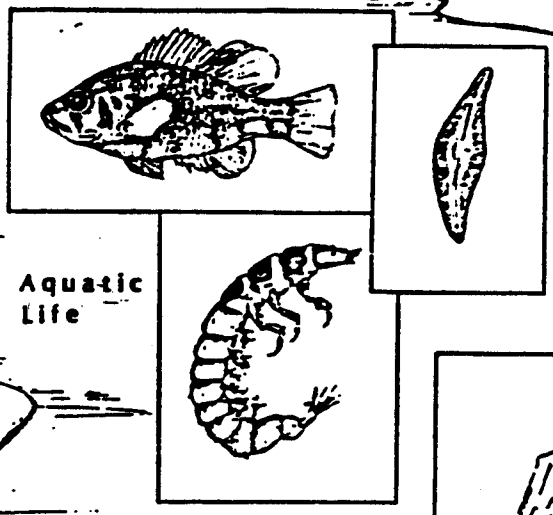
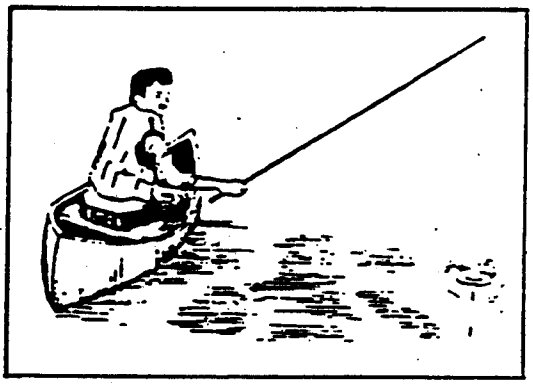
BAILEY RUN/CEDAR BROOK DRAINAGE BIOLOGICAL AND WATER QUALITY INVESTIGATION

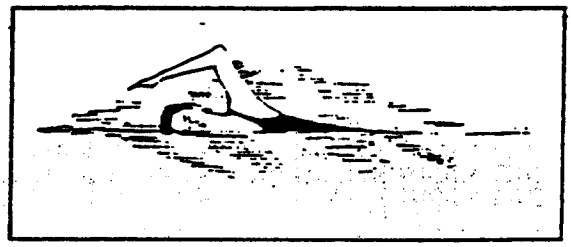
Outstanding Resource Waters

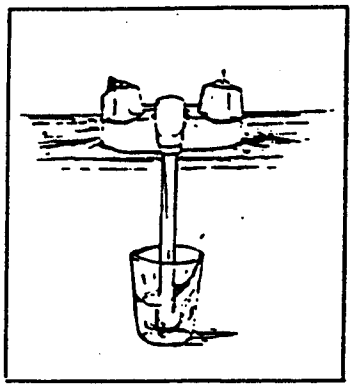


Aquatic Life



Recreation





Domestic Use

Division of Water
Biological Section
Technical Report No. 27

BAILEY RUN/CEDAR BROOK DRAINAGE
BIOLOGICAL AND WATER QUALITY INVESTIGATION

Kentucky Department for Environmental Protection
Division of Water
Biological Analysis Section

Frankfort, Kentucky

Technical Report No. 27

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This report has been approved for release:

Donald F. Harker, Jr., Director
Division of Water

Date: 3-12-88

LIST OF CONTRIBUTORS

Robert W. Logan
Project Leader

Gary V. Beck
Microbiologist

Samuel M. Call
Aquatic Invertebrate Zoologist

Ronald E. Houp
Aquatic Invertebrate Zoologist

Lythia Metzmeier
Phycologist

Michael R. Mills
Ichthyologist

Charles A. Roth
Aquatic Biologist

Clifford C. Schneider
Aquatic Invertebrate Zoologist

Donald K. Walker
Botanist

Albert Westerman
Aquatic Toxicologist

ABSTRACT

A biological and water quality investigation of the Bailey Run (5,716 acre) system was conducted from August 1986 to January 1987. The primary purpose of this study was to determine the effects of runoff from the abandoned dump site and the Universal Fasteners effluent on the Bailey Run system. Bailey Run and Cedar Brook contribute approximately 7 miles of streams to the Kentucky River drainage; 2.5 mi. are considered not to be supporting designated uses, 1.5 mi. are partially supporting uses with the remaining 3 miles supporting uses.

The Bailey Run drainage lies entirely in Anderson County in the Bluegrass Section of the Interior Low Plateaus Province. The basin is underlain by Ordovician age limestone with some clay and clay shales.

The principal basin impact arises from the discharge of industrial waste from Universal Fasteners. Additional impacts include runoff from the abandoned dump site, which is located at milepoint 1.4 on Cedar Brook, agriculture and a gravel removing operation occurring in the stream near the mouth.

High concentrations of polychlorinated biphenyls (PCBs) have been reported in the soils of the abandoned dump site. However, data from this study (water, sediment and fish tissue) indicate that the PCBs have not yet entered the aquatic ecosystem.

The impact from the Universal Fasteners effluent is the major impact occurring in the drainage. This discharge has severely degraded water of the Bailey Run system. Kentucky Surface Water Standards were violated for dissolved oxygen, chloride, free cyanide, iron, cadmium, zinc and mercury during the summer sampling period and free cyanide, phenolic compounds, iron, zinc, chromium and mercury during the winter sampling period. There were no violations of KSWS for fecal coliform bacteria observed in the drainage.

During the summer, 25 parameters exceeded the STORET means while 24 exceeded them during the winter sampling period. Sediment data yielded 14 parameters that were considered moderately or heavily polluted according to U.S. EPA guidelines.

Biological communities were either eliminated or severely altered by the Universal Fasteners effluent. The algal data shows that the effluent altered and reduced the community of the UT and Cedar Brook downstream of the UT to below the dump site. The lowest station on Cedar Brook and Bailey Run showed signs of recovery. The macroinvertebrate fauna was eliminated in the UT and dramatically altered and reduced in Cedar Brook. The community started recovering in the lower portions of Bailey Run. The fish community was eliminated in the UT and Cedar Brook to below the dump site. The lowest Cedar Brook and Bailey Run sites showed some recovery.

Bioassays conducted on stream water and sediment showed patterns of acute and chronic toxicity occurring from the point of Universal Fasteners discharge to the mouth of Bailey Run.

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RECOMMENDATIONS

(1) Based on the diversity of suitable aquatic habitat that exists throughout the Bailey Run drainage and the assumption that communities could recover with the elimination or improvement of the Universal Fasteners effluent, it is recommended that the entire drainage be designated for Aquatic Life/Warmwater Aquatic Habitat per 401 KAR 5:031 Section 4(1) and the criteria of that section be applied without modification.

(2) Based on the bacteriological and pH data collected from the Bailey Run system, it is recommended that the drainage be designated for primary and secondary contact recreation per 401 KAR 5:031 Section 6 and the criteria of that section be applied without modification.

(3) Since no public water supply withdrawal occurs in the Bailey Run system, this portion of the segment is not recommended for domestic water supply (401 KAR 5:031, Section 5).

(4) Based on data presented in this study, it is recommended that the discharge of Universal Fasteners be brought into compliance with water quality standards, or be eliminated from the watershed.

(5) Polychlorinated biphenyls (PCB) contaminated soils present at the dump should be removed before the PCBs migrate into the aquatic ecosystem.

(6) After the removal of PCB contaminated soils has been accomplished, follow-up sampling of soils and stream sediments, at and below the abandoned dump site, should be conducted to insure that the PCB ladened soils were successfully removed and the stream was not contaminated.

SUMMARY

1) The Bailey Run subbasin (5,716 acre) in Anderson County constitutes a portion of the Kentucky River segment (04014) according to the Water Quality Management Plan for Kentucky. The stream system lies in the Bluegrass section of the Interior Low Plateaus Province. Bailey Run is a fourth order stream which contributes approximately 7 miles of stream (Cedar Break and Bailey Run) to the Kentucky River Basin. Basin impacts, principally created by Universal Fasteners discharge, will need to be mitigated before the streams in the basin can achieve the recommended designated use of Aquatic Life/Warmwater Aquatic Habitat.

2) Biological and physicochemical data indicate that approximately 2.5 miles are not supporting designated uses, 1.5 miles are considered partially impaired, while the remaining 3 miles are meeting designated uses.

3) The major impact to the Bailey Run system is the Universal Fasteners effluent. Lesser impacts include a stream gravel removal operation occurring near the mouth and agriculture.

4) Kentucky Surface Water Standards (KSWS) for dissolved oxygen, chloride, free cyanide, iron, zinc, cadmium and mercury were violated during the summer sampling period at one or more sampled sites. Standards for free cyanide, phenolic compounds, iron, zinc, chromium and mercury were violated during the winter sampling period at one or more stations.

5) A total of 25 parameters exceeded STORET means during the summer sampling period while 24 exceeded STORET means during the winter sampling period at one or more sites.

6) A total of 14 sediment parameters, which include cyanide and nine metals, were considered as being in either the moderately or heavily polluted categories when compared to the U.S. EPA guidelines at one or more sampling locations. The concentrations of these tended to increase in an upstream direction towards Universal Fasteners.

7) Water, sediment and fish tissue data taken during this study from the Kentucky River above and below Bailey Run indicates that impacts occurring in Bailey Run system have not had a detectable effect on the Kentucky River.

8) Kentucky Surface Water Standards for fecal coliform bacteria were not exceeded during this study at any sampling location.

9) The Bailey Run system has well developed small stream aquatic habitats. It possesses good pool/riffle development throughout most of the system, as well as good bankside habitats. If the Universal Fasteners effluent were eliminated or substantially improved, all four impacted stream miles would be expected to recover and support a diverse aquatic flora and fauna.

10) Though high levels of polychlorinated biphenyls (PCBs) have been reported from the abandoned dump site, located at milepoint 1.4 on Cedar Brook, water, sediment and fish tissue data collected in this study indicate that the PCBs have not yet entered the aquatic ecosystem.

11) A total of 53 algal taxa were observed from the Bailey Run system. The algal community was severely stressed at three biological sampling locations in the Cedar Brook drainage, but started recovering in the lower portion of Cedar Brook (MP 0.7) and Bailey Run. Periphyton was scarce throughout the upper impacted portions of the Cedar Brook drainage.

12) The macroinvertebrate communities were severely stressed in the Cedar Brook system, but began recovering in the lower portion of Bailey Run (MP 0.2). The taxa richness, total number of individuals and coefficient of community loss all indicate that the Universal Fasteners effluent is toxic to macroinvertebrates. Several major groups of aquatic insects (Ephemeroptera, Plecoptera and Trichoptera) were not observed in the impacted portion of the Cedar Brook system. These organisms would be expected to be present because there is suitable aquatic habitat throughout the drainage.

13) The fish fauna of the Bailey Run system was severely impacted by the Universal Fasteners effluent. A total of 15 species were taken from the basin. No fish were collected at three sites (14-4, 14-5 and 14-8). The Index of Biotic Integrity was calculated as fair at the lowest station on Cedar Brook and fair at the lowermost Bailey Run station and poor at the Bailey Run station above Cedar Brook because of low flow.

14) Fish tissue analyses showed no PCBs or other organic chemicals above Federal Food and Drug Administration (FDA) action levels. The only heavy metal to exceed STORET means was copper.

15) Water and sediment chronic and acute toxicity tests indicate that high toxicity occurs in the system from the Universal Fasteners discharge to the mouth of Bailey Run.

INTRODUCTION

The Bailey Run subbasin lies within Anderson County, Kentucky. This drainage, including its major tributary Cedar Brook, from the headwaters to the confluence with the Kentucky River (Kentucky River milepoint 84.57) is a portion of a 303(e) segment. This segment is designated as 04 (Kentucky River Basin) 014 (Kentucky River segment) in the River Basin Water Quality Management Plan for Kentucky (Miller, Wihry and Lee 1975).

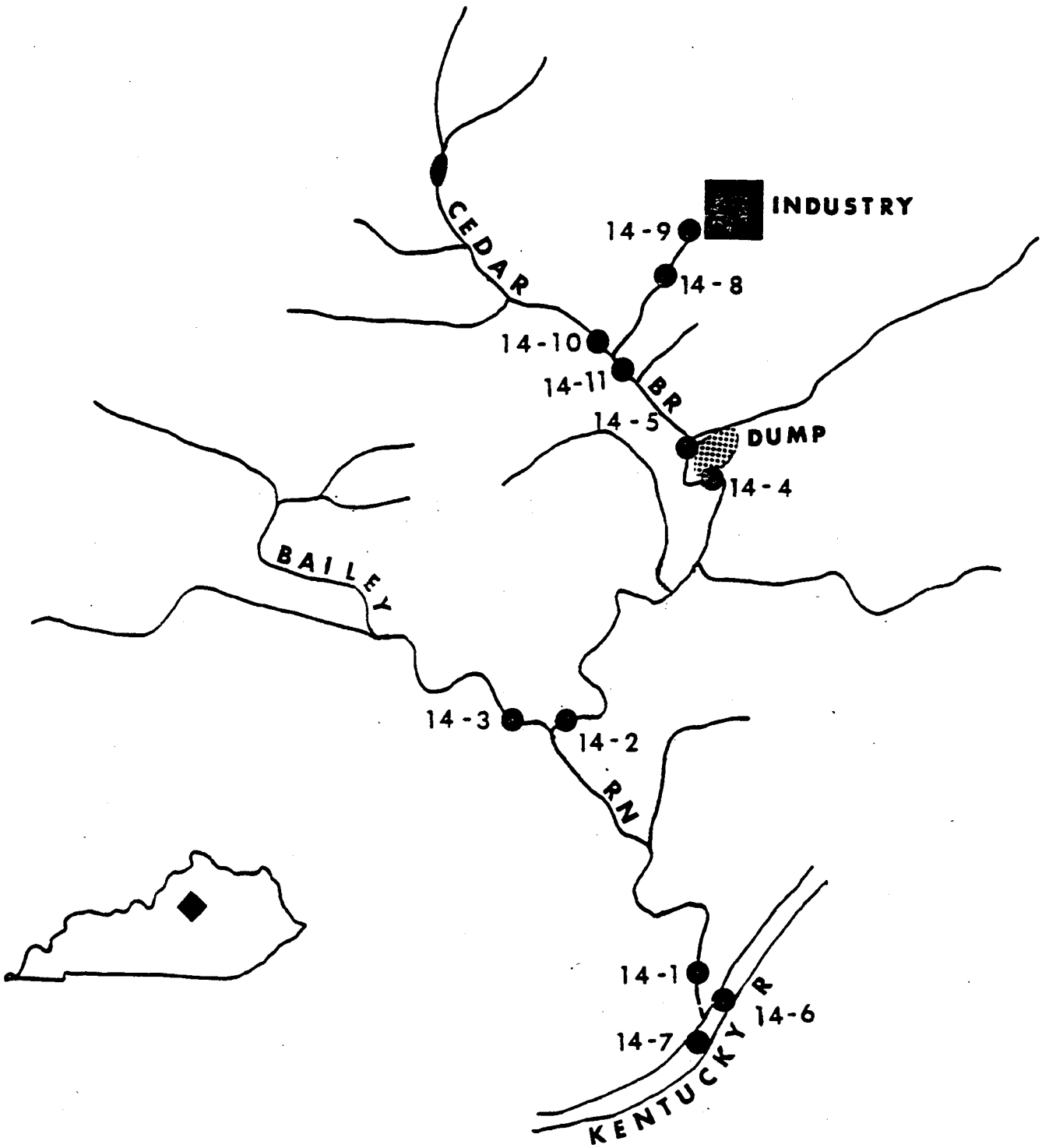
A survey of the Bailey Run subbasin was undertaken by the Kentucky Department for Environmental Protection (DEP) in August 1986. Eight sampling stations were established in the Bailey Run system and two in the Kentucky River mainstem. All stations, except 14-10, which was dry, were sampled once in the summer (August and September) during a low flow period (Figure 1), while all stations in the Bailey Run system were sampled once in the winter (December) during a moderate flow period. The location of these stations, dates sampled and parametric coverage are given in Appendix A. The purposes of this investigation were as follows:

1. To determine the existing water quality of the basin.
2. To determine the aquatic uses currently being achieved in the drainage.
3. To determine the causes of any impairments of the aquatic uses.
4. To determine what aquatic uses can be attained based on the physical, chemical and biological characteristics of the watershed.

However, because of time constraints and the design of the study, it was not always possible to address specific sources of constituents which may be impairing the aquatic uses or to recommend remedies for those problems. A more

FIGURE 1: MAP OF THE BAILEY RUN DRAINAGE

WITH SAMPLING LOCATIONS



detailed, multi-discipline approach would be required to study those aspects and determine an appropriate management program.

Literature Review

There is no existing literature concerning water chemistry or aquatic biology of the Bailey Run system. However, the United States Environmental Protection Agency (U.S. EPA) (1984) and the Division of Water (DOW) (1986) conducted toxicity tests on Universal Fasteners' effluent, which discharges to an unnamed tributary (UT) to Cedar Brook. A study of the abandoned dump site was conducted by Mohr (1986). He found elevated levels of polychlorinated biphenyls (PCBs) in the soils.

Basin Impacts and Stream Uses

The Universal Fasteners effluent, which is discharged to an unnamed tributary located in the headwaters of Cedar Brook (Figure 1) constitutes the major and most serious impact to the Bailey Run system. This discharge has devastated the aquatic life throughout a significant portion of Cedar Brook system (2.5 mi) and has seriously degraded a major portion of Bailey Run (1.4 mi). Other lesser impacts include runoff from an abandoned dump site, agricultural runoff, and a gravel removing operation that was occurring during both sampling periods in Bailey Run near the mouth (Station 14-1).

All designated stream uses in Cedar Brook have been eliminated below the confluence of the Universal Fasteners UT. The area around the mouth of Bailey Run is fished. The area of Bailey Run above Cedar Brook acts as a refugia for small stream fishes and serves as a nursery for fish fry in spring and early summer.

Primary contact recreation was not observed during this study; however, it may occur in the lower portions of the drainage around Tyrone, Kentucky. No domestic water supply withdrawals occur in the drainage; however, water is hauled from a spring near Tyrone.

Hunting for waterfowl, small mammals and deer may occur throughout the drainage in rural areas. Game animals, as well as non-game species, may utilize the various streams and adjacent buffer zones for breeding, rearing young, feeding and as a water supply. Trapping for small mammals such as muskrats, mink, etc., is also expected to occur in the drainage.

METHODS

Water samples were analyzed in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater (APHA 1985) and United States Environmental Protection Agency's (U. S. EPA) Methods for Chemical Analysis of Water and Waste (U.S. EPA 1979). Field turbidity measurements were taken with an HF Instruments Model DRT-15 turbidimeter. Field conductivity was determined with a Yellow Springs Instrument Company (YSI) Model 33 S-C-T meter. Field measurements for dissolved oxygen (DO) and water temperature were conducted with a YSI Model 54A oxygen meter. An Analytical Measurements Model 707B pH meter was used for field pH.

Biological samples were collected utilizing a variety of techniques. Qualitative algal samples were procured by selectively scraping or suctioning material from all available habitats. Samples were preserved in the field with 5% buffered formalin and transported to the Division of Water (DOW) biological laboratory for analysis. Diatoms were treated with 30% hydrogen peroxide and potassium dichromate to remove organic material (van der Werff 1955), identified and enumerated. Diatom relative abundance, species richness, species diversity ($\bar{d}$), and equitability (e) were generated by counting a minimum of 500 valves, using methods outlined in Weber (1973). A percent community similarity index (PSC) was also calculated for diatom data, using the method of Whittaker and Fairbanks (1958).

Macroinvertebrate samples were taken by selective picking various substrate types and by collecting in different habitats with a triangular kick net. Macroinvertebrate coefficient of community loss were calculated using the procedures outlined by Courtemanch and Davis (1987). Macroinvertebrate similarity was calculated using the methods outlined by Long (1963).

Fish were collected using a 3.4 m by 1.2 m, 0.3 cm mesh, common sense minnow seine. Both pool and riffle areas and all recognizable habitat types were sampled. The

fish samples were preserved in 10% formalin solution and transported to the DOW biological laboratory for enumeration and identification. Fish community structure was analyzed using the methods of Karr (1981). Fish tissue and sediment samples were collected and processed using methods outlined in the Biological Analysis Section's Standard Operating Procedures Manual (DOW 1987) and sent to Division of Environmental Services (DES) for analyses.

Bacteriological samples were collected from directly below the water's surface in 250 ml, wide mouth, sterile nalgene jars, placed on wet ice and returned for analysis to the DOW laboratory within six hours. Analyses for fecal coliform and fecal streptococcocus bacteria were performed using the membrane filter techniques outlined by Bordner et al. (1978).

Toxicity tests were conducted according to DOW (1987), Peltier and Weber (1985), Horning and Weber (1985), ASTM (1984), and Roth and Westerman (1987). Organisms used in the study included: fathead minnow (Pimephales promelas) eggs (less than eight hours old) and 10-day old fry, and waterfleas (Daphnia pulex) less than 24-hours old. Minnow eggs and fry were obtained from U.S. Environmental Protection Agency, Newtown Fish Toxicology Laboratory at Newtown, Ohio. Daphnia were cultured in the Biological Analysis Bioassay Culture unit at DOW in Frankfort, Kentucky.

The daphnid and embryo-larval tests were conducted at the culture temperature and in water of similar hardnesses to preclude the necessity of an acclimation period. The fry were temperature acclimated for 96-hours prior to test initiation.

PHYSICAL EVALUATION

Bailey Run, a fourth order tributary to the Kentucky River (MP 84.57), originates near Lawrenceburg, Kentucky, flowing 6.4 km (4 mi) in a northerly direction. The system drains approximately 5,716 acres. The principal tributary, Cedar Brook, rises in the City of Lawrenceburg and flows east for 5.6 km (3.5 mi). Stream flow for Cedar Brook, during periods of drought, is thought to be primarily the effluent of Universal Fasteners.

The Bailey Run subbasin lies in the Bluegrass Section of the Interior Low Plateaus Province (Quarterman and Powell 1978). The underlying rock strata are Ordovician age limestone with some clay or clay shale (McDowell et al. 1981). Elevations range from 214 m (780 ft) above mean sea level (msl) in the headwaters to 151 m (490 ft) above msl at the confluence with the Kentucky River. Average gradient for Cedar Brook is 12.6 m/km (65 ft/mi); and for Bailey Run is 14 m/km (72 ft/mi).

Stream habitat was diverse throughout the drainage; habitat types included pools, riffles, undercut banks, rock ledges, submerged roots, large boulders and man-made objects. Riparian buffer zones were well developed and bank stability was excellent in most areas. However, some problem areas exist where overstory vegetation had been removed from the stream banks. In addition, a gravel removing operation had disturbed the substrate at Bailey Run near its mouth (Station 14-1). Detailed information on each of the eleven sampling stations can be found in Appendix A.

PHYSICOCHEMICAL DISCUSSION

Physicochemical data were collected from the Bailey Run system during two sampling periods in 1986; once during the summer (August and September) and once during the winter (December). A total of 127 parameters were analyzed from surface water grab samples during the summer sampling period, while 142 were analyzed during the winter sampling period. Sediment samples were collected during the summer sampling period.

The physicochemical data from the summer and winter sampling periods appear in Tables 1 and 2, respectively. Those parameters that were below detection limits at all stations during both sampling periods appear in Appendix 13.

A review of the physicochemical data shows that five parameters exceeded Kentucky Surface Water Standards (KSWS) during both the summer and winter sampling periods (Table 3). In addition, dissolved oxygen, chloride and cadmium exceeded KSWS in the summer while chromium violated standards in the winter (Table 3). The violations were predominantly at stations impacted by the Universal Fasteners effluent. In general, the violations become more severe in an upstream direction moving toward the Universal Fasteners discharge. Only zinc and dissolved oxygen violated the KSWS at the control station (14-3) in the summer sampling period, and no parameters exceeded standards at station 14-3 during the winter sampling period.

Copper exceed U.S. EPA (1980) acute toxicity criteria at all stations except stations 14-6 and 14-7 (Kentucky River sites) during the summer sampling. Winter sampling data indicate that copper exceed acute toxicity criteria at stations 14-4, 14-5, 14-8 and 14-9.

A comparison of the physicochemical data to STORET (1979-1983) means show that 25 parameters exceeded the means in the summer and 24 parameters in the winter (Tables 4 and 5). As with the KSWS violations, the magnitude generally increased in an upstream direction toward the Universal Fasteners discharge. The control stations had

less parameters exceeding STORET (1979-1983) mean values.

High levels of polychlorinated biphenyls (PCBs) have been reported in the soils at the abandoned dump site (Mohr 1986). Data from this study (i.e., water, sediment and fish tissue) indicates that the PCBs had not yet entered the aquatic system.

The physicochemical data from water samples indicate that the Universal Fasteners effluent has introduced cyanide, heavy metals and organics, as well as other materials (Tables 1, 2, 3, 4 and 5) to the Bailey Run system. These have seriously degraded all of Cedar Brook below the UT and have impacted Bailey Run below Cedar Brook. The lowermost station shows evidence of some recovery. Data taken from the Kentucky River above and below Bailey Run (i.e., water, sediment and fish tissue) indicate that impacts occurring in the Bailey Run system have not had a detectable effect on the Kentucky River (Appendix F).

Sediment samples were collected from all stations except 14-10, which was dry during the summer sampling season. These data are presented in Table 6; those parameters, except PCBs, that were below detection levels at all stations are listed in Appendix B).

The sediment data indicates that those stations impacted by the Universal Fasteners effluent have high concentrations of cyanide and metals (Table 6 and 7). These concentrations generally increase in an upstream direction towards the Universal Fasteners effluent. Comparison of the sediment data to U.S. EPA (1977) guidelines (Table 7) shows 14 parameters fell in the moderately or heavily polluted categories at one or more sampling stations.

TABLE 1: PHYSICOCHEMICAL DATA FOR BAILEY RUN - CEDAR BROOK AND KENTUCKY RIVER IN THE VICINITY OF BAILEY RUN DURING THE SUMMER SAMPLING PERIOD

	STATIONS									
*Parameters (mg/l)	14-1	14-2	14-3	14-4	14-5	14-6	14-7	14-8	14-9	14-10
Dissolved Oxygen	ND	6.6	3.3	10.4	5.8	ND	ND	ND	10.1	ND
Acidity	13.0	7.8	9.0	4.4	<0.1	3.1	3.0	14.5	<0.1	ND
Alkalinity	206	228	231	198	288	95	94.8	245	237	ND
BOD_5	1.6	1.0	1.1	24.8	18.8	2.7	1.1	7.4	9.0	ND
COD	17.6	19.6	11.9	73.9	71.8	10.6	11	180	183	ND
Chloride	392	573	41	713	626	33.9	33.5	3,700	2,200	ND
Conductivity	2,040	2,460	664	3,120	3,120	417	415	11,700	7,610	ND
Cyanide, Amenable	<0.01	<0.01	<0.01	0.017	0.019	<0.01	<0.01	<0.01	<0.01	ND
Floride	0.46	0.79	0.17	2.02	2.08	0.18	0.21	0.90	1.15	ND
Hardness, total	137	127	40.6	461	313	68.1	67.1	554	362	ND
Phenol (4AAP)	<0.005	<0.005	0.005	ND	ND	<0.005	0.008	0.032	0.038	ND
pH	7.7	7.9	7.8	8.2	8.5	7.9	7.9	7.6	9.0	ND
TDS	1,140	1,480	364	1,950	1,950	212	202	6,574	4,363	ND
Sulfates	167	218	43.6	305	340	49.0	49.9	268	273	ND
TOC	5.0	5.9	4.4	36.1	46.9	3.8	3.7	61.6	58.6	ND
NH_3-N	<0.05	<0.05	<0.05	0.079	<0.05	0.135	0.126	0.088	0.110	ND
TKN	0.648	1.01	0.565	ND	2.11	0.639	0.717	2.53	1.42	ND
NO_3-N	0.085	0.165	0.075	1.65	1.40	0.405	0.405	6.90	7.30	ND
Phosphorus, Ortho	0.155	0.255	0.015	0.370	0.174	0.036	0.038	0.140	0.100	ND
Phosphorus, Total	0.302	0.392	0.139	0.800	0.785	0.080	0.073	1.71	2.49	ND
TSS	ND	ND	ND	13	12	ND	ND	27	31	ND
Calcium	112	106	107	190	142	42.1	43.6	191	140	ND
Magnesium	10.9	9.42	12.1	9.69	7.45	10.7	10.3	17.2	10.1	ND
Potassium	6.13	6.63	2.22	11.6	10.7	2.60	2.58	13.8	9.75	ND
Sodium	251	361	23.2	487	521	17.5	17.3	1,920	1,250	ND
Aluminum, total	0.067	0.109	0.061	0.088	0.550	0.078	0.084	0.065	0.081	ND
Arsenic, total	0.001	0.001	0.001	<0.001	0.001	0.001	0.002	<0.001	<0.001	ND
Barium, total	0.193	0.084	0.037	0.058	0.022	0.056	0.021	0.113	0.055	ND
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Cadmium, total	0.011	0.018	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	ND

TABLE 1: PHYSICOCHEMICAL DATA FOR BAILEY RUN - CEDAR BROOK AND KENTUCKY RIVER IN THE VICINITY OF BAILEY RUN DURING THE SUMMER SAMPLING PERIOD (CONT'D.)

	STATIONS									
*Parameters (mg/l)	14-1	14-2	14-3	14-4	14-5	14-6	14-7	14-8	14-9	14-10
Chromium, total	0.005	0.002	0.001	0.011	0.015	0.004	0.002	0.030	0.089	ND
Copper, total	0.024	0.039	0.019	0.132	0.219	0.010	0.010	3.36	1.63	ND
Iron, total	0.26	0.06	0.02	0.28	0.46	<0.01	0.06	0.800	1.03	ND
Manganese, total	0.37	0.04	0.09	0.41	0.23	0.05	0.05	0.22	0.070	ND
Mercury, total	0.0001	0.0001	0.0001	0.0003	0.0006	0.0001	<0.0001	0.0007	0.0014	ND
Nickel, total	0.025	0.030	0.003	0.190	0.132	0.002	0.002	0.220	0.220	ND
Selenium, total	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Silver, total	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	ND
Zinc, total	0.077	0.072	0.072	0.346	0.301	0.074	0.051	0.716	1.06	ND
Lead, total	<0.001	<0.001	<0.001	0.011	<0.001	0.001	0.002	0.001	<0.001	ND
Benzyl Alcohol	<0.020	<0.020	<0.020	<0.021	<0.021	<0.021	<0.020	0.033	0.067	ND
Aroclor 1016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1221	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1232	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1248	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1254	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1262	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Aroclor 1268	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ND
Sulfide, total	<0.1	<0.1	<0.1	ND	ND	<0.1	<0.1	<0.1	<0.1	ND

*Parameters are in mg/l unless otherwise stated

TABLE 2: PHYSICOCHEMICAL DATA FOR BAILEY RUN - CEDAR BROOK DURING THE WINTER SAMPLING

	STATIONS							
*Parameters (mg/l)	14-1	14-2	14-3	14-4	14-5	14-8	14-9	14-10
Dissolved Oxygen	ND	11.4	ND	10.2	10.2	9.4	ND	12.2
Acidity	2.1	3.8	1.1	3.1	<0.1	<0.1	<0.1	0.7
Alkalinity	202	207	181	197	195	239	295	81
BOD_5	0.9	1.1	0.5	3.1	0.7	28.0	41.6	1.2
COD	30.0	27.9	7.3	24.3	26.3	104	240	5.4
Chloride	81	115	41	213	245	213	275	11.4
Conductivity (umhos/cm)	728	869	538	1,180	1,250	3,750	4,500	538
Cyanide, Amenable	<0.01	<0.01	<0.01	0.039	0.051	<0.01	<0.01	<0.01
Fluoride	0.26	0.33	0.24	0.26	0.27	0.49	0.80	0.17
Hardness	257	291	177	297	296	453	116	228
Phenol (4 AAP)	0.005	<0.005	<0.005	<0.005	0.008	0.019	0.043	<0.005
pH (SU	8.1	8.1	7.9	8.2	8.3	8.6	9.2	8.1
TSS	2	4	7	6	8	6	167	6
TDS	422	526	309	692	766	2320	2890	316
Sulfate	64.6	80.0	46.8	85.7	90.7	227	298	50.6
TOC	5.6	3.4	2.0	8.9	8.6	55.9	103	2.0
Turbidity (NTU)	1.6	1.6	1	7	9	15	140	4.5
NH_4-N	<0.05	<0.05	<0.05	0.063	0.063	<0.05	0.082	<0.05
TKN	0.374	0.387	0.388	0.696	0.608	1.05	1.24	0.245
NO_3-N	2.90	3.30	3.10	3.30	3.50	6.10	5.80	3.40
Phosphorus-Ortho	0.175	0.255	0.084	0.235	0.290	0.900	2.60	0.062
Phosphorus-total	0.315	0.293	0.129	0.550	0.970	1.40	2.60	0.144
Calcium	92.2	101	77.8	100	101	179	170	82.8
Magnesium	9.91	9.95	9.33	10.5	10.8	8.77	7.19	10.5
Potassium	4.66	5.86	1.32	14.1	15.3	32.8	35.8	1.66
Sodium	52.7	74.3	21.4	132	151	543	686	7.8
Aluminum, total	0.042	0.040	0.044	0.132	0.183	0.284	0.420	0.042
Arsenic, total	<0.001	0.002	0.004	<0.001	0.002	<0.001	<0.001	<0.001
Barium, total	0.087	0.134	0.080	0.179	0.194	0.001	0.001	0.260
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001
Chromium, total	0.003	0.003	0.004	0.008	0.011	0.037	0.104	0.006

TABLE 2: PHYSICOCHEMICAL DATA FOR BAILEY RUN - CEDAR BROOK DURING THE WINTER SAMPLING (CONT'D.)

	STATIONS							
*Parameters (mg/l)	14-1	14-2	14-3	14-4	14-5	14-8	14-9	14-10
Copper, total	0.016	0.026	0.015	0.128	0.209	0.639	4.20	0.007
Iron, total	<0.01	<0.01	<0.01	0.19	0.41	0.76	6.78	0.02
Lead, total	0.002	0.001	0.002	0.003	0.002	<0.001	<0.001	0.001
Manganese, total	0.02	0.02	0.01	0.06	0.07	0.13	0.09	0.01
Mercury, total	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0008	0.0002
Nickel, total	0.003	0.013	<0.001	0.033	0.047	0.153	0.296	0.008
Selenium, total	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Silver, total	<0.001	0.040	<0..001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, total	0.007	<0.001	<0.001	0.121	0.168	0.379	1.61	0.008
Sulfide, total	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1221	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1232	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1242	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1248	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1254	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1262	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aroclor 1268	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bromodichloromethane	<0.001	<0.001	<0.001	0.006	0.012	<0.01	0.026	<0.001
Dibromochloromethane	<0.001	<0.001	<0.001	0.001	0.002	<0.01	<0.01	<0.001
Chloroform	<0.001	<0.001	<0.001	0.032	0.055	0.251	0.454	<0.001
Toluene	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.004	<0.001
Ethyl Benzene	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.003	<0.001
m-xylene	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.005	<0.001
Styrene	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.006	<0.001
o-Chlorotoluene	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.022	<0.001
Benzyl Alcohol	<0.020	<0.020	<0.020	<0.020	<0.020	0.066	0.062	<0.020
Benzene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
o-Xylene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	<0.001

*Parameters are in mg/l unless otherwise stated.

TABLE 3: BAILEY RUN/CEDAR BROOK PHYSICOCHEMICAL PARAMETERS THAT VIOLATE KENTUCKY SURFACE WATER STANDARDS

Parameter (mg/l)	STATIONS 14-1	14-2	Ctrl. 14-3	14-4	14-5	14-8	Eff. 14-9	Ctrl. 14-10	KSWS
Summer Sampling Period									
Chloride	-	-	-	713	629	3,700	2,200	ND	600
Cyanide	-	-	-	0.017	0.019	0.010	-	ND	0.005
Iron	-	-	-	-	-	-	1.03	ND	1.0
Zinc	0.077	0.072	0.072	0.346	0.301	0.716	1.06	ND	0.047
Mercury	-	-	-	0.0003	0.0006	0.0007	0.0014	ND	0.0002
Winter Sampling Period									
Cyanide	-	-	-	0.039	0.051	-	-	-	0.005
Phenols	0.005	-	-	-	0.008	0.019	0.043	-	0.005
Iron	-	-	-	-	-	-	6.78	-	1.0
Zinc	-	-	-	0.121	0.168	0.379	1.61	-	0.047
Mercury	-	-	-	-	-	-	0.0008	-	0.0002

TABLE 4: PHYSICOCHEMICAL PARAMETER THAT EXCEED STORET MEAN VALUES FOR THE SUMMER SAMPLING PERIOD

	STATIONS							
*Parameter	14-1	14-2	14-3	14-4	14-5	14-8	14-9	Mean
BOD_5	1.6	-	-	24.8	18.8	7.4	9.0	1.24
COD	17.6	19.6	11.9	73.5	71.8	180	183	13.12
Chloride	392	573	41.2	713	626	3,700	2,200	21.3
Conduct. (umhos/cm)	2,040	2,460	664	3,120	3,120	11,700	2,200	354
Tot. Diss. Solids	1,140	1,140	364	1,950	1,950	7,574	4,363	227
TOC	-	5.9	-	36.1	46.9	61.6	58.6	5.9
TKN	0.65	1.01	-	ND	2.11	2.53	1.42	0.64
NO3-N	-	-	0.750	1.65	1.40	6.90	7.30	0.716
Phosphorus, Total	0.302	0.392	-	0.800	0.785	1.71	2.49	0.147
Calcium	112	102	107	190	142	191	140	44.9
Potassium	6.13	6.63	-	11.6	10.7	13.8	9.75	3.6
Sodium	251	361	-	487	521	1,920	1,250	23.3
Chromium	0.005	-	-	0.011	0.015	0.030	0.089	0.003
Copper	0.025	0.039	0.019	0.132	0.219	3.36	1.63	0.009
Nickel	0.025	0.030	-	0.190	0.132	0.220	0.220	0.016
Zinc	0.077	0.072	0.072	0.346	0.301	0.716	1.07	0.038
Sulfate	167	218	-	305	340	268	273	68.5
Acidity	13.0	7.8	9.0	-	-	14.5	-	7.35
Alkalinity	206	228	231	198	288	245	237	85.8
Fluoride	0.46	0.79	0.17	2.02	2.08	0.90	1.15	0.13
Hardness	-	-	-	461	313	554	362	141
Magnesium	-	-	-	-	-	17.2	-	14.4
Aluminum	-	-	-	-	0.550	-	-	0.217
Barium	0.193	0.084	-	-	-	0.113	-	0.076
Cadmium	0.011	0.018	-	-	-	-	-	0.004

*Parameters are in mg/l unless otherwise stated

TABLE 5: PHYSICOCHEMICAL PARAMETERS THAT EXCEED STORET MEAN VALUES DURING THE WINTER SAMPLING PERIOD

	STATIONS								
*Parameters (mg/l)	14-1	14-2	14-3	14-4	14-5	14-8	14-9	14-10	Mean
Alkalinity	202	207	181	197	195	239	295	-	85.8
BOD_5	-	-	-	3.1	-	28.0	41.6	-	1.24
COD	30.0	27.9	-	24.3	26.3	104	240	-	13.12
Chloride	81	115	41	213	245	213	275	-	21.3
Conductivity umhos/cm	728	869	538	1180	1250	3750	4500	538	354
Fluoride	0.26	0.33	0.24	0.26	0.27	0.49	0.80	0.17	0.13
Hardness	257	291	177	297	296	453	116	228	141
TSS	-	-	-	-	-	-	167	-	54.5
TDS	422	526	309	692	766	2320	2890	316	227
Sulfate	-	80.0	-	85.7	90.7	227	298	-	68.5
TOC	-	-	-	8.9	8.6	55.9	103	-	5.68
TKN	-	-	-	0.696	-	1.05	1.24	-	0.640
NO_3-N	2.90	3.30	3.10	3.30	3.50	6.10	5.80	3.40	0.716
Phosphate, Total	0.315	0.293	-	0.550	0.970	1.40	2.60	-	0.147
Calcium	92.2	101	77.8	100	101	179	170	82.8	44.9
Potassium	4.66	5.86	-	14.1	15.3	32.8	35.8	-	3.60
Sodium	52.7	74.3	-	132	151	543	686	-	23.3
Aluminum, total	-	-	-	-	0.284	0.420	-	-	0.217
Barium, total	0.087	0.134	0.080	0.179	0.194	-	-	0.260	0.077
Chromium, total	-	-	0.004	0.008	0.011	0.37	0.104	0.006	0.003
Copper, total	0.016	0.026	0.015	0.128	0.209	0.639	4.20	-	0.009
Iron, total	-	-	-	-	-	-	6.78	-	1.03
Nickel, total	-	-	-	0.033	0.047	0.153	0.296	-	0.016
Zinc, total	-	-	-	0.121	0.168	0.379	1.61	-	0.038

*Parameters are in mg/l unless otherwise stated

TABLE 6: SEDIMENT DATA FOR BAILEY RUN - CEDAR BROOK AND KENTUCKY RIVER IN THE VICINITY OF BAILEY RUN DURING THE SUMMER SAMPLING PERIOD

Parameter (mg/kg)	14-1	14-2	14-3	14-4	14-5	14-6	14-7	14-8
COD	40,400	41,100	50,700	29,000	21,000	30,800	27,200	70,300
Cyanide, total	<0.790	1.86	< 1.61	8.33	14.3	<0.713	<0.815	247
Oil and Grease	150	750	720	450	1,880	275	480	2,380
Total Volatile Solids	42,000	39,000	51,000	34,000	41,000	33,000	33,000	35,000
Total Organic Carbon	11,700	10,800	11,500	7,900	6,190	3,970	5,340	28,100
Ammonia-Nitrogen	29.1	39.3	33.1	80.0	75.2	18.9	12.6	8.72
TKN	1,320	2,670	973	575	569	750	979	939
Aluminum	10,300	10,700	7,350	13,500	13,400	5,070	6,730	7,380
Arsenic	2.67	3.97	1.63	11.3	14.8	1.64	1.22	5.85
Cadmium	9.58	16.8	0.098	3.33	41.7	0.564	0.565	16.8
Chromium	19.0	21.1	10.9	50.4	43.8	9.36	39.5	312
Copper	86.1	164	10.3	908	175	14.8	11.7	8,510
Iron	24,800	22,300	18,200	49,500	75,700	15,700	21,700	26,600
Lead	31.3	34.7	22.1	44.7	77.5	13.2	13.5	52.3
Manganese	1,660	2,450	749	5,120	7,490	745	836	975
Mercury	0.183	0.247	0.030	0.339	0.277	0.041	0.035	0.612
Nickel	48.5	92.6	8.39	285	286	12.5	15.0	2,780
Zinc	100	193	41.1	405	244	48.9	52.1	14,400
Aroclor 1221	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1232	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1242	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1248	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1254	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1260	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1262	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1
Aroclor 1268	< 0.1	<0.1	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1

TABLE 7: BAILEY RUN/CEDAR BROOK SEDIMENT PARAMETERS THAT EXCEED U.S. EPA (1977) GUIDELINES

Parameter (mg/l)	STATIONS 14-1	14-2	Ctrl. 14-3	14-4	14-5	14-8
Cyanide	-	HP	-	HP	HP	HP
TKN	MP	HP	-	-	-	-
Arsenic	-	MP	-	HP	HP	MP
Cadmium	HP	HP	-	HP	HP	HP
Chromium	-	-	-	MP	MP	HP
Copper	HP	HP	-	HP	HP	HP
Iron	MP	MP	MP	HP	HP	HP
Lead	-	-	-	MP	HP	MP
Nickel	MP	HP	-	HP	HP	HP
Zinc	MP	MP	-	HP	HP	HP
COD	MP	MP	MP	-	-	MP
Oil and Greese	-	-	-	-	MP	HP
Ammonia	-	-	-	MP	MP	-
Manganese	HP	HP	HP	HP	HP	HP

MP - Moderately Polluted
HP - Heavily Polluted

BIOLOGICAL DISCUSSION

Biological data (bacteria, algae, macroinvertebrates, fish, fish tissue and toxicity) were collected from the Bailey Run system. Bacteria, fish and fish tissue were only collected during the summer sampling period. Algae, macroinvertebrate and toxicity data were collected during both summer and winter sampling periods.

The biological data indicate that the Universal Fasteners discharge has severely degraded Cedar Brook below the UT and has impacted Bailey Run below Cedar Brook. Macroinvertebrates and fish have been completely eliminated in the UT and either eliminated (fish) or severely reduced (macroinvertebrates) from the dump upstream to the UT. This portion of the Cedar Brook system has a reduced algal growth. Toxicity tests indicate that this portion of the stream system is extremely toxic to aquatic life.

The biological data shows that the lower portion of Bailey Run is starting to recover. The algae, macroinvertebrates and fish are the most diverse at the lowest station on Bailey Run (14-1).

Bacteria

The lack of bacteria recovered in the sample from Universal Fastener's effluent is further indication of the presence of toxic substances. Other physicochemical and biological data support this statement. Samples taken for fecal coliform/fecal streptococci analysis above and below the dump site showed no adverse influence from the dump to the bacteriological water quality in Cedar Brook.

Of the eight samples taken, none exceeded the fecal coliform and pH criteria for primary/secondary contact recreation (i.e. swimming/fishing) use. Fecal coliform/fecal streptococcal ratios, which are an indication of the source of fecal pollution (man or animal), indicated the main bacterial source was of animal origin. However, the fecal coliform counts were below the normal range (0.1 to 4.5), making most of the ratios questionable (Table 8).

The low fecal coliform counts are a possible reflection of toxic conditions caused by the Universal Fasteners effluent and/or possibly dry conditions during sampling.

Periphyton

Diatom communities in samples from the Bailey Run/Cedar Brook drainage were compared to show the effects of the Universal Fasteners effluent. Algal biomass was observed to be greatly reduced at sites affected by the effluent. During the December sampling period, the substrates at the control stations (14-3 and 14-10) were covered with a dense mat of diatoms, while periphyton of any kind was extremely scarce in the UT below Universal Fasteners (14-8) and in Cedar Brook above and below the dump site (14-5 and 14-4). Below the dump site (14-4) the substrate was covered with the green alga Chlamydomonas during the summer sampling period. The periphyton community began to visibly recover in Cedar Brook at the site just above the confluence with Bailey Run (14-2). Recent mechanical disturbance of the substrate at station 14-1 had a scouring effect on the periphyton, reducing its abundance.

Diatom community structure was measured using species richness, diversity and equitability indices. High values of these indices generally mean a community is undisturbed. Table 9 shows that the control stations (14-3 and 14-10) had higher values than the most disturbed stations during both summer and winter sampling periods. Station 14-10 was not sampled in summer because it is an intermittent stream and was dry at that time. From these indices, it appears that stations 14-4, 14-5 and 14-8 were severely disturbed while stations 14-2 and 14-1 showed some recovery from the impact of the industrial effluent.

The percent community similarity (PSC) index gives an indication of the similarity of two samples (Whittaker and Fairbanks 1958). This index compares the relative abundances of each species found in either of the samples. Values range from zero when samples have no species in common to 100 when two samples are identical.

Table 10 shows PSC values between control and impacted stations. Similarity between the two control stations was 42.25% in December, while similarities between controls and stations 14-4, 14-5 and 14-8 were much lower during both sampling periods (Table 10. Low similarities between these stations indicates that the diatom community structure has shifted from the natural community found at the control to one that is tolerant to the industrial effluent. Stations 14-1 and 14-2 were more similar to the control stations, this indicates that these two stations are far enough downstream from the industrial outfall that their diatom communities are beginning to recover.

Concentrations of several metals exceeded KSWS in the effluent from Universal Fasteners, and at several downstream stations (refer to Table 3). In addition, concentrations of cyanide and metals in the sediments were elevated well above control levels at most disturbed stations. Several studies have shown that heavy metals above certain concentrations will inhibit or be toxic to periphyton (Patrick 1977, Leland and Carter 1984, Leland and Carter 1985, Whitton and Say 1975).

Relative abundances of diatoms were calculated for all samples (Appendix C). During the summer sampling period, Epithemia sorex (23.1%), a species that prefers calcium rich streams such as those of this drainage, and Navicula minima (24.9%) were the dominant diatoms at the control station (14-3). Stations 14-4, 14-5 and 14-8 were nearly devoid of periphyton except for the layer of Chlamydomonas at 14-4. Diatom samples from 14-4 and 14-5 were dominanted by Nitzschia palea (95.0% and 97.2%, respectively), and station 14-8 was dominated by Amphora submontana. Nitzschia palea has been shown to be tolerant to water with high copper concentrations (Patrick 1977) and occurs at times in nearly monospecific communities in "very impure water" (Hustedt 1930).

Gomphonema angustatum, a common winter diatom, was abundant in control samples in December, but absent or very scarce in samples from impacted stations. This species has been shown to have a low resistance to zinc (Whitton and Say 1975).

While periphyton was very scarce at stations 14-4 and 14-5 samples from those stations were dominated by Nitzschia communis (82.7% and 78.7%, respectively), and Navicula minima was the most abundant diatom at station 14-8. Ecological preferences of these two species are unknown.

The data discussed here shows conclusively that the effluent from Universal Fasteners has had a severe effect on the diatom community of the UT and Cedar Brook downstream of the UT. Recovery of the community has begun at the station on Cedar Brook just above the confluence with Bailey Run. Elevated water and sediment levels of cyanide, metals, and other organic compounds, used in the plating process at Universal Fasteners, contributed to the near elimination of a natural periphyton community at stations 14-4, 14-5 and 14-8.

Macroinvertebrates

A total of 112 taxa were identified from the Bailey Run system. The most abundant organism encountered was the isopod Lirceus fontinalis. Though this species was encountered at all stations where macroinvertebrates were observed, it was scarce at impacted station while being very abundant at the control sites. The two controls had macroinvertabrate faunas that were typical of small, intermittent, limestone streams in central Kentucky. These streams are typically dominated numerically by isopods and have a moderate number of the pollution sensitive groups, the ephemeropterans (mayflies), plecopterans (stoneflies), and trichopterans (caddisfies).

The Universal Fasteners effluent has severely impacted the macroinvertebrate fauna of the Bailey Run system (Appendix F, Table 11). No macroinvertebrates were collected from the UT. The fauna in Cedar Brook consisted of only a few tolerant taxa and these were reduced in abundance. Those groups which are considered to be pollution sensitive, the ephemeropterans, plecopterans and trichopterans, were absent from Cedar Brook below the U.T. (Table 11). The reduced number of organisms and taxa is indicative of the presence of toxic wastes (Weber

1973). This is supported by coefficient of community loss (CCL) data (Table 12). In a study by Courtemanch and Davis (1987), all toxicity stressed waters studied generated a CCL value of above 0.75. As can be seen from this study, CCL data at all stations except the controls (and station 14-4 in the winter) had values that approached or exceeded the 0.75 value during both sampling periods (Table 12). The literature is replete with papers detailing the toxicity of cyanide and metals to aquatic life (refer to CWAC (1972) and U.S. EPA (1976)). Also, chloride values are known to be toxic to aquatic life in concentrations exceeding 600 mg/l (Birge et al. 1985). The elevated levels of metals, cyanide and chlorides in the water column and sediments have reduced or eliminated many species from the Bailey Run system.

A similarity index (Table 13) showed that no stations were similar during the summer sampling season. Two sites (14-5 and 14-8) had no organisms present and therefore could not be included in calculations of the index. Data from the winter sampling period showed that the two control stations were the only stations that were similar. Again, station 14-8 had no organisms and could not be compared to other stations. Becase of the similar nature of all sites, i.e. similar gradient, habitats, stream size, it would be expected that all stations would display similarity to each other. The dissimilarity between the perturbed sites and the controls is the result of an outside pollution source, i.e., the Universal Fasteners effluent.

Fish

Fish collections were attempted during the summer at all sites except 14-10, which was dry. In winter, fish were observed at 14-10, but no collections were made at that time. Fish communities (Appendix G), where present, were fairly typical of small streams within the Bluegrass Physiographic Region. An Index of Biotic Integrity (IBI) was calculated for all stations using the methods of Karr (1981) (Appendix G). Although the IBI rating at station 14-3 (control) was poor, this was a reflection of low flow conditions and paucity of riffle habitat. At sites further upstream (14-4, 14-5 and

14-8) no fish were collected after extensive seining. The poor water quality and lack of aquatic organisms has eliminated the fish communities in those areas. Not even stonerollers (a herbivore) were present even though algae was abundant at 14-4.

The fish tissue analysis (Table 14) showed no PCBs or other organic chemicals above FDA action levels. Of the heavy metals, only copper exceeded STORET means for fish tissue.

Toxicity Tests

The U.S. EPA (1984) and DOW (1986) conducted toxicity tests on the Universal Fasteners effluent. Data presented by U.S. EPA (1984) showed the Universal Fasteners effluent to be acutely toxic to both daphnids and minnows in static and flow-through tests. Toxicity tests conducted by DOW (1986) showed the Universal Fasteners effluent to be acutely toxic to fathead minnows (i.e., LC_{50} = 31.5%) and highly acutely toxic to Daphnia pulex and Ceriodaphnia (i.e., LC_{50} = 1.25% for both species).

Acute and chronic toxicity screening tests were conducted during January 15-24, 1987 on stream water and sediments collected from eight locations in the Bailey Run system (Figure 1). The acute tests performed were a 48-hour static Daphnia pulex (with 1/15/87 sample) bioassay, a 96-hour static-renewal fathead minnow (Pimephales promelas) bioassay, and a 96-hour sediment-elutriate fathead minnow (P. promelas) bioassay. Chronic testing consisted of a 9-day embryo-larval static-renewal bioassay on stream water and a 9-day embryo-larval solid-phase bioassay on the sediments from the eight Cedar Brook/Bailey Run locations.

The toxicity tests conducted on stream water from Bailey Run and Cedar Brook indicate that sites 14-1, 14-2, 14-4, 14-5, 14-8 and 14-11 were acutely and chronically toxic to Daphnia and Pimephales (Table 15). Water from sites 14-3 and 14-10 indicated slight acute and chronic toxicity to the minnow, but demonstrated no toxicity to the daphnid. Complete lethality was determined for all tests (acute and chronic) at sites 14-8, 14-11, 14-5 and 14-4. Toxicity decreased as samples were taken

downstream from the point discharge (the UT from Universal Fasteners, Inc.) Reductions in survival of 30% were determined in acute Daphnia, 40% reductions in fathead acute and 45% reductions in fathead chronic tests from 14-2. At site 14-1, 10%, 25% and 35% reductions in survival were seen in daphid and fathead acutes and fathead chronic tests, respectively. Water samples collected from Cedar Brook above the UT from Universal Fasteners and (14-10) from Bailey Run above the confluence of Cedar Brook (14-3) demonstrated extremely low toxicities.

Bioassays performed on stream sediments collected at the above locations showed a similar pattern of toxicity (Table 16). Sites 14-8 and 14-11 showed 100% lethality in both the acute sediment-elutriate and the chronic solid-phase tests. The chronic test was more sensitive. In the chronic bioassays, sites 14-5 and 14-4 also demonstrated complete lethality. Both tests (acute and chronic) indicated a graded response; the greater the distance downstream from the input (UT from Universal Fasteners) the higher the survival. Survival was good (i.e., 80%) at the two upstream control sites (14-3, 14-10) for both types of tests.

Additional tests were conducted on serial dilutions from sites 14-8 and 14-11 (Table 17), the sites in closest proximity to the Universal Fasteners input. Reduced survivals, at concentrations of elutriate down to 5% or less for the two stations, indicate that considerable cleanup of the sediments in these stream stretches will be required before they no-longer pose a threat to aquatic life.

Water quality characteristics determined during the tests are presented in Table 18. Dissolved oxygen levels remained above 60% of saturation as recommended by Peltier and Weber (1985) and Horning and Weber (1985). Hardness and pH were fairly high but were not unexpected for a limestone bedrock stream. The decrease in conductivity, as toxicity, was proportional to distance downstream from Universal Fasteners.

TABLE 8: BACTERIOLOGICAL DATA FOR BAILEY RUN/CEDAR BROOK AND KENTUCKY RIVER DURING THE SUMMER SAMPLING PERIOD

10-Sep-87

Station	Source	FC/100 ml	FS/100 ml	FC/FS
14-1	Bailey Run, mouth	896	370	0.23
14-2	Cedar Brook above Bailey Run	13	230	-
14-3	Bailey Run above confluence of Cedar Brook	5	160	-
14-4	Cedar Brook below Dump	64	410	0.16
14-5	Cedar Brook above Dump	15	400	-
14-6	Kentucky River above Bailey Run	6	2	-
14-7	Kentucky River below Bailey Run	2/2	5/8	-
14-9	Universal Fasteners Effluent	Less than 2	Less than 2	-

TABLE 9: DIATOM COMMUNITY STRUCTURE DATA

	August-September 1986					
	14-1	14-2	14-3*	14-4	14-5	14-8
Species richness	34	23	42	9	4	19
Diversity	3.63	2.94	3.39	0.39	0.23	2.73
Equitability	0.58	0.49	0.46	0.16	0.32	0.49

	December 1986						
	14-1	14-2	14-3*	14-4	14-5	14-8	14-10*
Species Richness	37	49	44	14	25	7	24
Diversity	2.81	4.31	3.83	1.15	1.61	1.29	2.11
Equitability	0.34	0.65	0.61	0.19	0.19	0.43	0.26

*Control Station

TABLE 10: SIMILARITY (PSC) BETWEEN CONTROL AND IMPACTED STATIONS

	August-September	December	
	14-3*	14-3*	14-10*
14-1	35.40	29.35	13.40
14-2	40.45	58.35	26.50
14-3*	-	-	42.25
14-4	1.15	4.75	3.80
14-5	1.15	17.20	13.25
14-8	3.30	12.40	2.65
14-10*	ND	42.25	-

*Control Station

TABLE 11: BAILEY RUN/CEDAR BROOK MACROINVERTEBRATE NUMERICAL DATA

Summer Sampling Period

	STATIONS						
	14-1	14-2	Ctrl. 14-3	14-4	14-5	14-8	Ctrl. 14-10
Total Number of Taxa	18	16	20	14	0	0	ND
Total Number of Individuals	76	61	78	73	0	0	ND
Ephem/Plecop/Trichop	3	3	6	0	0	0	ND
Winter Sampling Period							
Total Number of Taxa	27	22	37	18	9	0	34
Total Number of Individuals	86	82	263	39	33	0	332
Ephem/Plecop/Trichlp	6	2	9	0	2	0	5
Total (Winter + Summer)							
Total Number of Taxa	40	31	49	31	9	0	34
Ephem/Plecop/Trichop	7	5	14	0	0	0	5

TABLE 12: BAILEY RUN/CEDAR BROOK MACROINVERTEBRATE COEFFICIENT OF COMMUNITY LOSS

Summer Sampling

	14-1	14-2	14-4	14-5	14-8	14-10
Control 14-3	0.68	0.81	1.07	*	*	ND

Winter Sampling

	14-1	14-2	14-4	14-5	14-8	14-10
Control 14-3	0.89	1.32	1.56	3.67	*	0.53
Control 14-10	0.89	1.23	0.41	1.50	3.33	*

TABLE 13: BAILEY RUN/CEDAR BROOK MACROINVERTEBRATE SIMILARITY INDEX

Summer Sampling

	14-1	14-2	14-3	14-4	14-5	14-8
14-1						
14-2	30					
14-3	37	45				
14-4	19	13	36			
14-5	*	*	*	*		
14-8	*	*	*	*	*	

Winter Sampling

	14-1	14-2	14-3	14-4	14-5	14-8	14-10
14-1							
14-2	41						
14-3	29	29					
14-4	32	20	37				
14-5	22	16	28	33			
14-8	*	*	*	*	*		
14-10	33	26	54	30	28	*	

TABLE 14: BAILEY RUN/CEDAR BROOK FISH TISSUE DATA

	14-1		14-2		14-3	
Parameter (mg/kg)	Largemouth Bass W/B	Common Shiner W/B	White Sucker W/B	Longear Sunfish W/B	Green Sunfish W/B	Stone Roller W/B
Aluminun	41.9	48.6	60.0	101	15.0	113
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Beryllium	0.004	<0.001	0.002	0.025	0.001	0.005
Cadmium	<0.001	0.015	0.301	0.141	<0.001	0.003
Chromium	0.726	0.308	0.324	0.673	0.587	0.488
Copper	2.27	3.17	3.29	2.58	1.75	3.05
Lead	<0.005	0.688	0.100	0.221	0.069	<0.005
Manganese	7.21	7.14	11.6	36.8	7.34	20.0
Mercury	0.066	0.056	0.185	0.109	0.189	0.086
Nickel	0.524	0.330	0.332	1.24	0.211	0.377
Zinc	26.3	40.4	23.6	25.0	26.1	40.9
G-Chlordane	<0.010	0.014	0.013	0.001	0.023	<0.010
P,P'-DDE	<0.010	0.0011	0.010	0.015	0.019	<0.010
Dieldrin	<0.10	<0.010	0.010	<0.010	0.011	<0.010
P,P'DDD	<0.0.10	<0.010	0.011	<0.010	0.010	0.012
P,P'DDT	<0.010	<0.010	0.010	<0.010	0.010	0.014
Toxaphene	<0.1	<0.1	0.013	<0.01	<0.1	<0.1
Pentachlorophenol	<0.010	<0.010	0.050	<0.010	0.022	0.028
% Lipids	1.6	3.4	2.2	2.1	4.7	7.5

TABLE 15: ACUTE AND CHRONIC TOXICITY OF STREAM WATER FROM BAILEY RUN/CEDAR BROOK

Station Replicates		% Survival 48-Hour Acute Static *Daphnia pulex*	96-Hour Acute Static-Renewal *Pimephales promelas*	9-Day Static-Renewal Embryo-Larval Chronic *Pimephales promelas*
14-1	A	90	80	67
	B	90	70	62
	A + B/2	90	75	65
14-2	A	80	40	56
	B	60	80	55
	A + B/2	70	60	55
14-3	A	100	90	91
	B	100	100	90
	A + B/2	100	95	91
14-4	A	40	0	0
	B	0	0	0
	A + B/2	20	0	0
14-5	A	0	0	0
	B	20	0	0
	A + B/2	10	0	0
14-8	A	0	0	0
	B	0	0	0
	A + B/2	0	0	0
14-10	A	100	90	90
	B	90	80	90
	A + B/2	95	85	90
14-11	A	0	0	0
	B	0	0	0
	A + B/2	0	0	0
Control[2]	A	100	100	96
	B	80	100	94
	A + B/2	90	100	95

[1]The daphnid and minnow acute tests had 10 individuals per replicate (A and B), the chronic minnow test had atleast 50 eggs per replicate.

[2]Control water was synthetic culture water.

TABLE 16: STREAM SEDIMENTS TOXICITY TESTS CONDUCTED ON BAILEY RUN/CEDAR BROOK WITH FATHEAD MINNOWS (Pimephales promelas)[1]

Station	Replicate	% Survival: 96-Hour Acute Sediment-Elutriate	% Survival: 9-Day Embryo-larval Solid-Phase Chronic
14-1	A	90	54
	B	80	47
	A + B/2	85	51
14-2	A	60	36
	B	70	29
	A + B/2	65	33
14-3	A	90	80
	B	90	79
	A + B/2	90	80
14-4	A	60	0
	B	60	0
	A + B/2	60	0
14-5	A	40	0
	B	60	0
	A + B/2	50	0
14-8	A	0	0
	B	0	0
	A + B/2	0	0
14-10	A	70	77
	B	80	83
	A + B/2	75	80
14-11	A	0	0
	B	0	0
	A + B/2	0	0
Control[2]	A	100	93
	B	100	90
	A + B/2	100	92

[1]The acute test utilized 10 individuals per replicate, the chronic test had a minimum of 50 individuals per replicate.

[2]Control sediment was collected from a site that had previously shown high survivals (Yellow Creek at Cumberland Gap National Park, MP 16.4)

TABLE 17: SERIAL DILUATIONS OF SEDIMENT-ELUTRIATE 96-HOUR ACUTE BIOASSAYS

Station	Dilution	% Survival Replicates A	B	A + B/2
14-8				
	100%	0	0	0
	10%	60%	50%	55%
	1%	90%	90%	90%
	0.5%	100%	100%	100%
				LC_{50} =18.2%
14-11				
	100%	0	0	0
	25%	60%	50%	55%
	10%	60%	70%	65%
	5%	70%	80%	75%
				LC_{50} = 31.8%
	Control	100%	100%	100%

TABLE 18: WATER QUALITY CHARACTERISTICS DETERMINED DURING THE ACUTE AND CHRONIC BIOASSAYS (GIVEN AS RANGES)

Test[1] / Station	Temp (Co)	Dissolved Oxygen (mg/l)	pH (S.U.)	Conductivity (umhos/cm)	Alkalinity (as mg/l as $CaCO_3$)	Hardness (as mg/l as $CaCO_3$)
Parameter						
Acute Daphnia						
14-1	(21.7 - 25.3)	(8.6 - 11.8)	(8.2 - 8.4)	800	(224-240)	(228-244)
14-2	(21.6 - 25.3)	(8.5 - 11.2)	(8.1 - 8.4)	950	(208-232)	252-256)
14-3	(21.5 - 25.5)	(9.4 - 10.6)	(8.1 - 8.4)	470	(196-208)	(216-220)
14-4	(21.6 - 26.1)	(8.1 - 10.0)	(8.4 - 8.6)	1600	(264-284)	(240-248)
14-5	(21.5 - 25.8)	(8.1 - 10.0)	(8.3 - 8.9)	1550	(244-256)	(288-293)
14-8	(25.2 - 25.8)	9.8	8.9	2200	240	252
14-10	(21.7 - 25.5)	(8.3 - 10.0)	(8.1 - 8.4)	500	(204-228)	(272-276)
14-11T	26.6	10.2	8.4	1000	224	244
Control	(21.7-27.1)	(8.2-8.6)	(7.1-7.2)	100	28	28
Acute Minnow (Water)						
14-1	(22.0 - 22.2)	7.0	8.20	900	(240-244)	312
14-2	(22.0 - 22.3)	(6.9 - 7.1)	8.10	1000	(248-252)	(304-308)
14-3	(22.0 - 22.5)	7.1	(8.05 - 8.10)	510	(208-212)	280
14-4	(22.0 - 22.5)	(6.0 - 6.2)	(8.35 - 8.40)	1700	240	296
14-5	(22.0 - 22.1)	(6.2 - 6.3)	8.35	1700	264	352
14-8	22.1	6.0	8.80	2400	268	352
14-10	(22.0 - 22.5)	(6.9 - 7.3)	8.10	510	(224-28)	(300-304)
14-11T	(22.1-22.2)	(5.9 - 6.2)	8.40	1100	240	320
Control	(21.9 - 22.2)	(7.1 -7.4)	7.75	345	(92-96)	(140-144)
Chronic Minnow (Water)						
14-1	(24.8 - 25.2)	(6.2 - 7.1)	(7.96 - 8.20)	(900-910)	(240-244)	(312-316)
14-2	(24.8 - 25.2)	(6.3 - 7.2)	(8.00 - 8.15)	(1000-1015)	(240-244)	(308-312)
14-3	(24.8 - 25.2)	(6.4 - 7.1)	(7.96 - 8.05)	(510-520)	(212-216)	(280-284)
14-4	(24.8 - 25.2)	(6.0 - 6.1)	8.35	1700	240	296
14-5	(24.8 - 25.2)	(6.0 - 6.2)	8.35	1700	264	348

TABLE 18: WATER QUALITY CHARACTERISTICS DETERMINED DURING THE ACUTE AND CHRONIC BIOASSAYS (GIVEN AS RANGES) (CONT'D.)

Test[1] / Station	Temp (C°)	Dissolved Oxygen (mg/l)	pH (S.U.)	Conductivity (umhos/cm)	Alkalinity (as mg/l as $CaCO_3$)	Hardness (as mg/l as $CaCO_3$)
Acute Daphnia						
14-8	(24.8 - 25.2)	6.0	8.80	2400	272	352
14-10	(24.8 - 25.2)	(6.3 - 7.0)	(8.0 - 8.1)	(510-520)	(224-228)	(300-308)
14-11T	(24.8 - 25.2)	(6.0 - 6.1)	8.40	100	240	320
Control	(24.8 - 25.2)	(6.5 - 7.3)	(7.33 - 7.37)	(340 - 345)	(92-96)	(140-144)
Acute Minnow (Sediment-Elutriate)						
14-1	(21.8-22.0)	(6.1 - 6.2)	7.80	470	(132-136)	(212-216)
14-2	(21.8 - 22.6)	(5.8 - 6.1)	7.80	412	(120-124)	148
14-3	(21.8 - 22.3)	(6.0 - 6.1	7.72	370	(104-108	(160-164)
14-4	(21.6 - 22.2	(6.0 - 6.3)	7.80	498	(132-136)	132
14-5	(21.6 - 22.0)	(6.0 - 6.1)	7.90	505	(128-132)	216
14-8	(22.0 - 22.1)	5.6 - 5.8)	7.70	1280	(160-164)	88
14-10	(21.8 - 22.0)		7.80	378	(120-124)	164
14-11T	22.0	(5.7 5.8)	7.85	705	(172-176)	220
Control	(21.7 - 22.4)		7.75	380	(132-136)	(164-168)
Chronic Minnow (Sediment)						
14-1	(24.8 - 25.2)	7.2	7.75	385	(108-112)	(132-136)
14-2	(24.8 - 25.2)	(7.0 - 7.2)	7.75	385	(104-112)	(132-136)
14-3	(24.8 - 25.2)	(7.0 - 7.2)	7.75	390	(104-108)	(128-132)
14-4	(24.8 - 25.2)	(6.3 - 6.5)	7.75	390	(90-96)	(128-132)
14-5	(24.8 - 25.2)	(6.1 - 6.4)	7.75	410	(92-96)	(132-136)
14-8	(24.8 - 25.2)	(6.1 - 6.2)	7.75	425	(88-92)	(104-106)
14-10	(24.8 - 25.2)	(6.9 - 7.5)	7.75	390	(112-116)	(132-136)
14-11T	(24.8 - 25.2)	(6.2 - 6.5)	7.75	420	(88-92)	(106-112)
Control [2]	(24.8 - 25.2)	(7.0 - 7.5)	7.75	385	(88-92)	(136-140)

[1]The daphnid and minnow acute tests had 10 individuals per replicate (A and B), the chronic minnow test had at least 50 eggs per replicate.

APPENDIX A

SITE INFORMATION

Site Information

Site No:	04014001
Stream:	Bailey Run
County:	Anderson
Location:	Near Tyrone, off KY 1510
Latitude:	38°02'03"
Longitude:	84°50'21"
Stream Order:	IV
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	0.2
Sampling Dates:	9/9/86, 12/18/86
Type Sampling:	Biological/Physicochemical
Pool Width:	Above ford: 1.5 to 3m, below: 6 to 15m
Pool Depth:	.2 to .6m
Pool Substrate:	Cobble, pebble, gravel, fines
Riffle Width:	N/A
Riffle Depth:	N/A
Riffle Substrate:	N/A
Bank Height:	3 to 6m
Bank Slope:	Right: 60 + %, left: 30-40%
Riparian Vegetation - %	
Trees:	30
Shrubs:	20
Herbs:	30
Exposed:	15
Width:	0-20
Canopy over Stream - %	50-75
Bank Stability:	Fair
Erosion:	Left bank eroding; right bank has been excavated
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Pools, justicia beds, undercut banks, rock ledges, submerged roots and logs, large boulders, man-made objects, gravel bars
Hydraulic Structures:	Gravel bars
Physical Impacts:	Bulldozer along right bank
Nonpoint Sources:	KY-Stone Company, KY 1510

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	04014002
Stream:	Cedar Brook
County:	Anderson
Location:	Above Bailey Run
Latitude:	38°01'37"
Longitude:	84°51'18"
Stream Order:	III
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	0.07
Sampling Dates:	8/21/86, 12/18/86
Type Sampling:	Biological/Physicochemical
Pool Width:	3 to 18m
Pool Depth:	.2 to 1m
Pool Substrate:	Exposed bedrock, boulders with some cobble, pebble, gravel, fines
Riffle Width:	1 to 3m
Riffle Depth:	.08 to .2m
Riffle Substrate:	Boulder, cobble, pebble, gravel
Bank Height:	1 to 2m
Bank Slope	20 to 50%:

Riparian Vegetation - %

Trees:	40
Shrubs:	20
Herbs:	25
Exposed:	5
Width:	30 + m

Canopy over Stream - %:	75-100
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Riffles, pools, undercut banks, rock ledges submerged roots, large boulders, man-made objects, gravel bars
Hydraulic Structures:	Gravel bars
Physical Impacts:	N/A
Nonpoint Sources:	Gravel road

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	04014003
Stream:	Bailey Run
County:	Anderson
Location:	Above Cedar Brook
Latitude:	38°01'30"
Longitude:	84°51'22"
Stream Order:	III
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	1.6
Sampling Dates:	8/21/86, 12/18/86
Type Sampling:	Biological/Physicochemical
Pool Width:	6 to 12m
Pool Depth:	.2 to 1m
Pool Substrate:	Exposed bedrock, fines
Riffle Width:	N/A
Riffle Depth:	N/A
Riffle Substrate:	N/A
Bank Height:	6 to 15m
Bank Slope:	30 to 60%
Riparian Vegetation - %	
Trees:	60
Shrubs:	20
Herbs:	10
Exposed:	5
Width:	30 + m
Canopy over Stream - %	75 to 100
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Pools, undercut banks, rock ledges, submerged roots and logs, large boulders
Hydraulic Structures:	N/A
Physical Impacts:	N/A
Nonpoint Sources:	Gravel road

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	04014004
Stream:	Cedar Brook
County:	Anderson
Location:	Below dump
Latitude:	38°02'05"
Longitude:	84°52'14"
Stream Order:	III
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	1.4
Sampling Dates:	8/20/86, 12/17/86
Type Sampling:	Biological/Physicochemical
Pool Width:	6 to 12m
Pool Depth:	.2 to 5m
Pool Substrate:	Exposed bedrock, boulders
Riffle Width:	1.5 to 3m
Riffle Depth:	.08 to .2m
Riffle Substrate:	Exposed bedrock, boulders, cobble
Bank Height:	Right: 3m, left: 30m
Bank Slope	Right: 30%, left: 60%

Riparian Vegetation - %

Trees:	60
Shrubs:	20
Herbs:	10
Exposed:	5
Width:	Right: 3 to 30m, left: 3m

Canopy over Stream - %:	50 to 75
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Pool, riffles, undercut banks, rock ledges, submerged roots, large boulders
Hydraulic Structures:	N/A
Physical Impacts:	N/A
Nonpoint Sources:	Dump site

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	04014005
Stream:	Cedar Brook
County:	Anderson
Location:	Above dump
Latitude:	38°02'01"
Longitude:	84°52'01"
Stream Order:	III
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	1.68
Sampling Dates:	8/20/86, 12/17/86
Type Sampling:	Biological/Physicochemical
Pool Width:	3 to 6m
Pool Depth:	1.2 to 2.4m
Pool Substrate:	Exposed bedrock, boulders, cobble
Riffle Width:	.5 to 1.2m
Riffle Depth:	.05 to .1m
Riffle Substrate:	Exposed bedrock, boulders, cobble
Bank Height:	.3 to 1m
Bank Slope:	15 to 30%
Riparian Vegetation - %	
Trees:	50
Shrubs:	30
Herbs:	20
Exposed:	0-5
Width:	100+
Canopy over Stream - %	75 to 100
Bank Stability:	Excellent
Erosion:	N/A
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Pools, riffles, run, backwaters, undercut banks, rock ledges, submerged roots, large boulders
Hydraulic Structures:	N/A
Physical Impacts:	N/A
Nonpoint Sources:	N/A

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	04014006
Stream:	Kentucky River
County:	Anderson/Woodford
Location:	Below Bailey Run
Latitude:	38°02'22"
Longitude:	84°50'46"
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	84.0
Sampling Dates:	9/9/86
Type Sampling:	Physicochemical and Fish Tissue

Site Information

Site No:	04014007
Stream:	Kentucky River
County:	Anderson
Location:	Above Bailey Run
Latitude:	38°01'23"
Longitude:	84°49'48"
USGS Topo Quad:	Tyrone, KY
DOW Map No.:	13-42
RMI:	87 to 87.5
Sampling Dates:	9/9/86
Type Sampling:	Physicochemical and Fish Tissue

Site Information

Site No:	04014008
Stream:	UT to Cedar Brook
County:	Anderson
Location:	.35mi from confluence with Cedar Brook
Latitude:	38°01'57"
Longitude:	84°53'01"
Stream Order:	I
USGS Topo Quad:	Lawrenceburg, KY
DOW Map No.:	13-41
RMI:	0.35
Sampling Dates:	9/10/86, 12/17/86
Type Sampling:	Biological/Physicochemical
Pool Width:	1 to 3m
Pool Depth:	.1 to .2m
Pool Substrate:	Primarily fines
Riffle Width:	.6 to 1.2m
Riffle Depth:	.05 to .1m
Riffle Substrate:	Cobble, boulders, pebbles
Bank Height:	.3 to 1m
Bank Slope:	15 to 40%
Riparian Vegetation - %	
Trees:	50
Shrubs:	25
Herbs:	10
Exposed:	5
Width:	30 + m
Canopy over Stream - %	75 to 100
Bank Stability:	Excellent
Erosion:	N/A
Sedimentation:	Moderate
Imbeddedness:	½
Stream Habitat:	Pools, riffles, run, backwaters, undercut banks, rock ledges, submerged roots and logs, log piles, large boulders, dam
Hydraulic Structures:	3m dam
Physical Impacts:	N/A
Nonpoint Sources:	Agricultural fields

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	040140009
Stream:	Universal Fasteners effluent pipe
County:	Anderson
Location:	Factory Avenue, Lawrenceburg
Latitude:	38°02'01"
Longitude:	84°53'08"
Stream Order:	N/A
USGS Topo Quad:	Lawrenceburg, KY
DOW Map No.:	13-41
RMI:	0.5
Sampling Dates:	9/15/86, 12/17/86
Type Sampling:	Physicochemical

Site Information

Site No:	04014010
Stream:	Cedar Brook
County:	Anderson
Location:	Above UT
Latitude:	38°01'46"
Longitude:	84°52'12"
Stream Order:	II
USGS Topo Quad:	Lawrenceburg, KY
DOW Map No.:	13-41
RMI:	2.1
Sampling Dates:	12/17/86
Type Sampling:	Biological/Physicochemical
Pool Width:	3 to 6m
Pool Depth:	.05 to .1m
Pool Substrate:	Primarily exposed bedrock
Riffle Width:	.3 to .6m
Riffle Depth:	.02 to .05m
Riffle Substrate:	Cobble, pebble, gravel
Bank Height:	.3 to 2m
Bank Slope:	20 to 40%
Riparian Vegetation - %	
Trees:	25
Shrubs:	35
Herbs:	25
Exposed:	5
Width:	30 + m
Canopy over Stream - %	50 to 75
Bank Stability:	Good
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	¼
Stream Habitat:	Pools, riffles, undercut banks, rock ledges, submerged roots, large boulders, man-made objects
Hydraulic Structures:	Concrete dam
Physical Impacts:	N/A
Nonpoint Sources:	Gravel lane

ND - Not Determined
NA - Not Applicable

Site Information

Site No:	040140011
Stream:	Cedar Brook
County:	Anderson
Location:	Below UT to Universal Fasteners
Latitude:	38°01'48"
Longitude:	84°52'10"
Stream Order:	II
USGS Topo Quad:	Lawrenceburg, KY
DOW Map No.:	13-41
RMI:	2.02
Sampling Dates:	1/15/87
Type Sampling:	Toxics

APPENDIX B

WATER COLUMN, SEDIMENT AND FISH TISSUE DATA THAT WAS BELOW DETECTION LIMITS AT ALL STATIONS

LIST OF CHEMICAL COMPOUNDS WHICH WERE BELOW DETECTION LIMITS IN WATER SAMPLES AT ALL STATIONS

Methylene Chloride
1,2-Dichloroethene
1,2-Dichloroethane
1,1,1-Trichloroethane
Carbon Tetrachloride
Trichloroethene
1,2-Dichloropropane
Chloroethylvinyl ether
Bromoform
Tetrachloroethene
Chlorobenzene
p-Xylene
Total Xylenes
Phenol
Aniline
Bis-(2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
2-Methylphenol
Bis-(2-Chloroisopropyl) ether
4-Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethyphenol
Bis-(2-Chloroethoxy)methane
Benzoic Acid
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Napthalene
4-Chloroaniline
1,1,2,3,4,4-Hexachloro-1,3-butadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethyl Phthalate
Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethyl Phthalate
Fluorene
4-Chlorophenyl phenyl ether
4-Nitroaniline
2-Methyl-4,6-Dinitrophenol
N-Nitrosodiphenylamine
4-Bromophenylphenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Dibutyl Phthalate
Fluoranthene
Benzidine
Pyrene
Butyl Benzyl Phthalate
3,3'-Dichlorobenzidine
Benzo(A)Anthracene
Chrysene
Bis(2-Ethylhexyl)Phthalate
Dioctylphthalate
Benzo(B)Fluoranthene
Benzo(K)Fluoranthene
Benzo(A)Pyrene
Indeno(1,2,3-C,D)Pyrene
Dibenzo(A,H)Anthracene
Benzo(G,H,I)Perylene

LIST OF SEDIMENT PARAMETERS THAT WERE BELOW DETETION LIMITS AT ALL STATIONS

Hexachlorobenzene
Hexachlorocyclohexane, alpha isomer
Hexachlorocyclohexane, beta isomer
Hexachlorocyclohexane, gamma isomer
Hexachlorocyclohexane, delta isomer
Heptachlor
Aldrin
Heptachlor Epoxide
oxychlordane
t-Chlordane
c-Chlordane
t-Nonachlor
O, P' - DDE
P, P' - DDE
Dieldrin
Endrin
O, P' - DDD
P, P' - DDD
O, P' - DDT
P, P' - DDT
Total DDT
Methoxychlor
Mirex
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin Aldehyde
Endrin Ketone
Toxaphene
Technical Chlordane
Pentachlorophenol
2,3,4,5-Tetrachlorophenol
2,3,4,6-Tetrachlorophenol

LIST OF FISH TISSUE PARAMETERS THAT WERE BELOW DETECTION LIMITS AT ALL STATIONS

Hexachlorobenzene
Hexachlorocyclohexane, alpha isomer
Hexachlorocyclohexane, beta isomer
Hexachlorocyclohexane, gamma isomer
Hexachlorocyclohexane, delta isomer
Heptachlor
Aldrin
Heptachlor Epoxide
oxychlordane
t-Nonachlor
O, P' - DDE
Endrin
O, P' - DDD
O, P' - DDT
Methoxychlor
Mirex
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin Aldehyde
Endrin Ketone
2,3,4,5-Tetrachlorophenol
2,3,4,6-Tetrachlorophenol
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Aroclor 1262
Aroclor 1268

APPENDIX C

BAILEY RUN/CEDAR BROOK ALGAL SYNOPTIC LIST

BAILEY RUN - CEDAR BROOK SURVEY
DIATOM SPECIES LIST AND RELATIVE ABUNDANCES
August - September 1986

	14-1	14-2	14-3	14-4	14-5	14-8
Achnanthes lanceolata var. dubia	-	-	0.4	-	-	0.2
A. minutissima	3.5	-	0.2	-	-	-
A. pinnata	1.2	0.2	0.4	-	-	-
Amphora perpusilla	0.8	-	1.8	-	-	0.4
A. submontana	*	0.2	*	0.4	0.4	45.1
Bacillaria paradoxa	*	-	-	-	-	-
Caloneis bacillum	-	0.8	0.2	-	-	-
Cocconeis pediculus	-	-	*	0.2	-	0.4
C. placentula var. euglypta	*	-	0.4	-	-	-
Cyclotella atomus	6.7	-	1.6	-	-	-
C. meneghiniana	0.8	2.0	-	-	-	-
C. striata var. ambigua	1.0	1.4	-	-	-	-
Cymbella delicatula	-	-	*	-	-	-
C. prostrata var. auerswaldii	-	-	1.2	-	-	-
C. sinuata	0.2	-	-	-	-	-
C. tumida	-	-	*	-	-	-
Epithemia sorex	0.4	-	23.1	-	-	-
Fragilaria crotonensis	-	-	1.0	-	-	-
Gomphonema angustatum	-	-	0.6	-	-	-
G. gracile	0.2	-	0.6	-	-	-
G. parvulum	0.4	-	14.3	0.2	-	0.2
G. tenellum	-	-	-	-	-	9.5
G. truncatum	-	-	*	-	-	-
G. truncatum var. capitatum	-	-	0.6	-	-	-
Gyrosigma spencerii	-	-	*	-	-	0.4
Melosira varians	-	-	2.5	-	-	-
Navicula cryptocephala	0.2	-	-	-	-	4.6
N. cryptocephala var. veneta	0.4	1.2	0.2	-	-	5.0
N. heufleri var. leptocephala	0.6	1.8	0.2	-	-	-
N. lanceolata	-	-	*	-	-	4.2
N. luzonensis	1.0	0.8	0.4	0.2	-	-
N. menisculus var. upsaliensis	0.4	-	0.6	-	-	0.8

BAILEY RUN - CEDAR BROOK SURVEY
DIATOM SPECIES LIST AND RELATIVE ABUNDANCES (CONT'D.)
August - September 1986

	14-1	14-2	14-3	14-4	14-5	14-8
N. minima	22.9	30.0	24.9	0.2	1.0	0.2
N. pupula	-	-	*	-	-	-
N. radiosa var. tenella	1.0	4.1	0.6	-	-	0.2
N. rhynchocephala var. germanii	0.8	0.4	1.4	-	-	-
N. salinarum var. intermedia	-	-	*	-	-	16.8
N. secreta var. apiculata	0.8	-	-	-	-	-
N. symmetrica	1.0	1.2	-	-	-	-
N. tripunctata	-	0.2	0.2	-	-	3.0
N. spp.	-	-	-	-	-	0.4
Nitzschia amphibia	1.2	27.6	9.2	0.4	-	-
N. angustata var. acuta	0.4	0.8	-	-	-	-
N. apiculata	1.2	0.8	0.2	-	-	-
N. dissipata	2.3	-	-	-	-	-
N. filiformis	-	-	-	3.2	1.4	1.2
N. frustulum	22.3	6.7	3.3	-	-	-
N. linearis	-	-	-	0.2	-	-
N. palea	1.4	0.6	0.6	95.0	97.2	3.4
N. perminua	5.1	1.2	-	-	-	-
N. recta	-	-	0.6	-	-	-
N. sinuata var. tabellaria	-	-	8.0	-	-	-
Rhoicosphenia curvata	8.0	*	1.0	-	-	4.1
Stephanodiscus subtilis	-	-	0.2	-	-	-
Surirella ovalis	0.2	0.2	0.2	-	-	-
Synedra fasciculata	10.8	16.0	-	-	-	-
S. ulna	-	-	0.2	-	-	-
Thalassiosira weissflogii	3.1	1.6	-	-	-	-
Total Taxa	34	23	42	9	4	19
Diversity ($\bar{d}$)	3.631	2.937	3.391	0.391	0.227	2.735
Equitability (e)	0.577	0.488	0.455	0.165	0.320	0.486
#Taxa in 500 valve count	31	22	33	9	4	19

*Present, but not encountered in count of 500 valves

BAILEY RUN - CEDAR BROOK SURVEY
DIATOM SPECIES LIST AND RELATIVE ABUNDANCES
December 1986

	14-1	14-2	14-3	14-4	14-5	14-8	14-10
Achnanthes lanceolata	-	0.6	-	0.2	-	15.5	-
A. lanceolata var. dubia	0.2	0.4	1.6	-	1.5	-	1.2
A. minutissima	43.2	20.6	11.0	-	0.2	0.2	3.2
A. sp. 1	-	-	1.6	-	0.2	-	1.0
A. pinnata	2.6	1.5	0.2	-	-	-	-
A. spp	0.2	-	-	0.2	-	-	-
Amphora perpusilla	0.2	-	1.2	-	0.2	-	*
A. submontana	*	-	-	2.6	0.4	0.2	-
Caloneis bacillum	1.3	0.6	0.2	-	-	-	-
Cocconeis pediculus	*	-	0.4	-	0.4	-	-
C. placentula var. euglypta	*	-	*	-	-	-	0.5
Cyclotella striata var. ambigua	-	0.2	-	-	-	-	-
Cymbella minuta	-	-	0.8	-	-	-	0.2
C. sinuata	-	-	*	-	-	-	-
C. spp.	-	-	0.2	-	-	-	-
C. tumida	-	*	-	-	-	-	-
Epithemia sorex	-	-	*	-	-	-	-
Frustulia vulgaris	0.2	0.2	-	-	-	-	-
Gomphonema acuminatum	-	0.2	-	-	-	-	-
G. angustatum	-	2.1	13.2	-	2.7	-	67.6
G. olivaceum	1.7	4.4	16.4	-	1.0	-	4.6
G. parvulum	0.4	3.9	3.0	0.4	1.9	-	0.2
G. sphaerophorum	-	-	0.2	-	-	-	0.2
G. spp.	-	0.4	-	-	-	-	-
G. truncatum var. capitatum	-	-	0.2	-	-	-	-
Gyrosigma scalproides	-	-	-	0.2	-	-	-
G. spp.	-	*	*	-	-	-	-
Melosira varians	-	*	*	-	-	-	-
Meridion circulare	-	0.6	*	-	0.4	0.4	-
Navicula cryptocephala	-	0.2	-	-	-	-	0.5
N. cryptocephala var. veneta	2.8	8.1	16.0	-	1.2	-	8.5
N. lanceolata	*	0.4	0.2	0.2	0.4	-	-

BAILEY RUN - CEDAR BROOK SURVEY
DIATOM SPECIES LIST AND RELATIVE ABUNDANCES
December 1986

	14-1	14-2	14-3	14-4	14-5	14-8	14-10
N. luzonensis	0.2	0.2	0.6	-	-	-	1.2
N. menisculus var. upsaliensis	0.7	5.0	4.4	-	0.2	-	1.5
N. minima	7.1	12.5	12.4	1.6	2.7	72.0	2.4
N. minuscula	1.1	-	0.2	-	-	-	-
N. mutica	0.2	-	-	-	-	-	-
N. mutica var. undulata	-	*	-	-	-	-	-
N. paucivisitata	-	-	-	-	-	-	*
N. radiosa	-	0.2	-	0.2	0.6	-	-
N. radiosa var. tenella	*	0.4	0.2	-	-	-	-
N. rhynchocephala	-	-	-	-	0.2	-	-
N. salinarum var. intermedia	-	0.2	1.2	-	-	-	-
N. secreta var. apiculata	0.9	2.1	1.8	-	0.8	-	1.2
N. spp.	-	1.0	-	-	-	-	-
N. symmetrica	-	-	-	-	0.2	-	-
Nitzschia acicularis	*	-	-	-	-	-	-
N. amphibia	0.2	0.4	0.4	-	0.8	-	0.2
N. angustata var. acuta	-	1.0	0.2	-	-	-	-
N. apiculata	3.0	6.2	*	-	0.2	-	-
N. chasei	-	-	0.2	-	-	-	-
N. clausii	-	0.2	-	-	-	-	-
N. communis	0.6	0.8	-	82.7	78.7	8.9	-
N. dissipata	0.6	0.2	1.8	-	-	-	1.7
N. filiformis	-	1.2	-	1.4	-	-	-
N. fonticola	26.1	2.7	-	-	-	3.0	-
N. frustulum	*	6.6	1.2	-	0.4	-	0.2
N. linearis	-	0.6	1.2	-	-	-	-
N. microcephala	0.9	-	-	-	-	-	-
N. palea	0.8	2.7	2.2	3.6	3.5	-	1.7
N. paleacea	-	-	-	-	-	-	1.5
N. perminuta	-	0.2	-	-	-	-	-
N. recta	-	0.6	*	-	-	-	-
N. sinuata var. tabellaria	-	-	0.2	-	-	-	-

BAILEY RUN - CEDAR BROOK SURVEY
DIATOM SPECIES LIST AND RELATIVE ABUNDANCES
December 1986

	14-1	14-2	14-3	14-4	14-5	14-8	14-10
N. spp.	0.6	0.2	-	0.2	0.2	-	-
N. sublinearis	-	0.6	-	6.2	-	-	-
Rhoicosphenia curvata	2.3	1.5	1.2	0.4	1.2	-	0.2
Surirella angusta	0.9	0.8	-	-	-	-	-
S. ovalis	0.2	1.2	*	-	-	-	-
S. ovata	1.9	3.7	3.8	-	-	-	0.2
Synedra fasiculata	0.9	2.9	*	-	-	-	-
Total Taxa	37	49	44	14	25	7	24
Diversity ($\bar{d}$)	2.805	4.315	3.826	1.147	1.609	1.287	2.105
Equitability (e)	0.336	0.651	0.606	0.192	0.195	0.425	0.260
Number of Taxa in 500 valve count	29	45	34	14	25	7	22

*Present, but not encountered in count of 500 valves

APPENDIX D

BAILEY RUN/CEDAR BROOK MACROINVERTEBRATE SYNOPTIC LIST

MACROINVERTEBRATE SYNOPTIC LIST FOR THE BAILEY RUN AND CEDAR BROOK SYSTEM FOR SUMMER (SUM) AND WINTER (WIN)

Taxa	14-1		14-2		14-3		14-4		14-5		14-8		14-10	
	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
Porifera														
Spongilla sp.	-	-	-	-	-	-	-	-	-	-	-	-	ND	P
Eclipidrilus sp..	-	-	-	-	-	-	-	-	-	1	-	-	ND	-
Limbriculida														
Lumbriculus sp.	-	-	-	-	-	-	1	-	-	-	-	-	ND	-
Haplotaxida														
Branchiura sowerbi	1	-	-	-	-	-	-	-	-	-	-	-	ND	-
Haplotaxis gordioides	-	-	-	-	-	-	-	-	-	-	-		ND	2
Turbellaria														
Phagocata sp.	-	-	-	-	-	-	-	-	-	-	-		ND	10
Limnophila														
Ferrissia rivularis	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Fossaria sp.	-	-	-	1	-	9	-	-	-	-	-	-	ND	-
Physella sp.	6	2	2	1	5	27	-	2	-	-	-	-	ND	23
Heterodonta														
Musculium lacustre	-	-	-	-	-	-	-	-	-	-	-		ND	7
Sphaerium transversum	-	-	-	-	-	-	-	1	-	-	-	-	ND	-
Pisidium sp.	-	-	-	-	-	1	-	1	-	-	-	-	ND	-
Amphipoda														
Crangonyx sp.	-	5	-	-	-	23	-	2	-	3	-	-	ND	16
Isopoda														
Lirceus fontinalis	-	4	2	4	7	86	-	15	-	22	-	-	ND	186

MACROINVERTEBRATE SYNOPTIC LIST FOR THE BAILEY RUN AND CEDAR BROOK SYSTEM FOR SUMMER (SUM) AND WINTER (WIN) (CONT'D.)

	14-1		14-2		14-3		14-4		14-5		14-8		14-10	
Taxa	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**
Decapoda														
Cambarus laevis	-	-	-	-	-	-	-	-	-	-	-		ND	3
Orconectes rusticus	2	-	-	-	1	2	-	-	-	-	-	-	ND	6
Ephemeroptera														
Baetis sp.	-	-	-	-	1	-	-	-	-	-	-	-	ND	-
Caenis sp.	3	3	1	-	16	-	-	-	-	-	-	-	ND	-
Cloeon sp.	-	-	-	-	2	-	-	-	-	-	-	-	ND	-
Heptagenia sp.	-	-	-	-	6	-	-	-	-	-	-	-	ND	-
Stenacron interpunctatum	-	-	-	-	3	-	-	-	-	-	-	-	ND	-
Stenonema femoratum	23	7	-	-	5	10	-	-	-	-	-	-	ND	14
Siphlonurus sp.	1	-	-	-	-	-	-	-	-	-	-	-	ND	-
Pseudocloeon sp.	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Unidentified Speciman	-	-	-	-	-	-	-	-	-	1	-	-	ND	-
Plecoptera														
Acroneuria evoluta	-	2	-	-	-	-	-	-	-	-	-	-	ND	-
Isoperla clio	-	-	-	-	-	13	-	-	-	-	-	-	ND	-
I. similus	-	3	-	-	-	-	-	-	-	-	-	-	ND	-
Isoperla sp.	-	-	-	-	-	-	-	-	-	-	-	-	ND	3
Strophopteryx sp.	-	-	-	-	-	-	-	-	-	-	-	-	ND	4
Unidentified Speciman	-	1	-	-	-	-	-	-	-	-	-	-	ND	-
Odonata														
Calopteryx maculata	-	9	2	19	4	1	-	1	-	-	-	-	ND	-
Argia bipunctulata	2	5	9	2	1	-	1	-	-	-	-	-	ND	-
Enallagma vesperm	-	-	-	2	-	-	-	-	-	-	-	-	ND	-
E. sp.	-	-	2	-	-	-	1	-	-	-	-	-	ND	-
Boyeria vinosa	-	1	-	2	-	-	-	-	-	-	-	-	ND	-
Erythemis simplicicollis	-	-	-	1	-	-	-	-	-	-	-	-	ND	-

MACROINVERTEBRATE SYNOPTIC LIST FOR THE BAILEY RUN AND CEDAR BROOK SYSTEM FOR SUMMER (SUM) AND WINTER (WIN) (CONT'D.)

	14-1		14-2		14-3		14-4		14-5		14-8		14-10	
Taxa	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
Hemiptera														
Belostoma fluminea	-	-	-	-	1	-	1	-	-	-	-	-	ND	-
Gerris remigis	1	-	1	-	2	1	-	-	-	-	-	-	ND	1
Trepobates inermis	2	-	-	-	-	-	-	-	-	-	-	-	ND	-
Microvelia americana	6	-	-	-	3	7	-	-	-	-	-	-	ND	-
Sigara sp.	-	1	-	-	-	2	-	-	-	-	-	-	ND	6
Coleoptera														
Agabus ambiguus	-	-	-	-	-	-	-	1	-	-	-	-	ND	-
A. gagates	-	-	-	-	-	5	-	-	-	-	-	-	ND	3
Hydroporus blanchardi	-	-	-	-	-	3	-	-	-	-	-	-	ND	3
H. undulatus	-	-	-	-	-	6	-	6	-	-	-	-	ND	-
Laccophilus fasiatus rufus	-	-	-	-	-	-	1	-	-	-	-	-	ND	1
L. maculosus maculosus	-	1	-	-	-	-	-	1	-	-	-	-	ND	-
Peltoelytes duodecimpunctatus	-	11	-	1	2	12	1	-	-	-	-	-	ND	6
Berosus pantherinus	-	-	-	-	-	-	1	-	-	-	-	-	ND	-
Enochrus pygmaeus nebulosus	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Hydrobius tumidus	-	-	-	-	-	-	1	-	-	-	-	-	ND	-
Tropisternus collaris striolatus	-	-	-	-	1	-	-	-	-	-	-	-	ND	-
T. natator	-	-	-	-	-	-	1		-	-	-	-	ND	-
T. blatchleyi blatchleyi	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
T. sp. (larvae)	-	-	-	1	-	-	2	-	-	-	-	-	ND	-
Dubiraphia bivittata	-	4	5	-	3	-	-	-	-	-	-	-	ND	-
Stenelmis crenata	-	-	1	-	-	1	-	-	-	-	-		ND	5
Ectopria nervosa	-	-	-	-	-	1	-	-	-	-	-	-	ND	3
Psephenus herricki	5	1	-	-	-	-	-	-	-	-	-	-	ND	-
Megaloptera														
Chauliodes pectinicornis	-	-	-	-	-	-	1	1	-	-	-	-	ND	1
Nigronia fasciatus	-	-	-	-	-	-	-	1	-	-	-	-	ND	4
N. serricornis	-	1	2	8	-	-	-	-	-	-	-	-	ND	1
Sialis sp.	-	1	-	-	-	-	-	-	-	-	-	-	ND	-

MACROINVERTEBRATE SYNOPTIC LIST FOR THE BAILEY RUN AND CEDAR BROOK SYSTEM FOR SUMMER (SUM) AND WINTER (WIN) (CONT'D.)

	14-1		14-2		14-3		14-4		14-5		14-8		14-10	
Taxa	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**	**Sum**	**Win**
Trichoptera														
Ceratopsyche sparna	-	-	21	-	-	6	-	-	-	-	-	-	ND	-
Cheumatopsyche sp.	-	5	9	4	-	8	-	-	-	-	-	-	ND	1
Hydropsyche betteni gp.	-	-	-	21	-	-	-	-	-	-	-	-	ND	-
Ironquia sp.	-	-	-	-	-	9	-	-	-	-	-	-	ND	4
Chimarra sp.	-	-	-	1	-	3	-	-	-	-	-	-	ND	-
Neophylax oligius	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Rhyacophila torva	-	-	-	-	-	2	-	-	-	-	-	-	ND	-
Unidentified speciman	-	-	-	-	-	-	-	-	-	1	-	-	ND	-
Diptera														
Bezzia/Johannsenomyia/ Palpomyia gp.	1	-	-	-	1	-	1	-	-	-	-	-	ND	-
Oxycera sp.	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Dolichopodidae	-	1	-	-	-	-	-	-	-	-	-	-	ND	-
Chrysops sp.	-	1	-	-	-	1	-	-	-	-	-	-	ND	-
Helius sp.	-	-	-	-	-	-	-	1	-	-	-	-	ND	-
Tipula sp.1	-	2	-	2	-	4	-	1	-	2	-	-	ND	8
T. sp. 2	-	-	-	-	-	6	-	1	-	1	-	-	ND	3
T. spl. 3	-	-	-	-	-	-	-	1	-	-	-	-	ND	-
T. sp. 4	-	1	-	-	-	-	-	-	-	-	-	-	ND	-
Hexatoma	-	1	-	-	-	-	-	-	-	-	-	-	ND	-
Anopheles sp.	-	-	-	-	1	-	4	-	-	-	-	-	ND	-
Corethrella sp.	-	-	-	-	-	-	-	-	-	1	-	-	ND	-
Ablabesmyia mallochi	3	-	1	-	-	-	-	-	-	-	-	-	ND	-
Chironomus decorus gp	10	-	-	-	-	-	-	-	-	-	-	-	ND	-
C. sp.	-	-	-	1	-	-	-	-	-	-	-	-	ND	-
Cricotopus algarum	-	-	1	-	-	-	-	-	-	-	-	-	ND	-
C. bicinctus	-	-	-	-	-	-	56	-	-	-	-	-	ND	-
C. tremulus	-	-	-	-	-	1	-	-	-	-	-	-	ND	1

MACROINVERTEBRATE SYNOPTIC LIST FOR THE BAILEY RUN AND CEDAR BROOK SYSTEM FOR SUMMER (SUM) AND WINTER (WIN) (CONT'D.)

Taxa	14-1		14-2		14-3		14-4		14-5		14-8		14-10	
	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
Conchapelopia sp.	-	6	-	5	-	-	-	-	-	-	-	-	ND	-
Cryptochironomus fulvus gp.	-	-	-	2	-	-	-	-	-	-	-	-	ND	-
Dicrotendipes neomodestus	-	-	1	-	-	-	-	-	-	-	-	-	ND	-
D. nervosus type II	1	-	-	-	-	-	-	-	-	-	-	-	ND	-
Endochironomus nigricans	-	-	-	-	13	-	-	-	-	-	-	-	ND	-
Eukiefferiella brevicalcar gp.	-	-	-	-	-	3	-	-	-	-	-	-	ND	2
E. rectangularis gp.	-	1	-	-	-	-	-	-	-	-	-	-	ND	-
Glyptotendipes meridionalis	-	-	-	1	-	-	-	-	-	-	-	-	ND	-
Microtendipes caelum	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Natarsia baltimoreus	-	-	-	-	-	-	-	1	-	-	-	-	ND	1
Hydrobaenus pillipes	-	-	-	-	-	-	-	1	-	-	-	-	ND	-
Parametriocnemus lundbecki	-	-	-	1	-	-	-	-	-	-	-	-	ND	1
Paratendipes albimanus	6	-	-	-	-	-	-	-	-	-	-	-	ND	1
Pentaneura sp.	-	-	-	-	-	-	-	-	-	-	-	-	ND	1
Polypedilum convictum	-	-	-	-	-	1	-	-	-	-	-	-	ND	-
Procladius sublettei	1	-	-	1	-	-	-	-	-	-	-	-	ND	-
Orthocladius obumbratus	-	-	1	-	-	-	-	-	-	-	-	-	ND	-
Rheotanytarsus exiguus gp	1	-	-	-	-	-	-	-	-	-	-	-	ND	-
Stenochironomus hilaris	-	-	-	1	-	-	-	-	-	-	-	-	ND	-
Stictochironomus divinctus	-	6	-	-	-	1	-	1	-	-	-	-	ND	1
Thienemannimyia sp.	1	-	-	-	-	-	-	-	-	-	-	-	ND	-
Zavrelia sp.	-	-	-	-	-	-	-	-	-	1	-	-	ND	-
Totals	19	27	16	22	20	37	14	18	0	9	0	0	ND	34

APPENDIX E

BAILEY RUN/CEDAR BROOK FISH SYNOPTIC LIST AND INDEX OF BIOTIC INTEGRITY (IBI)

BAILEY RUN/CEDAR BROOK
FISH SYNOPTIC LIST

Taxa	STATIONS Contl. 14-1	14-2	14-3	14-4	14-5	14-8
Catostomus commersoni	2	6	-	-	-	
Campostoma anomalum	49	34	106	-	-	-
Notropis atherinoides	53	2	-	-	-	-
N. chrysocephalus	19	-	1	-	-	-
Pimephales notatus	7	-	-	-	-	-
P. promelas	-	4	-	-	-	-
Rhinichthys atratulus	-	1	10	-	-	-
Semotilus atromaculatus	11	63	28	-	-	-
Gambusia affinis	1	-	-	-	-	-
Lepomis megalotis	2	2	-	-	-	-
L. macrochirus	-	-	1	-	-	-
L. cyanellus	-	-	1	-	-	-
Micropterus salmoides	9	-	-	-	-	-
Etheostoma caeruleum	10	-	-	-	-	-
E. flabellare	5	3	63	-	-	-
Total Number of Taxa	11	8	7			
Total Number of Individuals	168	115	214	NO FISH	NO FISH	NO FISH

Index of Biotic Integrity for Selected Stations In Bailey Run/Cedar Brook

		Number of Individuals			Proportion of Individuals (%)										
Station	Stream Size	Total Species	Total Individuals	Darter Species	Sunfish Species	Sucker Species	Intolerant Species	Omnivores	Insectivorous Cyprinids	Green Sunfish	Top Carnivores	Hybrids	Diseased etc.	Index	Class
Bailey Run 04014001	M	0/11	+/168	0/2	-/1	0/1	-/2	+/15	0/38	+/0	+/5	+/0	+	44	F
Cedar Brook 04014002	H	0/8	+/115	-/1	-/1	0/1	-/2	+/4	+/56	+/0	-/0	+/0	+	40	F
Bailey Run 04014003	H	0/7	+/214	-/1	0/2	-/0	-/1	+/5	-/13	+/2	-/0	+/0	+	36	P
Cedar Brook 04014004	H			NO FISH											
Cedar Brook 04014005	H			NO FISH											
Cedar Brook 04014008	H			NO FISH											

APPENDIX F

WATER COLUMN, SEDIMENT AND FISH TISSUE DATA FROM THE KENTUCKY RIVER ABOVE (STATION 14-6) AND BELOW (14-7) BAILEY RUN

WATER COLUMN DATA FROM THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6)

PARAMETER	CONCENTRATION
Acidity	3.1 mg/l
Alkalinity	95.0 mg/l
Biochemical Oxygen Demand - 5 Day	2.7 mg/l
Chemical Oxygen Demand	10.6 mg/l
Chloride	33.9 mg/l
Conductivity	417 micromhos
Cyanide, Amenable	] 0.010 mg/l
Fluoride	0.175 mg/l
Hardness, Total	68.1 mg/l
Phenol (4AAP)	] 0.005 mg/l
pH	7.9 S.U.
Total Dissolved Solids	212 mg/l
Sulfate	49.0 mg/l
Total Organic Carbon	3.8 mg/l
Ammonia-Nitrogen	0.135 mg/l
Total Kjeldhal Nitrogen	0.639 mg/l
Nitrate	0.405 mg/l
Phosphorus, Ortho	0.036 mg/l
Phosphorus, Total	0.080 mg/l
Calcium	42.1 mg/l
Magnesium	10.7 mg/l
Potassium	2.60 mg/l
Sodium	17.5 mg/l
Aluminum	0.078 mg/l
Arsenic	0.001 mg/l
Barium	0.056 mg/l
Beryllium	] 0.001 mg/l
Cadmium	] 0.001 mg/l
Chromium	0.004 mg/l
Copper	0.010 mg/l
Iron	] 0.01 mg/l
Lead	0.001 mg/l
Manganese	0.05 mg/l
Mercury	0.0001 mg/l
Nickel	0.002 mg/l
Selenium	] 0.001 mg/l
Silver	] 0.001 mg/l
Zinc	0.074 mg/l
Phenol	] 0.021 mg/l
Aniline	] 0.021 mg/l
Bis-(2-Chloroethyl) ether	] 0.021 mg/l
2-Chlorophenol	] 0.021 mg/l
1,3-Dichlorobenzene	] 0.021 mg/l
1,4-Dichlorobenzene	] 0.021 mg/l
Benzyl Alcohol	] 0.021 mg/l

WATER COLUMN DATA FROM THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (CONT'D.)

PARAMETER	CONCENTRATION
1,2-Dichlorobenzene	] 0.021 mg/l
2-Methylphenol	] 0.021 mg/l
Bis-(2-Chloroisopropyl) ether	] 0.021 mg/l
4-Methylphenol	] 0.021 mg/l
N-Nitroso-di-n-propylamine	] 0.021 mg/l
Hexachloroethane	] 0.021 mg/l
Nitrobenzene	] 0.021 mg/l
Isophorone	] 0.021 mg/l
2-Nitrophenol	] 0.021 mg/l
2,4-Dimethyphenol	] 0.021 mg/l
Bis-(2-Chloroethoxy)methane	] 0.021 mg/l
Benzoic Acid	] 0.021 mg/l
2,4-Dichlorophenol	] 0.021 mg/l
1,2,4-Trichlorobenzene	] 0.021 mg/l
Napthalene	] 0.021 mg/l
4-Chloroaniline	] 0.021 mg/l
1,1,2,3,4,4-Hexachloro-1,3-butadiene	] 0.021 mg/l
4-Chloro-3-methylphenol	] 0.021 mg/l
2-Methylnaphthalene	] 0.021 mg/l
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	] 0.021 mg/l
2,4,6-Trichlorophenol	] 0.021 mg/l
2,4,5-Trichlorophenol	] 0.021 mg/l
2-Chloronaphthalene	] 0.021 mg/l
2-Nitroaniline	] 0.021 mg/l
Dimethyl Phthalate	] 0.021 mg/l
Acenaphthylene	] 0.021 mg/l
2,6-Dinitrotoluene	] 0.021 mg/l
3-Nitroaniline	] 0.021 mg/l
Acenaphthene	] 0.021 mg/l
2,4-Dinitrophenol	] 0.084 mg/l
4-Nitrophenol	] 0.021 mg/l
Dibenzofuran	] 0.021 mg/l
2,4-Dinitrotoluene	] 0.021 mg/l
Diethyl Phthalate	] 0.021 mg/l
Fluorene	] 0.021 mg/l
4-Chlorophenyl phenyl ether	] 0.021 mg/l
4-Nitroaniline	] 0.021 mg/l
2-Methyl-4,6-Dinitrophenol	] 0.021 mg/l
N-Nitrosodiphenylamine	] 0.021 mg/l
4-Bromophenylphenylether	] 0.021 mg/l
Hexachlorobenzene	] 0.021 mg/l
Pentachlorophenol	] 0.021 mg/l
Phenanthrene	] 0.021 mg/l
Anthracene	] 0.021 mg/l
Dibutyl Phthalate	] 0.021 mg/l

WATER COLUMN DATA FROM THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (CONT'D.)

PARAMETER	CONCENTRATION
Fluoranthene	] 0.021 mg/l
Benzidine	] 0.021 mg/l
Pyrene	] 0.021 mg/l
Butyl Benzyl Phthalate	] 0.021 mg/l
3,3'-Dichlorobenzidine	] 0.021 mg/l
Benzo(A)Anthracene	] 0.021 mg/l
Chrysene	] 0.021 mg/l
Bis(2-Ethylhexyl)Phthalate	] 0.021 mg/l
Dioctylphthalate	] 0.021 mg/l
Benzo(B)Fluoranthene	] 0.021 mg/l
Benzo(K)Fluoranthene	] 0.021 mg/l
Benzo(A)Pyrene	] 0.021 mg/l
Indeno(1,2,3-C,D)Pyrene	] 0.021 mg/l
Dibenzo(A,H)Anthracene	] 0.021 mg/l
Benzo(G,H,I)Perylene	] 0.021 mg/l
Sulfide, Total	] 0.1 mg/l
Aroclor 1016	[0.001 mg/l
Aroclor 1221	[0.001 mg/l
Aroclor 1232	[0.001 mg/l
Aroclor 1242	[0.001 mg/l
Aroclor 1248	[0.001 mg/l
Aroclor 1254	[0.001 mg/l
Aroclor 1260	[0.001 mg/l
Aroclor 1262	[0.001 mg/l
Aroclor 1268	[0.001 mg/l

Sample holding time for Turbidity and Total Suspended Solids were exceeded by laboratory.

WATER COLUMN DATA FROM THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7)

PARAMETER	CONCENTRATION
Acidity	3.0 mg/l
Alkalinity	94.8 mg/l
Biochemical Oxygen Demand - 5 Day	1.1 mg/l
Chemical Oxygen Demand	11 mg/l
Chloride	33.5 mg/l
Conductivity	415 micromhos
Cyanide, Amenable	] 0.010 mg/l
Fluoride	0.21 mg/l
Hardness, Total	67.1 mg/l
Phenol (4AAP)	0.008 mg/l
pH	7.9 S.U.
Total Dissolved Solids	202 mg/l
Sulfate	49.9 mg/l
Total Organic Carbon	3.7 mg/l
Ammonia-Nitrogen	0.126 mg/l
Total Kjeldhal Nitrogen	0.717 mg/l
Nitrate	0.405 mg/l
Phosphorus, Ortho	0.038 mg/l
Phosphorus, Total	0.073 mg/l
Calcium	43.6 mg/l
Magnesium	10.3 mg/l
Potassium	2.58 mg/l
Sodium	17.3 mg/l
Aluminum	0.084 mg/l
Arsenic	0.002 mg/l
Barium	0.021 mg/l
Beryllium	] 0.001 mg/l
Cadmium	] 0.001 mg/l
Chromium	0.002 mg/l
Copper	0.010 mg/l
Iron	0.06 mg/l
Lead	0.002 mg/l
Manganese	0.05 mg/l
Mercury	] 0.0001 mg/l
Nickel	0.002 mg/l
Selenium	] 0.001 mg/l
Silver	] 0.001 mg/l
Zinc	0.051 mg/l
*Phenol	] 0.020 mg/l
*Aniline	] 0.020 mg/l
*Bis-(2-Chloroethyl) ether	] 0.020 mg/l
*2-Chlorophenol	] 0.020 mg/l
*1,3-Dichlorobenzene	] 0.020 mg/l
*1,4-Dichlorobenzene	] 0.020 mg/l
*Benzyl Alcohol	] 0.020 mg/l

WATER COLUMN DATA FROM THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (CONT'D)

PARAMETER	CONCENTRATION
*1,2-Dichlorobenzene	] 0.020 mg/l
*2-Methylphenol	] 0.020 mg/l
*Bis-(2-Chloroisopropyl) ether	] 0.020 mg/l
*4-Methylphenol	] 0.020 mg/l
*N-Nitroso-di-n-propylamine	] 0.020 mg/l
*Hexachloroethane	] 0.020 mg/l
*Nitrobenzene	] 0.020 mg/l
*Isophorone	] 0.020 mg/l
*2-Nitrophenol	] 0.020 mg/l
*2,4-Dimethyphenol	] 0.020 mg/l
*Bis-(2-Chloroethoxy)methane	] 0.020 mg/l
*Benzoic Acid	] 0.020 mg/l
*2,4-Dichlorophenol	] 0.020 mg/l
*1,2,4-Trichlorobenzene	] 0.020 mg/l
*Napthalene	] 0.020 mg/l
*4-Chloroaniline	] 0.020 mg/l
*1,1,2,3,4,4-Hexachloro-1,3-butadiene	] 0.020 mg/l
*4-Chloro-3-methylphenol	] 0.020 mg/l
*2-Methylnaphthalene	] 0.020 mg/l
*1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	] 0.020 mg/l
*2,4,6-Trichlorophenol	] 0.020 mg/l
*2,4,5-Trichlorophenol	] 0.020 mg/l
*2-Chloronaphthalene	] 0.020 mg/l
*2-Nitroaniline	] 0.020 mg/l
*Dimethyl Phthalate	] 0.020 mg/l
*Acenaphthylene	] 0.020 mg/l
*2,6-Dinitrotoluene	] 0.020 mg/l
*3-Nitroaniline	] 0.020 mg/l
*Acenaphthene	] 0.020 mg/l
*2,4-Dinitrophenol	] 0.080 mg/l
*4-Nitrophenol	] 0.020 mg/l
*Dibenzofuran	] 0.020 mg/l
*2,4-Dinitrotoluene	] 0.020 mg/l
*Diethyl Phthalate	] 0.020 mg/l
*Fluorene	] 0.020 mg/l
*4-Chlorophenyl phenyl ether	] 0.020 mg/l
*4-Nitroaniline	] 0.020 mg/l
*2-Methyl-4,6-Dinitrophenol	] 0.020 mg/l
*N-Nitrosodiphenylamine	] 0.020 mg/l
*4-Bromophenylphenylether	] 0.020 mg/l
*Hexachlorobenzene	] 0.020 mg/l
*Pentachlorophenol	] 0.020 mg/l
*Phenanthrene	] 0.020 mg/l
*Anthracene	] 0.020 mg/l
*Dibutyl Phthalate	] 0.020 mg/l
*Fluoranthene	] 0.020 mg/l
*Benzidine	] 0.020 mg/l
*Pyrene	] 0.020 mg/l

WATER COLUMN DATA FROM THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (CONT'D.)

PARAMETER	CONCENTRATION
*Butyl Benzyl Phthalate	] 0.020 mg/l
*3,3'-Dichlorobenzidine	] 0.020 mg/l
*Benzo(A)Anthracene	] 0.020 mg/l
*Chrysene	] 0.020 mg/l
*Bis(2-Ethylhexyl)Phthalate	] 0.020 mg/l
*Dioctylphthalate	] 0.020 mg/l
*Benzo(B)Fluoranthene	] 0.020 mg/l
*Benzo(K)Fluoranthene	] 0.020 mg/l
*Benzo(A)Pyrene	] 0.020 mg/l
*Indeno(1,2,3-C,D)Pyrene	] 0.020 mg/l
*Dibenzo(A,H)Anthracene	] 0.020 mg/l
*Benzo(G,H,I)Perylene	] 0.020 mg/l
Sulfide, Total	] 0.1 mg/l
Aroclor 1016	[0.001 mg/l
Aroclor 1221	[0.001 mg/l
Aroclor 1232	[0.001 mg/l
Aroclor 1242	[0.001 mg/l
Aroclor 1248	[0.001 mg/l
Aroclor 1254	[0.001 mg/l
Aroclor 1260	[0.001 mg/l
Aroclor 1262	[0.001 mg/l
Aroclor 1268	[0.001 mg/l

Sample holding time for Turbidity and Total Suspended Solids were exceeded by laboratory.

*Analytical results are suspect as the quality control criteria were exceeded on this sample.

SEDIMENT DATA FROM THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6)

PARAMETER	CONCENTRATION
Chemical Oxygen Demand	30,800 mg/kg
Cyanide, Total	] 0.713 mg/kg
Oil & Grease	275 mg/kg
Total Volatile Solids	33,000 mg/kg
Total Organic Carbon	3,970 mg/kg
Ammonia-Nitrogen	18.9 mg/kg
Total Kjeldahl Nitrogen	750 mg/kg
Aluminum	5,070 mg/kg
Arsenic	1.64 mg/kg
Cadmium	0.564 mg/kg
Chromium	9.36 mg/kg
Copper	14.8 mg/kg
Iron	15,700 mg/kg
Lead	13.2 mg/kg
Manganese	745 mg/kg
Mercury	0.041 mg/kg
Nickel	12.5 mg/kg
Zinc	48.9 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	] 0.01 mg/kg
c-Chlordane	] 0.01 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	] 0.01 mg/kg
Dieldrin	] 0.01 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	] 0.01 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	] 0.01 mg/kg
Total DDT	] 0.01 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg
Technical Chlordane	] 0.1 mg/kg

SEDIMENT DATA FROM THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (CONT'D.)

PARAMETER	CONCENTRATION
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg
Aroclor 1254	] 0.1 mg/kg
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg

SEDIMENT DATA FROM THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7)

PARAMETER	CONCENTRATION
Chemical Oxygen Demand	27,200 mg/kg
Cyanide, Total	] 0.815 mg/kg
Oil & Grease	480 mg/kg
Total Volatile Solids	33,000 mg/kg
Total Organic Carbon	5,340 mg/kg
Ammonia-Nitrogen	12.6 mg/kg
Total Kjeldahl Nitrogen	979 mg/kg
Aluminum	6,730 mg/kg
Arsenic	1.22 mg/kg
Cadmium	0.565 mg/kg
Chromium	39.5 mg/kg
Copper	11.7 mg/kg
Iron	21,700 mg/kg
Lead	13.5 mg/kg
Manganese	836 mg/kg
Mercury	0.035 mg/kg
Nickel	15.0 mg/kg
Zinc	52.1 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	] 0.01 mg/kg
c-Chlordane	] 0.01 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	] 0.01 mg/kg
Dieldrin	] 0.01 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	] 0.01 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	] 0.01 mg/kg
Total DDT	] 0.01 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg

SEDIMENT DATA FROM THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7)

PARAMETER	CONCENTRATION
Technical Chlordane	] 0.1 mg/kg
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg
Aroclor 1254	] 0.1 mg/kg
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg

FISH TISSUE DATA FOR THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (SIX BLUEGILL WHOLEBODY)

PARAMETERS	CONCENTRATION
Aluminum	91.8 mg/kg
Arsenic	] 0.005 mg/kg
Beryllium	0.003 mg/kg
Cadmium	] 0.001 mg/kg
Chromium	0.460 mg/kg
Copper	0.425 mg/kg
Lead	0.092 mg/kg
Manganese	25.0 mg/kg
Mercury	0.024 mg/kg
Nickel	0.237 mg/kg
Zinc	22.0 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	] 0.01 mg/kg
c-Chlordane	0.018 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	0.013 mg/kg
Dieldrin	0.016 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	0.012 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	] 0.01 mg/kg
Total DDT	0.025 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg

FISH TISSUE DATA FOR THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (SIX BLUEGILL WHOLEBODY) (CONT'D.)

PARAMETERS	CONCENTRATION
Aroclor 1254	] 0.1 mg/kg
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg
% Lipids	5.2%

FISH TISSUE DATA FOR THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (SIX BLUEGILL WHOLEBODY)

PARAMETERS	CONCENTRATION
Aluminum	65.2 mg/kg
Arsenic	] 0.005 mg/kg
Beryllium	0.003 mg/kg
Cadmium	] 0.001 mg/kg
Chromium	0.443 mg/kg
Copper	0.387 mg/kg
Lead	0.074 mg/kg
Manganese	17.8 mg/kg
Mercury	0.042 mg/kg
Nickel	0.374 mg/kg
Zinc	22.4 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	] 0.01 mg/kg
c-Chlordane	0.019 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	0.015 mg/kg
Dieldrin	0.012 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	] 0.01 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	] 0.01 mg/kg
Total DDT	0.015 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg
Aroclor 1254	] 0.1 mg/kg

FISH TISSUE DATA FOR THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (SIX BLUEGILL WHOLEBODY) (CONT'D.)

PARAMETERS	CONCENTRATION
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg
% Lipids	6.4%

FISH TISSUE DATA FOR THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (CARPSUCKER WHOLEBODY)

PARAMETERS	CONCENTRATION
Aluminum	20.2 mg/kg
Arsenic	] 0.005 mg/kg
Beryllium	0.001 mg/kg
Cadmium	] 0.001 mg/kg
Chromium	0.364 mg/kg
Copper	0.572 mg/kg
Lead	0.848 mg/kg
Manganese	50.0 mg/kg
Mercury	0.033 mg/kg
Nickel	0.159 mg/kg
Zinc	17.5 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	0.012 mg/kg
c-Chlordane	0.064 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	0.032 mg/kg
Dieldrin	0.022 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	0.034 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	0.037 mg/kg
Total DDT	0.10 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg

FISH TISSUE DATA FOR THE KENTUCKY RIVER ABOVE BAILEY RUN (STATION 14-7) (CARPSUCKER WHOLEBODY) (CONT'D.)

PARAMETERS	CONCENTRATION
Aroclor 1254	] 0.1 mg/kg
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg
% Lipids	8.0%

FISH TISSUE DATA FOR THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (CARPSUCKER WHOLEBODY)

PARAMETERS	CONCENTRATION
Aluminum	43.2 mg/kg
Arsenic	] 0.005 mg/kg
Beryllium	0.005 mg/kg
Cadmium	] 0.001 mg/kg
Chromium	0.466 mg/kg
Copper	0.639 mg/kg
Lead	0.097 mg/kg
Manganese	13.9 mg/kg
Mercury	0.034 mg/kg
Nickel	0.260 mg/kg
Zinc	16.7 mg/kg
Hexachlorobenzene	] 0.01 mg/kg
Hexachlorocyclohexane, alpha isomer	] 0.01 mg/kg
Hexachlorocyclohexane, beta isomer	] 0.01 mg/kg
Hexachlorocyclohexane, gamma isomer	] 0.01 mg/kg
Hexachlorocyclohexane, delta isomer	] 0.01 mg/kg
Heptachlor	] 0.01 mg/kg
Aldrin	] 0.01 mg/kg
Heptachlor Epoxide	] 0.01 mg/kg
oxychlordane	] 0.01 mg/kg
t-Chlordane	] 0.01 mg/kg
c-Chlordane	0.028 mg/kg
t-Nonachlor	] 0.01 mg/kg
O, P' - DDE	] 0.01 mg/kg
P, P' - DDE	0.012 mg/kg
Dieldrin	] 0.01 mg/kg
Endrin	] 0.01 mg/kg
O, P' - DDD	] 0.01 mg/kg
P, P' - DDD	0.013 mg/kg
O, P' - DDT	] 0.01 mg/kg
P, P' - DDT	] 0.01 mg/kg
Total DDT	0.025 mg/kg
Methoxychlor	] 0.01 mg/kg
Mirex	] 0.01 mg/kg
Endosulfan I	] 0.01 mg/kg
Endosulfan II	] 0.01 mg/kg
Endosulfan Sulfate	] 0.01 mg/kg
Endrin Aldehyde	] 0.01 mg/kg
Endrin Ketone	] 0.01 mg/kg
Toxaphene	] 0.1 mg/kg
Pentachlorophenol	] 0.01 mg/kg
2,3,4,5-Tetrachlorophenol	] 0.01 mg/kg
2,3,4,6-Tetrachlorophenol	] 0.01 mg/kg
Aroclor 1016	] 0.1 mg/kg
Aroclor 1221	] 0.1 mg/kg
Aroclor 1232	] 0.1 mg/kg
Aroclor 1242	] 0.1 mg/kg
Aroclor 1248	] 0.1 mg/kg

FISH TISSUE DATA FOR THE KENTUCKY RIVER BELOW BAILEY RUN (STATION 14-6) (CARPSUCKER WHOLEBODY) (CONT'D.)

PARAMETERS	CONCENTRATION
Aroclor 1254	] 0.1 mg/kg
Aroclor 1260	] 0.1 mg/kg
Aroclor 1262	] 0.1 mg/kg
Aroclor 1268	] 0.1 mg/kg
% Lipids	8.5%

APPENDIX G

LITERATURE CITED

LITERATURE CITED

(APHA) American Public Health Association. 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition. Am. Publ. Heal. Assoc., Am. Water Works Assoc., Water Poll. Contr. Fed., Washington, D.C.

(ASTM) American Society for Testing Materials. 1984. Standard Practices for Conducting Acute Toxicity Test with Fishes, Macroinvertebrates and Amphibians. ASTM Design. E729-80.

Birge, W.J., J.A. Black, A.G. Westerman, T.M. Short, S.B. Taylor and D.M. Bruser. 1985. Recommendations on Numerical Values for Regulating Iron and Chloride Concentrations for the Purpose of Protecting Warmwater Species of Aquatic Life in the Commonwealth of Kentucky. Memo. of Agreement No. 5429. Ky. Nat. Res. and Environ. Prot. Cab. 1985.

Bordner, R., J. Winter and P. Scarpino, editors. 1978. Micro-biological Methods for Monitoring the Environment, Water and Wastes. Environ. Monit. Supp. Lab., U.S. EPA, Cincinnati OH., EPA-600/8-78-017.

(CWQC) Committee on Water Quality Criteria. 1972. Water Quality Criteria. Environ. Studies Board, Nat. Acad. Sci., Nat. Acad. Eng., Washington, D.C

Courtemanch, D.L. and S.P. Davis. 1987. A coefficient of community loss to assess detrimental change in aquatic communities. Water Res., 21:217-222.

(DOW) Division of Water. 1986. Toxicity Tests on Universal Fasteners, Lawrenceburg, Anderson County, Kentucky NPDES KY0001724. KY Dept. Environ. Prot., Div. of Water, Biol. Anal. Sec., Frankffort, KY.

Horning, W.B. and C.I. Weber. 1985. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Environ. Mon. Sup. Lab., Off. Res. Devel. U.S. EPA, Cincinnati, OH.

Hustedt, F., 1930. The Pennate Diatoms. Translated by Norman Jensen, 1985. Koeltz Scientific Books. Strauss and Cramer. Germany.

LITERATURE CITED

Karr, J.R. 1981. Assessment of Biotic Integrity Using Fish Communities. Fisheries, 6:21-27.

Leland, H.V. and J.L. Carter. 1984. Effects of copper on species composition of periphyton in a Sierra Nevada, California, stream. Freshw. Biol., 14: 281-296.

Leland, H.V. and J.L. Carter. 1985. Effects of copper on production of periphyton, nitrogen fixation and processing of leaf litter in a Sierra Nevada, California, stream. Freshw. Biol., 15: 155-173.

Long, C.A. 1963. Mathematical Formulas Expressing Faunal Resemblance. Trans. Kan. Acad. Sci., 66:138-140.

McDowell, R.C., G.J. Grabowski, Jr. and S.L. Moore. 1981. Geologic Map of Kentucky. U.S. Geol. Surv. and the Eleventh KY. Geol. Surv., 4 Sheets, Univ. of KY, Lexington, KY.

Miller, Wihry and Lee. 1975. The River Basin Water Quality Management Plan for Kentucky-Kentucky River. KY. Dept. Nat. Res. and Environ. Prot.

Mohr, C. 1986. Site inspection report Cedar Brook Road Transformer Site Anderson County Kentucky. Uncont. Site Sec., Div. Waste Manag., Frankfort, KY.

Patrick, R., 1977. Ecology of Freshwater Diatoms and Diatom Communities. In: The Biology of Diatoms. Dietrich Werner, ed. Botanical Monographs Vol. 13. Blackwell Scientific Publications, Univ. CA Press, Berkely, CA.

Patrick, R. and C. Reimer. 1975. The Diatoms of the United States. Vol. 2, Part 1. Monog. Acad. Nat. Sci. Phil., No. 13.

Peltier, W. and C.I. Weber. 1985 Methods for Measuring the Acute Toxicity of Effluents to Aquatic Organisms. 3rd ed. Environ. Monit. Sup. Lab., U.S. EPA., Cincinati, OH.

Quarterman, E. and R.L. Powell. 1978. Potential ecological/geological natural landmarks of the Interior Low Plateaus. U.S. Dept. Int., Nat. Park Serv., Washington, D.C.

LITERATURE CITED

Roth, C.A. and A.G. Westerman. 1987. Methods for culturing and conducting toxicity test with Pimephales promelas, Daphnia pulex and Ceriodaphnia sp. 2nd Ed., Biol. Anal. Sect., Div. of Water, Ky Dept. Environ. Prot., Frankfort, KY.

STORET. 1979-1983. United States Environmental Protection Agency Water Quality File. U.S. EPA, Office of Reg. and Stds., Washington, D.C.

(U.S. EPA) U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. Environ. Prot. Agency, Washington, D.C., EPA-440/9-76-023.

_____. 1977. Guidelines for the Pollution Classification of Great Lakes Harbor Sediments. U.S. EPA., Region V, Chicago, IL.

_____. 1979. Methods for chemical analysis of water and wastes. Environ. Monit. Supp. Lab., Off. Res. Devel. U.S. EPA., Cincinnati, OH, EPA-600/4-79-020.

_____. 1980. Ambient water quality criteria for copper. U.S. EPA., Off. Water Reg. Stds., Washington, D.C., EPA 440/5-80-036.

_____. 1984. Lethality tests on Universal Fasteners, Lawrenceburg, Kentucky. U.S. EPA Ecolog. Sup. Br., Environ. Serv., Athens, GA, Unpublished.

Van der Werff, A. 1955. A new method of concentrating and cleaning diatoms and other organisms. Int. Ver. Theor. Angew. Limnol. Verh., 12:276-277.

Weber, C.I., editor. 1977. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. U.S. EPA, Environ. Res. Lab., Off. Res. and Devel., Cincinnati, OH, EPA-670/4-73-001.

Whitton, B.A. and P.J. Say. 1975. Heavy Metals. In: River Ecology. B.A. Whitton, ed. Univ. CA Press. Berkeley.

Whittaker, R.H. and C.W. Fairbanks. 1958. A study of plankton copepod communities in the Columbia Basins, Southeastern Washington. Ecology, 39:54.