ASSESSMENT OF WATER QUALITY AT SELECTED SITES IN THE WHITE RIVER BASIN, INDIANA, 1993 AND 1995 USING BIOLOGICAL INDICES

USGS

U.S. Department of the Interior—U.S. Geological Survey

As part of the National Water Quality Assessment (NAWQA) Program, fish communities were sampled at 11 sites in the White River Basin, Indiana, in 1993 and 1995 to help determine water-quality conditions. Ninety-one species of fish with representatives from 18 families were collected in the basin. Total numbers of fish collected at every site increased between collection years. The Index of Biological Integrity (IBI) and Qualitative Habitat Evaluation Index (QHEI) were calculated for all 11 sites in 1995. The QHEI scores indicated six sites had excellent habitat to support fish communities. Only three sites were rated in the "good" to "excellent" IBI water-quality categories, indicating some type of nonhabitat environmental degradation to the fish communities. Eight of the sites were rated in the "fair," "poor," or "very poor" IBI water-quality categories.

INTRODUCTION

In 1991, the U.S. Geological Survey began the National Water-Quality Assessment (NAWQA) Program. The long-term goals of the NAWQA Program are to describe the status and trends in the quality of a large, representative part of the Nation's surface- and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources (Hirsch and others, 1988).

The NAWQA Program uses an integrated approach to assess water quality. Multiple lines of evidence, including physical, chemical, and biological information, are collected to determine water-quality conditions at each site (Gurtz, 1994). This integrated approach is important because chemical monitoring alone can miss impacts such as habitat degradation, flow alterations, and heated effluent that can greatly influence the integrity of biological communities in streams (Gurtz, 1994).

A fish community is a group of interacting fish species that inhabit the same area. Fish communities reflect water-quality conditions in a stream because they are sensitive to a wide variety of environmental factors including habitat degradation, siltation, pesticides, nutrients, and change in flow regimes. The structure of the fish communities, including the types and numbers of species present and the age and health of the fish populations, can help investigators to determine the water quality of the stream. For example, warm-water streams in Indiana that contain great numbers of species typically indicate better water quality than a stream with fewer species.

DESCRIPTION OF THE WHITE RIVER BASIN

The White River Basin is part of the Mississippi River system and drains 11,350 square miles of central and southern Indiana (fig. 1). The White River is composed of two nearly equal-sized subbasins. The eastern part of the basin drains into the East Fork White River, and the western part of the basin drains into the main stem of the White River. The main stem and east fork converge near Petersburg, Ind., and flow 50 miles to the White River's confluence with the Wabash River in southwestern Indiana. Agriculture is the primary land use, with approximately 50 percent of the land used for cultivation of corn and soybeans. Indianapolis is the largest urban area and accounts for nearly 60 percent of a total basin population of 2.1 million.

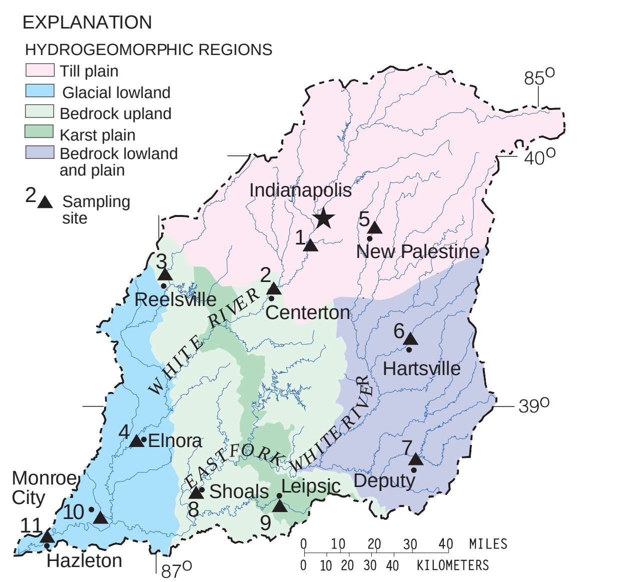

Figure 1. Location of sampling sites and hydrogeomorphic regions in the White River Basin, Indiana.

STUDY APPROACH

Fish communities were studied at 11sites in the White River Basin. The sites were selected to represent the different hydrogeomorphic regions and land uses in the basin (fig. 1 and table 1). A reach of the stream at each of the 11sites in the White River Basin was sampled between late June and early September 1993 and again in July and August 1995. Stream reaches were selected at each site on the basis of the width of the stream and the geomorphic channel units (pools, riffles, and runs). Reaches were selected at wadable sites to include as many different geomorphic channel units as possible within a 150-500 meter (m) length. In streams where repeating geomorphic channel units were not present, the length of the sampling reach was 20 times the channel width. A maximum reach length criterion of 1,000 m was used for nonwadable reaches (Meador and others, 1993). Fish were collected using Direct Current (DC) pulse electroshocking techniques, following NAWQA protocols (Meador and others, 1993). In 1993, a backpack electroshocker was used for sampling at wadable sites. In 1995, a tote barge electroshocker was used at wadable sites. A specially equipped shocking boat with a spherical ball anode was used at nonwadable sites in both years. Fish were

Table 1. Sampling site, drainage area, and land use at White River Basin sampling sites.

[boat sites in **bold font,** wadable sites in plain font, headwater site in *italics*]

Sampling site number (fig. 1), site name, and site abbreviation	Drainage area (square miles)	Land use (percent)			
		Urban	Agri-culture	Forest	Other
1. *Little Buck Creek near Indianapolis* (Buck)	17.0	57	42	< 1	< 1
2. **White River near Centerton** (Cent)	2,444	18	78	3	1
3. Big Walnut Creek at Reelsville (Wal)	318	1	83	15	1
4. **White River near Elnora** (Eln)	4,793	8	71	19	2
5. Sugar Creek near New Palestine (Sug)	93.4	3	95	1	1
6. Clifty Creek near Hartsville (Clif)	87.9	< 1	98	1	< 1
7. Muscatatuck River near Deputy (Musc)	293	4	71	24	1
8. **East Fork White River at Shoals** (Shoal)	4,927	5	69	25	1
9. Lost River near Leipsic (Lost)	34.8	< 1	94	5	< 1
10. Kessinger Ditch near Monroe City (Kess)	56.2	< 2	94	4	< 1
11. **White River at Hazleton** (Haz)	11,305	7	69	22	2

Table 2. Index of Biological Integrity (IBI) metrics from Ohio Environmental Protection Agency (1989). Metrics apply to stream types in parentheses.

[H - headwater sites; W - wadable sites; B - boat sites; DELT - Deformities, Eroded fins, Lesions, and Tumors].

1. Total number of native species (H,W,B)	6. Percentage of tolerant species (H,W,B)
2. Number of darter species (H,W)	7. Percentage of omnivores (H,W,B)
2. Percentage of round-bodied suckers (B)	8. Percentage of insectivores (H,W,B)
3. Number of sunfish species (W,B)	9. Percentage of top carnivores (W,B)
3. Number of headwaters species (H)	9. Percentage of pioneering species (H)
4. Number of sucker species (W,B)	10. Number of individuals (H,W,B)
4. Number of minnow species (H)	11. Percentage of simple lithophils (W,B)
5. Number of intolerant species (W,B)	11. Number of simple lithophil species (H)
5. Number of sensitive species (H)	12. Percentage of DELT anomalies (H,W,B)

identified to species level in the field if possible or in the laboratory by Michael J. Lydy and Jeffrey W. Frey, U.S Geological Survey, Indianapolis, Indiana. Vouchers and pictures were kept for quality assurance. Taxonomic verifications were conducted by Thomas P. Simon, U.S. Environmental Protection Agency, Chicago, and James R. Gammon, DePauw University, Greencastle, Ind. The voucher collection is located at the U.S Geological Survey office in Indianapolis.

Index of Biological Integrity (IBI) scores, which use fish population information to determine water-quality conditions, were calculated for each site from fish data collected in 1993 and 1995 following Ohio Environmental Protection Agency (1987) guidelines. The IBI assumes that different fish communities exist in degraded waters compared to waters that have not been degraded. The IBI combines 12 measures of fish-community structure and function called “metrics” (table 2). The metrics are designed to provide information by comparing the sampled community to a reference or minimally affected community. Ratings are assigned to each metric on the basis of expected values derived from reference conditions. The greater the deviation between the reference and the sampled community, the lower the rating for each metric. The IBI score is the sum of all 12 metrics. Because different fish communities inhabit different sized streams, different metrics are used depending on whether the stream is a headwater, wadable, or boat site (table 2). The IBI scores then can be classified by an integrity rating with a range of “excellent” to “very poor” to indicate the water quality of the stream (table 3). The maximum IBI score is 60; high scores indicate better water quality than lower scores.

The Qualitative Habitat Evaluation Index (QHEI) is an index tool similar to the IBI in which selected habitat characteristics that affect fish communities are rated and then combined into a total score. The metrics for the QHEI are not included in this text because of space limitations, but a full description is given in Ohio Environmental Protection Agency (1989). The QHEI is designed to evaluate the quality of the habitat available to fish and other biota in the stream. The maximum QHEI score is 100. QHEI scores were calculated from habitat data collected in 1995.

FINDINGS

Ninety-one species with representatives from 18 families of fish were collected within the basin (Baker and Frey, in press). Descriptions of the fish communities at each site are listed in table 4. Information on numbers of fish species, standardized number of fish caught per site, and IBI scores are shown in figure 2. Total numbers of fish collected increased at every site between 1993 and 1995. IBI scores for all of the boat sites in 1993 were very poor, mostly because of the low numbers of fish caught. Factors other than water quality (such as streamflow, sampling technique, and natural shifts in the fish-community structure) affect the number and type of fish caught. The number and type of fish caught, in turn, influence the IBI rating for the site and alter the assessment of water quality.

Table 4. Description of fish communities collected at White River Basin sites in 1993 and 1995. Families are used when large numbers of several species from the same family are present at the site.

Site name	Year	Predominant fish species / families
Little Buck Creek near Indianapolis	1993	stoneroller, creek chub, green sunfish
	1995	stoneroller, sand shiner, creek chub, bass
Lost River near Leipsic	1993	longear sunfish, rock bass, stoneroller, striped shiner
	1995	longear sunfish, striped shiner, stoneroller, rock bass, sculpin
Kessinger Ditch near Monroe City	1993	green and longear sunfish, shad, minnow
	1995	silvery minnow, bluegill, longear and green sunfish, catfish
Sugar Creek near New Palestine	1993	bass, longear sunfish, minnow, redhorse, darter
	1995	bass, striped shiner, minnow, sunfish, hogsucker, redhorse, darter
Clifty Creek at Hartsville	1993	minnow, longear sunfish, hogsucker, redhorse, bass, darter
	1995	minnow, river chub, hogsucker, redhorse, bass, rock bass, darter
Muscatatuck River near Deputy	1993	bluegill, sunfish, bluntnose minnow, redhorse, bass, darter
	1995	longear sunfish, bluegill, bass, redhorse, darter
Big Walnut Creek at Reelsville	1993	bass, minnow, redhorse
	1995	bass, spotfin shiner, minnow, hogsucker, redhorse, darter, sunfish
White River at Centerton	1993	shad, carp, catfish
	1995	spotfin shiner, minnow, bass, sunfish, redhorse, carpsucker
White River near Elnora	1993	carpsucker, gar, flathead catfish
	1995	silvery minnow, spotfin shiner, carpsucker, gar, shad, drum
East Fork White River at Shoals	1993	shad, longear sunfish, bass, buffalo
	1995	shad, longear sunfish, bass, redhorse
White River at Hazleton	1993	gar, drum, carpsucker
	1995	shad, silvery minnow, steelcolor shiner, drum, carp

Table 3. Integrity rankings for the Index of Biological Integrity (IBI)(Karr, 1981).

IBI score	Integrity ranking	Attributes
58-60	Excellent	Comparable to the best situation without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially because of the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some sign of stress.
40-44	Fair	Signs of some additional deterioration include loss of intolerant forms; fewer species; highly skewed trophic structure (increasing frequency of omnivores and other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very poor	Few fish present, mostly introduced or tolerant forms; hybrids common; other anomalies regular

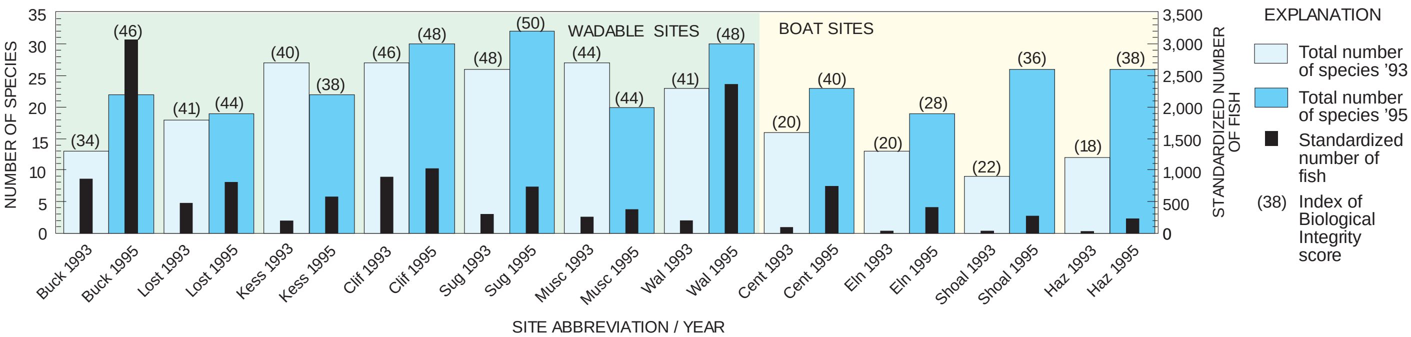

Figure 2. Number of species, standardized numbers of fish caught, and Index of Biological Integrity scores for sites in the White River Basin, 1993 and 1995. [Wadable sites standardized to fish caught per 300 meters, boat sites to fish caught per 1,000 meters; '93, 1993; '95, 1995]

Physical Factors Influencing IBI Scores

Differences in stream water levels caused by rainfall runoff affected the numbers of fish caught and the IBI scores between collection years. High water levels decrease the efficiency of electroshocking by 1) decreasing the specific conductance of the water, which reduces the effectiveness of the shocking equipment; 2) increasing the suspended solids, which makes it difficult to see and capture stunned fish; and 3) increasing the velocity of the stream, which makes capture more difficult because stunned fish are carried downstream more rapidly. The lower water level in 1995 accounts for the dramatic increase in fish caught at Big Walnut Creek that year (fig. 2). Low water levels in 1995 concentrated the fish and made collection more effective, compared to the high water levels in 1993 (fig. 3). The high water levels in 1993 at the four boat sites (White River at Centerton, near Elnora, at Hazleton, and East Fork White River at Shoals) also contributed to the low number of fish caught; average streamflow during the 8 days prior to collection in 1993 was from 77 to 241 percent greater than in 1995.

Differences in shocking efficiency between the backpack and tote barge shocking units affected the total numbers of fish caught and the IBI scores for 1993 and 1995. Total numbers of fish caught increased at all wadable sites in 1995 compared to 1993 (fig. 2); five of the seven sites had increases of greater than 75 percent in fish caught. Other factors, such as differences in water levels, contribute to the increased numbers of fish caught, but the magnitude of the increases suggest the tote barge was more efficient than the backpack unit for fish collection. At Little Buck Creek, Kessinger Ditch, and Sugar Creek, which had similar average flow for the 8 days prior to collection for both years, numbers of fish caught increased by 265, 111, and 135 percent, respectively.

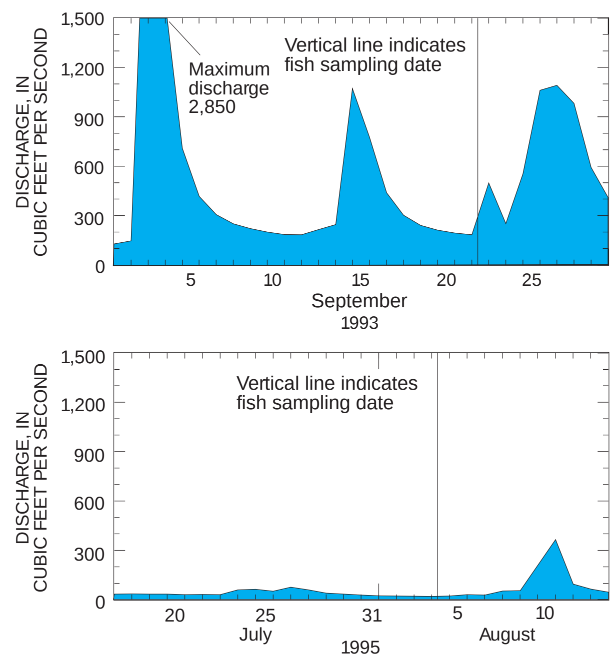

Figure 3. Discharge at Big Walnut Creek near the fish sampling date in 1993 and 1995.

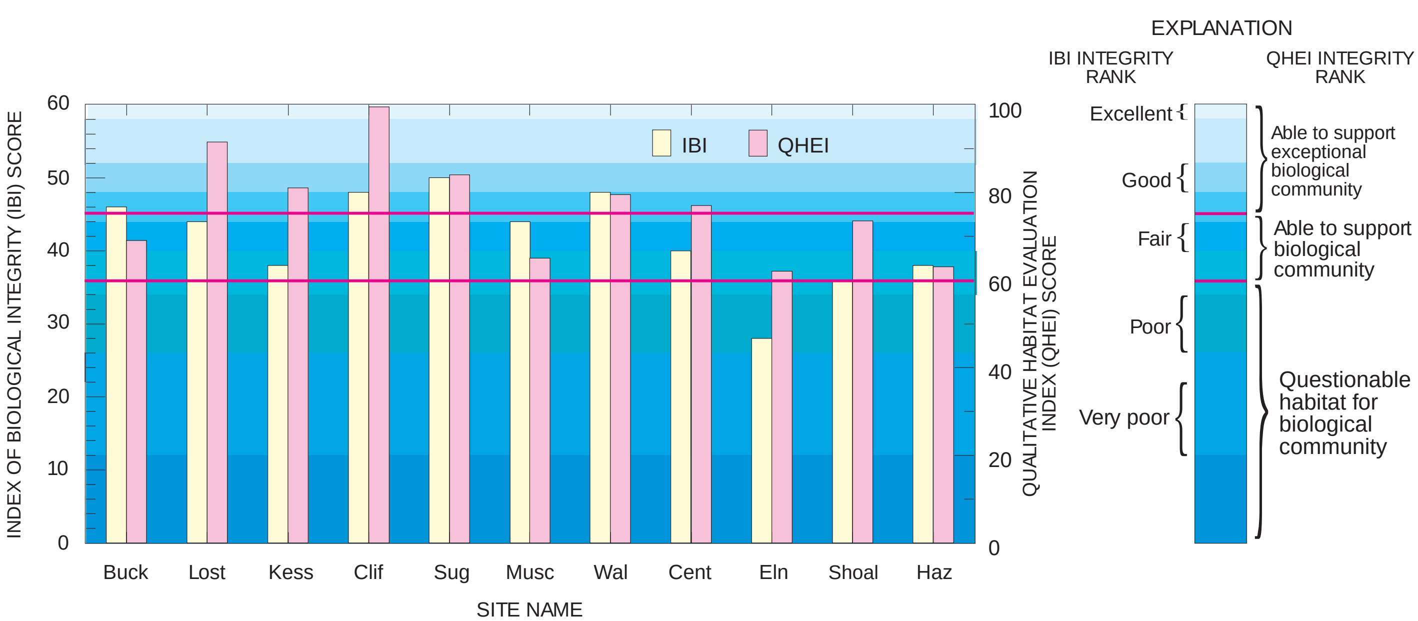

Figure 4. Index of Biological Integrity (IBI) and Qualitative Habitat Index (QHEI) scores for sites in the White River Basin in 1995. [IBI scores that fall between IBI integrity rankings (excellent to very poor) have attributes from both integrity rankings (table 3)].

Water-Quality Factors Influencing IBI Scores

IBI and QHEI scores and their corresponding integrity rankings for the White River Basin sites in 1995 are presented in figure 4. IBI scores for the White River Basin sites in 1993 and 1995 are shown in parentheses in figure 2. Of the six sites with exceptional QHEI scores, only three had "good" IBI integrity ratings indicating that water quality, and not habitat, limited the integrity of the fish community. Eight of the sites were rated in the "fair" to "very poor" IBI integrity classes.

Sites with higher QHEI scores (better fish habitat) generally had higher IBI scores (fig. 4). Different species require different types of habitat. For example, greenside darters have specific habitat requirements; they are found in riffles with rocky bottoms and fast currents in small to medium sized streams. Adequate habitat and cover are necessary for the protection and survival of fish communities. When erosion occurs, siltation increases and clogs riffles, resulting in a decrease in darter habitat. Likewise, when riparian zones along rivers are removed and the source for fallen logs disappears, populations of longear sunfish, smallmouth bass, and other species that rely on the fallen logs for protection from birds and other fish decline. The better habitat is reflected in the higher IBI scores at the sites with the higher QHEI scores (Sugar Creek, Clifty Creek, and Big Walnut Creek).

Changes in fish community composition accounted for changes in IBI scores at some sites. Individual IBI metrics can be examined to explain IBI scores that are much lower than their corresponding QHEI scores. For example, some species cannot tolerate many human impacts and, as water quality declines, these species are the first to disappear. Although the types of intolerant species may vary with region or environmental conditions, the presence of intolerant species, such as darters and redhorses at Sugar Creek and Clifty Creek, typically is an indicator of good water quality at these streams (fig. 5). Likewise, as these intolerant species disappear, more tolerant species such as green sunfish and white suckers increase in number. The influx of intolerant species at Little Buck Creek in 1995 and the corresponding decrease in tolerant species helps account for the 12-point increase in the IBI score and indicates water quality may be improving.

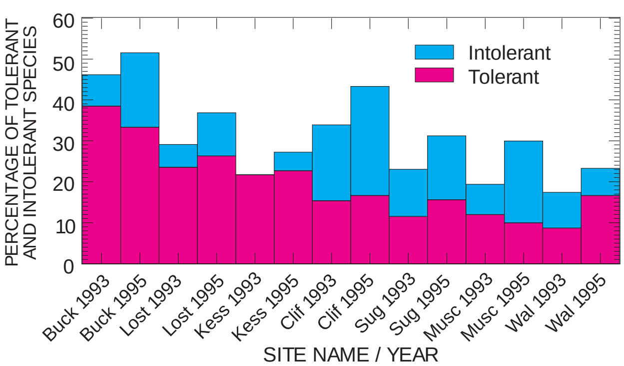

Figure 5. Percentage of tolerant and intolerant species at wadable sites in the White River Basin, 1993 and 1995.

The greatest discrepancy at wadable streams between sites with high QHEI scores and the corresponding IBI scores occurred outside the till plain. A high QHEI score for a given site suggests that, given all other factors being equal, the site should also have a high IBI score. A lower than expected IBI score, based upon the QHEI score, suggests non-habitat stresses such as poor water quality may be affecting the community populations. Clifty Creek, Lost River, Sugar Creek, Kessinger Ditch and Big Walnut Creek should support exceptional biological communities, on the basis of their QHEI scores (figure 4). Of these five sites, however, only Sugar Creek, Big Walnut, and Clifty Creek had an IBI rating of "good" for 1995. Even though Clifty Creek had a good rating, the IBI score was lower than expected because it had a near maximum QHEI score. Kessinger Ditch and Lost River also showed large differences between their IBI scores and their QHEI scores (fig. 4). One explanation for these trends could be differences in runoff rates. Sugar Creek and Big Walnut Creek flow through the till plain region, whereas Lost River (in the karst plain) and Clifty Creek (in the bedrock lowland and plain) flow through the bedrock regions. Streams flowing through bedrock areas (the bedrock uplands, bedrock lowland and plain, and karst plain regions) typically have higher runoff and lower base flows than streams flowing through the glacial materials (Carter and others, 1995). Runoff transports pesticides, nutrients, and sediment that can be harmful to fish communities. Another factor that could explain the trend of better water quality in the till plain is the difference in permeability of surficial geologic materials in the hydrogeomorphic regions. The more permeable deposits of the glacial lowland region permit quicker transport of pesticides and nutrients to streams than do deposits in the till plain. Kessinger Ditch flows through the glacial lowland region, and the highest pesticide concentrations were found there (Crawford, 1996). Further study is needed to confirm this finding, however, the lower IBI scores for sites outside of the till plain region indicate a possible hydrogeomorphic regional affect.

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Prepared by

J.W. Frey, N.T. Baker, M.J. Lydy, and W.W Stone

For more information, contact:
Project Chief
White River Basin Study
U.S. Geological Survey
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996
317-290-3333