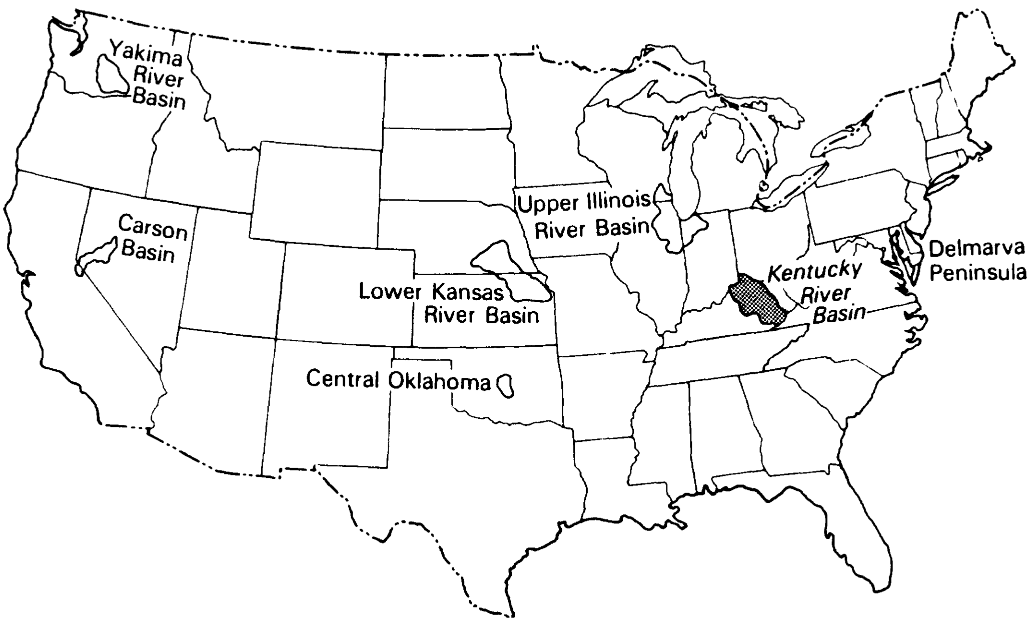
SUMMARY OF BIOLOGICAL INVESTIGATIONS RELATING TO SURFACE-WATER QUALITY IN THE KENTUCKY RIVER BASIN, KENTUCKY

by Arthur D. Bradfield and Stephen D. Porter



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SUMMARY OF BIOLOGICAL INVESTIGATIONS RELATING TO SURFACE-WATER QUALITY IN THE KENTUCKY RIVER BASIN, KENTUCKY

by Arthur D. Bradfield and Stephen D. Porter

ABSTRACT

Kentucky River Basin, an area of approximately 7,000 square miles (18,100 square kilometers), is divided into five hydrologic units that drain the Eastern Coal Field, Knobs, and Bluegrass physiographic regions. Data on aquatic biological resources collected in these five units by Federal, State, and private institutions were compiled and reviewed in this investigation. This report contains qualitative assessments of biological conditions in the major streams for which data were available. Readers needing quantitative information should refer to the original publications. An extensive reference list of reports containing biological data from the Kentucky River basin is included.

The three hydrologic units drained by the North, Middle, and South Forks of the Kentucky River are in the Eastern Coal Field physiographic region. Many streams in these hydrologic units are affected by drainage from coal mines and oil and gas operations. Many of these streams support only the more tolerant forms of aquatic biota, but those in undisturbed basins still support viable aquatic communities.

The Kentucky River from the confluence of the three forks to the Red River is in the Knobs physiographic region. Oil and gas operations and point-source discharges from municipalities have affected many streams in this part of the Kentucky River basin. The Red River, a Kentucky Wild River, supported a unique flora and fauna but is currently undergoing accelerated sedimentation. The Millers Creek drainage is affected by brines discharged from oil and gas operations, and some reaches support only halophilic algae and a few fish species.

The Kentucky River from the Red River to the Ohio River is in the Bluegrass physiographic region and is a set of impounded navigational pools formed by locks and dams. Sediment loads from agricultural sources and sewage effluent from rapidly growing urban centers have limited the aquatic biota in this part of the basin. Silver Creek and South Elkhorn Creek are particularly affected, and some aquatic communities are dominated by organisms tolerant of low dissolved oxygen concentrations. Biological data for Jessamine Creek, Dix River, North Elkhorn Creek, and Eagle Creek indicated adequate habitat and water quality for most commonly occurring aquatic organisms.

INTRODUCTION

The United States Geological Survey (USGS) began the National Water-Quality Assessment Program (NAWQA) in April 1986. This program was designed to provide a nationally-consistent description of current water quality conditions. Additional goals of the program were to define trends in water quality and to relate past and present environmental conditions to land- and water-use practices.

As a part of the initial phases of the NAWQA program in which assessment concepts and approaches were being tested, a study of the Kentucky River was initiated. Historical biological data collected for the Kentucky River basin were compiled and evaluated so that recommendations for the final study design could be made. The purpose of this report is to present a summary of the biological investigations that relate to surface-water quality in the Kentucky River basin. A secondary purpose is to provide qualitative assessments of biological conditions in the major streams and factors that affect those conditions. The summary information presented in this report is based on data that were available from Federal, State, and private sources.

The Kentucky River basin is divided into five hydrologic units (fig. 1) that drain three distinct physiographic regions (fig. 2). The three hydrologic units drained by the North, Middle, and South Forks Kentucky River are in the Eastern Coal Field physiographic region. The Kentucky River system from the confluence of the three forks to the Red River drains the Knobs physiographic region. The Kentucky River from the Red River to the Ohio River drains the Bluegrass physiographic region.

Streams are host to a variety of plants and animals that are dependent upon each other for food (Hynes, 1970). At the base of aquatic food chains or trophic structures are microscopic organisms such as bacteria, fungi, phytoplankton (suspended algae) and periphyton (attached, or benthic algae). These organisms obtain energy through photosynthesis (autotrophic) or by assimilation of instream organic material (facultative heterotrophic). They enhance water quality by removing and sequestering nutrients, heavy metals and other constituents, in addition to contributing to reoxygenation. Algae provide food for benthic macroinvertebrates (aquatic insects, mussels, and crustaceans) which in turn are a basic food supply for many species of fish. The more complex the trophic structure of a stream or river, the more efficiently it can "process" instream organic material for higher life forms (Cummins, 1974; Cummins and Klug, 1979).

Water-quality issues addressed in the NAWQA Program encompass a wide range of alterations to stream environments that directly or indirectly affect aquatic biota. Increased nutrient loads, changes in organic and inorganic constituent concentrations, and sediment transported from disturbed land can reduce or eliminate populations of intolerant organisms by causing acute or chronic toxicity, by affecting available food supply, or by destroying their habitat.

Because of the complex interactions of aquatic biota, considerable insight regarding water-quality conditions can be obtained by examining the types of organisms inhabiting a particular stream or river. Trophic-structure complexity can be estimated by considering the total number of aquatic species in a stream (taxa richness) and the distribution of individuals among different taxonomic groups (diversity and evenness) (Kentucky Department for Environmental Protection, 1987; Ludwig and Reynolds, 1988). In addition to these numerical measures of community structure, environmental requirements,

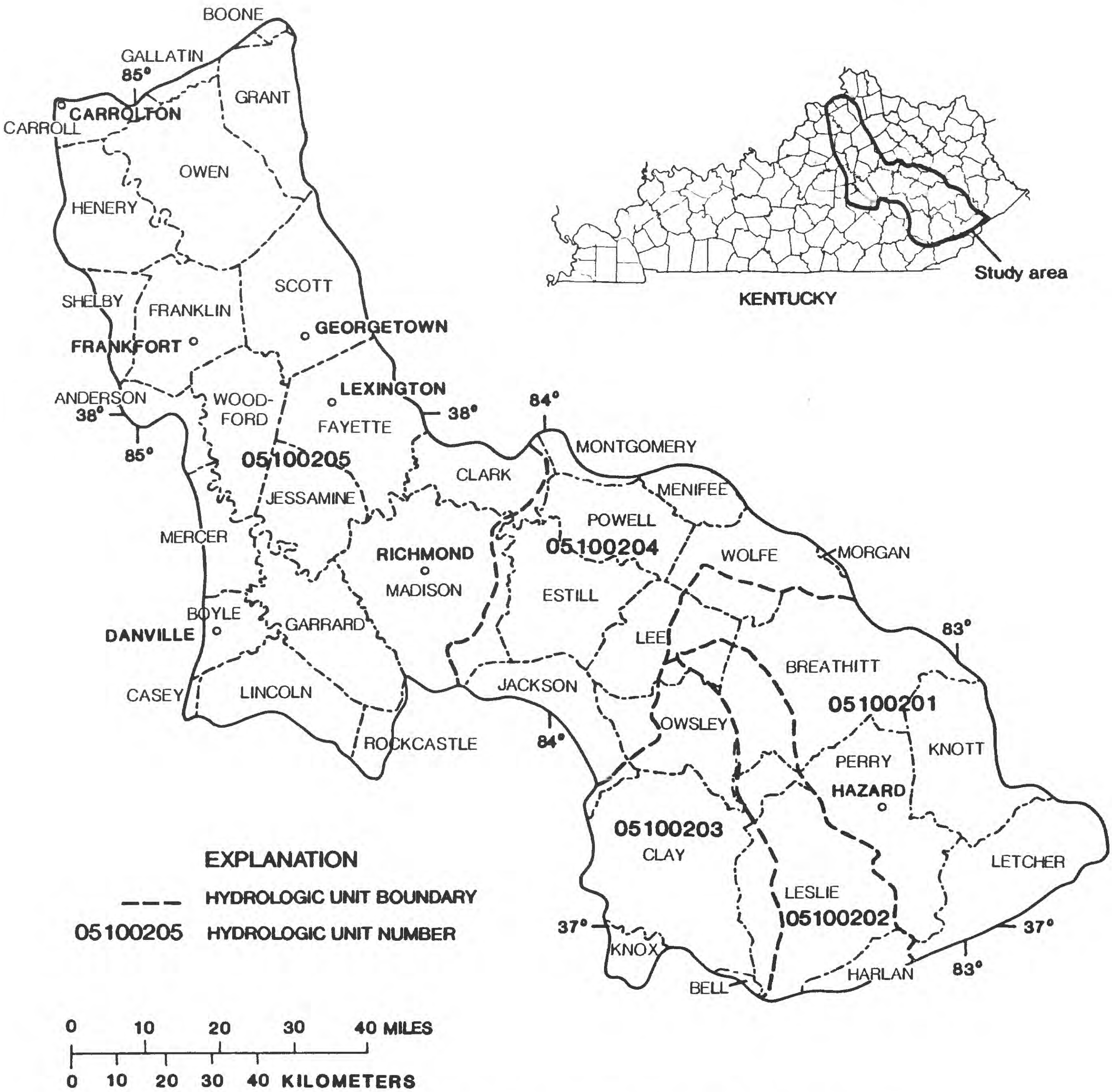

Figure 1.--Hydrologic units of the Kentucky River basin. (U.S. Geological Survey, 1976)

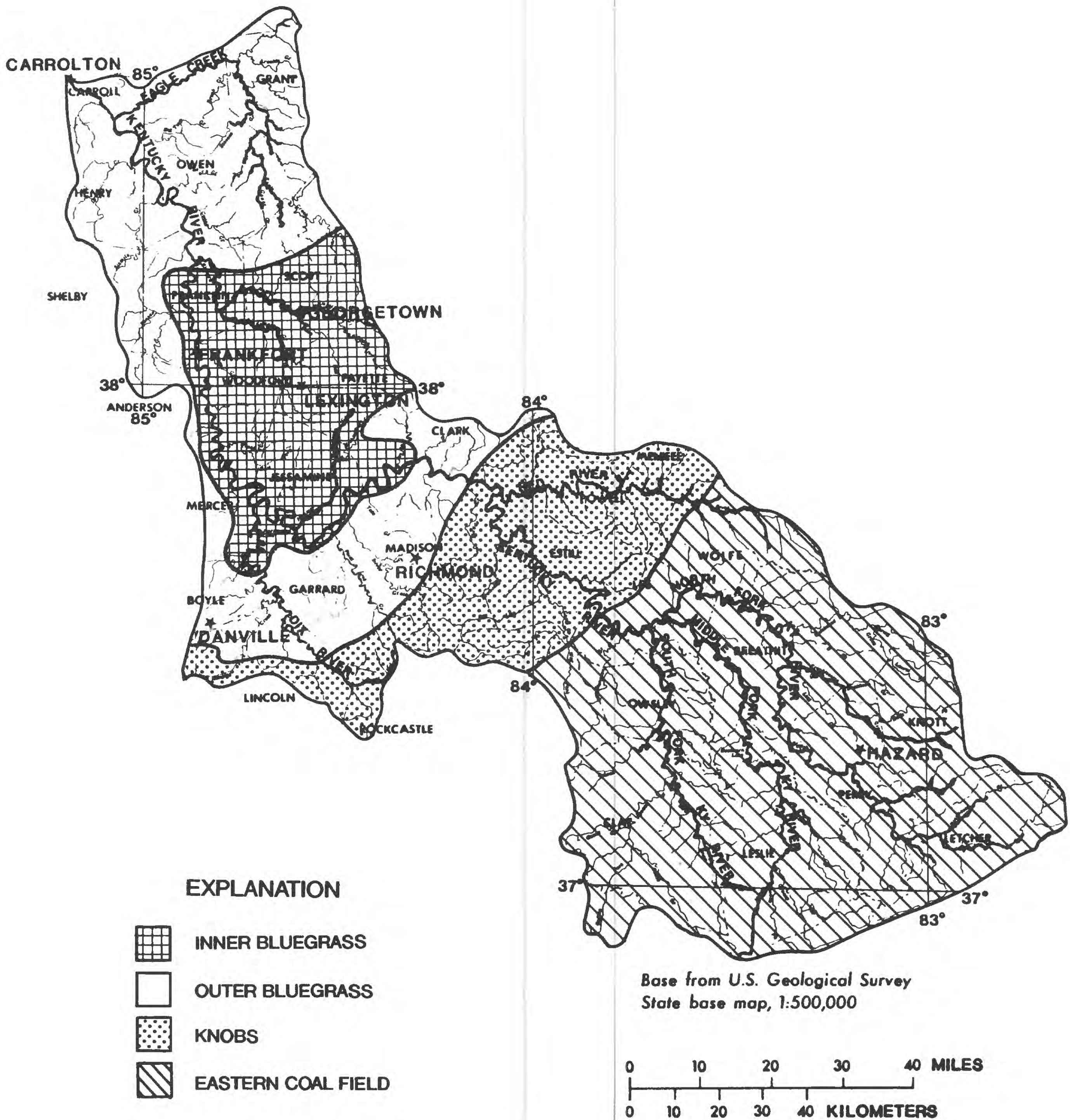

Figure 2.--Physiographic regions of the Kentucky River basin. (U.S. Department of Agriculture, 1981)

tolerance to pollution of dominant species, and the presence of intolerant species are important considerations. Biological data, along with information on water chemistry and physical habitat conditions, provide an integrated approach for assessing and monitoring the status of aquatic environments.

Streams in the Kentucky River basin and their biological communities were subjectively ranked for this report, provided sufficient biologic data were available. Generally, the stream biota or water quality was considered "good" if the stream environment was suitable to support a diverse biological community or if the presence of rare or sensitive species had been documented. Conversely, stream biota or water quality was considered "poor" or "degraded" if the stream environment was unsuitable to support a diverse biological community, if biota was dominated by tolerant species, or if the habitat was no longer suitable for rare or sensitive species.

Sources of Biological Data

Biological data have been collected in the Kentucky River basin by Federal, State, and academic organizations for more than a century. Early investigations of aquatic organisms were reported by Rafinesque (1820), Woolman (1892) and Danglade (1922). Later studies by university graduate students (Giovannoli, 1926; and Neel, 1938) added to the limited historical data for the Kentucky River.

Most of the information reviewed in this report are from studies conducted by the Kentucky Division of Water (KDOW), the Kentucky Nature Preserves Commission (KNPC), the Kentucky Department of Fish and Wildlife Resources (KDFWR), and the U.S. Geological Survey. Several notable research papers on specific groups of organisms were also reviewed and are included in the references. Of particular note are comprehensive works on the distribution of fish species (Burr and Warren, 1986; Kuehne, 1962a; Branson and Batch, 1974b, 1981a; Kuehne and Barbour, 1983, and Mills, 1988) and on the aquatic and wetland plants of Kentucky (Beal and Thieret, 1986).

Because the actual biological data are inherently more valuable than any single interpretation of the data, an extensive list of references is included in this report. References are divided into two lists: those that are actually cited in the report and additional references that contain biological data for streams in the Kentucky River Basin.

The authors express sincere appreciation to those who contributed to this report. We especially thank Ronald Cicerello and Richard Hannan of the Kentucky Nature Preserves Commission, Ron Houp and Lythia Metzmeier of the Kentucky Division of Water, and Jim Axon of the Kentucky Department of Fish and Wildlife Resources for supplying data and reviewing this report.

Rationale for Evaluations of Biological Data

Aquatic biological communities can provide valuable information for stream assessments. The abundance and distribution of aquatic species or groups of taxa reflect intermediate to long-term changes in water-quality conditions, as well as influences of drainage basin physiography. Algal communities can reflect relatively short-term (days to months) changes in water quality and aquatic habitat. For example, streams affected by oil-field brines frequently are dominated by halophilic ("salt-loving") diatoms, and streams which receive discharges of sewage effluents are characterized by dense growths of algal taxa associated with nutrient enrichment. Streams subjected to organic enrichment are characterized by algae possessing heterotrophic capabilities (the ability to use reduced carbon compounds as an energy source).

Streams draining basins with substantial areas of land disturbance, such as surface mining or farming, often receive large amounts of sediment that reduce the diversity of aquatic habitat. The effects of sedimentation can be inferred by the dominance of epipelic (associated with sediments) algal taxa. Most undisturbed streams in eastern Kentucky are characterized by epilithic (attached to rocks) and epiphytic (attached to filamentous algae and aquatic plants) diatoms (Kentucky Division of Water, 1986; Harker and others, 1979).

Alterations of aquatic environments may also be detected by changes in the community composition of benthic macroinvertebrates. Streams with rocky substrata and well-oxygenated waters usually support communities dominated by aquatic insects such as Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). A shift in dominance to more tolerant taxa such as Dipterans (midges) and Oligochaetes (worms) often occurs in response to increases in sedimentation or nutrient enrichment.

Macroinvertebrates are excellent indicators of intermediate to long-term changes (months to years) in environmental quality because of their relatively long and complex life histories (Pennak, 1989). The number of macroinvertebrate taxa is often reduced in streams characterized by poor water quality or limited habitat. In contrast, streams with exceptional water quality and diverse habitat generally support many macroinvertebrate taxa. Pelecypoda (freshwater mussels) are essentially non-motile and have long life spans and specific habitat requirements; consequently, they are very useful for determining long term environmental trends. The occurrence of Pelecypoda in the Kentucky River basin offers the potential for determining long-term trends in bioaccumulation of toxic substances such as heavy metals, pesticides, and other synthetic organic compounds.

The number and types of fish species are also an indication of environmental quality. For example, the number of darter species usually decreases in streams with degraded water quality and large amounts of sediment (Clay, 1975). Clean-water streams support a variety of sensitive taxa, including game species such as trout and muskellunge as well as nongame fish including certain darter and minnow species. In contrast, fish communities in polluted water are frequently limited to tolerant species such as carp, and mosquito fish (<u>Gambusia</u> sp.) Because of their ability to avoid localized or temporary water-quality perturbations, fish are often less reliable as indicators of local water quality than macroinvertebrates and algae. However, the analysis of fish tissue can reveal important ecological information regarding bioaccumulation of toxic substances, and bioassay investigations using species such as fathead minnows can address problems of wastewater effluent toxicity.

Troublesome Creek, a tributary to the North Fork Kentucky River. Buckhorn Creek has historically been affected by mining but it seemed to be recovering in 1973 and to be providing a limited fishery for black bass and rock bass (Jones, 1973). Sedimentation was noted to have subsided in 1973 but silt deposits were still prominent in some sections of the stream. Despite elevated concentrations of some water-quality constituents, Buckhorn Creek seems to be one of the largest relatively healthy aquatic systems in the Kentucky River drainage.

More recent data collected by the KNPC indicated that biological communities of Buckhorn Creek were relatively unaffected, although elevated specific conductance and sulfate concentrations were observed (Harker and others, 1979). Many species of benthic algae, including several uncommon diatoms and desmids, were supported by Buckhorn Creek. One hundred and six algal species, indicating favorable water-quality and microhabitat conditions, were identified during 1978. Diatom communities were dominated (94 percent relative abundance) by epilithic (attached to rocks) species associated with well-oxygenated lotic waters. The relative lack of epipelic (associated with sediments) species indicated that siltation was not a substantial problem. A total of 41 macroinvertebrate taxa were collected in 1978 which was viewed as similar to most other sites in the Kentucky River drainage, but lower than in collections from high-quality streams of eastern Kentucky. The fish of Buckhorn Creek have been well documented with a total of 42 species known for the drainage (Kuehne, 1962a, 1962b; Lotrich, 1973; Harker and others, 1979). Collections by KNPC revealed the presence of several darter species, including *Percina copelandi* and *Etheostoma sagitta spilotum*. The latter species is listed as being of special concern and warranting some level of protection (Warren and others, 1986). In addition, 12 cyprinid (minnow) species, indicative of good water quality and adequate habitat, were collected.

Intensive macroinvertebrate investigations were conducted by Phillippi (1984) in Buckhorn Creek and Clemmons Fork. Numerous taxa of Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera were collected over a 3-year sampling period. Considering the amount of land disturbance in the North Fork Kentucky River basin, the Buckhorn Creek drainage is an important source for faunal recolonization of Troublesome Creek and other river systems downstream. Buckhorn Creek, including Clemmons Fork and Coles Fork, was recommended as an Outstanding Resource Water by the KNPC (Hannan and others, 1982). Additional biological information on Buckhorn Creek and Clemmons Fork is presented by Shearer and others (1977), Clayton (1984), Springer and Coltharp (1978), and Bush (1959).

Troublesome Creek

Troublesome Creek, a fifth-order stream, is the largest eastern tributary of the North Fork Kentucky River (fig. 3). Woolman (1892) described the conditions in Troublesome Creek as pristine. In recent years, however, extensive contour and deep mining in the basin, a mountain top removal project, and sewage effluents from Hindman, Kentucky have severely degraded the aquatic resources of this stream (Harker and others, 1979; Miller and others, [no date]). Elevated concentrations of chemical constituents, such as sulfate concentrations greater than 200 mg/L, indicate significant land-use impacts. Aquatic communities were considered moderately diverse, but low total numbers suggest poor water quality or limited habitat.

As late as 1973, some reaches near the mouth of Troublesome Creek and Balls Fork, a major tributary, supported a viable fishery (Jones, 1973). Data collected in 1978 by the KNPC indicated that conditions had degraded throughout the Troublesome Creek drainage as indicated by elevated concentrations for some constituents and excessive turbidity. Benthic algae, macroinvertebrate, and fish populations were moderately diverse but total numbers of organisms were low (Harker and others, 1979).

Troublesome Creek supported 79 benthic algal species but the algal standing crop was described as sparse (Harker and others, 1979). Although diatom communities were dominated by species which are typically found in eastern Kentucky streams (e.g. <u>Achnanthes minutissima</u>), the occurrence of tolerant species of <u>Nitzschia</u>, <u>Gomphonema</u>, and <u>Navicula</u> possibly indicated moderate to high levels of sedimentation and nutrient or organic enrichment (Lowe, 1974). High algal diversity noted in the KNPC study did not reflect the extensive land disturbance in the basin, but rather was attributed to a large number of species with sparse populations (Harker and others, 1979).

Degraded environmental conditions were also reflected in the benthic invertebrate community. High sample diversity with low numbers of individual organisms has been documented in numerous studies of the effects of mining on aquatic biota. Generally the number of individuals of all taxa declined due to sedimentation and reduction of available habitat (Lotrich, 1973; Harker and others, 1979; Chadwick and Canton, 1984; Bradfield, 1986a and b). Macroinvertebrate samples collected by the KDFWR (Prather, 1985) included four species of Plecoptera; however, the community was dominated by Dipterans (24 taxa). The predominance of Dipteran (fly larvae) taxa indicated that the macroinvertebrate community in Troublesome Creek was adversely affected by mining, primarily through sedimentation and reduction of benthic habitat. Members of the Plecoptera (stoneflies), aquatic insects usually prevalent in unaffected streams of eastern Kentucky, were not detected by KNPC during 1978. The presence of only 25 taxa of macroinvertebrates at the Troublesome Creek site was comparable to numbers of taxa observed at other sites affected by mining.

Despite the obvious effects on the stream from coal mining and domestic sewage, many species of fish, including 10 darter species and 12 cyprinds, have been collected during biological surveys of Troublesome Creek (Lotrich, 1973; Harker and others, 1979). However, field observations generally indicated sparse populations of most species. Prather (1985) suggested that extensive sedimentation in pools limited the total number of individuals.

Carr Fork

Carr Fork originates in Knott County and flows southwesterly before joining the North Fork Kentucky River. Carr Fork Lake, an impoundment of the stream in Knott County, was classified as an oligotrophic reservoir prior to 1984 (Kentucky Division of Water, 1984); however, the trophic status was revised to eutrophic in a later assessment as a result of increased abundance

The Kentucky River system drains three distinct physiographic regions (fig. 2) which have been subdivided into five hydrologic units (fig. 1). Flora and fauna in areas with different geology, stream gradient, and land-use patterns are not readily comparable and would not necessarily reflect differences in environmental quality. Undisturbed streams in different physiographic regions have water-quality conditions that reflect the geology of the area. For example, streams draining sandstones and shales have lower concentrations of some dissolved constituents than streams draining more soluble limestones. Many aquatic species have specific physiological requirements for dissolved constituents, such as calcium, that may not be met in a particular physiographic region. Consequently the absence of such taxa would not be indicative of poor environmental quality. Streams draining similar physical environments should support similar organisms and consequently provide for a more realistic comparison of water-quality conditions in the basin. Because environmental disturbances frequently affect the entire aquatic community, groups of organisms commonly sampled in water quality surveys will be discussed collectively. The following sections of this report contain discussions of available biological data obtained from streams that comprise the Kentucky River system.

BIOLOGICAL CHARACTERISTICS OF THE KENTUCKY RIVER BASIN

Hydrologic Unit 05100201 - North Fork Kentucky River

The North Fork Kentucky River system drains Hydrologic Unit 05100201 (fig. 3), an area of approximately 1,310 mi^2 (3,390 km^2) in the Eastern Coal Field. Streams discussed in this section of the report include Buckhorn Creek, Troublesome Creek, Carr Fork, Laurel Fork, and the North Fork Kentucky River mainstem. This area is underlain by sandstone, siltstone, shale, and numerous coal beds. The topography is characterized by steep slopes and narrow valleys.

Mining of bituminous coal and the production of oil and gas are important land-use activities in the basin. When conducted improperly, these activities have resulted in severe degradation of aquatic environments (Branson and Batch, 1971, 1974a; Curtis, 1972, 1973; Dyer, 1982). Increased constituent concentrations and sediment loads transported to streams have resulted in the elimination of all but the most tolerant species of aquatic biota in localized areas. Brines improperly discharged from oil and gas operations continue to be a serious threat to streams in the Kentucky River basin (Kentucky Division of Water, 1986). Of the rivers draining the upper Kentucky River basin, the North Fork Kentucky River system seems to be the most degraded in terms of water quality, sedimentation, and the capacity to support diverse aquatic communities.

Buckhorn Creek

Buckhorn Creek is a fourth-order, moderately high gradient stream which originates in northwest Knott County and flows in a westerly direction to join

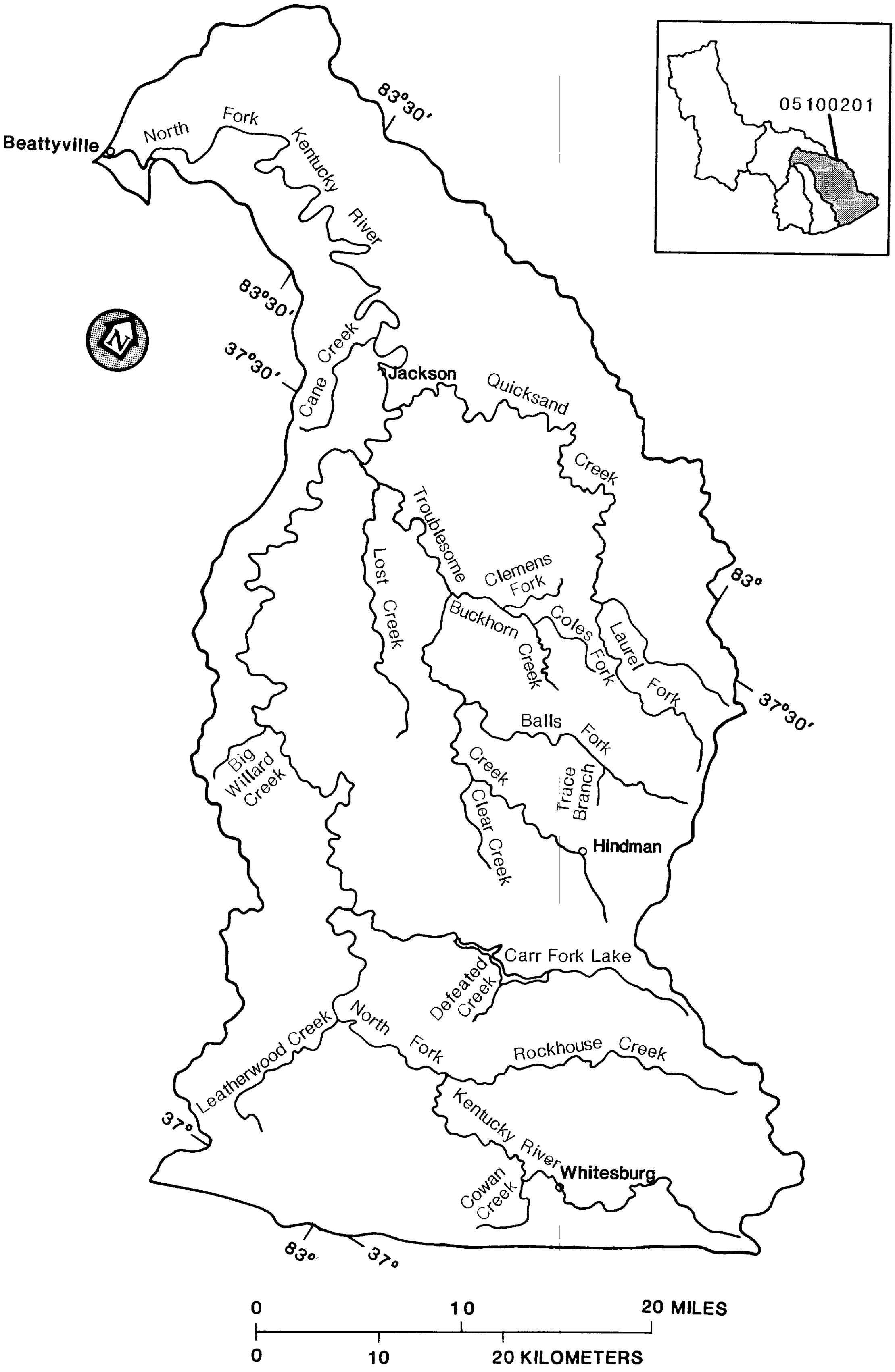

Figure 3.--Hydrologic Unit 05100201, North Fork Kentucky River.

of algae (Kentucky Division of Water, 1986). Carr Fork Lake was noted to be undergoing accelerated sedimentation (U.S. Army Corps of Engineers, 1986) and recreational uses were impaired due to water turbidity in 1982-83 (Kentucky Division of Water, 1984b). Extensive mining by strip, auger, and deep methods has occurred in the Carr Fork drainage. Contour strip mining, in approximately 40 percent of the basin, resulted in severe sedimentation problems in the Carr Fork Reservoir (U.S. Army Corps of Engineers, 1986). According to Jones (1973), Carr Fork below the dam was polluted by acid-mine water, and excessive siltation was occurring upstream from the reservoir. High constituent concentrations and specific conductance values have been documented at several sites by Harker and others (1979) and the U.S. Geological Survey (1978-82).

The primary threat to aquatic biota of Carr Fork seemed to be loss of habitat due to sediment from mined lands. Data collected by the KNPC in 1978 indicated a limited algal flora and a limited number of benthic invertebrate species compared to undisturbed drainages (Harker and others, 1979). The diatom community in Carr Fork was dominated by the epipelic genus Nitzchia which was an indication of environmental stress (Lowe, 1974).

Carr Fork supported a diverse fish fauna, although effects on the quality of the fishery were documented by Jones (1973). He also noted that acid-mine drainage and siltation were widespread problems. Carr Fork is a relatively low gradient stream with heavily silted pools. This was reflected in the dominance of Etheostoma flabellare, E. nigrum, and Percina maculata, darter species which are noted for their tolerance of turbid waters (Harker and others, 1979).

Unpublished macroinvertebrate data for Carr Fork upstream from Carr Fork Lake, Trace Fork, Defeated Creek, and the Carr Fork Lake tailwaters are available from the U.S. Army Corps of Engineers, Louisville District.

Laurel Fork of the Quicksand Creek Basin

Laurel Fork, a third order stream, begins in northwest Knott County, and flows westward before joining Quicksand Creek. The Quicksand Creek drainage with the exception of Laurel Fork, has been affected by sedimentation from mining operations for a number of years (Jones, 1973; Miller and others, [no date]).

Investigations of aquatic biota in Laurel Fork during 1978 revealed diverse, productive communities associated with good water quality and habitat diversity. Although there was some mining in the Laurel Fork basin, water-quality data did not indicate elevated concentrations of constituents usually associated with streams draining disturbed lands (Dyer and Curtis, 1977; Dyer, 1982). For example, sulfate concentrations during 1978 were less than 10 mg/L (Harker and others, 1979). Values for other chemical and physical characteristics were typical for eastern Kentucky streams draining basins with little land disturbance.

Benthic algal communities in the Laurel Fork basin were moderately diverse (Harker and others, 1979) and were dominated by filamentous green algae and pennate diatoms which are associated with well-oxygenated waters. Low diatom diversity was attributable to large populations of Achnanthes minutissima, a typical Eastern Kentucky stream diatom (Harker and others, 1979) rather than poor water quality. Several intolerant diatoms such as Cymbella delicatula and Gomphonema rhombicum were common, and these are often indicative of good water quality (Harker and others, 1979). This study yielded the greatest number of macroinvertebrate species, including several intolerant species, observed by the KNPC in the Kentucky River basin. Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) were particularly diverse. A total of 50 taxa were identified, reflecting abundant habitat and good water quality. Laurel Fork was recommended for consideration as a "refugium" for macroinvertebrates in the Quicksand Creek watershed. This "refugium" would provide a source of organisms for recolonization of degraded downstream areas (Harker and others, 1979).

A total of 27 fish species, including eight darter species and numerous cyprinids, have been collected from the Laurel Fork basin (Jones, 1973; Harker and others, 1979). The stream was recommended as a "put-and-take" trout fishery and supported a "limited good quality" fishery for black bass and panfish (Jones, 1973). Although effects from mining were not apparent during 1978, additional monitoring was recommended by KNPC to document potential effects of land-disturbance activities on the ichthyofauna (Harker and others, 1979). No additional biological information was available for other stream reaches of the heavily mined Quicksand Creek drainage basin.

North Fork Kentucky River

Extensive mining has taken place over much of the North Fork basin and sediment loads have been a chronic problem. Jones (1973) noted that the effects of mining were evident in North Fork Kentucky River from Whitesburg to Jackson, but he did find some small tributary streams which were relatively unaffected. Water-quality data for the North Fork Kentucky River at Jackson (Kentucky Division of Water, 1986; U.S. Geological Survey, 1978-82) reflect the effects of drainage from mining operations and discharge from domestic sewage treatment facilities. Although there are several sites for which chemical water-quality data are available, biological data for the North Fork Kentucky River mainstem are limited.

The KDFWR conducted a study of the North Fork Kentucky River in 1982 to evaluate muskellunge populations and habitat conditions. Collections from several sites yielded 64 taxa of macroinvertebrates. Dipterans contributed the most species (17 taxa) followed by the Ephemeroptera (15) and Trichoptera (8). The Diptera species may have reflected degraded habitat conditions such as siltation of the substrate, because tributary streams with rocky substrates contained Ephemeroptera and Plecoptera as the predominant taxa. However, a total of 45 species of fish were identified, many of which were considered to represent unaffected communities (Prather, 1985).

Data collected by the KDOW at a site on the North Fork Kentucky River at Jackson indicated sediment and nutrient/organic enrichment of the water. The effects of this enrichment generally were reflected in the biological communities. Phytoplankton standing crop of 969 cells/mL and chlorophyll a concentrations of 3.5 μg/L were low when compared with other Kentucky streams. The plankton community was dominated by benthic pennate diatoms, including facultative nitrogen heterotrophs, epipelic and halophilic species. Based on data from artificial substrata, an attached algal biomass of 4,049 mg/m^2 and a standing crop of 48 mg chlorophyll a/m^2 were high which reflected nutrient enrichment. Sixteen taxa of invertebrates were collected on artificial substrata at this site during 1985. Several mayflies tolerant of siltation were identified, including species of *Caenis* and *Tricorythodes*. Others such as *Ochotrichia* occurred in sufficient numbers to indicate nutrient enrichment (Kentucky Division of Water, 1986).

Williams (1975) documented nine species of freshwater mussels in the North Fork Kentucky River. Some of these species were probably represented by relic shells. The habitat for mussels had been reduced in the North Fork Kentucky River due to "drastic environmental changes that have occurred in the past 50 to 75 years" (Williams, 1975).

Hydrologic Unit 05100202 - Middle Fork Kentucky River

Streams that contribute to the Middle Fork Kentucky River drain Hydrologic Unit 05100202 (fig. 4), an area of approximately 552 mi^2 (1,430 km^2). Streams discussed in this section of the report include Greasy Creek, Cutshin Creek, Squabble Creek, and the Middle Fork Kentucky River mainstem. This is the smallest hydrologic unit in the Kentucky River basin.

The Middle Fork Kentucky River basin is in the Eastern Coal Field, an area underlain by sandstone, siltstone, shale, and interbedded coal beds. Surface waters are moderately hard with low buffering capacity. Primary land-use includes coal mining, oil and gas production, silviculture, and a limited amount of agriculture. Although these land-use practices have affected many streams in this hydrologic unit, effects on water quality and aquatic biota do not appear to be as severe as those in the North Fork Kentucky River Basin.

Buckhorn Lake, a mesotrophic reservoir (Kentucky Division of Water, 1986), is on the Middle Fork Kentucky River. Built in 1961, the lake occupies approximately 1,200 acres (486 hectares) and is operated by the U.S. Corps of Engineers primarily as a flood control reservoir (Prather, 1985). Algal blooms have been observed in the headwater area of Buckhorn Lake as a probable result of nutrient loads discharged into the Middle Fork from the Hyden wastewater treatment plant (Kentucky Division of Water, 1984a). The Middle Fork below Buckhorn Lake benefits from low-flow augmentation and reduced sediment loads. A survey of biological and water-quality conditions of the Middle Fork before and after the dam was constructed was reported by Turner (1967). Unpublished macroinvertebrate data for the Middle Fork Kentucky River at three sites upstream from Buckhorn Lake and from the tailwaters are available from the U.S. Army Corps of Engineers, Louisville District.

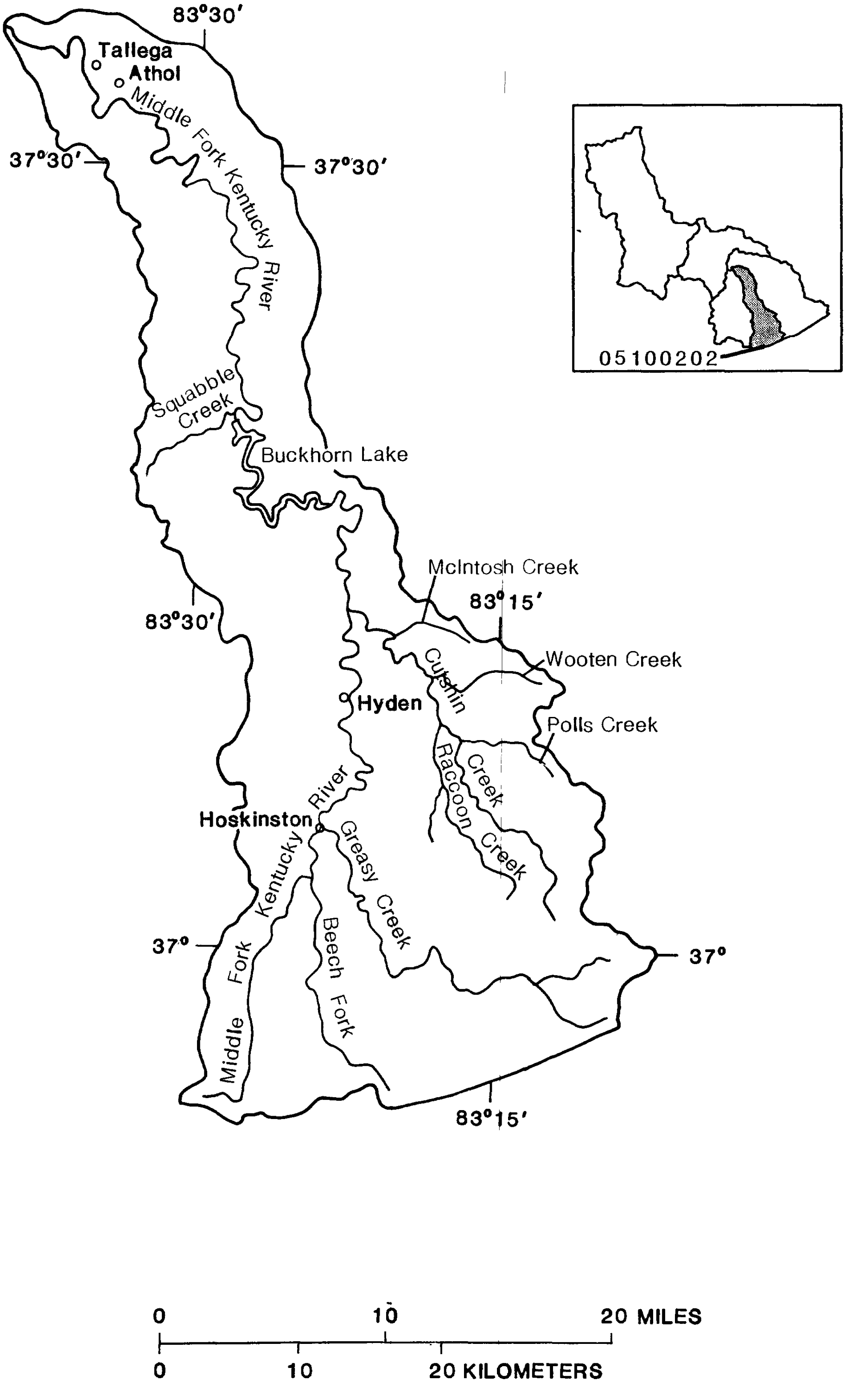

Figure 4.--Hydrologic Unit 05100202, Middle Fork Kentucky River.

Greasy Creek

Greasy Creek, a fourth-order stream, begins in Harlan County and flows northwesterly to join the Middle Fork Kentucky River near Hoskinston, Kentucky. Water quality of Greasy Creek was reported as excellent by Jones (1973); however, a study conducted by KNPC in 1978 indicated conditions had degraded (Harker and others, 1979). Although water-quality analyses did not reveal elevated constituent concentrations, turbid waters and silt deposits had been observed, warranting further monitoring of Greasy Creek. Biological investigations revealed diverse, productive aquatic communities during the late 1970's; however, these resources may have been adversely affected by recent changes in land use such as increased mining activities.

The benthic algal flora of Greasy Creek was moderately diverse in 1978, and samples contained a large variety of desmids (nine species) and diatoms. A total of 77 algal species were identified. While the predominant diatoms in the community (Cymbella delicatula, Achnanthes pseudolinearis, Gomphonema olivaceoides var. hutchinsoniana) were regarded by KNPC as characteristic of high-quality water (Harker and others, 1979), other species were more characteristic of streams that have slightly acidic pH conditions and increased sediment deposition.

The macroinvertebrate community in Greasy Creek was moderately diverse, and 36 taxa were represented. Most species were recognized as typical eastern Kentucky macroinvertebrates which tolerate a wide variety of environmental conditions. Plecoptera, Ephemeroptera, and Trichoptera, as well as other major insect groups were well represented in the community.

The ichthyofauna described by Turner (1967) and Jones (1973) appeared to be unchanged as of 1978. Harker and others (1979) cited Greasy Creek as supporting one of the most diverse ichthyofaunas in the Kentucky River basin. Thirty-two species, including 10 darter species and numerous cyprinids, were collected during 1978. These species indicated good water quality and habitat availability. Although most accounts indicate Greasy Creek to be a high quality stream, the KNPC expects the quality of the Greasy Creek fishery to deteriorate because of "rapidly expanding watershed perturbations" (Kentucky Nature Preserves Commission, written commun., 1988).

Greasy Creek is an important source for faunal recolonization of downstream areas adversely affected by land-use activities. Greasy Creek was recommended as an Outstanding Resource Water which would provide a muskellunge habitat for spawning and a small-mouth bass and rock bass habitat and fishery (Hannan and others, 1982).

Cutshin Creek

Cutshin Creek, a high-gradient third-order stream, begins in southeastern Leslie County and flows northwesterly before joining the Middle Fork Kentucky River north of Hyden, Kentucky. Cutshin Creek, the largest tributary to the Middle Fork, is a source of sediment and water of poor quality to the Middle Fork Kentucky River (Jones, 1973; Harker and others, 1979). More than 30 percent of the Cutshin Creek basin had been surface mined by 1969. Cutshin Creek has been subjected to recurring fish kills from oil drilling and mining operations initiated during the early to mid-1980's (Kentucky Division of Water, 1986). Reclamation of disturbed lands will help to prevent further degradation of this resource (Miller and others, [no date]).

Data collected on Cutshin Creek by KNPC in 1978 indicated that the stream was affected by mine drainage. Elevated concentrations of sulfate, magnesium, sodium, and calcium were observed during low-flow conditions. Habitat conditions did not appear to be seriously affected at the KNPC sampling site. It was assumed that the high-gradient of the stream prohibited the deposition of sediment (Harker and others, 1979). Aquatic communities were reported as diverse, but were dominated by taxa which can withstand a wide range of environmental conditions.

The benthic algal community was characterized by 88 taxa, consisting of both common high-quality stream species and epipelic taxa associated with sediments (Harker and others, 1979). Diatom diversity was high, but the diatom community was dominated by taxa which exhibited a broad range of tolerance to a variety of environmental factors.

The macroinvertebrate community consisted of 34 taxa, and most aquatic insect groups were represented in the samples. Diversity was high and most organisms were recognized as typical of streams in Kentucky (Harker and others, 1979).

Woolman (1892) reported 20 species of fish from the lower reaches of Cutshin Creek. Jones (1973) reported 32 species, including eight darter species, from four sites in Cutshin Creek. In contrast, Harker and others (1979) collected 12 species including five darters during 1978. Although KNPC stated that the available data did not suggest degradation of the ichthyofauna in recent years, the number of fish species reported by KNPC was substantially less than that reported in 1973.

Squabble Creek

Squabble Creek is a moderate gradient, third-order stream that originates in eastern Perry County and joins the Middle Fork Kentucky River about 4 miles (6.4 km) below Buckhorn Lake. Because of its location, this stream is an important source of aquatic flora and fauna to the Middle Fork downstream of Buckhorn Lake. Squabble Creek is affected by drainage from old strip mines and discharges from two small sewage treatment plants (Harker and others, 1979).

Water-quality data for Squabble Creek exhibited elevated concentrations of constituents such as sulfate associated with mining (Harker and others, 1979, Dyer and Curtis, 1977). The effects of sewage effluent were indicated by elevated nutrient concentrations. Flocculent masses and iron ochre seeps were also observed (Harker and others, 1979). Biological investigations of Squabble Creek supported available water-quality data, and indicated environmental stresses due to poor water quality or reduced habitat.

The benthic algal assemblage contained 82 taxa. Blue-green and green algae were common, and filamentous growths were apparently restricted to rocks near the sewage outfall (Harker and others, 1979). The diatom flora in this stream was among the most diverse observed in the Kentucky River basin; however, this was attributed to the occurrence of numerous pollution-tolerant species such as Nitzschia palea, N. intermedia, and Navicula symmetrica). Sparse populations of intolerant and facultative forms were observed in the KNPC collections. Based upon KNPC interpretation of algal data, the water quality of Squabble Creek was degraded.

Thirty-nine taxa of macroinvertebrates were collected by KNPC during 1978. Species diversity was considered moderate (Harker and others, 1979). The community consisted of typical stream taxa; however, no intolerant forms were noted. It was stated that siltation and channelization of the stream bed were the primary factors affecting the macroinvertebrate fauna at the sampled site.

Twenty species of fish, including five darter species, rainbow trout, and carp, were collected from Squabble Creek by Harker and others (1979). The majority of the game and commercial fishes were represented by juveniles. Impacts to fish populations were difficult to evaluate at this site due to its proximity to the Middle Fork Kentucky River. It seemed likely that some of the species collected by the KNPC might have migrated from the Middle Fork Kentucky River. Squabble Creek provides spawning and feeding sites for many migratory fish species that are effectively blocked from upstream reaches by the Buckhorn Lake dam.

Middle Fork Kentucky River

The Middle Fork Kentucky River begins in southern Leslie County, is joined by Beech Fork and Greasy Creek, and flows northward to join the North Fork Kentucky River near Beattyville, Kentucky. Primary factors affecting aquatic biota of the Middle Fork are the large amounts of sediment moving through the drainage as a result of mining and point-source discharges from municipalities.

A total of 62 taxa of invertebrates were collected from three sites in a study by the KDFWR, with Cheumatopsyche sp. being the dominant aquatic insect. Numerous Asiatic clams, Corbicula fluminea, were also collected (Prather, 1985). High diversity values in samples collected from headwater sites indicated little degradation of upstream reaches. Lower diversity values from samples collected at downstream stations may have been due to the influence of tributary streams affected by mining operations. Differences in habitat conditions due to sedimentation might have explained changes in benthic community structure at downstream sites.

Limited data on fish species at two sites on the Middle Fork is provided by Jones (1973). Sections of the river supported populations of rock and smallmouth bass. The tailwaters of Buckhorn Lake supported a trout fishery. Recent data on aquatic fauna and flora of the Middle Fork have been collected by Prather (1985) and the Kentucky Division of Water (1986).

A total of 45 species of fish were collected from the Middle Fork at three sites in 1982 and 1983 as part of an investigation of muskellunge streams in Kentucky (Prather, 1985). The most numerous species from the drainage were golden redhorse, gizzard shad, longear sunfish, and freshwater drum. The dominance of these species was probably due to increased stream size.

The Middle Fork Kentucky River above Buckhorn Lake supported few muskie due to shallow stream depth and restrictions to upstream migration as a result of the dam. Better habitat existed from below the dam to the mouth of the Middle Fork (Prather, 1985). The American brook lamprey, a species listed as being of special concern by KAS-KNPC was collected from the Middle Fork Kentucky River (Warren and others, 1986). This section of the river was recommended as an Outstanding Resource Water (Hannan and others, 1982).

Data collected by the KDOW at a site near Tallega indicated productive biological communities, although limited sedimentation and nutrient enrichment might have been occurring. Samples collected in 1985 showed a low phytoplankton standing crop (350 cells/mL) and a low chlorophyll a concentration (2.2 μg/L). However, species diversity values were reported as high. Algal species identified from plankton samples consisted largely of dislodged benthic diatoms, which is typical of shallow streams and explained the high diversity observed at this site. Periphyton biomass (1750 mg/m^2) and standing crop (3.6 mg chlorophyll a/m^2) were lower than in many other streams in eastern Kentucky. The benthic algal community was moderately diverse. Fifty two diatom taxa were identified from artificial substrates, and samples were dominated by typical epiphytic and epilithic stream diatoms.

Middle Fork Kentucky River supported an adequate distribution of functional groups of macroinvertebrates, which indicates a variety of habitats in the stream (R. Houp, Kentucky Division of Water, oral commun., 1987). The benthic macroinvertebrate assemblage on artificial substrates was represented by 15 taxa. The benthic macroinvertebrates included species such as Caenis and Tricorythodes that are tolerant of siltation, but which typically live in well-oxygenated waters.

The Middle Fork Kentucky River near Athol supported a commercial mussel bed at the turn of the century according to Williams (1975). Eighteen species of freshwater mussels were documented during his investigation of the Middle Fork, some of which might have been represented by relic shells (Williams, 1975). No beds were large enough to have commercial value. A large riffle area at the U.S. Geological Survey gaging station near Tallega supported some macrophyte beds and seemed to be a good freshwater mussel habitat. Additional biological information on the Middle Fork Kentucky River are presented by Branson and Batch (1984).

Hydrologic Unit 05100203 - South Fork Kentucky River

The South Fork Kentucky River system drains Hydrologic Unit 05100203 (fig. 5), an area of approximately 741 mi^2 (1,920 km^2). Similar to the North and Middle Fork basins, the South Fork Kentucky River basin lies in the Eastern Coal Field which is underlain by sandstone, siltstone, shale, and coal

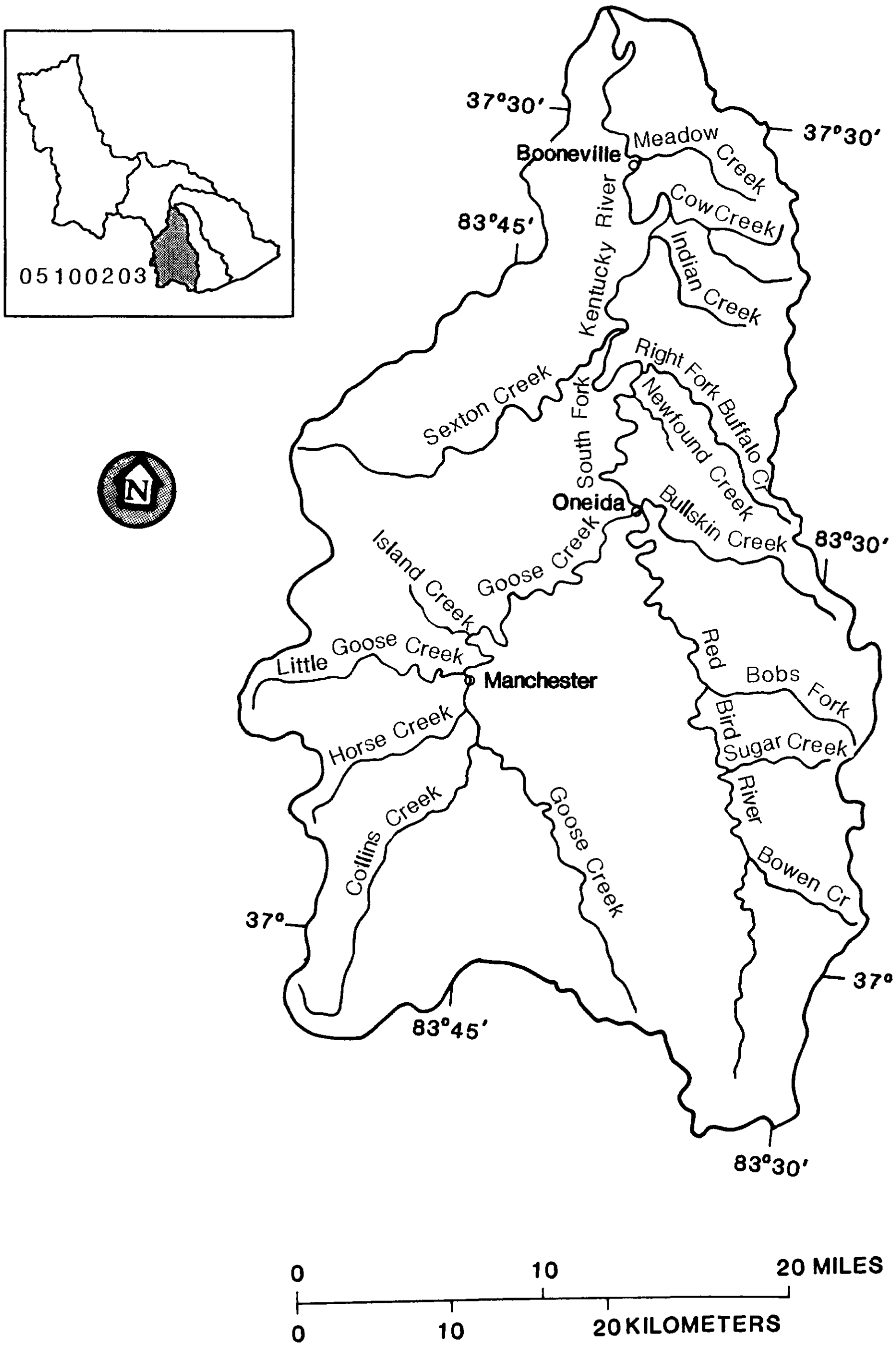

Figure 5.--Hydrologic Unit 05100203, South Fork Kentucky River.

beds. Land use is similar to the other two basins, and coal mining and oil and gas production are the primary industries. Major tributaries to the South Fork Kentucky River discussed in this section include Goose Creek, Collins Fork, Red Bird River, Buck Creek, Sexton Creek, and the South Fork Kentucky River mainstem.

Goose Creek

Goose Creek, a moderate-gradient fourth-order stream, begins in Clay County and joins the Red Bird River at Oneida, Kentucky to form the South Fork Kentucky River. Major tributaries to Goose Creek include Collins Fork and Little Goose Creek. The upper reaches of Goose Creek seem to have good water quality and support diverse aquatic communities. The lower half of Goose Creek is affected by acid-mine drainage and sediment from Horse Creek and Little Goose Creek (Harker and others, 1979). These conditions and the presence of sediment deposits were noted in earlier investigations (Jones, 1973). Jones stated that Collins Fork was relatively unaffected and provided cold water and long deep pools for smallmouth bass, rock bass, and muskellunge.

Mine drainage in the past severely affected the fish of lower Goose Creek (Turner, 1958). Several fish kills attributable to coal-mining discharges occurred at Goose Creek during the period 1969-73, and pH values ranged from 4.2 to 5.1 over much of the stream's length during 1969 (Brewer, 1980). Water-quality conditions seem to have improved in the basin according to recent investigations, however the effects of siltation are still apparent.

Data collected in 1982 by the KDFWR indicated that Sexton Creek, Goose Creek, and Collins Fork were "high quality muskellunge streams." Macroinvertebrate fauna were diverse but were dominated by species of Cheumatopsyche, Isonychia, and Stenonema. These taxa were common in most Kentucky streams which illustrated their wide range of tolerance to moderate pollution. The muskellunge habitat of Little Goose Creek had been eliminated due to sedimentation in most of the pools (Jones and Stephens, 1984).

An upstream site on Goose Creek was sampled twice in 1978 by the KNPC (Harker and others, 1979). Water-quality analyses performed during the study indicated good water quality. Benthic algal communities were diverse, and contained several environmentally sensitive species. Eighty algal species were identified during the study and many species of desmid algae were reported. The diatom flora was moderately diverse and dominated by Cymbella deliculata (45 percent relative abundance) and Achnanthes pseudolinearis (16 percent). These taxa were generally abundant in high quality, eastern Kentucky streams (Harker and others, 1979).

A total of 44 macroinvertebrate taxa were collected from Goose Creek and Ephemeroptera contained the most species. Wide fluctuations in species diversity and density of organisms were noted in this study, which might have indicated environmental stress due to siltation or localized habitat disturbance (Harker and others, 1979).

Twenty six fish species, including eight darter species, were collected in Goose Creek during 1978. These collections compared favorably with those of Jones (1973), Turner (1958), and Woolman (1892) and might have indicated relatively stable conditions. The collection of the northern brook lamprey, Ichthyomyzon fosser, was apparently the first record of this non-parasitic lamprey from the Kentucky River system (Harker and others, 1979).

The Goose Creek drainage is an important stream in the South Fork Kentucky River system. It provides a source of organisms for recolonization of invertebrate communities and some of the last muskellunge habitat in the basin. Goose Creek and Collins Fork were identified as Sport Fishery Resources by the KDFWR and consequently were recommended as Outstanding Resource Water (Hannan and others, 1982). Protection from the effects of mining operations and the discharge of treated sewage from Manchester are goals to improve conditions in the Goose Creek basin (Miller and others, [no date]).

Red Bird River

The Red Bird River, a fifth-order moderate-gradient stream, is the largest tributary to the South Fork, and it drains the area east of the Goose Creek drainage in the upper part of the South Fork basin.

Biological investigations indicated some effects from sediment in the headwater area of the Red Bird River, but the biological quality improved in downstream reaches. Metzmeier (1987) reported low phytoplankton chlorophyll a concentrations of 0.5 to 1.8 μg/L and a standing crop of 535 to 2400 cells/mL in the Red Bird River during 1985. This seemed to be typical for small eastern Kentucky streams. Predominant algal taxa included Achnanthes and Nitzschia species and other benthic diatoms. Fewer sensitive species, such as Achnanthes deflexa and Cymbella delicatula, were observed at headwater sites than at sites in the lower reaches of Red Bird River. During the early 1970's, the stream was reported to be affected to a limited extent by silt from strip mines in the headwaters (Jones, 1973). The fishery was diverse and contained a total of 42 species. Fishing was considered good from the mouth upstream to Sugar Creek, and fishing pressure was described as heavy. Jones cited abundant fish food in the river in the form of benthic invertebrates.

Forty-four macroinvertebrate taxa were documented by Jones and Stephens (1984). High macroinvertebrate density was noted, particularly during summer. All major insect groups were represented. The Red Bird River did provide some habitat for muskellunge, but it had the lowest catch rate of the five streams yielding muskellunge in the South Fork Kentucky River basin (Jones and Stephens, 1984). This stream, from the confluence with Sugar Creek to the mouth, was designated as a Sport Fishery Resource and recommended as an Outstanding Resource Water (Hannan and others, 1982). Additional fisheries data on the Red Bird River are presented by Clayton (1984).

Sexton Creek

Sexton Creek was studied in several fishery investigations (Jones, 1973; Brewer, 1980; Jones and Stephens, 1984). Fish populations were reported to be adversely affected by acid-mine drainage during the early 1970's (Jones, 1973). Fish kills in Sexton Creek attributable to coal-mining discharges during the early 1970's were also reported by Brewer (1980).

Water quality and habitat availability of Sexton Creek seemed to have improved during the past 10 years. A total of 42 macroinvertebrate taxa were collected from Sexton Creek during 1982 (Jones and Stephens, 1984). Samples collected during spring were high in diversity but contained relatively few individuals. The opposite was true during summer when samples contained large numbers of common taxa. At least in lower reaches, the effects of mining on stream quality have been reduced since 1982 because Sexton Creek was reported to have one of the highest densities of muskellunge of all South Fork Kentucky River streams (Jones and Stephens, 1984). Because of valuable habitat for muskellunge and golden redhorse, Sexton Creek was recommended as an Outstanding Resource Water by the KNPC (Hannan and others, 1982).

Buck Creek

Buck Creek, a fourth-order stream, begins in Owsley County and flows northeast to join the South Fork Kentucky River near Booneville. Harker and others (1979) reported that concentrations of sulfate and magnesium seemed to be elevated relative to undisturbed streams in the area as reported by Dyer (1982). Otherwise, water-quality constituents and properties indicated reasonably good water quality. Seventy-eight benthic algal species were identified from Buck Creek during 1978. Diatom diversity was moderately low because of the dominance of Achnanthes minutissima, which is a common characteristic of many eastern Kentucky streams. Many epipelic (associated with sediments) taxa were present but not particularly abundant. Most dominant species were considered tolerant to a wide range of water-quality conditions.

The macroinvertebrate community was represented by all major insect groups. Ephemeropterans contained the most species, but several species of Trichoptera and Plecoptera were also present. Although only 37 taxa were collected, the community exhibited high diversity and evenness values, possibly indicating good water quality and adequate habitat. The effects of past and present surface mining on stream macroinvertebrates were not clearly definable with the data available (Harker and others, 1979).

Fish collected from Buck Creek were typical for most eastern Kentucky drainages. Nineteen species, including eight darter species, were collected. Etheostoma sagitta spilotum (arrow darter), which was listed as being of special concern (Warren and others, 1986), was collected from Buck Creek. Extreme turbidity was present following a rainstorm at the time of sampling, indicating that sedimentation from surface mines or agricultural lands could pose a threat to aquatic resources.

South Fork Kentucky River

The South Fork Kentucky River begins with the confluence of the Red Bird River and Goose Creek at Oneida, Kentucky. It then flows north for approximately 40 miles (64 km) to join the Kentucky River at Beattyville.

Water-quality and biological data were collected at two sites on the South Fork by the KDFWR in 1982 (Jones and Stephens, 1984). Specific conductance values tended to increase at downstream sites, a common phenomenon in most river systems. Phytoplankton diversity and taxa richness increased from upstream to downstream sampling sites (Metzmeier, 1987). In contrast, invertebrate taxa richness and diversity consistently decreased, indicating a compounding of environmental effects as tributaries with poor water quality and large sediment loads joined the South Fork mainstream. Summer macroinvertebrate samples were dominated by common, more pollution tolerant mayfly taxa (*Isonychia*, *Baetis*, *Stenonema*) and the caddisfly, *Cheumatopsyche*.

The South Fork Kentucky River at Booneville is sampled routinely by the KDOW. This site is affected by sedimentation from land-disturbance activities and nutrient enrichment resulting from numerous sewage treatment effluent discharges. Limited agriculture in flood-plain areas also contributes sediment and nutrients. Phytoplankton and periphyton chlorophyll *a* concentrations (5 $\mu g/L$ and 8 mg/m^2, respectively) were lower than in many eastern Kentucky streams (Kentucky Division of Water, 1986). This might have been due to shading by riparian vegetation. The plankton community was dominated by centric diatoms and benthic pennate diatoms, likely indicative of higher nutrient concentrations and a more lentic environment. The periphyton community on artificial substrata was dominated by *Melosira varians* and *Achnanthes linearis*. These are common species which can tolerate a wide range of water-quality conditions (Lowe, 1974).

Benthic invertebrate community structure appeared to indicate a lack of habitat and impaired water-quality conditions. Only 11 taxa of invertebrates were collected on artificial substrata which was the lowest number collected at tributary sites sampled by the KDOW (Kentucky Division of Water, 1986). Half of these taxa were Dipteran larvae, possibly indicating greater sediment deposition than at upstream sites with higher stream gradients. Williams (1975) documented 17 species of freshwater mussels in the South Fork Kentucky River, although some taxa might have been represented by relic shells.

Because the South Fork Kentucky River below the confluence of Goose Creek and Red Bird River still provided some muskellunge habitat, this section to the mouth was recommended as an Outstanding Resource Water by the KNPC. (Hannan and others, 1982). Additional biological information on the South Fork Kentucky River are presented by Branson and Batch (1983) and Molloy (1988).

Hydrologic Unit 05100204 - the Kentucky River from the South Fork Kentucky River to the Confluence with the Red River

Hydrologic Unit 05100204 (fig. 6), encompasses approximately 1070 mi^2 (2,770 km^2) of the Knobs physiographic region. The Knobs are erosional remnants of Mississippian and Pennsylvanian formations. Differential weathering properties of rocks in the Knobs region result in sandy limestone and sandstone caprock over softer shales, providing for sharp contrast in relief. Streams draining this hydrologic unit include the Kentucky River below its confluence with the South Fork, Station Camp Creek, and the Red River drainage. The unique geology of the Knobs region of the Kentucky basin separates the Eastern Coal Field from the Bluegrass Region. Recreational centers include Red River Gorge, the Red River Wild River Segment, and Natural Bridge State Park.

Land-use effects on aquatic resources relate primarily to brines from oil and gas operations and sedimentation from mining. Pollution from non-point agricultural sources is more of a problem in this region than in the steeper terrain of the Eastern Coal Field because of increased farming of wider floodplains. Sewage effluents contributed by the major urban centers also tend to have more detrimental effects on water quality in this area because of the low velocity. Streams discussed in this section include Sturgeon Creek, Ross Creek, Millers Creek, Station Camp Creek, Middle and South Forks of the Red River, Red River, and the Kentucky River from Beattyville, Kentucky to the Red River confluence.

Sturgeon Creek

Sturgeon Creek, a fifth-order stream, begins in eastern Jackson County and flows northeast before joining the Kentucky River immediately below Lock 14. Little Sturgeon Creek is the main tributary. Sturgeon Creek forms part of the eastern boundary of the Daniel Boone National Forest.

Although mining practices in the Sturgeon Creek basin pose a potential threat to aquatic life, available data indicate that Sturgeon Creek is a high quality stream. This assessment is based on the occurrence of sensitive diatom species, diverse macroinvertebrate communities, and a large number of fish species. Because several fish species collected from Sturgeon Creek have been listed as being of special concern (Warren and others, 1986), it was recommended by both the KDFWR and KNPC for designation as an Outstanding Resource Water (Hannan and others 1982).

Data collected on Sturgeon Creek by the KNPC indicated the stream was somewhat impaired by surface mining (Harker and others, 1979). Primary effects on the aquatic biota were the result of elevated constituent concentrations and sedimentation. In contrast, Kornman (1985) reported that Sturgeon Creek was a high-quality stream and was recommended by KDFWR for designation as Outstanding Resource Waters on the merit of muskellunge habitat and fishery. Although the biological community of Sturgeon Creek seemed to be productive, Harker and others (1979) reported that large-scale land disturbances could have a detrimental effect on aquatic biota in the stream.

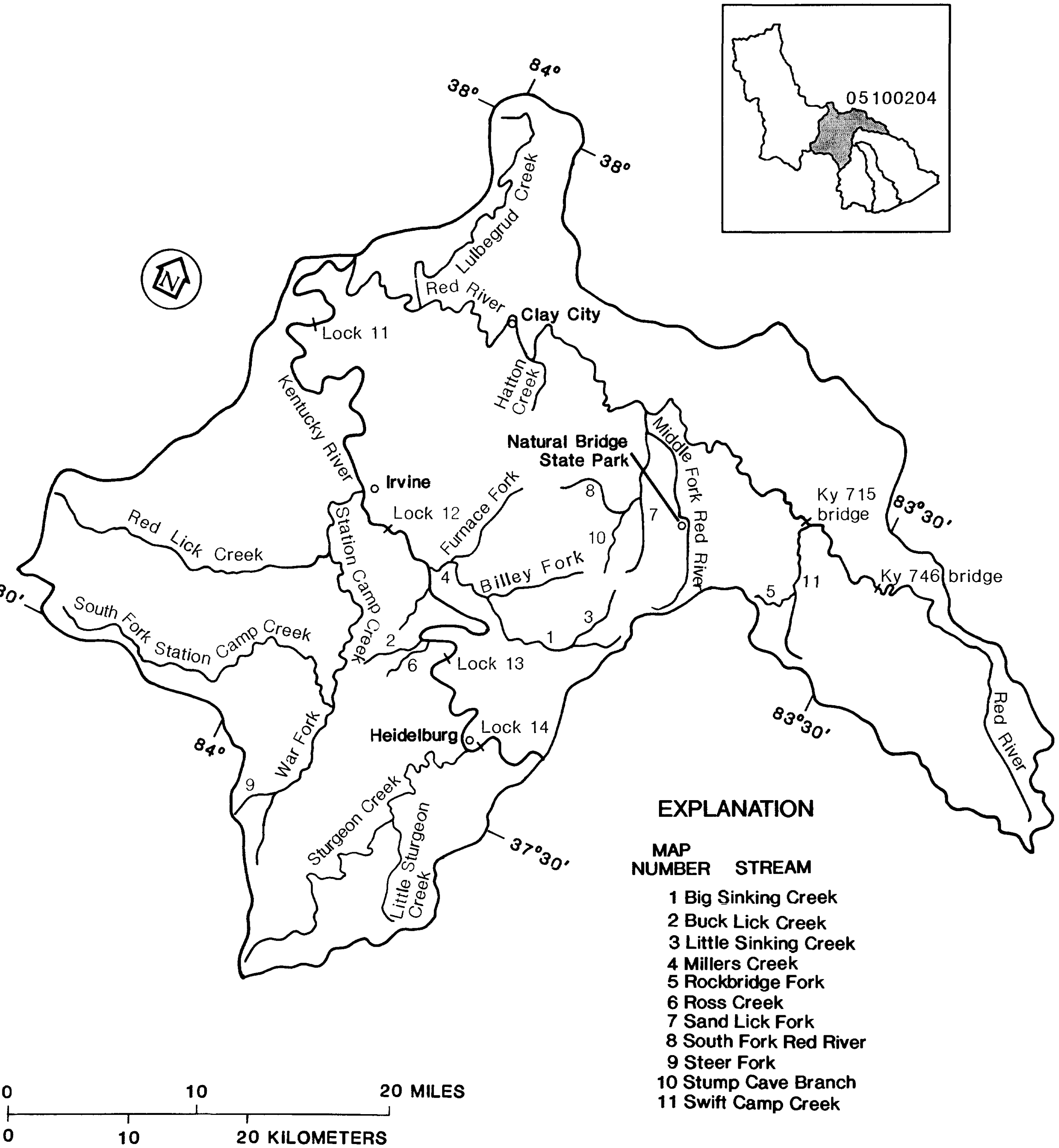

Figure 6.--Hydrologic Unit 05100204, the Kentucky River from the South Fork Kentucky River to the confluence with the Red River.

Sturgeon Creek supported a diverse flora and fauna during 1978. Although the total number of algal species observed was relatively low (44 taxa), diatom species such as Achnanthes pseudolinearis, Cymbella deliculata, and Gomphonema rhombicum were present in sufficient numbers to indicate good water quality conditions. Forty one taxa of benthic macroinvertebrates were collected during this investigation, including members of the Plecoptera and Megaloptera (dobsonflies and fishflies) commonly found in small, cool woodland streams (Harker and others, 1979). Kornman (1985) reported 36 macroinvertebrate taxa with samples dominated by dipterans, mayfly nymphs, and sphaeriid clams.

Jones (1973) stated that Sturgeon Creek was a high quality stream, providing habitat for a variety of sport fish including muskellunge and trout. Harker and others (1979) reported 27 fish species, including 11 darter species. The occurrence of Etheostoma sagitta spilotum was noteworthy as this species was listed as being of special concern (Warren and others, 1986). Kornman (1985) reported 47 fish species from two sites in Sturgeon Creek and stated that 56 species were known from the Sturgeon Creek basin. He identified three Percina (darter) species which were listed as being of special concern (Warren and others, 1986). Additional biological data on Sturgeon Creek are reported by Gilbert (1887), Kuehne and Bailey (1961), and the Kentucky Division of Water (1981).

Millers Creek and Ross Creek

Biological studies were conducted by KDOW in the Ross Creek and Millers Creek basins during the early 1980's as a result of environmental concerns regarding brine discharges from oil and gas operations. Streams in both basins had elevated specific conductance and elevated concentrations of chloride and barium.

Biological investigations of streams in the Millers Creek basin were conducted by the Kentucky Division of Water. Most streams surveyed were moderately to severely affected by brines from oil and gas operations. Chloride concentrations in the upper reaches generally exceeded 2,000 mg/L. A total of 162 algal species were identified from collections at 17 sites. Total taxa observed ranged from 20 species at severely affected sites to 100 species at moderately affected sites. Halophilic (tolerant to brines) and epipelic (associated with sediments) species were common (Kentucky Division of Water, written commun., 1988).

Headwater areas of Big Sinking Creek, Little Sinking Creek, Billey Fork and Furnace Fork supported low densities of macroinvertebrate organisms. Samples contained 6 to 20 tolerant taxa such as Dipterans, Odonata, and Gastropoda. Members of the Ephemeroptera, Plecoptera, and Trichoptera were generally absent in these reaches. These organisms are considered common in most eastern Kentucky streams (Harker and others, 1979). Diatom communities were dominated by halophilic taxa such as Cymbella pusilla and Nitzchia filiformis. Fish communities were severely affected by brines, and most streams supported less than 10 tolerant species (Mills, 1988). Two sampling sites on Big and Little Sinking Creek were apparently devoid of fish (Logan and others, in press).

Biological communities were also affected by brines in the lower reaches of Millers Creek, where chloride concentrations were greater than 1,000 mg/L. Small, relatively unaffected tributaries to Big Sinking Creek contained diverse, productive aquatic communities (Mills and Kentucky Division of Water, written commun., 1988). Background concentrations of chloride in streams not affected by brine discharges were typically less than 10 mg/L. It was apparent that high concentrations of constituents of brine-water discharges in this area of the Kentucky River basin were toxic to many indigenous aquatic organisms.

The flora and fauna of Buck Lick Creek and Ross Creek below the confluence with Buck Lick Creek were also severely degraded by brine discharges. Algal and macroinvertebrate communities were adversely affected and limited to taxa tolerant to elevated salinity. The fish fauna was eliminated in Buck Creek, and reduced numbers of taxa and individuals were noted in Ross Creek below Buck Lick Creek (Logan and others, 1983b).

Station Camp Creek

Station Camp Creek is a fifth-order stream formed by the confluence of War Fork and South Fork in Jackson County. It then flows northwest to join the Kentucky River at Irvine. Based upon published interpretations of available biological data, Station Camp Creek can be considered one of the largest high quality watersheds in the Kentucky River system. Algal communities were dominated by sensitive species, and the macroinvertebrate communities were diverse and contained numerous species of mayflies, stoneflies, and caddisflies. Fifty-five fish species have been identified in the basin, including a sizeable muskellunge population. Station Camp Creek, including War Fork and South Fork, were recommended as Outstanding Resource Waters (Hannan and others, 1982).

Macroinvertebrate collections contained all major groups of insects, mollusks, and crustaceans. A total of 69 taxa, including a diverse population of mayflies, were collected from Station Camp Creek (Kornman, 1985). This large number and diversity indicated abundant habitat and good water quality conditions at the time of sampling. Samples collected by the KDFWR, as part of a muskellunge streams investigation, contained 44 species of fish. These 44 species plus species identified in other studies (Carter, 1970; Branson and Batch, 1974b; Kornman, 1985; Mills, 1988) brought the total of known fish species in the basin to at least 55.

The KDOW sampled two sites on Station Camp Creek during 1984 (Logan and others, in press). An average of 47 diatom taxa was identified. Collections were dominated by species associated with good water quality such as Achnanthes deflexa and Cymbella delicatula. Macroinvertebrate communities were diverse. Many species of Ephemeroptera, Plecoptera, and Trichoptera were reported. Results were similar to those reported by Kornman (1985).

Villosa lienosa, considered of special concern (Warren and others, 1986) has been collected from the drainage. Limited data for South Fork Station Camp Creek are presented by KDOW (1981). Additional references regarding biological studies in the Station Camp drainage are presented by Hannan and others (1982).

Red River Basin

The Red River system drains much of Hydrologic Unit 05100204 east of the Kentucky River. Major tributaries include the Middle and South Forks of the Red River, Swift Camp Creek, and Lulbegrud Creek. The Red River from the State Highway 746 bridge to the State Highway 715 bridge has been designated as a Kentucky Wild River in accordance with Kentucky Revised Statute 146.230 (Miller and others, 1980). The remaining sections provide habitat for muskellunge and were recommended as an Outstanding Resource Water (Hannan and others, 1982). Streams in this basin have been the subject of numerous biological investigations because of their unique aquatic environments (Kuehne, 1962a; Branson, 1970; Carter, 1970; Branson and Batch, 1974b, 1982b; Harker and others, 1979; and Houp, 1980). Hannan and others (1982) presented additional references on the Red River system.

Mainstem of the Red River and tributaries

The algal flora of the Red River above the confluence with the Middle Fork Red River is perhaps the most diverse in the Kentucky River basin. Harker and others (1979) reported 104 algal species, including several unusual desmid species. The diatom community was dominated by typical epilithic species characteristic of well-oxygenated waters. Although epipelic and halophilic species were present in the diatom community, which might have reflected upstream land disturbance, the community as a whole indicated excellent water quality during the late 1970's. Phytoplankton and periphyton chlorophyll *a* and biomass were low (Kentucky Division of Water, 1986) which was typical for shaded, lower-order streams. The phytoplankton community was dominated by benthic diatom species (Kentucky Division of Water, written commun., 1988; Metzmeier, 1987) which was also viewed as typical. Phytoplankton and periphyton data at five sites in the Red River basin are discussed by Metzmeier (1987) and Molloy (1988), respectively.

Increases in the relative abundance of epipelic (associated with sediments) diatoms were observed during the mid-1980's which might have reflected upstream land disturbance. The absence of the red algae, *Lemanea*, formerly abundant in the upper reaches of the Red River, was attributed to a loss of rock substrate due to deposition of coarse sediments rather than adverse water quality (Kentucky Division of Water, 1986).

Macroinvertebrate collections in the Red River revealed diverse assemblages of aquatic insects and freshwater mussels (Harker and others, 1979; Houp, 1980; Kornman, 1985; Kentucky Division of Water, 1986). Collections during 1978 included 43 taxa of macroinvertebrates (Harker and others, 1979) dominated by Ephemeropterans (mayfly nymphs). All functional groups of macroinvertebrates were well represented. Studies conducted by KDOW revealed additional species not reported by Harker and others (1979). The KDOW samples contained seven species of Ephemeroptera and eight species of Trichoptera, reflecting an abundance of clean, rocky substrate and good water quality (R. Houp, Kentucky Division of Water, oral commun., 1988). Fifteen species of freshwater mussels were reported from the Wild River section of the Red River by Houp (1980). Although the entire mussel community seemed to have been eliminated by the effects of sedimentation during the early 1980's (Kentucky Division of Water, 1986), recent collections revealed 19 live species of mussels in the Wild River segment and downstream in 1988 (R. Cicerello, Kentucky Nature Preserves Commission, written comm., 1988).

The ichthyofauna of the Red River has been thoroughly investigated (Branson and Batch, 1974b; Brewer, 1980; Harker and others, 1979). Kornman (1985) reported that 85 species have been identified from the entire Red River basin. Harker and others (1979) reported 20 species, including seven darter species, from the Red River upstream of the confluence with the Middle Fork Red River. Sampling conducted by KDOW revealed similar results during the late 1970's and early 1980's; however, a reduction in numbers of fish species, particularly darters, was observed during 1985. This was also attributed to loss of habitat as a result of sedimentation (Kentucky Division of Water, 1986).

Kornman (1985) reported 31 species of fish, including 10 darter species, from 17 low-order tributaries to the Red River upstream of the confluence with the Middle Fork Red River. The occurrence of <u>Etheostoma</u> <u>sagitta</u> <u>spilotum</u> in Rockbridge Fork (Greenberg and Steigerwald, 1981; and Kornman, 1985) was noteworthy because it had been listed as being of special concern (Warren and others, 1986). Swift Camp Creek, a high quality tributary to the Red River, was recommended as an Outstanding Resource Water by the KNPC based upon the occurrence of listed fish species and good water quality (Hannan and others, 1982). Definitive studies of aquatic biota of the Swift Camp Creek drainage have not been conducted. Considering the recent loss of habitat in the Red River as a result of sedimentation, these relatively unaffected tributary streams provide important sources for the reestablishment of intolerant fauna.

Bioassay studies revealed acute toxicity to fathead minnows in the Red River near Hazel Green particularly during the fall of 1986. A review of water-quality data from the Environmental Protection Agency's water quality data storage and retrieval system STORET (1979-1985) revealed that detectable levels of dieldrin, DDT, chlordane, and heavy metals were measured in fish-tissue samples. Some toxicity to fathead minnows was documented during 1986 and 1987 at the ambient monitoring station at Clay City (Kentucky Division of Water, written commun., 1988). However, analyses of biological communities in this reach of the Red River generally indicated good water quality and habitat availability.

Biological data on downstream reaches of the Red River near Clay City were reported by Hannan and others (1984), Metzmeier (1987), and Molloy (1988). Water-quality conditions were substantially improved from those observed upstream in the Middle and South Forks, although chloride concentrations were somewhat elevated. The algal community was relatively diverse and 84 species were reported, including the rare red alga, <u>Thorea</u> <u>ramosissima</u>. The diatom community was dominated by <u>Achnanthes</u> <u>deflexa</u> var.

alpestris (= A. pseudolineraris) during July 1983, indicative of good water quality. Samples collected during October were dominated by more tolerant taxa (Hannan and others, 1984).

The macroinvertebrate community exhibited high diversity and was dominated by Ephemeropterans and Dipterans. Thirty-five taxa were reported from quantitative samples collected during summer. Two freshwater mussel taxa (Potamilus alatus and Tritogonia verrucosa) were collected, and relic shells representing four other taxa were also collected. Three species of mussels not reported by Houp (1980) were identified during the 1984 study (Hannan and others, 1984).

Twenty-five species of fish, including 10 darter species, were collected by Hannan and others (1984). The occurrence of Ammnocrytpa pellucida was noteworthy because it was listed as being of special concern in Kentucky (Warren and others, 1986).

Hatton Creek and Lulbegrud Creek, two third-order streams that join Red River below Clay City, were sampled by the KNPC (Harker and others, 1979; Hannan and others, 1984, respectively). Both streams were characterized by good water quality and diverse biological communities. Three species of live mussels were collected from Lulbegrud Creek. One species, Villosa lienosa was listed as being of special concern in Kentucky (Warren and others, 1986).

Middle and South Forks Red River

Biological and water-quality investigations of the Middle and South Forks of the Red River indicated that these streams were affected by oil and gas production and coal mining in the basin. The Kentucky Division of Water (written commun., 1988) reported extremely high concentrations of chloride (1,500-10,000 mg/L), and specific conductance values (4,500-27,000 μS/cm). The poor water quality affected the biological community structure at virtually all sampling sites in this part of the Red River basin.

Algal communities were dominated by halophilic species tolerant of high concentrations of dissolved salts. A total of 232 algal species were identified from samples collected at eight stations in the Middle and South Forks of the Red River basin (Kentucky Division of Water, written commun., 1988). Although this number was rather large, only a few intolerant species were collected in the basin. The number of algal taxa ranged from 30 species at Stump Cave Branch (specific conductance = 27,000 μS/cm) to 135 species in the Middle Fork Red River (specific conductance = 591 μS/cm). The predominance of Amphora delicatula, Cymbella pusilla, and Mastogloia smithii was very unusual and indicated highly saline conditions.

Macroinvertebrate communities were also affected by brine (Kentucky Division of Water, written commun., 1988). Although 48 taxa were reported in this study, the number of species observed ranged from 2 at the most affected site to 25 in the Middle Fork Red River. Communities were dominated by tolerant Dipterans and Odonates (dragonflies and damselflies). The total number of individuals collected generally was low.

The ichthyofauna of the Middle and South Fork Red River was also severely affected by brine waters from oil and gas operations. Twenty nine species were reported from the basin. No fish were collected from the most affected sites (Sand Lick Creek and Stump Cave Branch), 11 to 12 species were collected from several sites in the South Fork, and 19 species were collected from the downstream sites on the Middle Fork Red River (Kentucky Division of Water, unpublished data). Although nine darter species were collected during this study, they were largely restricted to downstream areas in the basin where water quality had apparently improved.

Kentucky River Mainstem from Beattyville to Red River Confluence

The mainstem Kentucky River in Hydrologic Unit 05100204 is a seventh-order river extending from the confluence of the North, Middle, and South Forks of the Kentucky River near Beattyville, Kentucky, to the Red River confluence (fig. 6). Included in this section are Kentucky River navigational pools 11 though 14.

Biological communities from the Kentucky River at Heidelburg have been routinely sampled by the KDOW since 1978. The data collected at this site indicate that the aquatic communities and their habitats have been affected by land-use patterns. Biological collections described in the Kentucky Report to Congress (Kentucky Division of Water, 1986) indicated phytoplankton standing crop and chlorophyll _a_ were consistently higher when compared with other biological monitoring stations. Blue-green algal blooms (_Microcystis flos-aquae_, _Anabaena_ sp.) were reported upstream from Lock 14, and attached algal biomass and standing crop were elevated. This was partially attributed to wastewater effluent discharges at Beattyville and the impounded nature of the river. Evaluation of benthic diatom assemblages collected since 1978 indicated that the effects of oil and gas operations may have been most pronounced during the early to mid 1980's. More recent collections (1985-86) contained fewer halophilic (tolerant of brines) species, indicating a reduction in the amount of brines reaching streams.

Macroinvertebrate communities (on artificial substrata) have remained relatively consistent since the late 1970's. Habitat restrictions had apparently limited the invertebrate community to a greater extent than had poor water quality conditions (Kentucky Division of Water, 1986). Qualitative macroinvertebrate collections from submerged substrata in soft sediments frequently included burrowing mayflies and dipterans, and mayfly, stonefly, and caddisfly larvae (Kentucky Division of Water, 1982). Sedimentation from upstream land disturbance at this slow moving, deep-water site had reduced benthic macroinvertebrate habitat. Historically, the river supported viable mussel populations (Danglade, 1922), but no mussel beds were observed in the Lock 14 pool by Williams (1975).

The ichthyofauna of the Lock 14 pool was typical of a large river (Kentucky Division of Water, 1982); the pool supports a sport fishery as well as a limited commercial fishery. Thirteen fish species were reported by Williams (1975) and 27 species were collected by Jones (1973) at two sites in the Lock 14 pool. Detectible levels of chlordane, aldrin, dieldrin, and several heavy metals had been detected in fish tissue samples based on a review of data in the STORET data base (1979-1981). Bioassay studies revealed acute toxicity to fathead minnows during the fall of 1986 and the spring and winter of 1987 at this site (Kentucky Division of Water, written commun., 1988).

Williams (1975) reported 13 species of fish at Lock 14, which was considerably less than the 20 to 22 species observed at Locks 11 through 13. This might have reflected large sediment loads that are transported by the Kentucky River and then deposited upstream from Lock 14. Paddlefish were only observed at Lock 11 during 1973. This apparently was one of the last published records of this unique species in the Kentucky River basin. Although no mussels were observed by Williams (1975) in the Lock 14 pool, four species were collected from the Lock 13 and Lock 11 pools and six species from the Lock 12 pool. None of these mussel beds were large enough to be considered commercially valuable.

Hydrologic Unit 05100205 - the Kentucky River from the Red River to the Confluence with the Ohio River

Hydrologic Unit 05100205 (fig. 7), is the largest in the Kentucky River basin, and it covers approximately 3,200 mi^2 (8,290 km^2). The north-central area of the basin is the Inner Bluegrass region, which is characterized by a gently rolling upland underlain by thick-bedded limestones. Surrounding this region is the Outer Bluegrass Region, an area of thin-bedded limestones that include inter-bedded shales. Streams discussed in this section include Silver Creek, Jessamine Creek, Dix River, Elkhorn Creek, Eagle Creek, and the Kentucky River mainstem.

Primary effects of land-use on aquatic biota in this hydrologic unit are related to sediment from agricultural sources and nutrient enrichment from wastewater treatment plant effluents. Sewage discharges from large population centers combined with the slow-moving, deep-water conditions in the lock systems account for the accelerated eutrophication in some river segments.

Tributary streams to the Kentucky River in Hydrologic Unit 05100205 that were not evaluated because of extremely limited or no biological data include: Howards Creek, Boone Creek, Muddy Creek, Tate Creek, Paint Lick Creek, Hickman Creek, Clear Creek, Glenns Creek, Benson Creek, Flat Creek, Cedar Creek, Severn Creek, Sixmile Creek, Drennon Creek, Big Twin Creek, Mill Creek, White Creek.

Silver Creek

The Silver Creek basin is in the Outer Bluegrass region and it flows northward through Madison County to join the Kentucky River. This fourth-order stream was once "one of the best streams in the drainage, supporting a good sport fishery for black and rock bass" (Jones, 1973). However, Jones calls attention to pollution from the Berea wastewater treatment plant. Bioassay studies conducted by KDOW indicated acute toxicity to fathead minnows in the effluent and the receiving stream below the plant (Kentucky Division of Water, written commun., 1988). Problems with low dissolved oxygen

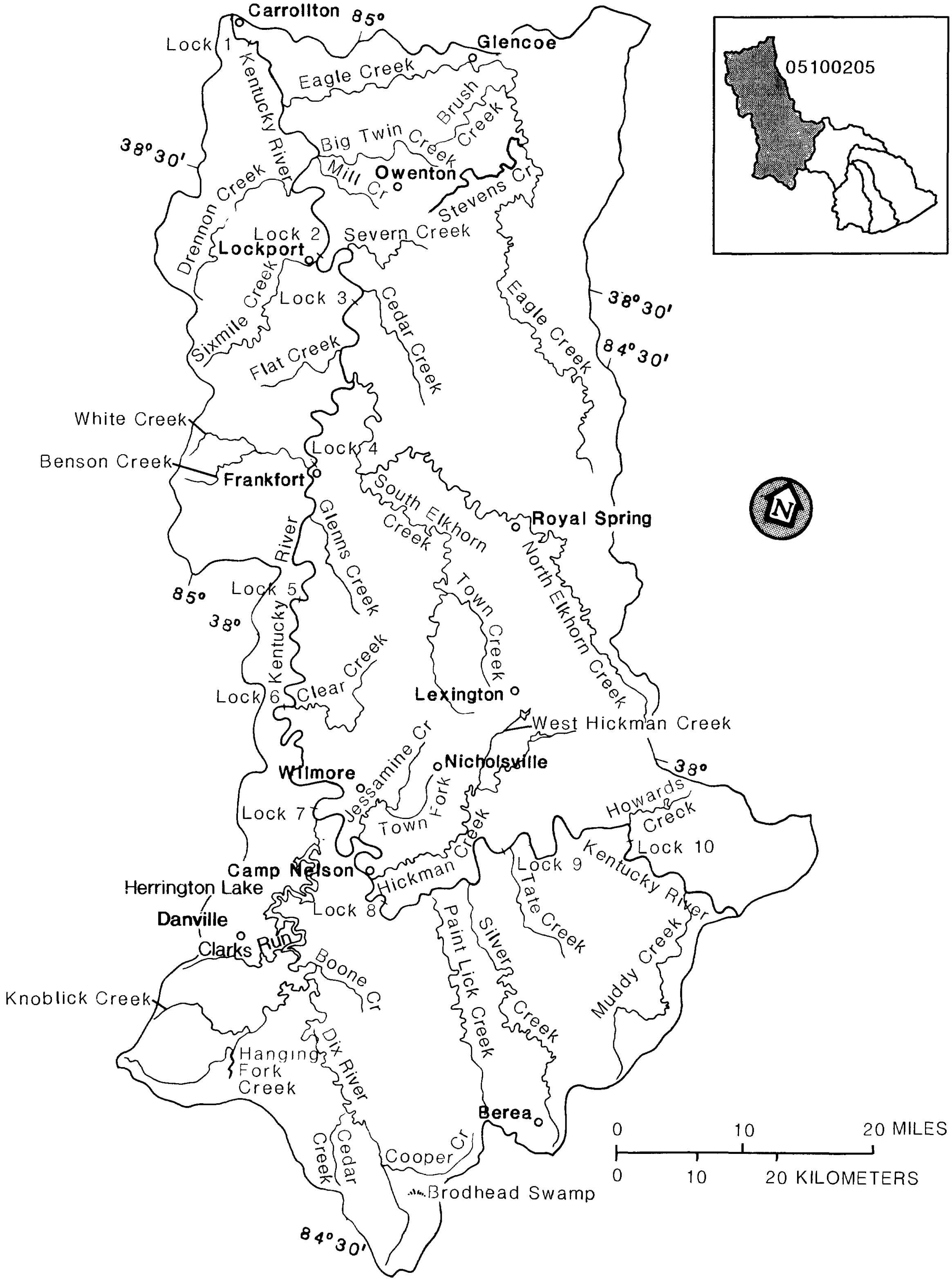

Figure 7.--Hydrologic Unit 05100205, the Kentucky River from the Red River to the confluence with the Ohio River.

concentrations and elevated levels of ammonia due to sewage effluent were also noted during the mid-1970's (Miller and others, [no date]).

Because of chronic pollution from the discharge of treated domestic wastewater and nutrient enrichment from agricultural runoff to Silver Creek, a more intensive investigation was conducted by the KDOW in 1982 (Logan and others, 1984). Water-quality violations were observed for undissociated hydrogen sulfide, phthalate esters, aluminum, mercury, and fecal coliform bacteria.

Habitats for aquatic organisms were reported to be abundant, although dense growths of filamentous algae, likely indicative of high nutrient levels, were present at all sampling sites (Logan and others, 1984). A total of 142 taxa of attached algae were identified during the study and 80 to 90 taxa were present at a given sampling site. The algal community was dominated by taxa associated with nutrient enrichment and high tolerance to a wide variety of water-quality conditions.

Macroinvertebrate communities were diverse and characterized by many species. Samples were dominated by Chironomidae (31 taxa), Ephemeroptera (15 taxa), and Plecoptera (5 taxa). The relatively rare caddisfly, Dibusa angata, was collected from Silver Creek upstream from the confluence with Kentucky River (Logan and others, 1984; Resh and Houp, 1986). Results from this investigation indicated abundant macroinvertebrate habitat and good water quality in this reach of Silver Creek despite localized elevated phosphorus concentrations downstream of the Berea wastewater treatment plant.

Eighteen species of fish, including four darter taxa, were identified during the KDOW study. Jones (1973) reported 10 additional fish species in Silver Creek near the mouth. Logan and others (1984) rated the fish communities in Silver Creek as fair upstream from Berea and good in downstream sections of the stream. Silver Creek provided habitat for smallmouth bass, and it was designated as a Sport Fishery Resource and was recommended as an Outstanding Resource Water (Hannan and others, 1982).

The quality of water in Silver Creek generally improved from the headwater reaches to its confluence with the Kentucky River. Acute toxicity and reduced biological diversity was observed upstream as a result of point-source discharges in 1982 (Logan and others, 1984). Biological communities had partially recovered in downstream reaches based on the presence of relatively sensitive species; but nutrient enrichment from non-point source agricultural runoff was indicated by dense growths of filamentous algae. Additional biological data for Silver Creek are reported by Houp (1970), Crisp and Crisp (1974), and Wolfe and others, (1978).

Jessamine Creek

Jessamine Creek, a fourth-order stream, originates in north-central Jessamine County and flows in a southerly direction to join the Kentucky River near Wilmore. This stream was classified as an Outstanding Resource Water due to the presence of three species of bats (Myotis grisescens, Myotis sodalis, and Myotis keenii) that inhabited the gorge (Hannan and others, 1982). The first two species were recognized as endangered at the Federal level and Myotis keenii was listed as being of special concern within Kentucky (Warren and others, 1986). Myotis grisescens relies on aquatic insect emergence for food; and any degradation of water quality in Jessamine Creek could affect their survival (Hannan and others, 1982).

Jones (1973) reported 23 fish species from Jessamine Creek and indicated that the stream supported bass and bluegill for sport fishing. Jessamine Creek and Town Fork (fig. 6) were reported to be degraded by effluents from wastewater treatment plants serving Wilmore and Nicholasville (Miller and others, [no date]). Bioassay studies conducted by the KDOW indicated acute toxicity to fathead minnows in the Nicholasville and Wilmore sewage effluents in Town Branch downstream from the Wilmore wastewater treatment plant.

A later survey of the fishes of Jessamine Creek and Town Branch indicated no substantial alteration of the fish fauna had occurred as of 1983 (Barton, 1984). A total of 1,555 individuals, representing 26 species, were collected. Among the most abundant species were the minnows Campostoma anomalum, Pimethales notatus, and Semotilus atromaculatus (30.5 percent, 14.8 percent, and 4.1 percent, respectively).

Although this stream drains one of the most scenic gorges in the Inner Bluegrass Region of the Kentucky drainage, no systematic biological survey has been conducted in the Jessamine Creek basin. Sources of pollution to Jessamine Creek are primarily agricultural runoff and municipal sewage effluent. Improvements in effluent quality are of major concern in the preservation of resources in the Jessamine Creek basin. Limited biological data for the Jessamine Creek system were reported by MacGregor (1973), Howell (1975), and Houp (1981).

Dix River Basin

The Dix River originates in west-central Rockcastle County and flows north approximately 85 miles (137 km) before joining the Kentucky River. The Dix River is a major sixth-order tributary to the Kentucky River, and it drains a large part of the Outer Bluegrass region in Hydrologic Unit 05100205. Herrington Lake, an impoundment of the lowest part of the Dix River, forms a eutrophic reservoir (Kentucky Division of Water, 1984a). Algal assays performed by U.S. Environmental Protection Agency, Region IV, indicated that Herrington Lake was phosphorus limited (Kentucky Division of Water, 1984a). The Herrington Lake dam probably mitigates the effects of non-point source (agricultural) sedimentation and nutrient enrichment occurring in the Dix River basin downstream. Hypolimnetic water released from Herrington Lake during summer results in the Dix River being cooler and less turbid than other major tributaries to the Kentucky River.

Copper Creek and Hanging Fork are the two major tributaries to the Dix River. Clarks Run, a tributary to the impounded portion of the Dix River, receives wastewater discharges from Danville. The Dix River was identified as an important sport fishery resource by the KDFWR, and was recommended as an Outstanding Resource Water by Hannan and others (1982). Brodhead Swamp, on the eastern edge of the basin, was identified as being an ecologically important feature in the basin (Hannan and Lasetter, 1982). Fish investigations in the Dix River system were summarized by Branson and Batch (1981a). They characterized the Dix River as being a "moderately depauperate river system, due to the absence of many fish species which occur in other segments of the Kentucky River."

Copper Creek, a fourth-order tributary stream to the Dix River, was sampled by the KNPC in 1983 during an investigation of the Kentucky oil shale region (Hannan and others, 1984). The stream seemed to be more affected by non-point source agricultural runoff than by oil and gas operations.

A total of 78 species of algae was collected from Copper Creek with diatoms accounting for the majority of taxa. Euplanktonic green algal taxa were common during summer low-flow conditions when Copper Creek was characterized by a series of slowly flowing pools. Diatom communities were dominated by Achnanthes minutissima, a common epilithic species (Lowe, 1974).

Although 50 macroinvertebrate taxa were identified during the study, the community was dominated by Chironomidae and Oligochaeta (Hannan and others, 1984). The abundance of these organisms probably indicated organic and nutrient enrichment from agricultural sources. Field observations indicated heavy use of the stream by cattle, as well as large amounts of organic matter (Hannan and others, 1984).

Twenty-one species of fish were reported by Hannan and others (1984). The fish community was dominated by pollution-tolerant species. Branson and Batch (1981a) reported an additional 11 species at two other sites in the Copper Creek drainage.

The upper part of the Dix River above Copper Creek was sampled by Hannan and others (1984). A total of 88 algal species were identified from the Dix River. Algal communities were similar to those observed at the Copper Creek site. Euplanktonic species were common. The diatom community was dominated by Achnanthes minutissima.

Macroinvertebrate communities were dominated by Ephemeroptera (notably Caenis sp.) and Chironomidae. Although fewer taxa were identified at this upstream site, additional representatives of Ephemeroptera, Plecoptera, and Trichoptera were observed. This indicates that environmental conditions in the upper Dix River may have been better than those in Copper Creek. Fish communities were similar to those observed in Copper Creek (Hannan and others, 1984).

Jones (1973) presented fisheries data on the Dix River, Hanging Fork, Cedar Creek, and Knoblick Creek. He considered the Dix River to support good fisheries for several game species. Samples from three sites on the Dix River yielded from 14 to 18 species. Collections from three sites on Hanging Fork Creek contained 25 species, including five darter species. While only seven species were collected in Knoblick Creek, the banded sculpin was only collected from this stream (Jones, 1973). Cedar Creek supported 17 species, including four darter species.

The upper parts of the Dix River system (Dix River, Copper Creek) were affected by non-point source agricultural activities. Biological communities were dominated by taxa which tolerate a wide range of water-quality conditions. Few sensitive species were collected. Fisheries investigations of Hanging Fork during the early 1970's revealed more sensitive species than were observed in upstream reaches of the Dix River system. Downstream portions of the system (Clarks Run) were adversely affected by point-source discharges from Danville. Acute toxicity to fathead minnows was documented in 1986 and 1987, with particularly low survival in the summer of 1987 (Kentucky Division of Water, written commun., 1988). The presence of Herrington Lake Dam on the Dix River near its confluence with the Kentucky River influenced biological communities by preventing upstream fisheries migration. The dam also provided for cool, low-turbidity inflow to the Kentucky River during summer. Additional published data for streams in the Dix River system include Greeson (1963), Blankenship and Crockett (1971), and Branson and Batch (1981b). Unpublished biological data for streams in the Dix River system are available from the Kentucky Division of Water, Biological Branch.

North Elkhorn Creek

The Elkhorn Creek system originates in Fayette County, and flows northwest through Scott and Woodford Counties before merging in Franklin County (fig. 7). The mainstem of Elkhorn Creek then flows northward to join the Kentucky River approximately 10 miles (16 km) downstream from Frankfort. The Elkhorn Creek system is of particular importance to the Kentucky drainage. Some stream segments are recommended as Outstanding Resource Waters while others are among the most degraded streams in the Bluegrass region.

North Elkhorn Creek is an extremely popular recreational resource (Selhinger and Underwood, 1980). This stream was recommended for inclusion as an Outstanding Resource Water because of viable populations of several organisms, including the freshwater mussels Leptodea leptodon and Simpsonaias ambigua (Hannan and others, 1982). Data collected in 1968 by the KDFWR indicated good water quality and a stable biological environment; however, some industrial and domestic sewage pollution was noted (Laflin, 1970). Sewage effluent from the Georgetown wastewater treatment plant discharged into North Elkhorn Creek was toxic to fathead minnows in May of 1986 (Kentucky Division of Water, written commun., 1988). Acute toxicity was also observed in the receiving stream above and below the effluent discharge point.

North Elkhorn Creek supported a valuable sport fishery for smallmouth and rock bass (Jones, 1973). Because it provided habitat for smallmouth bass, North Elkhorn Creek was designated as a Sport Fishery Resource and recommended as an Outstanding Resource Water (Hannan and others, 1982). Biological monitoring of North Elkhorn Creek and its major tributaries by the KDOW is currently in progress (1989), particularly with regard to potential effects of industrial discharges on water quality. Laflin (1970) reported physicochemical and biological data from two locations in the North Elkhorn basin. Macroinvertebrate communities were dominated by Trichoptera and Coleoptera, although Plecoptera, Ephemeroptera, Diptera, and Gastropoda were common. Freshwater mussels were reported but not identified to species. Thirty five fish species were collected during a 2-year sampling period, including five darter species. Additional biological information for North Elkhorn Creek and its tributaries is reported by Lachner and Jenkins (1967), Jones (1968), Heer (1974), Westerman (1980), Elkin (1984), and Taylor (1984).

South Elkhorn Creek

In sharp contrast to North Elkhorn Creek, South Elkhorn Creek is severely degraded by sewage effluent discharged into Town Branch by Lexington (Laflin, 1970; Jones, 1973; Hannan and others, 1982; Kentucky Division of Water, 1986; and Miller and others, [no date]). Although both streams drain areas of similar geology, data collected by Laflin (1970) indicated the South Fork supported a different fauna from the North Fork and mainstem Elkhorn Creek.

Biological investigations of several sites in the South Elkhorn Creek drainage were conducted by the KDFWR in 1968 and 1969 (Laflin, 1970). Benthic invertebrate collections from South Elkhorn Creek below Town Branch were composed primarily of Tubifex worms which are characteristic of grossly polluted streams. Samples collected above Town Branch and from an area of recovery downstream on South Elkhorn Creek contained more insect taxa, but members of the Plecoptera and other insects intolerant of organic enrichment were reduced. A total of 28 fish species were collected from South Elkhorn Creek during 1968 and 1969 (Laflin, 1970). Fish populations below Town Branch were severely affected due to low concentrations of dissolved oxygen.

Water-quality and biological investigations were conducted at seven locations in the South Elkhorn Creek drainage during the summer of 1981 (Logan and others, 1983a). Results indicated degraded environmental conditions throughout the system. A total of 190 algal taxa were collected during the study, ranging from 62 taxa in Town Branch below the treatment plant to 112 taxa at a downstream site. Algal communities at most sites were dominated by diatoms associated with nutrient enrichment (Nitzschia palea, Gomphonema parvulum, Synedra ulna). Benthic algal standing crop and biomass were elevated downstream from the wastewater treatment plant discharge, reflecting nutrient loading from the Lexington facility, as well as agricultural non-point sources. Algal communities had partially recovered in South Elkhorn Creek near its confluence with North Elkhorn Creek (Logan and others, 1983a).

Although 74 macroinvertebrate taxa were collected during the study, the number of species identified at the various sampling sites ranged from 18 to 28. Benthic macroinvertebrate communities were dominated by Chironomidae, Gastropoda, and Isopoda at severely degraded sites. At upstream (control) sites, communities were dominated by Ephemeroptera, Coleoptera, and Trichoptera, indicating better water quality at those sites. Macroinvertebrate communities had partially recovered in South Elkhorn Creek near its confluence with North Elkhorn Creek. Live specimens of the freshwater mussel Lampsilis radiata luteola were collected at the most downstream site on South Elkhorn Creek. Relic shells, representing nine additional mussel taxa, were also observed indicating that a diverse mussel fauna once inhabited South Elkhorn Creek (Logan and others, 1983a).

A total of 23 fish species, including four darter species, were collected from South Elkhorn Creek. Darters only occurred at the control (upstream) sites and at the most downstream sites. Fish communities at sites with degraded water quality were limited to less than five tolerant species.

Biological data collected by the KDOW on South Elkhorn Creek near Midway were similar to that reported by Logan and others (1983a). Data from STORET (1984-1986) revealed that phytoplankton chlorophyll a (5-16 mg/L) and standing crop (3,500-10,000 cells/mL) were elevated relative to Kentucky streams of similar size. Periphyton chlorophyll a (53 mg/m^2) and ash-free dry weight (4,300 mg/m^2) were high, which corresponded to high nutrient values typically observed at this station. Benthic algal assemblages were dominated by tolerant taxa (Gomphonema parvulum, Navicula luzonensis, Nitzschia palea) (Kentucky Division of Water, 1986).

Macroinvertebrate assemblages on artificial substrates were limited to one tolerant isopod species, Lirceus fontinalis, and this indicates toxicity to most species of macroinvertebrates (Kentucky Division of Water, 1986). Bioassay investigations indicated consistent toxicity to fathead minnows, particularly during the summer of 1987 (Kentucky Division of Water, written commun., 1988). Additional biological data on South Elkhorn Creek are presented by Aliff (1973, 1977), Jones (1973), Small (1975), Birge and others (1975, 1977), Call (1976), Keyes (1976), and Taylor (1984).

Eagle Creek

Eagle Creek is the last major tributary to join the Kentucky River before it discharges into the Ohio River. Eagle Creek was recommended for inclusion as an Outstanding Resource Water by the KNPC (Hannan and others, 1982). Biological data are routinely collected by the KDOW at a site at Glencoe as part of a water quality monitoring network. Data from STORET (1984-1985) revealed that phytoplankton standing crop (5,000-25,000 cells/mL) and chlorophyll a (16-33 $\mu g/L$) were higher at this site than at other sites. The community was dominated by Skeletonema potamos and other eutrophic species, resulting in low diversity and equitability values (Kentucky Department of Environmental Protection, 1986) for phytoplankton samples (Kentucky Division of Water, 1986). Periphyton chlorophyll a, biomass, and species composition were considered typical for Kentucky streams. Macroinvertebrate communities were dominated by Ephemeroptera, Plecoptera, and Trichoptera, which reflects good water quality and habitat conditions. Mussel collections yielded two species of unionid mussels, the Asiatic clam, Corbicula, and relic shells representing an additional eight species (Kentucky Division of Water, 1986). Analysis of fish tissue from Eagle Creek revealed detectible concentrations of chlordane, PCB's, DDT, methoxychlor, and heavy metals. Bioassay investigations in Eagle Creek revealed toxicity to fathead minnows, particularly during the fall of 1986 and summer of 1987.

The major point-source discharge in the basin is the Owenton wastewater treatment plant, which discharges to Stevens Creek, an upstream tributary to Eagle Creek. Bioassay investigations revealed no toxicity to fathead minnows in the treatment plant effluents or in the receiving stream during July, 1986 (Kentucky Division of Water, written commun., 1988). Additional information on the biota of Eagle Creek is presented in Horseman and Branson (1973) and Taylor (1981).

Kentucky River

The mainstem Kentucky River within Hydrologic Unit 05100205 consists of a series of navigational pools formed by Kentucky River Locks and Dams 1-10. With the exception of historical fisheries and freshwater mussel information presented by Williams (1975), biological data seem to be limited to three locations: Lock 7 pool near Camp Nelson, Lock 3 pool below Frankfort, and Lock 2 pool at Lockport. Sedimentation and nutrient enrichment from non-point agricultural sources, point-source discharges, and urban runoff affect biological communities in the Kentucky River.

Williams (1975) reported 17 to 22 fish species at Locks 5 through 10, but only 15 species at Lock 3, and 10 species at Locks 1 and 2. Most pools sampled by Williams (1975) supported from 10 to 15 species of freshwater mussels. Fewer taxa were reported from the pools at Locks 2, 3, and 6. Three mussel beds were observed that could be considered commercially valuable. These were in the pools of Locks 3, 5, and 8. Dominant species included _Megalonaias gigantea_, _Quadrula quadrula_, and _Amblema costata_ (Williams, 1975).

The KDOW currently monitors two stations on the Kentucky mainstem in Hydrologic Unit 05100205. Data collected at Camp Nelson (Lock 7 pool) and below Frankfort (Lock 3 pool) are summarized by the KDOW (1986).

Phytoplankton communities in the Kentucky River at Camp Nelson were dominated by taxa associated with nutrient enrichment. Chlorophyll _a_ (38 $\mu g/L$) and algal standing crop (> 10,000 cells/mL) were elevated (Kentucky Division of Water, 1986 and Kentucky Division of Water, written commun., 1988). In addition, periphyton chlorophyll _a_ (36 mg/m^2) and ash-free dry weight (6 g/m^2) were elevated. Localized sources of nutrient enrichment included Hickman Creek, which received wastewater discharges from parts of Lexington and joins the Kentucky River upstream from Camp Nelson. Other sources included wastewater discharges and non-point source nutrient enrichment from agricultural sources.

Macroinvertebrate assemblages on artificial substrata were dominated by Trichoptera and Ephemeroptera (Kentucky Division of Water, 1986). Community structure was probably more influenced by available habitat-types than water quality.

Analyses of fish tissues revealed detectable concentrations of chlordane and heavy metals. Sources of these pollutants were unknown but were probably related to housing construction and light industry in the greater Lexington metropolitan area. Data from STORET (1979-1981) revealed that concentrations of most organic compounds in fish tissues were near or below detection limits. Bioassay investigations revealed acute toxicity to fathead minnows, particularly during the fall of 1986 and the summer of 1987 (A. Westerman, Kentucky Division of Water, written commun., 1988). Bioassays of wastewater effluents from the West Hickman (Lexington) wastewater treatment plant revealed toxicity in the final effluent and in the receiving stream of West Hickman Creek. Additional biological data are reported for 10 sampling sites on West Hickman Creek by Heer (1974).

Phytoplankton communities in the Kentucky River near Frankfort (Lock 3 pool) were dominated by centric diatoms associated with nutrient enrichment. Chlorophyll a was variable (3 to 42 $\mu g/L$) and was influenced by differences in discharge and suspended solids on different sampling dates. Standing crop averaged 5,000 cells/mL (Kentucky Division of Water, 1986; Kentucky Division of Water, written commun., 1980) Periphyton chlorophyll a and ash-free dry weight were also variable, but generally high (>55 mg/m^2 and >4 g/m^2, respectively). Dominant taxa on artificial substrates included *Melosira varians* and *Cocconeis placentula* var. *euglypta*, species which commonly occur in nutrient-rich waters.

Macroinvertebrate assemblages on artificial substrata were similar to those at the Camp Nelson station, and indicated similar water quality and habitat conditions. Yearly investigations since the early 1980's indicated a relatively stable environment in this section of the Kentucky River (Kentucky Division of Water, 1986).

Analyses of fish tissue indicated detectable levels of chlordane, aldrin, dieldrin, DDT, and heavy metals. Chlordane levels exceeded FDA action levels during 1984 (Kentucky Division of Water, 1986). Bioassay investigations revealed acute toxicity to fathead minnows during 1986 and 1987 (Kentucky Division of Water, written commun., 1988). Bioassay studies conducted on discharge from the Frankfort wastewater treatment plant revealed no acute toxicity in the effluent or in the Kentucky River below the discharge during the summer of 1985 (A. Westerman, Kentucky Division of Water, written commun., 1988).

The U.S. Geological Survey collected limited biological data at the Kentucky River at Lock 2 from 1978 to 1982. Phytoplankton communities were dominated by centric diatoms, blue-green algae, and green algae (Order Chlorococcales). Periodic blue-green algal blooms had been observed in this reach of the river. In general, algal communities were similar to those reported by KDOW from the Kentucky River below Frankfort (Kentucky Division of Water, 1982 and 1984b).

RARE AND ENDANGERED SPECIES IN THE KENTUCKY RIVER BASIN

Pollution in any form is recognized as a potential threat to organisms inhabiting aquatic environments. Those species with little tolerance to changes in environmental conditions are quickly eliminated, often before the changes are noticed by man. Elimination of an indigenous species permanently changes the trophic structure of the affected ecosystem.

As a result of recent improvements in sampling techniques, advancements in taxonomy, and increased public awareness, it is now feasible to monitor aquatic systems for changes in biological community structure associated with pollution. This makes it possible to identify those species that are being adversely affected by pollution and, hopefully, take steps to prevent or at least to lessen such losses.

The need for protection of aquatic resources has been recognized by the Congress and has led to the passage of numerous environmental laws and regulations (Clean Water Act, National Pollutant Discharge Elimination System, Surface Mining Control and Reclamation Act). In Kentucky, surface water standards (401 Kentucky Administrative Regulations 5:031) have been enacted and agencies have been created to assess and monitor the biological integrity of Kentucky streams. The following information (table 1) was compiled by the KNPC. It identifies those streams in the Kentucky drainage in need of protection and lists some of the species currently being monitored by the Commission. It is not intended to be a complete listing of threatened or endangered species or a listing of high quality streams in the basin. Additional information on rare or endangered plants and animals in Kentucky is presented in Warren and others (1986).

SUMMARY

The Kentucky River basin, an area of approximately 7,000 mi^2 (18,100 km^2), is divided into five hydrologic units that drain the Eastern Coal Field, Knobs, and Bluegrass physiographic regions. The diversity of aquatic habitat in the Kentucky River basin reflects differences in physiography of these regions. In addition to the natural variations in aquatic biota due to physiography, stream water quality and biota are often affected by man's activities, including land-use and waste-disposal practices. These differences in aquatic environments are often reflected in the structure and composition of biological communities. Biological data collected by Federal, State, and private institutions were used to evaluate environmental conditions of streams in the Kentucky River basin.

The three hydrologic units drained by the North, Middle, and South Forks Kentucky River are in the Eastern Coal Field, an area underlain by sandstone, siltstone, and shale with numerous interbedded coal seams. Mining of bituminous coal and the production of oil and gas are important land-use activities in this physiographic region. Water of poor quality and large amounts of sediment transported from disturbed land have severely altered many streams in this part of the Kentucky River basin.

The North Fork Kentucky River system seemed to be the most degraded with regard to water quality and the capacity of streams to support diverse biological communities. Buckhorn Creek and Laurel Fork were relatively unaffected by mining and supported numerous species of algae, benthic invertebrates, and fish. However, Troublesome Creek, Carr Fork, and most of Quicksand Creek were adversely affected by mine drainage and generally supported fewer, more tolerant species of aquatic organisms.

The Middle Fork Kentucky River system is also affected by mining and point and non-point source discharges. Most streams for which biological data were available seemed to be impaired by elevated constituent concentrations and loss of habitat due to sediment deposition. Greasy Creek supported diverse communities in the early 1970's and was considered an important fishery and source for faunal recolonization of more degraded downstream

Table 1.--High quality Kentucky River basin streams based on the presence of species monitored by the Kentucky Academy of Science and the Kentucky Nature Preserves Commission (Hannan and others, 1982)

[Species listed below are fish species unless otherwise noted.]

Stream reach	Remarks
Buckhorn Creek and tributaries upstream from the confluence with Troublesome Creek. (Breathitt and Knott counties)	Provides habitat for Etheostoma sagitta spilotum.
Eagle Creek from the backwaters of the Kentucky River upstream to Clarks Creek. (Carroll, Gallatin, Grant, and Owen counties)	Provides habitat for Simpsonaias ambigua (freshwater mussel).
Elkhorn Creek from the mouth upstream on the North Fork to the US 25 highway bridge. (Franklin and Scott counties)	Provides habitat for Alasmidonta marginata (freshwater mussel), Nocomis biguttatus, and Simpsonaias ambigua (freshwater mussel).
Middle Fork Kentucky River from Tallega upstream to Buckhorn Reservoir tailwaters. (Breathitt, Lee, and Perry counties)	Provides habitat for Ammocrypta pellucida, Etheostoma tippecanoe, Noturus stigmosus, and Percina evides.
Middle Fork Kentucky River from Buckhorn Reservoir upstream to headwaters (including tributaries). (Harlan and Leslie counties)	Provides habitat for Ammocrypta pellucida, Etheostoma sagitta spilotum, Ichthyomyzon fossor, and Lampetra appendix.
North Fork Kentucky River in the vicinity of Rock Lick Creek. (Breathitt and Lee counties)	Provides habitat for Etheostoma maculatum and Percina evides.

Table 1.--High quality Kentucky River basin streams based on the presence of species monitored by the Kentucky Academy of Science and the Kentucky Nature Preserves Commission--Continued (Hannan and others, 1982)

[Species listed below are fish species unless otherwise noted.]

Stream reach	Remarks
Red River and most tributaries from State Highway 746 bridge downstream to Indian Creek. (Menifee, Powell, and Wolfe counties)	Provides habitat for *Alasmidonta marginata* (freshwater mussel), *Ammocrypta pellucida*, *Clinostomus elongatus*, *Lampetra appendix*, and *Simpsonaias ambigua* (freshwater mussel).
South Fork Kentucky River from the vicinity of Booneville upstream, including Sexton and Buffalo Creeks, to the headwaters on Goose Creek, including Laurel and Horse Creeks, and Red Bird River, including Big Creek. (Clay, Knox, Leslie, and Owsley counties).	Provides habitat for *Ammocrypta pellucida*, *Etheostoma tippecanoe*, *Ichthyomyzon fossor*, *Noturus stigmosus*, *Percina evides*, and *Villosa lienosa* (freshwater mussel).
Station Camp Creek from Red Lick Creek to the headwaters. (Estill and Jackson counties)	Provides habitat for *Villosa lienosa* (freshwater mussel).
Sturgeon Creek from Brush Creek and Travellers Rest (Little Sturgeon Creek) downstream to the Kentucky River backwaters (Lee and Owsley counties)	Provides habitat for *Etheostoma sagitta spilotum*.

reaches. Biological investigations of Cutshin Creek and Squabble Creek indicated environmental stresses due to poor water quality and reduced habitat. Headwater reaches of the Middle Fork Kentucky River and reaches below Buckhorn Dam were relatively unaffected by land uses in the basin.

The South Fork Kentucky River system did not seem to be as severely degraded as the other Forks, possibly due to less mining activity in this basin. Sections of Goose Creek, Red Bird River, Sexton Creek, and Buck Creek supported viable populations of algae, benthic invertebrates, and fish; however some local water quality problems were observed in each basin. Loss of habitat due to sediment transported from mined land appeared to be the primary threat to aquatic biota in the South Fork Kentucky River system.

The Kentucky River from the confluence of the three forks near Beattyville to the Red River drains the Knobs physiographic region. Land-use effects in this area of Kentucky are primarily related to discharges of brines from oil and gas operations and sediment from mining operations. Non-point agricultural runoff and discharges of sewage effluents are more significant in the Knobs than in the steeper terrain of the Eastern Coal Field.

The Millers Creek and Ross Creek drainages were severely degraded by brines and supported only a few tolerant species and few individuals. Many of the headwater reaches of these streams were devoid of fish. Sturgeon Creek and Station Camp Creek supported numerous species of aquatic organisms, some of which were recognized as being of special concern in Kentucky (Warren and others, 1986).

The Red River system drains much of this hydrologic unit east of the Kentucky River. Major tributaries include the Middle and South Forks of the Red River, Swift Camp Creek, and Lulbegrud Creek. The Red River from the State Highway 746 bridge to the State Highway 715 bridge has been designated as a Kentucky Wild River (Miller and others, 1980). A wide variety of water-quality conditions exist in this system. High quality streams that support diverse biological communities include the upper Red River, Swift Camp Creek, and Lulbegrud Creek. Streams affected by brine include reaches of the South and Middle Forks of the Red River.

The Kentucky River from the Red River to the confluence with the Ohio River drains the largest hydrologic unit in the Kentucky River basin. The north-central area of the basin lies in the Inner Bluegrass region, which is characterized by a gently rolling upland underlain by thick-bedded limestones. Surrounding this region is the Outer Bluegrass region, an area underlain by thin-bedded limestones that include inter-bedded shales.

Primary effects of land use on aquatic biota in this hydrologic unit are related to deposition of sediment from agricultural sources and nutrient enrichment from wastewater treatment plant effluents. Sewage discharges from large population centers combined with the slow, deep water conditions in the lock system of the Kentucky River account for the accelerated eutrophication of some river reaches.

The Kentucky River from the Red River confluence to the Ohio River is an impounded set of navigational pools. Heavy sediment loads from tributary streams and discharges from rapidly-growing urban centers have drastically altered environmental conditions in the Kentucky River over the last 50 to 75 years (Williams, 1975). Silver Creek and South Elkhorn Creek were severely degraded due to effluent discharged from the Berea and Lexington wastewater treatment plants. Biological data available for Jessamine Creek, the Dix River system, sections of North Elkhorn Creek, and Eagle Creek indicated adequate water quality and habitat for most commonly occurring aquatic organisms.

Although some streams in the basin continue to support diverse biological communities and have excellent water quality, many streams in the Kentucky River system have been altered to some extent by man's activities. Sediment transported from mined lands, oil and gas operations, agricultural lands, and construction sites has reduced the available habitat for many species. This increased sedimentation coupled with discharges from urban centers, nutrient enrichment from agricultural runoff, and brine associated with oil and gas production have affected water quality and habitat conditions and led to decreases in numbers of aquatic species and individuals in many Kentucky River basin streams.

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