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Quarterly Progress Report

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Biological Monitoring Program for East Fork Poplar Creek

Submitted to

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Health, Safety, Environment and Accountability
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1. Introduction

In May 1985, a National Pollutant Discharge Elimination System (NPDES) permit was issued for the Oak Ridge Y-12 Plant. As a condition of the permit, a Biological Monitoring and Abatement Program (BMAP) was developed to demonstrate that the effluent limitations established for the Y-12 Plant protect the classified uses of the receiving stream (East Fork Poplar Creek; EFPC), in particular, the growth and propagation of aquatic life (Loar et al. 1989). A second objective of the BMAP is to document the ecological effects resulting from the implementation of a water pollution control program designed to eliminate direct discharges of wastewaters to EFPC and to minimize the inadvertent release of pollutants to the environment. Because of the complex nature of the discharges to EFPC and the temporal and spatial variability in the composition of the discharges, a comprehensive, integrated approach to biological monitoring was developed. A new permit was issued to the Y-12 Plant on April 28, 1995 and became effective on July 1, 1995. Biological monitoring continues to be required under the new permit. The BMAP consists of four major tasks that reflect different but complementary approaches to evaluating the effects of the Y-12 Plant discharges on the aquatic integrity of EFPC. These tasks are (1) toxicity monitoring, (2) biological indicator studies, (3) bioaccumulation studies, and (4) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

Monitoring is currently being conducted at five sites, although sites may be excluded and/or others added depending upon the specific objectives of the various tasks. Criteria used in selecting the sites include: (1) location of sampling sites used in other studies, (2) known or suspected sources of downstream impacts, (3) proximity to U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) boundaries, (4) concentration of mercury in the adjacent floodplain, (5) appropriate habitat distribution, and (6) access. The sampling sites include upper EFPC at kilometers (EFKs) 24.4 and 23.4 [upstream and downstream of Lake Reality (LR) respectively]; EFK 18.7 (also EFK 18 and 19), located off the ORR and below an area of intensive commercial and limited light industrial development; EFK 13.8 (also EFK 14), located upstream from the Oak Ridge Wastewater Treatment Facility (ORWTF); and EFK 6.3 located approximately 1.4 km below the ORR boundary (Fig. 1.1). Other sampling sites on EFPC are utilized as appropriate for individual tasks. Brushy Fork (BF) at kilometer (BFK) 7.6 is used as a reference stream in most tasks of the BMAP. Additional sites off the ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Hinds Creek, Paint Rock Creek, and the Emory River in Watts Bar Reservoir (Fig. 1.2).

2. Toxicity Monitoring (L. A. Kszos and A. J. Stewart)

2.1. Introduction

The ambient toxicity monitoring task includes three subtasks: toxicity monitoring, toxicity experiments, and supporting studies. Toxicity monitoring uses U.S. Environmental Protection Agency (EPA) approved methods with *Ceriodaphnia dubia* and fathead larvae to provide systematic information that can be used to determine changes in the biological quality of EFPC through time. Toxicity experiments are conducted to test specific hypotheses about stream water quality. These hypotheses are addressed experimentally by the systematic application of ambient toxicity test methods. Supporting studies are used to (1) investigate the relationship between the physicochemical and biological conditions in EFPC, particularly as they relate to processes or rates of ecological recovery and (2) develop better methods for accurately predicting ecological recovery with changes in water quality in EFPC. Toxicity monitoring at the upstream sites from Bear Creek Road [Lake Reality outfall or LR-o (EFK 23.8), LR inlet or LR-I (EFK 24.1) are conducted quarterly. Testing of the ambient sites downstream from Bear

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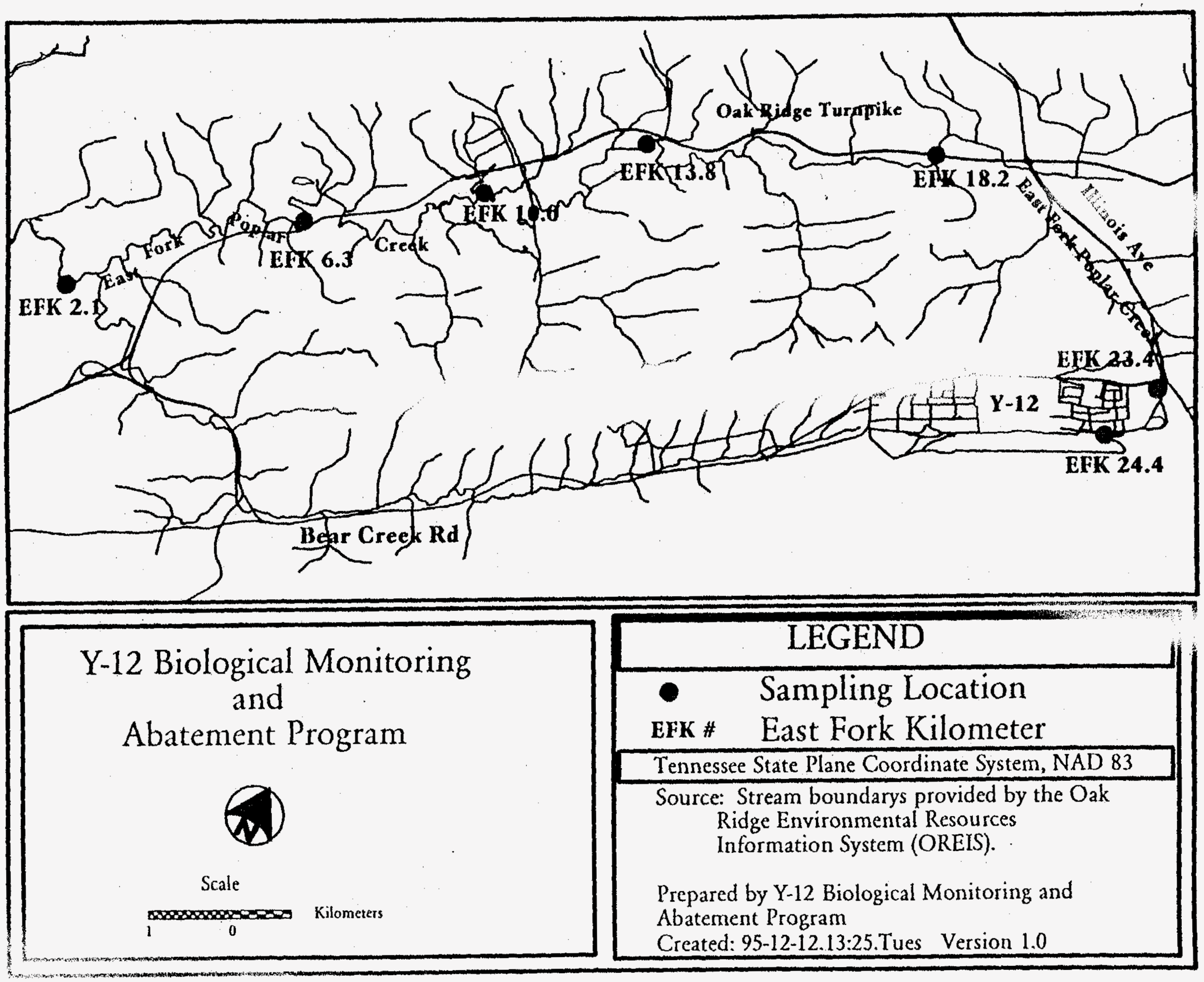

Figure 1.1. Location of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 Plant.

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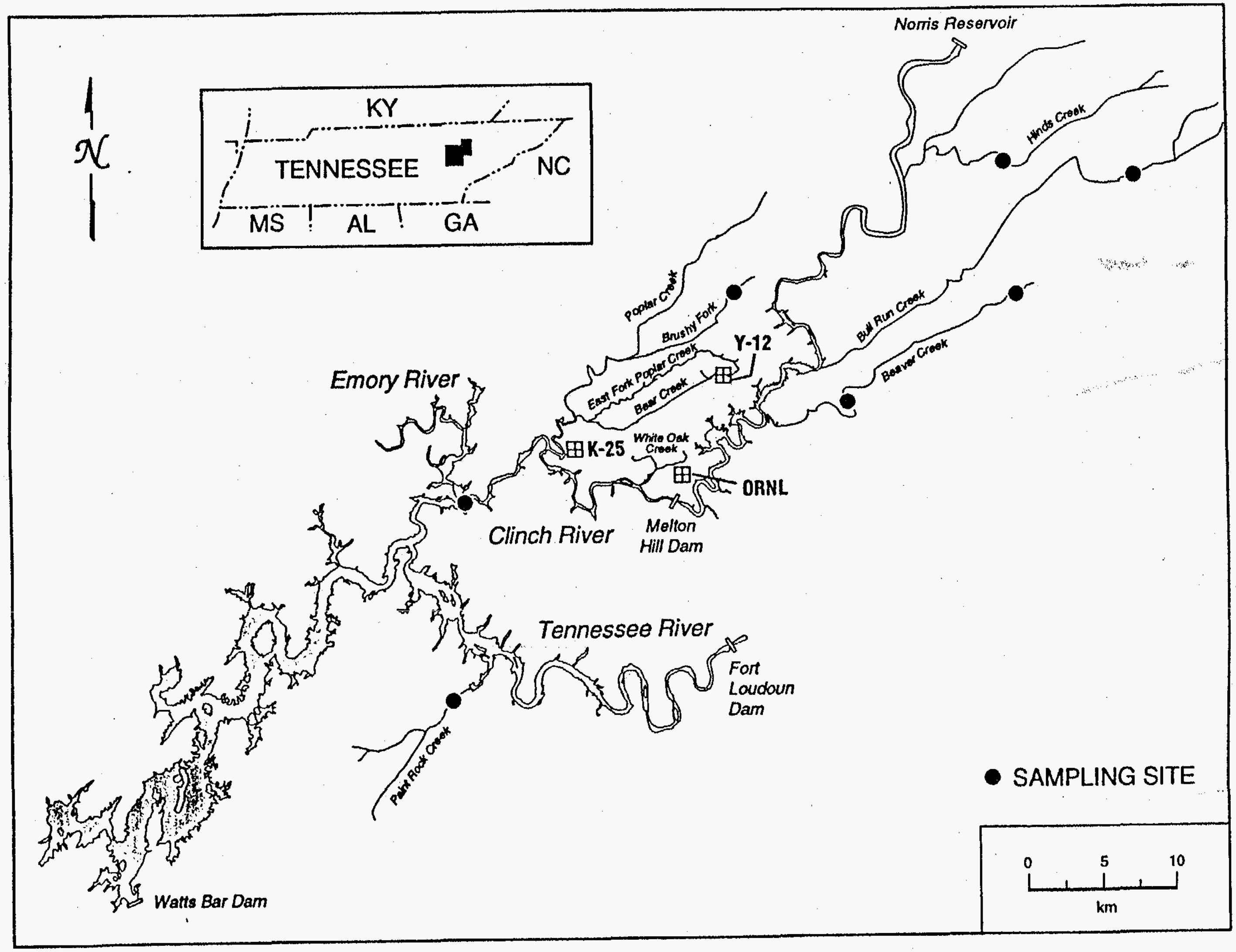

Figure 1.2. Location of reference sites in relation to the Oak Ridge Y-12 Plant.

Creek Road (EFKs 22.8, 21.9, 20.5, 18.2, 13.8, and 10.9) have been discontinued under BMAP. As required by the Y-12 Plant's National Pollutant Discharge Elimination System (NPDES) permit, quarterly toxicity tests with fathead minnows and *Ceriodaphnia* are conducted at Outfall 201. Because of the close proximity of Outfall 201 (an instream NPDES location in upper EFPC) to EFK 25.1, only toxicity tests at the outfall are conducted. The tests of water from Outfall 201 meet the intent of the BMAP Plan (Adams et al. 1996) to conduct quarterly toxicity tests at EFK 25.1. The results of the Outfall 201 tests are reported here and on the Discharge Monitoring Reports issued by the Y-12 Plant to the Tennessee Department of Environment and Conservation.

2.2 Results/Progress

2.2.1 Toxicity monitoring

Ambient water samples from EFK 24.1 and EFK 23.8, and effluent samples from Outfall 201, were evaluated for toxicity to *Ceriodaphnia dubia* during July 8–14, 1998. On each sampling day, grab samples of stream water or time-proportional composite samples from Outfall 201 were collected for testing. Results of the toxicity tests and attendant water-quality chemical analyses are shown in Tables 2.1 and 2.2. During the test period, *Ceriodaphnia* survival was 100% in all samples. *Ceriodaphnia* reproduction in the stream water or effluent samples was not significantly different compared to the control.

Table 2.1. Results of *Ceriodaphnia dubia* toxicity tests of ambient sites from East Fork Poplar Creek and Outfall 201 conducted July 8–13, 1998

\Sample	Concentration (%)	Survival (%)	Mean Reproduction (offspring/surviving female ± SD)
		Ambient sites	
Control	100	100	27.9 ± 3.1
EFK 24.1	100	100	25.6 ± 2.6
EFK 23.8	100	100	26.9 ± 3.5
		Outfall 201	
Control	100	100	26.8 ± 2.9
Outfall 201	100	100	27.4 ± 3.3
	80	100	25.6 ± 2 9

Note: EFK = East Fork Poplar Creek kilometer. SD = standard deviation.

Table 2.2. Summary (mean ± SD) of water chemistry analyses conducted during toxicity tests of ambient samples from East Fork Poplar Creek, June 8–13, 1998

Sample	pH (su)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Conductivity (µS/cm)
Control	8.31 ± 0.07	81.0 ± 3.4	97.3 ± 1.6	208.0 ± 2.4
Outfall 201	8.07 ± 0.08	91.5 ± 3.1	113.0 ± 0.7	246.0 ± 8.7
EFK 24.1	8.15 ± 0.11	94.8 ± 1.1	127.0 ± 6.8	278.2 ± 2.5
EFK 23.8	8.12 ± 0.08	97.0 ± 1.4	129.0 ± 4.9	292.8 ± 5.6

Note: EFK = East Fork Poplar Creek kilometer. SD = standard deviation.

2.2.2 Special Studies

During July 20–24, a five-day study was conducted to determine if stream-bed gravel was important as a sink for fine particulate matter in upper EFPC. Six pans, each 15.5 cm by 20 cm by 3 cm, were filled level-full with sieved, well-rinsed pea gravel. The gravel-filled pans were then covered with aluminum foil before being embedded in gravel, underwater, at six locations in the diversion ditch of upper EFPC. After placement, the aluminum-foil covers of the pans were removed carefully, so that the gravel in the pans was flush-level with gravel in the stream bed and exposed to the over-flowing water. The pans were positioned in the stream working from upstream sites to downstream sites, so that fine particulate matter disturbed while positioning a pan could not artificially contribute to the accumulation of fine particles in any of the other pans.

Eight samples of stream water from the diversion ditch just upstream from Lake Reality were collected and analyzed for turbidity and total suspended solids. Two *in situ* water-quality monitoring units, each programmed to record data on water temperature, turbidity, conductivity and pH, at 15-min intervals, were also deployed in upper EFPC. One of these devices was placed upstream of the stream reach where the pans were deployed; the other was placed downstream of the pans, immediately upstream from Lake Reality.

On the fifth day of the study, the pans were carefully re-covered *in situ* before being taken from the stream bed. The fine material that had accumulated in each pan was then separated from the pan's pea-gravel substrate by sieving and rinsing; this material was then concentrated onto pre-weighed glass-fiber filters. The filters (with their attendant load of fine particles) were then dried, weighed, ashed at 525 °C, and re-weighed to determine the net rate of deposition of inorganic and organic matter to EFPC stream-bed gravel. The data, expressed as grams of dry matter (inorganic plus organic) or grams of dry organic matter deposited per m^2 per day, are summarized as follows:

total dry matter: 536.1± 159.4 $g/m^2/day$ (mean ± SE)

organic dry matter: 26.8 ± 5.3 $g/m^2/day$ (mean ± SE)

The mean organic-matter content of the particulate matter trapped in the pans was 6.7%.

The results of this simple study suggest that interstices between gravel substrates in upper EFPC may be a significant short-term sink for materials such as Hg or PCBs, which tend to associate strongly with particulate matter. The study also shows that relatively uncomplicated methods probably can be used to estimate exchange rates of fine particles between water and gravel in upper EFPC.

3. Biological Indicator Monitoring

3.1 Bioindicators of Fish Health (*S. M. Adams*)

3.1.1 Introduction

This task involves the use and application of bioindicators of fish health, in addition to other investigative approaches, to evaluate the effects of water quality and other environmental variables on fish in EFPC. A suite of diverse bioindicators of fish health has been monitored since fall 1985 to evaluate the health of a sentinel species, the redbreast sunfish (*Lepomis auritus*), as a component of the BMAP program.

3.1.2 Results/Progress

This quarterly report presents the results of a special study conducted to determine if water quality in EFPC has an effect on the genetic integrity of *in situ* redbreast sunfish populations. DNA polymorphisms (i.e., the existence, in a population, of two or more alleles of a gene), detected by the Randomly Amplified Polymorphic DNA (RAPD) technique, were used as biomarkers to assess genetic diversity and genetic distance among populations of redbreast sunfish in EFPC and reference streams. The RAPD technique employs the polymerase chain reaction (PCR) with short oligonucleotide (i.e., linear sequence of up to 20 nucleotides joined by phosphodiester bonds) primers to produce DNA fragments which, when analyzed by gel electrophoresis, form banding patterns similar to DNA fingerprints of a population. A total of 13 primers produced 45 polymorphic DNA bands among all populations of fish tested in EFPC and two reference streams. Although only slight differences in genetic diversity were detected among sunfish within EFPC, the diversity of EFPC populations differed significantly from that of the reference populations.

Genetic relationships among populations can be graphically demonstrated by grouping fish according to the frequency of occurrence of various polymorphic DNA bands. In Figure 3.1, individuals from EFPC and reference sites were grouped into seven different clusters using bands which showed increased frequency downstream of the Y-12 Plant (genotypes A-G). Individuals which composed one particular cluster (cluster A, Fig. 3.1) shared a specific genotype which occurred at a much higher frequency in fish from the more contaminated sites (EFK 23 and 19) than in those individuals from less contaminated sites (i.e., lower EFPC and reference sites). This particular shared genotype was found in 31% of the EFK 23 population, in 18% of fish from EFK 19, 11% of individuals at EFK 14, 12 % of the population at EFK 5, 4% at Brushy Fork, and 7 % of the fish at Hinds Creek populations. The downstream pattern in this shared genotype is consistent with the downstream gradient observed for mercury in EFPC fish.

Genotoxic exposure (i.e., exposure to toxins which effect DNA) can act as a selective force by eliminating sensitive genotypes within a population, with a predictable shift in genotype frequencies of the affected population. Mercury is a known genotoxic agent which can cause genetic alterations in

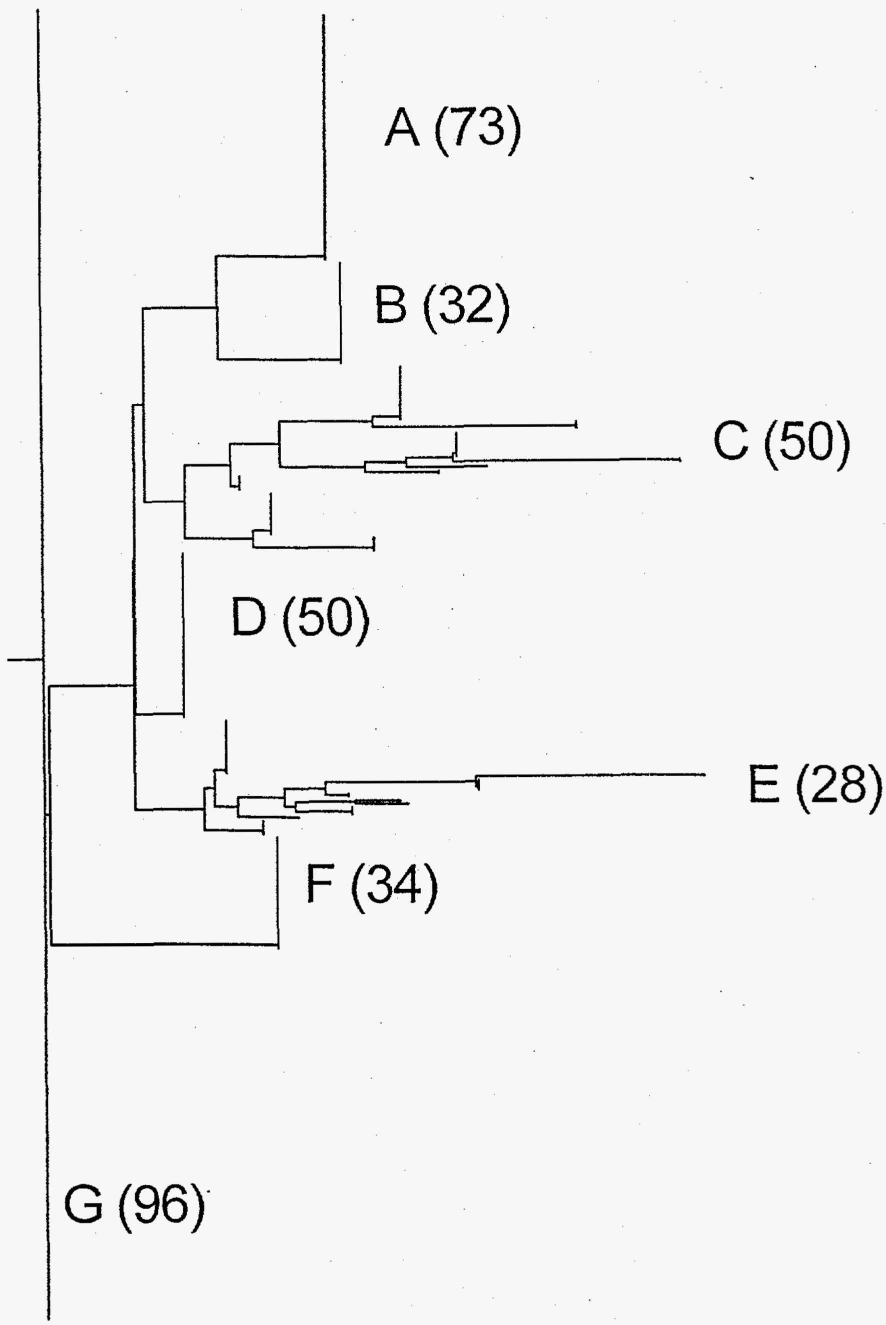

Figure 3. 1. Phenogram generated using bands which showed increased frequency in East Fork Popular Creek downstream of the Y-12 Plant. Genotype A represents fish with a genotype present in increased frequency in the more highly impacted sites compared to reference sites. Numbers in parentheses beside each of the 7 major genotypes (A-G) represent the number of fish represented by that particular genotype.

exposed organisms. Previous studies involving a very different molecular technique (DNA strand-break analysis: Hinzman 1993) have demonstrated that the DNA of EFPC fish is much more susceptible to strand-breakage and therefore differs significantly from reference fish DNA. Together, these results suggest that the fish populations in EFPC have undergone selective pressure, possibly due to exposure to mercury or other potential genotoxic agents in the upper reaches of the stream, and now, as a consequence, differ significantly from populations of sunfish in other uncontaminated streams in the area. Presumably, fish in EFPC that possess a particular genotype (i.e., those possibly derived from selective pressure from contaminants) should therefore have a selective advantage over fish not possessing this specific genotype and would represent a resistant population. As levels of mercury and other contaminants in EFPC continue to decline, we might expect to see, therefore, a gradual return to more generalized genotypes or those genotypes characteristic of the redbreast sunfish population before exposure to contaminants.

Identification of genetic biomarkers that have direct links to exposure to particular pollutants (such as mercury) would represent a powerful research tool that could be useful both in EFPC and in other aquatic systems. DNA responses such as these could serve as (1) biomarkers of genotoxic exposure, (1) bioindicators of potential genotoxic effects on populations and communities, (3) function as a useful environmental management tool, and (4) serve as indicators of the success of environmental restoration (such as is occurring in EFPC).

3.2 Bioindicators of Reproductive Competence (*M. S. Greeley, Jr.*)

3.2.1 Introduction

Successful reproduction of fish populations requires that adult fish be capable of producing and spawning viable gametes. To address the reproductive competence of adult fish in EFPC, various reproductive indicators, representing several different levels of reproductive organization related to gamete production, have been routinely examined in redbreast sunfish sampled from EFPC and reference streams at the beginning of each annual breeding season since 1988. Establishment and maintenance of stable fish populations also require that offspring be able to develop normally into subsequent reproductive cohorts. Beginning in 1990, water samples from several sites in EFPC and other streams on and about the ORR have been tested for their effects on fish developmental processes utilizing a variation of an EPA-standard medaka (*Oryzias latipes*) fish embryo-larval test (Benoit et al., 1991).

3.2.2 Results/Progress

Adult Reproductive Health —The annual BMAP monitoring of fish reproductive health was conducted at four sites in EFPC and at two reference sites during May and June 1998. Plasma and gonadal samples from the 1998 fish collections continue to be analyzed. Results are expected soon and will be reported in the next Y-12 BMAP quarterly report.

Developmental Health Testing —Medaka (fish) embryo tests have consistently shown that water from all sites tested in EFPC interferes with normal development and is often lethal to medaka embryos. A series of recently-completed medaka tests conducted under a number of different culture conditions are now being analyzed in relationship to the results of previous tests of EFPC water. These studies will be reported in the next quarterly report, as well as in the 4th Y-12 BMAP Report that is currently under development.

4. Bioaccumulation Monitoring

4.1 Routine Bioaccumulation Monitoring (*M. J. Peterson and G. R. Southworth*)

4.1.1 Introduction

Bioaccumulation monitoring conducted since 1985 as part of the EFPC BMAP has identified mercury and polychlorinated biphenyls (PCBs) as substances that accumulate to concentrations in fish that may pose health concerns to human consumers. Redbreast sunfish (*Lepomis auritus*) are collected twice annually from seven sites along the length of EFPC to evaluate spatial and temporal trends in mercury and PCB contamination. Largemouth bass, a species that achieves a large size, is at the top of the food chain, and contains relatively high levels of intramuscular lipids, are sampled once annually in upper EFPC to evaluate the maximum mercury and PCB concentrations likely in the EFPC system.

Presented in this quarterly report is a summary of the mercury trends in upper EFPC. Mercury data collected through spring 1998 is included. A more detailed discussion of the mercury issue is being prepared for the Annual Mercury Abatement Report for 1998. Final draft of this document will be transmitted to TDEC in November.

4.1.2 Results/Progress

Mean mercury concentrations in redbreast sunfish collected from EFPC in May 1998 are presented in Table 4.1. Sunfish averaged between 0.5 and 0.8 µg/g throughout EFPC. Fish from Lake Reality and station 17 (EFK 23.4) contained the lowest average mercury concentrations in May 1998, but the averages at these sites have varied widely since flow management activities were initiated in the fall of 1996. The intermittent functioning of the Lake Reality bypass experiment during this period may be the primary cause. Greater than 70% of the fish collected from East Fork Poplar Creek in May 1998 exceeded EPA's screening value of 0.6 µg/g. However, only three fish exceeded the 1 µg/g Food and Drug Administration threshold limit. Mean mercury concentrations in fish from throughout EFPC in May 1998 were greater than an order of magnitude higher than fish from an uncontaminated stream in east Tennessee. Mercury concentrations in sunfish from Hinds Creek, an uncontaminated reference site, averaged 0.06 µg/g (Table 4.1).

Mercury concentrations in fish in upper EFPC (EFK 24.8) and at the plant boundary (EFK 23.4) show a consistent downward trend from 1994 - 1998 (Fig. 4.1). These results suggest that reductions in concentrations of total and dissolved inorganic mercury in upper EFPC are being translated into reduced bioaccumulation of mercury. They support the conclusion that a site specific model of the relationship between concentrations of mercury in water and fish may be more appropriate than a saturation or threshold model in describing mercury bioaccumulation in EFPC. If this is so, it may be possible to achieve mercury concentrations in sunfish of less than 0.5µg/g at aqueous mercury concentrations in the 100 -200 ng/L range. Mercury concentrations in this range now occur in EFPC immediately upon mixing of the Outfall 200 (N/S pipe) and raw water flows in upper EFPC, but rise to 400 -600 ng/L at Station 17. Sources associated with the streambed and underlying karst system may be the cause of this increase.

Table 4.1. Average (± SE) concentrations of mercury (µg/g, wet wt.) in muscle tissue of redbreast sunfish collected from East Fork Poplar Creek and Hinds Creek, May 1997 – May 1998.

Site	May 1997	December 1997	May 1998
EFK 24.5	1.22 ± 0.10	0.77 ± 0.06	0.77 ± 0.06
EFK 24.0 (Lake Reality)	0.45 ± 0.03	0.76 ± 0.11	0.57 ± 0.03
EFK 23.4	0.52 ± 0.09	0.76 ± 0.07	0.56 ± 0.03
EFK 18.2	0.72 ± 0.06	0.72 ± 0.09	0.70 ± 0.08
EFK 13.8	0.68 ± 0.04	0.97 ± 0.14	0.66 ± 0.02
EFK 6.3	0.76 ± 0.05	1.11 ± 0.15	0.79 ± 0.07
Hinds Creek	0.09 ± 0.02	0.08 ± 0.01	0.06 ± 0.01

Note: EFK = East Fork kilometer. Hinds Creek is an uncontaminated reference stream. N = 6 fish/site. Some fish were collected slightly prior to or after the month shown.

4.2 PCB Source Identification *(J. F. McCarthy)*

4.3.1 Introduction

Passive monitoring of polychlorinated biphenyls (PCB) using semipermeable membrane devices (SPMD) is being employed to determine the sources and sinks of PCBs at the Y-12 Plant.

4.3.2 Results/Progress

The results of an SPMD deployment in March-April 1998, conducted at the 13 sites along upper EFPC, will be reported in the next quarterly report and in the 4^{th} Y-12 BMAP Report that is currently under development.

5. Community Monitoring

5.1 Periphyton (*W. R. Hill*)

5.1.1 Introduction

Periphyton monitoring in EFPC occurs four times a year (as close to a quarterly sampling regime as environmental conditions will allow). Rocks and their associated periphyton are collected from three sites on EFPC (EFKs 24.4, 23.4, 6.3) and one site on Brushy Fork (BFK 7.6). Four rocks from each site are used in determining algal biomass (chlorophyll *a*) and rate of photosynthesis (^{14}C incorporation).

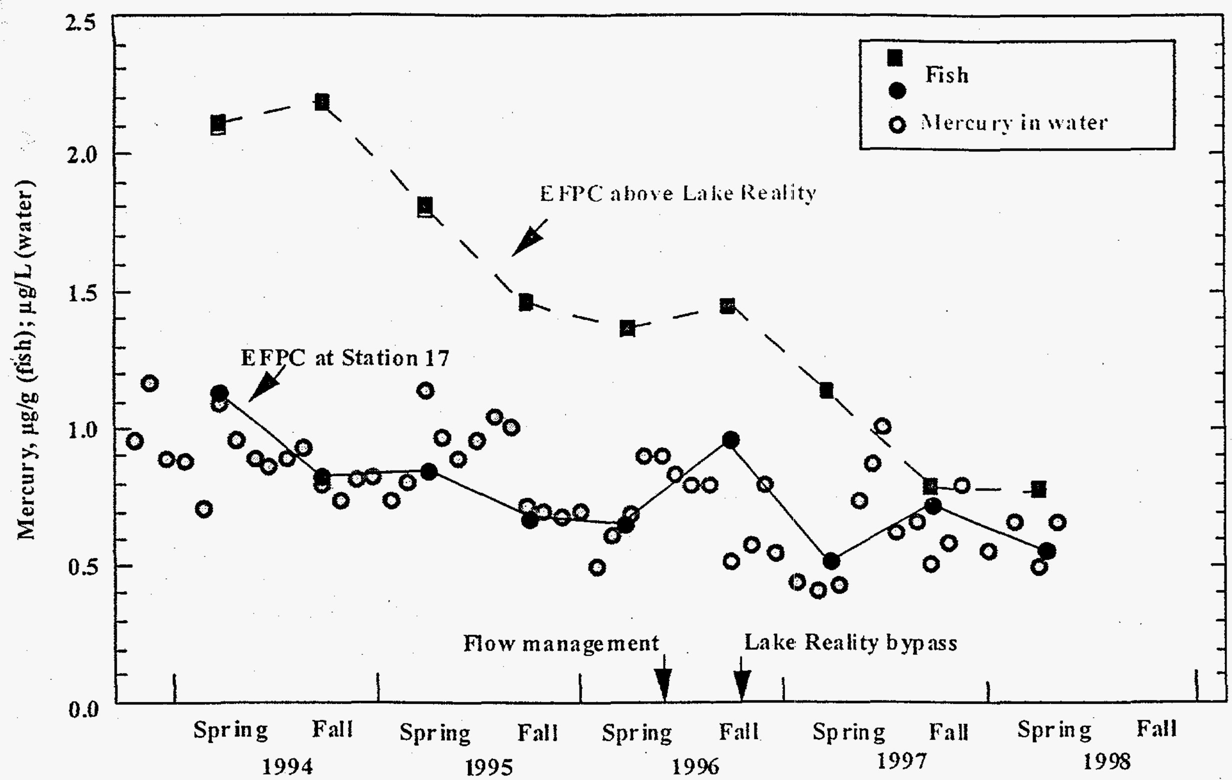

Figure 4.1. Average mercury concentration in redbreast sunfish fillets, East Fork Poplar Creek above and below Lake Reality, and monthly average total mercury concentration in water at Station 17, 1994 - 1998 .

5. Community Monitoring

5.1 Periphyton (*W. R. Hill*)

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5.1.2 Results/Progress

Periphyton biomass (as represented by chlorophyll *a*) and photosynthesis was measured on July 16, 1998. The results of the periphyton analysis appear in Table 5.1. Chlorophyll *a*, and photosynthesis, and chlorophyll-specific photosynthesis for EFK 24.4, EFK 6.3, and BFK 7.6 were within the range of historical means and were roughly similar to data obtained in April, 1998. In contrast, a large decrease in chlorophyll-specific photosynthesis occurred at EFK 23.4.

The mean chlorophyll-specific photosynthetic rate of 0.17 measured in July is lower than any of the annual mean rates calculated for this site during the past 10 years, and was less than 50% of the rate measured in the last sampling period (April). Chlorophyll *a* levels were normal for this site, so the low chlorophyll-specific photosynthetic rate indicates photosynthetic impairment. The actual photosynthetic rate, 6.6 μgC/cm^2/h, is not in itself unusually low, but it is low considering the amount of algal biomass present. The specific cause of photosynthetic depression at this site is unclear, but it is probably related to the Lake Reality bypass, which began July 9. Increased sediments, decreased temperature, or increased toxicant exposure associated with the bypass of Lake Reality may have reduced photosynthesis at EFK 23.4, which is immediately downstream of Lake Reality.

Table 5.1. Means and standard errors for biomass, photosynthesis, and chlorophyll-specific photosynthesis rates of periphyton collected from EFPC and Brushy Fork, July 16, 1998.

Site	Algal biomass (μg chla/cm^2)	Photosynthesis (μgC/cm^2/h)	Chlorophyll-specific photosynthesis (μgC/μgchla/h)
EFK 24.4	41.2 ± 7.6	9.2 ± 0.9	0.24 ± 0.03
EFK 23.4	40.6 ± 5.1	6.6 ± 0.6	0.17 ± 0.01
EFK 6.3	15.3 ± 3.0	6.3 ± 0.4	0.44 ± 0.06
BFK 7.6	8.6 ± 1.7	2.4 ± 0.3	0.31 ± 0.07

Note: EFK = East Fork kilometer, BFK = Brushy Fork kilometer

Periphyton in EFPC was sampled for metals analysis on September 3, 1998. These samples were sent to Southwest Research Institute for ICP metals analysis on September 9. Samples stored from collections made in the fall of 1997 were sent to Southwest for ICP analysis along with this year's samples.

5.2 Benthic Macroinvertebrate Community (*J. G. Smith*)

5.2.1 Introduction

The objectives of the benthic macroinvertebrate task are to monitor the benthic macroinvertebrate community in EFPC in order to provide information on the ecological condition of the stream, and to evaluate the response of macroinvertebrates to operational changes, abatement activities, or remedial actions at the Y-12 Plant as a measure of the effectiveness of these actions. To meet these objectives, routine quantitative benthic macroinvertebrate samples have been collected approximately twice annually (April and October) since 1985 from four sites on EFPC (EFK 24.4, EFK 23.4, EFK 13.8, and EFK 6.3). Since 1986, up to two reference sites unimpacted by industrial discharges have also been monitored, including one site each on Brushy Fork (BFK 7.6) and Hinds Creek (HCK 20.6) (Figs.1.1 and

1.2).In addition to routine benthic macroinvertebrate community studies, an in situ bioassay, using a locally available clam as the test organism, has also been periodically conducted. Such a study was initiated in early September 1998. A summary of the results to date is given below.

5.2.2 Results/Progress

Benthic Macroinvertebrate Community Studies — Average values for total taxonomic richness (number of taxa/sample) and richness of the Ephemeroptera, Plecoptera, and Trichoptera (number of EPT taxa/sample) for samples collected during the April sampling periods from 1986 through 1997 are presented in Figure 5.1. These two metrics have generally been dependable for evaluating the condition of EFPC, and identifying temporal changes indicative of improving conditions. EPT richness is particularly useful because the three major insect orders that comprise the metric are generally intolerant of poor environmental conditions.

From 1985 through 1998, total and EPT richness values were clearly low at EFK 24.4 and EFK 23.4 in April and October sampling periods compared to reference sites. However, total and EPT richness have generally increased through time at these two sites, while at the reference sites no consistent trends in change have occurred. Since 1985, total richness has almost tripled at EFK 24.4 and EFK 23.4 in both sampling seasons, and since 1990, EPT taxa have consistently occurred and their numbers have generally increased through time at EFK 24.4 and EFK 23.4. From 1989 through 1997, total taxonomic richness at EFK 13.8 consistently fell within the range exhibited by the reference sites. Except for the April sampling periods from 1995 through 1998, this has generally be true of EPT richness at EFK 13.8 as well.

These results indicate that the macroinvertebrate community at EFK 23.4 and EFK 24.4 remained significantly degraded through 1998. However, subtle but persistent increases in total richness and richness of pollution intolerant taxa at these sites, particularly since the early 1990s, indicate that conditions have improved in upper EFPC since 1985. Within a distance of about 10 km further downstream of EFK 23.4 (i.e., EFK 13.8), the macroinvertebrate community, as judged from total and EPT richness only, exhibits characteristics that indicate minimal or no impact relative to reference sites.

In Situ Clam Bioassay — An in situ bioassay using a locally available clam (*Spherium fabale*) was initiated in early September 1998. Clams were placed in situ in cages at three sites in EFPC (EFK 24.4, EFK 23.4, and EFK 13.8) and one site each in three reference streams: Brushy Fork (BFK 7.6), Cox Creek (CXK 0.2), and Hinds Creek (HCK 20.6). After 21 days of exposure, clams were retrieved, their lengths measured (growth), and they were checked for mortality. At this time, only 44% of the clams were alive at EFK 24.4 and EFK 23.4, while at EFK 13.8 and the reference sites, survival was over 93 % (Fig. 5.2). Clams in EFPC grew little, including those at EFK 13.8. At the reference sites on the other hand, clams grew an average of 0.17 mm at Brushy Fork and over 0.4 mm at Cox Creek and Hinds Creek.

5.3 Fish Community (*M. G. Ryon*)

5.3.1 Introduction

Fish population and community studies can be used to assess the ecological effects of water quality and/or habitat degradation. Fish communities, for example, include several trophic levels and

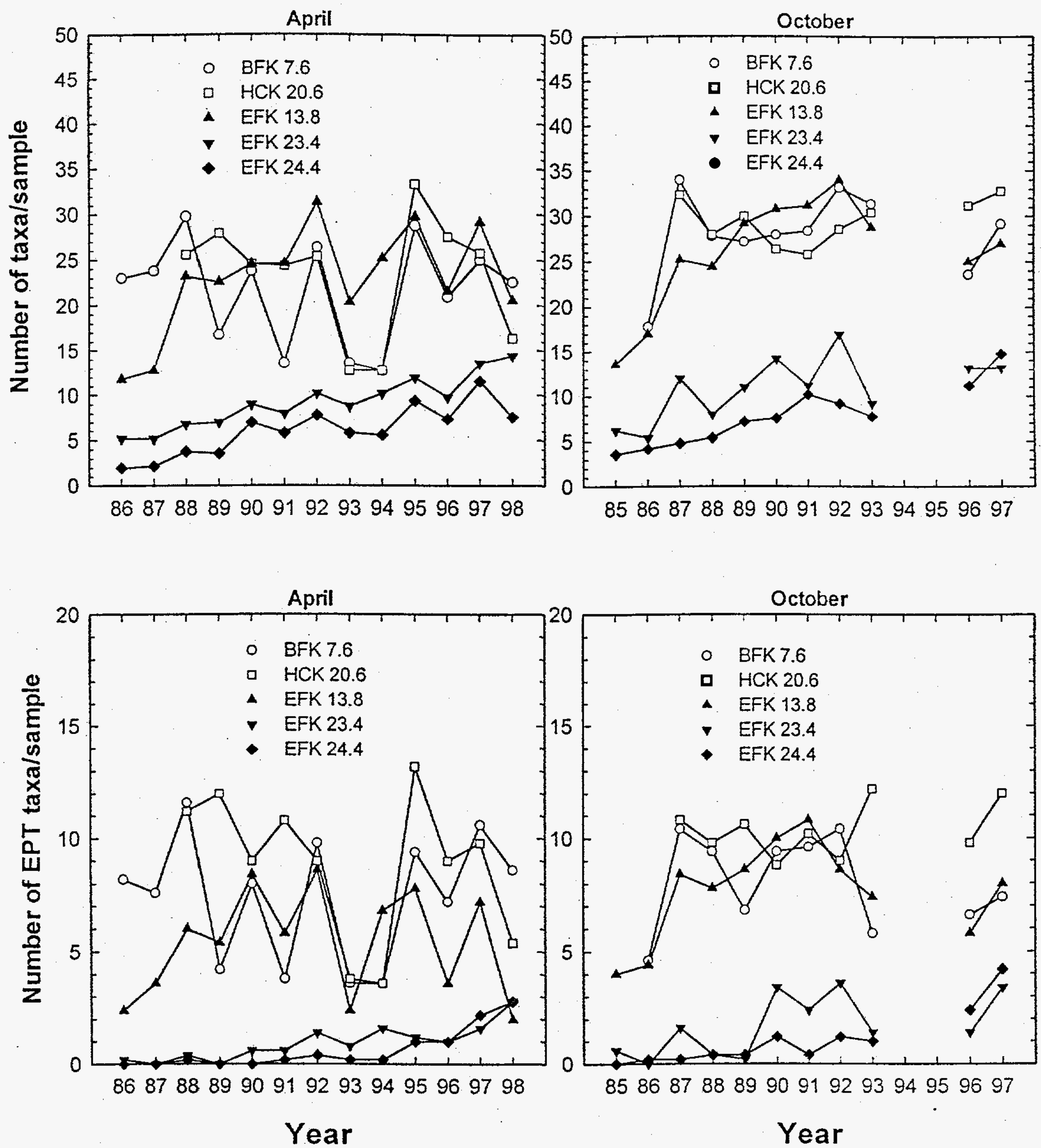

Figure 5.1. Mean total taxonomic richness (number of taxa/sample) and taxonomic richness (number of EPT taxa/sample) of the pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) of the benthic macroinvertebrate communities in EFPC and reference sites in Brushy Fork (BFK 7.6) and Hinds Creek (HCK 20.6) in April and October 1985 - 1998. Note that processing of samples collected in the October 1994 and 1995 sampling periods is not yet complete.

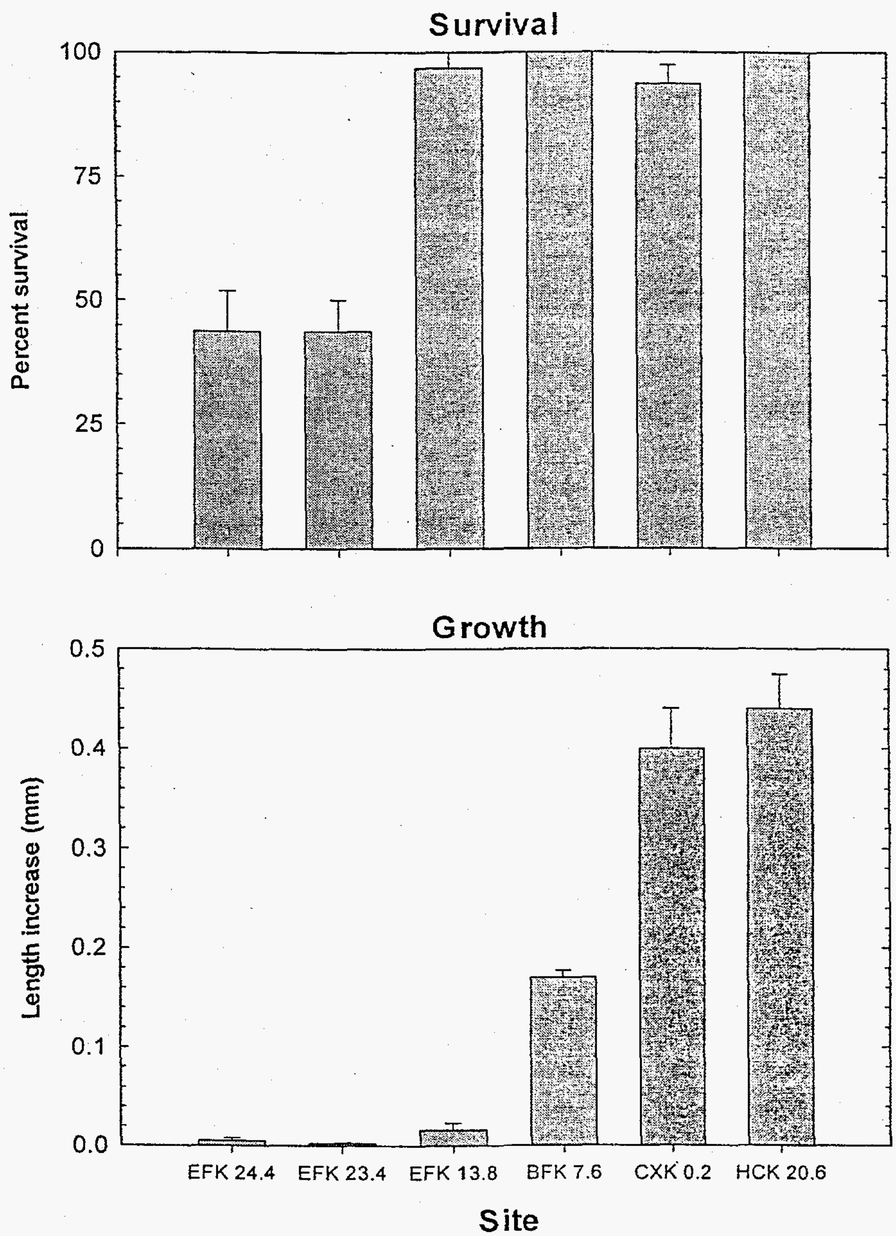

Figure 5.2. Mean survival (percent) and growth (length increase in mm) of clams (*Sphaerium fabale*) placed in situ in East Fork Poplar Creek and reference sites in Brushy Fork (BFK 7.6), Cox Creek (CXK 0.2), and Hinds Creek (HCK 20.6), September 4 through September 24, 1998.

species that are at or near the end of food chains. Consequently, they integrate the direct effects of water quality and habitat degradation on primary producers (periphyton) and consumers (benthic invertebrates) that are utilized for food. Because of these trophic interrelationships, the well-being of fish populations has often been used as an index of water quality. Moreover, statements about the condition of the fish community are easily understood by the general public.

The two primary activities conducted by the Fish Community Studies task in EFPC are: (1) biannual, quantitative estimates of the fish community at six EFPC sites and two reference stream sites; and (2) investigative procedures in response to fish kills near the Y-12 Plant. The quantitative sampling of fish populations is conducted by electrofishing during the March–April and September–October periods. The resulting data are used to estimate population size (numbers and biomass per unit area), determine length frequency, estimate production, and calculate Index of Biotic Integrity values. Fish kill investigations are conducted in response to chemical spills, unplanned water releases, or when dead fish are observed in EFPC. The basic tool used for fish kill investigations is a survey of upper EFPC (above Bear Creek Road to the N/S Pipes) in which numbers and locations of dead, dying, and stressed fish are recorded. This baseline is supplemented by special toxicity tests, histopathological examinations, and water quality measurements in an effort to determine the cause of observed mortality.

5.3.2 Results/Progress

No field activity associated with the quantitative fish community sampling was conducted during this quarter. Data analysis and summarizations were made in preparation for the annual state-of-the-creek address in August. Included in these analyses were temperature patterns in EFPC which indicated a general decline in mean temperatures, particularly following flow management. No substantial fish kills occurred during this quarter and a survey was not conducted to evaluate the background levels of mortality in EFPC above Bear Creek Road.

To help assess the potential for habitat restoration within the diversion channel, substrate studies were conducted. These studies focused on the stability of smaller cobble rock under various flow conditions within the channel and were conducted in conjunction with the benthic macroinvertebrate task. Statistical analyses of these data are being done, but in general there was little movement (<30 m) of a majority of the rock, particularly those rocks deployed in existing gravel substrate riffles. The lack of movement might be expected given the absence of any appreciable precipitation events.

6. Data Management (*S. W. Christensen*)

6.1. Introduction

Environmental Compliance projects are required by provisions of the Oak Ridge Reservation Federal Facilities Agreement (FFA) and the State of Tennessee Oversight Agreement (TOA) to transmit their data to the Oak Ridge Environmental Information System (OREIS). BMAP data managers receive data packages from the PIs of the other tasks, transform the data into appropriate OREIS formats, and facilitate the data transfer to OREIS. This task also administers the BMAP workstation.

6.2. Results/Progress

During the last quarter, data managers processed first and second quarter 1998 data for the toxicity testing task, and sent these to OREIS. Data processing continued on fish community studies data from fall 1997. Data management system operation, maintenance, and upgrade activities were also conducted.

7. Upcoming Field Activities

This section of the Y-12 BMAP quarterly report is meant to provide information to the Y-12 Environmental Compliance Office and other interested parties concerning BMAP plans for field activities in upper EFPC and adjacent environs during the upcoming calendar quarter.

Toxicity monitoring —We plan to determine water-to-substrate net deposition rates of fine particulate matter for upper EFPC and several other streams concurrently, during periods of base flow and slightly elevated flow, to help validate the method. Analysis of the trapped fine particulate matter for selected constituents (e.g., mercury) also could be used to develop and parameterize a stream contaminant-spiraling model proposed previously

Bioindicators — Periodic medaka tests of water from upper EFPC are anticipated to occur this quarter.

Bioaccumulation — Fall/winter sampling of fish for bioaccumulation studies will begin this quarter.

Community Studies — During the next quarter, the fall quantitative sampling will be conducted at all sites, including references, for both the fish and benthic macroinvertebrate community studies. A follow-up substrate study may also be conducted in the diversion channel, if time permits. One aim of this study would be to evaluate movement of substrate during and following significant rainfall events.

8. References

Benoit, D. A., G. W. Holcombe and R. L. Spehar. 1991. Guidelines for conducting early life stage toxicity tests with Japanese Medaka (*Oryzias latipes*). EPA/600/3-91/063. Environmental Research Laboratory - Duluth. Duluth, Minnesota.

Loar, J. M., S. M. Adams, L. J. Allison, J. M. Giddings, J. F. McCarthy, G. R. Southworth, J. G. Smith, and A. J. Stewart. 1989. The Oak Ridge Y-12 Plant Biological Monitoring and Abatement Program for East Fork Poplar Creek. ORNL/TM-10265. Oak Ridge National Laboratory. Oak Ridge, Tennessee.