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Big Bayou Creek and Little Bayou Creek Watershed Monitoring Program

L. A. Kszos
M. J. Peterson
M. G. Ryon
J. G. Smith

Environmental Sciences Division
Publication No. 4797

Date of Issue: March 1999

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
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ENVIRONMENTAL SCIENCES DIVISION

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Prepared for
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Environmental Compliance
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ACRONYMS

BMAP	Biological Monitoring and Abatement Program
BMP	Biological Monitoring Program
BBK	Big Bayou Creek kilometer
DOE	U.S. Department of Energy
ESD	Environmental Sciences Division
EPT	Ephemeroptera, Plecoptera, Trichoptera
IBI	Index of biological integrity
KDOW	Kentucky Division of Water
KPDES	Kentucky Pollutant Discharge Elimination System
LMES	Lockheed Martin Energy Systems, Inc.
LMUS	Lockheed Martin Utility Systems, Inc.
LUK	Little Bayou Creek kilometer
MAK	Massac Creek kilometer
ORNL	Oak Ridge National Laboratory
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RGA	regional gravel aquifer
SAS	statistical analysis system
SWMU	solid waste management unit
USEC	United States Enrichment Corporation
USGS	U.S. Geological Service
WKWMA	West Kentucky Wildlife Management Area

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EXECUTIVE SUMMARY

Biological monitoring of Little Bayou and Big Bayou creeks, which border the Paducah Site, has been conducted since 1987. Biological monitoring was conducted by the University of Kentucky from 1987 to 1991 and by staff of the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) from 1991 through March 1999. In March 1998, renewed Kentucky Pollutant Discharge Elimination System (KPDES) permits were issued to the U.S. Department of Energy (DOE) and United States Enrichment Corporation. The renewed DOE permit requires that a watershed monitoring program be developed for the Paducah Site within 90 days of the effective date of the renewed permit. This plan outlines the sampling and analysis that will be conducted for the watershed monitoring program.

The objectives of the watershed monitoring are to (1) determine whether discharges from the Paducah Site and the Solid Waste Management Units (SWMUs) associated with the Paducah Site are adversely affecting instream fauna, (2) assess the ecological health of Little Bayou and Big Bayou creeks, (3) assess the degree to which abatement actions ecologically benefit Big Bayou Creek and Little Bayou Creek, (4) provide guidance for remediation, (5) provide an evaluation of changes in potential human health concerns, and (6) provide data which could be used to assess the impact of inadvertent spills or fish kills. According to the KPDES permit, the goal of the watershed monitoring program is to ensure that the DOE cleanup will result in these watersheds [Big Bayou and Little Bayou creeks] achieving compliance with the applicable water quality criteria.

Study Area

The Paducah Site site is owned by DOE. Effective July 1, 1993, DOE leased the plant production operation facilities to the United States Enrichment Corporation (USEC). Lockheed Martin Corporation created a new subsidiary, Lockheed Martin Utility Services (Utility Services), to manage the leased facilities for USEC under the prior management contract. Under the terms of the lease, USEC has assumed responsibility for compliance activities directly associated with uranium enrichment operations. Bechtel Jacobs Company LLC is the management contractor for DOE responsibilities at the site. These responsibilities include the site Environmental Restoration Program; the Depleted Uranium Hexafluoride (DUF_6) Cylinder Program; the bulk of the Waste Management Program, including waste inventories predating July 1, 1993; wastes generated by current DOE activities; wastes containing "legacy" constituents, such as asbestos, polychlorinated biphenyls (PCBs), and transuranics; and KPDES compliance at outfalls not leased to USEC. DOE has also retained manager and cooperator status of Resource Conservation and Recovery Act (RCRA) storage facilities not leased to USEC. DOE and USEC have negotiated the lease of specific site facilities, prepared memorandums of agreement to define their respective roles and responsibilities under the lease, and developed organizations and budgets to support their respective functions.

The Paducah Site is located in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is ~24 km upstream of the site, and the confluence of the Ohio River with the Mississippi River is ~90 km downstream of the site. Surface drainage from the Paducah Site is in two streams, Big Bayou Creek and Little Bayou Creek.

These streams meet ~4.8 km north of the site and discharge to the Ohio River at kilometer 1524. Big Bayou Creek is a perennial stream with a drainage basin extending from ~4 km south of Paducah Site to the Ohio River; part of its 14.5-km course flows along the western boundary of the plant. Little Bayou Creek originates in the Western Kentucky Wildlife Management Area and flows for 10.5 km north toward the Ohio River; its course includes part of the eastern boundary of the plant where up to 100% of the flow can be attributed to effluent discharges during the drier seasons of the year. The watershed areas for Big Bayou Creek and Little Bayou Creek are about 4819 and 2428 ha respectively.

Historical Watershed Monitoring

The macroinvertebrate and fish communities in Big Bayou and Little Bayou creeks were monitored at least annually by ORNL from 1991 to 1997 at five stream locations. Three sites were located on Big Bayou Creek (Big Bayou Creek kilometer [BBK] 12.5, BBK 10.0, BBK 9.1) and one site each was located on Little Bayou Creek (LUK 7.2) and Massac Creek (MAK 13.8), a reference site located south of the Paducah Site. Additional qualitative or quantitative samples have been taken irregularly, but this core group of sites represents 6–7 years of historical data. The bioaccumulation of PCBs in longear sunfish (*Lepomis megalotis*) has been evaluated by ORNL for 7 years at 3 sites on Little Bayou Creek (LUK 9.0, LUK 7.2, and LUK 4.3). The bioaccumulation of PCBs in spotted bass has been evaluated for 6 years at one site on Big Bayou Creek (BBK 9.1). Similar to the community sampling, additional sites and parameters have been monitored since 1991, but this core group of sites and analyses represents the key historical data. Although the sampling locations were originally chosen to bracket point-source discharges, they are also located in close, downstream proximity of the SWMUs that discharge to Big Bayou and Little Bayou creeks

Historically, the benthic macroinvertebrate community at the study sites (BBK 10.0, BBK 9.1, and LUK 7.2) has not displayed signs of major stress when compared to the reference sites (BBK 12.5 and MAK 13.8). Taxonomic richness and richness of the pollution sensitive mayflies, stoneflies, and caddisflies have been generally comparable at study and reference sites, and total densities and densities of mayflies at the study sites have generally been similar to, and often greater than at reference sites. Although these results were not indicative of major stress, there have been some characteristics suggestive of low-level stress. Very high total community and mayfly densities were occasionally observed at BBK 9.1 and BBK 10.0, and the oligochaetes frequently made up a high proportion of the community at BBK 9.1, BBK 10.0, and LUK 7.2. Such characteristics are often seen in streams that receive excess inputs of nutrients, and thus, suggest the presence of low-level stress.

The fish community in Big Bayou Creek at BBK 9.1 has shown only minimal impacts from plant discharges. Species richness at BBK 9.1 has been within the range found at reference sites, but the site has generally lacked darter species and has had fewer sensitive species than at the Massac Creek reference site. Fish abundance (density) at the site has varied widely but has generally been within the range of densities at MAK 13.8. At BBK 10.0, greater impacts have been indicated in the fish community. Species richness has been consistently lower than at the reference site (Massac Creek), and the site has consistently lacked darter, sucker, and other sensitive species. Fish abundance at the site has varied widely and has been at or above densities at the reference site in all sample periods. High densities and biomass, based on domination by central stoneroller (*Campostoma anomalum*) and longear sunfish, along with low species richness indicate some nutrient enrichment at BBK 10.0. There appear to be minimal or no impacts to the fish community in Little Bayou Creek at LUK 7.2. Species richness has been within the range found at reference sites, and occasionally, rare species (e.g., redspotted sunfish, *Lepomis minatus*) have been collected. Fish abundance at the site has varied widely and has been close to or above densities at the BBK 12.5 reference site in 6 of 13 sample periods.

Measurements of PCBs in longear sunfish at the uppermost site in Little Bayou Creek has demonstrated a constant but decreasing input of PCBs to the headwaters. Average concentrations in sunfish at LUK 9.0 have decreased from nearly 2 $\mu g/g$ in spring 1992 to less than 0.4 $\mu g/g$ in fall 1997. As headwater inputs decrease, the relative importance of instream contamination as a source will increase. In the absence or reduction of continued upstream inputs, contaminated sediments should be gradually washed out downstream and buried, and the downstream profile in which PCB concentrations at LUK 7.2 (and eventually LUK 4.3) exceed those at LUK 9.0 should become more frequent or typical.

Watershed Sampling and Analysis

This plan was developed using historical monitoring data and guidance from "Methods for Assessing Biological Integrity of Surface Waters" published by the Kentucky Department for Environmental Protection. Based on the strength of the historical data, the fish and benthic macroinvertebrate communities will be sampled only once each year in the fall at three locations in Big Bayou Creek (BBK 12.5, BBK 10.0, and BBK 9.1), and one location each in Little Bayou Creek (LUK 7.2) and Massac Creek (MAK 13.8). The bioaccumulation of PCBs in fish will be monitored by collecting longear sunfish annually from three locations on Little Bayou Creek (LUK 9.0, LUK 7.2, and LUK 4.3) and by collecting spotted bass annually from one location in Big Bayou Creek (BBK 9.1). Massac Creek (MAK 13.8) will serve as a source of noncontaminated fish.

Benthic macroinvertebrate samples will be collected with a Surber square-foot bottom sampler from randomly selected locations within a designated riffle at each of five sites. Samples will be processed in a laboratory following standard operating procedures. Organisms will be identified to the lowest practical taxon and enumerated. Instream and riparian habitat, and water quality will be assessed at each site following standard procedures outlined by the U.S. Environmental Protection Agency. Analyses of the data will include, but not necessarily be limited to, general descriptive and parametric statistics to evaluate trends in temporal and spatial changes that could be associated with abatement activities or remedial actions. Metrics of the benthic macroinvertebrate community such as total density, total taxonomic richness, taxonomic richness of the pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera, percent community similarity index, and dominants in common will be included in the analysis of the data.

Quantitative sampling of the fish communities at the five sites in the Paducah Site area will be conducted by electrofishing. An 80- to 120-m reach of each site will be sampled using a 3-pass removal estimate with block-nets defining the sample reach. Data from these samples will be used to estimate species richness, population size (numbers and biomass per unit area), and annual production. Data will also be adapted to create an Index of Biotic Integrity (IBI) that is consistent with Kentucky Division of Water guidelines. All fish sampling sites overlap sites used in the benthic macroinvertebrate community task. All field sampling will be conducted according to standard operating procedures.

The concentration of PCBs in fish will be determined in longear sunfish from the Little Bayou Creek sites and spotted bass (*Micropterus punctulatus*) from Big Bayou Creek. Fillets of individual sunfish and composited fillet samples of the spotted bass will be analyzed for PCBs. PCB analyses will be conducted using Soxhlet extraction techniques according to SW-846 Method 3540 and analysis by capillary column gas chromatography using SW-846 Method 8080. In addition to blanks and laboratory control standards, standard reference materials and/or spike samples of fish known to be uncontaminated will be run to demonstrate recovery of the analytes. Fish from uncontaminated reference sites will also be analyzed with each submission to demonstrate the absence of false positives or interferences, and establish background levels.

Quality Assurance

The quality of the data and analysis for each parameter will be assured by following the Biological Monitoring and Abatement Program (BMAP) Quality Assurance (QA) Plan and by use of project-specific QA plans. The BMAP QA plan identifies requirements, assigns responsibilities for ensuring achievement of program objectives, and describes guidelines to be followed during BMAP activities. The major elements of the BMAP QA plan are: (1) description of the program, (2) personnel training and qualification, (3) quality improvement, (4) documents and records, (5) work processes, (6) design, (7) procurement, (8) inspection and acceptance testing, (9) management assessment, (10) independent assessment, and (11) data management. Projects within this plan require varying degrees of quality assurance; therefore, each discrete project has a separate but abbreviated quality assurance plan that identifies specific QA requirements. Each project QA plan contains standard operating procedures which will be followed for sampling and analysis.

1. INTRODUCTION

Biological monitoring of Little Bayou and Big Bayou creeks, which border the Paducah Site, has been conducted since 1987. The first plan developed for the Paducah Site was the result of a Kentucky Pollutant Discharge Elimination System (KPDES) Agreed Order issued by the Commonwealth of Kentucky Natural Resources and Environmental Protection Cabinet on September 24, 1987. The plan for the biological monitoring program (BMP) of the receiving streams (Little Bayou Creek and Big Bayou Creek) was prepared by the University of Kentucky, reviewed by staff at the Paducah Site and Oak Ridge National Laboratory (ORNL), and submitted by the U.S. Department of Energy (DOE) to the Kentucky Division of Water (KDOW) for approval. The Paducah Site BMP implemented in 1987, consisted of ecological surveys, toxicity monitoring of effluents and receiving streams, evaluation of bioaccumulation of trace contaminants in biota, and supplemental chemical characterization of effluents. Because research staff from the Environmental Sciences Division (ESD) at ORNL were experienced in biological monitoring, they served as reviewers and advisers throughout the planning and implementation of the Paducah Site BMP. Data resulting from BMP conducted by the University of Kentucky were presented in a 3-year report issued in December 1990 (Birge et al. 1990) and a progress report issued in December 1991 (Birge et al. 1992).

Beginning in fall 1991, ESD added data collection and report preparation to its responsibilities for the Paducah Site BMP. Prior to ORNL's initiation of the instream monitoring task for the Paducah Site BMP, a site selection study was conducted in 1990 with an emphasis on locating reference sites (Kszos 1994a). Qualitative sampling of the fish and invertebrate communities at many of these and other sites was conducted in 1996 to further evaluate the suitability of the reference sites used since 1991 (Kszos 1997). Initially, sampling of the benthic invertebrate and fish communities in Big Bayou and Little Bayou creeks was conducted. In addition, the bioaccumulation of chemicals (PCBs, metals including mercury, organics, and radionuclides) in fish and toxicity monitoring were conducted at many sites in Big Bayou and Little Bayou creeks. After a sufficient baseline data set had been established, the sampling and analysis efforts were reduced to more efficiently meet the needs of the Paducah Site. Results of these studies have been compiled in annual reports (Kszos 1994a; Kszos et al. 1994b; Kszos 1996a, b; 1997; 1998).

The watershed monitoring for the Paducah Site currently consists of three major tasks: (1) effluent toxicity monitoring, (2) bioaccumulation studies, and (3) ecological surveys of fish communities. In the current KPDES permit issued to DOE, effluent toxicity monitoring requirements are separate from the watershed plan and are therefore not discussed further. During 1997, three study sites on Big Bayou Creek (Fig. 1.1), Big Bayou Creek kilometer (BBK) 12.5, BBK 10.0, and BBK 9.1; one site on Little Bayou Creek (Fig. 1.1), Little Bayou Creek kilometer (LUK) 7.2; and one off-site reference site on Massac Creek (Fig. 1.2), Massac Creek kilometer (MAK) 13.8, were routinely sampled to assess the health of the fish communities. Three sites in Little Bayou Creek (LUK 9.0, LUK 7.2, and LUK 4.3 [Fig. 1.1]) and one site on Big Bayou Creek (BBK 9.1) were used for the biomonitoring task; Massac Creek (MAK 13.8) served as a local source of uncontaminated fish in 1997. A summary of the site locations is given in Table 1.1.

In March 1998, renewed KPDES permits were issued to the DOE and United States Enrichment Corporation (USEC) for PGDP. The renewed DOE permit requires that a

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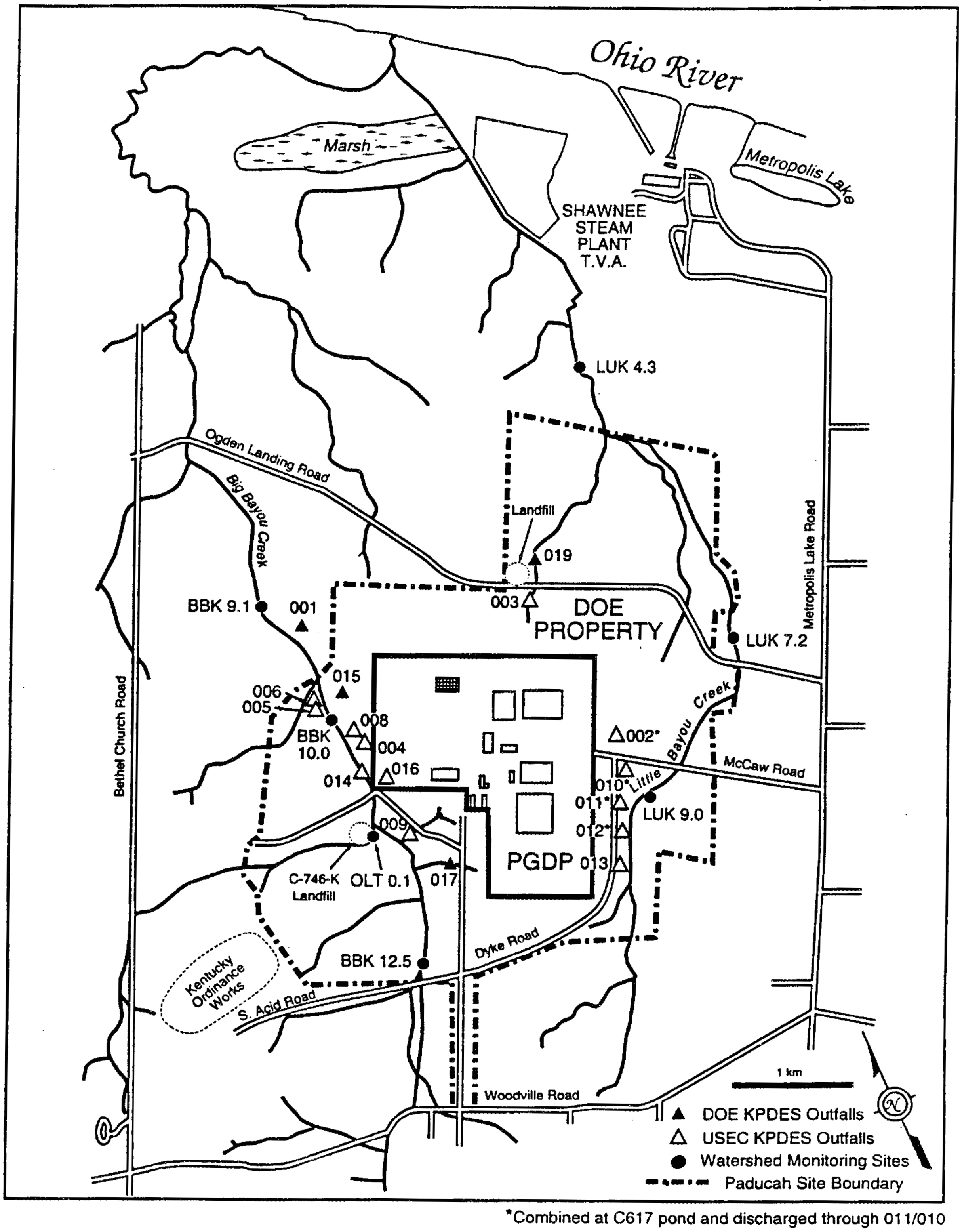

*Combined at C617 pond and discharged through 011/010

Fig. 1.1. Location of Watershed Monitoring Program sites and Kentucky Pollutant Discharge Elimination System (KPDES) outfall locations for the Paducah Site. Outfalls 001, 015, 017, and 019 are the responsibility of DOE. BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; T.V.A. = Tennessee Valley Authority, DOE = U.S. Department of Energy.

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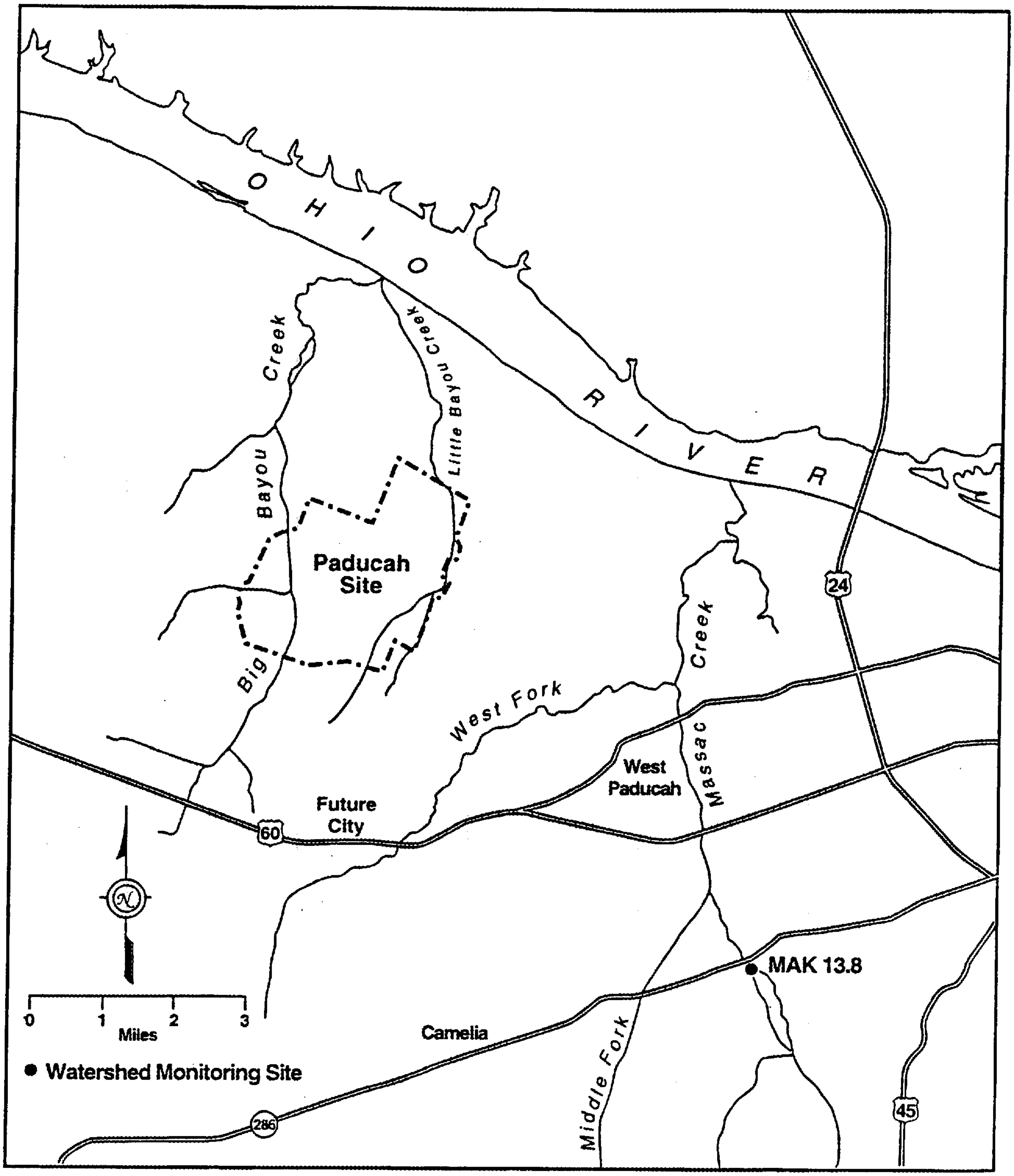

Fig. 1.2. Map of the Paducah Site in relation to the geographic region. The reference site for Paducah Site watershed monitoring activities is located on Massac Creek at kilometer (MAK) 13.8.

Table 1.1. Locations and names of sampling sites included in the Paducah Site Watershed Monitoring Program, 1998

Current site name[a]	Location[b]
Big Bayou Creek	
BBK 12.5[c]	~200 m downstream of bridge on South Acid Road
BBK 10.0	~50 m upstream of Outfall 006
BBK 9.1	~25 m upstream of flume at gaging station at Bobo Road
Little Bayou Creek	
LUK 9.0	~25 m downstream of Outfall 010
LUK 7.2	~110 m downstream of bridge on Route 358
LUK 4.3	~500 m downstream of Outfall 018
Massac Creek	
MAK 13.8[c]	~40 m upstream of bridge on Route 62, 10 km SE of the Paducah Site

[a]Site names are based on stream name and distance of the site from the mouth of the stream. For example, Big Bayou Creek kilometer (BBK) 9.1 is located 9.1 km upstream of the mouth; LUK = Little Bayou Creek kilometer; and MAK = Massac Creek kilometer.

[b]Locations are based on approximate distances from a major landmark (e.g., bridge or outfall) to the bottom of the reach.

[c]Reference site.

watershed monitoring program be developed within 90 days of the effective date of the renewed permit (Appendix A). The submittal of this plan meets this requirement. This plan was developed from previous monitoring efforts with guidance from "Methods for Assessing Biological Integrity of Surface Waters" published by the Kentucky Department for Environmental Protection (KDOW 1993).

In addition to watershed monitoring, Bechtel Jacobs Company LLC, and previously Lockheed Martin Energy Systems, conducts extensive environmental monitoring of sediment, terrestrial wildlife, and water at the Paducah Site. The monitoring program is revised annually, and results are summarized in annual site environmental reports (cf. LMES 1997a, 1997b). The current monitoring program may be found in Bechtel Jacobs Company 1998.

2. WATERBODY DATA

2.1 STREAM NAMES

Little Bayou Creek, Big Bayou Creek, Massac Creek (reference site).

2.2 MAJOR RIVER BASIN

Ohio River.

2.3 STREAM ORDER (AT MOUTH)

Little Bayou Creek is third order. Big Bayou Creek is fourth order.

2.4 COUNTY OR COUNTIES IN THE SURVEY

McCracken County.

2.5 UNITED STATES GEOLOGICAL SURVEY 7.5 MIN QUADRANGLE NAMES

Little Bayou Creek and Big Bayou Creek are located in the Heath (N3700-W8845) and Joppa (N3707.5-W8845) United States Geological Survey (USGS) quadrangles. Massac Creek (a reference site) is located in the Paducah West (N3700-W8837.5) USGS quadrangle.

3. SURVEY DATES

Tentative starting dates for surveys - October 1, 1998. The bioaccumulation of PCBs in fish, the fish community, and the benthic macroinvertebrate community will be sampled annually in the fall at the locations shown in Table 3.1.

Table 3.1. Sampling locations and parameters for watershed monitoring plan

	Parameter		
Site[a]	Bioaccumulation of PCBs	Fish community	Benthic macroinvertebrate community
Big Bayou Creek			
BBK 12.5[c]		X	X
BBK 10.0		X	X
BBK 9.1	X	X	X
Little Bayou Creek			
LUK 9.0	X		
LUK 7.2	X	X	X
LUK 4.3	X		
Massac Creek			
MAK 13.8[b]	X	X	X

[a]BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer.

[b]Reference site.

4. OBJECTIVES

The objectives of the watershed monitoring are to (1) determine whether discharges from the Paducah Site and Solid Waste Management Units associated with the Paducah Site are adversely affecting instream fauna, (2) assess the ecological health of Little Bayou and Big Bayou creeks, (3) assess the degree to which abatement actions ecologically benefit Big Bayou Creek and Little Bayou Creek, (4) provide guidance for remediation, (5) provide an evaluation of changes in potential human health concerns, and (6) provide data which could be used to assess the impact of inadvertent spills or fish kills. According to the KPDES permit, the goal of the watershed monitoring program is to ensure that the DOE cleanup will result in these watersheds [Big Bayou and Little Bayou creeks] achieving compliance with the applicable water quality criteria (Appendix A).

5. STUDY AREA DESCRIPTION

5.1 STUDY AREA

The Paducah Site is owned by the Department of Energy (DOE). Effective July 1, 1993, DOE leased the plant production operation facilities to the United States Enrichment Corporation (USEC). Lockheed Martin Corporation created a new subsidiary, Lockheed Martin Utility Services (Utility Services), to manage the leased facilities for USEC under the prior management contract. Under the terms of the lease, USEC has assumed responsibility for compliance activities directly associated with uranium enrichment operations. Bechtel Jacobs Company LLC is the management contractor for DOE responsibilities at the site. These responsibilities include the site Environmental Restoration Program; the Depleted Uranium Hexafluoride (DUF_6) Cylinder Program; the bulk of the Waste Management Program, including waste inventories predating July 1, 1993; wastes generated by current DOE activities; wastes containing "legacy" constituents, such as asbestos, polychlorinated biphenyls (PCBs), and transuranics; and Kentucky Pollutant Discharge Elimination System (KPDES) compliance at outfalls not leased to USEC. DOE has also retained manager and cooperator status of Resource Conservation and Recovery Act (RCRA) storage facilities not leased to USEC. DOE and USEC have negotiated the lease of specific site facilities, prepared memorandums of agreement to define their respective roles and responsibilities under the lease, and developed organizations and budgets to support their respective functions.

5.2 GEOHYDROLOGY

The Paducah Site is located in the Jackson Purchase region of western Kentucky. It lies in the northern margin of the Mississippi Embayment of the Gulf Coastal Plain Province. The Mississippi Embayment was a large sedimentary trough, oriented roughly north-south, which existed during the Cretaceous and Tertiary periods. The sedimentary sequence overlying the Mississippian age bedrock in the vicinity of the Paducah Site consists mainly of fine- to medium-grained clastic materials, including (from youngest to oldest) a basal gravel (i.e., Tuscaloosa Formation) or rubble zone, the McNary Formation, the Porters Creek Clay, and undifferentiated Eocene sands (Olive 1980).

Following deposition of the embayment sediments, the embayment was either uplifted and/or sea level lowered, resulting in the development of an erosional surface that truncated the sediments. Subsequently, during the late Tertiary and Quaternary periods, a unit designated as the Continental Deposits was laid down in the region. The Continental Deposits have been interpreted as originally being deposited in an alluvial fan that covered most of the Jackson Purchase region (Olive 1980). The Continental Deposits have been informally divided into a lower gravel region and an upper silt or clay unit; each unit varies in thickness from 0 to 32 m (LMES 1997a). Immediately overlying the Continental Deposits, Pleistocene loess (originating as windblown material generated by glacial activity) was deposited in a layer of variable thickness (3–10 m). Recent Ohio River alluvial deposits occur at lower elevations along the river's floodplain.

Current understanding of local groundwater hydrology in the vicinity of the Paducah Site is dominated by the recognized importance of the Continental Deposits. This unit is termed the regional gravel aquifer (RGA) and is the uppermost aquifer underlying most of the Paducah Site and the contiguous area north. This groundwater flow system is primarily developed in Pleistocene sands and gravels of the lower member of the Continental Deposits. The Continental Deposits rest upon terraces cut by the ancestral Tennessee and Tennessee-Ohio rivers. Terrace escarpments occurring under the south end of the Paducah Site form the southern limit of the RGA.

Groundwater flow in the loess and the upper member of the Continental Deposits is primarily oriented downward because of the interbedded sand and gravel lenses and the significantly lower potentiometric surface of the RGA. Within the RGA, flow is directed north, discharging into the Ohio River. The hydrology of the RGA was first investigated by USGS in the mid-1960s. Results of these studies indicated that the gravel is saturated over most of its areal extent in the region of the plant, and wells completed within it are reported to be capable of producing yields of up to 3790 L/min. For a more detailed description of the geohydrology of the area, see D'Appolonia 1983; GeoTrans 1990; TERRAN 1990; CH2M Hill 1991; and Kornegay et al. 1992.

5.3 STREAM LENGTH, DRAINAGE BASIN AREA, MAJOR TRIBUTARIES

The Paducah Site is located in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is ~24 km upstream of the site, and the confluence of the Ohio River with the Mississippi River is ~90 km downstream of the site. Surface drainage from the Paducah Site is two small streams, Big Bayou Creek and Little Bayou Creek (Fig. 1.1). These streams meet ~4.8 km north of the site and discharge to the Ohio River at kilometer 1524 (Fig. 1.2). The Paducah Site is located on a local drainage divide; surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Big Bayou Creek. Big Bayou Creek is a perennial stream with a drainage basin extending from ~4 km south of the Paducah Site to the Ohio River; part of its 14.5-km course flows along the western boundary of the plant. Little Bayou Creek originates in the Western Kentucky Wildlife Management Area and flows for 10.5 km north toward the Ohio River; its course includes part of the eastern boundary of the plant. The watershed areas for Big Bayou Creek and Little Bayou Creek are about 4819 and 2428 ha respectively. These streams exhibit widely fluctuating discharge characteristics that are closely tied to local precipitation and facility effluent discharge rates. Natural runoff makes up a small portion of the flow, and, during dry weather, effluents from the Paducah Site operations can constitute about 85% of the normal base flow in Big Bayou Creek and 100% in Little Bayou Creek during the dry season, which extends from summer to early fall.

The lower Big Bayou Creek drainage has low to moderate gradient, and the lower reaches are within the flood plain of the Ohio River. The drainage basin is included in ecoregion 72 (Interior River Lowland) of the contiguous United States (Omernik 1987). Vegetation is a mosaic of forest, woodland, pasture, and cropland. Additional information on vegetative cover, bank structure, channel morphology, substrate and cover variables, and flow conditions obtained during a 1991 survey are published in Kszos (1994a).

5.4 FLOW CHARACTERISTICS

Flow data were provided by the United States Geological Survey (USGS), Water Resources Division, for two USGS gaging stations: one on Little Bayou Creek located 0.4 mi downstream of the Paducah Site (USGS gaging station 03611900) and one on Big Bayou Creek upstream of the Paducah Site (USGS gaging station 03611850). There are no active USGS gaging stations on Big Bayou Creek downstream of the Paducah Site. For both locations, the period of record is October 1990 to November 1991, and June 1993 through 1997. The drainage areas of the stations on Little Bayou Creek and Big Bayou Creek are 5.78 mi^2 and 14.9 mi^2 respectively. The water stage recorder at the Little Bayou Creek station is 324.8 ft above National Geodetic Vertical Datum of 1929 (levels by DOE) and at Big Bayou Creek is 330 ft above sea level (from topographic map). A summary of discharge at the two USGS stations is provided in Table 5.1.

5.5 LAND USE

The area surrounding the Paducah Site is mostly rural, with residences and farms surrounding the plant. Immediately adjacent to the Paducah Site is the West Kentucky Wildlife Management Area (WKWMA), 850 ha of managed habitat either deeded or leased to the Commonwealth of Kentucky.

The population within a 80-km radius of the plant is about 300,500 people. The unincorporated communities of Grahamville and Heath are within 2–3 km east of the facility. The largest cities in the region are Paducah, Kentucky, and Cape Girardeau, Missouri, located about 16 and 64 air km away respectively (U.S. Department of Commerce 1991).

5.6 LOCATION OF POINT SOURCES OF POLLUTION

As per the KPDES permit, DOE has responsibility for four outfalls (015, 017, 019, and 001) on the Paducah Site. Outfalls 015, 017 and 019 contain only surface runoff from the plant. Outfall 001 discharge consists of combined treated wastewaters from the C-752 Waste Storage and Treatment Building, the C-616 Wastewater Treatment Facility, the Vortec Vitrification Project (construction not completed), the C-612 Northwest Groundwater Treatment System, and miscellaneous untreated nonprocess wastewaters associated with the C-335, C-337, C-535, C-537, C-746-A and C616 buildings and ancillary areas, C-600 Steam Plant and C-614 Pump and Treat Facility.

The majority of effluents discharged to Big Bayou and Little Bayou creeks are from USEC outfalls and consist primarily of once-through cooling water, although a variety of effluents (uranium-contaminated as well as noncontaminated) result from activities associated with uranium precipitation and facility-cleaning operations. Conventional liquid discharges such as domestic sewage, steam-plant wastewaters, and coal-pile runoff also occur.

Monitoring of individual outfalls and the landfill outfall is conducted in accordance with the KPDES Permit. Table 5.2 lists the outfalls in the DOE and USEC permits and their

Table 5.1. **Flow data for Little Bayou Creek (USGS gaging station 03611900) and Big Bayou Creek (USGS gaging station 03611850)**

	Water Year (October to September)				
Parameter (ft^3/sec)	1993–1994	1994–1995	1995–1996	1996–1997	1991–1997
			Little Bayou Creek[a]		
Annual total	2659	1836	1593	3752	
Annual mean	7.29	5.03	4.35	10.3	7.07
Highest annual mean					10.3
Lowest annual mean					4.35
Highest daily mean	195 (Nov 17)	138 (Feb 15)	200 (Jul 30)	506 (Mar 1)	506
Lowest daily mean	0.38 (Oct 18)	0.02 (May 25)	0.45 (Aug 14)	0.7 (May 18)	0.02
Annual seven-day minimum	0.43 (Oct 7)	0.56 (Nov 30)	0.57 (Aug 14)	0.81 (Oct 1)	0.43 (Sep 25, 1991)
Instantaneous peak flow	842 (Nov 17)	607 (Apr 20)	475 (Jun 12)	1300 (Mar 1)	1300
Instantaneous peak stage	8.56 (Nov 17)	7.48 (Apr 20)	9.35 (May 15)	11.26 (Mar 1)	11.26
Annual runoff (ft^3/sec)	1.26	0.87	0.75	1.78	1.22
Annual runoff (inches)	17.11	11.82	10.26	24.15	16.62
10 percent exceeds	12	7.0	5.1	17	9.1
50 percent exceeds	1.4	1.3	0.9	2.1	1.2
90 percent exceeds	0.83	0.73	0.65	1.0	0.7

Table 5.1 (continued)

Parameter (ft^3/sec)	1993–1994	1994–1995	1995–1996	1996–1997	1991–1997
	Water Year (October to September)				
			Big Bayou Creek[b]		
Annual total	7603	7374	6018	11283	
Annual mean	20.8	20.2	16.4	30.9	21.7
Highest annual mean					30.9
Lowest annual mean					16.4
Highest daily mean	391 (Jan 25)	415 (Feb 15)	458 (Jun 12)	923 (Mar 1)	923
Lowest daily mean	2.0 (Sep 3)	4.0 (Aug 16)	2.4 (Sep 24)	1.9 (Oct 9)	1.9
Annual seven-day minimum	3.1 (Sep 7)	4.7 (Jul 15)	4.3 (Aug 21)	3.5 (Oct 4)	3.1
Instantaneous peak flow	1490 (Nov 17)	1220 (Jun 23)	1660 (Jul 30)	1750 (Mar 1)	1750
Instantaneous peak stage	11.7 (Nov 17)	10.4 (Jun 23)	12.2 (Jul 30)	12.60 (Mar 1)	12.6
Annual runoff (ft^3/sec)	1.4	1.36	1.10	2.07	1.46
Annual runoff (inches)	18.98	18.41	15.03	28.17	19.80
10 percent exceeds	27	28	20	53	28
50 percent exceeds	8.3	8.8	7.2	12	8.3
90 percent exceeds	4.6	5.7	5.3	5.3	4.9

[a]Location: Lat 37°08'22", long 88°47'26"; McCracken County, Hydrologic Unit 05140206, on left bank on reservation of Tennessee Valley Authority Shawnee Steam Plant, 30 ft upstream of bridge on unnamed county road, 1.1 mi southwest of Shawnee Steam Plant, 2.2 mi upstream from Big Bayou Creek, downstream of the Paducah Site, 2.3 mi north of Grahamville, and at mile 2.2.

[b]Location: Lat 37°08'41", long 88°49'38"; McCracken County, Hydrologic Unit 05140206, near right bank on downstream side of bridge on State Highway 358, 750 ft downstream of Brushy Creek, 1.4 mi north of the Paducah Site, 3.6 mi northwest of Grahamville, and at mile 4.1.

Table 5.2. Kentucky Pollutant Discharge Elimination System (KPDES) permitted outfalls at the Paducah Site
Locations in bold are the responsibility of DOE

Location[a]	Discharge source	Contributing processes
001	**C-616, C-600, C-400, C-410, C-635, C-335, C-337, C-535, C-537, C-746-A, C-747-A, C-635-6**	**Recirculating cooling water blowdown treatment effluent, coal-pile runoff, once-through cooling water, surface runoff, roof and floor drains, treated uranium solutions, sink drains, discharge from the Northwest Plume Pump and Treat Facility**
002	C-360, C-637, C-337-A	Once through cooling water, roof and floor drains, sink drains, extended aeration sewage treatment system
004	C-615 sewage treatment plant, C-710, C-728, C-750, C-100, C-620, C-400	Domestic sewage, laboratory sink drains, motor cleaning, garage drains, laundry, machine coolant treatment filtrate, condensate blowdown, once-through cooling water
006	C-611 secondary lagoon	Water treatment plant sludge, sand filter backwash, laboratory sink drains from Outfall 005
008	C-743, C-742, C-741, C-723, C-721, C-728, C-729, C-400, C-420, C-410, C-727, C-411, C-331, C-310, C-724, C-744, C-600, C-405, C-409, C-631, C-720	Surface drainage, roof and floor drains, once-through cooling water, paint shop discharge, condensate, instrument shop cleaning area, metal-cleaning rinse water, sink drains
009	C-810, C-811, C-331, C-333, C-310, C-100, C-102, C-101, C-212, C-200, C-300, C-320, C-302, C-750, C-710, C-720	Surface drainage, roof and floor drains, condensate, once-through cooling water, sink drains
010	C-531, C-331	Switchyard runoff, roof and floor drains, condensate, sink drains
011	C-340, C-533, C-532, C-315, C-333, C-331	Once-through cooling water, roof and floor drains, switchyard runoff, condensate, sink drains
012	C-633, C-533, C-333-A	Roof, floor, and sink drains, condensate, surface runoff, extended aeration sewage treatment system
013	Southeast corner of the plant	Surface runoff
015	**West central plant areas**	**Surface runoff**
016	Southwest corner of the plant	Surface runoff
017	**Extreme south area of the plant**	**Surface runoff**
019	**Landfill at north of plant**	**Surface runoff**

[a]Numeral indicates outfall designation. Locations also identified in Fig. 1.1 of this report.

Note: This table was taken from Kornegay et al. 1994 (Paducah Gaseous Diffusion Plant Environmental Report for 1993. ES/ESH-53. Oak Ridge National Laboratory, Oak Ridge, Tennessee) contributing processes; Fig. 1.1 shows the location of the outfalls. Eight of the 17 outfalls discharge continuously to the receiving streams. Outfalls 001, 006, 008, and 009 discharge continuously to Big Bayou Creek; outfalls 002, 010, 011, and 012 are combined at the C-617 pond and discharge through Outfall 010 continuously to Little Bayou Creek. After PCBs were detected in sediments from Outfall 011 in June 1994, the combined C-617 lagoon discharge was diverted on a full-time basis to Outfall 010. Outfall 011 has been a stormwater outfall since the change (C. C. Travis, USEC, Environmental Waste Management Division, Environmental Compliance Department, personal communication).

5.7 LOCATION OF AREA SOURCES OF POLLUTION

As indicated in Section 4, one of the objectives of the program is to determine whether discharges from the Paducah Site and Solid Waste Management Units (SWMUs) associated with the Paducah Site are adversely affecting instream fauna. The Paducah Site has 208 SWMUs that were identified as areas in use or used for the management of solid waste, or were potentially contaminated by routine or systematic release. Runoff from 174 of the SWMUs drains to KPDES monitored outfalls. Runoff from 34 SWMUs runoff to either Big Bayou or Little Bayou creeks. Table 5.3 describes the SWMUs and gives the contaminants of concern along with the discharge location and the receiving stream. Because drainage from some of the SWMUs does not flow through a KPDES outfall, it is of benefit to initiate an in-stream watershed monitoring program to identify any adverse affects from these SWMUs. This in-stream monitoring will protect the creeks by providing early indication of contaminant release from SWMUs and outfalls. In addition it will negate the need for sampling at each individual SWMU.

Table 5.3. Description of solid water management units (SWMUs) at the Paducah Site

SWMU	Description	Concern[b]	Discharge location[c]
1	C-747-C Oil Landfarm	TCE, PCB, U, OIL, TCA	BB, 15
2	C-749 Uranium Burial Ground	U, oils, TCE	BB,15
3	C-404 Low-level Radioactive Waste Burial Ground	U	BB,15
4	C-747 Contaminated Burial Ground	U	BB,1&15
5	C-746-F Classified Burial Ground	Rad	BB,1
6	C-747-B Burial Ground	Rad	BB,1
7	C-747-A Burial Ground	Rad, Metals, PAHs	BB,1
8	C-746-K Landfill	Iron, TCE, TCA	BB, MILE 6.71 (KM 10.83)
9	C-746-S Residential Landfill	NA	LB, MILE 2.89 (KM 4.65)
10	C-746-T Inert Landfill	NA	LB, MILE 2.89 (KM 4.65)
11	C-400 Trichlorethylene Leak Site	TCE	BB,8
12	C-747-A UF4 Drum Yard	Rad	BB,1
13	C-746-P Clean Scrap Yard	None	BB,1
14	C-746-E Contaminated Scrap Yard	Rad	BB,1
15	C-746-C Scrap Yard	Rad	BB,1
16	C-746-D Classified Scrap Yard	Rad	BB,1
17	C-616-E Sludge Lagoon	Cr (non-haz)	BB, 1
18	C-616-F Full Flow Lagoon	Cr (non-haz)	BB, 1
19	C-410-B HF Neutralization Lagoon	Arsenic, lead, cadmium	BB, 1

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
20	C-410-E HF Emergency Lagoon	None	BB, 1
21	C-611-W Sludge Lagoon	Metals, rad	BB, 6
22	C-611-Y Overflow Lagoon	Metals, rad	BB, 6
23	C-611-V Lagoons	Metals, rad	BB, 6
24	C-750-D Undergrounds Storage Tank	Oils/PCBs	BB, 8
25	C-750 1000 Gallon Waste Oil Tank	NA	BB, 8
26	C-400 to C-404 Underground Transfer Line	Rad	BB, 1 &15
27	C-722-400 to C-404 Underground Transfer Line	Solvents, metals	BB, 8
28	C-712 Acid Neutralization Tank	Rad, organic, metals	BB, 8
29	C-746-B TRU Storage Area	NA	BB, 1
30	C-747-A Burn Area	Metals and PAHs	BB, 1
31	C-720 Compressor Pit Water Storage Tank	Rad	BB, 8
32	C728 Clean Waste Oil Tank	Solvents, oil	BB, 8
33	C-728 Motor Cleaning Facility	Solvents, rad, oil BB, 8	BB, 8
34	C-746-M PCB Waste Storage Area	NA	BB, 1 & 15
35	C-337 PCB Waste Storage Area Unit 2	NA	LB, 2
36	C-337 PCB Waste Storage Area Unit 6	NA	LB, 2
37	C-333 PCB Waste Storage Area	NA	LB, 10 & 11
38	C-615 Sewage Treatment Plant	PCBs, U	BB, 4
39	C-746-B PCB Waste Storage Area	NA	BB, 1

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
40	C-403 Neutralization Tank	Rad	BB, 8
41	C-410-C Neutralization Tank	Arsenic, cadmium, lead	BB, 8
42	C-616 Chromate Reduction Facility	Cr, rad, PCB	BB, 1
43	C-746-B Waste Chemical Storage Area	NA	BB, 1
44	C-733 Hazardous Waste Storage Area	NA	BB, 8
45	C-746-R Water Solvent Storage Area	NA	BB, 17
46	C-409 Hazardous Waste Pilot Plant	NA	BB, 1 & 8
46	C-746-Q Hazardous and Low Level Mixed Waste Storage Building	NA	LB, 11 & 12
47	C-400 Technetium Storage Tank Area	Rad, Cr	BB, 1 & 8
48	C-400-A Gold Dissolver Storage Tank	NA	BB, 1 & 8
49	C-400-B Waste Solutions Storage Tank	NA	BB, 1 & 8
50	C-400-C Nickel Stripper Evaporation Tank	NA	BB, 1 & 8
51	C-400-D Lime Precipitation Unit	NA	BB, 1 & 8
52	C-400 Waste Decontamination Solution Storage Tanks	NA	BB, 1 & 8
53	C-400 NaOH Precipitation Unit	NA	BB, 1 & 8
54	C-400 Degreaser Solvent Recovery Unit	NA	BB, 1 & 8
55	C-405 Incinerator	Rad	BB, 1 & 15
56	C-540-A PCB Waste Staging Area	PCB	LB, 10 & 11
57	C-541-A PCB Waste Staging Area	PCB	LB, 2 & BB, 1

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
58	N-S Diversion Ditch (Outside Plant Security Fence)	Rad	BB, 1
59	N-S Diversion Ditch (Inside Plant Security Fence)	Rad	BB, 1
60	C-375-E2 Effluent ditch (KPDES 002)	Cr	LB, 2
61	C-375-E5 Effluent Ditch (KPDES 013)	Cr	LB, 13
62	C-375-S6 Southwest Ditch (KPDES 009)	Laboratory waters (rad, organics, Metals)	BB, 9
63	C-375-W7 Oil Skimmer Ditch KPDES 008)	Oils	BB, 8
64	Little Bayou Creek	Cr	LB
65	Big Bayou Creek	Cr	BB
66	C-375-E3 Effluent Ditch (KPDES 010 Ditch)	Cr	LB, 10
67	C-375-E4 Effluent Ditch (KPDES 011)	Cr	LB, 11
68	C-375-W8 Effluent Ditch (KPDES 015)	Cr	BB, 15
69	C-375-W9 Effluent Ditch (KPDES 001)	PCBs, rad, oil	BB, 1
70	C-333-A Vaporizer	PCB, oil	LB, 11
71	C-337-A Vaporizer	PCB, oils	LB, 2 & 10 & 11
72	C-200 UST	NA	BB, 8
73	C-710 UST	NA	BB, 8
74	C-340 PCB Transformer Spill Site	PCB, Oil	BB, 1 & 8
75	C-633 PCB Spill Site	PCB, Oil	LB, 12
76	C-632-B Sulfuric Acid Storage Tank	None	BB, 1
77	C-634-B Sulfuric Acid Storage Tank	None	LB, 12

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
78	C-420 PCB Spill Site	PCB	BB, 8
79	C-611 PCB Spill Site	PCB	BB, MILE 6.52 (KM 10.49)
80	C-540-A PCB Spill Site	PCB	LB, 10 & 11
81	C-541 PCB Spill Site	PCB	BB, 1
82	C-531 Electric Switchyard	PCB, chlorinated solvents	LB, 10 & 11
83	C-533 Electric Switchyard	PCB, chlorinated solvents	BB, 1
84	C-535 Switchyard	PCB, chlorinated solvents	BB, 1
85	C-537 Switchyard	PCB, chlorinated solvents	BB,1
86	C-631 Pumphouse and Cooling Tower	Chromium	BB, 8
87	C-633 Pumphouse and Cooling Tower	Chromium	LB, 12 & 13
88	C-635 Pumphouse and Cooling Tower	Chromium	LB, 2 & BB, 1
89	C-637 Pumphouse and Cooling Tower	Chromium	LB, 2
90	C-720 Underground Petroleum Naptha Pipe	NA	DOES NOT EXIST
91	UF6 Cylinder Drop Test Area	TCE	BB, 15
92	Fill Area for Dirt from the C-420 PCB Spill Site	PCB	LB, 10 & BB, 8
93	Concrete Rubble Pile	Rad	LB, 13
94	KOW Trickling Filter and Leach Field	Semivolatiles	BB, MILE 6.73 KM 10.83
95	KOW Burn Area	TNT, volatiles, semivolatiles	BB, MILE 6.52 KM 10.49
96	C-333 Cooling Tower Scrap Wood Pile	NA	REMOVED
97	C-601 Diesel Spill	Fuel oil (diesel)	BB, 15

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
98	C-400 Basement Sump	TCE	BB, 8
99	C-745 Kellogg Building Site	TCE	LB, 2 & 10 & 11
100	Fire Training Area	Oil, solvents	BB, 8 & 16
101	C-340 Hydraulic System	PCBs	LB, 10 & 11
102	Plant Storm Sewer	PCB, rad	OUTFALLS 2, 8, 9, 10, 11, 12, 15, 16, 17
103	Concrete Rubble Pile(s)	NA	BB, MILE 7.68 (KM 12.35)
104	Concrete Rubble Pile(s)	NA	BB, MILE 7.73 (KM 8.27)
105	Concrete Rubble Pile(s)	NA	LB, 11
106	Concrete Rubble Pile(s)	NA	LB, 10
107	Concrete Rubble Pile(s)	NA	LB, 2
108	Concrete Rubble Pile(s)	Rad	LB, MILE 5.36 (KM 8.63)
110	Concrete Rubble Pile(s)	NA	LB, 10 & 11
111	Concrete Rubble Pile(s)	NA	LB, MILE 2.89 (KM 4.65)
112	Concrete Rubble Pile(s)	NA	LB, MILE 2.39 (KM 3.58)
113	Concrete Rubble Pile(s)	Rad	LB, MILE 2.39 (KM 3.58)
114	Concrete Rubble Pile(s)	NA	LB, MILE 1.23 (KM 1.98)
115	Concrete Rubble Pile(s)	NA	RIVER
116	Concrete Rubble Pile(s)	NA	RIVER
117	Concrete Rubble Pile(s)	NA	RIVER

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
118	Concrete Rubble Pile(s)	NA	BB, MILE 5.49 (KM 8.84)
119	Concrete Rubble Pile(s)	NA	BB, MILE 5.93 (KM 9.54)
120	Concrete Rubble Pile(s)	NA	BB, 6 & MILE 6.05
121	Concrete Rubble Pile(s)	NA	BB, MILE 6.73 (KM 10.83)
122	Concrete Rubble Pile(s)	NFA	DOES NOT EXIST
123	Concrete Rubble Pile(s)	NA	BB, MILE 6.79 (KM 10.93)
124	Concrete Rubble Pile(s)	NA	BB, MILE 6.79 (KM 10.93)
125	Concrete Rubble Pile(s)	NA	BB, MILE 6.79 (KM 10.93)
126	Concrete Rubble Pile(s)	NA	BB, MILE 6.79 (KM 10.93)
127	Concrete Rubble Pile(s)	NA	BB, MILE 8.16 (KM 13.13)
128	Concrete Rubble Pile(s)	NA	BB, MILE 7.68 (KM 12.35)
129	Concrete Rubble Pile(s)	NA	BB, 8
130	C-611 550 Gallon Gasoline UST (West of C-611)	Gasoline	BB, MILE 6.52 (KM 10.49)
131	C-611 50 gallon UST	NA	BB, MILE 6.52 (KM 10.49)
132	C-611 2000 Gallon Oil UST (North of C-611)	Fuel oil	BB, MILE 6.52 (KM 10.49)
133	C-611 Unknown Size, Grouted UST (South of C-611)	Diesel	BB, MILE 6.52 (KM 10.49)
134	C-611 1000 Gallon Diesel/Gasoline Tank (Southeast of C-611)	Diesel	BB, MILE 6.52 (KM 10.49)
135	C-333 PCB Soil Contamination (Northside of C-333)	PCB	LB, 10 & 11
136	C-740 TCE Spill Site (Northwest Corner, C-740 Concrete Pad)	TCE	BB, 8
137	C-746-A Inactive PCB Transformer Area	PCB	BB, 15

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
138	C-100 South Side Berm	Mercury, lead	BB, 9
139	C-746-A1 Underground Storage Tank	Diesel	BB, 15
140	C-746-A2 Underground Storage Tank	NA	DOES NOT EXIST
141	C-720 Inactive TCE Degreaser Unit	NA	BB, 8 & 9
142	C-750-A 10,000 Gallon UST	NA	BB, 8 & 9
143	C-750-B 10,000 Gallon UST	NA	BB, 8 & 9
144	C-746-A Hazardous and Mixed Waste Storage Facility	NA	BB, 1
145	Residential/Inert Landfill Borrow Area	None	LB, MILE 2.89 (KM 4.65)
146 thru 152	Concrete Rubble Piles	NA	BALLARD COUNTY
153	C-331 PCB Soil Contamination (West)	PCB	BB, 9
154	C-331 PCB Soil Contamination (Southeast)	PCB	LB, 10 & 11
155	C-333 PCB Soil Contamination (West)	PCB	BB, 9
156	C-310 PCB Soil Contamination (West)	PCB	BB, 9
157	KOW Toluene Spill Area	Toluene	BB, MILE 6.79 (KM 10.93)
158	Chilled Water System Leak Site	Chromium	BB, 9
159	C-746-H3 Storage Pad	PCB	BB, 8
160	C-745 Cylinder Yard Spoils Area (PCB Soils)	PCB	LB, 12 & 13
161	C-743-T01 Trailer Site (Soil Backfill)	PCB	BB, 8 & 16
162	C-617-A Sanitary Water Line (Soil Backfill)	PCB	LB, 10 & 11

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
163	C-304 Building/HVAC Piping system (Soil Backfill)	PCB	BB, 9
164	KPDES Outfall Ditch 017 Flume (Soil Backfill)	PCB	BB, 17
165	C-616-L Pipeline and Vault Soil Contamination	PCBs, U, Tech	BB, 1 & 15
166	C-100 Trailer Complex Soil Contamination (East)	Tech	BB, 9
167	C-720 Whiteroom Sump	Cyanides, silver, tin, lead, gold, chromium	BB, 8 & 9
168	KPDES Outfall Ditch 012	Chromium, dioxins	LB, 12
169	C-410-E HF Vent Surge Protection Tank	Chromium	BB, 8
170	C-729 Acetylene Building drain Pits	Acetylene	BB, 8 & 9
171	C-617-A Lagoons	Chromium	LB, 10 & 11
172	C-726 Sandblasting Facility	Rad	BB, 1 & 15
173	C-746-A Trash Sorting Area	NA	BB, 1
174	C-745-K Low Level Storage Area	NA	BB, 17
175	Concrete Rubble Pile (28)	Rad	LB, 2
176	C-331 RCW Leak Northwest Side	Chromium	BB, 8
177	C-331 RCW Leak East Side	Chromium	LB, 10 & 11
178	C-724-A Paint Spray Booth	PCBs	BB, 8
179	Plant Sanitary Sewer System	Unknown	BB, 4 & 8
180	Outdoor Firing Range (WKWMA)	Lead	BB, MILE 6.73 (KM 10.83)
181	Outdoor Firing Range (PGDP)	Lead	BB,8
182	Western Portion of Yellow Waterline	TNT isomers	BB, MILE 6.73 (KM 10.83)

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
183	McGraw UST	Oil	BB, 17
184	PCB Concrete Rubble Pile (29)	NA	BB, MILE 6.73 (KM 10.83)
185	C-611-4 Horseshoe Lagoon	Lead	BB, MILE 6.43 (KM 10.35)
186	C-751 Fuel Facility	NA	BB, 9
187	C-611 Septic System	NA	BB, MILE 6.71 (KM 10.83)
188	C-633 Septic System	NA	LB, 12,13, 11 & 10
189	C-637 Septic System	NA	LB, 2
190	C-337-A Sewage Treatment Aeration Tank	NA	BB, 1; LB, 2
191	C-333-A Sewage Treatment Aeration Tank	NA	LB, 12
192	C-710 Acid Interceptor Pit	PCB, Carbon tet, TCE, U, Tech	BB, 9
193	McGraw Construction Facilities (Southside Cylinder Yards)	TCE, PCB	LB, 13
194	McGraw Construction Facilities (Southside)	TCE, PCBs	BB, 17
195	Curlee Road Contaminated Soil Mounds	Rad	BB, 9 & 16
196	C-746-A Septic Tank	None	BB
197	Concrete Rubble Pile (30)	NA	BB, MILE 5.24 (KM 8.43)
198	C-410-D Area Soil Contamination	PCB, rad	BB, 8
199	Big Bayou Creek Monitoring Station	Mercury	BB, MILE 5.93 (KM 8.90)
200	Soil Contamination South of TSCA Waste Storage Facility	PCB, U, Tech	BB, 1 & 15
201	Northwest Groundwater contamination Plume	TCE, Tech	UNDERGROUND PLUME
202	Northeast Groundwater Contamination Plume	TCE	UNDERGROUND PLUME

Table 5.3 (continued)

SWMU	Description	Concern[b]	Discharge location[c]
203	C-400 Sump	PCBs, TCE, rad	BB, 1 & 8
204	Dyke Road Historical Staging Area	TCE	LB, 10 & 11
205	Eastern Portion of Yellow Water Line	Sulfates, nitrates, TNT, isomers	BB, MILE 6.14 (KM 9.88)
206	C-753-A TSCA Waste Storage Building	NA	BB, 1 & 15
207	C-752-A ER Waste Storage Building	NA	BB, 1 & 15
208	C-746-U Landfill	NA	LB, MILE 2.89 (KM 4.65)

[a]D=Draft; DOE=U. S. Department of Energy; EPA=U. S. Environmental Protection Agency; FS= feasibility study; KDEP= Kentucky Department of Environmental Protection ; NA= not applicable; NFA=No further action; RI=remedial investigation; ROD=record of decision; SAP=sampling and analysis plan; SOW=statement of work.

[b]Cr=chromium; PCB=polychlorinated biphenyl; Rad=radionuclides; TCE=trichloroethylene; U=uranium.

[c]BB=Big Bayou Creek; 1-15=Kentucky Pollutant Discharge Elimination System outfall location; KM=kilometer; LB=Little Bayou Creek, RIVER=Ohio River.

6. PARAMETER COVERAGE

The benthic macroinvertebrate and fish communities in Big Bayou and Little Bayou creeks were monitored at least annually by ORNL from 1991 to 1997 at five stream locations (BBK 12.5, BBK 10.0, BBK 9.1, LUK 7.2 and MAK 13.8; Fig. 1.1 and Table 1.1). Additional qualitative or quantitative samples have been taken at other sites and times, but this core group of sites represents 6–7 years of historical data. Based on the strength of this historical data, monitoring of the macroinvertebrate and fish communities will be conducted annually at these same locations. Although the location of these sites was originally based upon bracketing point-source discharges, they are also located in close, downstream proximity of the SWMUs that discharge to Big Bayou and Little Bayou creeks. For example, the C-746-K landfill (SWMU 8) discharges at BBK 10.83 (Table 5.3), and a monitoring site will be located at BBK 10.0. The data from the monitoring locations will document the instream conditions downstream of both the point- and area-source (SWMUs) discharges.

The bioaccumulation of PCBs in longear sunfish (*Lepomis megalotis*) has been evaluated by ORNL for 7 years at 3 sites on Little Bayou Creek (LUK 9.0, LUK 7.2, and LUK 4.3; Fig. 1.1, Table 1.1). The bioaccumulation of mercury and PCBs in spotted bass (*Micropterus punctulatus*) has been evaluated for 6 years at one site on Big Bayou Creek (BBK 9.1; Fig. 1.1, Table 1.1). Similar to the community sampling, additional sites and parameters have been monitored since 1991, but this core group of sites and analyses represents the key historical data. Therefore, PCB concentrations in longear sunfish from Little Bayou Creek will continue to be monitored once per year, and PCB concentrations in spotted bass from Big Bayou Creek will continue to be monitored once per year.

6.1 BENTHIC MACROINVERTEBRATE COMMUNITY

6.1.1 Introduction

Benthic macroinvertebrate community studies were conducted by ORNL for the Paducah Site BMP from September 1991 through March 1997 (Kszos et al. 1998; Roy et al. 1996). These studies consisted of routine collections of quantitative benthic macroinvertebrate samples from riffles at three locations in Big Bayou Creek (BBK 9.1, BBK 10.0, and BBK 12.5; Fig. 1.1) and one location each in Little Bayou Creek (LUK 7.2) and Massac Creek (MAK 13.8). With few exceptions, differences in macroinvertebrate community characteristics indicative of major stress were not observed between study (BBK 10.0, BBK 9.1, and LUK 7.2) and reference (BBK 12.5 and MAK 13.8) sites (Figs. 6.1, 6.2, 6.3). Taxonomic richness and richness of the pollution sensitive mayflies, stoneflies, and caddisflies (EPT richness) were generally comparable at study and reference sites. Total densities and densities of mayflies at the study sites were generally similar to, and often greater than at reference sites. Although these results were not indicative of major stress, there were some characteristics suggestive of a low-level stress. Very high total community and mayfly densities were occasionally observed at BBK 9.1 and BBK 10.0, and the oligochaetes frequently made up a high proportion of the community at BBK 9.1, BBK 10.0, and LUK 7.2. Such characteristics are often seen in streams that receive excess inputs of nutrients.

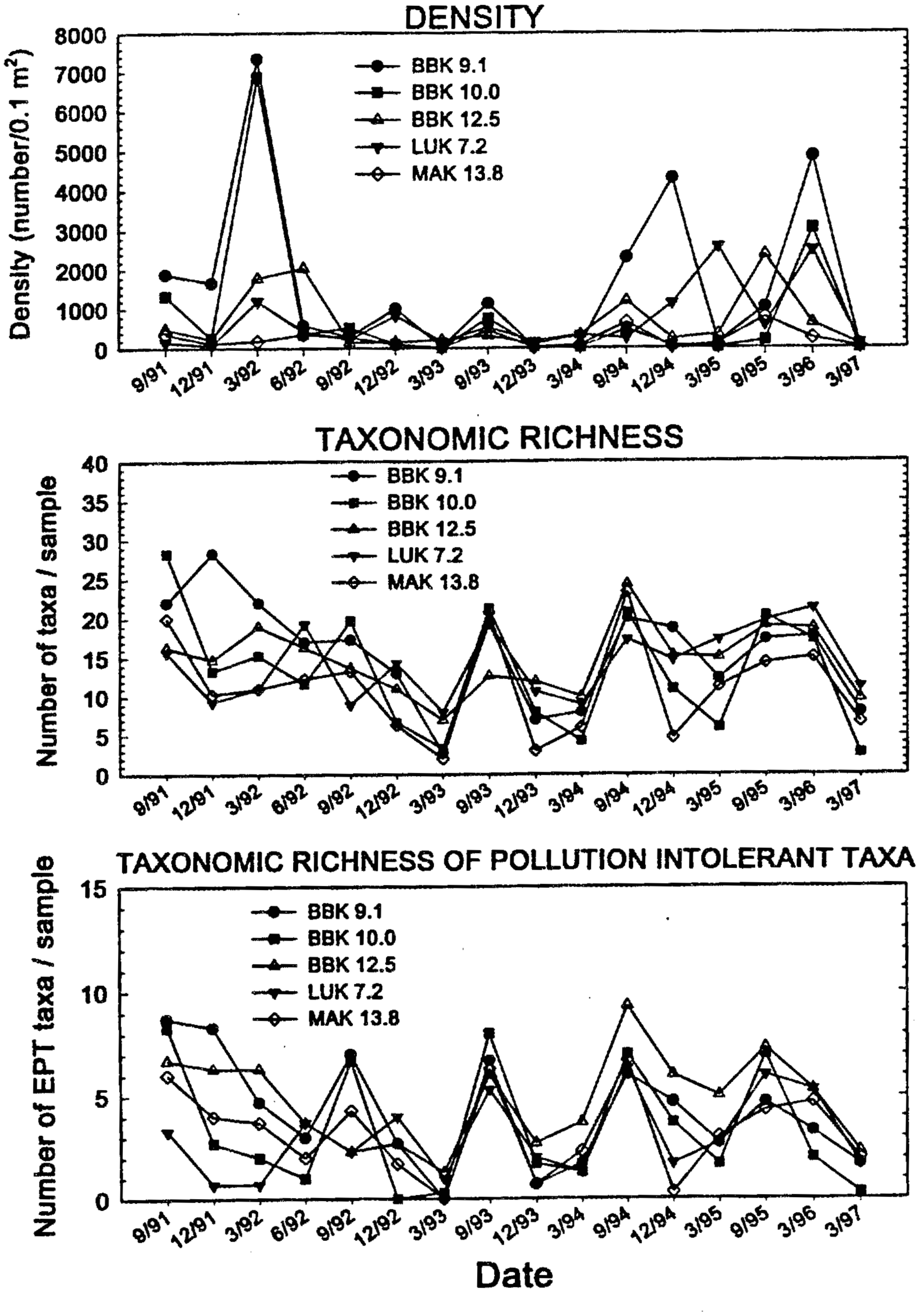

Fig. 6.1. Means for total density, total taxonomic richness, and richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) of the benthic macroinvertebrate communities in Big Bayou Creek, Little Bayou Creek, and Massac Creek in Paducah, Kentucky, September 1991– March 1997. BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer.

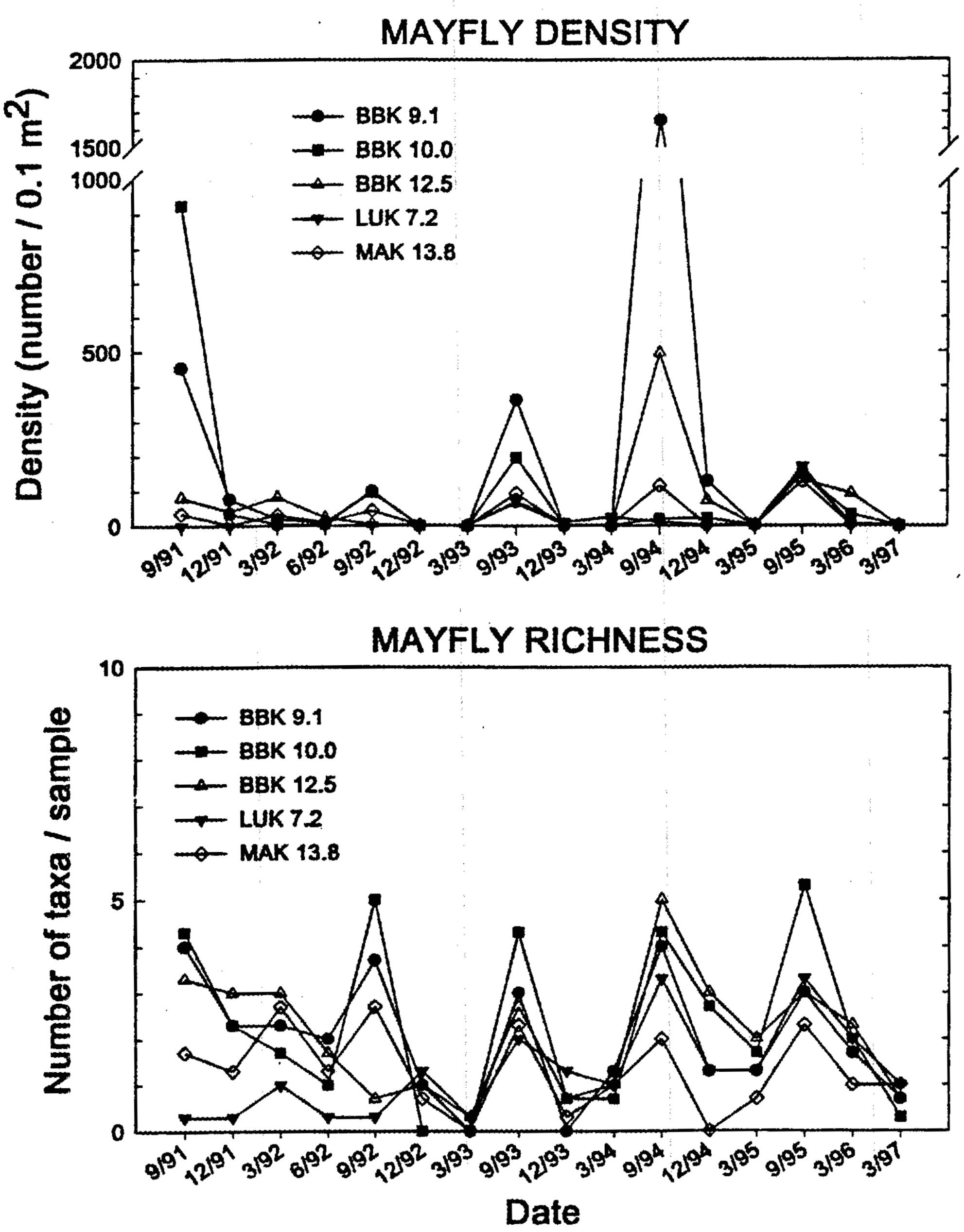

Fig. 6.2. Means for total density and total taxonomic richness of mayflies (Ephemeroptera) in Big Bayou Creek, Little Bayou Creek, and Massac Creek in Paducah, Kentucky, September 1991–March 1997. BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer.

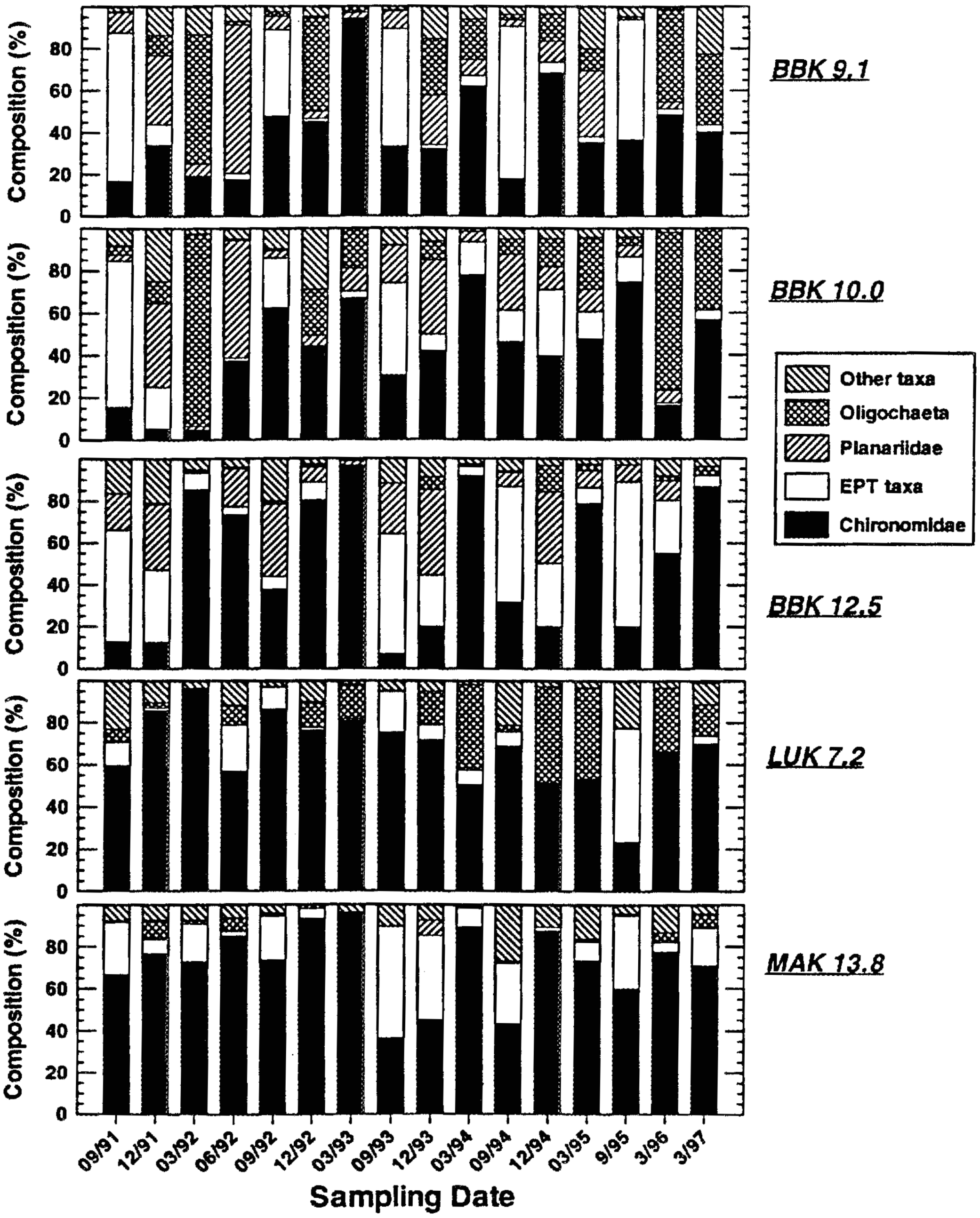

Fig. 6.3. Mean relative abundance (i.e., percent of total community density) of selected benthic macroinvertebrate taxa in Big Bayou Creek, Little Bayou Creek, and Massac Creek in Paducah, Kentucky, September 1991-March 1997. BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer.

Sampling and analysis of the benthic macroinvertebrate communities under the BMP was discontinued in 1998 because there was no indication of major stress on the community. The annual sampling proposed in this plan recognizes the KDOW position that monitoring of multiple types of organisms provides a more complete evaluation of the aquatic ecosystem (KDOW 1993).

6.1.2 Sample Collection and Analysis

Quantitative benthic macroinvertebrate samples have historically been collected with a Surber square-foot bottom sampler since 1991 (Smith 1997). One of the most beneficial outcomes of continuously monitoring biota is that it provides a long-term record of changes in the composition and structure of the community. Such a long-term record is useful for distinguishing natural temporal changes from changes associated with unusual events, such as those associated with a perturbation or remedial action. Many sampling techniques exist for collecting macroinvertebrates (Merritt and Cummins 1996), but each technique generates unique results (Turner and Trexler 1997). Thus, continued monitoring using techniques previously used at the Paducah Site ensures comparability with, and maximum benefit from, historical data, while a change in techniques would either greatly limit or negate the usefulness of these data.

To maintain continuity with monitoring efforts that have been in place since 1991, three quantitative benthic macroinvertebrate samples will be collected once annually (September) with a Surber square-foot bottom sampler (1 ft^2 or 0.09 m^2) from randomly selected locations within a designated riffle at each of five sites. Sampling in September will provide results that can be better integrated with those of the fish community studies, which will also have an annual collection period in September. Sampling sites will include three in Big Bayou Creek (BBK 9.1, BBK 10.0, and BBK 12.5) and one each in Little Bayou Creek (LUK 7.2) and Massac Creek (MAK 13.8); BBK 12.5 and MAK 13.8 will serve as reference sites (Figs. 1.1 and 1.2). Each sample will be preserved in 95% ethanol in the field to compensate for any water remaining with the debris in the sample. The ethanol will be replaced with fresh 80% ethanol within one week after collection to ensure a proper level of preservative until the samples can be processed. Further details of the procedures that will be followed in the collection and maintenance of samples are in the Biological Monitoring and Abatement Program Benthic Macroinvertebrate Community Studies Quality Assurance Plan (Smith and Smith 1995).

Samples will be processed in a laboratory following standard operating procedures (Smith and Smith 1995). Briefly, each sample will be placed in a U. S. Standard No. 60-mesh sieve (250-μm openings) and gently rinsed with tap water. Small aliquots will then be placed in a white tray partially filled with water, and the organisms removed from the sample debris with forceps; sorting will be facilitated with a magnified illuminated lamp. This process will be repeated with the remaining sample material until it is entirely sorted. Finally, organisms will be identified to the lowest practical taxon and enumerated.

Instream and riparian habitat will be visually assessed at each site following standard procedures outlined by the U.S. Environmental Protection Agency (Barbour et al. 1997). This visual assessment scores the quality of various characteristics of habitat within and upstream of a study site. The individual scores for each characteristic are totaled, and a maximum score of 200 can be obtained for sites with the highest quality habitat. A physical characterization and water quality assessment of each site will also be completed following the procedures recommended by the U.S. Environmental Protection Agency (Barbour et al. 1997).

6.1.3 Data Analysis

Data will be managed and analyzed on a personal computer or work station with Statistical Analysis System (SAS) software and procedures (SAS 1985a,b). Analyses will include, but not necessarily be limited to, general descriptive and parametric statistics (e.g., analysis of the variance) to evaluate trends in temporal and spatial changes that could be associated with abatement activities or remedial actions. Metrics that have been routinely included in Paducah Site BMP benthic macroinvertebrate community assessments will be included, such as total density, total taxonomic richness, and taxonomic richness of the pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT richness) (Roy et al. 1996; Smith 1997), as will other metrics that are commonly used by KDOW (e.g., percent community similarity index, dominants in common) (KDOW 1993).

6.2 FISH COMMUNITY

6.2.1. Introduction

Fish population and community studies can be used to assess the ecological effects of changes in water quality and habitat. These studies offer several advantages as indicators of environmental quality (see Karr et al. 1986, Karr 1987) and are especially relevant to assessment of the biotic integrity of Little Bayou and Big Bayou creeks. These creeks receive mixed effluents with a variety of stressors; the fish community includes species that may be sensitive to only one (e.g., temperature) or many of these stressors. Thus, analysis of the fish community may provide some indication as to which stressors are having the most impact. Monitoring of fish communities has been used in a Biological Monitoring Program (BMP) administered by ESD for receiving streams at the Paducah Site since 1991. Changes in the fish communities in these streams have indicated impacts close to the Paducah Site (in Big Bayou Creek near Outfall 008; Kszos 1994) and impacts possibly associated with elevated temperatures (Roy et al. 1996). Fish community data have also indicated an absence of impacts at downstream locations where discharges from the Paducah Site are less of an influence (e.g., at LUK 4.3 in Little Bayou Creek, Kszos 1996a).

6.2.1.1 Historic trends in Little Bayou Creek

The fish communities of Little Bayou Creek have been quantitatively sampled in the spring and fall at LUK 7.2 for 7 years. Qualitative surveys (1-pass, catch-per-effort) of the Little Bayou Creek fish fauna have also been made using quarterly samples at LUK 9.2, from November 1993 through August 1994, and at LUK 9.0, from November 1994 through November 1995. Additional qualitative samples were made at a downstream location, LUK 4.3, with spring and fall samples from March 1992 through March 1994 and samples in September 1995 and March 1996.

The quantitative data indicate that the fish community in Little Bayou Creek at LUK 7.2 is only minimally impacted from plant discharges (Kszos 1994; Kszos et al. 1994; Kszos 1996a,b; Kszos 1997, Kszos et al. 1998). Species richness is within the range found at reference sites (Fig. 6.4A) and occasionally, rare species (e.g., redspotted sunfish, *Lepomis minatus*) are taken at the site. Fish abundance (density) at the site varies widely, and has been close to or above densities at the BBK 12.5 reference site in 6 of 13 sample periods (Fig 6.4C); density averages

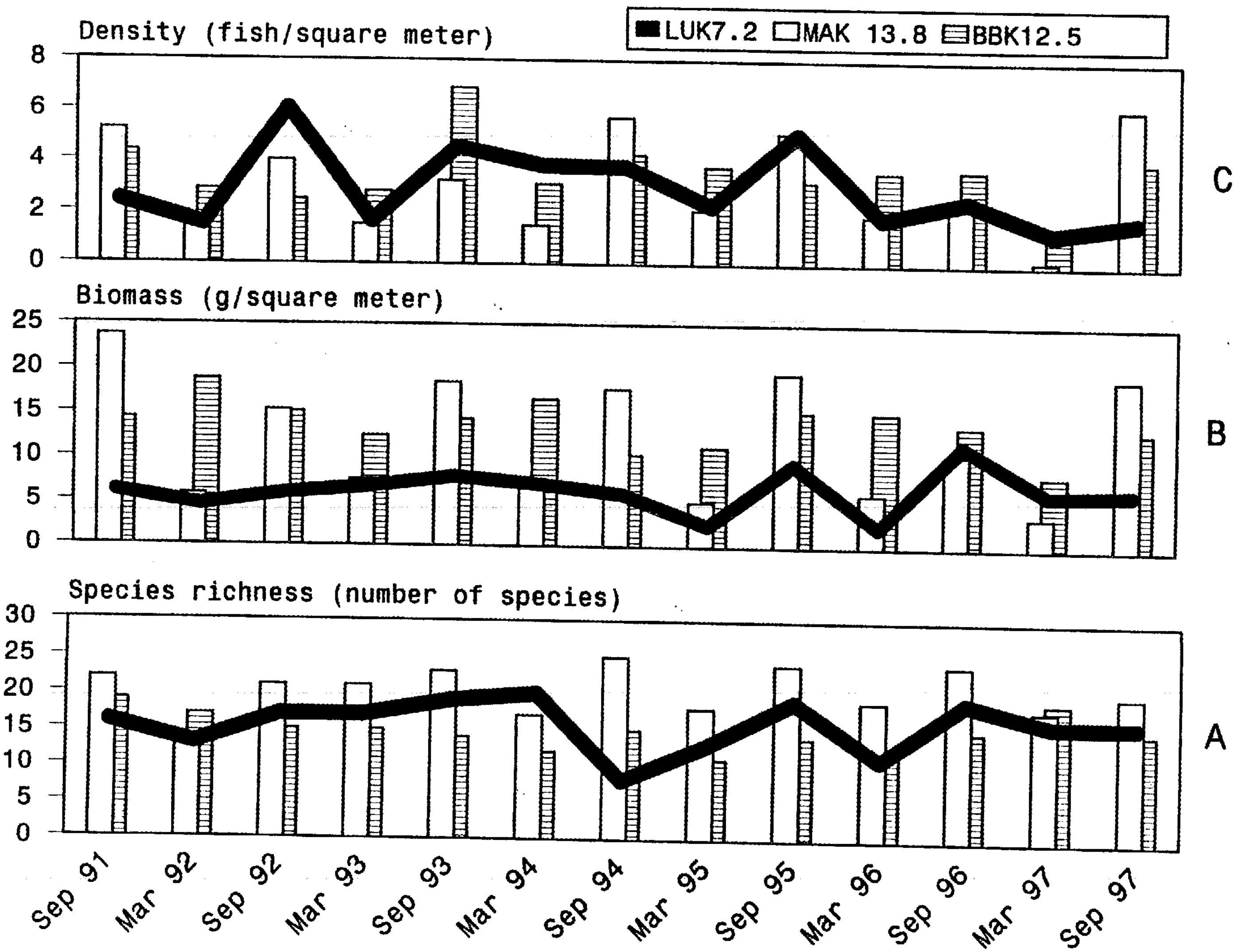

Fig. 6.4. Fish community data for Little Bayou Creek (LUK 7.2) and reference sites (MAK 13.8 and BBK 12.5). LUK = Little Bayou Creek kilometer; BBK = Big Bayou Creek kilometer; MAK = Massac Creek kilometer.

about 3.5 fish per m^2. Fish biomass at the site is much less than at the BBK 12.5 reference (Fig. 6.4B) and averages about 6.3 g per m^2.

Qualitative sample data indicate that the fish community in Little Bayou Creek at LUK 4.3 has not been impacted from plant operations (Kszos 1994; Kszos et al. 1994; Kszos 1996a,b). Species richness ranges from 20-40 species per sample and catch-per-effort ranges from 2–8 fish/min (Fig 6.5A,B). Rare species for this region (Ryon and Carrico 1998) have been taken at the site including the sand shiner (*Notropis stramineus*), river shiner (*Notropis blennius*), redspotted sunfish, black buffalo (*Ictiobus niger*), and tadpole madtom (*Noturus gyrinus*). Sampling at other qualitative sites immediately below outfalls K010/011 indicated that elevated temperatures could pose seasonal problems for the fish community, with some species that are more sensitive to higher temperatures migrating out of the immediate vicinity during the warmer months (Roy et al. 1996).

6.2.1.2 Historic trends in Big Bayou Creek

The fish communities of Big Bayou Creek have been quantitatively sampled in the spring and fall at three sites, BBK 9.1, BBK 10.0, and BBK 12.5 (used as a reference site) for 7 years. Qualitative estimates (1-pass, catch-per-effort) of the Big Bayou Creek fish fauna have also been conducted quarterly at BBK 9.4 and Outfall 001, from November 1993 through November 1995, and at BBK 10.4 from August 1994 through November 1995.

Quantitative data indicate that the fish community in Big Bayou Creek has been impacted somewhat by plant operations (Kszos 1994; Kszos et al. 1994; Kszos 1996a,b; Kszos 1997, Kszos et al. 1998). At BBK 9.1, the fish community has shown only minimal impacts from plant discharges. Species richness at BBK 9.1 is within the range found at reference sites (Fig. 6.6A), but the site generally lacks darter species and has fewer sensitive species than the Massac Creek, MAK 13.8 reference. Fish abundance (density) at the site varies widely through time, and has been close to or above densities at the MAK 13.8 reference in 6 of 13 sample periods (Fig. 6.6C); density averages about 1.7 fish per m^2. Fish biomass at the site is much greater than the MAK 13.8 reference (Fig. 6.6B) and averages more than 21 g per m^2.

At BBK 10.0, greater impacts from plant operations are indicated in the fish community. Species richness is consistently lower than at the MAK 13.8 reference (Fig. 6.6A), and the site consistently lacks darter, sucker, and other sensitive species. Fish abundance (density) at the site varies widely, and has been at or above densities at the MAK 13.8 reference in all sample periods (Fig. 6.6C); density averages about 3.9 fish per m^2. Fish biomass at the site is usually greater than the MAK 13.8 reference (Fig 6.6B) and averages more than 18 g per m^2. High densities and biomass, based on domination by central stoneroller (*Campostoma anomalum*) and longear sunfish, along with low species richness indicate some nutrient enrichment at BBK 10.0. Sampling of nutrient levels supported this enrichment analysis (Kszos 1997). Temperature impacts were noted in qualitative fish community sampling (Roy et al. 1996) in sites adjacent to Outfall 001, where seasonal migration changes the composition of the fish community, with more sensitive species absent in the warmer seasons. However, these temperature impacts are very restricted and don't appear to extend to the areas of Big Bayou Creek where quantitative sampling is conducted.

6.2.2 Sample Collection and Analysis

Quantitative sampling of the fish communities at the five sites on or near the Paducah Site will be conducted by electrofishing in September of each year (Table 3.1). Data from these

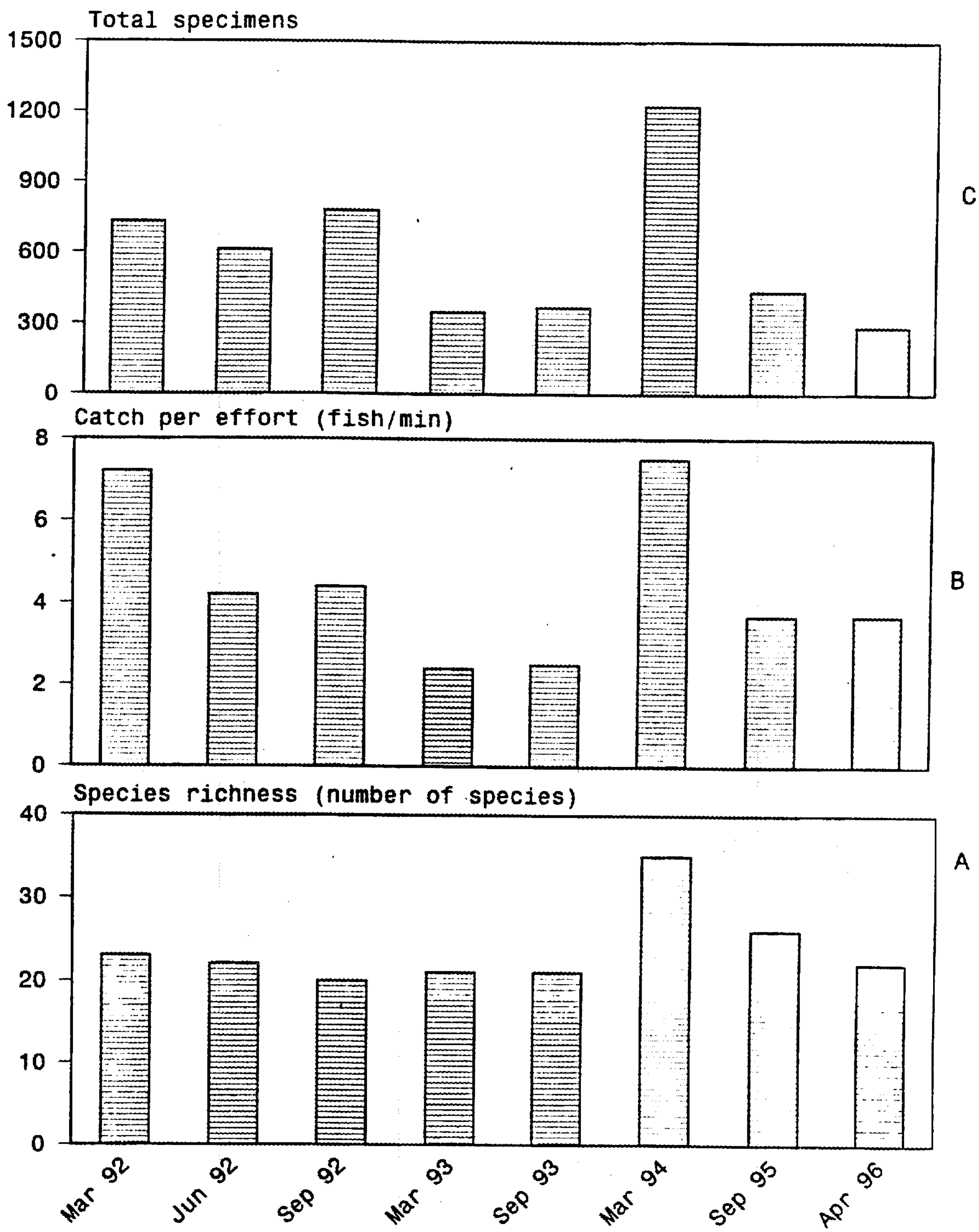

Fig. 6.5. Fish community data for qualitative site in Little Bayou Creek (LUK 4.3). LUK = Little Bayou Creek kilometer.

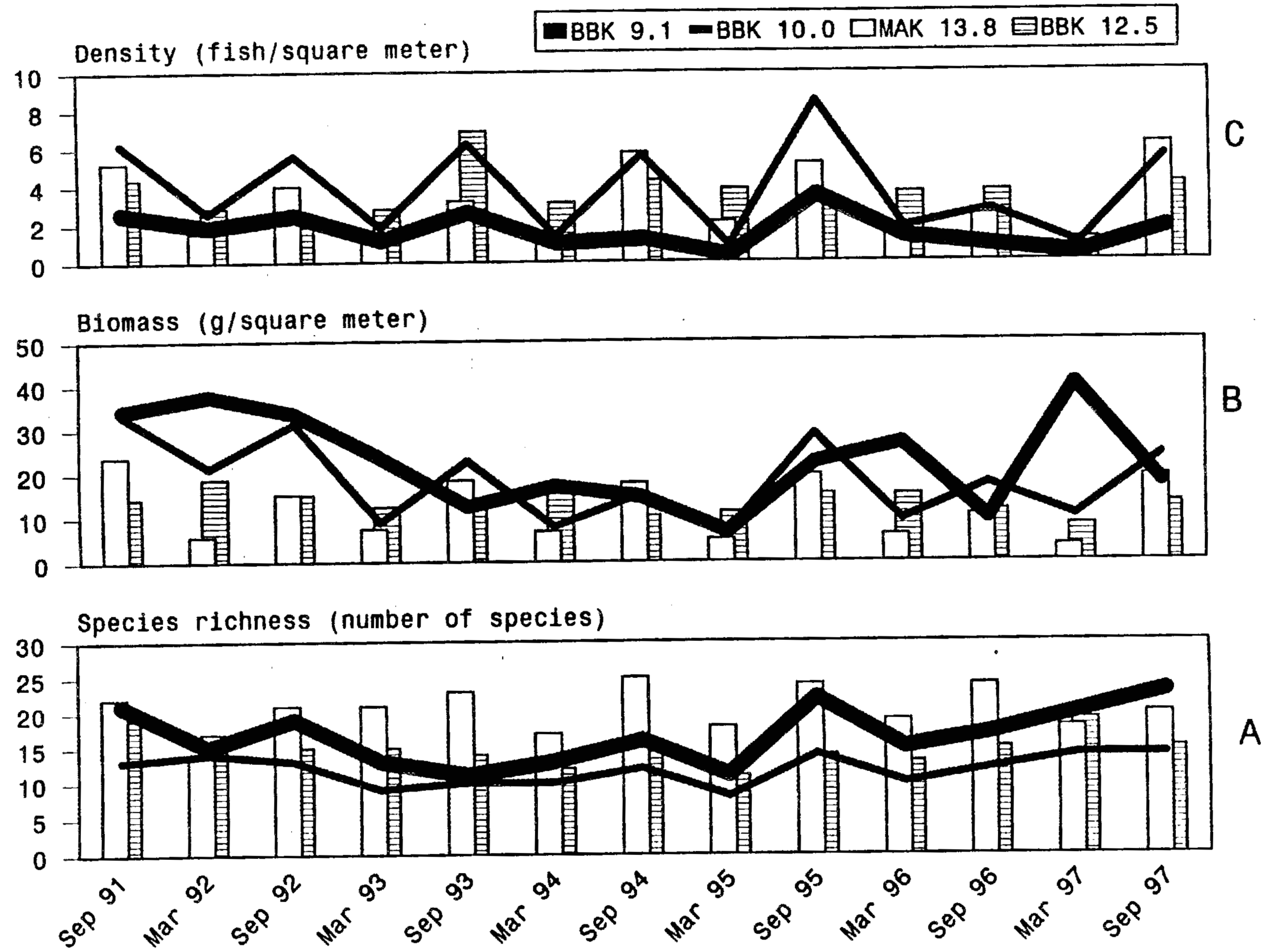

Fig. 6.6. Fish community data for Big Bayou Creek (BBK 9.1 and 10.0) and reference sites (MAK 13.8 and BBK 12.5). BBK = Big Bayou Creek kilometer; MAK = Massac Creek kilometer.

samples will be used to estimate species richness, population size (numbers and biomass per unit area), and calculate annual production; community measures that have been examined in the previous BMP. Data will also be adapted to create an Index of Biotic Integrity (IBI) that is consistent with Kentucky Division of Water guidelines (KDOW 1993; Mills et al.1997). Fish sampling sites either overlapped or are within 100 m of the sites included in the benthic macroinvertebrate monitoring task. All field sampling will be conducted according to standard operating procedures (Ryon 199a).

The quantitative sampling will be continued so that comparisons can be made with historic data for the sites. This sampling provides additional information on length classes, biomass, and annual production that allow for a more detailed evaluation, as needed, to help determine impacts associated with point- and area-sources. The sampling methods will continue to be based on 3-pass removal estimates with block-nets defining the sample reach. The use of blocknets and taking measures of length and weight are alternatives identified by the USEPA as acceptable for a fish evaluation (Barbour et al. 1997).

All stream sampling will be conducted using two or three Smith-Root backpack electrofishers, depending on stream size. Each unit can deliver up to 1200 V of pulsed direct current in order to stun fish. The sample sites will be 80 to 120 m in length and include riffle, run, and pool habitats. After 0.64-cm-mesh seines are placed across the upper and lower boundaries of the fish sampling site to restrict fish movement, a five- to nine-person sampling team electrofishes the site in an upstream direction on three consecutive passes. All appropriate habitats will be sampled, and a consistent degree of effort will be expended on each pass, tempered by the number of fish present (i.e., less effort may occur on the second and third passes, only because fewer fish remain). Stunned fish will be collected and stored, by pass, in seine-net holding pens (0.64-cm-diam mesh) or in buckets during further sampling.

Following the electrofishing, fish will be anesthetized with MS-222 (tricaine methanesulfonate), identified, measured (total length), and weighed using Pesola spring scales. Individuals are recorded by 1-cm size classes and species. After ten individuals of a species-size class are measured and weighed, additional members of that size class will only be measured. At sites with extremely high densities, specimens of some species may be merely counted after a sufficient number of lengths and weights have been obtained. Length-weight regressions based on the measured individuals will be used to estimate missing length and weight data. Observations will also be made of obvious diseases, parasites, injuries or deformities on individual fish that may be related to stress at the site. Generally specimens will not be preserved from the sampling. However, fish that are unique or new to a site, or that may require taxonomic verification will be preserved in a 10% formalin solution for later taxonomic analysis. The identifications for these specimens will typically be verified by a second ichthyologist (e.g., D. A. Etnier at the University of Tennessee), and then cataloged in the fish reference collection or donated to reference collections at academic institutions.

After processing fish from all passes, the fish will be allowed to fully recover from the anesthesia and returned to the stream. Any additional mortality that occurs as a result of processing will be noted at that time and reported in the annual State Scientific collecting permit renewal application.

Following completion of fish sampling, the length, mean width, mean depth, and pool:riffle ratio of the sampling reach will be measured at each site. Photos will be made of the sampling reach to document obvious changes in channel morphology or habitat structure. Also, a qualitative habitat evaluation will be made at each site using methodologies recommended by Rankin (1987), Barbour et al. (1997) and/or KDOW (1993).

6.2.3 Data Analysis

Quantitative species population estimates will be calculated using the maximum likelihood method of Carle and Strub (1978). Biomass will be estimated by multiplying the population estimate by the mean weight per size class. To calculate density and biomass per unit area, total numbers and biomass will be divided by the surface area (m^2) of the study reach. These data will be compiled and analyzed by a comprehensive Fortran 77 program developed by ESD staff (Railsback et al. 1989).

Annual production will be estimated at each site using a size-frequency method (Garman and Waters 1983) as modified by Railsback et al. (1989). Production will be calculated for the period between the fall sampling date of the current year and the preceding year.

The Index of Biotic Integrity (IBI) is an analysis tool developed by Karr et al. (1986) that provides an integrative assessment of fish condition and abundance, species richness and composition, and trophic composition. Although originally designed for analysis of Midwestern streams, the IBI has been adapted to many regions of the United States (Miller et al. 1988). Analysis of fish community data using an IBI is a standard approach for many state water quality organizations (Barbour et al. 1997), and is utilized in Kentucky (KDOW 1993; Mills et al. 1997). The Kentucky IBI is based on an electrofishing or seine sample of all available habitats at a site, including pool, run, and riffle for approximately an hour to generate a relative abundance estimate and provide community composition data (Mills et al. 1993). The resulting data are compared to regional references and to adjusted metrics in the IBI to determine a relative ranking of the site. Currently, the state is in the process of developing regional reference data (e.g., see Mills et al. 1997), but a reference data set for the Mississippi Alluvial Plain, including Big Bayou and Little Bayou creeks has not been developed (M. Compton, KDOW, personal communication 1998). Until the state has developed a regional reference for this ecoregion, we will calculate our IBI values based on data generated from our sampling in the region (Ryon and Carrico 1998; and Paducah Site Biological Monitoring Program annual reports). Much of the guidance provided by the Kentucky Division of Water (KDOW 1993; Mills et al. 1997) will still be applicable to determine IBI ratings (e.g., the classification of Kentucky fishes). Any deviations from this guidance will be documented and justified in the annual presentation of fish community data in watershed monitoring reports.

Data collected from the habitat surveys of the sample sites will be compiled in a qualitative habitat index that provides a relative rating of each site. These ratings will be useful for year to year comparisons, for comparisons to the upper Big Bayou Creek and Massac Creek references, and to help document any habitat deficiencies that may influence the fish communities.

6.3 BIOACCUMULATION

6.3.1 Introduction

Bioaccumulation monitoring of PCBs has been conducted by ORNL as part of the Paducah Site BMP. From April 1992 to April 1996, twice per year sampling of longear sunfish for PCBs was conducted at four sites on Big Bayou Creek (BBK 12.5, 10.0, 9.1, and 2.8; BBK 2.8 was eliminated in 1995). From October 1992 through March 1999, monitoring of PCBs in spotted bass (*Micropterus punctulatus*) at BBK 9.1 has also been conducted. Results of this monitoring are published in Kszos et al. 1994; Kszos 1996a, b, 1997, 1998. PCB concentrations in sunfish in Big Bayou Creek declined to near background levels over the

1992–95 period; therefore monitoring in this stream was reduced to a single site at BBK 9.1 which is located immediately below the most downstream Paducah Site discharge to Big Bayou Creek. Because Big Bayou Creek is capable of supporting a limited sport fishery for larger game fish, the spotted bass was chosen as the representative species for this fishery. Results of the most recent monitoring events are presented in Table 6.1.

Twice per year monitoring of PCBs in longear sunfish has been conducted at three sites on Little Bayou Creek (LUK 9.0, 7.2, and 4.3) since April 1992. The long-term pattern of mean PCB concentrations in fish at the uppermost site in Little Bayou Creek gives evidence of continued but decreased inputs of PCBs to the creek headwaters (Fig. 6.7). Considerable temporal improvement has been evident in PCB contamination in Little Bayou Creek, where average concentrations in sunfish at LUK 9.0 have decreased from nearly 2 $\mu g/g$ in spring 1992 to less than 0.4 $\mu g/g$ in fall 1997. As headwater inputs decrease, the relative importance of in-stream contamination as a source of contamination to fish increases. In the absence or reduction of continued upstream inputs, contaminated sediments should be gradually washed out and/or buried, and the downstream profile in which PCB concentrations at LUK 7.2 (and eventually LUK 4.3) exceed those at LUK 9.0 should become more frequent or typical.

6.3.2 Sample Collection and Analysis

Because sunfish are short-lived and have small home ranges, they represent recent contaminant exposure at the site of collection and are thus ideal monitoring tools for evaluating spatial and temporal trends in contamination. Collections of sunfish will be restricted whenever possible to fish of a size large enough to be kept by sport fisherman in order to minimize effects of covariance between size and contaminant concentrations and to provide data directly applicable to assessing risks to people who might eat fish from these creeks. Six longear sunfish, > 40 g in weight, will be collected at each site. Smaller fish may be taken when low abundance of larger fish makes a full collection of 40 g or larger sunfish impractical or difficult.

All fish will be collected by backpack electrofishing. Longear sunfish will be collected for PCB analysis at three sites on Little Bayou Creek, LUK 9.0, LUK 7.2 and LUK 4.3 (Fig. 1.1) in the fall. Spotted bass will be collected from BBK 9.1 in the fall for PCB analysis. Massac Creek (MAK 13.8) will be sampled concurrently and will serve as a local source of uncontaminated fish.

For filet analysis, each fish will be tagged with a unique four-digit tag wired to the lower jaw and placed on ice in a labeled ice chest. Fish will be held on ice and processed within 48 hours of collection. Each fish will be weighed and measured, then filleted, scaled, and rinsed in process tap water. Samples of sunfish for specific analyses will be excised, wrapped in heavy duty aluminum foil, labeled, and frozen in a standard freezer at 15°C. For spotted bass, filets will be wrapped and labeled as were sunfish samples, but at a later date the frozen filets will be partially thawed, cut into 2- to 4-cm pieces, and homogenized in a stainless steel blender. A 25-g sample of the ground tissue will be wrapped in heavy duty aluminum foil, labeled, frozen, and submitted to an analytical laboratory for PCB analyses. Any remaining tissue from filets of sunfish or larger fish will be wrapped in foil, labeled, and placed in the freezer for short-term archival storage. PCB analyses will be conducted using Soxhlet extraction techniques according to SW-846 Method 3540 and analysis by capillary column gas chromatography using SW-846 Method 8080 (EPA 1986).

Table 6.1. Mean concentration of PCBs (μg/g, wet weight) in filets of fish from streams near the Paducah Site October 1996, May 1997, and October 1997

Site[a]	Species[b]	Mean[c]	SE	Range	n
		October 1996			
BBK 9.1	Spotted bass	0.45	0.07	0.30–0.58	4
LUK 9.0	Longear sunfish	0.64	0.13	0.35–1.19	6
LUK 7.2	Longear sunfish	0.72	0.07	0.48–0.93	6
LUK 4.3	Longear sunfish	0.13	0.06	<0.01–0.32	5
MAK 13.8	Redbreast sunfish	<0.01			4
		May 1997			
LUK 9.0	Longear sunfish	0.62	0.04	0.47–0.78	6
LUK 7.2	Longear sunfish	0.48	0.12	0.22–0.85	6
LUK 4.3	Longear sunfish	0.12	0.04	<0.01–0.27	5
MAK 13.8	Longear sunfish	<0.01			4
		October 1997			
BBK 9.1	Spotted bass	0.07	<0.01	0.06–0.07	4
LUK 9.0	Longear sunfish	0.37	0.10	0.13–0.66	6
LUK 7.2	Longear sunfish	0.48	0.15	0.12–1.11	6
LUK 4.3	Longear sunfish	0.06	0.01	<0.01–0.12	6
MAK 13.8	Longear sunfish	<0.01			4

[a]BBK = Big Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer.

[b]Spotted bass = *Micropterus punctulatus*; Longear sunfish = *Lepomis megalotis*; Redbreast sunfish = *Lepomis auritus*.

[c]Value of ½ the detection limit was used in calculating means for samples

In addition to blanks and laboratory control standards routinely run by the analytical lab, standard reference materials (fish, whenever possible) and/or spike samples of fish known to be uncontaminated, will be run to demonstrate complete recovery of analytes in the analytical procedure. Fish from uncontaminated reference sites will also be analyzed with each submission to demonstrate the absence of false positives or interferences, and establish background levels of contaminants. Approximately 10% of the samples will be run in duplicate, and spikes or standard reference fish and uncontaminated reference fish will each constitute approximately 10% of the samples submitted.

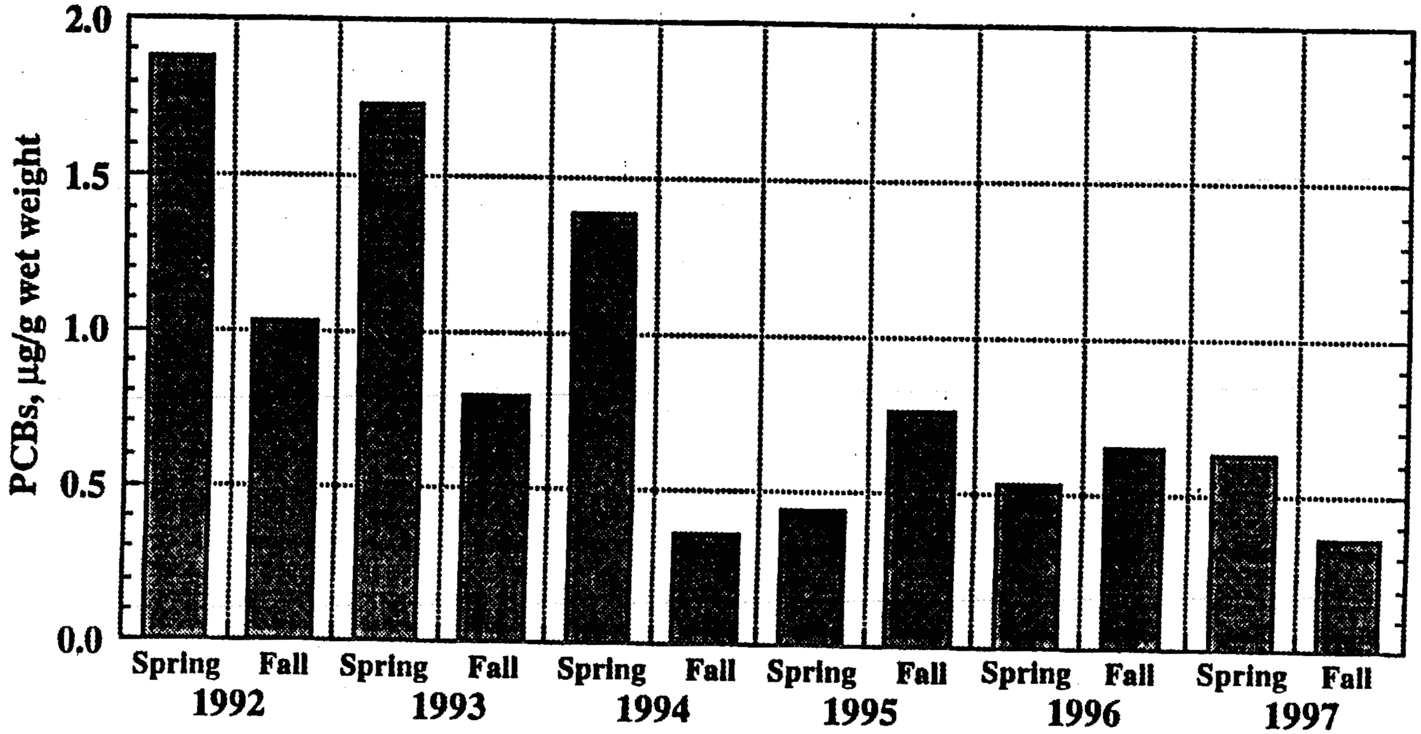

Fig. 6.7. Temporal changes in average PCB concentrations in longear sunfish (*Lepomis megalotis*) from Little Bayou Creek (LUK 9.0) near the Paducah Site.

6.3.3 Data Analysis

Data will be processed according to project-specific standardized technical procedures to ensure quality and integrity (Peterson and Phipps 1997). Analytical data will be evaluated for performance on quality assurance samples and reviewed for possible errors. Data will then be tabulated in an electronic spreadsheet.

Statistical summaries and tests will be generated using SAS software and procedures (SAS 1985a, b), or their equivalent. In addition to summary statistics, statistical tests will include where appropriate: tests for normality and homogeneity of variances, analysis of variance with various multiple comparison procedures for comparisons among individual means, or individual means versus reference site means. Analysis of covariance will be used for analyses where contaminant concentrations vary as a function of fish size, and linear and possibly non-linear regression procedures will be used to evaluate trends.

Results will be evaluated with respect to historical trends and response to specific events, such as remedial actions or major environmental changes. Careful attention will be given to evaluating data with respect to background levels of contamination, and levels which approach or exceed thresholds of concern for risks to human consumers or fish-eating wildlife. Temporal and spatial patterns of contamination will be evaluated to gain insight into the nature and location of contaminant sources, and data from open literature publications and other site-specific environmental studies will be used to gain greater understanding of bioaccumulation concerns at the Paducah Site.

7. QUALITY ASSURANCE (QA) STATEMENT

The quality of the data and analysis for each parameter listed in Section 6 is assured by use of the Biological Monitoring and Abatement Program (BMAP) Quality Assurance (QA) Plan (Phipps 1994) and by use of project QA plans (Smith and Smith 1995, 1999b, Peterson and Phipps 1997). The BMAP QA plan identifies requirements, assigns responsibilities for ensuring achievement of program objectives, and describes guidelines to be followed during BMAP activities. The BMAP QA program was developed based on the structure of DOE Order 5700.6C (Quality Assurance). The BMAP QA plan also incorporates applicable ORNL QA guidance for non-nuclear facilities. The major elements of the BMAP QA plan are: (1) description of the program, (2) personnel training and qualification, (3) quality improvement, (4) documents and records, (5) work processes, (6) design, (7) procurement, (8) inspection and acceptance testing, (9) management assessment, (10) independent assessment, and (11) data management.

Projects within BMAP require varying degrees of quality assurance; therefore, each discrete project has a separate but abbreviated quality assurance plan that identifies QA requirements specific to the project. The abbreviated QA plans reference the sections of the program plan applicable to each project. Special attention is directed to unique QA circumstances and requirements within the individual project. These requirements are documented as a feature distinctive to the project. This method allows emphasis on project-important needs and permits flexibility of procedural implementation within projects without requiring major programmatic changes. Uncontrolled copies of the benthic macroinvertebrate community studies, fish community studies, and bioaccumulation monitoring-aquatic project QA plans will be submitted to the KDOW under separate cover. Standard operating procedures (Table 7.1) have been written for each parameter in Section 6 and are available upon request.

Quality assurance/quality control activities for the benthic macroinvertebrate community sampling and analysis include, but are not limited to the following. A quality control check will be conducted of one randomly chosen sample replicate to assess processing efficiency and taxonomic accuracy by the contract laboratory. The outcome of this quality control check is supplemented by the outcome of similar checks on other projects. The quality of data and its accuracy will be verified through a series of checks (e.g., visual screening and analyses with standard computer programs) to identify data errors. Samples will be collected and processed according to project-specific standard operating procedures (Table 7.1; Smith and Smith 1995).

Quality assurance/quality control activities for the fish community sampling and analysis include, but are not limited to the following. Collected fish will be identified to the lowest possible taxon (species preferred) by a trained ichthyologist. Suspect specimens or specimens in which field identification is difficult will be preserved, transported to the laboratory and the identification verified by an outside ichthyologist. Quality assurance and verification procedures will be performed on fish community data with emphasis on inappropriate length and weight relationships, and correct entry of date, site, and species identification. These procedures will include SAS and FORTRAN programs (see Railsback et al. 1989). Samples will be collected and processed according to project-specific standard operating procedures (Table 7.1; Ryon 1999a).

Table 7.1. Applicable standard operating procedures available for collection of benthic macroinvertebrate and fish community data, and bioaccumulation of contaminants in fish data

Parameter	Standard operating procedure
Benthic macroinvertebrate community	Site selection, identification, and naming
	Replicate sample specific physical characteristics: stream samples
	Water quality measurements
	Selection of specific locations to collect replicate samples
	Quantitative sample collection
	Qualitative sample collection
	Sample chain-of-custody
	Transporting benthic macroinvertebrate samples
	Sample storage and maintenance
	Management and quality assurance of data
	Laboratory procedures for sorting invertebrate samples
	Biomass measurement
Fish community	Selection of sample sites
	Stream electrofishing for quantitative fish population estimation
	Field processing for fish population estimation
	Data recording and management of fish population - Newton Messagepad 100 Field Computer
	Measurement of area sampled for fish population estimation
	Calculating estimates of fish population size, density, biomass and production
	Cataloging and maintaining the ichthyological reference collections
	Field standardization and use of Pesola Spring scales

Table 7.1 (continued)

Parameter	Standard operating procedure
Fish community (continued)	Processing and verifying fish population data
	Voucher identification of fish at BMAP Sites
Bioaccumulation in fish	Collection and handling of resident aquatic organisms for bioaccumulation studies
	Processing of aquatic organisms for contaminant analysis
	Recording data and chain-of-custody information

Quality assurance for the bioaccumulation in fish sampling and analysis is evaluated by a combination of blind duplicate analyses, analysis of biological reference standards and uncontaminated fish, and determination of recoveries of analyte spikes to uncontaminated fish. SAS software and procedures will be used to calculate the mean, standard error, and standard deviation of PCB concentrations in fish at each site (SAS 1985 a,b). Samples will be collected and processed according to project-specific standard operating procedures (Table 7.1; Peterson and Phipps 1997).

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APPENDIX A
PART I.C. OF KPDES PERMIT KY0004049 ISSUED TO THE UNITED STATES DEPARTMENT OF ENERGY, EFFECTIVE APRIL 1, 1998

B. Schedule of Compliance

The permittee shall achieve compliance with all requirements on the effective date of this permit.

C. Big Bayou Creek and Little Bayou Creek Watershed Monitoring Program

As previously stated in the fact sheet for this permit USEC has leased gaseous diffusion process for the enrichment of uranium from the DOE and as such is obtaining a separate permit for a number of outfalls previously covered by this permit. Also as previously stated in the fact sheet DOE is currently involved with the cleanup of historic contamination and spills at the facility. The storm water runoff from the areas being remediated and those to be remediated by DOE can have a direct impact on the quality of the discharges through the outfalls now covered under the USEC permit. In light of the obvious compliance and enforcement problems this arrangement presents the Division of Water is proposing that DOE conduct an ongoing watershed monitoring program to determine the success of the cleanup efforts in lieu of establishing end of pipe limits on PCBs. This watershed monitoring program for Big Bayou and Little Bayou watersheds shall be developed using the guidelines issued by the Division of Water in "Methods for Assessing Biological Integrity of Surface Waters" and shall be reviewed by the Division of Water. The goal of this monitoring program will be to ensure that the DOE cleanup will result in these watersheds achieving compliance with the applicable water quality criteria. To that end within ninety (90) days of the effective date of the permit DOE shall submit to the Division of Water a study plan detailing the methodology for the monitoring program. Within ninety (90) days of the Division of Water review and concurrence the study plan DOE shall commence the implementation of the plan. Annual reports shall be submitted to the Division of Water by April 28th of the following year. The Division of Water may request more frequent reports if circumstances warrant such a submission.

D. Priority Pollutants

During the term of the permit the permittee shall conduct at least two complete scans for those pollutants listed on Form C, Section V, Part C from each designated outfall and shall be submitted to the Division of Water.

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