or four years later. This is especially critical for those areas of the State that have documented pollution problems that may be contributing to severe health problems or causing stream degradation. While the community proceeds through the grant process and study's remedial measures, continued pollution occurs. Although it will not discharge a community's responsibility to adequately treat its wastewater through the EPA grants program, one possible alternative for an interim solution is applying for the Department of Housing and Urban Development's single purpose grants for abating pollution problems causing an imminent threat to public health or safety. Several communities have already utilized this alternative with much success. For instance, the Town of Hudson, located in Steuben County, successfully secured U.S. HUD funds to alleviate local health problems as an interim measure to their community pollution problems. Again, this will not preclude the town's responsibility to provide more permanent pollution control measures, but may be used as only an alternative for alleviating the more severe and unique pollution cases.

Another deterent is often the poor operation, maintenance, or performance of a treatment plant only a few years after its completion. The basic operation of the facility cannot only be the responsibility of a community; the State must also assure that, through proper training of personnel, proper operational levels are maintained. Some operational problems persist because of organic and hydraulic overloading, but many deficiencies are primarily related to the maintenance of equipment and operation of the facility.

An EPA performance survey for 1976-1978 "Efficiency of Municipal Wastewater Treatment Works" concludes that a large number of plants could be brought into compliance through improvements in operation and maintenance of influent controls, and minor plant or equipment changes.

In addition, the U.S. EPA believes that wide-spread performance problems make it imperative to improve these practices, since massive expenditures for treatment facilities are only cost-effective with proper operation and maintenance. In light of such circumstances, continued efforts should be made to continue, and even expand, the existing operator certification program.

The general operation and maintenance of a municipal sewage treatment facility is usually regarded as a community obligation. In most instances, an operator is sent to a two-week training course, passes a test, and upon certification is expected to properly run his facility. A cooperative effort by the State to insure further in-house training could substantially improve performance. The State should pursue a formal quarterly seminar (in-house) to acquaint operators with problems occurring with wastewater treatment. This could be further refined if on-site field inspectors supplemented this training during their investigations. However, the municipality must also contribute through the review of its sewer users charges. If it is necessary to establish and maintain a pretreatment program, it is the community's responsibility to ensure that toxic or otherwise unacceptable material is placed into the pretreatment system to prevent failure or poor operation of the final treatment facility.

Above all, the extent to which major municipalities and industries will be able to meet the Act's objectives are largely dependent upon continuing and increasing Federal funding for the planning, construction grants, and the allocation of Federal cost-sharing monies for the control of agricultural nonpoint source pollution. It is apparent that compliance with Federal mandates must be a cooperative effort of all Federal, State, and local governments.

VI. Appendices

Appendix A-1:

Ohio River Water Quality Assessment

An assessment of Ohio River water quality for the years 1978 and 1979 is based upon data obtained by operative monitoring systems. The Ohio River Valley Water Sanitation Commission (ORSANCO) administers several such surveillance networks: automated monitoring of several key indicators; sampling manually for physical characteristics, minerals, nutrients, trace metals and organics, radioactivity, and bacteria; and biological monitoring of fish tissues and populations. Amplifying these data collected by the Commission is water quality information furnished by water utilities in the Ohio River Basin. All these types of water quality data are compared to water quality criteria recommended by the Commission and to state standards applicable to individual Ohio River segments.

OHIO RIVER WATER QUALITY

A general survey of data collected in 1978 and 1979 indicates that half (10) of the substances for which the Commission has recommended criteria remained at acceptable levels during the entire period. Five more quality indicators--temperature, pH, cadmium, dissolved lead, and sulfate--were within criteria limits in all but one percent of the samples, or even less. Only five water quality characteristics were unacceptable for significant periods of time: fecal coliform bacteria, phenolics, mercury, dissolved oxygen, and cyanide. A summary of water quality for 1978 and 1979 is shown by river segment in Table S-1.

Fecal coliform bacteria are indicators of contamination by domestic waste discharges, combined sewer overflows, and urban runoff. Because the water used for drinking undergoes extensive purification, the criterion for recreational water use is more stringent; actual physical contact with the water is involved. The public water supply criterion was met most of the time during the two-year period, but the recreational criterion was not. Bacteria levels were consistently highest at West Point, below Louisville, and at North Bend, which is just downstream from the Cincinnati metropolitan area. Both cities are in the process of improving their sewage treatment facilities.

Table S-1: Summary of Water Quality by Segment
Ohio River 1978-9

Segment Number	Description	Milepoints	Thermal	DO	Nutrients	Bacteria	Suspended Solids	Dissolved Solids	pH	Metals	Cyanide Phenolics	Pesticides in Fish
1	Point to Beaver River	0.0- 25.4	0	0	0	1	0	0	0	1	2	3
2	Beaver River to PA/OH/WV State Line	25.4- 40.0	0	0	0	0	0	0	0	1	2	-
3	State Line to Pike Island Dam	40.0- 84.2	0	0	0	2	0	0	0	1	2	1
4	Pike Island to Hannibal Dam	84.2-126.4	1	1	0	2	0	0	0	1	1	2
5	Hannibal to Willow Island Dam	126.4-161.8	0	0	0	0	0	0	0	1	1	-
6	Willow Island to Belleville Dam	161.8-203.9	0	0	0	1	0	1	0	1	1	1
7	Belleville to Kanawha River	203.9-265.7	0	0	0	0	0	0	0	1	1	-
8	Kanawha to Big Sandy River	265.7-317.1	0	0	0	1	1	0	1	1	1	1
9	Big Sandy to Scioto River	317.1-356.5	0	0	0	0	1	0	0	1	1	-
10	Scioto to Meldahl Dam	356.5-436.2	0	0	0	0	1	0	0	1	1	0
11	Meldahl to Little Miami River	436.2-464.1	0	0	0	1	1	0	1	1	1	-
12	Little Miami to Great Miami River	464.1-491.1	0	1	0	2	1	0	0	1	1	-
13	Great Miami to Kentucky River	491.1-545.8	0	1	0	1	0	0	0	1	1	1
14	Kentucky River to McAlpine Dam	545.8-605.0	0	1	0	1	0	0	0	1	0	1
15	McAlpine to Cannelton Dam	605.0-720.7	0	1	1	3	2	0	0	1	1	1
16	Cannelton to Newburgh Dam	720.7-776.1	0	1	1	1	1	0	0	1	0	-
17	Newburgh to Wabash River	776.1-848.0	0	1	1	1	2	0	1	1	1	0
18	Wabash to Smithland Dam	848.0-918.5	0	0	1	1	1	0	0	1	0	-
19	Smithland to Mississippi River	918.5-981.0	1	1	1	1	1	0	0	1	0	-

0 = No problem
1 = Slight problem, criteria exceeded in less than 10 percent of samples
2 = Moderate problem, criteria exceeded in 10-50 percent of samples
3 = Severe problem, one or more designated uses precluded
- = No data

Phenolics may taint fish flesh or cause taste-and-odor problems for drinking water supplies. During 1978 and 1979, the Commission's recommended criterion was exceeded more frequently on the upper and middle river. Values were greatest during February of both years. Though excessive concentrations of phenolics are still a problem, the number of values exceeding the ORSANCO criterion decreased from 96 to 657 samples (14 percent) in 1977, to 24 of 382 (6.3 percent) in 1979. Discharges from coke and chemical plants are the major source of phenolics in the upper river; increasingly effective treatment, as presently required, should minimize the phenolics problem.

Mercury levels in water are limited to prevent bio-accumulation in fish and subsequent harmful transfer to humans through the food chain. There has been an increase in mercury values exceeding the criterion, due in part to the capability of the laboratory to detect lower values. If that change in detection limit is taken into account, however, the number of excessive values of mercury detected in 1979 is still three times that measured in 1977. State and federal agencies have been investigating the problem, though no sources of the high levels of mercury have been identified. It is encouraging to note, however, that fish flesh samples analyzed in 1978 contained no excessive amounts of mercury.

Dissolved oxygen must be present in rivers to support aquatic life. Values exceeding criteria were most frequent during the two-year period in the river's midsection. When waste treatment facilities in the Cincinnati and Louisville metropolitan areas are fully operational, the situation should improve substantially.

Fish are sensitive to high levels of cyanide. The cyanide criterion was exceeded only in samples from the first 200 miles of the river. Because low water temperatures inhibit the natural processes by which cyanide decomposes, concentrations were highest during winter months. Industrial discharges, especially steel mills, are a major source of cyanide. Though levels exceeded the criterion in the upper river in some months, no fish kills resulted. Fewer excessive values of cyanide were noted in 1978 and 1979 than in previous years.

In addition to cyanide and phenolics, other water quality characteristics are showing improvement. Levels of chloride, hardness, sulfate, and turbidity no longer pose major threats to Ohio River water quality. Dissolved oxygen and pH levels in the upper river are more consistently meeting recommended criteria.

Biological data indicate that the desirable fish species are appearing in an increasingly larger portion of the river. Species variety in the upper river is improving, and the number of sensitive species there is increasing. More commercially valuable fish are appearing in the middle and lower rivers.

Problems remain, however, as indicated by increasing detection in water of excessive values of both mercury and fecal coliform bacteria. Fish tissue analyses indicated in 1979 that some species are bioaccumulating both chlordane, a pesticide, and polychlorinated biphenyls. These chemicals pose a threat to the safety of the food chain. Water pollution control programs are now being channeled to the investigation and elimination of these problems.

SPECIAL QUALITY PROBLEMS

Safeguarding the Ohio River as a source of drinking water for the more than three million people who use it poses special problems in water pollution control. The detection of organic substances in the water and the analysis of treatment processes to deal with such substances have become major issues in the 70's. On a day-to-day basis, detection and reporting of spills into water supplies must be effective to ensure the safety of drinking water. Two Commission programs have addressed these issues.

A two-year study which concluded in 1978 measured raw water levels of selected organic substances; it also evaluated the impact of modifications to drinking water treatment processes on the removal of trihalomethanes, a group of organic substances formed during treatment. Eleven water utilities participated in the project, which was funded by the utilities, the U. S. Environmental Protection Agency (U. S. EPA), and ORSANCO. Data from the study, along with supplemental analyses of samples from additional sites, indicated that chloroform was the purgeable halocarbon found most frequently; it was present in 71 percent of the samples from the Ohio River, at a maximum concentration of 4.5 micrograms per liter. Of the solvent-extractable halocarbons, the three dichlorobenzenes and 1,2,4-trichlorobenzene were found most frequently. Some polyaromatic hydrocarbons were presumptively identified at levels too low to quantify. Since there are no generally accepted criteria for these organic materials in water, the aquatic life or human health significance of these results cannot be assessed.

In 1977, the nationally publicized spill of carbon tetrachloride into the Kanawha River increased concern about lack of information on organic substances in water supplies and lack of communication among water pollution control agencies when spill events occurred. To meet this challenge, the Commission revised and improved its role in the interstate reporting of spills, offering assistance in both calculation of instream concentrations and time-of-travel. A total of 305 spills to the Ohio and its tributaries was reported to the Commission in 1978 and 1979.

More important, as a result of the carbon tetrachloride incident, a new detection system was formed to give immediate notification to water utilities and concerned agencies when unusual levels of organic substances were found in the Ohio and the major tributaries. With the assistance of U. S. EPA, seven sites were placed on line in early 1978 and equipment for four additional sites purchased in late 1979. The system has demonstrated that: 1) the detection of increased levels of organic compounds in raw water does, in fact, provide safer water to consumers; 2) the specific locating of a spill event aids regulatory agencies in identifying sources of pollution; and 3) the presence of an organics detection system acts as a deterrent to surreptitious discharging of materials.

Table A-2 ;
Grouping of Indiana Lakes by Cluster Analysis

ID No.	Lake	Area	Mean Depth	Index
442.	Brookville Reservoir	5260.0	7.4	23
397.	Wawasee (South Basin)	3060.0	22.0	15
379.	Wawasee (Mid-E Basin)	3060.0	22.0	16
380.	Wawasee (SE Basin)	3060.0	22.0	18
197.	Mississinewa Res.	3180.0	17.5	20
198.	Mississinewa Res.	3180.0	17.5	20
199.	Mississinewa Res.	3180.0	17.5	20
202.	Mississinewa Res.	3180.0	17.5	20
201.	Mississinewa Res.	3180.0	17.5	20
200.	Mississinewa Res.	3180.0	17.5	20
205.	Mississinewa Res.	3180.0	17.5	20
204.	Mississinewa Res.	3180.0	17.5	20
203.	Mississinewa Res.	3180.0	17.5	20
219.	Mississinewa Res.	3180.0	17.5	20
218.	Mississinewa Res.	3180.0	17.5	20
196.	Mississinewa Res.	3180.0	17.5	16
Group II	Subgroup A			
55.	Beaver Dam	146.0	22.5	16
444.	New	50.0	17.6	7
209.	Stone	125.0	19.9	6
315.	George	488.0	25.0	9
178.	Saugany	74.0	29.6	1
151.	South twin	116.0	31.0	8
447.	Cedar (Tri-Lake)	131.0	30.0	8
330.	Gage	327.0	30.6	8
314.	Gage	332.0	30.5	8
32.	Indiana	122.0	27.9	11
	Subgroup B			
103.	Tippecanoe	768.0	37.0	12
104.	Tippecanoe	768.0	37.0	12
339.	James (Upper Basin)	1034.0	32.5	16
341.	James (Lower Basin)	1034.0	32.5	17
340.	James (Middle Basin)	1034.0	32.5	22
308.	Clear	800.0	31.2	25
454.	Shriner	111.0	45.0	19
257.	Crooked	206.0	43.9	3
258.	Crooked	206.0	43.9	3
259.	Crooked	206.0	43.9	3
138.	Olin	103.0	38.0	10
139.	Olin	103.0	38.0	10
143.	Oliver	362.0	40.0	10

ID No.	Lake	Area	Mean Depth	Index
98.	Silver	102	14.9	51
97.	Silver	102	14.9	51
44.	Nyona (S. Basin)	104	12.9	54
313.	Fish	59	12.7	54
242.	Bougher	32	12.2	54
321.	Wible	49	13.3	55
83.	Little Barbee	74	13.0	56
87.	McClures	32	12.8	51
70.	Diamond	79	16.2	60
420.	Loomis	62	15.0	56
356.	Pigeon	61	15.2	57
22.	Story	77	13.2	60
	Subgroup C			
306.	Charles	150	5.0	75
317.	Sylvan	575	14.0	62
161.	Cedar	781	8.6	70
162.	Cedar	781	8.6	70
163.	Cedar	781	8.6	70
164.	Cedar	781	8.6	70
165.	Cedar	781	8.6	70
69.	Kokomo Res. #2	484	7.0	66
	Subgroup D			
109.	Yellow Creek	151	31.1	67
117.	Cotton	31	30.0	66
107.	Winona (Central Basin)	562	29.7	56
136.	Navoo	38	25.0	50
333.	Big Otter	69	25.8	52
451.	Loon	222	25.8	46
105.	Wabee	187	25.4	60
449.	Goose	84	25.9	61
455.	Troy-Cedar	93	27.3	60
91.	Ridinger	136	21.0	58
342.	Little Otter	34	21.8	58
54.	Beaver Dam	146	22.5	55
Group V				
6.	Yellow Ood	133	14.2	11
137.	North Twin	135	15.7	13
82.	Kuhn	137	9.4	15
273.	Bass	88	10.0	17
174.	Fishtrap	102	10.0	18
155.	Wall	141	11.6	13
407.	Elk Creek	47	12.5	13
114.	Brokesha	36	10.0	11
419.	Lime	30	11.	10
418.	Lime	30	11.	10
63.	Crystal	76	12.2	10

ID No.	Lake	Area	Mean Depth	Index
33.	Simonton	282	5.5	6
377.	Merom Gravel Pit	55	6.0	5
176.	Lower Fish	134	6.5	8
115.	Cedar	120	8.5	9
30.	Heaton	87	7.4	10
154.	Stone	116	14.7	2
102.	Syracuse	414	12.9	4
11.	Deam	195	12.5	5
Group VI	Subgroup A			
72.	Goose	27	20.0	15
296.	Gooseneck	25	20.0	15
394.	Pleasant (Steuben Co.)	53	22.5	20
416.	Kickapoo			
192.	Myers	96	20.8	21
153.	Still	30	20.7	19
121.	Eve	31	21.6	18
188.	Lawrence	69	22.9	13
366.	Snow	421	19.0	20
367.	Snow (S. Basin)	421	19.0	18
101.	Stanton	32	15.0	20
113.	Blackman	67	18.1	20
77.	Hoffman	180	17.6	23
131.	Messick	68	21.3	34
271.	Smalley	69	22.0	34
268.	Sacarider	33	22.4	35
236.	Latta	42	21.4	36
443.	Lukens	46	22.	30
331.	Upper Long	86	22.1	32
442.	Blue	239	21.	30
316.	Stienbarger	73	21.8	39
260.	Diamond	105	24.6	21
269.	Sand (Chain O'Lakes)	47	27.0	23
110.	Adams	308	25.0	28
146.	Pretty	184	25.7	25
453.	Round (Tri-Lake)	125	25.	30
264.	Little Long	71	24.6	32
132.	Messick	68	21.3	26
267.	Round	99	21.6	24
388.	Flint	86	20.0	25
158.	Westler	88	20.1	25
157.	Westler	88	20.1	25
194.	Pretty	97	22.1	28
329.	Fox	142	22.2	27
148.	Royer	69	23.6	26
149.	Royer	69	23.6	26
94.	Sechrist	105	23.7	24
	Subgroup B			
244.	Big	288	24.7	38
80.	James	282	26.9	39
79.	James	282	26.9	39

ID No.	Lake	Area	Mean Depth	Index
	Subgroup C			
301.	Hamilton	802	20.7	31
Group III	Subgroup A			
106.	Webster	774	7.0	37
31.	Hunter	99	11.3	20
172.	Hog	59	11.7	21
184.	Holem	40	9.8	23
360.	Round B (Steuben)	30	11.3	23
371.	Walters	53	10.4	26
347.	Long B (Steuben)	154	11.9	24
84.	Little Chapman	177	11.2	25
230.	Engle	48	14.0	26
290.	Bell	38	13.4	24
283.	Hartz	28	13.2	23
365.	Silver	238	10.7	28
125.	Hackenberg	42	12.1	29
111.	Appleman	52	11.3	30
180.	Upper Fish	139	7.5	22
85.	Little Pike	25	5.6	31
370.	Tamarack	47	5.0	30
18.	Flat	26	8.1	35
207.	Clear	106	7.2	30
288.	Bass	61	7.4	31
277.	Riddles	77	8.3	30
389.	Long (Porter)	65	8.0	33
179.	Swede	33	8.0	32
40.	Lake 16	27	8.1	32
310.	Crooked (Middle Basin)	828	12.8	23
177.	Pine	282	13.0	22
336.	Jimmerson	434	10.1	22
208.	Hudson	432	11.7	23
414.	Quick Creek (Hardy)	705	12.5	19
58.	Big Chapman (W. Basin)	581	10.5	18
57.	Big Chapman (N. Basin)	581	10.5	18
	Subgroup B			
38.	Flethher	45	19.6	46
452.	Old	32	19.4	48
120.	Emma	42	16.7	44
318.	Tamarack	50	17.6	42
59.	Caldwell	45	17.8	46
243.	Bear	32	12.2	54
231.	Gordy	31	21.9	43
64.	Dewart (SE Basin)	551	16.3	36
65.	Bewart (SW Basin)	551	16.3	36
66.	Dewart (NW Basin)	551	16.3	36
303.	Big Turkey	450	16.2	44
187.	Lake of the Woods	416	16.4	42

ID No.	Lake	Area	Mean Depth	Index
195.	Boggs Creek	600	12.5	45
62.	Center	120	17.2	31
145.	Pigeon	61	19.0	27
328.	Pleasant (St. Joseph)	29	18.0	29
262.	Gilbert	28	17.5	28
76.	Hill	67	19.4	31
237.	Millers	28	14.6	35
265.	Long (Chain O'Lakes)	40	15.8	33
249.	Long (At Laketon)	48	16.0	30
287.	Barton	94	14.3	32
439.	Salinda	70	15.0	31
216.	Dixon	33	14.5	30
89.	Pike	203	13.9	37
215.	Cook	93	17.7	40
254.	Bixler	120	17.4	38
245.	Cree	58	15.7	39
373.	West Otter	118	16.6	35
56.	Big Barbee	304	18.6	38
	Subgroup C			
78.	Irish	182	12.8	45
270.	Skinner	125	14.0	45
320.	Waldron	216	14.4	43
256.	Crane	28	12.9	45
238.	Muncie	47	12.3	46
185.	Koontz	346	9.2	42
395.	Lake Pleasant	424	8.2	40
20.	Cedar	28	8.2	40
412.	Spectacle	62	8.7	40
307.	Cheeseboro	27	10.0	40
88.	Muskelonge	32	9.4	40
221.	Griffey Res.	130	10.0	40
434.	Round (At Laketon)	48	11.2	43
152.	Star Mill Dam	38	10.0	43
345.	Lime-Kiln	25	10.0	42
60.	Boner	40	9.2	43
128.	Little Turkey	135	11.5	36
396.	Shakamak	56	10.9	38
241.	Bartley	34	12.6	35
93.	Sawmill	36	10.3	33
29.	Fish	34	10.0	35
272.	Sparta	31	5.5	40
2.	Rainbow	45	6.0	41

ID No.	Lake	Area	Mean Depth	Index
144.	Oliver	362.0	40.0	10
142.	Oliver	362.0	40.0	10
141.	Oliver	362.0	40.0	10
140.	Oliver	362.0	40.0	10
127.	Lake of the Woods	136.0	40.2	18
96.	Shoe	40.0	40.0	14
	Subgroup C			
95.	Shock	37.0	32.7	28
159.	Witmer	204.0	34.5	27
160.	Witmer	204.0	34.5	27
119.	Dallas	283.0	35.2	28
118.	Dallas	283.0	35.2	28
391.	McClish	35.0	34.6	18
129.	Martin	26.0	34.2	35
130.	Martin	26.0	34.2	35
456.	Martin	26.0	34.2	35
255.	Bowen	30.0	36.0	41
247.	Knapp	88.0	34.5	41
122.	Fish	100.0	40.5	39
123.	Fish	100.0	40.5	39
286.	Ball	87.0	40.5	34
112.	Big Long	388.0	40.5	33
Group III				
189.	Maxinkuckee	1864.0	24.5	18
190.	Maxinkuckee	1864.0	24.5	18
18.	Dogwood	1300.0	18.0	16
446.	Shafer Dam	1291.0	10.2	23
41.	Manitou	1156.0	8.8	48
240.	J.C. Murphy	1515.0	5.0	47
210.	Eagle Creek Res.	1500.0	12.5	34
212.	Eagle Creek Res.	1500.0	12.5	34
280.	Bass	1400.0	10.0	36
281.	Bass	1400.0	10.0	39
213.	Eagle Creek Res.	1500.0	12.5	42
211.	Eagle Creek Res.	1500.0	12.5	38
214.	Geist Res.	1800.0	12.0	35
68.	Morse Res.	1375.0	15.4	40
9.	Freeman	1547.0	16.8	38
Group IV	Subgroup A			
3.	Cedarville Res.	245	4.0	61
170.	Wolf (Main Ind. Basin)	385	5.0	58
206.	Wolf (Illinois Basin)	385	5.0	59
169.	George (Hobart)	282	5.0	55
50.	Starve Hollow	145	6.8	58
191.	Mill Pond	136	6.1	58
440.	Kunkel	25	6.0	59

ID No.	Lake	Area	Mean Depth	Index
37.	Bruce	245	7.3	61
375.	Kelly Bayoe	40	3.0	64
460.	Maria	50	5.0	62
335.	Howard	27	4.8	64
43.	Mt. Zion Mill Pond	38	5.0	65
167.	George (N. Basin)	78	3.0	55
168.	George (S. Basin)	78	3.0	55
459.	Long Pond	38	4.0	58
173.	Horseshoe	35	3.0	60
171.	Crane	58	3.0	50
327.	Chamberlain	51	3.5	50
278.	Sously	40	4.0	50
279.	South Clear	51	2.0	50
275.	Mud 7101	197	2.0	50
441.	Moser	26	6.0	55
462.	Sandborn Old Bed Lake	30	6.0	54
463.	White Oak	30	5.0	55
458.	Halfmoon Bed Pond	38	5.0	55
150.	Shipshewana	202	6.7	51
166.	Dalecarlia	193	6.0	51
348.	Loon	163	4.6	53
274.	Czmanda	90	5.0	50
284.	Langenbaum	48	5.4	51
364.	Shallow	65	5.0	51
124.	Green	62	5.0	51
	Subgroup B			
46.	South Mud	94	10.9	66
291.	Big Bower	25	11.2	66
292.	Big Center	46	8.5	71
293.	Golden (SE Basin)	119	15.2	66
295.	Golden (Middle Basin)	119	15.2	66
438.	Salinda	70	15.0	63
294.	Golden (NW Basin)	119	15.2	71
346.	Long A (Near Pleasant)	92	16.7	74
183.	Gilbert	37	13.2	75
350.	Marsh	56	20.0	57
24.	Ferdinand	42	10.5	55
235.	High	123	10.1	53
325.	Hogback (NE Basin)	146	10.1	57
334.	Hogback (NE Basin)	146	10.1	57
51.	Brushcreek Res.	167	10.0	55
324.	Hogback (SW Basin)	146	10.1	60
337.	Hogback (NE Basin)	146	10.1	59
45.	Rock	56	11.1	61
436.	Scales	66	7.9	50
390.	Mink	35	10.0	50
71.	Flatbelly	326	13.3	54
61.	Carr	79	17.0	50
343.	Long A (Near Pleasant)	92	16.7	53
86.	Loon	40	16.8	52

Table A-3; A Summary of the Lake Groupings from Cluster Analysis

	Area	Mean Depth	Index
Group I	3060-3180	17.5-22.0	16-20
Group II			
A	50-48	17.6-31.0	1-16
B	40-1034	31.2-45.0	3-25
C	37-388	32.7-40.5	18-41
Group III	1291-1864	5.0-24.5	23-48
Group IV			
A	26-385	2.0-7.3	50-65
B	25-326	7.9-20.0	50-75
C	150-575	5.0-14.0	62-75
D	31-562	21.0-31.1	46-67
Group V	30-414	5.5-15.7	2-18
Group VI			
A	25-421	15.0-27.0	13-39
B	228-282	24.7-26.9	38-39
C	802	20.7	31
Group VII			
A	25-828	5.0-13.2	18-37
B	28-551	12.2-19.6	27-54
C	25-424	5.5-14.4	33-46

Table A-4
1979 Summary of Materials Spilled

	Number of Spills	Percent of Spills	Amount Spilled (gal)	Percent Spilled (gal)
Petroleum Products	177	51%	528,877	59%
Acids and Bases	25	7%	61,548	7%
Misc. Chemicals	30	9%	122,827	14%
Food Products	4	1%	7,100	1%
Agricultural Related Products	72	21%	168,012	19%
Misc. Materials	37	11%	3,967	1%
Total	345*	100%	891,332	100%

*Spill incidents involved more than one kind of material.

Table A-5
1979-Sources of Materials Spilled

		Number		Percent
Transportation Spills		108		32%
Trucks	57		17%	
Railroads	30		9%	
Pipelines	19		6%	
Ships and Barges	2		1%	
Industrial		103		31%
Agricultural		34		10%
Miscellaneous and Unknown Sources		38		11%
Commercial		54		16%
Total		338		100%

Table A-6
1979-Circumstance of Spills

	Number	Percent
Equipment malfunction	147	43%
Transportation accident	47	14%
Vandalism	13	4%
Employee error	80	24%
Intentional	21	6%
Unknown	20	6%
Miscellaneous	10	3%
Total	338	100%

Table A-7
Fish Kill Sources
1979

Transportation Spills		8
Trucks	4	
Railroad	1	
Pipelines	3	
Ships and Barges	0	
Industrial Sources		2
Industrial Waste	1	
Spill of Product during Processing	0	
Spill of Product from Storage	1	
Other	0	
Agricultural Sources		25
Spill from Storage Facility	12	
Runoff from Fields	10	
Discharge of Waste Materials	2	
Unknown	1	
Public and Service Public Utilities		4
Sewage System	3	
Water Utilities	0	
Storage Facilities	1	
Commercial Sources		4
Spills from Storage Facilities	2	
Discharge of Waste Materials	2	
Other	0	
Unknown Sources		3
Natural Causes		4
	Total	50

Table A-8
Condition or Materials Responsible for Fish Kills
1979

Petroleum Products	4
Fertilizers	12
Pesticides	3
Animal Waste	20
Sewage	3
Organic Chemicals and Chemical Waste (other than petroleum products)	0
Food and Food Waste	1
Inorganic Materials and Wastes	1
Unknown Materials	2
Natural Causes	4
Total	50

Table A-9

NUMBER OF FISH KILLS INVESTIGATED & TYPES OF CAUSES (1947-79)

Year	Sewage	Water Treatment	Agricultural	Industrial	Individual	Natural+ Causes	Unknown	*Total
1947	--	--	--	--	--	--	--	19
1948	--	--	--	--	--	--	--	37
1949	--	--	--	--	--	--	--	34
1950	--	--	--	--	--	--	--	12
1951	--	--	--	--	--	--	--	20
1952	--	--	--	--	--	--	--	20
1953	--	--	--	--	--	--	--	26
1954	--	--	--	--	--	--	--	33
1955	--	--	--	--	--	--	--	16
1956	--	--	--	--	--	--	--	29
1957	--	--	--	--	--	--	--	8
1958	--	--	--	--	--	--	--	12
1959	--	--	--	--	--	--	--	26
1960	2	1	1	11	0	1	3	19
1961	2	0	1	9	0	1	6	19
1962	3	1	2	9	0	0	6	21
1963	7	0	3	6	1	1	7	25
1964	11	0	0	8	0	3	6	28
1965	7	0	4	4	1	0	4	20
1966	1	0	3	10	1	0	4	19
1967	10	0	2	7	1	1	5	26
1968	3	0	2	7	0	2	0	14
1969	6	0	2	12	0	1	1	22
1970	2	0	2	6	0	0	8	18
1971	7	0	10	7	0	5	8	37
1972	6	0	1	8	0	0	7	22
1973	5	0	6	6	0	1	7	25
1974	4	0	6	3	0	0	3	16
1975	6	1	5	11	0	2	6	31
1976	10	1	11	10	3	1	2	38
1977	10	0	8	9	0	0	11	37
1978	2	0	9	14	1	1	5	32
1979	3	0	33	6	1	4	3	50
Totals	107	4	111	163	9	24	102	811

(1947-1979)

1960-79 Total = 519

*1960-79 only

+Does not include winter kills caused by ice cover

*Table A-10 Regional Erosion Estimates
Potential and Gross

Region 1B

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
B1	Houghton-Adrian	2.0	Low	.5	Low
B2	Maumee-Gilford-Sebewa	6.0	Low	1.2	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	2.8	Low
E3	Oshtemo-Fox	21.0	Low	4.2	Low
F2	Plainfield-Maumee-Oshtemo	11.0	Low	1.7	Low
J1	Brookston-Ordell-Corwin	11.0	Low	3.9	Low
J2	Crosier-Brookston	24.0	Low	6.1	Medium
L1	Parr-Brookston	22.0	Low	5.1	Medium
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	6.6	Medium

Region 2

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A2	Fox-Genesee-Eel	27.0	Low	4.0	Low
B1	Houghton-Adrian	2.0	Low	.7	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	3.7	Low
C2	Sebewa-Gilford-Homer	10.0	Low	3.4	Low
D1	Milford-Bono-Rensselaer	8.0	Low	2.0	Low
E2	Elston-Shipshe-Warsaw	16.0	Low	4.8	Low
E3	Oshtemo-Fox	21.0	Low	3.6	Low
J2	Crosier-Brookston	24.6	Low	5.3	Medium
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	3.2	Low

Region 3A

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A2	Fox-Genesee-Eel	27.0	Low	4.8	Low
B1	Houghton-Adrian	2.0	Low	.7	Low
C2	Sebewa-Gilford-Homer	10.0	Low	4.6	Low
E2	Elston-Shipshe-Warsaw	16.0	Low	3.2	Low
E3	Oshtemo-Fox	21.0	Low	3.2	Low
F2	Plainfield-Maumee-Oshtemo	11.0	Low	.5	Low
K1	Blount-Pewamo	19.0	Low	5.7	Medium
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	5.1	Medium
M2	Morely-Blount-Pewamo	49.0	Medium	9.1	Medium

Region 3B

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A2	Fox-Genessee-Eel	27.0	Low	7.2	Medium
B1	Houghton-Adrian	2.0	Low	.7	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	2.8	Low
D1	Milford-Bono-Rensselaer	8.0	Low	1.9	Low
K1	Blount-Pewamo	19.0	Low	4.9	Low
K2	Hoytville-Nappanee	9.0	Low	2.6	Low
L3	Miami-Grosier-Brookston-Riddles	33.0	Medium	6.6	Medium
M2	Morley-Bount-Pewamo	49.0	Medium	7.3	Medium

Region 4

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	2.9	Low
B2	Maumee-Gilford-Sebewa	6.0	Low	1.2	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	3.0	Low
E2	Elston-Shipshe-Warsaw	16.0	Low	3.3	Low
E3	Oshtemo-Fox	21.0	Low	3.8	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.3	Medium
F2	Plainfield-Maumee-Oshtemo	11.0	Low	4.7	Low
I1	Ragsdale-Raub	14.0	Low	4.3	Low
I2	Sable-Ipava	14.0	Low	4.1	Low
I3	Fincastle-Ragsdale	20.0	Low	5.4	Medium
I4	Reesville-Ragsdale	26.0	Low	6.6	Medium
J1	Brookston-Ordell-Corwin	11.0	Low	3.4	Low
J2	Crosier-Brookston	24.0	Low	4.5	Low
J3	Crosby-Brookston	18.0	Low	3.7	Low
L1	Parr-Brookston	22.0	Low	5.6	Medium
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	4.4	Low
L4	Miami-Crosby-Brookston	62.0	Medium	7.6	Medium
L5	Miami-Hennepin-Crosby	161.0	High	9.2	Medium
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	9.0	Medium
L7	Russell-Hennepin-Fincastle	235.0	High	4.3	Low

Region 5

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	2.8	Low
A2	Fox-Genesee-Eel	27.0	Low	4.7	Low
B2	Maumee-Gilford-Sebewa	6.0	Low	1.6	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	3.1	Low
E3	Oshtemo-Fox	21.0	Low	3.1	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.1	Medium
F2	Plainfield-Maumee-Oshtemo	11.0	Low	1.6	Low
I3	Fincastle-Ragsdale	20.0	Low	4.9	Low
J2	Crosier-Brookston	24.0	Low	4.6	Low
J3	Crosby-Brookston	18.0	Low	4.7	Low
K1	Bount-Pewamo	19.0	Low	3.7	Low
L3	Miami-Crosier-Brookston-Riddles	33.0	Medium	5.1	Medium
L4	Miami-Crosby-Brookston	62.0	Medium	9.2	Medium
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	9.7	Medium
M2	Morley-Blount-Pewamo	49.0	Medium	7.3	Medium

Region 6

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A2	Fox-Genesee-Eel	27.0	Low	3.7	Low
C1	Rensselaer-Darroch-Whitaker	12.0	Low	2.8	Low
J3	Crosby-Brookston	18.0	Low	3.6	Low
K1	Blount-Pewamo	19.0	Low	4.4	Low
L4	Miami-Crosby-Brookston	62.0	Medium	5.8	Medium
M2	Morley-Blount-Pewamo	49.0	Medium	6.7	Medium

Region 8

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	2.9	Low
A2	Fox-Genesee-Eel	27.0	Low	5.5	Medium
C1	Rensselaer-Darroch-Whitaker	12.0	Low	2.9	Low
D2	Patton-Lyles-Henshaw	15.0	Low	3.8	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.5	Medium
E5	Parke-Negley	464.0	Very High	7.2	Medium
G	Princeton-Bloomfield-Whitaker	76.0	Medium	5.1	Medium
I3	Fincastle-Ragsdale	20.0	Low	4.7	Low
J3	Crosby-Brookston	18.0	Low	3.9	Low
L4	Miami-Crosby-Brookston	62.0	Medium	6.3	Medium
L5	Miami-Hennepin-Crosby	161.0	High	6.7	Medium
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	7.9	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	7.9	Medium
O3	Cincinnati-Vigo-Ava	279.0	High	11.5	High
Q2	Crider-Hagerstown-Bedford	213.0	High	9.9	Medium
R1	Berks-Gilpin-Weikert	569.0	Very High	8.8	Medium

Region 9

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A2	Fox-Genesee-Eel	27.0	Low	4.5	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.5	Medium
I3	Fincastle-Ragsdale	20.0	Low	5.1	Medium
J3	Crosby-Brookston	18.0	Low	3.3	Low
L4	Miami-Crosby-Brookston	62.0	Medium	4.8	Low
L5	Miami-Hennepin-Crosby	161.0	High	4.1	Low
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	9.3	Medium
N3	Avonburg-Clermont	32.0	Low	4.5	Low
O4	Cincinnati-Rossmoyne	275.0	High	13.5	High
R3	Edin-Switzerland	741.0	Very High	40.5	Very High

Region 10

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	3.0	Low
A4	Stendal-Haymond-Wakeland-Nolan	26.0	Low	3.6	Low
E5	Parke-Negley	464.0	Very High	5.7	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	6.3	Medium
O3	Cincinnati-Vigo-Ava	279.0	High	6.7	Medium
P	Wellston-Zanesville-Berks	457.0	Very High	7.7	Medium
Q2	Crider-Hagerstown-Bedford	213.0	High	8.8	Medium
R1	Berks-Gilpin-Weikert	469.0	Very High	5.2	Medium
R2	Corydon-Weikert-Berks	669.0	Very High	7.8	Medium

Region 11

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	2.2	Low
A4	Stendal-Haymond-Wakeland-Nolan	26.0	Low	2.5	Low
E4	Fox-Ockley-Westland	37.0	Medium	5.7	Medium
E5	Parke-Negly	464.0	Very High	4.5	Low
G	Princeton-Bloomfield-Ayshine	76.0	Medium	5.0	Medium
I3	Fincastle-Ragsdale	20.0	Low	5.4	Medium
J3	Crosby-Brookston	18.0	Low	3.9	Low
L4	Miami-Crosby-Brookston	62.0	Medium	7.8	Medium
L5	Miami-Hennepin-Crosby	161.0	High	9.6	High
L6	Miami-Russell-Fincastle-Ragsdale	103.0	High	12.5	High
N1	Bartle-Peoga-Dubois	70.0	Medium	4.6	Medium
N3	Avonburg-Clermont	32.0	Medium	4.6	Low
O3	Cincinnati-Vigo-Ava	269.0	High	5.7	Medium
O4	Cincinnati-Rossmoyne	275.0	High	10.4	High
P	Wellston-Zanesville-Berks	457.0	Very High	12.5	High
Q2	Crider-Hagerstown-Bedford	213.0	High	10.3	High
R1	Berks-Gilpin-Weikert	469.0	Very High	5.3	Medium

Region 12

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A1	Genesee-Eel-Shoals	16.0	Low	3.8	Low
A4	Stendal-Haymond-Wakeland-Nolan	26.0	Low	2.6	Low
N3	Avonburg-Clermont	32.2	Medium	3.9	Low
O4	Cincinnati-Rossmoyne	275.0	High	15.7	Very High
R3	Edin-Switzerland	741.0	Very High	24.9	Very High

Region 13A

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A3	Sloan-Ross-Vincennes-Zipp	14.0	Low	4.5	Low
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	3.7	Low
C3	Lyles-Ayrshine-Princeton	12.0	Low	4.1	Low
D2	Patton-Lyles-Henshaw	15.0	Low	3.5	Low
E2	Elston-Shipshe-Warsaw	16.0	Low	4.8	Low
G	Princeton-Bloomfield-Ayrshine	76.0	Medium	6.7	Medium
H	Alford	169.0	High	10.8	High
I4	Reesville-Ragsdale	26.0	Low	5.7	Medium
I5	Ava-Vigo	28.0	Low	5.2	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	6.1	Medium
O1	Hosmer	143.0	High	12.9	Medium
O3	Cincinnati-Vigo-Ava	279.0	High	10.5	Medium
P	Wellston-Zanesville-Berks	457.0	Very High	12.1	Medium
Q1	Crider-Bedford-Lawrence	181.0	High	11.9	Medium
Q2	Crider-Hagerstown-Bedford	213.0	High	13.0	Medium
Q3	Crider-Baxter-Corydon	235.0	High	14.5	Medium
R1	Berks-Gilpen-Weikert	469.0	Very High	4.6	Low
R2	Corydon-Weikert-Berks	669.0	Very High	12.5	Medium

Region 13B

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A3	Sloan-Ross-Vincennes-Zipp	14.0	Low	3.8	Low
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	3.4	Low
D2	Patton-Lyles-Henshaw	15.0	Low	5.0	Medium
D3	Zipp-Markland-McGary	50.0	Medium	5.8	Medium
G	Princeton-Bloomfield-Ayrshine	76.0	Medium	9.1	Medium
H	Alford	169.0	High	16.9	Very High
I4	Reesville-Ragsdale	26.0	Low	6.4	Medium
N1	Bartle-Peoga-Dubois	70.0	Medium	10.9	High
N2	Weinbach-Wheeling	32.0	Medium	7.7	Medium
O1	Hosmer	143.0	High	10.7	High
O2	Zanesville-Wellston-Tilsit	307.0	High	11.3	High

Region 14

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	3.2	Low
N3	Avonburg-Clermont	32.0	Medium	4.7	Low
O4	Cincinnati-Rossmoyne	275.0	High	9.5	Medium
P	Wellston-Zanesville-Berks	457.0	Very High	15.3	Very High
Q1	Crider-Bedford-Lawrence	181.0	High	13.5	High
Q2	Crider-Hagerstown-Bedford	213.0	High	9.1	Medium
Q3	Crider-Baxter-Corydon	235.0	High	14.5	High
R1	Berks-Gilpen-Weikert	469.0	Very High	5.6	Medium
R2	Corydon-Weikert-Berks	669.0	Very High	4.2	Low
R3	Edin-Switzerland	741.0	Very High	6.2	Medium

Region 15

	Soil Association	Potential (tons/acre/yr.)	P-Rating	Gross (tons/acre/yr.)	G-Rating
A4	Stendal-Haymond-Wakeland-Nolin	26.0	Low	2.9	Low
D3	Zipp-Markland-McGay	50.0	Medium	6.1	Medium
H	Alford	169.0	High	16.8	Very High
N1	Bartle-Peoga-Dubois	70.0	Medium	6.8	Medium
N2	Weinbach-Wheeling	32.0	Low	6.5	Medium
O1	Hosmer	143.0	High	11.9	High
O2	Zanesville-Wellston-Tilsit	307.0	High	10.7	High
P	Wellston-Zanesville-Berks	457.0	Very High	8.4	Medium
Q1	Crider-Bedford-Lawrence	181.0	High	7.7	Medium
Q2	Crider-Hagerstown-Bedford	213.0	High	6.6	Medium
Q3	Crider-Baxter-Corydon	235.0	High	8.4	Medium

*Developed by Soil and Water Conservation Committee (SWCC).

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