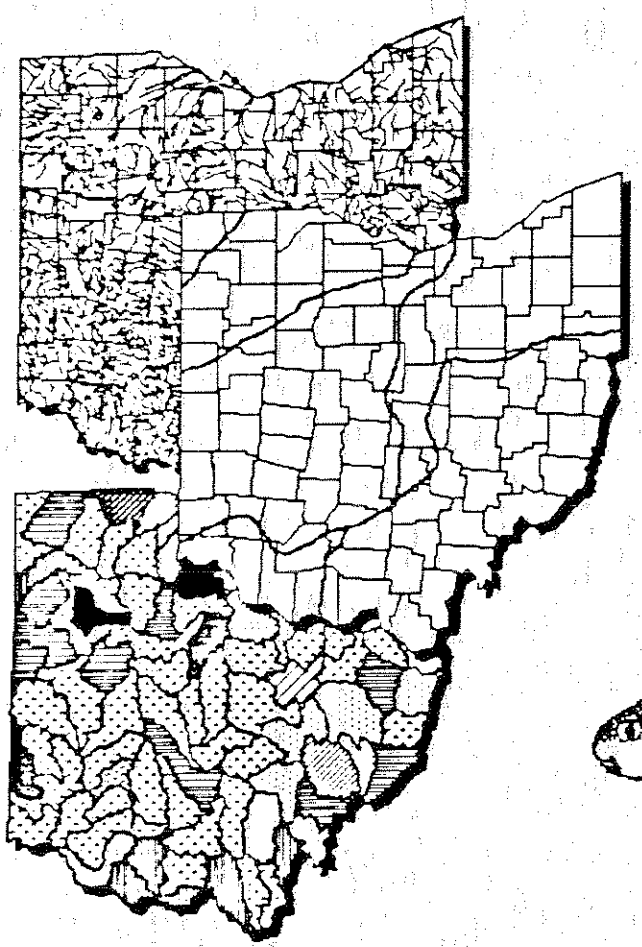
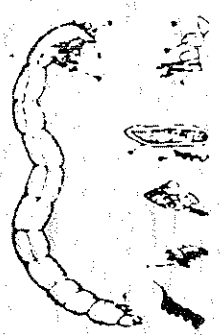
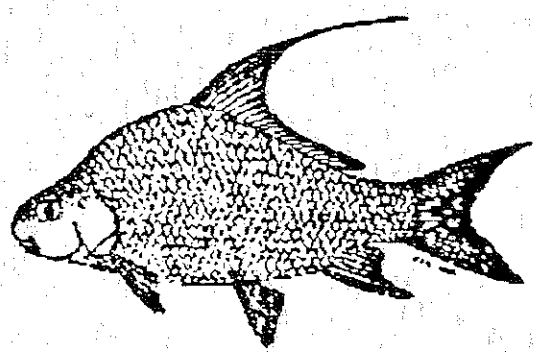
State of Ohio
Environmental Protection Agency

Ecological Assessment Section
Division of Water Quality
Planning & Assessment

1990 Biological and Water Quality Study of the Stillwater River Basin (Darke, Miami, and Montgomery Counties, Ohio) and Trend Assessment: 1982 to 1990







May 22, 1991

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

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This evaluation and report would not have been possible without the assistance of numerous other full and part time Ohio EPA staff. We also thank land owners who provided access and James Surber and Paul Johnson for information on stream channel modifications in Darke and Miami Counties.

Based on the results of the 1990 monitoring effort, the following conclusions and recommendations are made for the Stillwater River Basin.

CONCLUSIONS

* The 1990 results show improved water quality and biological conditions within the basin since 1982. Improvements are primarily attributed to reduced pollutant loadings from upgraded municipal wastewater treatment plants (WWTPs) and have resulted in more miles attaining existing aquatic life use designations. Since 1982, the aquatic life use attainment status of the Stillwater River, Greenville Creek, Painter Creek, and Swamp Creek (combined) has changed from 7.5 to 25.8% of the miles attaining, 44.7 to 60.1% of the miles partially attaining, and 47.8 to 14.1% of the miles not attaining. Further improvements are expected following recent and future upgrades.

* During 1990, the Stillwater River basin had relatively good surface water quality, except for consistently high fecal coliform bacteria levels and episodic elevations of nutrients which were primarily attributed to livestock and poultry operations. Chemical sediment quality in the basin appeared to be very good (results from four streams sampled during 1986 and 1990 show no contamination by heavy metals). Aquatic macroinvertebrate assemblages also reflected good water quality throughout most of the watershed. Of the 44 locations sampled (eight streams), 61% of the assemblages were considered exceptional, 14% very good, 11% good, 9% marginally good, 2% fair, and 2% poor. Fish assemblages reflected more impacted conditions due primarily to widespread channelization in Darke County. Of the 50 locations sampled, only 25% of the fish index values were considered exceptional, 14% very good, 15% good, 17% marginally good, 23% fair, and 7% poor.

* The 1990 aquatic life attainment status within the Stillwater Basin (41 locations in eight streams with both macroinvertebrate and fish data; includes recommended use changes) was 44% FULL attainment, 51% PARTIAL attainment, and 5% NON attainment. Causes of the PARTIAL and NON attainment were attributed to point source pollution (enrichment from WWTP discharges and CSOs), habitat alterations (channelization and impoundment), and nonpoint source pollution (runoff from animal husbandry operations and possibly failing on-site septic systems). The principal receiving stream for the basin, the Stillwater River, was the highest quality stream in the study area.

* Survey results showed no evidence of acute toxicity in the mixing zone or downstream from the **Englewood WWTP** discharge. The discharge appeared to have a slight impact on macroinvertebrates (organic enrichment), but did not impair the aquatic life use (EWH) of the Stillwater River. Fish assemblages showed no negative impacts in the mixing zone or at river mile (RM) 8.4. Bioassay test results from five different time periods during 1989 and 1990 have shown variability in effluent toxicity. ENSR Consulting and Engineering results showed acute and chronic toxicity to *Ceriodaphnia*, but no toxicity to fathead minnows. Ohio EPA acute toxicity tests showed no toxicity to *Ceriodaphnia*, but acute toxicity (composite effluent sample) during one of four periods to fathead minnows. Partial attainment between RM 5.0 and 1.2 is attributed to sanitary sewer overflow impacts.

* Water quality and biological results showed no acute toxicity in the mixing zone or downstream from the **Greenville WWTP**. Macroinvertebrate and fish assemblages were impaired, however, downstream from the discharge. A second discharge, comprised of effluents from BASF and Corning Glass, which also enters on the opposite bank may also be contributing to the impairment. Macroinvertebrates declined from exceptional to very good quality with compositional changes attributed to organic enrichment. Fish assemblages exhibited a greater impact and declined from marginally good/fair to poor/fair quality between the mixing zone and RM 14.3. Recent bioassay test results of the Greenville WWTP from two different time periods have shown no acute toxicity to fathead minnows or *Ceriodaphnia*.

* Nonpoint source pollution has reportedly killed more fish and other aquatic life than point source discharges within the basin during the previous eight years. Water Pollution Fish Kill and Stream Litter Investigation Reports

compiled by the ODNR, Div. of Wildlife show manure, as the suspected pollutant from animal husbandry operations, to be a significant negative impact on aquatic life within the basin. Between 1983 and 1987, six separate investigations were conducted in Darke County resulting in a total reported kill (primarily fish) of 130,432 animals.

* Dredging, straightening, and the removal of woody riparian vegetation are common stream management practices throughout the watershed that negatively impact aquatic life and have significantly reduced the aquatic life use potential of many streams within the Stillwater River basin.

RECOMMENDATIONS

Aquatic Life Use Designations: Recommended Changes

1. **Stillwater River (EWH)** The segment upstream from RM 57.0 (Beisner Rd.bridge) should be changed from EWH to WWH due to previous channel modifications which have resulted in lower physical habitat quality and non attainment of EWH biocriteria by fish assemblages.
2. **North Fork Stillwater River (WWH)** The North Fork should be redesignated Modified Warmwater Habitat (MWH) due to extensive channel modification and an on-going maintenance program. Physical habitats are predominated by MWH attributes, including a low gradient, which precludes attainment of the WWH use.
3. **Swamp Creek (WWH)** Due to extensive channel modification and the on-going maintenance program, Swamp Creek upstream from RM 6.5 (Pittsenbarger Rd.) should also be redesignated Modified Warmwater Habitat (MWH). At RM 8.8, the ditch is predominated by modified habitat attributes, has a QHEI of 28, and supports a poor quality fish assemblage.
4. **Painter Creek (EWH)** Painter Creek upstream from RM 5.5 (Darke Co. line) should also be changed to Modified Warmwater Habitat (MWH) due to extensive channel modifications and the on-going maintenance program. Within Darke County, the ditch has a mean QHEI of 44, a gradient of 3.4 feet/mile, and fish assemblages of fair to poor quality.

Aquatic Habitats and Nonpoint Source Runoff

1. Consideration should be given by County Engineers to modifying and where possible, reducing or eliminating existing channel maintenance programs which adversely affect the quality of surface waters within the basin. Ohio EPA recommends a full review of any existing maintenance or new channel modification programs on named streams to insure that the drainage benefits are commensurate with the environmental damage.
2. Control measures should be implemented by animal husbandry operations to prevent future fish kills and excessive pollutant loadings. Livestock access to streams should be minimized.
3. The status of failing on-site septic systems within the watershed should be determined and improved.
4. Where ever possible, consideration should be given to the removal of low-head dams in the Stillwater River and Greenville Creek.

Recommended Monitoring for Basin Year 1995 (or sooner, time and resources permitting)

1. Follow-up monitoring should be conducted in Ballinger Run to evaluate Combined Sewer Overflow (CSO) discharges by the City of Bradford.
2. Swamp Creek sites should be resampled to evaluate possible biological improvement(s) associated with the proposed watershed program (SCS/ASCS), if funded.
3. The source of the elevated copper concentration in the North Fork should be investigated.
4. Recent and future WWTP upgrades should be assessed for additional recovery not detected by this survey.
5. Monitoring should be conducted in Sycamore Ditch to further assess and differentiate impacts from the Arcanum WWTP and Arcanum Iron and Metal Company.
6. Monitoring should be conducted in Bridge Creek to assess impacts from dischargers and the sludge site/landfill.
7. The discharge to Greenville Creek, comprised of effluents from BASF and Corning Glass, should be

evaluated for whole effluent toxicity and chemical-specific characteristics.

INTRODUCTION

Ohio EPA conducted its first comprehensive water quality survey of the Stillwater River Basin during the summer of 1982. OEPA (1986) reports the findings of this survey and is referenced for additional information. Since 1982, additional pollution abatement measures were implemented in the basin including: in 1983 Union City WWTP eliminated a discharge to Dismal Creek and a major upgrade occurred at the Union WWTP; in 1986 Ansonia WWTP added an aerater; in 1987 Arcanum added lagoons and a pump station; and in 1988 major upgrades occurred at the Greenville and Englewood WWTPs. Improvements were also recently made to Versailles CSOs. Future upgrades are planned for the Union WWTP during 1991 and the Versailles WWTP and West Milton WWTP during 1992.

During the summer of 1990, OEPA staff returned to the Stillwater River Basin and sampled water chemistry at 39 locations, performed water quality modeling at nine locations, effluent chemistry at two discharges, sediment chemistry at two locations, organic water chemistry at eight locations, macroinvertebrates at 44 locations, and fish at 50 locations (Table 1).

1990 study objectives were to:

* monitor and assess potential impacts from point and nonpoint source pollution,
* evaluate existing aquatic life use designations,
* provide support for Water Quality Based Effluent Limit (WQBEL) reports for the Englewood and Greenville WasteWater Treatment Plant (WWTP) National Pollution Discharge Elimination System (NPDES) permits,
* evaluate the current aquatic life attainment status of existing and recommended aquatic life use designations and characterize the quality of surface waters within the basin,
* determine if ambient conditions have improved since 1982 with the implementation of additional pollution control strategies within the Stillwater River basin.

The findings of this evaluation may factor into regulatory actions taken by the agency (e.g. WQS, NPDES permits) and eventually be incorporated into the State water quality management plans and biennial 305(b) report.

STUDY AREA

The Stillwater River watershed drains 673.2 square miles and is located in the Eastern Corn Belt Plains ecoregion. It covers the majority of Darke County, the western side of Miami County, and a small portion of Montgomery County from below West Milton to the confluence with the Great Miami River in Dayton. A small portion of the watershed is also located in Indiana. Major tributaries include Greenville Creek, Painter Creek, Ludlow Creek, Swamp Creek, and North Fork Stillwater River. Most of the streams in the watershed have Warmwater Habitat (WWH) aquatic life use designations except for Painter Creek, Greenville Creek, and the mainstem of the Stillwater which have been designated Exceptional Warmwater Habitat (EWH). Additionally, the Stillwater River from Riffle Rd. to the Englewood Dam (RM 55.9 to 9.0) and Greenville Creek from State Line Rd. to the confluence with the Stillwater River (RM 34.5 to 0.0) have been designated Scenic Rivers by the Ohio Department of Natural Resources (ODNR) which qualifies them as State Resource Waters (SRW) in Ohio Water Quality Standards. The Stillwater River downstream from the Englewood Dam is designated Recreational.

Land uses in the watershed are predominantly agricultural with 90% of the land used for farming.

Harvested cropland accounts for 79% of the total area. Darke county is also consistently in the top ten counties in Ohio for animal production. The 1987 Census of Agriculture reported more than 5.3 million chickens in Darke County alone. Other livestock operations are swine and dairy (MVRPC, 1987) This level of agricultural land use creates a number of nonpoint source problems from croplands (sediments, nutrients and pesticides) and livestock (nutrients and sediment). Disposal of animal wastes requires extensive land areas for spreading to ensure that runoff will not cause water quality problems. Many smaller streams have been channelized and deepened to assist in drainage from cropfields.

Most industry in the watershed is light manufacturing with Greenville having the greatest concentration. Most point source dischargers are sewage treatment plants for the cities and villages. Greenville and Englewood are the large dischargers with the villages of West Milton, Covington, Bradford, Versailles, Ansonia, Arcanum, Pleasant Hill, and Union also having treatment plants. Smaller villages (pop. <1,000) are scattered throughout the watershed and mainly served by on-site septic systems.

Landforms have been shaped by glaciation which left flat to gently rolling terrain, one or more buried valley aquifers, glacial till and in some areas exposed limestone. Soils in the watershed tend to be neutral to slightly alkaline and drainage varies from well drained to very poorly drained depending on the parent material and topography.

METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the OEPA Manual of Surveillance Methods and Quality Assurance Practices (OEPA 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes II - III (OEPA 1987a, 1989b, 1989c), and Rankin (1989) for aquatic habitat assessment. Macroinvertebrates were sampled using quantitative (artificial substrates) and qualitative (natural substrates) techniques. Fish were sampled by electrofishing using the boat and wading methods.

Attainment/non-attainment of aquatic life uses is determined by using Ohio's biological criteria (OEPA 1987a, 1987b, 1989b, 1989c, 1990). The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (Mlwb), both of which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH]) and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes et al. 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981).

Attainment of an aquatic life use is FULL if all three indices meet the applicable criteria, PARTIAL if one or more attains and at least one does not attain, and NON if all three fail to meet the applicable criteria or when one organism group indicates poor or very poor performance, even if the other group is attaining the applicable criteria.

Table 1. List of OEPA sampling locations (water chemistry-C, modeling-M, effluent chemistry-E, sediment-S, organics-O, macroinvertebrate-B, and fish-F) in the Stillwater River Basin during 1990.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Stillwater River				
63.0	C,M,B,F	40 15 05 / 84 39 05	SR 49; ust. Ansonia	Rossburg
61.8	C	40 14 35 / 84 40 47	Zumbrum Rd.	Ansonia
58.0	M	40 13 10 / 84 37 48	Ust. N. Fork Stillwater	Ansonia
57.0	C,M,B,F	40 13 01 / 84 36 46	Beisner Rd.	Dawn
52.4	B,F	40 10 29/ 84 33 12	Steffen Rd.	Dawn
47.8	F	40 11 26 / 84 31 32	SR 121	Dawn
46.1	C	40 11 28 / 84 30 05	Boyer Rd.	Dawn
44.2	B	40 11 18 / 84 28 28	Ust. Barnes Rd.	Versailles
43.7	F	40 10 56 / 84 27 58	Ust. Seibt Rd.	Versailles
43.5	C,O	40 10 51 / 84 27 47	Seibt Rd.	Versailles
37.8	F	40 09 41 / 84 24 07	SR 185	Versailles
37.7	B	40 09 04 / 84 24 04	Dst. SR 185	Versailles
32.5	C	40 07 47 / 84 23 54	US 36	Pleasant Hill
32.1	C	40 06 53 / 84 21 25	Bridge St.	Pleasant Hill
31.2	F	40 06 11 / 84 21 21	Dst. Greenville Cr. & Covinton	Pleasant Hill
30.9	B	40 05 54 / 84 21 19	Ust. Falknor Rd.	Pleasant Hill
30.6	F	40 05 43 / 84 21 09	Falknor Rd.	Pleasant Hill
28.1	F	40 03 38 / 84 21 11	Ust. Lauver Rd.	Pleasant Hill
27.9	C,S,O	40 03 28 / 84 21 21	Lauver Rd.	Pleasant Hill
27.7	B	40 03 21 / 84 21 29	Dst. Lauver Rd.	Pleasant Hill
25.3	F	40 02 16 / 84 21 12	Ust. and dst. Penny Rd.	Pleasant Hill
25.2	B	40 02 13 / 84 21 10	Ust. PennyRd.	Pleasant Hill
25.1	C	40 02 13 / 84 21 10	Penny Rd.	Pleasant Hill
18.3	B	39 58 37 / 84 19 30	Dst. West Milton Dam	West Milton
18.2	C	39 58 33 / 84 19 29	Dst. West Milton Dam	West Milton
18.0	F	39 58 28 / 84 19 30	Dst. West Milton Dam	West Milton
16.5	C	39 56 56 / 84 18 51?	West Milton WWTP mixing zone	West Milton
16.4	B	39 57 03 / 84 19 02	Dst. West Milton WWTP	West Milton
16.0	F	39 56 48 / 84 18 44	Dst. West Milton WWTP	West Milton
12.2	B	39 54 34 / 84 17 52	Old Springfield Rd.	West Milton
11.5	F	39 54 00 / 84 17 43	Dst. Union WWTP, ust. Martindale Rd.	West Milton
11.4	C,B	39 53 54 / 84 17 33	Dst. Union WWTP, Martindale Rd.	West Milton
9.1	B	39 52 14 / 84 17 11	Ust. dam, ust. Englewood WWTP	Trotwood
9.0	F	39 52 09 / 84 16 56	Ust. dam, ust. Englewood WWTP	Trotwood
8.9	C,O	39 52 10 / 84 16 57	Ust. dam, ust. Englewood WWTP	Trotwood
8.8	C,E,O,B,F	39 52 05 / 84 16 51	Englewood WWTP mixing zone	Trotwood
8.6	C,O,B	39 52 05 / 84 16 41	Dst. Englewood WWTP	Trotwood
8.4	F	39 51 51 / 84 16 17	Dst. Englewood WWTP	Trotwood
5.0	C,F	39 50 09 / 84 14 02	Philadelphia Rd.	Dayton North
4.8	B	39 50 19 / 84 13 46	Adj. Frederick Pike	Dayton North
1.5	B	39 47 52 / 84 12 24	Dst. Siebenthaler Drive	Dayton North
1.2	F	39 47 40 / 84 12 19	Ust. mouth	Dayton North
Greenville Creek				
34.5	C	40 07 38 / 84 48 28	State Line Rd.	Union City
34.2	B,F	40 07 43 / 84 48 10	McClure Rd.	Union City
29.0	F	40 08 55 / 84 43 05	Ust. Fisher Rd.	Ansonia
28.9	C,B	40 08 55 / 84 43 56	Fisher Rd.	Ansonia
23.2	F	40 06 32 / 84 38 45	Ust. Daly Rd.	Greenville West
22.4	C	40 06 17 / 84 38 54	Old WTP intake	Greenville West
22.3	M,B	40 06 17 / 84 38 54	Old WTP	Greenville West
20.8	B	40 06 26 / 84 37 56	Treaty of Greenville Park	Greenville West

Table 1. continued.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
20.6	F	40 06 34 / 84 37 46	Treaty of Greenville Park	Greenville West
19.6	C,O,F	40 06 02 / 84 37 07	Ust. Greenville WWTP	Greenville East
19.5	M,B	40 06 01 / 84 37 05	Ohio Street	Greenville East
19.3	C,E,S,O,B,F	40 05 57 / 84 36 47	Greenville WWTP mixing zone	Greenville East
19.2	F	40 05 55 / 84 36 43	Dst. Greenville WWTP	Greenville East
19.1	B	40 06 00 / 84 36 38	Dst. Greenville WWTP	Greenville East
18.8	C,O	40 06 10 / 84 36 25	US 127	Greenville East
18.3	B	40 06 15 / 84 35 56	Jaysville Rd.	Greenville East
18.0	C,M	40 06 02 / 84 35 46	SR 36	Greenville East
17.3	F	40 05 44 / 84 35 14	Dst. Jaysvill Rd.	Greenville East
16.2	C,M,B	40 06 12 / 84 34 30	Willis Rd.	Greenville East
15.4	F	40 05 48 / 84 34 06	Dst. Willis Rd.	Greenville East
14.3	F	40 06 09 / 84 32 58	Bears Mill dam pool	Greenville East
13.7	M,B	40 06 29 / 84 32 30	Bears Mill Rd.	Greenville East
12.0	F	40 06 27 / 84 30 52	Dst. Bears Mill Dam	Greenville East
11.9	F	40 06 27 / 84 30 44	Dst. Bears Mill Dam	Greenville East
10.6	F	40 06 32 / 84 29 41	Ust. Gettysburg Rd.	Gettysburg
10.5	C,B	40 06 35 / 84 29 40	Gettysburg Rd.	Gettysburg
10.3	F	40 06 40 / 84 28 29	Ust. Gettysburg	Gettysburg
6.1	C	40 06 08 / 84 25 48	SR 721	Gettysburg
5.5	B	40 06 25 / 84 25 21	Adj. Covington - Gettysburg Rd.	Gettysburg
5.0	F	40 06 49 / 84 25 03	Ust. Buckneck Rd.	Gettysburg
1.4	B	40 06 30 / 84 22 21	Dst. Range Line Rd.	Pleasant Hill
0.8	C	40 06 40 / 84 21 48	Covington - Gettysburg Rd.	Pleasant Hill
0.1	F	40 07 08 / 84 21 33	@ mouth	Pleasant Hill
North Fork Stillwater				
0.5	F	40 13 13 / 84 38 16	Ust. SR 118	Ansonia
0.4	C,M,B	40 13 12 / 84 38 12	SR 118	Ansonia
Swamp Creek				
8.9	C	40 16 54 / 84 30 18	Versailles - Yorkshire Rd.	North Star
8.8	B,F	40 16 53 / 84 30 17	Versailles - Yorkshire Rd.	North Star
4.5	F	40 14 24 / 84 28 06	Long Rd.	Versailles
4.4	C,B	40 14 26 / 84 28 03	Long Rd.	Versailles
1.6	C,F	40 12 49 / 84 29 57	Dst. SR 121	Versailles
1.5	B	40 12 47 / 84 29 55	Dst. SR 121	Versailles
Indian Creek				
2.0	F	40 13 54 / 84 30 37	Dst. Conover Rd.	Dawn
1.9	C,B	40 14 00 / 84 30 46	Conover Rd.	Dawn
Painter Creek				
16.2	B,F	39 59 46 / 84 33 33	Ivester Park	Arcanum
15.5	C,B	39 59 28 / 84 32 25	Hollandsburg-Arcanum Rd.	Arcanum
15.2	F	39 59 20 / 84 32 40	Ust. Sycamore Ditch	Arcanum
15.0	C,B,F	39 59 24 / 84 32 24	Dst. Sycamore Ditch (WWTP & landfill)	Arcanum
10.1	B,F	40 02 05 / 84 29 02	Ust. Arcanum Rd.	Gettysburg
1.0	C,B	40 04 42 / 84 22 02	Adj. Sugar Grove Rd.	Pleasant Hill
0.5	F	40 04 48 / 84 21 20	Adj. Sugar Grove Rd., dst. falls	Pleasant Hill
0.2	F	40 04 54 / 84 21 18	Owens Rd.	Pleasant Hill.
Mud Creek				
5.9	C,B,F	40 01 34 / 84 40 30	Weaver - Ft. Jefferson Rd.	Greenville West
4.7	C	40 02 30 / 84 40 21	Byrket Rd.	Greenville West
4.6	B,F	40 02 29 / 84 40 20	Byrket Rd.	Greenville West
0.2	F	40 06 02 / 84 38 25	Ust. SR 502	Greenville West
0.1	C,B	40 06 06 / 84 38 22	SR 502	Greenville West
Prairie Outlet				
0.8	C,B,F	40 01 34 / 84 39 30	Weaver - Ft. Jefferson Rd.	Greenville West

RESULTS AND DISCUSSION

Chemical/Physical Water Quality (Tables 1-7, 12-13; Figs. 1-3, 7-14)

* Streams in the study area supported generally good water quality except for exceedences (Ohio Water Quality Standards) of iron and fecal coliform bacteria which were common throughout the basin during 1990. Exceedences of the iron standard are common throughout Ohio's surface waters and are due to naturally high levels in the soil. Fecal coliform/fecal streptococcus ratios (i.e. < 0.7 is generally indicative of bacterial contamination from animal waste and > 4.0 indicates human waste contamination) for Mud Creek, Prairie Outlet, Swamp Creek, the North Fork Stillwater River, the lower portion of Painter Creek, and the upper reaches of Greenville Creek and the Stillwater River were, for the most part, indicative of animal waste runoff from livestock and poultry operations.

* Record amounts of rain fell throughout most of Ohio during 1990 resulting in above normal flows. Comparison of 1990 annual discharge rates (cfs) in the Stillwater River and Greenville Creek to the previous eight years shows 1990 minimum annual discharges were significantly higher, mean rates slightly higher than the other high flow years, and maximum annual rates comparable to other high flow years. During this study, mean monthly flows were generally the highest during July 1990.

Stillwater River

* Dissolved oxygen levels in the Stillwater River were generally above the 6.0 mg/l EWH criterion except for the three locations (RM 63.0 - 57.0) measured with Datasonde monitors. In this upper segment, mean values ranged from 7.9 to 5.1 with minimum values of 4.5 to 4.6. Algal respiration may account for much of the diurnal flux (the open canopy of this segment is conducive to algae growth). The lower levels at RM 58.0 and 57.0 may be due to nutrient loading from CSOs and the Ansonia WWTP. These sites are in the segment recommended for redesignation to WWH (the observed D.O. values meet WWH standards).

* Investigation by Ohio EPA personnel revealed an unpermitted animal waste discharge to a tributary which caused an exceedence of the fecal coliform standard and greatly elevated fecal streptococcus levels at the Zumbrun Road site (RM 61.8).

* Copper values exceeded the 30-day average water quality criteria in the Stillwater River downstream from the confluence of the North Fork Stillwater at RM 57.0 (0.035 ppm) and in the North Fork at RM 0.4 (0.030 ppm). While not exceeding water quality criteria, lead concentrations were also elevated at both sites (0.012 ppm, 0.016 ppm, respectively). Arsenic (0.063 ppm), also elevated at RM 57.0 of the Stillwater, would have been in violation of public water supply criteria (0.05 ppm) if there had been any surface water intakes within 500 yards. All of these elevated concentrations occurred on July 12, a day of exceptionally high flows. The elevated concentrations on the North Fork occurred upstream from the Ansonia WWTP discharge (RM 0.2) and should be further investigated. The Darke County Engineers' Office practice of spraying herbicides for stream bank maintenance and/or the common practice of copper sulfate application for control of pond algae may be contributing factors.

* Elevated concentrations of ammonia, BOD_5, and phosphorus were found in the West Milton WWTP mixing zone (RM 16.5 of the Stillwater). The historically high nutrient loadings at this facility will be addressed by the planned expansion and upgrade planned for 1992.

* Sampling for organic chemicals revealed concentrations of chloroform and toluene in the Englewood WWTP mixing zone and Di-N-Butyl Phthalate at RM 27.9 of the Stillwater River. However, all concentrations were well below the water quality criteria for each parameter.

Greenville Creek

* An extremely high nitrate-nitrite concentration (1200 ppm) was recorded in Greenville Creek at RM 28.9. Flows on the day the sample was taken (8/09/90) were the lowest of the seven days sampled and the source of enrichment is unknown.

* Dissolved oxygen levels in Greenville Creek were also conducive to aquatic life and above 6.0 mg/l except for three locations (RM 22.3, 18.0, 16.2) measured with Datasonde monitors. At these sites, minimum values ranged from 5.06 to 5.95 mg/l.

North Fork Stillwater River

* The North Fork of the Stillwater River (upstream from the Ansonia WWTP) had exceedences of the iron, fecal coliform, dissolved oxygen, and copper standards. The lowest minimum dissolved oxygen concentration (2.43 mg/l) in the study area was recorded at RM 0.45. Concentrations of nitrates, phosphorus, and BOD_5 were also elevated and attributed to agricultural runoff and on-site septic systems. Channelization and on-going maintenance practices also contribute to the degraded water quality.

Swamp Creek

* The water quality in Swamp Creek was similar to the North Fork's and also showed patterns of nonpoint source impacts with exceedences of the iron, fecal coliform, and dissolved oxygen criteria as well as elevated levels of nitrates, phosphorus and BOD_5. As noted before, agricultural crop production, animal waste, and channelization contribute to the degradation of water quality.

* Additionally, an acute zinc violation (CMC) and an elevated lead concentration (0.016 ppm) were recorded downstream from the Versailles WWTP at RM 1.6. An elevated copper value (0.025ppm) was recorded in the headwaters at RM 8.9.

Indian Creek

* Indian Creek, a tributary to Swamp Creek, had exceedences of iron and fecal coliform and elevated nitrate concentrations.

Painter Creek

* Ammonia, lead and D.O. exceedences were recorded in Painter Creek downstream from Sycamore Ditch (Arcanum WWTP discharge) at RM 15.0. Runoff from the Arcanum Iron and Metal Comprehensive Environmental Response Compensation and Liability Act (CERCLA) site, which contains old batteries, is also located on Sycamore Ditch and may account for the elevated lead concentrations and should be monitored in the future. D.O. levels were also low at RM 15.5 on Painter Creek and may be attributed to sewage contamination from failing on-site septic systems and/or CSOs and possibly large quantities of decomposing lawn and grass clippings deposited in and adjacent to the stream.

Mud Creek

* A zinc concentration (1.2 ppm) in Mud Creek at RM 5.9 violated the maximum criteria for WWH aquatic life. A small pile of metal scraps observed on the bank the day of the violation is suspected as the source of the zinc.

Prairie Outlet

* Prairie Outlet, a tributary to Mud Creek, had exceedences of iron and fecal coliform and elevated nitrate concentrations.

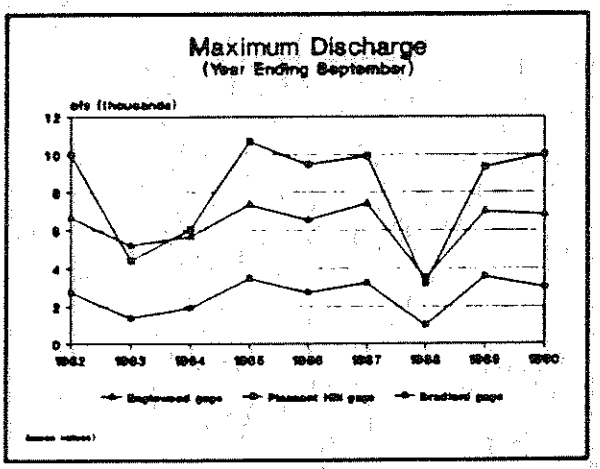
Table 2. Chemical/physical parameters measured in the Stillwater River Basin study area, 1990.[a]

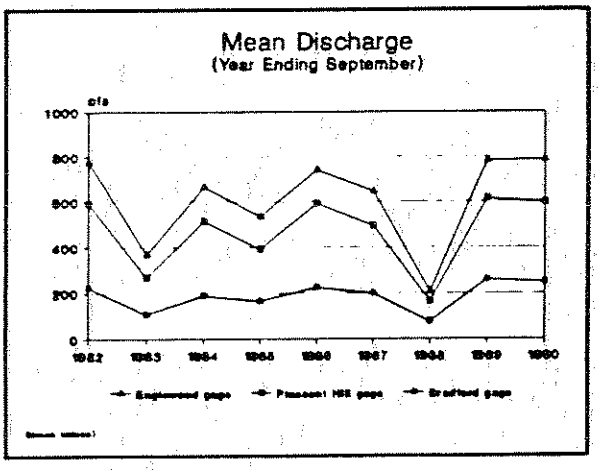
. Flow (field)	. Residue, Total Nonfilterable
. Dissolved Oxygen (field)	. Residue, Dissolved (TDS)
. Temperature (field)	. Fecal Coliform
. 5-day Biochemical Oxygen Demand (BOD5)	. Fecal Streptococcus
. Total Organic Carbon	. Hardness (CaCO3)
. Chemical Oxygen Demand (COD)	. Arsenic-Total (As-T)
. Chloride (Cl)	. Cadmium-Total (Cd-T)
. Conductivity (lab)	. Calcium-Total (Ca-T)
. Cyanide (Cn)	. Chromium-Total (Cr-T)
. Nitrate-Nitrite, as N (NO3-NO2)	. Copper-Total (Cu-T)
. Nitrite, as Nitrogen (NO2-N)	. Iron-Total (Fe-T)
. Ammonia-Nitrogen (NH3-N)	. Lead-Total (Pb-T)
. Total Kjeldahl Nitrogen (TKN)	. Magnesium-Total (Mg-T)
. pH (lab)	. Nickel-Total (Ni-T)
. Phosphorus-Total (P-T)	. Zinc-Total (Zn-T)

[a] Scans for Base-Neutral and Acid Extractables (BNAs) and Volatile Organic Compounds (VOCs) were performed at the following locations: Stillwater River (RM 43.5, RM 27.9, RM 8.9, RM 8.8, RM 8.6); Greenville Creek (RM 19.6, RM 19.3, RM 18.8).

Table 3. Flow measurements (cfs) in the Stillwater River Basin on chemical/physical sampling days during 1990.

Stream Name River Mile	7/12	7/26	8/09	8/23	9/06	9/20	10/04
Stillwater River							
46.1	N/A	66.26	13.2	N/A	17.26	28.54	N/A
27.9	4154	409.9	112.9	2399	N/A	178.5	141.5
8.9	N/A	621.4	179.5	1912	167.6	183.7	196.4
Greenville Creek							
19.6	N/A	N/A	50.8	N/A	79.55	N/A	N/A
6.1	500.1	181.0	70.95	1601	93.83	114.3	178.3
North Fork Stillwater							
0.4	N/A	5.60	1.2	11.28	1.68	1.41	N/A
Swamp Creek							
1.6	N/A	15.5	4.2	79.20	0.56	11.13	N/A
Indian Creek							
1.9	N/A	5.7	1.6	15.89	1.53	3.32	N/A
Painter Creek							
15.0	N/A	6.0	2.5	3.36	1.1	1.512	3.4
4.4	700.0	20.0	9.5	9.0	7.0	7.0	12.5
Mud Creek							
0.1	N/A	24.4	14.7	N/A	13.74	15.72	N/A





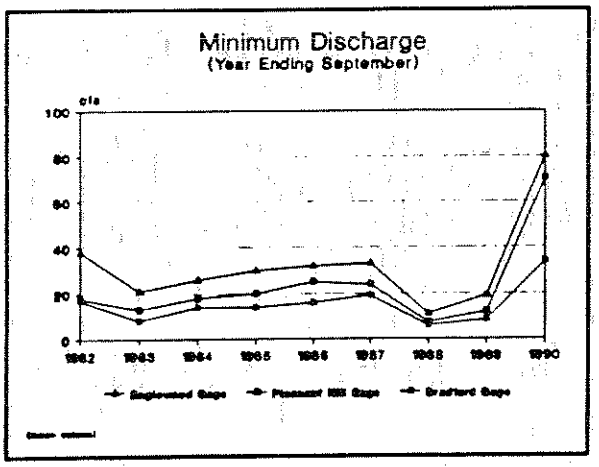
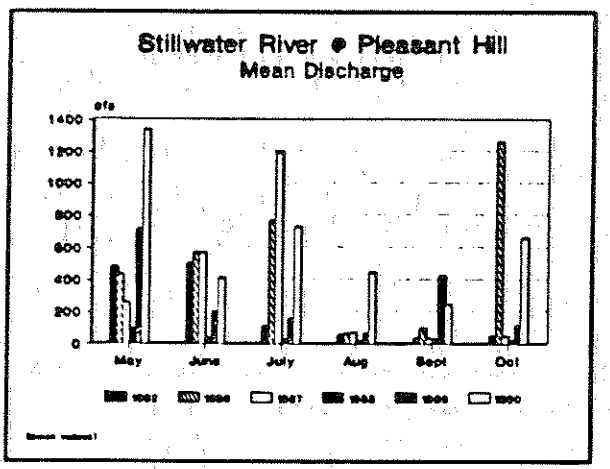
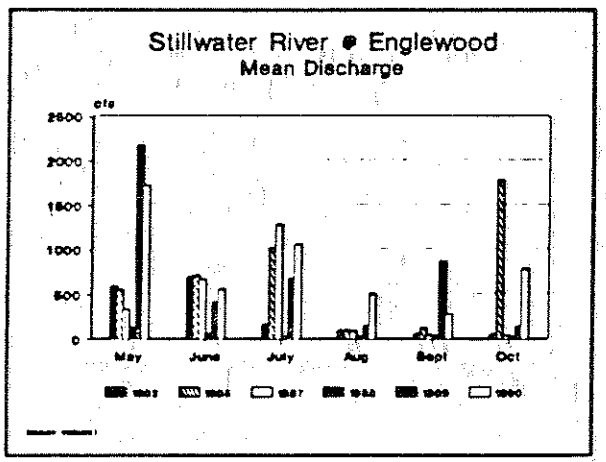


Figure 1. Comparison of annual mean, maximum and minimum flows (cfs) in the Stillwater River (Pleasant Hill- RM 27.9, Englewood-RM 8.9) and Greenville Creek (near Bradford-RM 6.1) from October 1981 to September 1990. (USGS 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991).





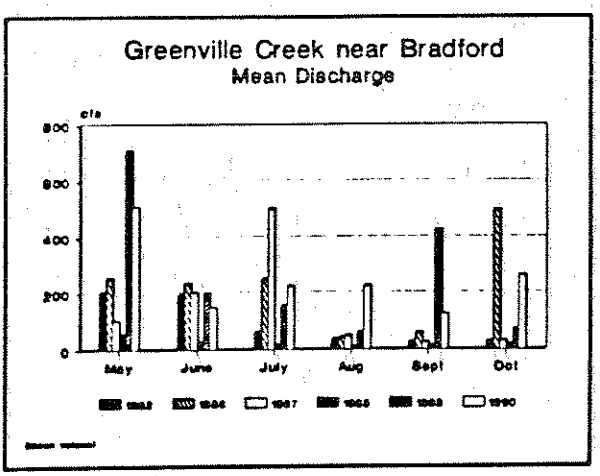


Figure 2. Comparison of mean monthly flows (cfs) (May - October) in the Stillwater River (Pleasant Hill-RM 27.9, Englewood-RM 8.9) and Greenville Creek (near Bradford-RM 6.1) for 1982 and from 1986 - 1990. (USGS 1983, 1987, 1988, 1989, 1990, 1991).

Table 4. Exceedences of Ohio EPA Warmwater/Exceptional Warmwater Habitat water quality criteria (OAC 3745-1) for chemical/physical parameters measured in the Stillwater River Basin study area, 1990.

Stream Name River Mile	Exceedences: Parameter (ppm)[a]
Stillwater River	
63.0	Iron* (28.5, 3.28, 6.65); Fecal coliform (14000, 12000, 6000)
61.8	Iron* (23.7, 4.07, 6.83); Fecal coliform (>60000, 40000, 4800, 11000)
57.0	Copper (.035*); Iron* (35.5, 1.98, 3.79, 8.3); Fecal coliform (24000, 5100, 4500, 4900, >60000, 1700)
46.1	Iron* (17.0, 1.24, 4.93, 1.72); Fecal coliform (18000, 2800, 1040, >60000)
43.5	Iron* (23.1, 1.64, 4.76, 1.8); Fecal coliform (56000, 1060, 4100, >60000, 1500)
32.5	Iron* (24.7, 1.94, 5.64); Fecal coliform (1530)
32.1	Iron* (22.0, 2.12, 7.0); Fecal coliform (43000, 4700, 4000)
27.9	Iron* (20.7, 2.34, 8.52, 1.11); Fecal coliform (23000, 5800)
25.1	Iron* (21.3, 2.31, 9.67, 1.12); Fecal coliform (18000, 4700)
18.2	Iron* (1.05, 1.61)
16.5	Iron* (1.49, 1.17); Fecal coliform (1600)
11.4	Iron* (29.4, 2.54, 14.1, 1.09, 1.67, 1.17); Fecal coliform (17000, 1140, 4300)
8.9	Iron* (3.75, 2.07, 12.7, 2.11, 1.12, 2.34); Fecal coliform (1040, 5800)
8.8	Iron* (2.46, 12.3, 1.81); Fecal coliform (12000, 5000)
8.6	Iron* (3.8, 1.67, 13.2, 1.99, 1.08, 2.24); Fecal coliform (1200, 15000, 1430)
5.0	Iron* (14.2, 3.14, 1.05, 14.8, 1.36, 1.92, 2.2); Fecal coliform (9000, 5700, 2400)
Greenville Creek	
34.5	Iron* (14.3, 2.83, 3.45); Fecal coliform (23000, 22000, 8000)
28.9	Iron* (11.2, 1.22, 3.76, 2.12);Fecal coliform (38000, 9000, 1020, 36000); Nitrate-Nitrite (1200[b])
22.4	Iron* (5.14, 1.54, 1.12, 4.12); Fecal coliform (12000, 2900, 16000)
19.6	Iron* (7.49, 1.77, 1.09, 5.3, 1.23); Fecal coliform (35000, 20000, 1080, 4500)
19.3	Iron* (1.48, 4.14); Fecal coliform (2300, 1800, 11000, 3000)
18.8	Iron* (7.37, 1.77, 4.28, 1.02); Fecal coliform (12000, 1060, 2400, 15000, 4700, 1060)
18.0	Iron* (6.68, 1.76, 4.45, 1.26); Fecal coliform (15000, 1600, 4900, 1080, 1300, 4400)
16.2	Iron* (5.4, 1.81, 4.4, 1.62); Fecal coliform (7000, 4700, 3300, 1300)
10.5	Iron* (1.52, 6.16, 1.88, 5.75); Fecal coliform (5700, 5800, 2800, 1100)
6.1	Iron* (1.05, 9.88, 2.24, 5.42); Fecal coliform (10000, 5500, 1200)
0.8	Iron* (22.4, 1.67, 6.55); Fecal coliform (28000, 3400)
North Fork Stillwater	
0.4	Copper (.030*); Iron* (42.7, 1.22, 1.32, 13.4); Fecal coliform (14000, 1700, 3000, >60000)
Swamp Creek	
8.9	Dissolved Oxygen (4.8*); Iron* (37.3, 1.27, 2.49, 13.4); Fecal coliform (>60000, 1600, 2000, >60000)
4.4	Iron* (15.9, 1.75, 2.75, 15.3); Fecal coliform (>60000, 1100, 10000, >60000)
1.6	Zinc (0.4**); Iron* (17.9, 2.91, 10.8); Fecal coliform (>60000, 1160, 3000, 4900, 5700, >60000)
Indian Creek	
1.9	Iron* (20.2, 1.46, 3.34, 1.05, 10.1); Fecal coliform (44000, 1900, 1500, >60000)

Table 4. continued.

Stream Name / River Mile	Exceedences: Parameter (ppm)[a]
Painter Creek	
15.5	Dissolved Oxygen (5.3**, 4.4**, 3.9**); Iron* (8.03); Fecal coliform (>60000, 1020, 1140, 11000, 32000)
15.0	Dissolved Oxygen (5.0**, 3.0**); Ammonia (1.06*); Lead (.016*); Iron* (7.88, 1.04); Fecal coliform (>60000, 1100, >60000);
1.0	Iron* (8.27); Fecal coliform (24000)
Mud Creek	
5.9	Zinc (1.2**); Iron* (5.71, 1.04, 3.0, 3.63, 3.43); Fecal coliform (4800, 6900);
4.7	Iron* (12.0, 1.29, 3.5, 1.55); Fecal coliform (>60000, 5000, 1800, 1120, 3300);
0.1	Iron* (9.14, 2.41, 1.46, 5.17, 1.82, 2.26, 1.38); Fecal coliform (22000, 2200, 1700, 22000, 3500, 25000)
Prairie Outlet	
0.8	Iron* (6.35, 2.8); Fecal coliform (13000, 2700)

[a] Fecal coliform--exceedence of Primary Contact Recreation standard (#/100ml)

[b] Exceedence of agricultural water supply 30-day average

* Exceedence of numerical criteria for prevention of chronic toxicity (CAC) or WWH criteria for D.O.

** Exceedence of numerical criteria for prevention of acute toxicity (AAC) or EWH criteria for D.O.

Table 5. Selected parameter results [mean (min. - max.)][a] of chemical/physical sampling in the Stillwater River Basin study area during 1990 (* denotes exceedence of numerical criteria for prevention of chronic toxicity; ** denotes exceedence of numerical criteria for prevention of acute toxicity).

Stream RM	No. Samples	D.O. (mg/l)	Temp (C)	ph(SU)	Conductivity (umhos/cm)
Stillwater River					
63.0	7	9.7 (7.4-11.5)	15.3 (8.5-19.0)	7.88 (7.23-8.28)	596 (437-722)
61.8	7	9.2 (7.2-10.8)	14.9 (8.8-19.0)	7.86 (7.44-8.23)	619 (467-740)
57.0	7	8.4 (6.7-10.2)	15.6 (8.9-19.2)	7.85 (7.61-8.21)	620 (407-775)
46.1	7	8.5 (7.0-11.0)	20.0 (16.2-25.0)	8.10 (7.70-8.55)	641 (384-760)
43.5	7	8.1 (7.7-8.5)	15.8 (9.5-20.1)	7.98 (7.73-8.37)	641 (392-783)
32.5	7	8.6 (7.8-10.0)	16.2 (9.6-20.8)	8.12 (7.83-8.47)	592 (341-759)
32.1	7	10.6 (8.9-13.0)	16.2 (9.8-20.8)	8.26 (7.95-8.59)	578 (307-692)
27.9	7	10.1 (8.7-11.6)	16.8 (10.0-20.8)	8.23 (7.82-8.58)	569 (303-706)
25.1	7	10.7 (8.7-13.4)	15.7 (10.5-21.2)	8.33 (7.89-8.54)	595 (295-694)
18.2	3	10.7 (9.3-11.8)	14.0 (10.5-20.8)	8.31 (8.26-8.34)	637 (564-710)
16.5	5	9.6 (7.6-11.2)	16.5 (10.8-20.5)	8.28 (8.02-8.56)	677 (633-727)
11.4	7	9.8 (8.2-11.0)	17.8 (11.2-22.0)	8.20 (7.87-8.37)	516 (256-653)
8.9	6	8.4 (7.3-9.1)	19.0 (15.0-23.0)	8.20 (8.01-8.39)	563 (345-663)
8.8	6	8.1 (7.3-9.4)	19.3 (17.0-22.0)	8.11 (8.00-8.30)	733 (354-1120)
8.6	6	8.5 (7.5-9.4)	19.2 (15.0-23.0)	8.19 (8.03-8.39)	564 (345-665)
5.0	7	9.9 (7.4-18.0)	20.1 (7.0-27.0)	8.20 (7.73-8.55)	531 (263-654)
Greenville Creek					
34.5	7	8.1 (6.4-10.6)	17.0 (14.0-20.0)	7.87 (7.54-8.11)	557 (390-662)
28.9	7	8.2 (7.3-9.3)	16.9 (14.0-20.0)	7.99 (7.64-8.30)	567 (397-660)
22.4	7	7.9 (7.0-9.1)	17.7 (14.0-21.0)	8.02 (7.67-8.28)	610 (425-684)
19.6	7	7.6 (6.5-8.7)	17.7 (10.2-22.0)	8.05 (7.73-8.35)	614 (425-686)
19.3	6	8.3 (7.2-9.2)	17.9 (14.0-20.0)	8.02 (7.70-8.29)	642 (472-690)
18.8	7	8.3 (7.1-9.5)	18.4 (14.5-22.0)	8.04 (7.65-8.31)	619 (439-688)
18.0	7	8.1 (7.0-9.5)	18.6 (15.0-22.0)	8.03 (7.67-8.30)	618 (433-687)
16.2	7	7.9 (7.0-9.5)	18.6 (14.5-22.0)	8.05 (7.86-8.32)	615 (427-694)
10.5	7	8.4 (7.4-10.0)	19.1 (15.0-23.0)	8.10 (7.70-8.39)	596 (381-678)
6.1	7	8.3 (7.0-9.4)	19.0 (15.0-23.0)	8.13 (7.77-8.43)	583 (337-695)
0.8	7	9.7 (8.2-11.2)	20.0 (15.5-25.0)	8.25 (7.98-8.51)	571 (304-691)
North Fork Stillwater					
0.4	7	9.1 (6.8-16.2)	19.5 (15.5-26.0)	7.99 (7.64-8.50)	637 (365-790)
Swamp Creek					
8.9	7	7.5 (4.8*-9.8)	15.3 (8.8-20.0)	7.74 (7.32-8.04)	628 (382-783)
4.4	7	7.9 (6.2-9.3)	14.5 (8.8-19.5)	7.76 (7.49-8.08)	679 (467-831)
1.6	7	8.3 (6.4-12.0)	20.0 (16.2-25.0)	7.78 (7.43-8.17)	672 (460-853)
Indian Creek					
1.9	7	9.8 (6.6-16.0)	20.7 (16.0-27.0)	7.86 (7.49-8.14)	684 (454-895)
Painter Creek					
15.5	7	6.8 (3.9**-10.5)	17.1 (13.5-21.0)	7.97 (7.44-8.90)	574 (307-703)
15.0	7	7.0 (3.0**-10.6)	17.7 (13.0-21.0)	7.89 (7.54-8.11)	669 (316-867)
1.0	7	9.5 (7.7-11.2)	20.6 (17.0-25.0)	8.40 (7.81-8.77)	584 (376-646)
Mud Creek					
5.9	7	7.9 (6.7-8.8)	18.4 (15.0-21.0)	7.94 (7.68-8.14)	605 (407-691)
4.7	7	8.1 (7.2-8.7)	16.9 (14.0-19.0)	7.83 (7.44-8.22)	628 (492-697)
0.1	7	6.9 (5.0-8.2)	18.1 (14.5-21.5)	7.90 (7.65-8.23)	641 (458-722)
Prairie Outlet					
0.8	7	8.0 (6.7-8.8)	16.6 (13.0-19.0)	7.88 (7.60-8.26)	654 (393-753)

Table 5. continued.

Stream RM	No. Samples	NO3-NO2 (mg/l)	NO2-N (mg/l)	NH3-N (mg/l)	Phos-T (mg/l)
Stillwater River					
63.0	7	7.77 (1.69-24.10)	0.10 (0.03-0.37)	0.15 (0.05-0.74)	0.17 (0.05-0.46)
61.8	7	7.74 (1.55-18.90)	0.09 (0.03-0.30)	0.18 (0.05-0.67)	0.20 (0.05-0.46)
57.0	7	5.36 (1.01-16.60)	0.12 (0.03-0.50)	0.18 (0.05-0.76)	0.23 (0.06-0.61)
46.1	7	4.79 (1.45-14.40)	0.07 (0.02-0.23)	0.10 (0.05-0.43)	0.25 (0.10-0.53)
43.5	7	5.31 (1.59-17.80)	0.09 (0.02-0.36)	0.14 (0.05-0.64)	0.25 (0.13-0.48)
32.5	7	4.08 (1.44-9.92)	0.07 (0.02-0.23)	0.09 (0.05-0.32)	0.21 (0.08-0.50)
32.1	7	3.67 (1.86-8.64)	0.07 (0.02-0.24)	0.09 (0.05-0.26)	0.23 (0.09-0.65)
27.9	7	3.83 (1.96-8.06)	0.06 (0.02-0.25)	0.08 (0.05-0.23)	0.20 (0.12-0.45)
25.1	7	3.84 (2.05-7.87)	0.04 (0.02-0.12)	0.08 (0.05-0.21)	0.37 (0.10-1.12)
18.2	3	3.02 (2.42-3.52)	0.02 (0.02-0.03)	0.05 (0.05-0.05)	0.15 (0.13-0.17)
16.5	5	4.90 (2.38-7.25)	0.08 (0.02-0.13)	1.93 (0.05-5.52)	1.04 (0.12-1.62)
11.4	7	4.03 (2.04-6.91)	0.08 (0.02-0.21)	0.07 (0.05-0.16)	0.24 (0.12-0.46)
8.9	6	3.52 (2.41-6.79)	0.04 (0.02-0.08)	0.05 (0.05-0.06)	0.39 (0.14-1.23)
8.8	6	4.37 (1.62-6.43)	0.07 (0.04-0.11)	0.10 (0.05-0.16)	1.19 (0.38-2.42)
8.6	6	3.51 (2.41-6.86)	0.05 (0.02-0.11)	0.05 (0.05-0.05)	0.21 (0.13-0.33)
5.0	7	3.53 (2.09-6.85)	0.06 (0.02-0.14)	0.06 (0.05-0.13)	0.24 (0.15-0.40)
Greenville Creek					
34.5	7	3.74 (1.16-9.68)	0.06 (0.02-0.17)	0.07 (0.05-0.16)	0.36 (0.05-1.78)
28.9	7	3.92[b] (1.86-8.60[b])	0.05 (0.02-0.12)	0.16 (0.05-0.58)	0.14 (0.05-0.33)
22.4	7	2.99 (1.76-4.94)	0.04 (0.02-0.09)	0.09 (0.05-0.21)	0.10 (0.05-0.21)
19.6	7	2.70 (1.67-4.32)	0.04 (0.02-0.09)	0.06 (0.05-0.11)	0.10 (0.05-0.20)
19.3	6	2.87 (2.09-4.74)	0.03 (0.02-0.06)	0.07 (0.05-0.18)	0.37 (0.06-0.74)
18.8	7	2.94 (1.99-4.37)	0.04 (0.02-0.08)	0.06 (0.05-0.12)	0.23 (0.13-0.55)
18.0	7	2.94 (1.98-4.38)	0.04 (0.02-0.06)	0.06 (0.05-0.11)	0.19 (0.15-0.22)
16.2	7	2.84 (1.86-4.28)	0.04 (0.02-0.07)	0.06 (0.05-0.13)	0.19 (0.14-0.32)
10.5	7	3.21 (1.98-6.00)	0.04 (0.02-0.07)	0.07 (0.05-0.16)	0.20 (0.12-0.38)
6.1	7	3.37 (1.80-7.46)	0.04 (0.02-0.12)	0.07 (0.05-0.19)	0.18 (0.10-0.33)
0.8	7	3.37 (1.65-7.57)	0.06 (0.02-0.22)	0.07 (0.05-0.18)	0.20 (0.11-0.38)
North Fork Stillwater					
0.4	7	5.54 (0.10-24.00)	0.10 (0.02-0.33)	0.21 (0.05-0.92)	0.51 (0.05-1.42)
Swamp Creek					
8.9	7	7.35 (0.10-32.10)	0.11 (0.02-0.33)	0.18 (0.05-0.60)	0.27 (0.10-0.55)
4.4	7	6.90 (0.29-29.70)	0.11 (0.02-0.27)	0.24 (0.05-0.89)	0.35 (0.06-0.79)
1.6	7	7.31 (1.98-26.60)	0.11 (0.03-0.27)	0.25 (0.05-0.86)	0.52 (0.21-0.80)
Indian Creek					
1.9	7	7.21 (0.25-27.1)	0.13 (0.02-0.44)	0.25 (0.05-1.21)	0.28 (0.05-0.72)
PainterCreek					
15.5	7	3.55 (0.29-10.30)	0.06 (0.03-0.10)	0.11 (0.05-0.28)	0.29 (0.05-1.17)
15.0	7	2.68 (0.27-10.00)	0.10 (0.07-0.15)	0.48 (0.05-1.06*)	0.29 (0.21-0.33)
1.0	7	3.69 (0.37-12.50)	0.04 (0.02-0.14)	0.07 (0.05-0.19)	0.23 (0.05-0.88)
Mud Creek					
5.9	7	1.31 (0.72-2.45)	0.06 (0.03-0.11)	0.09 (0.05-0.17)	0.09 (0.05-0.16)
4.7	7	2.74 (1.19-7.68)	0.05 (0.02-0.11)	0.08 (0.05-0.29)	0.09 (0.05-0.21)
0.1	7	2.98 (1.54-8.10)	0.05 (0.02-0.10)	0.07 (0.05-0.19)	0.24 (0.05-0.81)
Prairie Outlet					
0.8	7	5.20 (1.84-17.50)	0.05 (0.02-0.11)	0.07 (0.05-0.16)	0.40 (0.05-2.03)

Table 5. continued.

Stream RM	No. Samples	BOD5 (mg/l)	Res. Nflt-T (mg/l)	Fecal Coli.[c] (#/100ml)	Fecal Strep. (#/100 ml)
Stillwater River					
63.0	7	4.5 (1.0-13.0)	189 (5-1080)	4943 (440-14000)	24124 (110-94000)
61.8	7	4.6 (1.0-13.0)	194 (5-1050)	16816 (250-60000)	21426 (30-77000)
57.0	7	5.1 (1.0-15.0)	202 (5-1070)	14454 (980-60000)	22205 (100-88000)
46.1	7	2.2 (1.0-5.1)	85 (6-402)	11871 (280-60000)	11689 (70-60000)
43.5	7	3.5 (1.0-11.0)	155 (5-870)	17707 (290-60000)	23336 (50-100000)
32.5	7	2.8 (1.0-10.0)	122 (5-644)	657 (90-1530)	9134 (10-60000)
32.1	7	2.1 (1.0-6.0)	128 (6-672)	7595 (130-43000)	9298 (20-60000)
27.9	7	2.3 (1.0-6.0)	138 (10-646)	4511 (210-23000)	9036 (20-60000)
25.1	7	1.5 (1.0-3.0)	57 (9-227)	4095 (60-18000)	10620 (20-60000)
18.2	3	1.2 (1.0-1.5)	24 (20-28)	353 (100-800)	43 (10-90)
16.5	5	7.4 (1.4-27.0)	26 (17-48)	428 (10-1600)	70 (10-150)
11.4	7	2.2 (1.0-5.8)	211 (14-980)	3467 (180-17000)	9081 (10-60000)
8.9	6	1.8 (1.0-2.9)	95 (25-310)	1355 (20-5800)	504 (100-1370)
8.8	6	1.8 (1.0-4.0)	85 (24-328)	2888 (10-12000)	1053 (10-5200)
8.6	6	1.6 (1.0-3.0)	96 (25-318)	3170 (350-15000)	1414 (90-7090)
5.0	7	2.3 (1.0-5.2)	157 (30-498)	2639 (100-9000)	8903 (30-60000)
Greenville Creek					
34.5	7	2.1 (1.0-4.5)	79 (5-419)	7911 (320-23000)	13853 (150-60000)
28.9	7	2.1 (1.0-4.6)	56 (5-271)	12297 (420-38000)	10760 (60-60000)
22.4	7	1.6 (1.0-3.4)	41 (8-138)	4889 (740-16000)	10969 (200-60000)
19.6	7	1.8 (1.0-3.0)	61 (13-223)	9043 (880-35000)	12175 (340-60000)
19.3	6	1.5 (1.0-2.6)	29 (8-94)	4820 (820-11000)	2072 (190-6600)
18.8	7	1.7 (1.0-3.2)	57 (6-222)	5283 (760-15000)	10409 (110-60000)
18.0	7	1.7 (1.0-3.2)	50 (6-169)	4122 (573-15000)	9957 (130-60000)
16.2	7	1.8 (1.0-3.6)	49 (8-181)	2640 (560-7000)	9946 (100-60000)
10.5	7	1.6 (1.0-2.9)	49 (12-132)	2410 (270-5800)	9849 (20-60000)
6.1	7	1.6 (1.0-3.4)	63 (13-234)	2681 (230-10000)	9277 (20-60000)
0.8	7	1.8 (1.0-4.4)	108 (7-574)	4717 (20-28000)	9299 (40-60000)
North Fork Stillwater					
0.4	7	4.2 (1.0-15.0)	188 (5-1160)	13310 (560-60000)	22324 (70-95000)
Swamp Creek					
8.9	7	5.3 (1.0-15.0)	167 (7-1020)	17920 (440-60000)	23149 (80-100000)
4.4	7	5.8 (1.0-24.0)	72 (5-366)	19066 (700-60000)	23892 (260-100000)
1.6	7	6.2 (1.0-20.0)	134 (5-432)	22460 (1160-60000)	23261 (160-100000)
Indian Creek					
1.9	7	5.2 (1.0-16.0)	129 (15-450)	15686 (560-60000)	8993 (260-60000)
Painter Creek					
15.5	7	2.0 (1.0-3.7)	32 (5-196)	15203 (480-60000)	9910 (210-60000)
15.0	7	2.9 (1.0-7.8)	33 (5-182)	20526 (533-60000)	23162 (220-100000)
1.0	7	1.6 (1.0-3.9)	104 (5-505)	3872 (180-24000)	10076 (20-60000)
Mud Creek					
5.9	7	1.8 (1.0-3.8)	77 (5-185)	1975 (240-6900)	9031 (110-60000)
4.7	7	1.9 (1.0-5.0)	75 (7-328)	10366 (480-60000)	9963 (190-60000)
0.1	7	2.1 (1.0-5.1)	84 (32-227)	12733 (1700-25000)	18612 (520-63000)
Prairie Outlet					
0.8	7	1.6 (1.0-3.4)	23 (5-110)	2599 (300-13000)	9666 (90-60000)

[a] Means calculated using detection limits as the minimum value where reported minimum was less than detection limit.

[b] Excludes NO3-NO2 value of 1200 mg/l (exceedence of Ohio EPA agricultural water supply quality criteria).

[c] Minimum values at Swamp Creek RM 1.6 and Mud Creek RM 0.1 and all maximum values (except Stillwater RM 18.2) are exceedences of primary contact recreation standard.

Table 6. Summary of data (mean/minimum-maximum) recorded with Datasonde continuous monitors at nine locations in the Stillwater River Basin during July, 1990.

Stream RM	N[a]	D.O. (mg/l)	Temp (C)	pH (SU)	Conductivity (umhos/cm)
Stillwater River (EWH)					
63.0	18	7.88 (4.64***-14.79)	24.06 (19.68-31.09)	7.89 (7.57-8.41)	626 (520-690)
58.0	20	5.11*** (4.52***-6.20)	23.30 (22.77-23.61)	7.67 (7.62-7.76)	671 (650-710)
57.0	19	6.00 (4.63***-9.74)	22.62 (20.99-25.77)	7.74 (7.57-8.07)	743 (730-770)
Greenville Creek (EWH)					
22.3	22	7.64 (5.95***-9.04)	25.38 (23.86-26.19)	8.32 (8.21-8.38)	660 (640-680)
19.5	21	7.43 (6.53-8.96)	24.57 (22.89-25.85)	8.12 (8.06-8.20)	--
18.0	26	7.07 (5.06***-10.34)	24.18 (22.3-25.98)	8.00 (7.82-8.27)	712 (460-760)
16.2	24	7.42 (5.82***-8.62)	24.63 (22.85-25.72)	8.03 (7.77-8.14)	724 (700-750)
13.7	23	6.64 (6.02-7.59)	25.31 (24.33-26.91)	8.01 (7.93-8.12)	716 (700-740)
North Fork Stillwater (WWH)					
0.4	15	6.74 (2.43**-15.28)	23.21 (19.47-30.45)	7.91 (7.40-8.98)	728 (620-790)

[a] Number of hourly readings.

* Violation of average D.O. criterion for WWH (5 mg/l).

** Violation of minimum D.O. criterion for WWH (4 mg/l).

*** Violation of minimum D.O. criterion for EWH (6 mg/l).

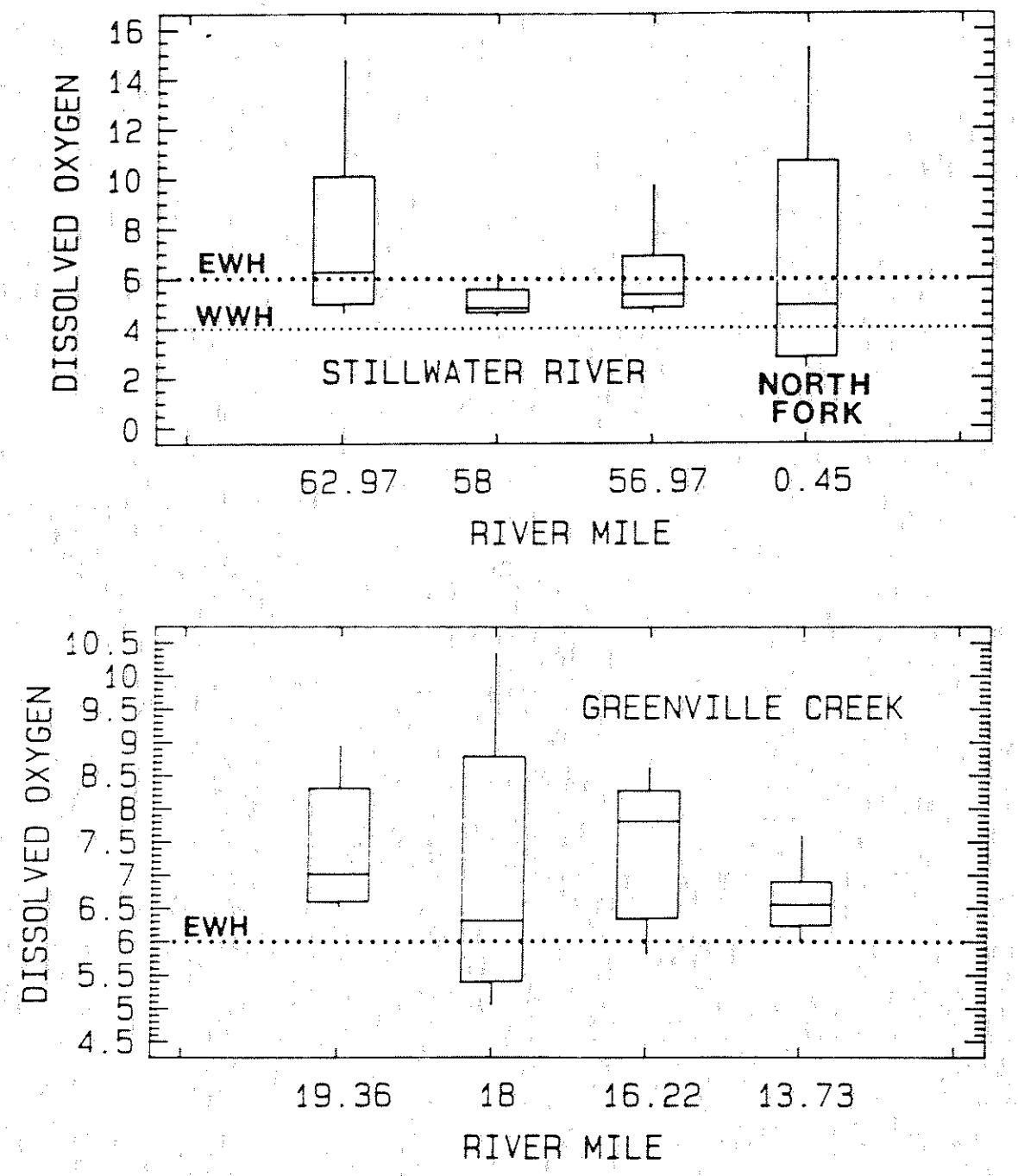


Figure 3. Boxplots of dissolved oxygen data (mg/l) recorded with Datasonde continuous monitors at various locations in the Stillwater River, North Fork, and Greenville Creek during the summer of 1990. Minimum criteria for the WWH (4 mg/l) and EWH (6mg/l) use designations are indicated.

Sediment Quality (Tables 1,7)

* Sediment chemistry results from two 1990 sites and five 1986 sites remarkably showed no contamination by heavy metals in four streams in the Stillwater River Basin. All concentrations were considered 'non-elevated' based on a stream sediment classification system described by Kelly and Hite (1984). This represents very clean sediment compared to other rivers and streams throughout Ohio.

Table 7. Concentrations (mg/kg dry weight) of heavy metals in sediments of four streams at seven locations in the study area during 1986 and 1990. All parameter concentrations, excluding nickel, were ranked based on a stream sediment classification system described by Kelly and Hite (1984).

Stream (Year) RM	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc
Stillwater River (1986)								
60.0	4.8[a]	0.36[a]	12.40[a]	16.0[a]	15,200[a]	18.3[a]	13.0	43.0[a]
44.2	2.4[a]	0.18[a]	10.00[a]	8.0[a]	9,990[a]	12.0[a]	8.0	35.0[a]
Stillwater River (1990)								
27.9	1.0[a]	0.08[a]	3.95[a]	5.4[a]	-	10.7[a]	3.8	17.7[a]
Greenville Creek (1986)								
26.5	3.7[a]	0.33[a]	9.00[a]	11.0[a]	12,600[a]	11.6[a]	11.0	43.0[a]
Greenville Creek (1990)								
19.3	0.7[a]	0.05[a]	3.20[a]	4.1[a]	-	17.6[a]	2.2	18.0[a]
Painter Creek (1986)								
3.2	2.3[a]	0.31[a]	12.00[a]	12.0[a]	12,100[a]	23.2[a]	9.0	53.0[a]
Indian Creek (1986)								
1.9	5.3[a]	0.33[a]	11.00[a]	13.0[a]	17,500[a]	14.0[a]	14.0	58.0[a]

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

Physical Habitat for Aquatic Life (Tables 8, 10, 11; Figs. 5, 6)

* In the study area, Qualitative Habitat Evaluation Index (QHEI) scores ranged from 100.0 to 28.0 reflecting exceptional to very poor physical habitat for aquatic life within the basin. The quality was typically very good at natural sites and fair to very poor at modified sites. Historically, stream channels in Darke County have been extensively modified by dredging, straightening and other drainage related practices. Virtually all stream channels in the county have been modified except for parts of the Stillwater River and Greenville Creek (J. Surber pers. comm.). Many of the modified channels are currently being maintained in accordance with the Ohio Drainage Law (ORC 6131). Sixteen low-head dam impoundments also negatively affect the quality of aquatic habitats locally in the Stillwater River and Greenville Creek.

Stillwater River

* Between RM 63.0 and RM 57.0, the quality of physical habitats in the Stillwater River has been reduced (mean QHEI = 51.0; range 40.5 - 61.5) due to previous (mixture of old and new)

channelization. At RM 63.0, the total number of MWH attributes are greater than expected and further recovery is precluded by continued channel maintenance (bank vegetation control). Downstream, habitat quality improves with increased WWH attributes (mean QHEI = 82.5; range 74.0 - 89.0) and aquatic habitats become typical of moderate-size Eastern Corn Belt Plains streams consisting of alternating series of pools and riffle-run complexes. Other habitat modifications consist of 12 shallow impoundments (created by low-head dams) interspersed between RM 32.2 and 3.3. Despite high turbidity levels during 1990, substrates remained relatively silt free and composed of predominantly cobble, gravel, and sand.

Greenville Creek

* QHEI scores in Greenville Creek ranged from 59.0 (RM 19.6) to 100.0 (RM 5.0) representing fair to excellent quality habitat. The sites with scores less than 60.0 were associated with channelization (RM 19.6) or impoundment (RM 14.3). RM 14.3 was the only site where the number of MWH attributes was greater than WWH attributes. Overall, QHEI scores averaged 78.1 suggesting that Greenville Creek is capable of supporting the existing EWH aquatic life use designation. No MWH attributes (high or moderate influence) were observed at RM 83.5 or from RM 11.9 to 0.1. Greenville Creek has four low-head dams between RM 22.6 and 1.6.

North Fork Stillwater

* The North Fork contains poor quality habitat (QHEI 28.0) due to past channelization and an on-going maintenance program. The total number of MWH attributes (10) overwhelmingly dominate the natural WWH attributes (2) indicating the low quality of physical habitats precludes attainment of the WWH use.

Swamp Creek

* In the headwaters, Swamp Creek also contains poor aquatic habitat due to past and present (brush maintenance) channel modifications. These conditions preclude attainment of the WWH use. Habitats improve longitudinally downstream (QHEI = 48 at RM 4.5, 62.0 at RM 1.6).

Indian Creek

* Indian Creek is currently maintained (brush) and the continued absence of riparian woody vegetation jeopardizes its recovery from channelization. Severe bank erosion was observed along the stream because of this practice. The QHEI was 52.0.

Painter Creek

* Aquatic habitats in Painter Creek change markedly from the channelized segment in Darke County to the lower natural reach (Miami Co.) with exposed limestone bedrock. QHEI scores ranged from 36.0 - 57.0 (mean = 44.1) in Darke Co., and 87.0 - 92.0 (mean = 89.5) in Miami Co. Throughout most of Darke Co., Painter Creek is currently under brush maintenance which precludes attainment of the WWH use.

Mud Creek

* Mud Creek QHEIs ranged from 55.5 to 63.0 reflecting past channelization. However, it is not under a maintenance program and the number of WWH attributes were greater than MWH attributes at all three sites. Mud Creek's flow is augmented by an American Aggregates facility (limestone processing) at RM 7.8 which should be beneficial to achieving the WWH use. The mean QHEI for the segment was 59.2.

Prairie Outlet

* Despite old channelization, physical habitats in Prairie Outlet (a headwater tributary of Mud Creek) were diverse and conducive to achieving the WWH use. Prairie Outlet is also not under a maintenance program and the QHEI scored a 68.5.

Table 8. Matrix of QHEI scores and corresponding Warmwater and Modified Warmwater Habitat attributes from the Stillwater River Basin during 1990.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	MWH Attributes (High Influence): Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total (High Influence) MWH Attributes	MWH Attributes (Moderate Influence): Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Silt/Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
STILLWATER RIVER																																	
Year: 90																																	
63.0	40.5	1.12						■	■		■		4	●	●		●		4				▲	▲							2	1.00	1.40
57.0	61.5	2.00		■				■	■	■	■		6	●					1	▲	▲			▲	▲							4	.29	.86
52.4	78.5	2.27	■	■		■	■	■	■	■	■		9						0													0	.10	.10
47.8	79.5	3.76	■	■		■	■	■	■	■	■		9						0					▲								1	.10	.20
43.7	78.5	2.54	■	■		■	■	■		■			7						0					▲				▲	▲			3	.13	.50
37.8	83.5	7.69	■	■		■		■	■	■			7						0					▲					▲			2	.13	.38
31.2	89.0	4.63	■	■	■	■	■	■	■	■	■		10						0													0	.09	.09
30.6	81.0	3.33	■	■		■	■	■	■	■	■		9						0				▲									1	.10	.20
28.1	74.0	3.33	■	■		■	■	■	■	■	■		9		●				1				▲	▲								2	.20	.40
25.3	86.5	5.15	■	■	■	■	■	■	■	■	■		10						0													0	.09	.09
18.0	85.5	3.70	■	■	■	■	■	■	■	■	■		10						0				▲									1	.09	.18
16.0	85.0	3.66	■	■		■		■	■	■	■		8						0					▲								1	.11	.22
11.5	82.0	2.44	■	■		■	■	■	■	■	■		9						0													0	.10	.10
9.0	78.0	.10	■	■	■	■		■	■	■	■		9						0				▲	▲								2	.10	.30
8.8	81.0	3.30	■	■	■	■	■	■	■	■	■		10						0					▲								1	.09	.18
8.4	88.0	3.34	■	■		■	■	■	■	■	■		9						0													0	.10	.10
5.0	89.0	5.41	■	■	■	■	■	■	■	■	■		10						0													0	.09	.09
1.2	80.5	4.69	■	■	■	■		■	■	■	■		9						0				▲	▲								2	.10	.30
PAINTER CREEK																																	
Year: 90																																	
16.2	36.0	3.36						■	■	■			3	●	●	●		●	4				▲	▲			▲					3	1.25	2.00
15.2	44.5	3.36		■				■	■	■			4	●		●		●	3				▲	▲	▲		▲					4	.80	1.60
15.0	39.0	3.36						■		■	■	■	4	●	●	●			3				▲	▲	▲		▲					4	.80	1.60
10.1	57.0	3.33						■	■	■	■	■	5		●				1	▲			▲	▲								3	.33	.83
0.5	92.0	33.33	■	■	■	■		■	■	■	■	■	9			●			1					▲								1	.20	.30
0.2	87.0	33.33	■	■	■	■		■	■	■	■	■	9						0					▲								1	.10	.20
GREENVILLE CREEK																																	
Year: 90																																	
34.2	83.5	8.69	■	■		■	■	■	■	■	■		9						0													0	.10	.10
29.0	68.0	4.76		■		■		■	■				5						0	▲				▲				▲	▲			4	.17	.83
23.2	87.0	.85	■	■	■	■	■	■	■	■	■		10						0													0	.09	.09
20.6	70.5	.85		■		■	■	■	■	■	■		8						0	▲			▲									2	.11	.33
19.6	59.0	.85		■			■	■	■	■	■		6						0	▲			▲	▲								3	.14	.57
19.3	67.0	.85		■	■	■	■	■	■	■	■		8						0	▲												1	.11	.22

Table 8. continued.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	MWH Attributes (High Influence): Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total (High Influence) MWH Attributes	MWH Attributes (Moderate Influence): Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Riffle Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
19.2	65.0	.85	■	■	■	■	■	■	■	■	■	■	8						0	▲			▲				▲				3	.11	.44
17.3	66.5	.85	■	■	■	■	■	■	■	■	■	■	9						0	▲											1	.10	.20
15.4	61.0	1.29		■	■	■	■			■	■		6				●		1	▲							▲			▲	3	.29	.71
14.3	59.5	.10	■			■	■				■		4						0		▲		▲				▲	▲		▲	5	.20	1.20
12.0	84.0	4.55	■	■	■	■	■	■	■	■	■	■	9						0								▲				1	.10	.20
11.9	92.5	4.55	■	■	■	■	■	■	■	■	■	■	10						0												0	.09	.09
10.6	98.5	4.95	■	■	■	■	■	■	■	■	■	■	9						0												0	.10	.10
10.3	92.5	4.95	■	■	■	■	■	■	■	■	■	■	9						0												0	.10	.10
5.0	100.0	6.49	■	■	■	■	■	■	■	■	■	■	10						0												0	.09	.09
4.2	84.5	6.49	■		■	■	■	■	■	■	■	■	9						0												0	.10	.10
0.1	89.0	14.71	■	■	■	■	■	■	■	■	■	■	10						0												0	.09	.09
MUD CREEK																																	
Year: 90																																	
5.9	63.0	21.74		■			■	■	■	■	■		6	●		●			2				▲	▲							2	.43	.71
4.6	59.0	3.07					■	■	■	■	■		5		●	●			2	▲	▲		▲	▲							4	.50	1.17
0.2	55.5	1.18	■		■		■			■	■	■	6		●				1		▲		▲	▲			▲				4	.29	.86
PRAIRIE OUTLET																																	
Year: 90																																	
0.8	68.5	15.87	■	■	■	■	■	■	■	■	■	■	9						0		▲										1	.10	.20
SWAMP CREEK																																	
Year: 90																																	
8.8	28.0	2.86								■	■		2	●	●	●	●	●	5		▲		▲	▲	▲		▲				5	2.00	3.67
4.5	48.0	2.41						■		■	■	■	4		●				1	▲	▲		▲	▲			▲				5	.40	1.40
1.6	62.0	3.76	■		■		■			■	■	■	6						0				▲	▲			▲				3	.14	.57
INDIAN CREEK																																	
Year: 90																																	
2.0	52.0	4.85	■			■	■			■	■	■	6						0	▲			▲				▲				3	.14	.57
N. FK. STILLWATER RIVER																																	
Year: 90																																	
0.5	28.0	2.86								■	■		2	●	●	●	●		4		▲		▲	▲	▲		▲			▲	6	1.67	3.67

Key QHEI Components

Macroinvertebrate Communities (Tables 1, 9, 11, 14; Figs. 4, 15, 18, 19)

* Macroinvertebrate results from 44 sites within the 1990 Stillwater River study area ranged from poor to exceptional quality.

Stillwater River

* All stations sampled within the Stillwater River had exceptional or very good macroinvertebrate communities. The Invertebrate Community Index (ICI) ranged from 42 (very good) at RM 27.7 to 54 (exceptional) at RM 63.0. Mayfly and caddisfly diversity was generally high; total number of taxa collected from artificial and natural substrates ranged from 10 at RM 51.2 to 22 at RM 9.1. Percentage of tolerant taxa and other dipteran/non-insect taxa were generally low throughout the river. No significant impact was detected from *any* of the dischargers to this river.

* The macroinvertebrate community sampled at RM 51.2 had the lowest mayfly and caddisfly diversity with 9 taxa collected from the artificial substrates (compared to 11 at RM 57.0), 7 taxa from the natural substrates (compared to 11 at RM 57.0), and 10 total taxa at the station (compared to 14 at RM 57.0). This slight drop in diversity coupled with a slight increase in percent tolerant taxa to 6.3% (compared to 0.6% at RM 57.0) may indicate a slight impact from Ansonia. The mayfly and caddisfly diversity generally return to upstream conditions at the next downstream station (RM 44.2) but the percent tolerant taxa remain slightly elevated until RM 30.9.

* The ICI at RM 30.9 (ICI=44) and RM 27.7 (ICI=42) dropped out of the exceptional range downstream from the Greenville Creek confluence and Covington. Mayfly and caddisfly diversity remain relatively high but at RM 27.7 dipteran taxa richness dropped to 5 (compared to 14 at RM 30.9) coupled with an increase in the percent of filter feeding midges of the *Rheotanytarsus exiguus* group to 65% (compared to 48% at RM 30.9 and 22% at RM 37.7). Midges of this group can become dominant in areas with moderate flow and high amounts of suspended organic particulates (Simpson and Bode 1980). This data indicates a mild organic enrichment from upstream sources (Covington WWTP or Greenville WWTP).

* The macroinvertebrate community sampled in the Englewood WWTP mixing zone (RM 8.8) maintained relatively high mayfly and caddisfly diversity without any increase in pollution tolerant taxa. Toxicity was not indicated by the data. Downstream from the Englewood mixing zone (RM 8.6) the taxa diversity declined on the artificial substrates (24 total taxa compared to 37 at RM 8.8, 12 mayfly and caddisfly taxa compared to 18 at RM 8.8, and 6 dipteran taxa compared to 12 at RM 8.8). This decline may be due to a slight impact (organic enrichment) from Englewood. The diversity generally increased at downstream stations.

Greenville Creek

* The macroinvertebrate communities sampled in Greenville Creek were generally in the exceptional range. Mayfly, stonefly, and caddisfly diversity was generally high; total number of taxa collected from artificial and natural substrates ranged from 15 at RM 34.2 to 24 at RM 10.5. The summer stonefly, *Acroneuria evoluta*, was collected at the three stations upstream from Greenville (RMs 34.2, 28.9, 22.3). Summer stoneflies are usually only collected from high quality streams.

* The sample located in the Greenville WWTP mixing zone (RM 19.3) did not indicate any toxicity from the discharge (ICI=48). Mayfly and caddisfly diversity remained high while some compositional changes indicated a slight impact of a non-toxic nature. The sample located 0.2 mile downstream from the discharge (RM 19.1) indicated a slight impact from the WWTP discharge. The ICI dropped from 50 at RM 19.5 to 42 at RM 19.1 indicating a slight impairment of the EWH ICI criterion. The percent tolerant taxa at Rm 19.1 increased to 10.7 percent compared to 2.8 percent at RM 19.5. These changes reflected mild organic enrichment attributed to the WWTP discharge. The ICI value recovered to 50 at RM 18.3.

* The ICI score at RM 1.4 dropped out of the exceptional range to a value of 40 (good). The drop in ICI was due to a decrease in percent mayflies and species diversity. The percentage of filter feeding caddisflies increased substantially between RM 5.5 (17.1%) and RM 1.4 (49.2%), a good indication of an increase in suspended fine particulate organic matter. Qualitative sampling, however, indicated no decline in the diversity of pollution sensitive taxa; 17 taxa of mayflies and caddisflies were collected. The lower ICI at RM 1.4 may have been due to slight organic enrichment that resulted in an increase in filter feeding organisms and a proportional decrease in percentage of other taxa groups.

North Fork Stillwater River

* Qualitative sampling in the North Fork Stillwater River (RM 0.4) revealed a good macroinvertebrate community. Forty-one total taxa were collected including 11 taxa of mayflies and caddisflies. Predominant organisms were hydropsychid caddisflies, the mayfly genus *Baetis*, and midges.

Swamp Creek

* The macroinvertebrate communities sampled at the two stations upstream from Versailles (RMs 8.8, 4.4) were not achieving the WWH ICI biocriterion of 36 (ICIs of 30 and 32, respectively). Mayfly and caddisfly diversity and proportionality were low with dipterans and non-insects predominant. These two sites were considered impacted by channelization coupled with the influence of nonpoint agricultural and livestock runoff.

* The ICI increased to 42 (very good) at the station (RM 1.5) located downstream from Versailles and the Versailles WWTP (RM 2.1); all community measures either remained about the same or improved compared to upstream stations.

Indian Creek

* Qualitative sampling in Indian Creek (RM 1.8) revealed a marginally good macroinvertebrate community. Forty-four total taxa were collected including eight taxa of mayflies and caddisflies. Predominant organisms were hydropsychid caddisflies, blackflies, and the mayfly genus *Baetis*. The community appeared impacted by channelization coupled with agricultural and livestock runoff.

Painter Creek

* Qualitative sampling in Painter Creek (RM 16.2) upstream from Arcanum revealed a marginally good macroinvertebrate community. Forty-five total taxa were collected including 8 taxa of mayflies and caddisflies. Predominant organisms were midges, hydropsychid caddisflies, and the mayfly genus *Baetis*. The community in this headwater stream seemed impacted by channelization along with agricultural and livestock runoff.

* The sample at RM 15.5 had a community that achieved the WWH criterion (36) with an ICI of 40. However, the observation of increased attached filamentous algae, black silt, and a septic odor indicated the presence of some organic wastes originating from Arcanum.

* The macroinvertebrate community (RM 15.0) downstream from Sycamore Ditch (RM 15.0) severely declined to the poor range (ICI=10). Pollution tolerant oligocheates accounted for 61.8 percent of the sample at the station . The Arcanum WWTP (RM 0.4) and the Arcanum Iron and Metal Company (RM 0.5) are located on Sycamore Ditch. Although additional field sampling is needed to determine the proportion of impact that can be attributed to these two dischargers, a predominance of oligocheates is indicative of sewage enrichment. The macroinvertebrate communities downstream (RMs 10.1, 1.0) recovered to exceptional (ICI=56) and very good (ICI=42), respectively.

Mud Creek and Prairie Outlet

* The macroinvertebrate communities sampled in Mud Creek and Prairie Outlet ranged from

marginally good (ICI=32) at Mud Creek RM 5.9 to exceptional (ICI=48) at Mud Creek RM 4.6. A relatively high percentage of tolerant taxa (9.9, 11.2,and 21.5 %) in Mud Creek (RMs 5.9, 4.6, 0.1, respectively) indicated these stations were slightly impacted. These streams have been extensively channelized in the past and likely receive agricultural and livestock runoff. Mud Creek receives augmented flow from an American Aggregates facility (RM 7.8) which mines and processes (crushes) limestone aggregate. The additional flow which is cool and clear may be beneficial to aquatic organisms by depressing summer water temperatures and maintaining constant flows.

Table 9. Summary of macroinvertebrate data collected from multiple-plate artificial substrate samplers (quantitative sampling) and from natural substrates (qualitative sampling) in the Stillwater River study area, 1990.

Stream River Mile	Narrative Evaluation	Quantitative Evaluation ICI	No. Quant. Taxa	Density orgs./ft^2	No. Qual. Taxa	Qual. EPT[a]
Stillwater River (EWH)						
63.0	Exceptional	54	43	1671	45	11
57.0	Exceptional	50	39	2032	38	11
52.4	Exceptional	46	41	824	35	7
44.2	Exceptional	46	44	1440	44	10
37.7	Exceptional	48	45	985	42	13
30.9	Very Good	44[ns]	31	1640	46	17
27.7	Very Good	42[ns]	23	2409	41	13
25.2	Exceptional	46	31	3261	39	15
18.3	Exceptional	48	33	2414	42	14
16.4	Exceptional	46	31	5246	49	17
12.2	Exceptional	46	32	977	51	20
11.4	Exceptional	48	27	1774	38	13
9.1	Exceptional	50	37	3404	41	15
8.8	Exceptional	46	37	3620	27	9
8.6	Very Good	44[ns]	24	1723	37	12
4.8	Exceptional	50	34	1782	44	17
1.5	Exceptional	48	29	2578	38	13
Greenville Creek (EWH)						
34.2	Exceptional	52	41	325	50	10
28.9	Exceptional	54	41	534	43	16
22.3	Exceptional	52	40	474	39	15
20.8	Exceptional	56	40	1757	47	18
19.5	Exceptional	50	52	597	51	14
19.3	Exceptional	48	60	488	45	12
19.1	Very Good	42[ns]	49	491	53	16
18.3	Exceptional	50	52	793	51	18
13.7	Exceptional	50	37	544	38	14
10.5	Exceptional	50	47	546	46	20
5.5	Exceptional	48	38	473	35	16
1.4	Good	40*	22	1533	47	17
Swamp Creek (WWH)						
8.8	Fair	30*	29	271	36	4
4.4	Marg. Good	32[ns]	44	365	39	4
1.5	Good	42	40	1052	45	9

Table 9. continued.

Stream River Mile	Narrative Evaluation	Quantitative Evaluation ICI	No. Quant. Taxa	Density orgs./ft^2	No. Qual. Taxa	Qual. EPT[a]
Painter Creek (EWH)						
15.5	Good	40*	33	694	46	8
15.0	Poor	10*	29	743	20	1
10.1	Exceptional	56	40	1471	41	12
1.0	Very Good	42[ns]	37	847	48	12
Mud Creek (WWH)						
5.9	Marg. Good	32[ns]	35	205	45	7
4.6	Exceptional	48	38	476	40	9
0.9	Exceptional	46	43	246	45	8
Prairie Outlet (WWH)						
0.8	Good	44	39	445	48	6

Stream River Mile	Narrative Evaluation[b]	Qualitative Evaluation No. Qual. Taxa	Qual. EPT[a]	Relative Density	Predominant Organisms
Greenville Creek (EWH)					
16.2	Very Good	53	13	Moderate	Mayflies, caddisflies, midges
North Fork Stillwater River (WWH)					
0.4	Good	41	11	Moderate	Caddisflies, *Baetis*, midges
Indian Creek (WWH)					
1.8	Marg. Good	44	8	Moderate	Caddisflies, blackflies, *Baetis*
Painter Creek (EWH)					
16.2	Marg. Good	45	8	Moderate	Midges, caddisflies, *Baetis*

ECOREGION BIOCRITERIA: Eastern Corn Belt Plains

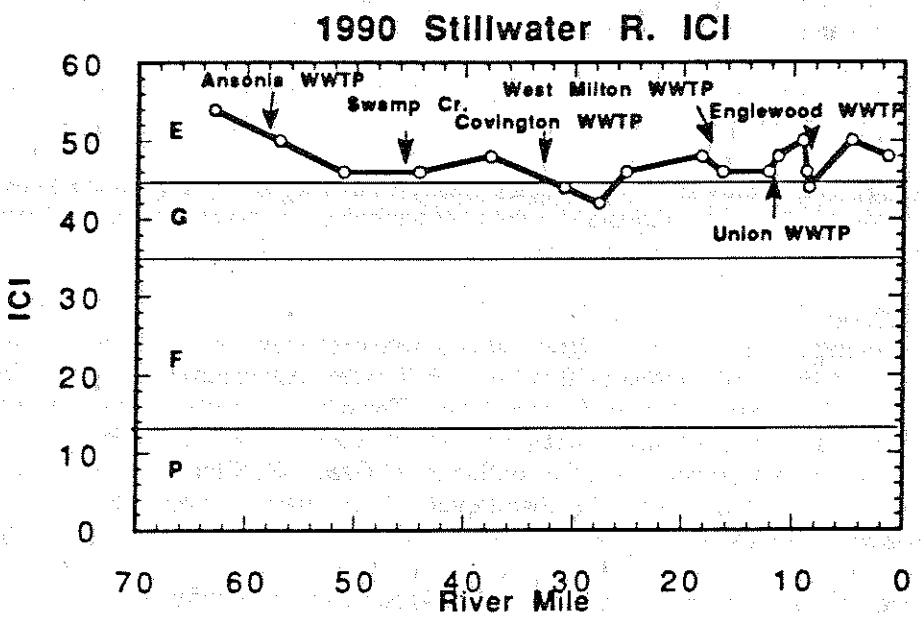
Index	WWH	EWH
ICI	36	46

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

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

a EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) taxa diversity.

b A qualitative evaluation based on Ohio WQS narrative definitions of the aquatic life uses is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores.



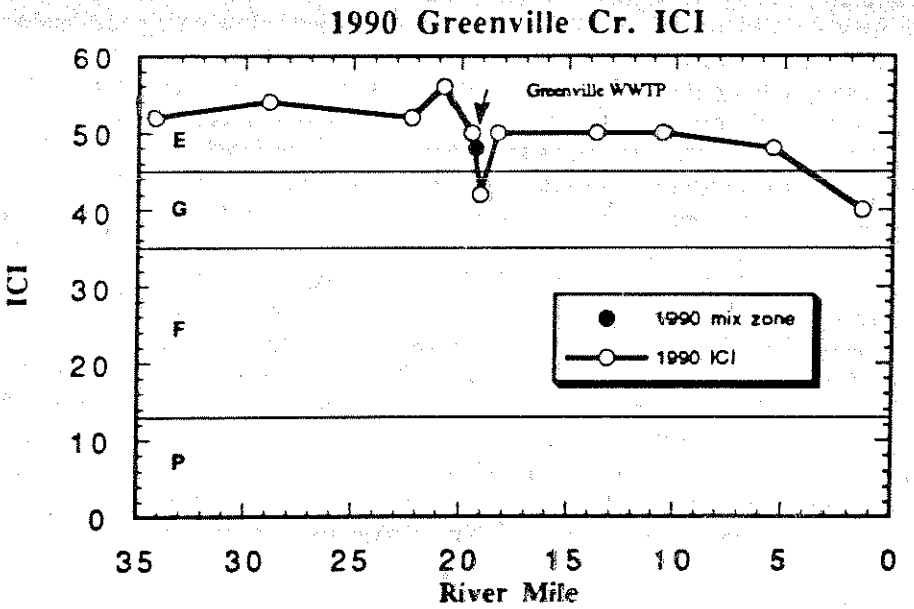


Figure 4. Longitudinal trend of the Invertebrate Community Index (ICI) in the Stillwater River and Greenville Creek, 1990. E denotes exceptional invertebrate communities (meets EWH criterion), G denotes good invertebrate communities (meets WWH criterion), and F and P denote fair and poor invertebrate communities (non-attainment of aquatic life use).

Fish Communities (Tables 1, 10, 11, 14, 15; Figs. 5, 6, 16, 17)

* Throughout the survey, a total of 26,312 fish (57 fish species from 9 families) were collected from 50 locations in 8 streams. The most diverse families were minnows (19 species) followed by sunfish and perch (10 species each), suckers (8 species), and catfish (6 species). Narratively (based on Ohio EPA biological criteria), fish assemblages in the study area ranged from exceptional to poor in quality.

* Channelization and associated maintenance practices have negatively impacted fish assemblages in many Darke County streams by degrading habitat, exacerbating nonpoint impacts, and reducing the biological recovery potential of several streams.

Stillwater River

* Fish assemblages in the Stillwater River ranged from exceptional to fair in quality (Fig. 5). Of the 36 biological index scores (18 sites, 2 per site), 36% were considered exceptional, 22% very good, 11% good, 25% marginally good, and 6% fair. The highest quality fish assemblages (least impacted) occurred at RM 25.3 (downstream from the Pleasant Hill WWTP at Penny Rd.) and RM 31.2 (downstream from Covington and the confluence of Greenville Creek) where all values were considered exceptional. Conversely, the lowest quality (most impacted) occurred at RM 51.2 and 47.8 (downstream from the Ansonia WWTP) where values were only fair to marginally good.

* Five to ten miles downstream from the City of Ansonia and the confluence of the North Fork, MIwb scores declined from marginally good to fair. Although IBI scores remained marginally good, a predominance of common carp at RM 47.8 suggests organic enrichment and a possible dissolved oxygen sag in this reach of the stream due to excessive organic loadings from the Ansonia WWTP and CSOs. Fish assemblages improved gradually downstream and achieved EWH criteria (nonsignificant departure) between RM 37.8 and 30.6. The decline in MIwb to the good range at RM 28.1 (resulting in partial attainment) is attributed to impoundment by a mill dam downstream from Lauver Rd. Fish assemblages returned to the very good to exceptional range from RM 25.3 to 16.0. At RM 11.5, downstream from the City of Union WWTP, the MIwb declined below very good quality (marginally good) suggesting an impact from the wastewater discharge. A substantial increase in the numerical abundance and weight of common carp is indicative of excessive nutrient enrichment. Downstream, the MIwb improved to the exceptional/very good range thru RM 8.4, but the IBI declined to marginally good upstream (RM 9.0) and in the mixing zone of the Englewood WWTP (RM 8.8). The decline at RM 9.0 is attributed to impoundment by a low-head dam and at RM 8.8 to a reduced sampling distance. The highest MIwb in the study area was recorded at RM 8.8 and may be skewed positively by the short sampling distance. The high value suggests no toxic (acute or chronic) impact, but rather enrichment from the Englewood WWTP. Downstream at RM 8.4, the IBI increased to the exceptional range (along with a very good MIwb) suggesting no negative impacts to fish assemblages by the Englewood WWTP discharge. In the lower five miles of the Stillwater River, IBI values remained very good or exceptional, but MIwb values declined to the good range. The partial attainment may be attributed to impacts from the Greater Northridge sanitary sewer overflow discharges (part of the Dayton WWTP).

* The Stillwater River supports a diverse fish community (i.e. accounted for 93% of the fish species (53 of 57) collected within the study). The highest mean number of species (27.5 - 27.0 species) were collected upstream from Covington at RM 43.7 and 37.8. The lowest mean number of species (14.3) occurred near the mouth at RM 1.2. Dominant species in the Stillwater River (18 sites combined) were by percent numbers: golden redhorse (20%), gizzard shad (11%), green sunfish (8%), longear sunfish (6%), and northern hog suckers (6%). At specific sites, other numerically dominant species included greenside darters, black redhorse, smallmouth bass, common carp and bluntnose minnows. By weight, dominant species (18 sites combined) consisted of golden redhorse (31%), common carp (27%), followed by black redhorse (6%). Additional species at individual sites included white suckers, creek chubs, quillback, northern hog suckers, gizzard shad, river redhorse,

and largemouth bass.

* The Stillwater River downstream from Greenville Creek supports a healthy population of river redhorse; a species listed as special interest on the ODNR, Div. of Wildlife list of rare, endangered, and threatened species. Seventy-two individuals were captured during this survey between RM 31.2 and 1.2. The status of the river redhorse appeared to be similar or slightly better during 1990 than during 1982. The mean relative number collected during 1990 was 4.0/km as apposed to 2.7/km during 1982. Relative weight also showed an increase from 1.7 kg/km during 1982 to 4.1 kg/km during 1990. No Ohio endangered or threatened fish species were collected from the Stillwater River by Ohio EPA personnel during 1990 or 1982.

* The Stillwater River supports a recreational sport fisheries due to the presence of a healthy, stable population of smallmouth bass and other sunfish species. Similar to the river redhorse, the relative number of smallmouth bass in 1990 (19.6/km) also showed a slight increase over the 1982 abundance (15.6/km). Relative weight increased from 2.3 kg/km during 1982 to 3.7 kg/km during 1990.

Greenville Creek

* Fish assemblages in Greenville Creek ranged from fair to exceptional in quality and appeared more impacted than assemblages in the Stillwater River (Fig. 6). Lower than expected fish index values were attributed to point source discharge(s) and local habitat alterations (channelization and impoundment). Of the 33 biological index scores, only 15% were considered exceptional, 12% very good, 18% good, and 18% marginally good while 33% were fair and 3% poor. The highest quality assemblages occurred in the headwaters (RM 34.2) and near the confluence with the Stillwater River (RM 0.1) where all values were exceptional and achieved the EWH IBI and MIwb criteria. Conversely, the lowest quality fish assemblages occurred downstream from the Greenville WWTP between RM 19.2 and 14.3 where values were fair to poor in quality. QHEI scores were also generally lowest in this section of the stream and appeared to be a contributing factor to the lower IBI and MIwb scores.

* Longitudinally, MIwb and IBI scores showed a declining trend from RM 29.0 to 14.3 and a increasing trend from 14.3 to 0.1. Channelization at RM 29.0 and negative effects caused by impoundments on stream fish communities at RM 23.2 resulted in a trend of decline in community index scores upstream from the town of Greenville. Further declines in the quality of fish assemblages occurred within Greenville upstream from the WWTP due to storm sewers with direct sewer hook-ups (illegal), combined sewer overflows (CSOs), and old channelization. In the mixing zone of the Greenville WWTP, no avoidance was detected suggesting no acute effluent toxicity. The MIwb score, in fact, was marginally higher than the site immediately upstream. Discussions with Ohio EPA SWDO DWPC staff revealed that a siphon overflow in the middle of the sampling zone upstream from the WWTP historically had discharged raw sewage. The impairment from this problem could at least be as severe as the impact currently associated with the mixing zone of the WWTP. Further declines occurred downstream from the WWTP mixing zone to RM 14.3. This impairment could be the result of a delayed impact from the WWTP or from other discharge(s). Potential discharges located immediately upstream from the sampling site are Corning Glass, BASF, and an abandoned dump situated on Bridge Creek. Lower habitat quality within this segment may also be contributing to the lower biological performance. However, as mentioned previously, changes in habitat were insufficient alone to explain the magnitude of impairment suggesting the largest percentage is coming from point source stresses. Gradual improvement occurred from the Bears Mill Dam (RM 14.0) to the mouth as a result of natural recovery processes and no additional inputs of stress.

* Greenville Creek also supports a diverse fish community which comprised of 81% of the fish species (46 of 57) collected in the study area. Numerically, dominant species (17 sites combined) were longear sunfish (21%), white suckers (9%) and bluntnose minnows (8%). By weight, the

fauna was predominated by common carp (32%), white suckers (21%), and golden redhorse (19%). Rare nongame species collected in Greenville creek included the bigeye chub and least darter.

North Fork Stillwater River

* As the result of extensive channel modifications and on-going maintenance practices, the North Fork supported a poor quality fish assemblage upstream from the Ansonia WWTP. Although an exceedence of the WWH copper criterion (chronic) occurred during the survey, the IBI of 26 meets expectations for Modified Warmwater Habitat for headwater streams in Ohio's Eastern Corn Belt Plains ecoregion. Fish assemblages in the stream are not expected to improve significantly beyond this level considering the modified habitat (QHEI = 28) and on-going full maintenance program. The fauna was dominated by three highly tolerant species; green sunfish, creek chub, and yellow bullhead.

Swamp Creek

* In its headwaters, fish assemblages in Swamp Creek were also poor quality due to extensive channel modification and the on-going brush maintenance program. Downstream, the quality of habitat gradually improved to a QHEI of 48 at RM 4.5 and 62 at RM 1.6. The IBI remained in the poor range at RM 4.5, but improved to fair quality at RM 1.6. MIwb scores were indicative of fair quality at both locations. Although improved, the fish assemblage at RM 1.6 still did not attain WWH criteria for the MIwb or IBI. The non attainment may be attributed to a combination of impacts from the previous channel modification, the Versailles WWTP discharge, and possibly CSOs discharges. Biological assemblages are expected to improve after the scheduled upgrade for the WWTP.

* Throughout the survey, 29 fish species (51% of those in the study area) were collected from Swamp Creek (27 species occurred at RM 1.6). Dominant species consisted numerically of bluntnose minnows, followed by creek chub, green sunfish, and white suckers. By weight, white suckers followed by common carp and creek chubs were dominant. Fish assemblages in the Stillwater River improved downstream from the confluence of Swamp Creek.

Indian Creek

* Indian Creek, a headwater tributary of Swamp Creek, supported a fair fish assemblage dominated numerically by bluntnose minnows, green sunfish and creek chub, and by weight, creek chub, green sunfish, common carp, and yellow bullheads. Fish assemblages in Swamp Creek improved downstream from the confluence of Indian Creek.

Painter Creek

* Painter Creek supported poor to fair fish assemblages in the upper channelized segment in Darke County and good to exceptional assemblages in the lower natural segment in Miami County. Longitudinally, IBI scores were similar (27 - 30) between RM 16.2 and 10.1 and showed no significant change downstream from Sycamore Ditch (Arcanum WWTP and CERCLA site). The low IBI scores are primarily attributed to channel modifications and did meet Modified Warmwater expectations. Additionally, sewage contamination was observed at RM 16.2 and may also be contributing to the degraded upstream scores. QHEI scores ranged from 37 to 57 in the channelized sites and 87 to 89 downstream from the falls in the natural section. Painter Creek is currently under brush maintenance throughout most of Darke County.

* Compositionally, assemblages improved from a numerical dominance by fathead minnows, green sunfish, creek chub, blackstripe topminnow, and bluntnose minnows to striped shiner, bluntnose minnows, central stonerollers, rosefin shiner, longear sunfish, and greenside darters. By weight, assemblages were dominated by green sunfish, creek chub, yellow bullhead, common carp, and white suckers to black redhorse, common carp, green sunfish and northern hog sucker. Downstream (4.5 miles) from the confluence of Painter Creek, fish assemblages in the Stillwater River improved to their best quality.

Mud Creek

* Fish assemblages in Mud Creek gradually declined from exceptional quality in its headwaters to good quality downstream from Prairie Outlet to fair quality in the City of Greenville near its mouth. Dominant species shifted numerically from hornyhead chubs, fantail darters, creek chubs, and rainbow darters at RM 5.9 to green sunfish, rainbow darters, and white suckers at RM 4.6 to white suckers, green sunfish, longear sunfish, and bluegill at RM 0.2. By weight the percent composition shifted from a dominance of creek chubs, hornyhead chubs, and central stonerollers at RM 5.9 to white suckers, largemouth bass, and creek chubs at RM 4.6 to common carp and white suckers. Downstream from the confluence, Mud Creek had no apparent impact on fish assemblages in Greenville Creek.

Prairie Outlet

* In contrast to Mud Creek's high quality fish assemblage at RM 5.9, Prairie Outlet's fish assemblage was only fair quality and impaired despite a higher quality of habitat (QHEI = 68.5). Dominant species consisted numerically of green sunfish, bluegill sunfish, pumpkinseed, and hybrid sunfish and by weight white sucker and green sunfish. The quality of fish assemblages in Mud Creek declined from exceptional to good downstream from the confluence of Prairie Outlet. Prairie Outlet's flow is not augmented and the impairment may be attributed to runoff from several large livestock (veal) operations and possibly a concentration of on-site septic systems.

Table 10. Fish community and habitat index scores at 50 sampling locations in the 1990 Stillwater River study area.

Stream RM	Cum Species	Mean No. of Species	Mean Relative Number	Mean Relative Weight	Mlwb	IBI	QHEI	Narrative Evaluation
Stillwater River								
(EWH Mlwb/IBI criteria: wading 9.4/50)								
63.0	25	21.5	770	13.0	8.0*	38*	40.5	Marginally Good
57.0	28	23.0	563	14.9	7.9*	39*	61.5	Marginally Good
52.4	30	23.5	260	36.6	7.4*	36*	78.5	Fair/Marginally Good
47.8	29	24.0	465	72.1	7.3*	39*	79.5	Fair/Marginally Good
43.7	33	27.5	284	29.9	8.5*	43*	78.5	Good
37.8	32	27.0	348	28.0	9.0^{ns}	49^{ns}	83.5	Very Good
(EWH Mlwb/IBI criteria: boat 9.6/48)								
31.2	22	22.0	679	173.3	9.9	54	89.0	Exceptional
30.6	22	19.0	355	79.0	9.2^{ns}	48	81.0	Very Good/Exceptional
28.1	30	21.3	421	108.3	8.6*	49	74.0	Good/Exceptional
25.3	29	22.3	583	111.7	9.9	58	86.5	Exceptional
18.0	30	22.3	439	91.9	9.4^{ns}	55	85.5	Very Good/Exceptional
16.0	25	18.3	389	58.3	9.2^{ns}	51	85.0	Very Good/Exceptional
11.5	24	17.3	395	131.5	8.3*	48	82.0	Marginally Good/Exceptional
9.0	29	22.7	782	105.2	9.8	41*	78.0	Exceptional/Marginally Good
8.8	25	19.3	1253	143.4	10.4	41*	81.0	Exceptional/Marginally Good
8.4	31	21.3	406	83.8	9.5^{ns}	49	88.0	Very Good/Exceptional
5.0	23	17.0	269	91.0	8.7*	47^{ns}	89.0	Good/Very Good
1.2	20	14.3	348	113.0	9.0*	50	80.5	Good/Exceptional
Greenville Creek								
(EWH Mlwb/IBI criteria : headwater NA/50)								
34.2	25	23.0	1370	14.5	NA	53	83.5	Exceptional
(EWH Mlwb/IBI criteria : wading 9.4/50)								
29.0	26	23.5	482	11.8	8.7*	51	68.0	Good/Exceptional

Table 10. continued.

Stream RM	Cum. Species	Mean No. of Species	Mean Relative Number	Mean Relative Weight	MIwb	IBI	QHEI	Narrative Evaluation
(EWH MIwb/IBI criteria : boat 9.6/48)								
23.2	22	19.5	623	29.7	9.0*	37*	87.0	Good/Fair
20.6	21	18.5	468	48.9	8.9*	39*	70.5	Good/Marginally Good
19.6	22	18.5	440	32.9	8.2*	34*	59.0	Marginally Good/Fair
19.3	14	11.0	615	70.5	8.4*	34*	67.0	Marginally Good/Fair
19.2	20	17.0	396	84.0	7.8*	30*	65.0	Fair
17.3	19	15.5	311	84.0	6.5*	30*	66.5	Fair
15.4	17	13.5	269	65.2	7.1*	29*	61.0	Fair
14.3	13	12.5	218	53.5	6.3*	32*	59.5	Poor/Fair
12.0	21	21.0	743	80.7	9.2ns	38*	84.0	Very Good/Marginally Good
11.9	18	18.0	420	53.9	8.4*	32*	92.5	Marginally Good/Fair
10.6	22	22.0	570	35.2	9.2ns	46ns	98.5	Very Good
10.3	20	20.0	400	65.2	8.6*	38*	92.5	Good/Marginally Good
5.0	17	17.0	386	77.6	9.2ns	41*	100	Very Good/Good
4.2	21	21.0	812	55.4	9.6	42*	84.5	Exceptional/Good
0.1	26	23.0	565	47.3	9.6	51	89.0	Exceptional
North Fork Stillwater								
(WWH MIwb/IBI criteria: headwater NA/40)								
0.5	16	16.0	660	10.8	NA	26*	28.0	Poor
Swamp Creek								
(WWH MIwb/IBI criteria: headwater NA/40)								
8.8	17	17.0	2226	17.0	NA	24*	28.0	Poor
(WWH MIwb/IBI criteria: wading 8.3/40)								
4.5	19	19.0	1062	24.0	6.8*	26*	48.0	Fair/Poor
1.6	27	22.5	589	27.2	7.5*	33*	62.0	Fair
Indian Creek								
(WWH MIwb/IBI criteria: headwater 40/36)								
2.0	22	22.0	1117	15.1	NA	32*	52.0	Fair
Painter Creek								
(EWH MIwb/IBI criteria : headwater NA/50)								
16.2	12	9.5	405	1.4	NA	28*	36.0	Fair
15.2	10	8.0	168	5.7	NA	27*	44.5	Poor
15.0	17	7.5	621	66.1	NA	29*	39.0	Fair
(EWH MIwb/IBI criteria : wading 9.4/50)								
10.1	16	13.5	799	42.8	5.4*	30*	57.0	Poor/Fair
0.5	26	26.0	898	34.9	9.4	50	92.0	Exceptional
0.2	21	21.0	548	14.9	8.4*	46ns	87.0	Good/Very Good
Mud Creek								
(WWH MIwb/IBI criteria: headwater NA/40, wading 8.3/40)								
5.9	20	18.5	830	6.2	NA	57	63.0	Exceptional
4.6	23	19.0	362	13.4	NA	44	59.0	Good
(WWH MIwb/IBI criteria: headwater NA/40, wading 8.3/40)								
0.2	23	18.0	240	34.1	7.4*	35*	55.5	Fair
Prairie Outlet								
(WWH MIwb/IBI criteria: headwater NA/40)								
0.8	11	8.5	694	7.7	NA	33*	68.5	Fair

* Significant departure from applicable biological criterion (more than 4 IBI units; 0.5 Iwb units).

ns Value is a nonsignificant departure from biological criteria (≤ 4 IBI units, ≤ .5 MIwb units).

__ Underlined values are in the poor and very poor range.

NA Not applicable, headwater site.

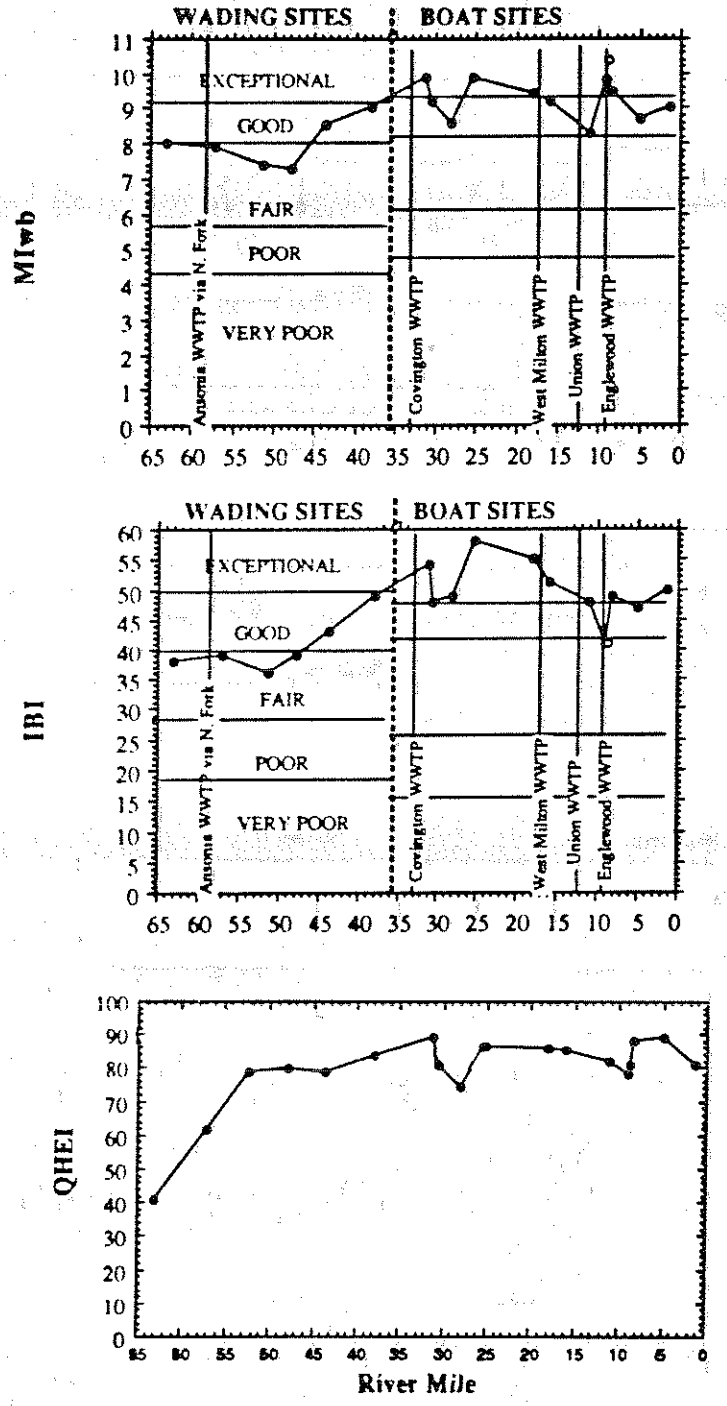


Figure 5. Longitudinal trend of the Modified Index of Well-Being (MIwb), Index of Biotic Integrity (IBI) and the Qualitative Habitat Evaluation Index (QHEI) in the Stillwater River during 1990. Solid circles denote river sampling locations and open circles denote mixing zones.

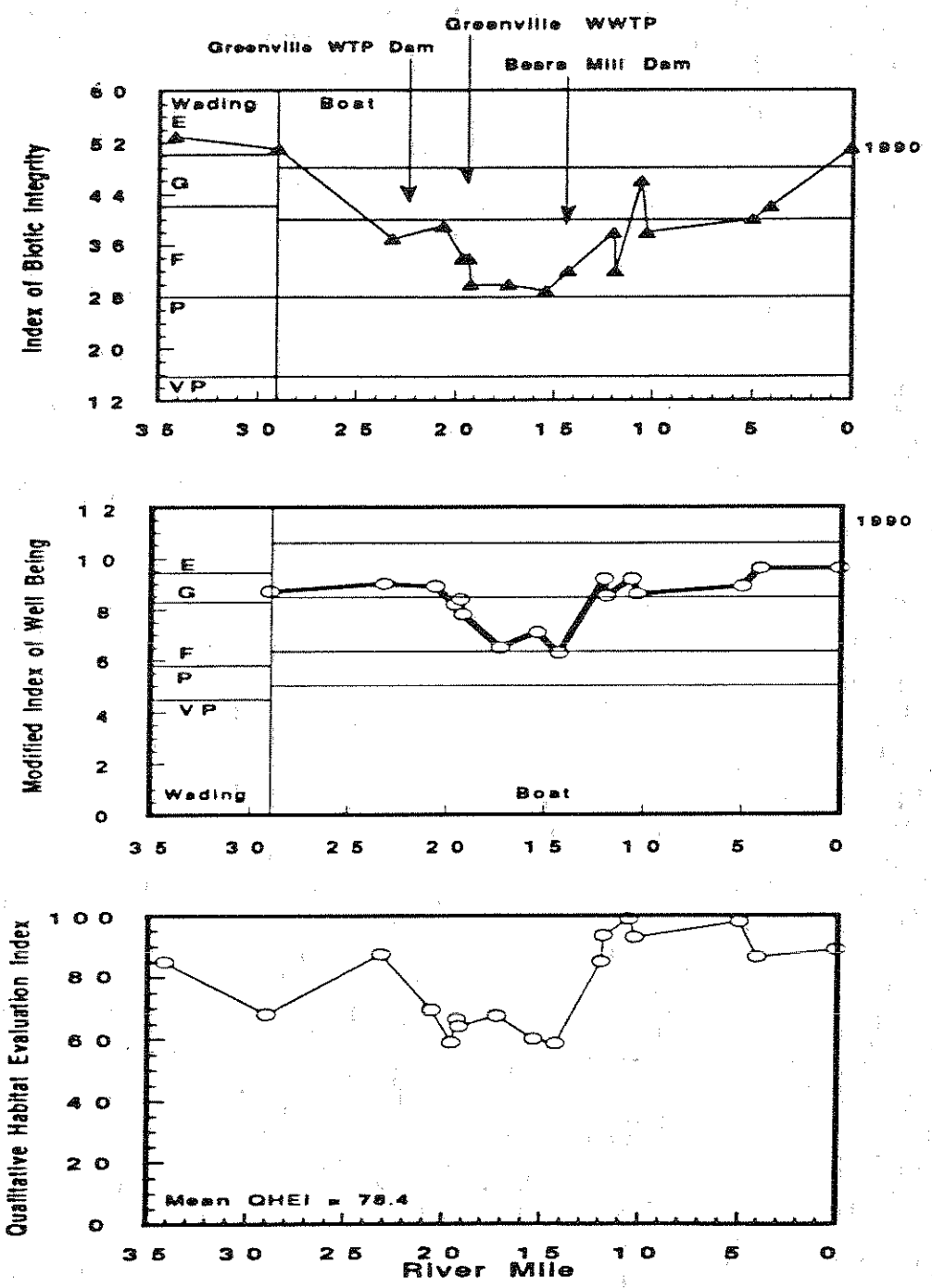


Figure 6. Longitudinal trend in the Index of Biotic Integrity, Modified Index of Well-Being, and the Qualitative Habitat Evaluation Index in the Greenville Creek study area based on sampling conducted during July-September, 1990.

Aquatic Life Use Attainment (Tables 1, 11, 14, 15)

* The 1990 aquatic life attainment status within the Stillwater Basin (41 locations in eight streams with both macroinvertebrate and fish data and based on recommended use changes) was 44% FULL attainment, 51% PARTIAL attainment, and 5% NON attainment. Causes of the PARTIAL and NON attainment were attributed to point source pollution (WWTP discharges), habitat alterations (channelization and impoundment), and nonpoint source pollution (runoff from animal husbandry operations and possibly failing on-site septic systems).

Stillwater River (presently EWH; recommended WWH upstream from RM 57.0)

* The 1990 EWH use attainment status in the Stillwater River was FULL at 44.4% of the sites, PARTIAL at 50% of the sites and NON at 5.6% of the sites due to a lack of macroinvertebrate data. If the segment upstream from RM 57.0 is redesiginated to WWH, as recommended, an additional 11.2% would change to FULL from PARTIAL attainment making FULL attainment at 55.6% of the sites.

Greenville Creek (EWH)

* The 1990 EWH use attainment status of Greenville Creek was predominantly PARTIAL (75.0% of the sites) with 12.5% in FULL attainment and the other 12.5% in NON attainment. Causes of PARTIAL and NON attainment were attributed to point source discharges and habitat alterations (old channelization and impoundment).

North Fork Stillwater River (presently WWH; recommended MWH)

* The North Fork was not attaining its current WWH use designation due to extensive channel modification, but was in FULL attainment of the recommended MWH use designation.

Swamp Creek (presently WWH; recommended MWH upstream from RM 6.5)

* Swamp Creek was in NON attainment of WWH criteria between RM 8.8 and 4.4 and PARTIALLY attained WWH at RM 1.5. The RM 8.8 location attained the recommended MWH designation. NON attainment of WWH criteria was attributed primarily to channelization.

Indian Creek (WWH)

* Indian Creek's PARTIAL attainment of the WWH aquatic life use at RM 2.0 is attributed to previous channel modification and the current brush maintenance program.

Painter Creek (presently EWH; recommended MWH upstream from RM 5.5)

* Painter Creek was in NON attainment of its current EWH criteria between RM 16.2 and 10.1, FULL attainment at RM 1.0/0.5, and PARTIAL attainment at RM 0.2. PARTIAL and NON attainment is attributed to point source impacts and channel modifications. Under the recommended MWH designation upstream from RM 5.5, Painter Creek would be in FULL attainment between RM 16.2 and 10.1, except for the NON attainment at RM 15.0 which appears to be caused by the Arcanum WWTP.

Mud Creek (WWH)

* Mud Creek was in FULL attainment between RM 5.9 and 4.6, but only PARTIAL attainment at RM 0.2/0.1. The cause of PARTIAL attainment at RM 0.2 (fish were not achieving biocriteria) may be attributed to lower habitat quality due to previous channelization.

Prairie Outlet (WWH)

* Prairie Outlet had an impacted fish assemblage at RM 0.8 which resulted in PARTIAL attainment of WWH. Impacts are attributed to runoff from several large livestock operations and a concentration of on-site septic systems.

Table 11. Summary of aquatic life use attainment status for 51 sampling locations in the Stillwater River basin during 1990. Attainment status is based on Eastern Corn Belt Plains (ECBP) criteria.

River Mile Fish/Benthic	MIwb	IBI	ICI	QHEI	Attainment Status Existing	Recommended	Comments
Stillwater River (EWH)							
(wading EWH criteria 9.4/50/46, WWH criteria 8.3/40/36)					(EWH)	(WWH)	
63.0/63.0	8.0*(ns)	38*(ns)	54	40.5	PARTIAL	FULL	Ust. N. Fork Stillwater
57.0/57.0	7.9*(ns)	39*(ns)	50	61.5	PARTIAL	FULL	Ust. Beisner Rd.
52.4/52.4	7.4*	36*(ns)	46	78.5	PARTIAL	No Change	Steffen Rd.
47.8/	7.3*	39*	-	79.5	[NON]	No Change	SR 121
43.7/44.2	8.5*	43*	46	78.5	PARTIAL	No Change	Seibt Rd.
37.8/37.7	9.0ns	49ns	48	83.5	FULL	No Change	SR 185
(boat criteria 9.6/48/46)							
31.2/30.9	9.9	54	44ns	89.0	FULL	No Change	Dst. Greenville Cr. & Covinton
30.6/-	9.2ns	48	-	81.0	[FULL]	No Change	Dst. Greenville Cr. & Covinton
28.1/27.7	8.6*	49	42ns	74.0	PARTIAL	No Change	Ust. Lauver Rd.
25.3/25.2	9.9	58	46	86.5	FULL	No Change	Penny Rd.
18.0/18.3	9.4ns	55	48	85.5	FULL	No Change	Dst. West Milton Dam
16.0/16.4	9.2ns	51	46	85.0	FULL	No Change	Dst. West Milton WWTP
/12.2	-	-	46	-	[FULL]	No Change	
11.5/11.4	8.3*	48	48	82.0	PARTIAL	No Change	Dst. Union WWTP
9.0/9.1	9.8	41*	50	78.0	PARTIAL	No Change	Dam pool, ust. Englewood WWTP
8.8/8.8	10.4	41*	46	81.0	**	No Change	Englewood WWTP mixing zone
8.4/8.6	9.5ns	49	44ns	88.0	FULL	No Change	Dst. Englewood WWTP
5.0/4.8	8.7*	47ns	50	89.0	PARTIAL	No Change	Philadelphia Rd.
1.2/1.5	9.0*	50	48	80.5	PARTIAL	No Change	Ust. mouth
Greenville Creek (EWH)							
(headwater criteria 50/36)					(EWH)	No Change	
34.2/34.2	NA	53	52	83.5	FULL	No Change	McClure Rd.
(wading criteria 9.4/50/46)							
29.0/28.9	8.7*	51	54	68.0	PARTIAL	No Change	Ust. Fisher Rd.
(boat criteria 9.6/48/46)							
23.2/22.3	9.0*	37*	52	87.0	PARTIAL	No Change	Ust. Daly Rd.
20.6/20.8	8.9*	39*	56	70.5	PARTIAL	No Change	Treaty of Greenville Park
19.6/19.5	8.2*	34*	50	59.0	PARTIAL	No Change	Ust. Greenville WWTP
19.3/19.3	8.4*	34*	48	67.0	**	No Change	Greenville WWTP mixing zone
19.2/19.1	7.8*	30*	42ns	65.0	PARTIAL	No Change	Dst. Greenville WWTP
17.3/18.3	6.5*	30*	50	66.5	PARTIAL	No Change	Dst. Jaysvill Rd.
15.4/16.2	7.1*	29*	VGns	61.0	PARTIAL	No Change	Willis Rd.
14.3/13.7	6.3*	32*	50	59.5	NON	No Change	Bears Mill dam pool
12.0/	9.2ns	38*		84.0	(PARTIAL)	No Change	Dst. Bears Mill Dam
11.9/	8.4*	32*		92.5	PARTIAL	No Change	Dst. Bears Mill Dam
10.6/10.5	9.2ns	46ns	50	98.5	FULL	No Change	Gettysburg Rd.
10.3/	8.6*	38*		92.5	(NON)	No Change	Gettysburg Rd.
5.0/5.5	9.2ns	41*	48	100.0	PARTIAL	No Change	Ust. Buckneck Rd.
4.2/	9.6	42*		84.5	(PARTIAL)	No Change	Buckneck Rd.
0.1/1.4	9.6	51	40*	89.0	PARTIAL	No Change	at mouth/ dst. Range Line Rd.

Table 11. continued.

River Mile Fish/Benthic	MIwb	IBI	ICI	QHEI	Attainment Status Existing	Recomm.	Comments
North Fork Stillwater (WWH)							
(headwater criteria 40/36)					(WWH)	(MWH)	
0.5/0.4	NA	26*	G	28.0	NON	FULL	Ust. SR 118
Swamp Creek (WWH)							
(headwater criteria 40/36)					(WWH)	(MWH)	
8.8/8.8	NA	24*	30*	28.0	NON	FULL	Versailles - Yorkshire Rd.
(wading criteria 8.3/40/36)					(WWH)	No Change	
4.5/4.4	6.8*	26*	32ns	48.0	NON	No Change	Dst. Long Rd.
1.6/1.5	7.5*	33*	42	62.0	PARTIAL	No Change	SR 121
Indian Creek (WWH)							
(headwater criteria 40/36)					(WWH)	No Change	
2.0	NA	32*	MGns	52.0	PARTIAL	No Change	Dst. Conover Rd.
Painter Creek (EWH)							
(headwater criteria 50/36)					(EWH)	(MWH)	
16.2	NA	28*	MG*	36.0	NON	FULL	Ivester Park
15.2/15.5	NA	27*	40*	44.5	NON	FULL	Ust. Sycamore Ditch
15.0/15.0	NA	29*	10*	39.0	NON	NON	Dst. Sycamore Ditch (WWTP & landfill)
(wading criteria 9.4/50/36)							
10.1/10.1	5.4*	30*	56	57.0	NON	FULL	Ust. Arcanum Rd.
0.5/1.0	9.4	50	42ns	92.0	FULL	No Change	Adj. Sugar Grove Rd., dst. falls
0.2/	8.4*	46ns	-	87.0	(PARTIAL)	No Change	Owens Rd.
Mud Creek (WWH)							
(headwater criteria 40/36)					(WWH)	No Change	
5.9/5.9	NA	57	32ns	63.0	FULL	No Change	Weaver - Ft. Jefferson Rd.
4.6/4.6	NA	44	48	59.0	FULL	No Change	Byrket Rd.
(wading criteria 8.3/40/36)							
0.2/0.1	7.4*	35*	46	55.5	PARTIAL	No Change	Ust. SR 502
Prairie Outlet (WWH)							
(headwater criteria 40/36)					(WWH)	No Change	
0.8/0.8	NA	33*	44	68.5	PARTIAL	No Change	Weaver - Ft. Jefferson Rd.

ns Nonsignificant departure from biological criteria (≤ 4 IBI and ICI units and ≤ 0.5 MIwb units).

* Significant departure from biological criteria (>4 IBI or ICI units; >0.5 MIwb units).

__ Underlined values are in the poor or very poor range.

** Biological criteria is not applied to mixing zone.

{ } One or more of the three required indices are lacking data.

G = Good, MG = Marginally Good, F = Fair, P = Poor, VP = Very Poor

NA Not applicable, headwater site.

TREND ASSESSMENT: 1982 to 1990

Chemical/Physical Water Quality (Tables 12, 13; Figs. 7 - 14)

* *Daytime* dissolved oxygen levels were generally higher and more conducive to aquatic life throughout the study area during 1990 than during 1982 (Fig. 7). The largest improvements occurred downstream from the Ansonia WWTP, Greenville WWTP, Versailles WWTP, and Arcanum and are primarily attributed to upgraded WWTPs. Slight decreases occurred in the Stillwater River at RM 8.9 and Greenville Creek at RM 0.8, however, levels remained high and conducive to aquatic life.

* A comparison of 1990 and 1982 5 day - biochemical oxygen demand (BOD_5) levels (Fig. 8) shows increased concentrations in the Stillwater River between RM 63.0 and 32.5, Greenville Creek between RM 34.5 and 22.4, Swamp Creek between RM 4.4 and 1.6, and at RM 0.4 in the North Fork. These increases are attributed to higher nonpoint source pollution loads due to elevated flows during 1990. Substantial decreases, attributed to upgraded WWTPs, have occurred in the Stillwater River downstream from RM 27.9 and Greenville Creek downstream from RM 18.8. BOD_5 levels have remained similar in Painter Creek downstream from Arcanum and upstream from Sycamore Ditch (WWTP).

* Since 1982, ammonia-nitrogen (NH_3-N) levels have markedly decreased in the Stillwater River downstream from the Ansonia WWTP (RM 57.0), in Greenville Creek downstream from the Greenville WWTP (RM 18.8 to 16.2), and in Swamp Creek downstream the Versailles WWTP (RM 1.6) (Fig. 9). Another notable decline occurred in the Stillwater River downstream from the Union WWTP (RM 11.4). Small increases, attributed to nonpoint sources, occurred in Greenville Creek at RM 28.8, Swamp Creek at RM 4.4, and the North Fork at RM 0.4.

* Total phosphorus (P-T) trends in the study area during 1990 showed substantial decreases since 1982 in the Stillwater River downstream from the Ansonia WWTP, in Greenville Creek downstream from the Greenville WWTP, and in Swamp Creek downstream from the Versailles WWTP (the largest decrease) (Fig. 10). Increased concentrations, which may also be attributed to increased nonpoint runoff from higher flows, were recorded at several locations in the Stillwater River, RM 34.5 in Greenville Creek, RM 4.4 in Swamp Creek, and RM 0.4 in the North Fork.

* Total nonfilterable residue (TSS) trends (Fig. 11) during 1990 were similar throughout the study area and showed generally higher levels of suspended solids than during 1982. These increases are also attributed to increased nonpoint source runoff (primarily soil erosion) due to elevated flows.

* Nitrate-Nitrite (NO_3-NO_2) trends (Fig. 12) were also higher in the study area during 1990 than during 1982. These increases are also primarily attributed to nonpoint source runoff, although nitrification at upgraded WWTPs is also a contributing source. Concentrations during 1990 in Swamp Creek and the North Fork were extremely elevated compared to background levels in Ohio's Eastern Corn Belt Plains ecoregion.

* Total copper (Cu-T) trends (Fig. 13) in the study area during 1990 showed slight increases over 1982 levels at several sites in the Stillwater River, Swamp Creek and the North Fork (largest increase). Although higher, these levels were still generally conducive to aquatic life.

* Total zinc (Zn-T) concentrations (Fig. 14) during 1990 also increased compared to 1982 levels in the Stillwater River downstream from RM 46.1, at several sites in the lower segment of Greenville Creek, and in Swamp Creek (RM 1.6 had the largest increase), the North Fork and Painter Creek. The 1990 levels were still conducive to aquatic life. The sources of the zinc are unknown.

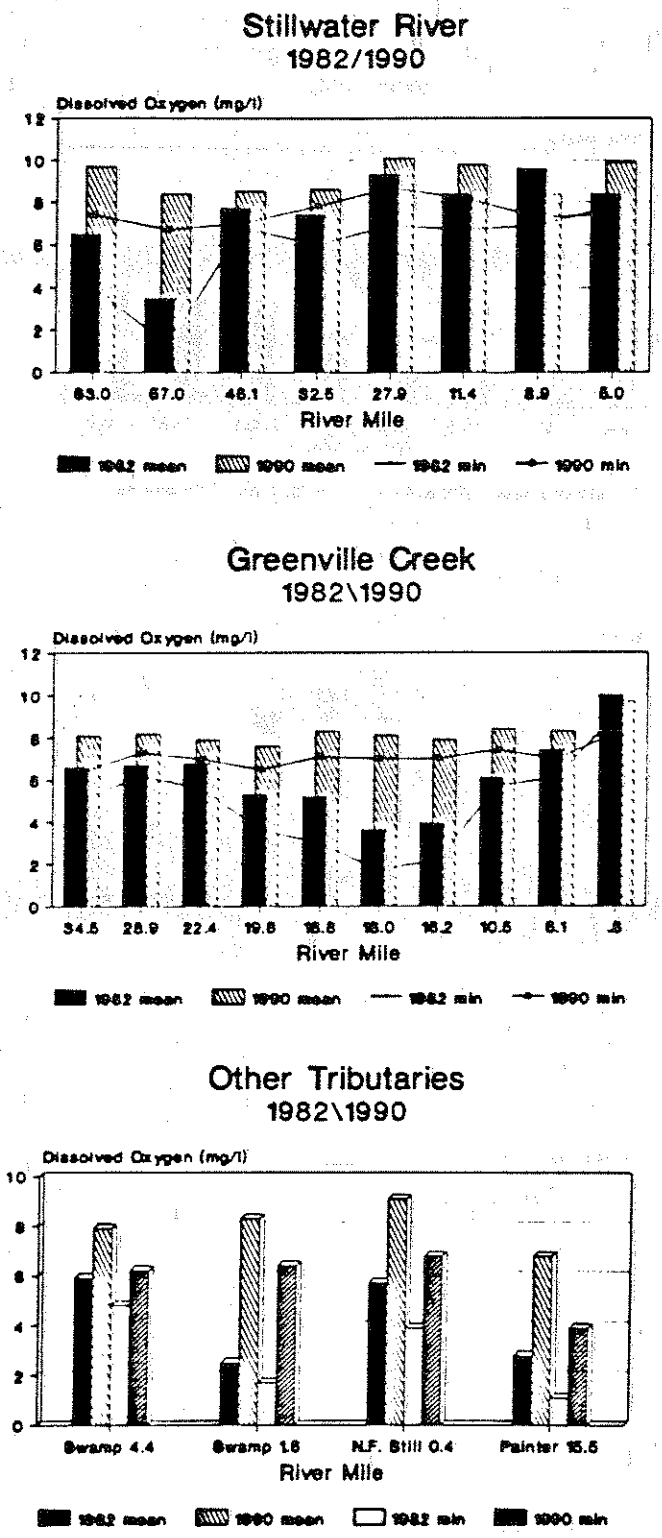
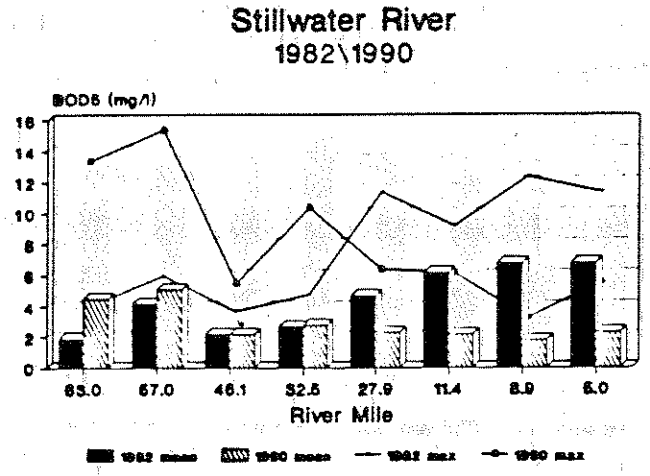
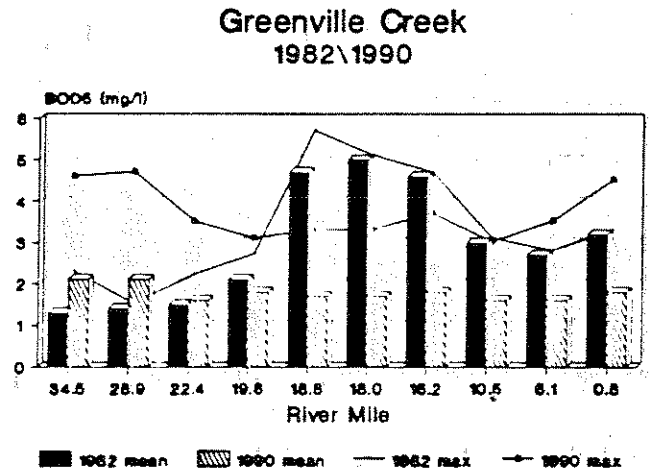


Figure 7. Dissolved oxygen (DO) trends in the study area: 1990 vs. 1982.





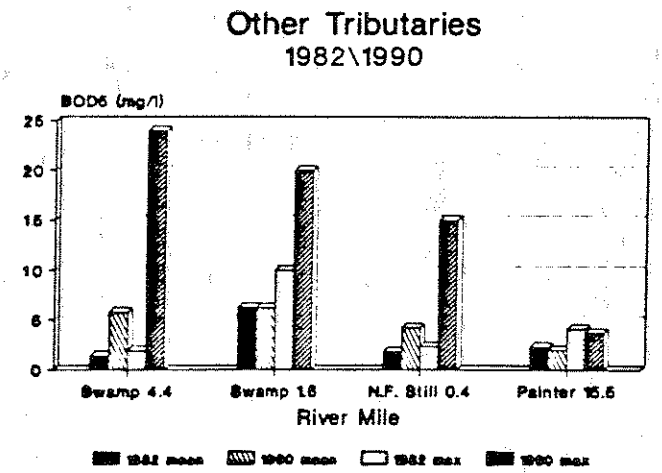


Figure 8. Biochemical oxygen demand - 5 day (BOD_5) trends in the study area: 1990 vs. 1982.

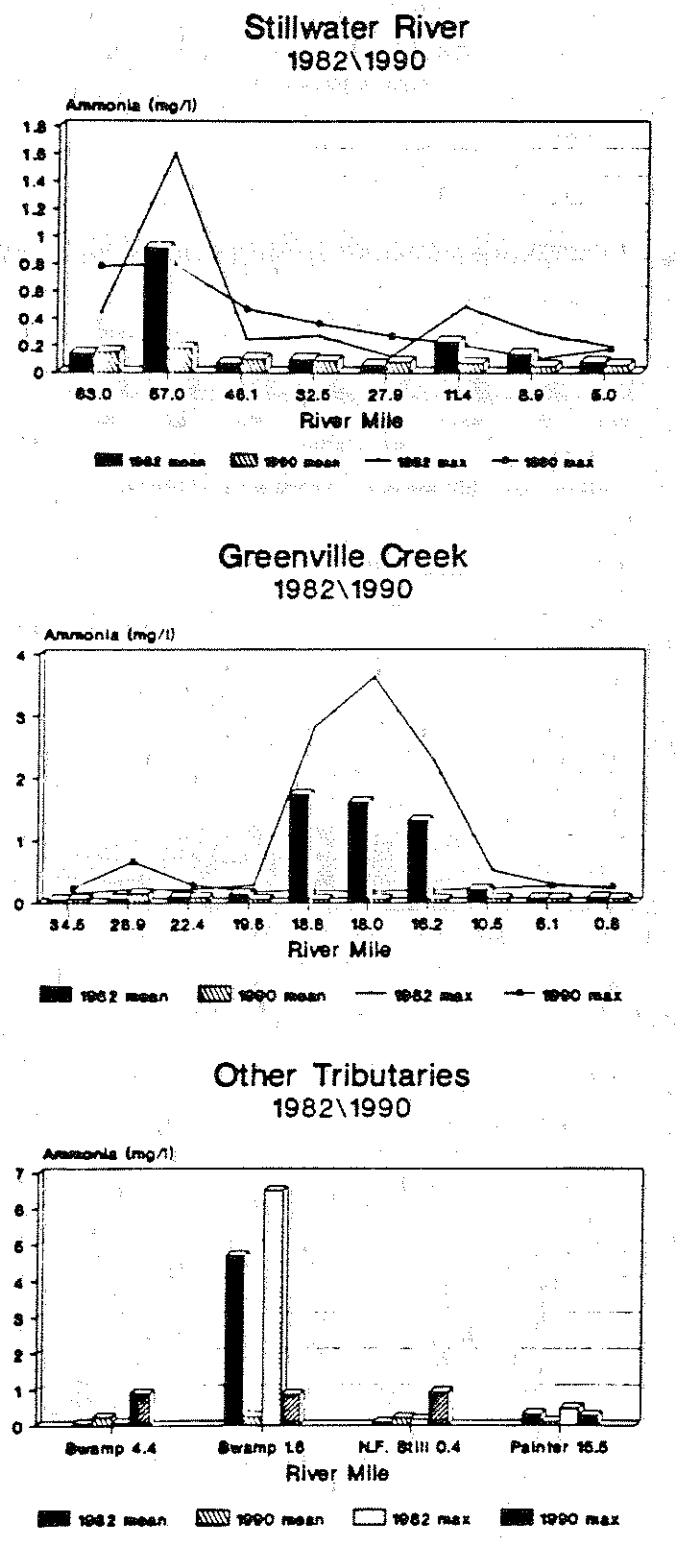


Figure 9. Ammonia-nitrogen (NH_3-N) trends in the study area: 1990 vs. 1982.

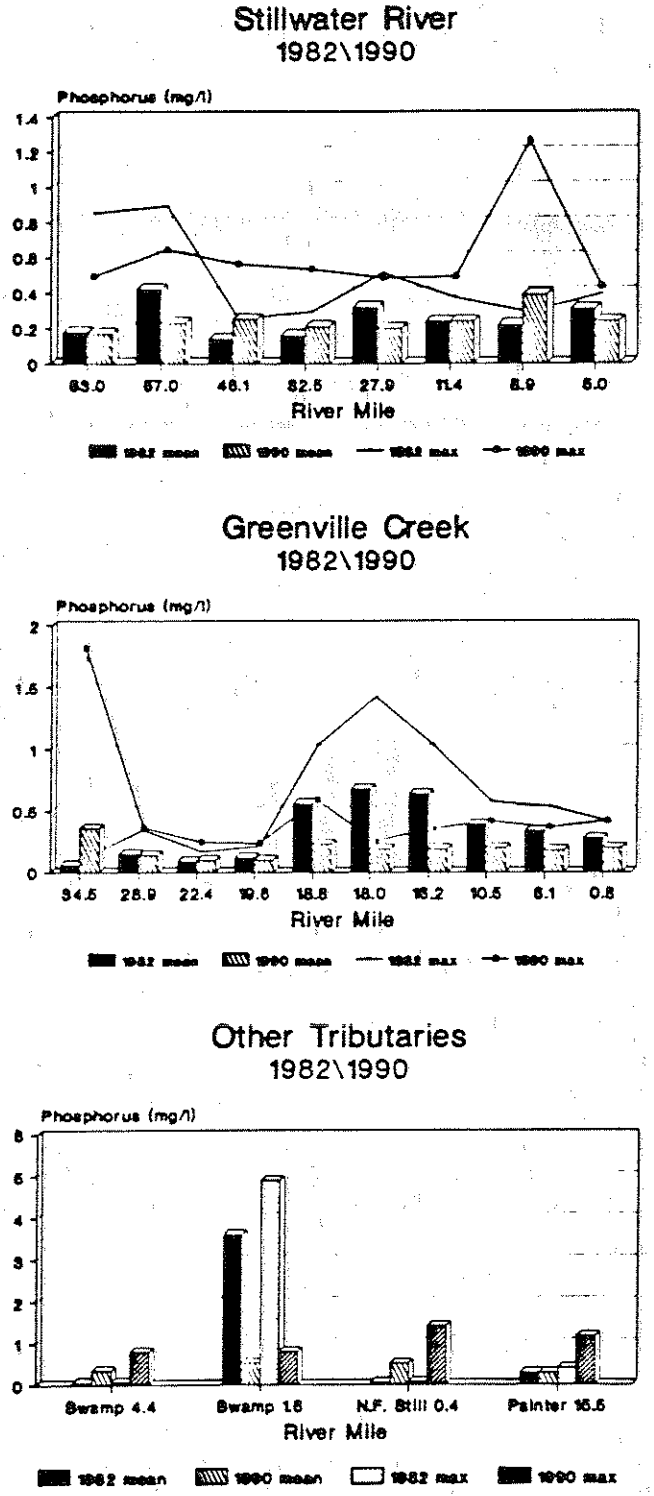


Figure 10. Phosphorus- total (P-T) trends in the study area: 1990 vs. 1982.

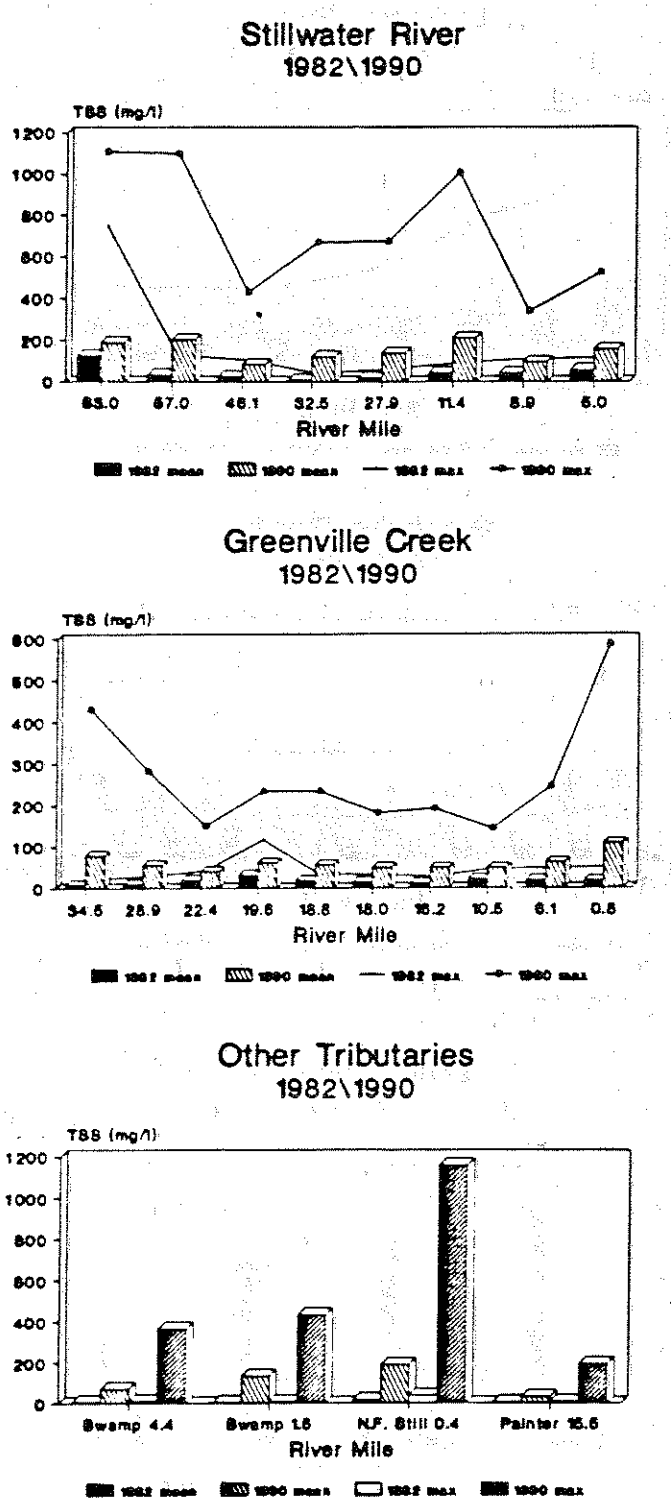
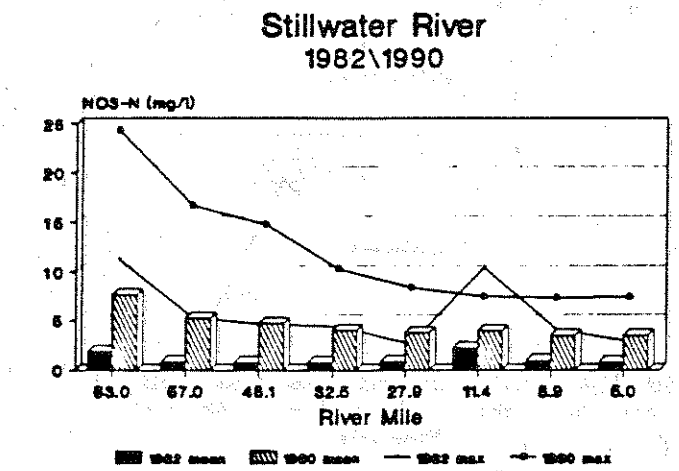
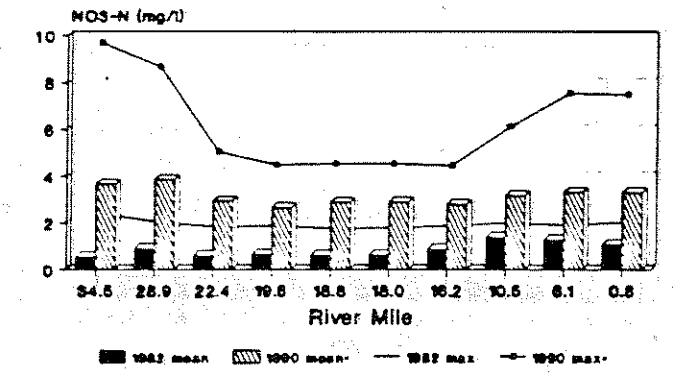


Figure 11. Total nonfilterable residue (TSS) trends in the study area: 1990 vs. 1982.





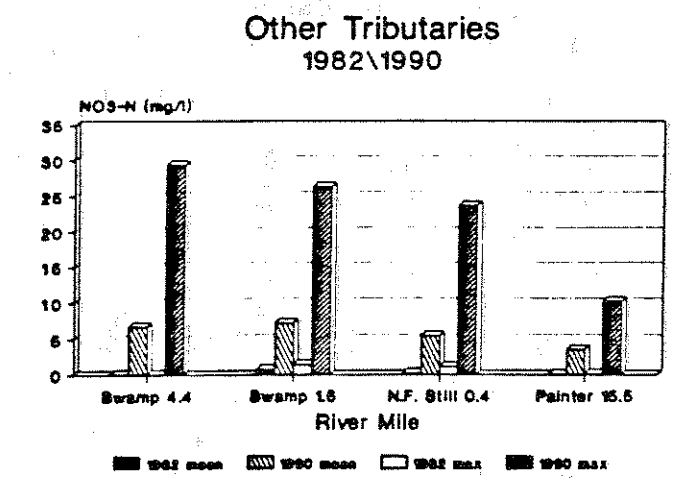
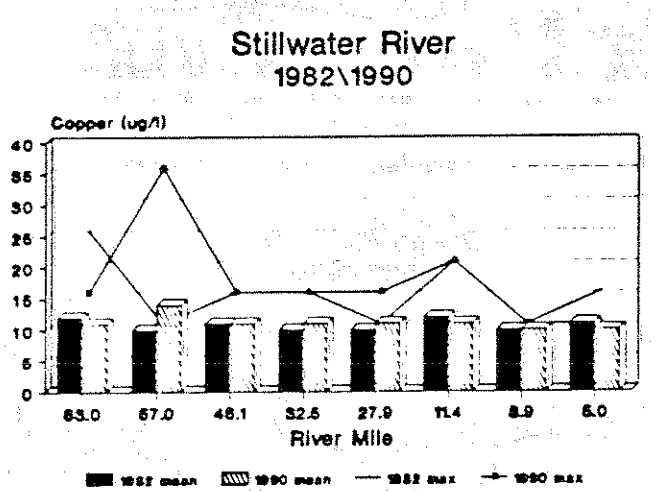


Figure 12. Nitrate-Nitrite (NO_3-NO_2) trends in the study area: 1990 vs. 1982.



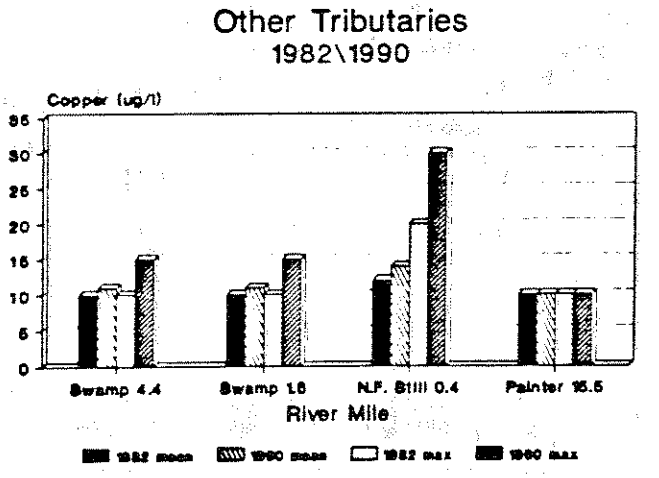


Figure 13. Copper-total (Cu-T) trends in the study area: 1990 vs. 1982.

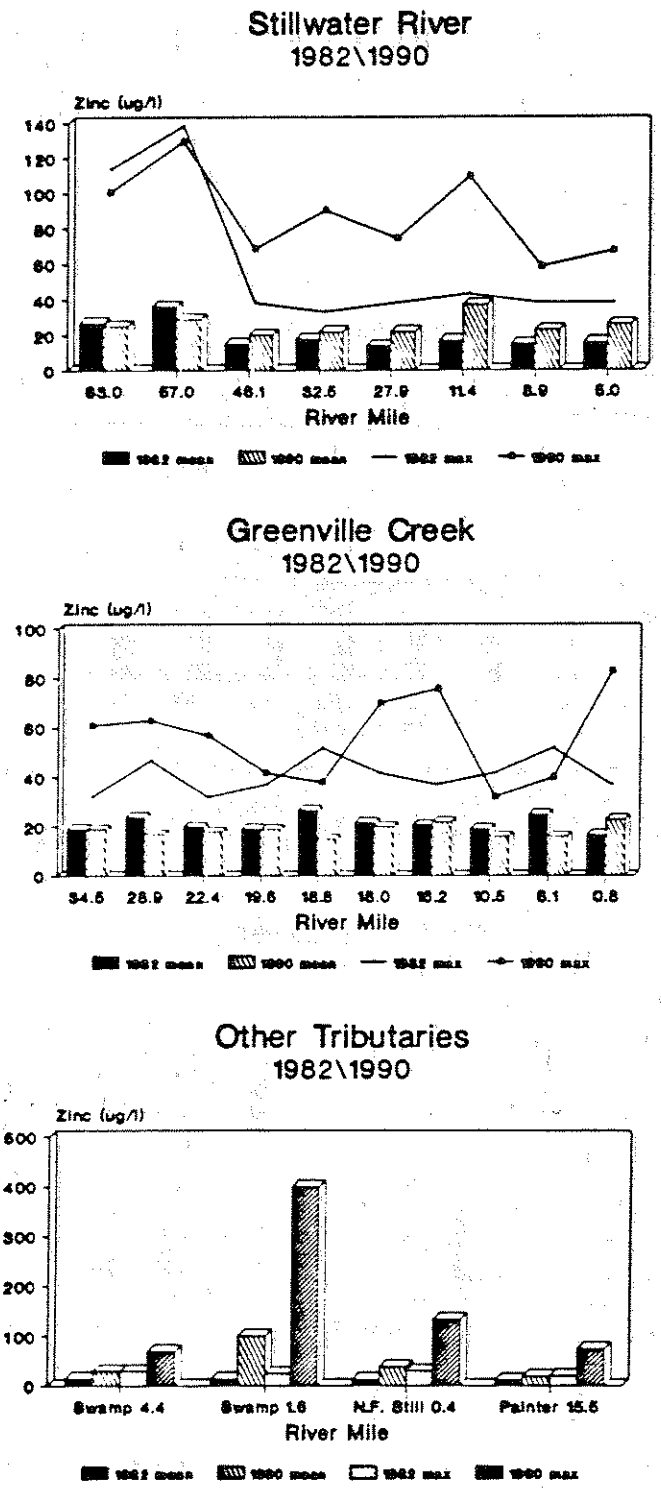


Figure 14. Zinc-total (Zn-T) trends in the study area: 1990 vs. 1982.

Pollutant Loadings (Tables 12, 13; Figs. 7 - 14)

* A comparison of mean annual loadings (kg/day) from the Englewood WWTP prior to upgrade (1982 - 1987) to post-upgrade (1989 - 1990) shows decreases in mean NH_3-N (24.4 to 11.3), BOD5 (76.8 to 34.6 (CBOD5)), and TSS (98.1 - 79.2). Nitrate-N increased from 9.1 to 22.4 kg/day because of the nitrification of NH_3-N.

* A comparison of annual mean loadings (kg/day) from the Greenville WWTP prior to upgrade (1982 - 1987) to post-upgrade (1989 - 1990) shows mean decreases in NH_3-N (47.9 to 3.0) and BOD5 (75.6 to 42.8 (CBOD5)) and increases in nitrate-N (8.2 to 149.2) and TSS (82.7 to 84.4).

* During the same periods, annual mean discharge flows (MGD) have increased slightly at the Englewood WWTP (1.4 to 1.7) and significantly at the Greenville WWTP (1.5 to 2.6).

* Ranked from the highest to lowest amount of discharge, cumulative third quarter average daily flow (MGD) of the 21 dischargers in the Stillwater River basin during the last five years was 8.7 during 1990, 7.5 during 1987, 7.0 during 1989, 6.9 during 1986, and 5.6 during 1988.

* Ranked from the highest to lowest daily mean loadings (kg/day), cumulative third quarter daily discharges of ammonia-N from 11 dischargers in the Stillwater River basin during the last five years was 147.4 during 1987, 113.6 during 1986, 78.5 during 1988, 38.5 during 1989, and 25.6 during 1990. The overall decline was 83% of the 1987 loading.

* Daily mean loadings of total suspended solids (kg/day), ranked from the highest to lowest for cumulative third quarter daily discharges from 12 dischargers in the Stillwater River basin during the last five years was 581.8 during 1987, 316.0 during 1990, 307.3 during 1986, 285.1 during 1988, and 251.5 during 1989. The overall decline was 57% of the 1987 loading.

* Daily mean loadings of CBOD5 (kg/day), ranked from the highest to lowest for cumulative third quarter daily discharges from 11 dischargers in the Stillwater River basin during the last five years was 218.9 during 1987, 201.1 during 1989, 191.6 during 1990, 153.9 during 1986, and 152.5 during 1988. The overall decline was 30% of the 1987 loading.

Table 12. Third Quarter (July 1 - September 30) mean loadings (kg/day) of CBOD5, total suspended solids (TSS), and ammonia-N (NH3-N) for dischargers in the Stillwater River Basin study area for the period 1986-1990. (Facilities arranged in order from upstream to downstream).

Facility River Mile	Average Daily Flow (MGD)					CBOD5 (kg/day)				
	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
Ansonia WWTP										
58.0, 0.2	0.19	0.19	0.16	0.29	0.18	9.9	11.0	7.7	2.9	1.8
Rolin Acres WWTP										
54.2, 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Versailles WWTP										
45.9, 2.1	0.22	0.24	0.15	0.28	0.29	4.7*	5.4	0.9	1.3	0.7
Bradford WWTP										
33.8, 2.5, 1.3	0.14	0.20	0.13	0.21	0.24	18.1*	20.7*	19.2*	15.4*	20.1*
Bradford WTP										
33.8, 2.5, 1.3	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-
American Aggregates										
32.3, 21.3, 7.8	0.8	0.8	N/A	N/A	0.8	-	-	-	-	-
Allied Aftermarket										
32.3, 19.5 & 17.8	N/A	0.19	0.14	0.003	0.006	-	-	-	-	-
Greenville WWTP										
32.3, 19.4	1.5	1.8	1.5	2.8	2.6	14.8	94.1	27.7	18.2	39.2
Corning Glass Works										
32.3, 19.2	0.4	0.5	0.6	0.6	0.5	-	-	-	-	-
Gettysburg WTP										
32.3, 10.5	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-
Beatrice Food Ingredients[a]										
32.3, 0.4	0.006	0.005	0.02	0.002	0.005	-	-	-	-	-
Covington WWTP										
32.2	0.40	0.40	0.34	0.45	0.36	5.5	4.7	4.2	7.8	3.7
New Tech Plastics										
31.9, 0.3	0.02	0.02	0.02	0.01	0.01	-	-	-	-	-
Arcanum WWTP										
29.8, 15.0, 0.6	0.42	0.36	0.20	0.50	0.54	14.0	12.2	5.9	28.8	18.4
Pleasant Hill WWTP										
26.2	0.10	0.13	0.09	0.13	0.11	0.8	0.5	1.1	0.8	0.6
Christopher's MHP										
17.9, 1.2	N/A	0.02	0.02	0.01	0.01	N/A	0.3*	0.1*	0.1	0.1
West Milton WTP										
17.4	0.01	0.01	0.01	0.02	0.02	-	-	-	-	-
West Milton WWTP										
16.6	0.51	0.30	0.27	0.47	0.35	28.6	37.8	38.0	118.9	34.4
Union WWTP										
11.7, 0.5	0.94	0.98	0.70	N/A	1.11	27.4	15.7	40.0	N/A	45.7
Englewood WWTP										
8.8	1.22	1.29	1.21	1.16	1.52	30.1	16.5	7.7	6.9	26.9
Greater Northridge SD										
8.0 - 2.2	N/A	N/A	N/A	N/A	N/A	-	-	-	-	-

Table 12. continued.

Facility River Mile	TSS (kg/day) 1986	1987	1988	1989	1990	NH3-N (kg/day) 1986	1987	1988	1989	1990
Ansonia WWTP 58.0, 0.2	25.1	26.3	15.0	3.4	15.0	0.16	0.14	0.04	0.07	0.02
Rolin Acres WWTP 54.2, 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Versailles WWTP 45.9, 2.1	4.7	7.3	3.1	7.8	5.2	7.8	9.3	1.7	0.3	0.1
Bradford WWTP 33.8, 2.5, 1.3	6.8	40.7	21.4	32.1	42.6	0.2	0.4	1.0	0.4	1.1
Bradford WTP 33.8, 2.5, 1.3	-	-	-	-	-	-	-	-	-	-
American Aggregates 32.3, 21.3, 7.8	N/A	N/A	N/A	N/A	N/A	-	-	-	-	-
Allied Aftermarket 32.3, 19.5 & 17.8	-	-	-	-	-	-	-	-	-	-
Greenville WWTP 32.3, 19.4	46.3	301.4	60.3	55.9	60.9	29.5	88.2	52.4	3.2	2.4
Corning Glass Works 32.3, 19.2	6.1	11.8	12.7	6.0	5.1	-	-	-	-	-
Gettysburg WTP 32.3, 10.5	-	-	-	-	-	-	-	-	-	-
Beatrice Food Ingredients[a] 32.3, 0.4	-	-	-	-	-	-	-	-	-	-
Covington WWTP 32.2	18.5	18.0	17.6	18.0	9.7	0.2	0.1	1.9	1.7	0.9
New Tech Plastics 31.9, 0.3	-	-	-	-	-	-	-	-	-	-
Arcanum WWTP 29.8, 15.0, 0.6	14.2	8.4	6.2	31.8	16.6	0.6	0.8	0.5	2.0	0.5
Pleasant Hill WWTP 26.2	1.5	0.9	2.2	2.5	2.1	0.8	0.3	0.8	0.9	0.7
Christopher's MHP 17.9, 1.2	N/A	0.2	0.1	0.1	0.3	N/A	N/A	0.07	0.04	0.02
West Milton WTP 17.4	N/A	N/A	N/A	N/A	N/A	-	-	-	-	-
West Milton WWTP 16.6	N/A	30.3	31.1	60.5	22.1	48.7	19.2	17.0	26.5	14.1
Union WWTP 11.7, 0.5	40.6	47.5	40.1	N/A	87.0	24.7	14.9	2.0	N/A	1.4
Englewood WWTP 8.8	143.5	89.0	75.3	33.4	49.4	0.9	14.1	1.1	3.4	4.4
Greater Northridge SD 8.0 - 2.2	-	-	-	-	-	-	-	-	-	-

[*] BOD5 (kg/day)

[a] Formerly Westerville Creamery

Table 13. Flow (MGD) and mean annual loadings (kg/day) of select parameters for the Englewood WWTP and Greenville WWTP from 1982-1990.

Facility Year (Dec-Nov)	Flow	NH3-N	Nitrate-N	Phos-T	BOD5	TSS
Englewood WWTP						
1982	1.502	47.03	4.29	15.39	68.57	71.00
1983	1.277	13.83	19.86	7.35	61.83	89.66
1984	1.372	34.65	6.1	6.60	40.97	71.38
1985	1.485	14.74	6.1	7.05	145.67	123.85
1986	1.592	20.92	N/A	N/A	76.60	122.94
1987	1.361	15.50	N/A	N/A	67.44	109.86
1988	1.359	16.49	14.53	N/A	34.88	87.51
1989	1.633	12.63	20.34	N/A	38.33[a]	96.38
1990	1.765	10.01	24.51	N/A	30.84[a]	62.04
Greenville WWTP						
1982	1.539	79.76	3.039	-	135.89	56.61
1983	1.411	87.03	4.32	-	114.01	115.79
1984	1.446	42.51	21.02	-	64.76	64.92
1985	1.444	15.07	N/A	-	45.02	49.32
1986	1.712	9.13	4.23	-	33.39	44.59
1987	1.436	53.71	N/A	-	60.73[a]	164.75
1988	1.616	44.85	30.66	-	26.38[a]	45.60
1989	2.642	2.80	161.78	-	35.01[a]	81.98
1990	2.642	3.12	136.55[b]	-	50.66[a]	86.72

[a] CBOD5

[b] NO3-NO2

Biological Assessment (Tables 14, 15; Figs. 15 - 19)

* Macroinvertebrate and fish assemblages in the Stillwater River basin have shown improvement at most sampling sites since the 1982 survey. This was primarily attributed to reduce point source pollutant loadings from upgraded municipal wastewater treatment facilities. The 1990 results suggest that impacts from point source discharges still exist, but are much less than during 1982.

* Despite relatively good chemical water quality, channelization remains a limiting factor in the ability to attain the WWH and EWH use designation in several stream segments.

* Manure runoff (nonpoint source pollution from animal husbandry operations) is listed as the suspected pollutant in six ODNR fish kill investigations resulting in a total kill of 130,432 animals in Darke County within the Stillwater Basin between 1983 and 1987. Although no kills were reported during 1988, 1989, or 1990 (or observed during this survey), runoff from these agricultural operations is negatively impacting fish and macroinvertebrate assemblages within the watershed.

Stillwater River

* Macroinvertebrate communities in the upper portion of the Stillwater River demonstrated improvements in 1990 compared to 1982 (Fig. 15). The positive response of the macroinvertebrate communities suggested a lessening of effects from nonpoint sources (i.e. channelization, agricultural and livestock runoff) upstream from Ansonia and improvements in wastewater treatment brought on line in 1986 at the Ansonia WWTP. The remainder of the river had similar trends in both years with ICI values ranging from 40 (good) to 50 (exceptional) in 1982 and 44 (very good) to 50 (exceptional) in 1990. Since 1982, ICI scores at 14 commonly sampled locations have shown a mean increase of 4.4 ICI units (range - 6 to +22) (Table 14). ICI scores increased at nine of the locations, were equal at two, and decreased at three locations. Area of Degradation Value (ADV) negative statistics, which indicates quantified departure from ICI biocriteria, declined from 11.3/mi. to 0.0/mi. while positive statistics, which indicates quantified performance above ICI biocriteria, increased from 14.9/mi to 51.5/mi. (Table 15).

* Fish assemblages in the Stillwater River have also shown overall improvement (Fig. 16). Comparison of 1990 to 1982 MIwb values at 15 commonly sampled locations, shows a mean increase of 0.5 MIwb units (range -1.9 to +2.5) (Table 14). Values increased at nine locations, were equal at one, and decreased at five. ADV negative statistics for the MIwb have declined from 42.9/mi. to 22.3/mi. while positive statistics have increased from 2.3/mi. to 8.3/mi. (Table 15). Differences between IBI values over the eight year period at 16 locations ranged from - 4 to + 11 IBI units with a mean increase of 3.3. Values increased at 10 locations, were the same at two, and declined at four. ADV negative statistics for the IBI have decreased from 41.6/mi. to 24.4/mi. while positive statistics have increased from 29.3/mi. to 40.9/mi.

* Reported fish kills in the Stillwater River since 1982 include; a tributary where 24 animals (mostly fish) were killed (6 August 1984) and chicken manure from an animal husbandry operation was the suspected pollutant; 11,223 animals in the mainstem on 11 August 1984 (the source is unknown) in Darke Co. In Miami Co., 33 animals were also killed in Brush Creek, a tributary of Ludlow Creek, on 15 August 1984 and cattle manure was listed as the suspected pollutant.

Greenville Creek

* The 1990 macroinvertebrate results for Greenville Creek exhibited substantial improvement over those collected in 1982 (Fig. 15). The relatively minor impairment detected downstream from the Greenville WWTP in 1990 rapidly recovered within one mile; similar improvements were not noted for nearly 5.6 miles in 1982. In addition, the near-field impact to the community was less severe in 1990 as compared to 1982. Improvement in waste treatment brought on line in 1988 at the Greenville WWTP was the most likely reason for the noted changes. Since 1982, ICI scores at 10 commonly sampled locations have shown a mean increase of 12.6 ICI units (range - 4 to +32) (Table 14).

Scores increased at eight of the locations and decreased at two locations. ADV negative statistics declined from 59.6/mi. to 1.2/mi. while positive statistics increased from 20.7/mi. to 70.2/mi. (Table 15).

* Since the 1982 survey, fish assemblages have also shown improvement (Fig. 17). MIwb values increased at all 12 commonly sampled locations (mean = 1.1 MIwb units, range +0.3 to +1.9). ADV negative statistics declined from 47.4/mi. to 30.8/mi. while positive statistics increased from 0.0/mi. to 4.0/mi. IBI values showed a mean increase of 3.5 IBI units(range -4 to +19). Values increased at nine sites, were equal at one, and decreased at three. ADV negative statistics declined from 98.8/mi. to 57.0/mi. while positive statistics increased from 0.8/mi. to 5.9/mi. (Table 15). The greatest IBI increase occurred upstream from Greenville (RM 29.0) and may be due to eliminated pollutant loadings into Dismal Creek from the Union City WWTP.

* Since 1982, reported fish kills within the Greenville Creek watershed (Darke Co.) are: 6,889 animals in Dismal Creek on 4 April 1986 (manure suspected from animal husbandry operation); 122,057 animals in a tributary and mainstem on 17 July 1984 (hog manure suspected from animal husbandary operation).

North Fork Stillwater River

* Macroinvertebrate and fish communities in the North Fork of the Stillwater River were similar in 1982 and 1990 suggesting no improvement in water quality and/or physical habitat. The ICI value in 1982 was 40 (good) with midges and the mayfly genera *Stenacron* and *Caenis* most numerous. Qualitative sampling in 1990 produced comparable results with 41 taxa collected including 11 varieties of mayflies and caddisflies. Caddisflies, the mayfly genus *Baetis*, and midges were observed to predominate the community. The 1990 IBI value (26) was the same as in 1982.

Swamp Creek

* The macroinvertebrate community in Swamp Creek demonstrated substantial improvement downstream from the Versailles WWTP (RM 2.1) in 1990 compared to 1982 (Fig. 18). The 1990 ICI value was 42 (good) at RM 1.5 compared to 8 (poor) and 16 (fair) in 1982 at RMs 1.7 and 0.3, respectively. The observed changes in 1990 reflected improvements in waste treatment (including CSOs) by Versailles. Since 1982, ADV negative statistics (ICI) declined from 108.3/mi. to 6.0/mi. while positive statistics increased from 10.3/mi. to 20.5/mi. (Table 15).

* Since 1982, IBI values improved the most (+8) downstream from the Versailles WWTP (RM 1.6) and remained similar at RM 4.5 (+1). ADV negative statistics decreased from 136.6/mi. to 92.1/mi. while positive statistics remained at 0.

* One fish kill has been reported in Swamp Creek since 1982 consisting of 55 animals on 5 October 1983. Manure was the suspected pollutant from an animal husbandry operation.

Indian Creek

* The macroinvertebrate communities in Indian Creek were similar in 1982 and 1990. The community in 1982 was evaluated as marginally good, the same as it was in 1990. Numbers of mayfly and caddisfly taxa collected both years were comparable as were the observed predominate populations.

* The IBI at Conover Rd. showed an increase of 9 units, but improved only to fair quality.

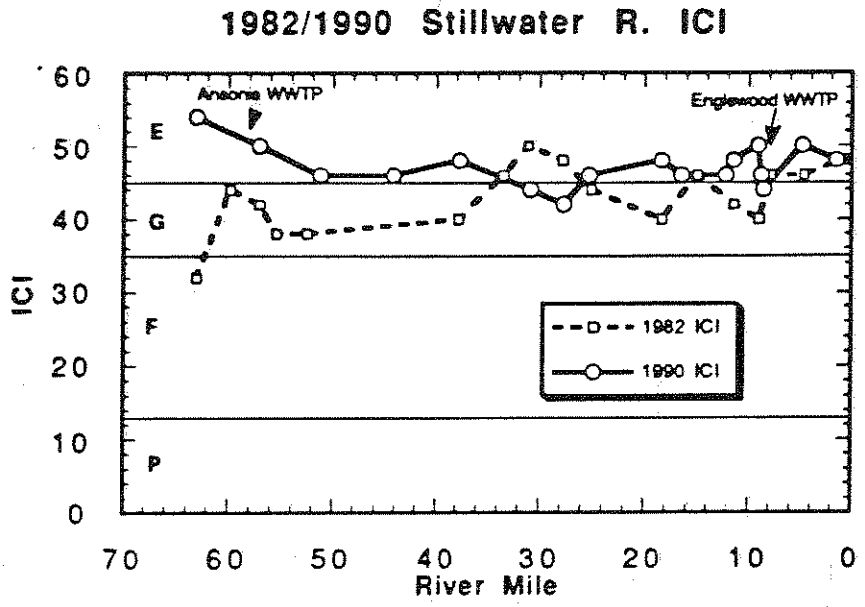
* One fish kill was reported in a tributary of Indian Creek on 11 May 1984. Fifty-eight animals were killed and cow manure was listed as the suspected pollutant from an animal husbandry operation.

Painter Creek

* The macroinvertebrate communities were similar in Painter Creek in 1982 and 1990 except more community degradation was detected downstream from Sycamore Ditch in 1990 (Fig. 19). The Arcanum WWTP discharges to Sycamore Ditch at RM 0.4 and the Arcanum Iron and Metal Co. hazardous waste site is located at RM 0.5. The increased severe biological degradation in Painter Creek downstream from Sycamore Ditch strongly supports the need for improved wastewater treatment in this area.

* IBI values in Painter Creek have shown the most improvement downstream from the WWTP between RM 10.1 and 0.5 (+6 to +8) and little improvement upstream from RM 15.2 (0 - +1). Since 1982, ADV negative statistics declined from 188.5/mi. to 65.5/mi. while positive statistics increased from 0.0/mi. to 45.8/mi.

* Hog manure was listed by ODNR as the suspected pollutant from an animal husbandry operation which killed 1,349 animals in Painter Creek (Darke County) on 4 August 1987.



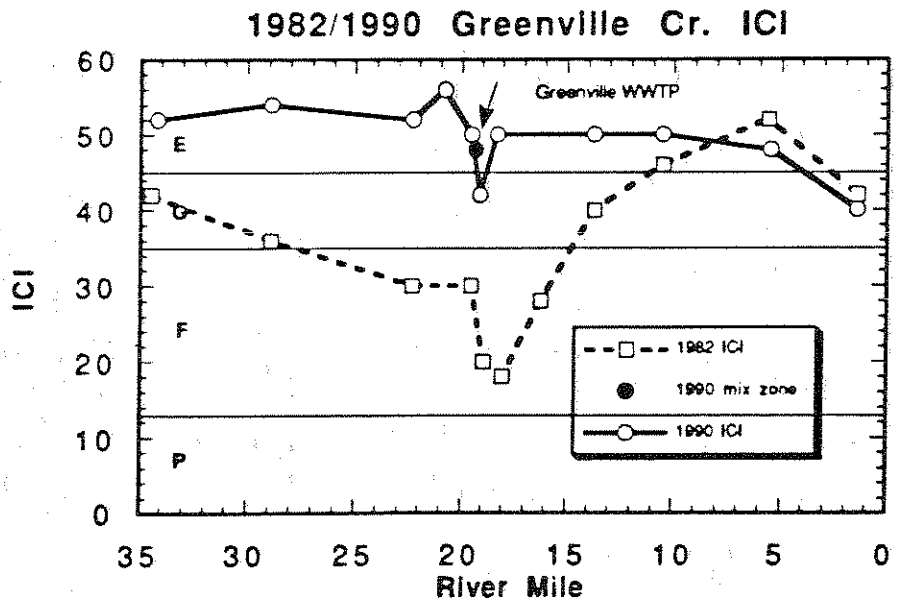


Figure 15. Longitudinal trend of the Invertebrate Community Index (ICI) in the Stillwater River and Greenville Creek, 1982 and 1990. E denotes exceptional invertebrate communities (meets EWH criterion), G denotes good invertebrate communities (meets WWH criterion), and F and P denote fair and poor invertebrate communities (non-attainment of aquatic life use).

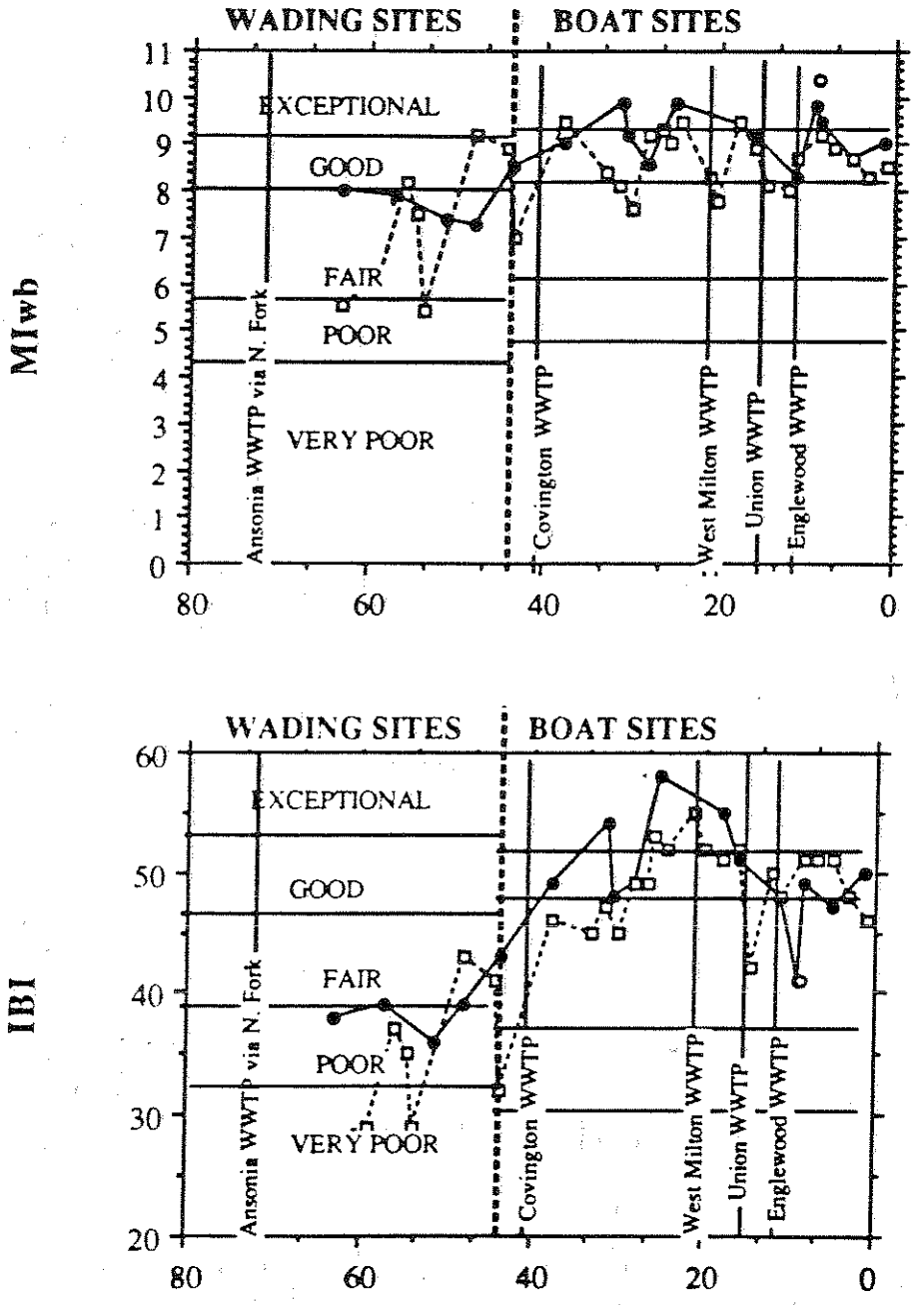


Figure 16. Comparision of 1982 and 1990 Modified Index of Well-Being (MIwb) and Index of Biotic Integrity (IBI) trends in the Stillwater River. Solid black and open circles denote 1990 values and open squares represent 1982 scores.

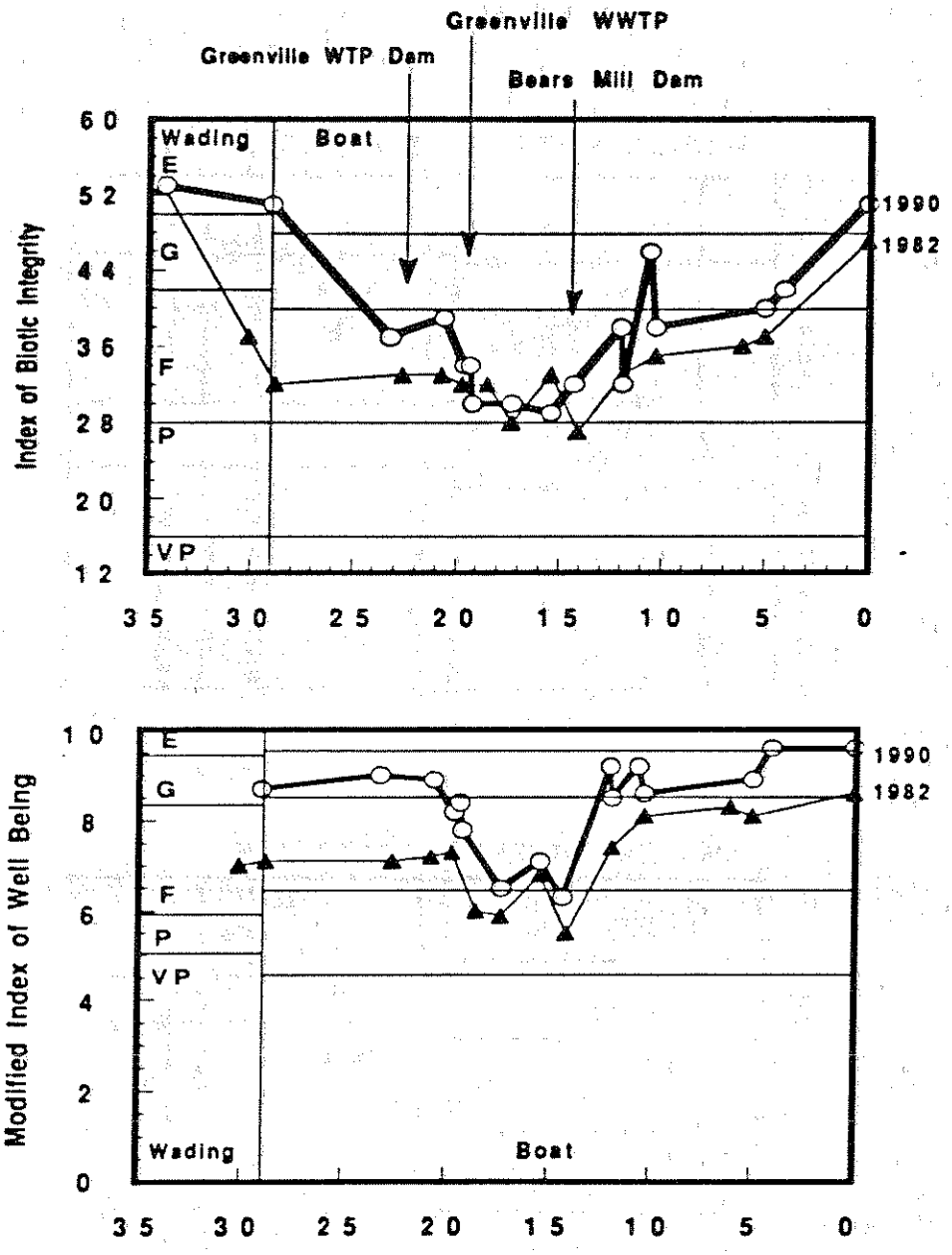


Figure 17. Comparision of 1982 and 1990 Modified Index of Well-Being (MIwb) and Index of Biotic Integrity (IBI) trends in Greenville Creek.

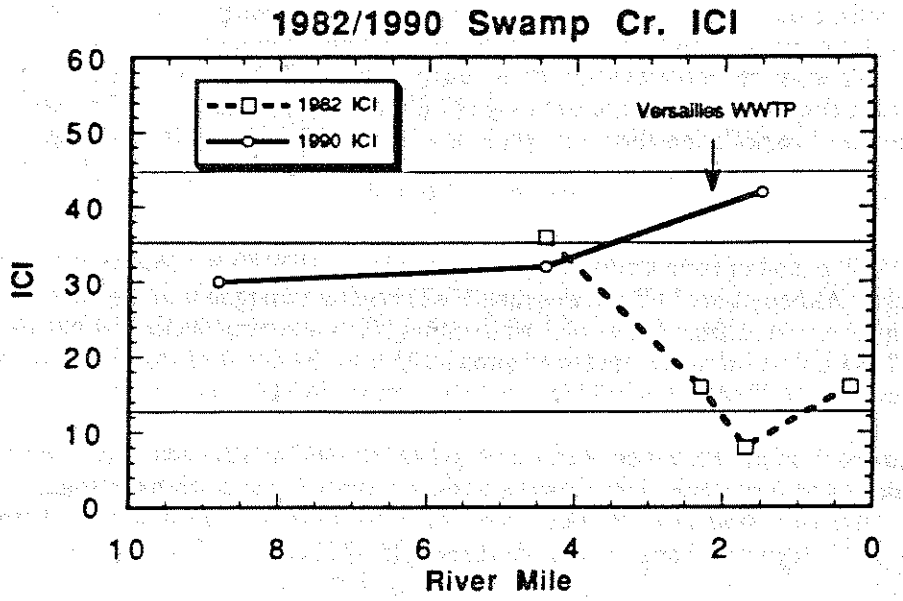


Figure 18. Longitudinal trend of the Invertebrate Community Index (ICI) in Swamp Creek, 1982 and 1990. E denotes exceptional invertebrate communities (meets EWH criterion), G denotes good invertebrate communities (meets WWH criterion), and F and P denote fair and poor invertebrate communities (non-attainment of aquatic life use).

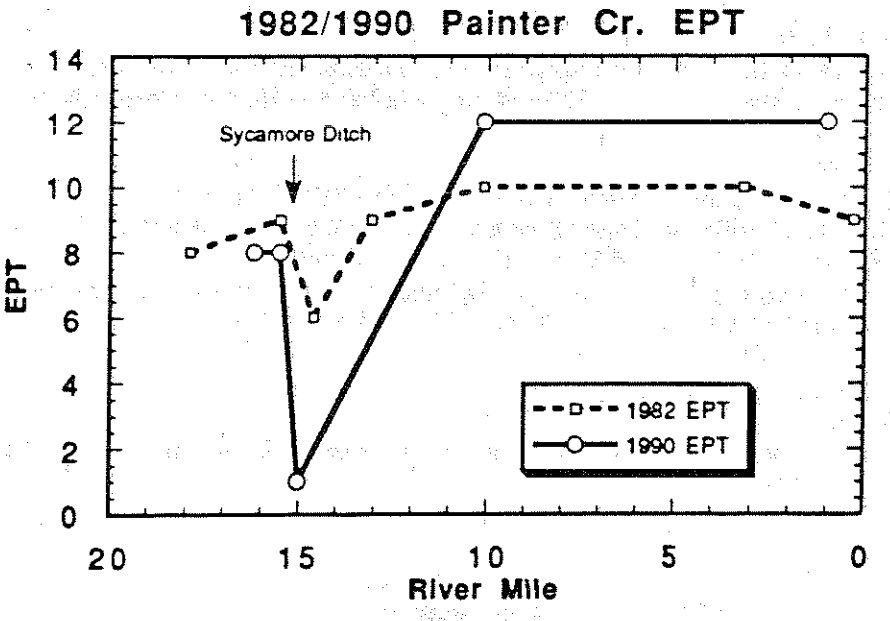


Figure 19. Longitudinal trend of the qualitative EPT (total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) taxa diversity) in Painter Creek, 1982 and 1990.

Attainment Status Trends: 1982 to 1990 (Tables 14-15)

* Since the 1982 survey, the attainment status has improved in one or more reaches of five out of six streams in the study area. Based on existing aquatic life use designations, changes in the attainment status during the eight year period (Stillwater River, Greenville Creek, Painter Creek, and Swamp Creek) consist of increases in miles attaining (7.5% to 25.8%) and partially attaining (44.7% to 60.1%) and a decrease in miles not attaining (47.8% to 14.1%) (Table 15). Improvements are primarily attributed to pollution abatement projects at major WWTPs resulting in improved water quality.

Stillwater River

* Since 1982, the attainment status of the Stillwater River (EWH) has shown considerable improvement. Although not FULLY attaining EWH criteria throughout the segment during 1990, miles attaining increased from 8.2 to 24.1 while miles NON attaining declined from 16.4 to 0.0. Total miles PARTIALLY attaining has remained similar (35.9 vs. 37.8). A change in the use designation to WWH upstream from RM 57.0 would results in 30.1 miles in FULL attainment.

* A comparison of the attainment status during 1990 to 1982 at 12 commonly sampled locations with fish and macroinvertebrate data shows a positive change in use attainment status in six reaches (RM 63.0 - 16.0; two NON to PARTIAL, four PARTIAL to FULL), no change in 4 reaches (RM 11.5 - 1.0), and a negative change in one short reach (RM 28.1-27.7; FULL to PARTIAL).

Greenville Creek

* Since 1982, the EWH attainment status of Greenville Creek has shown less improvement than in the Stillwater River. Extrapolated miles attaining increased only slightly from 0 to 1.2 while miles not attaining decreased from 16.1 to 0.3. Miles partially attaining increased from 13.0 to 27.6.

* In the nine reaches with 1990 and 1982 fish and macroinvertebrate data, five reaches have shown a positive change in the attainment status during the previous eight years (RM 29.0 - 17.3; NON to PARTIAL). The other four reaches have remained the same (one FULL, two PARTIAL, one NON).

North Fork Stillwater

* The North Fork has shown no change in the NON attainment of its existing WWH designation (the use attainment status would be FULL during 1982 and 1990, if designated MWH).

Swamp Creek

* Since 1982, the attainment status of Swamp Creek (WWH) has shown some improvement in the lower reach. Overall miles attaining remained 0, miles not attaining increased from 3.6 to 5.0, and miles partially attaining increased from 0 to 2.4 (miles sampled increased from 4.5 to 8.8 in 1990). Compared to the two sites sampled during 1982 and 1990, Swamp Creek's attainment status has remained NON at RM 4.5 and increased from NON to PARTIAL downstream from the Versailles WWTP (RM 1.7 - 1.5).

Indian Creek

* Indian Creek (RM 2.0-1.9) has shown an improvement in its attainment status from NON to PARTIAL since 1982.

Painter Creek

* Since 1982, the use attainment status in Painter Creek, based on the current EWH designation has remained NON between RM 16.2 - 10.1, but increased from NON to FULL downstream from RM 1.0. Extrapolated, miles attaining since 1982 increased from 0 to 4.2 while miles not attaining decreased from 16.1 to 10.9. Miles PARTIALLY attaining increased slightly from 0 to 1.0. If designated MWH upstream from RM 5.5, approximately 6.0 additional miles would be in FULL attainment as opposed to PARTIAL.

Table 14. Comparison of 1982 and 1990 biological index scores and use attainment status for commonly sampled reaches in the Stillwater River Basin. Bold print denotes the 29 reaches with fish and macroinvertebrate data. Underlined attainment status signifies a negative change since 1982.

RM (1982-1990) Fish/Macro.	MIwb 1982/1990(diff.)	IBI 1982/1990(diff.)	ICI 1982/1990(diff.)	Attainment Status 1982/1990
Stillwater River *(wading EWH criteria 9.4/50/46)*				
63.0/63.0	**5.5*/8.0*(+ 2.5)**	**28*/38*(+10)**	**32*/54(+22)**	**NON/PARTIAL**
57.0/57.0	-/7.9*	-/39*(+10)	42ns/50(+8)	(PARTIAL)/PARTIAL
53.7-52.4/52.4	**5.4*/7.4*(+2.0)**	**29*/36*(+7)**	**38*/46(+8)**	**NON/PARTIAL**
47.8/-	9.2ns/7.3*(-1.9)	43*/39*(-4)	-/-	(PARTIAL/NON)
43.4-43.7/44.2	7.0*/8.5*(+1.5)	32*/43*(+11)	-/46	(NON)/PARTIAL
37.8/37.8-37.7	**9.5/9.0ns(-0.5)**	**46ns/49ns(+3)**	**40*/48(+8)**	**PARTIAL/FULL**
(boat EWH criteria 9.6/48/46)				
31.5-31.2/31.1-30.9	**8.1*/9.9(+1.8)**	**47ns/54(+7)**	**50/44ns(-6)**	**PARTIAL/FULL**
30.1-30.6/-	7.6*/9.2ns(+1.6)	45ns/48(+3)	-/-	(PARTIAL/FULL)
28.1/27.8-27.7	**9.2ns/8.6*(-0.6)**	**49/49(0.0)**	**48/42ns(-6)**	**FULL/PARTIAL**
25.8-25.3/25.1-25.2	**9.0*/9.9(+0.9)**	**53/58(+5)**	**44ns/46(+2)**	**PARTIAL/FULL**
18.0/18.3	**9.5/9.4ns(-0.1)**	**51/55(+4)**	**40*/48(+8)**	**PARTIAL/FULL**
16.0/14.9-16.4	**8.9*/9.2ns(+0.3)**	**52/51(-1)**	**46/46(0)**	**PARTIAL/FULL**
11.5/11.4	**8.7*/8.3*(-0.4)**	**48/48(0)**	**42ns/48(+6)**	**PARTIAL/PARTIAL**
9.0/9.0-9.1	-/9.8	-/41*	40*/50(+10)	(NON)/PARTIAL
8.4/7.9-8.6	**9.2ns/9.5ns(+0.3)**	**51/49(-2)**	**46/44ns(-2)**	**FULL/FULL**
5.0/4.7-4.8	**8.7*/8.7*(0.0)**	**51/47ns(-4)**	**46/50(+4)**	**PARTIAL/PARTIAL**
1.0-1.2/0.8-1.5	**8.5*/9.0*(+0.5)**	**46ns/50(+4)**	**48/48(0)**	**PARTIAL/PARTIAL**
Greenville Creek *(wading EWH criteria 9.4/50/46)*				
34.4-34.2/34.5-34.2	**NA**	**53/53(0)**	**42/52(+10)**	**FULL/FULL**
28.8-29.0/28.9	**7.1*/8.7*(+1.6)**	**32*/51(+19)**	**36*/54(+18)**	**NON/PARTIAL**
(boat EWH criteria 9.6/48/46)				
22.6-23.2/22.3	**7.1*/9.0*(+1.9)**	**33*/37*(+4)**	**36*/52(+16)**	**NON/PARTIAL**
20.7-20.6/20.8	7.2*/8.9*(+1.7)	33*/39*(+6)	-/56	(NON)/PARTIAL
19.7-19.6/19.5	**7.3*/8.2*(+0.9)**	**32*/34*(+2)**	**30*/50(+20)**	**NON/PARTIAL**
18.5-19.2/18.9-19.1	**6.0*/7.8*(+1.8)**	**32*/30*(-2)**	**20*/42ns(+22)**	**NON/PARTIAL**
17.3/18.0-18.3	**5.9*/6.5*(+0.6)**	**28*/30*(+2)**	**18*/50(+32)**	**NON/PARTIAL**
15.4/16.2	6.8*/7.1*(+0.3)	33*/29*(-4)	-/VGns	(NON)/PARTIAL
14.1-14.3/13.7	**5.5*/6.3*(+0.8)**	**27*/32*(+5)**	**40*/50(+10)**	**NON/NON**
11.9/-	7.4*/8.4*(+1.0)	33*/32*(-1)	-/-	(NON/NON)
10.6/10.5	-/9.2ns	-/46ns	46/50(+4)	(FULL)/FULL
10.3/	8.1*/8.6*(+0.5)	35*/38*(+7)	-/-	(NON/NON)
5.0/5.6-5.5	**8.1*/9.2ns(+1.1)**	**37*/41*(+4)**	**52/48(-4)**	**PARTIAL/PARTIAL**
0.1/1.4	**8.6*/9.6(+1.0)**	**47ns/51(+4)**	**42ns/40*(-2)**	**PARTIAL/PARTIAL**
North Fork Stillwater *(headwater WWH criteria 40/36)*				
0.5-0.4/0.4	**NA**	**26*/26*(0)**	**40/G**	**NON/NON**
Swamp Creek *(wading WWH criteria 8.3/40/36)*				
4.5/4.4	**-/6.8***	**25*/26*(+1)**	**36/32ns(-4)**	**NON/NON**
1.6/1.7-1.5	**-/7.5***	**25*/33*(+8)**	**8*/42(+34)**	**NON/PARTIAL**
Indian Creek(1983/1990) *(headwater WWH criteria 40/36)*				
2.0/1.9	**NA**	**23*/32*(+9)**	**16*/MG**	**NON/PARTIAL**

Table 14. Continued.

RM (1982-1990) Fish/Macro.	MIwb 1982/1990(diff.)	IBI 1982/1990(diff.)	ICI 1982/1990(diff.)	Attainment Status 1982/1990
***Painter Creek** (headwater EWH criteria 50/46)*				
16.2/17.9-16.2	NA	27*/28*(+1)	G*/MG*	NON/NON
15.5-15.2/15.5	NA	27*/27*(0)	G*/40*	NON/NON
15.0/14.6-15.0	NA	-/29*	G*/10*	(NON)/NON
(wading EWH criteria 9.4/50/46)				
10.1/10.1	-/5.4*	24*/30*(+6)	G*/56	NON/NON
0.2-0.5/0.3-1.0	-/9.4	42*/50(+8)	G*/42ns	NON/FULL

ns Nonsignificant departure from biological criteria (≤ 4 IBI and ICI units and ≤ 0.5 MIwb units).

* Significant departure from biological criteria (>4 IBI or ICI units; >0.5 MIwb units).

__ Underlined values are in the poor or very poor range.

** Biological criteria is not applied to mixing zone.

( ) One or more of the three required indices are lacking data.

G = Good, MG = Marginally Good, F = Fair, P = Poor, VP = Very Poor .

NA Not applicable, headwater site.

Table 15. Area of Degradation Value (ADV) statistics for the Stillwater River, Greenville Creek, Painter Creek, and Swamp Creek during 1982 and 1990.

Upper RM	Lower RM	Year	Attainment Status: Meeting	Partial	Not Meeting	Index	ADV Statistics: Bio-Criteria	Miles	N	Negative Statistics: Mean Value	Minimum	Percent Deviation	ADV	Miles < Criteria	Positive Statistics: Mean Value	Maximum	Percent Positive	ADV	Miles > Criteria
STILLWATER RIVER																			
Ecoregion Biocriteria						IBI[a]	49	59.9	27	37	28	19.9	2494	27.4	49	55	1.12	1755	33.1
63.0	3.1	82	8.2	35.9	16.4	Iwb	9.5	59.9	27	7.9	5.4	12.9	2570	43.9	9.2	9.5	1.02	140	16.6
						ICI	46	55.1	15	39	38	6.4	675	25.4	45	50	1.07	895	30.8
Ecoregion Biocriteria						IBI[a]	49	61.8	18	39	36	14.2	1506	22.9	51	58	1.15	2530	39.0
63.0	1.2	90	24.1	37.8	0.0	Iwb	9.5	61.8	18	8.2	7.3	8.2	1380	36.7	9.4	10.4	1.04	515	25.2
						ICI	46	61.5	13	-	-	.-	-	.-	47	54	1.12	3182	61.9
GREENVILLE CREEK																			
Ecoregion Biocriteria						IBI[a]	48	28.7	13	36	27	23.6	2848	27.2	45	47	1.03	27	2.9
28.9	0.1	82	0.0	13.0	16.1	Iwb	9.6	28.7	13	7.6	5.5	16.8	1365	17.9	-	8.6	-	-	.
						ICI	46	27.5	9	31	18	25.3	1716	16.1	47	52	1.12	596	12.1
Ecoregion Biocriteria						IBI[a]	48	28.9	15	37	29	16.1	1648	23.2	48	51	1.07	177	5.9
29.0	0.1	90	1.2	27.6	0.3	Iwb	9.6	28.9	15	8.2	6.2	9.0	890	21.3	9.3	9.6	1.03	120	7.8
						ICI	46	27.5	8	41	40	3.5	36	2.4	50	56	1.19	2028	25.8
PAINTER CREEK																			
Ecoregion Biocriteria						IBI[a]	50	16.0	7	27	24	40.7	3017	16.1	-	42	-	-	.
16.2	0.2	82	0.0	0.0	16.1	Iwb	0.5	0.0	7										
						ICI													
PAINTER CREEK																			
Ecoregion Biocriteria						IBI[a]	50	16.0	9	36	22	21.9	1048	10.4	59	50	1.28	732	5.7
16.2	0.2	90	4.2	1.0	10.9	Iwb	9.4	9.9	3	7.0	5.4	20.7	835	9.0	9.1	9.4	1.02	15	1.5
						ICI	46	0.5	1	-	-	.-	-	.-	56	56	1.33	154	1.1
SWAMP CREEK																			
Ecoregion Biocriteria						IBI[a]	40	2.9	3	25	25	31.0	396	3.6	-	25	-	-	.
4.5	1.6	82	0.0	0.0	3.6	Iwb	0.5	0.0	3										
						ICI	36	2.7	3	19	8	39.3	314	2.5	35	36	1.10	30	1.0
Ecoregion Biocriteria						IBI[a]	40	7.2	3	27	24	25.3	672	7.4	-	33	-	-	.
8.8	1.5	90	0.0	2.4	5.0	Iwb	8.3	2.9	2	7.1	6.8	8.8	125	3.6	-	7.5	-	-	.
						ICI	36	7.3	3	31	30	4.0	84	3.3	36	42	1.11	150	4.1

a ADV statistics based on the ecoregional biocriteria

b ADV statistics based on local expectations (e.g., upstream values)

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LIST OF APPENDIX TABLES

Appendix Tables are avalible upon written request:

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