CHEMICAL QUALITY OF BOTTOM SEDIMENTS IN SELECTED STREAMS, JEFFERSON COUNTY, KENTUCKY, APRIL–JULY 1992

By Brian L. Moore *and* Ronald D. Evaldi

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
inch (in.)	2.54	centimeter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	28.32	cubic decimeter per second
cubic feet per second per square mile [(ft^3/s) mi^2]	10.93	cubic decimeter per second per square kilometer

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8$$

Abbreviated bottom-sediment units used in this report: Chemical concentrations are reported in milligrams per kilogram (mg/kg). These units express the concentration of chemical constituents as the mass (milligrams) of the element per unit mass (kilogram) of material analyzed. One thousand micrograms per kilogram (µg/kg) is equivalent to 1 mg/kg.

Chemical Quality of Bottom Sediments in Selected Streams, Jefferson County, Kentucky, April–July 1992

By Brian L. Moore *and* Ronald D. Evaldi

Abstract

This report presents the results of a study by the U.S. Geological Survey, in cooperation with the Louisville and Jefferson County Metropolitan Sewer District, to describe the chemical quality of bottom sediments in selected streams of Jefferson County, Ky., April–July 1992. Bottom sediments from 25 stream sites in the county were analyzed for percent volatile solids and concentrations of nutrients, major metals, trace elements, miscellaneous inorganic compounds, and synthetic organic compounds. Statistical high outliers of the constituent concentrations analyzed for in the bottom sediments were defined as a measure of possible elevated concentrations. Statistical high outliers were determined for at least 1 constituent at each of 12 sampling sites in Jefferson County.

Of the 10 stream basins sampled in Jefferson County, the Middle Fork Beargrass Creek Basin, Cedar Creek Basin, and Harrods Creek Basin were the only three basins where a statistical high outlier was determined for any of the measured constituents. In the Pennsylvania Run Basin, total volatile solids, nitrate plus nitrite, and endrin constituents were statistical high outliers. Pond Creek was the only basin where five constituents were statistical high outliers—barium, beryllium, cadmium, chromium, and silver. Nitrate plus nitrite and copper constituents were the only statistical high outliers determined in the Mill Creek Basin. In the Floyds Fork Basin, nitrate plus nitrite, phosphorous, mercury, and silver constituents were the only statistical high outliers. Ammonia was the only statistical high outlier found in the South Fork Beargrass Creek Basin. In the Goose Creek Basin, mercury and silver constituents were the only statistical high outliers. Cyanide was the only statistical high outlier in the Muddy Fork Basin.

INTRODUCTION

Sediment contamination is one of the major end results of pollutant discharges into freshwater aquatic environments. Recent sediment-quality studies by the U.S. Environmental Protection Agency (USEPA) and the National Academy of Sciences indicate that, in some places, pollutant discharges have resulted in sediment contamination high enough to harm aquatic life and the consumers of that aquatic life (U.S. Environmental Protection Agency, 1992). For many toxic materials, sediments are the primary repository; in many cases, sediments are the principal source of contamination to the food chain. Although heavy metals, nutrients, and oxygen-demanding materials are naturally occurring sediment constituents, elevated concentrations can generally be attributed directly or indirectly to human activities. The occurrence of unnatural constituents such as pesticides in sediments are related directly to human activities in the watershed (Illinois Environmental Protection Agency, 1984).

Jefferson County, Ky.—which includes Louisville, the largest city in the State—is a rapidly developing urban area. Urbanization has replaced rural land with residences, businesses, industrial facilities, shopping centers, and parking lots. Urbanization generally increases the potential for change in the types and quantities of contaminants discharged to the surface waters of the county. A concern exists that the quality of bottom sediments in many streams and drainage channels in Jefferson County is being degraded by various contaminants from point and nonpoint sources, including effluents from sewage and industrial wastewater-treatment plants, stormwater runoff from a variety of land-use areas, and leachates from septic tanks, impoundments, and landfills.

In 1992, the U.S. Geological Survey (USGS) and the Louisville and Jefferson County Metropolitan Sewer District (MSD) began a cooperative program to evaluate the chemical quality of bottom sediments in selected streams in Jefferson County, Ky. (fig. 1). The study involved collection of bottom-sediment samples at 25 stream sites previously used for water-quality sampling.

Purpose and Scope

This report presents bottom-sediment data obtained from 25 sites in 10 basins in Jefferson County during April–July 1992. Specifically, this report (a) describes the study area and the techniques of data collection and analysis and (b) presents data, in tables and maps, for 4 categories of chemical constituents. Concentrations of selected constituents in the bottom sediments were evaluated to assess the quality of the streambeds and to identify stream segments where constituent concentrations were highest.

Description of Study Area

Jefferson County encompasses approximately 400 mi^2 in north-central Kentucky along the Ohio River (fig. 1) and is the most densely populated county in the State. The 10 stream systems that drain Jefferson County and parts of five surrounding counties have a combined drainage area of approximately 600 mi^2. Streams in northern and eastern Jefferson County generally originate outside the county.

Climate

The climate of Louisville is classified as "moist-continental" by Strahler and Strahler (1979). It is characterized by changeable weather with short periods of extreme conditions. Weather systems generally track north from the Gulf of Mexico, bringing warm moist air in the summer, or southeast from Canada, bringing occasional arctic air masses to the area in the winter. As a result, winters are moderately cold (temperatures rarely below 0°F), and summers are warm (temperatures rarely above 100°F). The coldest month is January, during which the daily minimum temperature averages 30.4°F; the warmest month is July, during which the daily maximum temperature averages 91.6°F (National Oceanic and Atmospheric Administration, 1994).

The average annual precipitation at Louisville is 44.4 in. (Mike Callahan, National Oceanic and Atmospheric Administration, oral commun., 1994). October is the driest month on average, and March is the wettest. Thunderstorms usually contribute substantially to the rainfall in the spring and summer. Snow usually falls from November through March, although it has snowed as late as April and as early as October. Average annual snowfall is 18.0 in.

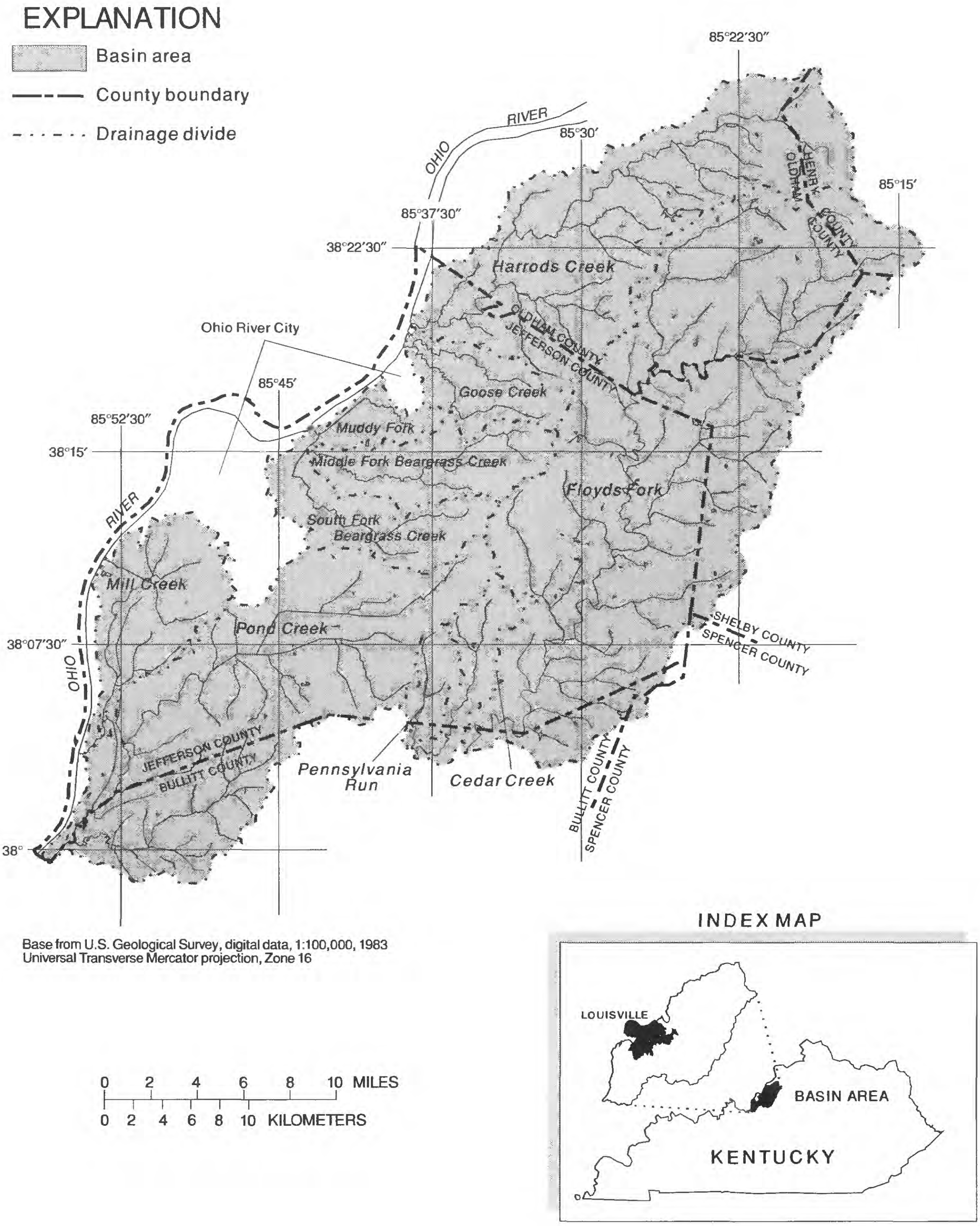


Figure 1. Major stream basins in Jefferson County, Kentucky.

Population and Land Use

According to the 1990 census, the population of Jefferson County was approximately 665,000 (Louisville Chamber of Commerce, 1992). This population represents a 3-percent decline from the 1980 census figure and a 4-percent decline since 1970. The Louisville Chamber of Commerce, however, projected that the population of Jefferson County will increase to 673,000 by the end of 1994.

Generalized land use of Jefferson County is shown in figure 2. Land-use data are from the 1983 National Atmospheric and Space Administration high-altitude aerial photographs and National High-Altitude Photography program photographs, digitized at a scale of 1:250,000 (U.S. Geological Survey, 1986). The change in land use from 1983 to 1993 is unknown; however, on the basis of the 1983 land-use information, most commercial and industrial land is within the Louisville city limits. With some exceptions, residential land use predominates within and immediately outside the city limits. Land uses within the drainage basins of the bottom-sediment sampling sites are listed in table 1.

The eastern, southern, and southwestern parts of the county are mostly agricultural and forest land; however, some industrial land use is within these areas: an industrial park in the Floyds Fork Basin, an industrial park and truck-assembly plant in the Harrods Creek Basin, and at large manufacturing facilities in the Pond Creek Basin.

Geology

The generalized geology of Jefferson County, consists of beds of limestone, shale, and dolomite of Ordovician, Silurian, Devonian, and Mississippian age overlain by glacial outwash and lacustrine deposits of Quaternary age (fig. 3). The following discussion of the geology of Jefferson County is excerpted mainly from the Geologic Map of Kentucky (McDowell and others, 1981) and the accompanying text (McDowell, 1986) with additional information from MacCary (1956).

Limestone and shale of Ordovician age crop out in the eastern one-fifth of Jefferson County, which is generally the Floyds Fork Basin. The limestone is mainly composed of whole- and broken-fossil fragments set in a matrix of fine- to coarse-grained fossil fragments. The shale is highly calcareous and silty, and eroded to produce ridges separated by relatively broad, flat stream valleys. Other Ordovician rocks in eastern Jefferson County include siltstone and dolomite.

Rocks of Silurian age crop out in a broad belt extending north to south across the central part of Jefferson County and are the predominant rock units within the Cedar Creek, Pennsylvania Run, Harrods Creek, and Goose Creek Basins. These rocks also crop out in the stream valleys of Muddy Fork and in the Middle and South Forks of Beargrass Creek. The Silurian rocks are of marine origin and consist of dolomite and shale and minor amounts of limestone and chert.

Carbonate rocks of Devonian age dominate in the Middle and South Fork Beargrass Creek and Muddy Fork Basins. Devonian carbonates are overlain by a thick sequence of shale. Limestone and organically rich black shale of Devonian age crop out in central and north-central Jefferson County, within the Pond Creek and Middle Fork Beargrass Creek Basins. Thin beds of phosphatic quartz sandstone are common in the limestone.

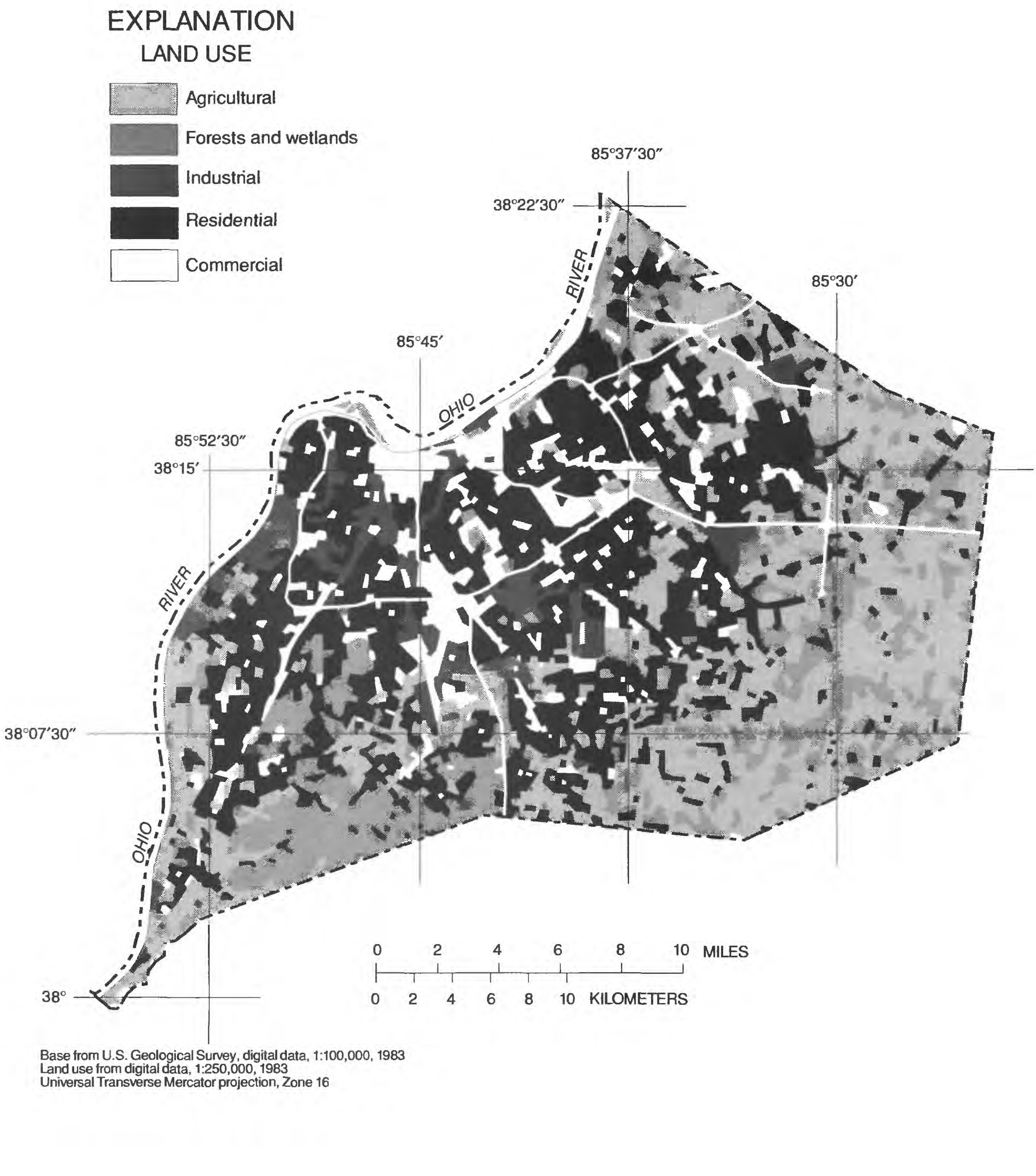


Figure 2. Generalized land use in Jefferson County, Kentucky.

Table 1. Land uses within the drainage basins of selected streams in Jefferson County, Kentucky

Site number and name		Drainage area, in square miles[1]	Land use, in percentage of drainage area[2]				
			Agricultural	Commercial	Forests and wetlands	Industrial	Residential
1	Pond Creek at Pendleton Road	82.0	19.5	9.5	24.5	8.2	38.3
2	Mill Creek at Orell Road	13.9	30.2	6.9	14.7	5.1	43.1
3	Pond Creek at Manslick Road	63.9	19.2	11.3	18.4	10.4	40.7
5	South Fork Beargrass Creek at Winter Avenue	22.3	10.6	16.7	4.0	12.5	56.2
6	South Fork Beargrass Creek at Trevilian Way	16.9	14.1	16.4	2.0	12.7	54.8
7	Middle Fork Beargrass Creek at Old Cannons Lane	18.4	16.3	23.2	2.6	4.4	53.5
8	Middle Fork Beargrass Creek at Beals Branch Road	22.6	13.2	22.2	2.1	6.2	56.3
9	Spring Ditch at Private Drive below Hanses Road	2.4	20.0	15.3	1.8	37.3	25.6
10	Muddy Fork at Mockingbird Valley Road	6.5	3.1	12.1	5.8	6.7	72.3
11	Goose Creek at U.S. Highway 42	9.8	26.3	11.7	4.5	3.6	53.9
12	Little Goose Creek at U.S. Highway 42	5.8	51.2	14.7	8.4	.1	25.6
13	Goose Creek at Old Westport Road	6.8	27.3	12.7	3.3	1.7	55.0
14	Pope Lick at Pope Lick Road	3.0	29.4	14.6	8.6	0	47.4
15	Floyds Fork at former State Highway 155	138	71.5	2.1	12.1	1.1	13.2

Table 1. Land uses within the drainage basins of selected streams in Jefferson County, Kentucky—Continued

Site number and name		Drainage area, in square miles[1]	Land use, in percentage of drainage area[2]				
			Agricultural	Commercial	Forests and wetlands	Industrial	Residential
16	Chenoweth Run at Gelhaus Road	11.7	34.8	5.1	10.9	12.7	36.5
17	Fern Creek at Old Bardstown Road	3.4	21.7	2.5	9.5	0	66.3
18	Northern Ditch at Preston Highway	11.4	24.5	7.4	7.5	4.4	56.2
19	Fishpool Creek at Bost Road	5.4	34.4	4.6	4.2	2.4	54.4
20	Southern Ditch at Minors Lane	13.1	25.2	7.7	13.8	1.3	52.0
21	Floyds Fork at Bardstown Road	214	66.4	2.0	14.4	1.4	13.6
22	Cedar Creek at Thixton Road	11.3	55.9	1.0	14.2	.3	28.6
23	Pennsylvania Run at Mount Washington Road	6.2	46.4	1.2	18.2	.8	33.4
24	Mill Creek Cutoff at Dover Road	16.0	4.7	12.5	14.0	6.8	62.0
25	Harrods Creek at Hunting Creek Drive	100	66.5	3.0	20.2	1.9	8.4
26	Long Run at State Highway 1531	23.7	74.9	1.5	16.5	1.3	5.8

[1]Source: Digital data from 1986 and 1989 aerial photographs at a scale of 1:4,800.

[2]Source: Digital data from 1983 aerial photographs at a scale of 1:250,000.

Rocks of Mississippian age crop out in the south-central part of Jefferson County, primarily within the Pond Creek Basin. These Mississippian rocks are composed of a sequence of fine-grained sediments that become coarser upward. Siltstone caps a few of the knobs and low hills and also crops out along the sides of the highest ridges.

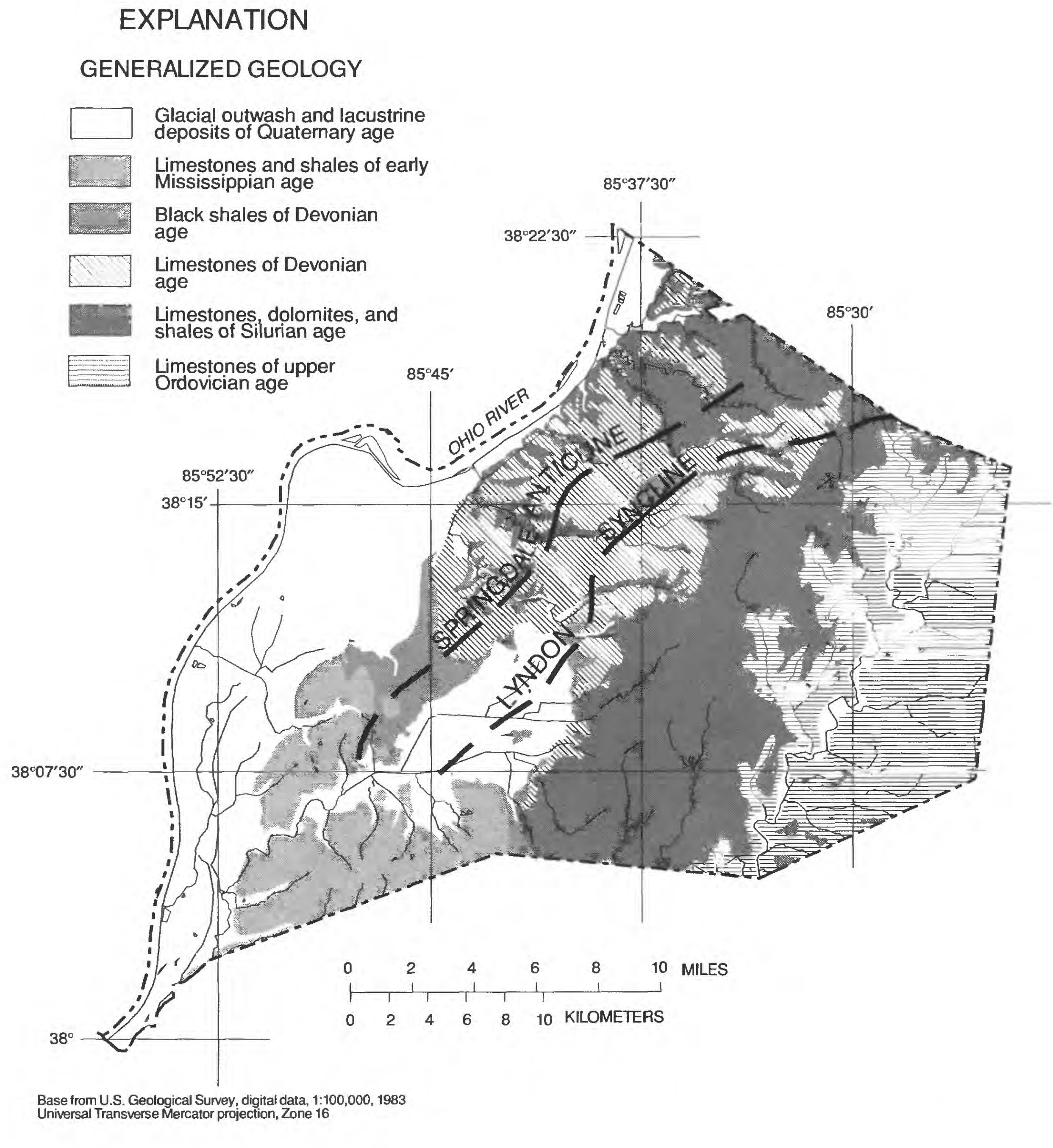


Figure 3. Generalized geology of Jefferson County, Kentucky.

Unconsolidated sediments consisting of gravel, sand, silt, and clay of Quaternary age overlie most of western Jefferson County. The Mill Creek and Ohio River City Basins are overlain extensively by these sediments. The deposits are thin except for alluvium along the bottom of the valley in the Floyds Fork Basin. Lacustrine sediments in the deposits are thin except for alluvium along the bottom of the valley in the Floyds Fork Basin, lacustrine sediments in the Pond Creek Basin, and outwash and other glacial deposits along the Ohio River.

Surface-Water Hydrology

The major stream basins in Jefferson County are Harrods Creek, Goose Creek, Muddy Fork, Middle Fork Beargrass Creek, South Fork Beargrass Creek, Floyds Fork, Cedar Creek, Pennsylvania Run, Pond Creek, and Mill Creek (fig. 1). These basins range in size from 8.5 mi^2 (Pennsylvania Run) to 222.4 mi^2 (Floyds Fork). Four of these basins—Cedar Creek, Harrods Creek, Pennsylvania Run, and Floyds Fork—extend outside Jefferson County into five surrounding counties. The Louisville metropolitan area and areas of the county that drain directly to the Ohio River have been designated as the Ohio River City Basin (fig. 1). The Louisville metropolitan area consists of a dense commercial central business district that is mainly drained by a complex system of combined sewers; few open channels are present in the district.

The average discharge of stream basins in the Jefferson County area is about 1.3 $(ft^3/s)/mi^2$ and is approximately uniform throughout the area (table 2). Basin discharge during hydrologic extremes, however, can differ widely throughout the county. Peak discharge of streams in rural areas of Kentucky is related to drainage area and basin morphologic characteristics, including main-channel slope, basin shape, and channel sinuosity (Choquette, 1988).

Table 2. Streamflow and basin characteristics at selected continuous-record streamflow-gaging stations in Jefferson County, Kentucky

[mi^2, square mile; ft/mi, feet per mile; ft^3/s, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile; Data sources: drainage area, digital data from 1986 and 1989 aerial photographs at a scale of 1:4,800; channel slope and peak 100-year unit flow from Melcher and Ruhl, 1984; and 7-day, 10-year low flow and streamflow-variability index from Ruhl and Martin, 1991]

Site number and name		Drainage area (mi^2)	Channel slope (ft/mi)	Period of record (water years[1])	Average flow (ft^3/s)	Average unit flow ($(ft^3/s)/mi^2$)
3	Pond Creek at Manslick Road	63.9	12	1944–92	89.5	1.40
6	South Fork Beargrass Creek at Trevilian Way	16.9	19	1940 1945–53 1955–62 1971–83 1989–92	22.5	1.29
7	Middle Fork Beargrass Creek at Old Cannons Lane	18.4	18	1944–92	25.3	1.35
15	Floyds Fork at former State Highway 155	138	5.5	1944–92	178	1.28

[1]The 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends.

BOTTOM-SEDIMENT COLLECTION AND LABORATORY ANALYSES

Bottom sediment is defined as the sediment mixture of which the streambed is composed (Ward and Harr, 1990). As mentioned previously, bottom-sediment samples were collected at 25 stream sites in Jefferson County (fig. 4 and table 3) that were previously included as part of a streamwater-quality monitoring network. Site selection for this sampling network was designed to ensure collection of representative data from all the major drainage basins in Jefferson County outside the Ohio River City Basin. Potential sources of contaminants in the drainage area of each sampling site were identified by the MSD (Pamela J. Pulliam, Louisville and Jefferson County Metropolitan Sewer District, written commun., 1992; table 3). Bottom-sediment sampling began in April 1992 and ended in July 1992; two stream sites were sampled each week. Data were collected jointly by personnel from the MSD and the USGS. Laboratory analyses were done by the MSD.

Bottom-Sediment Collection

Bottom sediment was collected by use of a stainless-steel spoon during periods of low flow when wading was possible. Because sediment deposition in streams is not equally distributed across the stream profile (Illinois Environmental Protection Agency, 1984), field personnel had to locate areas of reduced velocity where sediment deposition was likely. Field personnel selected deposits of fine texture (muck and ooze) characteristically high in organic materials, clay, and silt. Gravel, twigs, and other debris were avoided. Bottom sediment was collected from the top 2 to 3 centimeters of bottom material and was placed in a sieve bottom. Samples were collected from multiple locations within a cross section and composited to ensure a representative sample.

All of the sampling equipment was prewashed with a laboratory-grade detergent and then rinsed with tapwater. Immediately before sampling, all sampling equipment was rinsed with methanol to remove residual organics and then was rinsed with native water. When collecting samples by hand, field personnel pressed the edge of the stainless-steel spcoon lightly into the sediment and drew it forward, thus allowing bottom sediment to roll over the side and into the spoon. The spoon was removed with minimal disturbance to allow sediment to remain in the spoon. Once an adequate quantity of bottom sediment was collected, the composited sample was placed into a 2-millimeter sieve (no. 10) on top of a 63-micrometer sieve (no. 230) and a sieve bottom. After wet sieving the coarse bottom sediment through the 2-millimeter sieve with native water, the top sieve was removed and the remaining sediment was wet sieved with native water through the 63-micrometer sieve into the sieve bottom. The sediment, less than 63 micrometers in size, was then transferred into a baked, widemouthed, amber-glass jar, was stored on ice, and was transported to the laboratory for analysis.

Laboratory Analyses

Bottom-sediment samples were analyzed for volatile solids, nitrate plus nitrite, ammonia, organic nitrogen, phosphorus, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, thallium, zinc, cyanide, chlordane, endrin, lindane, methoxychlor, and toxophene (table 4). The MSD laboratory used methods approved by the USEPA, as listed in 40 CFR, Part 136 (Code of Federal Regulations, 1990).

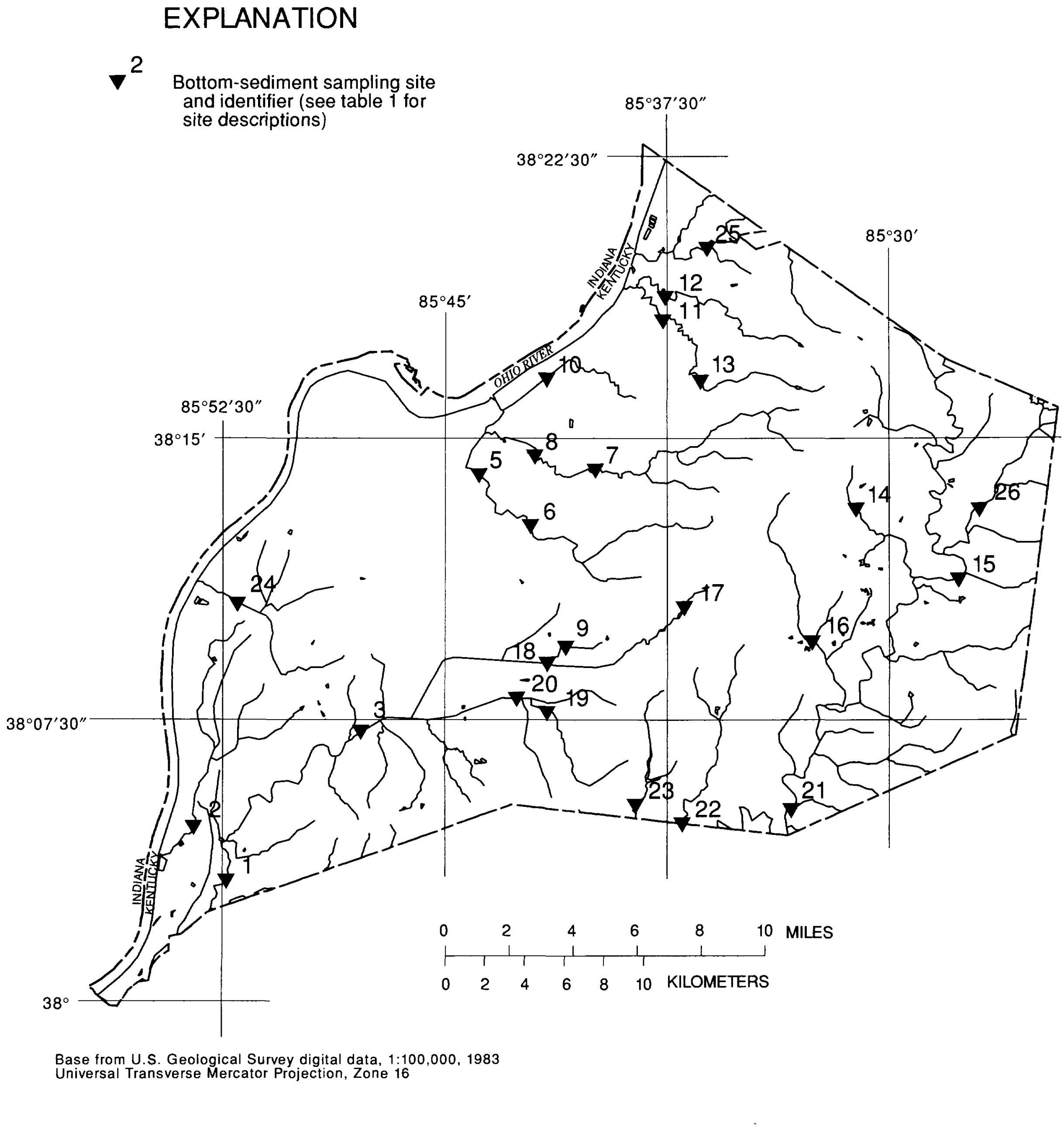


Figure 4. Bottom-sediment sampling sites in Jefferson County, Kentucky.

Table 3. Bottom-sediment sampling sites in Jefferson County, Kentucky, and potential sources of contaminants in their respective drainage basins

[NPR, nonpoint runoff; WTE, wastewater-treatment-plant effluent; STD, septic-tank discharges; IW, industrial wastewater; CSO, combined-sewer or sanitary-sewer overflows]

Site number and name		Potential sources of contaminants[1]
1	Pond Creek at Pendleton Road	NPR, WTE, STD, IW
2	Mill Creek at Orell Road	NPR, WTE, STD
3	Pond Creek at Manslick Road	NPR, WTE, STD, IW
5	South Fork Beargrass Creek at Winter Avenue	NPR, CSO
6	South Fork Beargrass Creek at Trevilian Way	NPR, CSO
7	Middle Fork Beargrass Creek at Old Cannons Lane	NPR, CSO
8	Middle Fork Beargrass Creek at Beals Branch Road	NPR, WTE, STD, CSO
9	Spring Ditch at Private Drive below Hanses Road	NPR, WTE
10	Muddy Fork at Mockingbird Valley Road	NPR, WTE, STD
11	Goose Creek at U.S. Highway 42	NPR, WTE, STD
12	Little Goose Creek at U.S. Highway 42	NPR, WTE, STD
13	Goose Creek at Old Westport Road	NPR, WTE, STD
14	Pope Lick at Pope Lick Road	NPR, WTE, STD
15	Floyds Fork at former State Highway 155	NPR, WTE, STD
16	Chenoweth Run at Gelhaus Road	NPR, WTE
17	Fern Creek at Old Bardstown Road	NPR, WTE
18	Northern Ditch at Preston Highway	NPR, WTE, STD, IW
19	Fishpool Creek at Bost Road	NPR, WTE, STD
20	Southern Ditch at Minors Lane	NPR, WTE, STD
21	Floyds Fork at Bardstown Road	NPR, WTE, STD
22	Cedar Creek at Thixton Road	NPR, WTE, STD
23	Pennsylvania Run at Mt. Washington Road	NPR, WTE, STD
24	Mill Creek Cutoff at Dover Road	NPR, STD
25	Harrods Creek at Hunting Creek Drive	NPR, WTE, STD
26	Long Run at State Highway 1531	NPR, STD

[1]Source: Pamela J. Pulliam, Louisville and Jefferson County Metropolitan Sewer District, written commun., 1992.

Table 4. Methods used by the Louisville and Jefferson County Metropolitan Sewer District laboratory for analysis of bottom-sediment samples from selected streams in Jefferson County, Kentucky, April–July 1992

[USEPA, U.S. Environmental Protection Agency; mg/kg, milligrams per kilogram]

Constituent or property and unit	Method	USEPA[1] method number
Residue, volatile, total, in percent	Volatile-on-ignition, total, gravimetric	160.4
	Nutrients	
Nitrate plus nitrite, total, in mg/kg as N	Colorimetric, cadmium reduction	353.3
Nitrogen, ammonia, total, in mg/kg as N	Electrometric, ion-selective electrode	350.3
Nitrogen, organic plus ammonia, total, in mg/kg as N	Titrimetric, digestion-distillation electrode	351.3
Phosphorus, total, in mg/kg as P	Atomic emission spectrometric, induction-coupled argon plasma	200.7
	Major metals, trace elements, and miscellaneous inorganic compounds	
Antimony, total, in mg/kg as Sb	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Arsenic, total, in mg/kg as As	Digestion, graphite furnace, atomic absorption	206.2
Barium, total, in mg/kg as Ba	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Beryllium, total, in mg/kg as Be	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Cadmium, total, in mg/kg as Cd	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Chromium, total, in mg/kg as Cr	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Copper, total, in mg/kg as Cu	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Cyanide, total, in mg/kg as CN	Colorimetric, barbituric acid	335.2
Iron, total, in mg/kg as Fe	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Lead, total, in mg/kg as Pb	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Mercury, total recoverable, in mg/kg as Hg	Atomic absorption spectrometric, flameless	245.1
Nickel, total, in mg/kg as Ni	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Selenium, total, in mg/kg as Se	Digestion, graphite furnace, atomic absorption	270.2
Silver, total, in mg/kg as Ag	Atomic emission spectrometric, induction-coupled argon plasma	200.7

Table 4. Methods used by the Louisville and Jefferson County Metropolitan Sewer District laboratory for analysis of bottom-sediment samples from selected streams in Jefferson County, Kentucky, April–July 1992—Continued

[USEPA, U.S. Environmental Protection Agency; mg/kg, milligrams per kilogram]

Constituent or property and unit	Method	USEPA[1] method number
Major metals, trace elements, and miscellaneous inorganic compounds—Continued		
Thallium, total, in mg/kg as Th	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Zinc, total, in mg/kg as Zn	Atomic emission spectrometric, induction-coupled argon plasma	200.7
Synthetic organic compounds, composite samples		
Chlordane, total, in mg/kg	Hexane extraction, gas chromatograph with electron capture detection	608
Endrin, total, in mg/kg	Hexane extraction, gas chromatograph with electron capture detection	608
Lindane, total, in mg/kg	Hexane extraction, gas chromatograph with electron capture detection	608
Methoxychlor, total, in mg/kg	Hexane extraction, gas chromatograph with electron capture detection	608
Toxaphene, total, in mg/kg	Hexane extraction, gas chromatograph with electron capture detection	608

[1]Code of Federal Regulations, 1990.

The MSD laboratory performed all primary analyses of the bottom-sediment samples for the study. Quality-assurance samples consisted of two split samples between the MSD laboratory and the USGS National Water Quality Laboratory. Split samples were produced by dividing a composite sample into two aliquots. Aliquots from Southern Ditch at Minors Lane and Fishpool Creek at Bost Road (fig. 1) were sent to each laboratory. Differences between the laboratories' analytical results for the quality-assurance data sets were substantial but not unreasonable (table 5). The goal of the study was to explore and identify areas where concentrations of constituents seem to be high and therefore the results are not unreasonable for an exploratory study. Possible reasons for the differences in analytical results are (a) the methods used by the two labs were comparable, but not exactly the same and, (b) the detection limits were not the same for all constituents.

CHEMICAL QUALITY OF BOTTOM SEDIMENTS

Bottom sediments can collect physical debris and chemicals that are components of runoff. The concern associated with the chemicals sorbed to sediments is that many aquatic species spend much of their life cycles living in or on bottom sediments. Absorption and ingestion of these chemicals by sediment-dwelling organisms provide a pathway for these chemicals to be consumed by higher aquatic life and terrestrial wildlife, including humans. For many species, direct transfer of chemicals from sediments to organisms is a major route of exposure (Adams and others, 1992).

Table 5. Quality-assurance analyses of bottom-sediment samples from two sites in Jefferson County, Kentucky

[AS, arsenic; CD, cadmium; CR, chromium; CU, copper; FE, iron; PB, lead; HG, mercury; ZN, zinc; CLR, chlordane; END, endrin; LIN, lindane; MET, methoxychlor; TOX, toxaphene; MSD, Louisville and Jefferson County Metropolitan Sewer District; <, less than; USGS, U.S. Geological Survey; concentrations in milligrams per kilogram]

Site number and name	Laboratory	AS	CD	CR	CU	FE	PB	HG	ZN	CLR	END	LIN	MET	TOX
19 Fishpool Creek at Bost Road	MSD	0.2	0.1	7.7	10	7,770	6.6	0.02	35	<0.92	0.26	<0.20	<0.66	<0.35
	USGS	10	1.0	20	21	17,000	10	.04	63	1.0	.1	.1	.1	10
20 Southern Ditch at Minors Lane	MSD	<.2	.1	5.2	7.4	6,980	9.5	.01	36	<.92	.34	<.20	<.66	<.35
	USGS	14	1.0	10	19	23,000	20	.02	59	2.0	.1	.1	.1	10

Elevated concentrations of sediment constituents, heavy metals, nutrients, and oxygen demanding sediments, can generally be attributed to human activities. Detectable concentrations of most pesticides, which are not naturally occurring substances, are related directly to human influence in the drainage basin. Bottom-sediment data for streams in Jefferson County are listed in table 6.

The Illinois Environmental Protection Agency developed a classification scheme for defining elevated constituent concentrations in bottom sediments on the basis of standard deviations from mean concentrations of selected constituents in about 800 samples collected in Illinois. A somewhat similar approach was adopted for classification of constituent concentrations in bottom sediments of Jefferson County; however, because fewer samples were available, statistical high outliers were defined as a measure of possible elevated concentrations. Statistical high outliers, as defined by Tukey (1977), are values greater than 1.5 times the interquartile range above the 75th percentile of data and should be detected fewer than once in 100 times in a normal distribution (Helsel and Hirsch, 1992). The occurrence of statistical high outliers more frequently than expected indicates that the data may not originate from a normal distribution and may be affected by human activities. Except for volatile solids, the statistical high outliers for constituent concentrations in sediments in Jefferson County were less than the elevated concentrations for Illinois streams for the nine sampled constituents common to both data sets (table 7). All stream sites where constituent concentrations in bottom sediments identified as statistical high outliers are given in this report.

Total Volatile Solids

Total volatile solids, in percent, in the sediments ranged from 3.0 to 9.4; the median was 5.6. The largest concentration of volatile solids, 9.4 at Pennsylvania Run (site 23), was the only statistical high outlier. Volatile solids concentrations in bottom sediments at six of the seven sites sampled in the Pond Creek Basin were less than 5.0 (fig. 5).

Nutrients

In this report, nutrients are defined as phosphorus and nitrogen species. In order to grow, plants (including algae) require phosphorus and nitrogen, as well as trace amounts of other elements. Nitrogen and phosphorus in bottom sediments originate from natural and artificial sources. Some sources of nitrogen are municipal and industrial wastewater, feedlot runoff, leachate from waste disposals in dumps or landfills, atmospheric fallout, and mineralization of soil organic matter. Some sources of phosphorus are phosphorus-bearing minerals in the soil, decaying plant material, fertilizers, synthetic detergents, sewage effluents, and septic-tank leachates. Nitrate plus nitrite concentrations in bottom sediments ranged from 0.03 to 18 mg/kg; the median was 2.9 mg/kg. At Pope Lick (site 14), Pennsylvania Run (site 23), and Mill Creek Cutoff (site 24), nitrate plus nitrite concentrations were statistical high outliers, at 13 mg/kg or greater. No nitrate plus nitrite data were available for Middle Fork Beargrass Creek at Old Cannons Lane (site 7) or Middle Fork Beargrass Creek At Beals Branch Road (site 8).

Ammonia concentrations ranged from 24 to 131 mg/kg in bottom sediments and were highly variable throughout Jefferson County; the median was 53 mg/kg (fig. 6). Only the maximum concentration of 131 mg/kg, at South Fork Beargrass Creek at Winter Avenue (site 5), was the only statistical high outlier.

Table 6. Concentrations of constituents in bottom sediments of selected streams in Jefferson County, Kentucky, April–July 1992

[VS, volatile solids, in percent; N, nitrate plus nitrite; AM, ammonia, ON, organic nitrogen; P, phosphorus; SB, antimony; AS, arsenic; BA, barium; BE, beryllium; CD, cadmium; CR, chromium; CU, copper; FE, iron; <, less than; --, missing data; PB, lead; HG, mercury; NI, nickel; SE, selenium; AG, silver; TL, thallium; ZN, zinc; CN, cyanide; CLR, chlordane; END, endrin; LIN, lindane; MET, methoxychlor; TOX, toxaphene; concentrations in milligrams per kilogram]

Site number	Site name	Date	VS	N	AM	ON	P	SB	AS	BA	BE	CD	CR	CU	FE
1	Pond Creek at Pendleton Road	6/01/92	4.3	2.9	72	410	260	<0.3	1.0	30	0.2	0.1	6.4	7.3	7,200
2	Mill Creek at Orell Road	5/04/92	4.6	1.6	54	258	349	<.3	<.4	58	.4	.2	10	35	11,300
3	Pond Creek at Manslick Road	6/01/92	4.6	4.4	69	393	208	<.3	.5	54	.3	.1	8.3	8.7	8,130
5	South Fork Beargrass Creek at Winter Avenue	5/11/92	5.3	6.0	131	575	209	<.3	1.2	28	.2	.05	4.1	7.1	4,230
6	South Fork Beargrass Creek at Trevilian Way	5/11/92	3.2	3.4	55	279	160	<.3	1.1	37	.2	.1	5.8	15	7,320
7	Middle Fork Beargrass Creek at Old Cannons Lane	6/08/92	9.0	--	33	705	207	<.3	.3	32	.2	.2	4.0	8.9	3,710
8	Middle Fork Beargrass Creek at Beals Branch Road	6/08/92	7.6	--	45	738	234	<.3	.8	40	.2	.2	4.5	10	4,380
9	Spring Ditch at Private Drive below Hanses Road	4/06/92	4.2	.8	53	--	286	<.7	.4	47	.3	.3	13	10	5,830
10	Muddy Fork at Mockingbird Valley Road	5/20/92	5.6	4.1	98	502	346	<.3	1.2	40	.3	.1	6.5	8.0	7,370
11	Goose Creek at U.S. Highway 42	5/27/92	7.3	1.3	34	619	269	<.3	.6	34	.2	.1	3.5	8.4	3,670
12	Little Goose Creek at U.S. Highway 42	5/27/92	6.1	.9	32	566	219	<.3	.9	36	.2	.04	4.6	3.9	4,960
13	Goose Creek at Old Westport Road	6/29/92	5.9	4.2	33	670	346	<.3	.8	39	.2	.1	4.6	8.3	4,410

Table 6. Concentrations of constituents in bottom sediments of selected streams in Jefferson County, Kentucky, April–July 1992—Continued

[VS, volatile solids, in percent; N, nitrate plus nitrite; AM, ammonia, ON, organic nitrogen; P, phosphorus; SB, antimony; AS, arsenic; BA, barium; BE, beryllium; CD, cadmium; CR, chromium; CU, copper; FE, iron; <, less than; --, missing data; PB, lead; HG, mercury; NI, nickel; SE, selenium; AG, silver; TL, thallium; ZN, zinc; CN, cyanide; CLR, chlordane; END, endrin; LIN, lindane; MET, methoxychlor; TOX, toxaphene; concentrations in milligrams per kilogram]

Site number and name		Date	VS	N	AM	ON	P	SB	AS	BA	BE	CD	CR	CU	FE
14	Pope Lick at Pope Lick Road	6/15/92	5.0	13	24	475	255	<0.3	0.6	36	0.3	<0.03	5.5	4.1	6,760
15	Floyds Fork at former State Highway 155	4/28/92	5.9	1.3	44	695	575	<.3	.7	53	.4	<.03	7.0	14	8,760
16	Chenoweth Run at Gelhaus Lane	4/20/92	5.6	3.3	54	619	269	<.3	.6	56	.2	<.03	4.2	18	4,870
17	Fern Creek at Old Bardstown Road	4/20/92	5.1	3.4	54	625	280	<.3	.4	49	.3	.1	5.7	6.0	5,360
18	Northern Ditch at Preston Highway	4/06/92	3.0	.9	42	183	300	<1.4	1.0	101	.5	.3	9.3	13	8,980
19	Fishpool Creek at Bost Road	6/22/92	4.0	7.9	80	178	332	<.3	.2	50	.3	.1	7.7	10	7,770
20	Southern Ditch at Minors Lane	6/22/92	4.1	1.3	62	355	109	<.3	<.2	38	.3	.1	5.2	7.4	6,980
21	Floyds Fork at Bardstown Road	4/13/92	6.0	.3	77	550	431	<1.4	.9	32	.2	.2	3.7	18	5,590
22	Cedar Creek at Thixton Road	4/13/92	6.6	.03	43	257	133	<.7	.4	16	.1	<.07	2.1	1.8	2,510
23	Pennsylvania Run at Mt. Washington Road	6/15/92	9.4	17	47	760	352	<.3	.6	35	.2	.07	4.1	5.0	3,960
24	Mill Creek Cutoff at Dover Road	5/04/92	6.4	18	70	294	179	<.3	.9	13	.1	.1	3.4	4.7	3,800
25	Harrods Creek at Hunting Creek Drive	6/29/92	5.9	1.7	31	590	216	<.3	1.2	41	.3	<.03	4.1	3.8	6,150
26	Long Run at State Highway 1531	4/28/92	6.4	3.2	41	590	553	<.3	.6	37	.2	.1	5.3	6.9	6,140

Table 6. Concentrations of constituents in bottom sediments of selected streams in Jefferson County, Kentucky, April–July 1992—Continued

[VS, volatile solids, in percent; N, nitrate plus nitrite; AM, ammonia, ON, organic nitrogen; P, phosphorus; SB, antimony; AS, arsenic; BA, barium; BE, beryllium; CD, cadmium; CR, chromium; CU, copper; FE, iron; <, less than; --, missing data; PB, lead; HG, mercury; NI, nickel; SE, selenium; AG, silver; TL, thallium; ZN, zinc; CN, cyanide; CLR, chlordane; END, endrin; LIN, lindane; MET, methoxychlor; TOX, toxaphene; concentrations in milligrams per kilogram]

Site number and name		Date	PB	HG	NI	SE	AG	TL	ZN	CN	CLR	END	LIN	MET	TOX
1	Pond Creek at Pendleton Road	6/01/92	10	0.01	11	<1	0.2	<0.24	40	0.02	<0.92	0.29	<0.20	<0.66	<0.35
2	Mill Creek at Orell Road	5/04/92	18	.06	13	<1	<.06	<.24	48	<.01	<.37	.57	<.08	<.26	<.14
3	Pond Creek at Manslick Road	6/01/92	19	.01	12	<1	.2	<.24	50	.04	<.92	.11	<.20	<.66	<.35
5	South Fork Beargrass Creek at Winter Avenue	5/11/92	16	.04	5.4	<1	.2	<.24	35	.03	<.37	1.1	<.08	<.26	<.14
6	South Fork Beargrass Creek at Trevilian Way	5/11/92	14	.01	9.0	<1	.1	<.24	32	.01	<.37	.13	<.08	<.26	<.14
7	Middle Fork Beargrass Creek at Old Cannons Lane	6/08/92	19	.01	5.7	<1	.2	<.24	40	<.01	<.92	.70	<.20	<.66	<.35
8	Middle Fork Beargrass Creek at Beals Branch Road	6/08/92	28	.03	6.0	<1	.2	<.24	41	<.01	<.92	1.2	<.20	<.11	<.35
9	Spring Ditch at Private Drive below Hanses Road	4/06/92	12	.04	11	3	<.04	5.5	47	.02	<.37	.35	<.08	<.26	<.14
10	Muddy Fork at Mockingbird Valley Road	5/20/92	12	.03	8.4	<1	.2	<.24	30	.13	<.37	.25	<.08	<.26	<.14
11	Goose Creek at U.S. Highway 42	5/27/92	7.3	.03	3.7	<1	.1	<.24	18	.04	<.37	.60	<.08	<.26	<.14
12	Little Goose Creek at U.S. Highway 42	5/27/92	7.2	.01	4.9	<1	.1	<.24	17	.06	<.37	.48	<.08	<.26	<.14
13	Goose Creek at Old Westport Road	6/29/92	8.2	.09	4.3	<1	.4	<.24	22	--	<.92	.96	<.20	<.66	<.35

Table 6. Concentrations of constituents in bottom sediments of selected streams in Jefferson County, Kentucky, April–July 1992—Continued

[VS, volatile solids, in percent; N, nitrate plus nitrite; AM, ammonia, ON, organic nitrogen; P, phosphorus; SB, antimony; AS, arsenic; BA, barium; BE, beryllium; CD, cadmium; CR, chromium; CU, copper; FE, iron; <, less than; --, missing data; PB, lead; HG, mercury; NI, nickel; SE, selenium; AG, silver; TL, thallium; ZN, zinc; CN, cyanide; CLR, chlordane; END, endrin; LIN, lindane; MET, methoxychlor; TOX, toxaphene; concentrations in milligrams per kilogram]

Site number and name		Date	PB	HG	NI	SE	AG	TL	ZN	CN	CLR	END	LIN	MET	TOX
14	Pope Lick at Pope Lick Road	6/15/92	6.6	0.01	5.0	<1	0.3	<0.24	12	<0.01	<0.92	0.31	<0.20	<0.66	<0.35
15	Floyds Fork at former State Highway 155	4/28/92	29	.05	7.2	<1	<.06	<.24	22	.01	<.37	.05	<.08	<.26	<.14
16	Chenoweth Run at Gelhaus Lane	4/20/92	14	.08	4.9	.9	.4	<.24	23	.06	<.37	.14	<.08	<.26	<.14
17	Fern Creek at Old Bardstown Road	4/20/92	16	.03	5.6	<1	.2	<.24	25	.04	<.37	.43	<.08	<.26	<.14
18	Northern Ditch at Preston Highway	4/06/92	21	.03	14	<2	<.08	8.7	47	<.01	<.18	.05	<.04	<.13	<.07
19	Fishpool Creek at Bost Road	6/22/92	6.6	.02	9.6	<1	.2	<.24	35	<.05	<.92	.26	<.20	<.66	<.35
20	Southern Ditch at Minors Lane	6/22/92	9.5	.01	9.8	<1	.9	<.24	36	<.05	<.92	.34	<.20	<.66	<.35
21	Floyds Fork at Bardstown Road	4/13/92	7.9	.02	4.2	<2	<.08	5.3	16	.04	<.18	.12	<.04	<.13	<.07
22	Cedar Creek at Thixton Road	4/13/92	3.5	.01	1.7	<2	<.04	1.6	8	<.01	<.37	.29	<.08	<.26	<.14
23	Pennsylvania Run at Mt. Washington Road	6/15/92	5.6	.07	3.2	<1	.3	<.24	15	.06	<.92	1.5	<.20	<.66	<.35
24	Mill Creek Cutoff at Dover Road	5/04/92	10	.02	4.7	<1	<.06	<.24	26	<.01	<.37	.33	<.08	<.26	<.14
25	Harrods Creek at Hunting Creek Drive	6/29/92	5.9	.01	4.5	<1	.2	<.24	12	--	<.92	.72	<.20	<.66	<.35
26	Long Run at State Highway 1531	4/28/92	9.8	.01	4.9	<1	<.06	<.24	15	.05	<.37	.13	<.08	<.26	<.14

Table 7. Comparison of statistical high outlier values for constituent concentrations in stream-bottom sediments in Jefferson County, Kentucky, with elevated concentrations in Illinois stream-bottom sediments

[≥, greater than or equal to; --, missing data; volatile solids are in percent; all other entries are concentrations in milligrams per kilogram, dry weight]

Constituent	Statistical high outlier for Jefferson County stream-sediment data	Elevated concentration in Illinois stream sediments[1]
Total volatile solids	≥9.3	≥8.8
Nitrate plus nitrite	≥9.4	--
Ammonia	≥118	--
Organic nitrogen	≥1,090	--
Total phosphorus	≥552	≥1,100
Arsenic	≥1.8	≥11
Barium	≥74.2	--
Beryllium	≥.4	--
Cadmium	≥.3	≥1
Chromium	≥10.7	≥23
Copper	≥20.5	≥60
Cyanide	≥.1	--
Endrin	≥1.4	--
Iron	≥11,900	≥23,000
Lead	≥31.6	≥38
Mercury	≥.08	≥.10
Nickel	≥17.4	--
Silver	≥.4	--
Zinc	≥75.2	≥100

[1]Illinois Environmental Protection Agency, 1984.

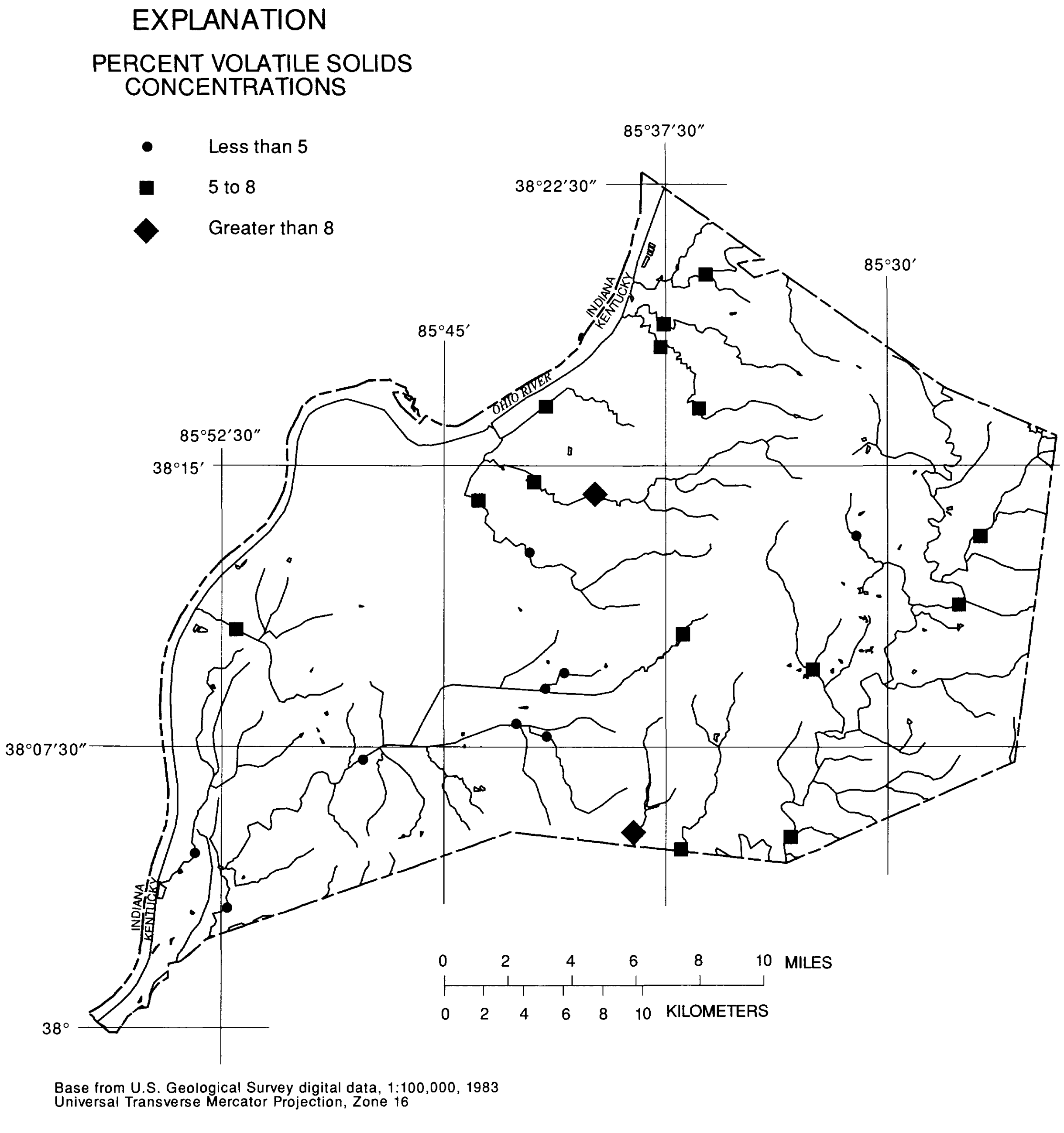


Figure 5. Percent volatile solids concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

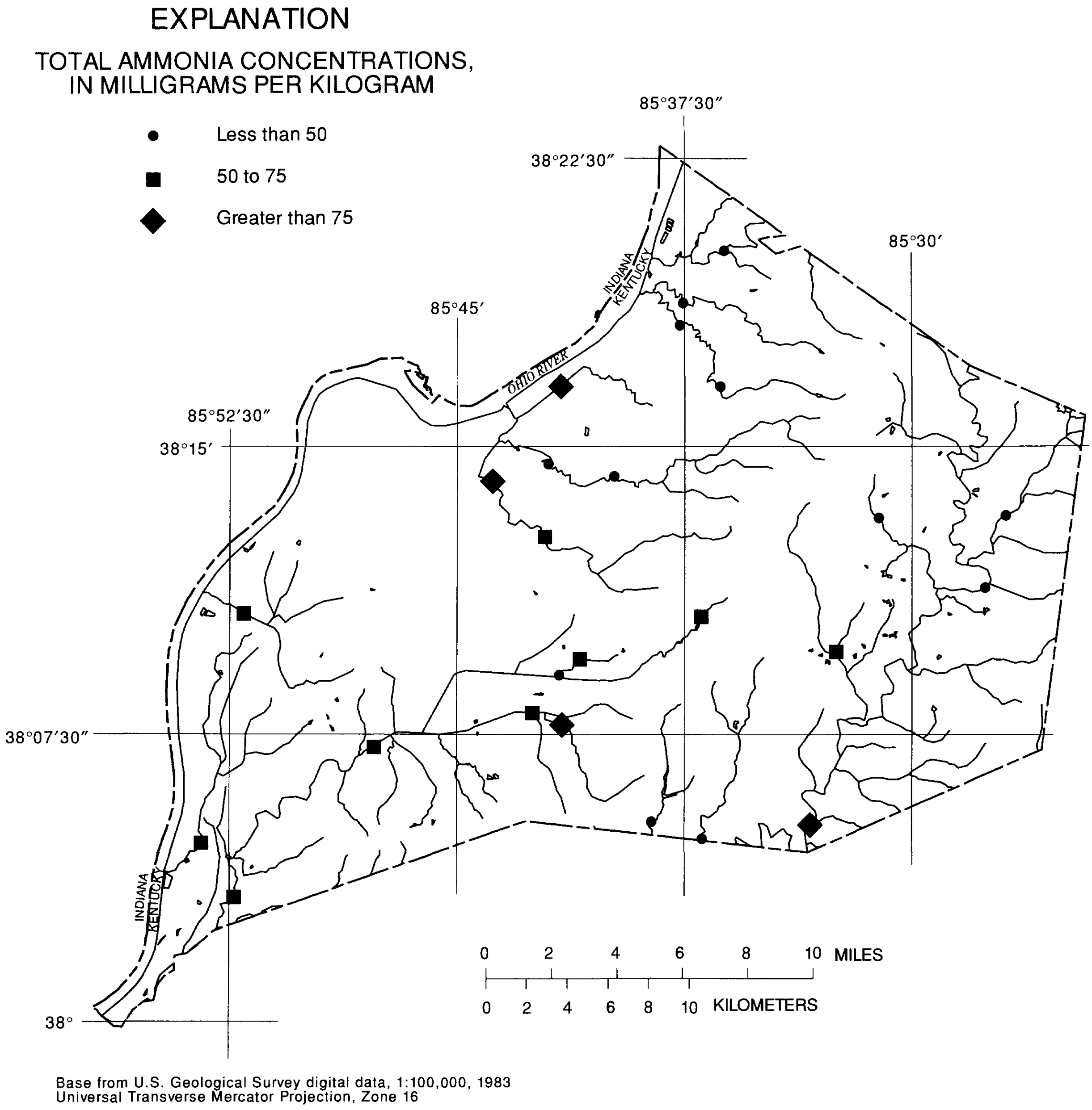


Figure 6. Total ammonia concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

Concentrations of organic nitrogen ranged from 178 to 760 mg/kg in bottom sediments; the median was 558 mg/kg. No organic nitrogen concentrations were considered to be statistical high outliers. Organic nitrogen enrichment is commonly a result of sewage effluent or industrial-waste discharges. Concentrations of organic nitrogen greater than 600 mg/kg were measured in bottom sediments of the Floyds Fork, Goose Creek, Middle Fork Beargrass, Pennsylvania Run, and Pond Creek Basins (fig. 7). Evaldi and others (1992) reported large total organic nitrogen yields in waters of the Floyds Fork, Goose Creek, and Pennsylvania Run Basins. No organic nitrogen data were available for Spring Ditch (site 9).

Concentrations of phosphorus in bottom sediments ranged from 109 to 575 mg/kg and were highly variable throughout the county; the median was 269 mg/kg (fig. 8). Concentrations measured in Floyds Fork (site 15) and in Long Run (site 26) were larger than the statistical high outlier value of 552 mg/kg.

Major Metals, Trace Elements, and Selected Inorganic Compounds

Major metals and trace metals are widely distributed throughout the aquatic environment. Land-use activities (agricultural, industrial, and mining) can increase metals concentrations in bottom sediments by several orders of magnitude greater than natural levels (Illinois Environmental Protection Agency, 1984). Elevated concentrations of metals are potentially toxic to aquatic organisms and can accumulate in the food chain. Major sources of input of metals to waterways include the extensive use of metals in industry and the resultant discharge of industrial wastewater directly into streams; atmospheric fallout from burning of fossil fuels; and increased soil erosion resulting from urbanization, poor farming practices, stream channelization, and road construction. Results for major metals, trace elements, and selected inorganic constituents and cyanide in bottom sediments are summarized in table 8 and figures 9–11.

Synthetic Organic Compounds

Organochloride insecticides are highly persistent and, thus, tend to accumulate in living organisms and sediment. Because organochlorines are synthetic compounds, natural background concentrations in sediment of uncontaminated streams should be zero. Chlordane, lindane, methoxychlor, and toxaphene were not detected above detection limits of the MSD laboratory in bottom sediments at any of the sampling sites.

Endrin concentrations in bottom sediments ranged from 0.05 to 1.5 mg/kg and generally were largest in the more urbanized parts of Jefferson County (fig. 12); the median was 0.33 mg/kg. The largest concentration of endrin, 1.5 mg/kg, was at Pennsylvania Run (site 23) and was the only statistical high outlier.

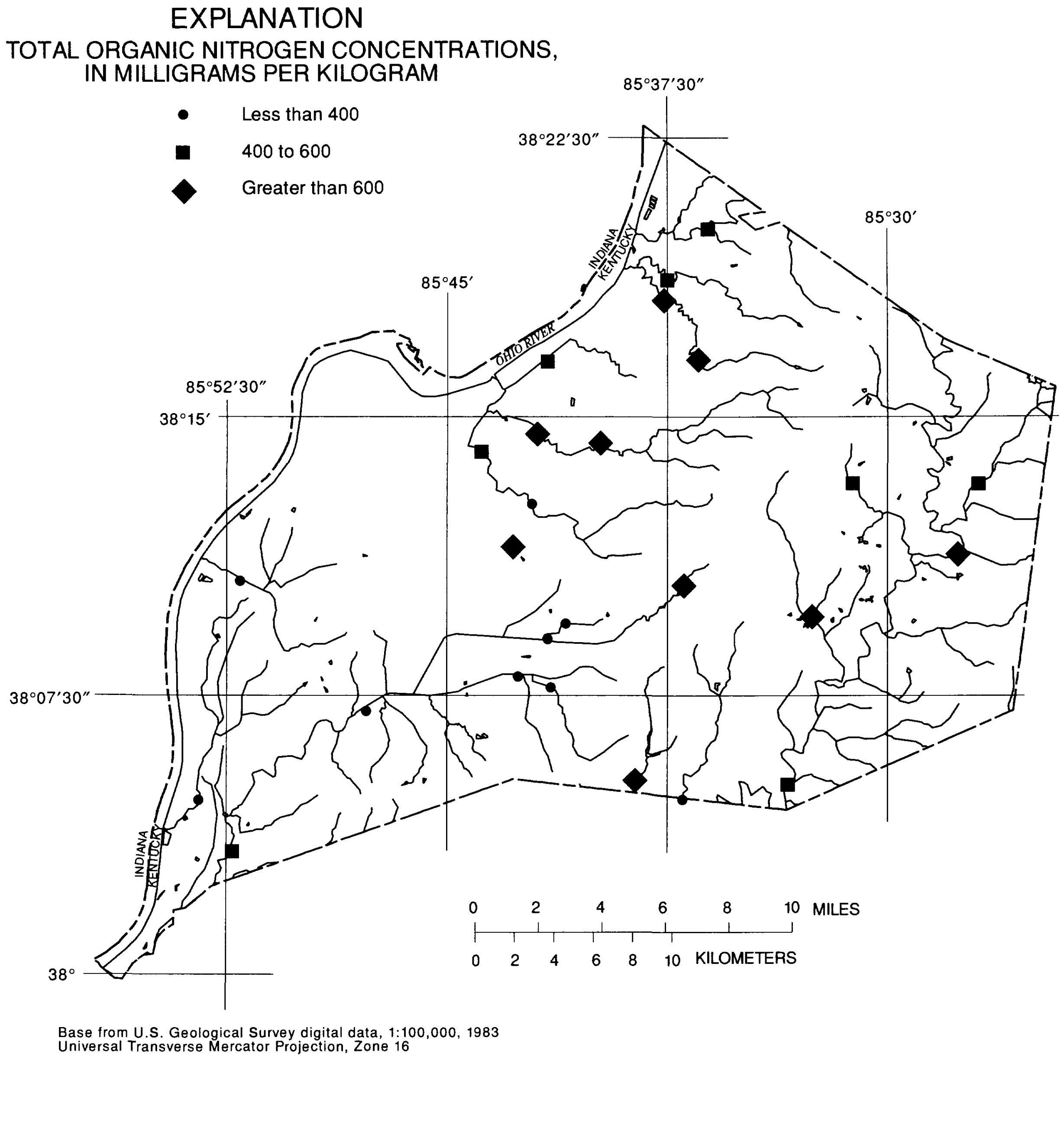


Figure 7. Total organic nitrogen concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

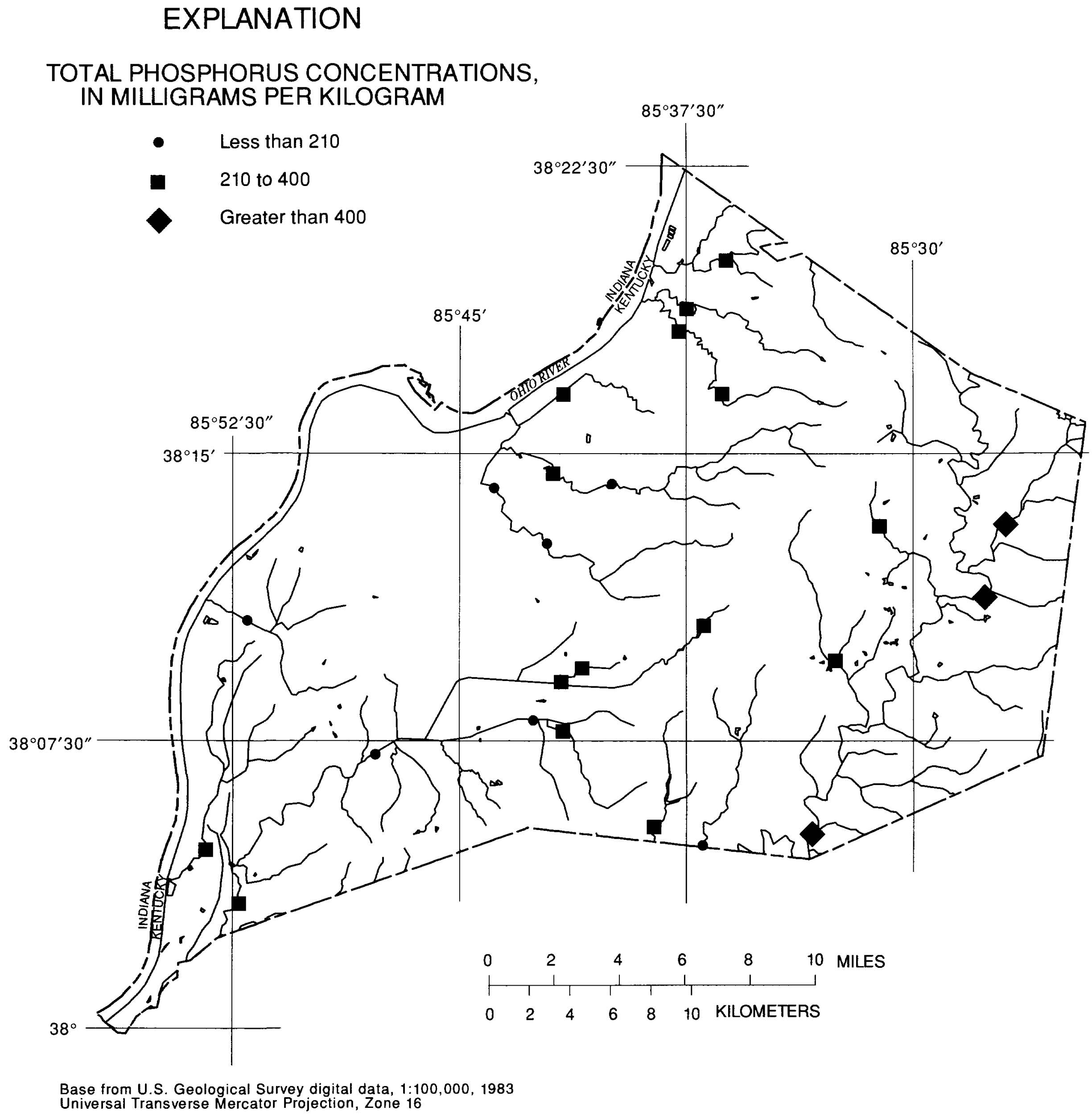


Figure 8. Total phosphorus concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

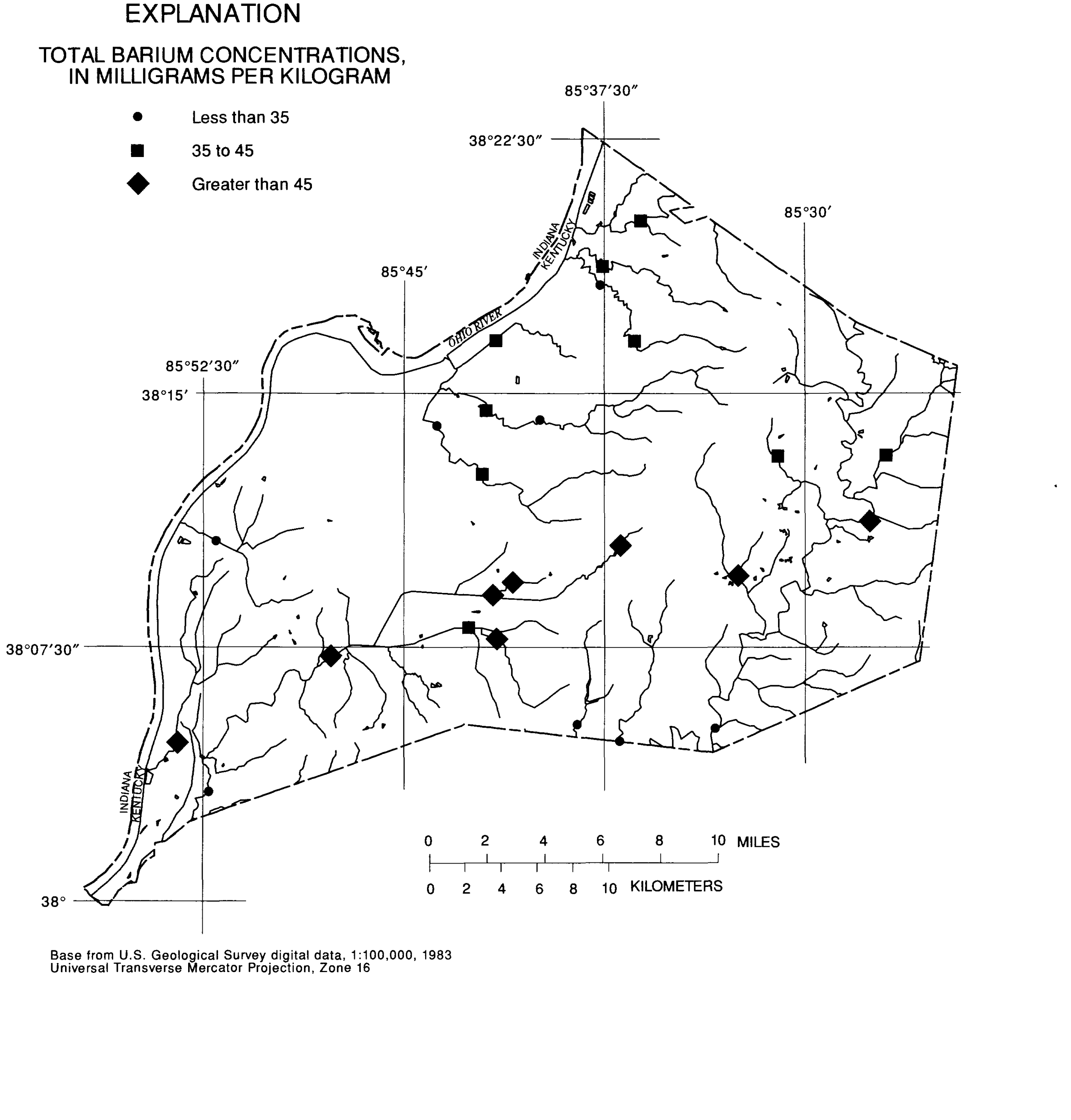
Table 8. Statistical summary of major metals, trace elements, selected inorganic constituents, and cyanide in bottom sediments in selected streams, Jefferson County, Kentucky, April–July 1992

[mg/kg, milligrams per kilogram of sediment; <, less than; --, not computed or not applicable. Site locations shown in fig. 4]

Constituent	Range in concentration (mg/kg)	Median concentration (mg/kg)	Sites where statistical high outlier value was exceeded
Antimony	<1.4	--	None
Arsenic	<0.2–1.2	0.6	None
Barium	13–101	38	Northern Ditch (site 18)
Beryllium	.1–.5	.2	Northern Ditch (site 18)
Cadmium	<.03–.3	.1	Spring Ditch (site 9), and Northern Ditch (site 18)
Chromium	2.1–13	5.2	Spring Ditch (site 9)
Copper	1.8–35	8.3	Mill Creek at Orell Road (site 2)
Cyanide*	<.01–.13	.01	Muddy Fork (site 10)
Iron	2,510–11,300	5,830	None
Lead	3.5–29	10	None
Mercury	.01–.09	.02	Goose Creek at Old Westport Road (site 13), and Chenoweth Run (site 16)
Nickel	1.7–14	5.6	None
Selenium	<2.0	--	None
Silver	<.04–.9	.2	Goose Creek at Old Westport Road (site 13), Chenoweth Run (site 16), and Southern Ditch at Minors Lane (site 20)
Thallium**	<.24	--	None
Zinc	8.0–50	26	None

*No cyanide data were available for Goose Creek at Old Westport Road (site 13) or Harrods Creek (site 25).

**Thallium was less than the detection limit at all but 4 sites; Spring Ditch (site 9), Northern Ditch (site 18), Floyds Fork at Bardstown Road (site 21), and Cedar Creek (site 22).



Base from U.S. Geological Survey digital data, 1:100,000, 1983
Universal Transverse Mercator Projection, Zone 16

Figure 9. Total barium concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

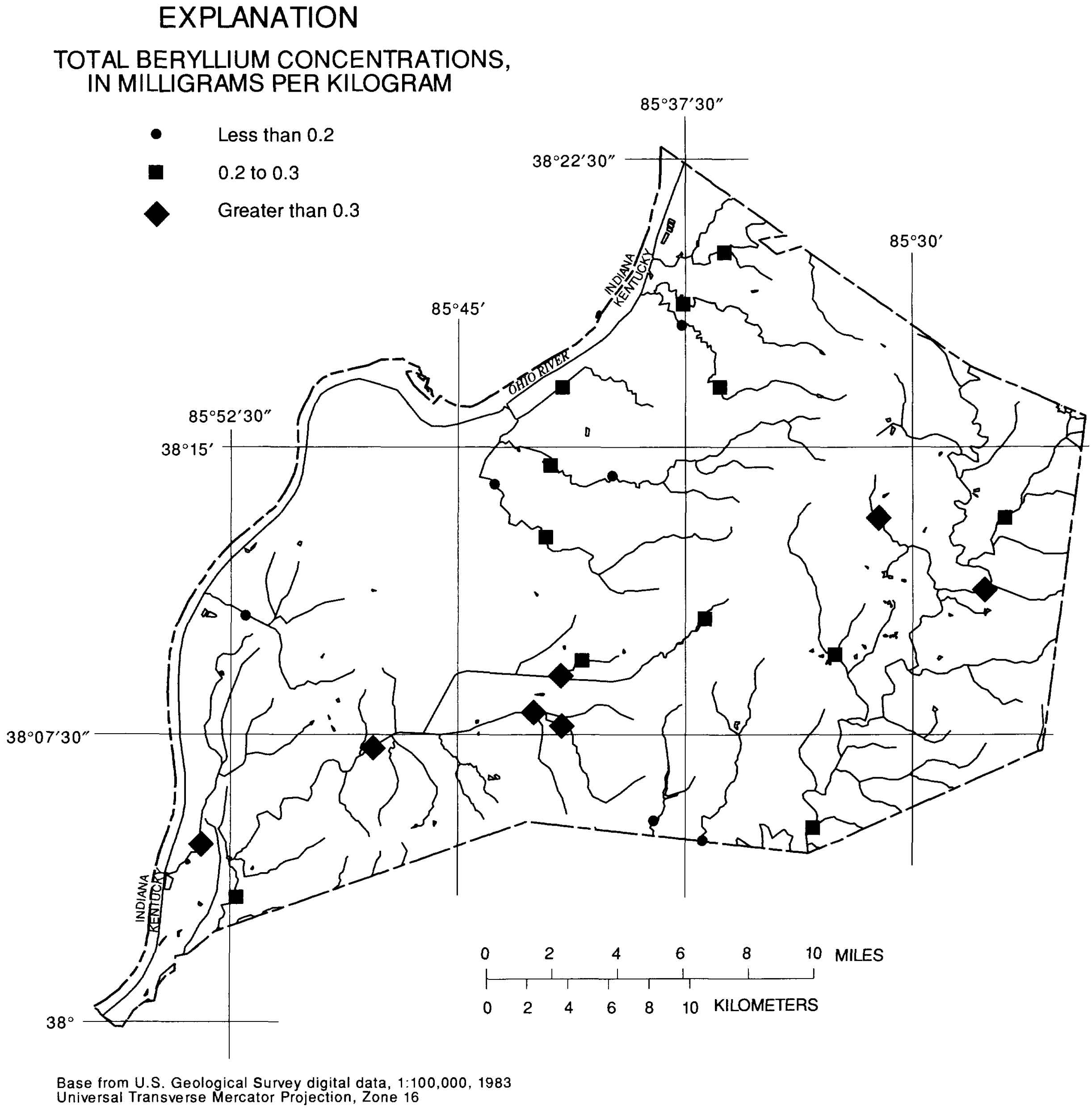


Figure 10. Total beryllium concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

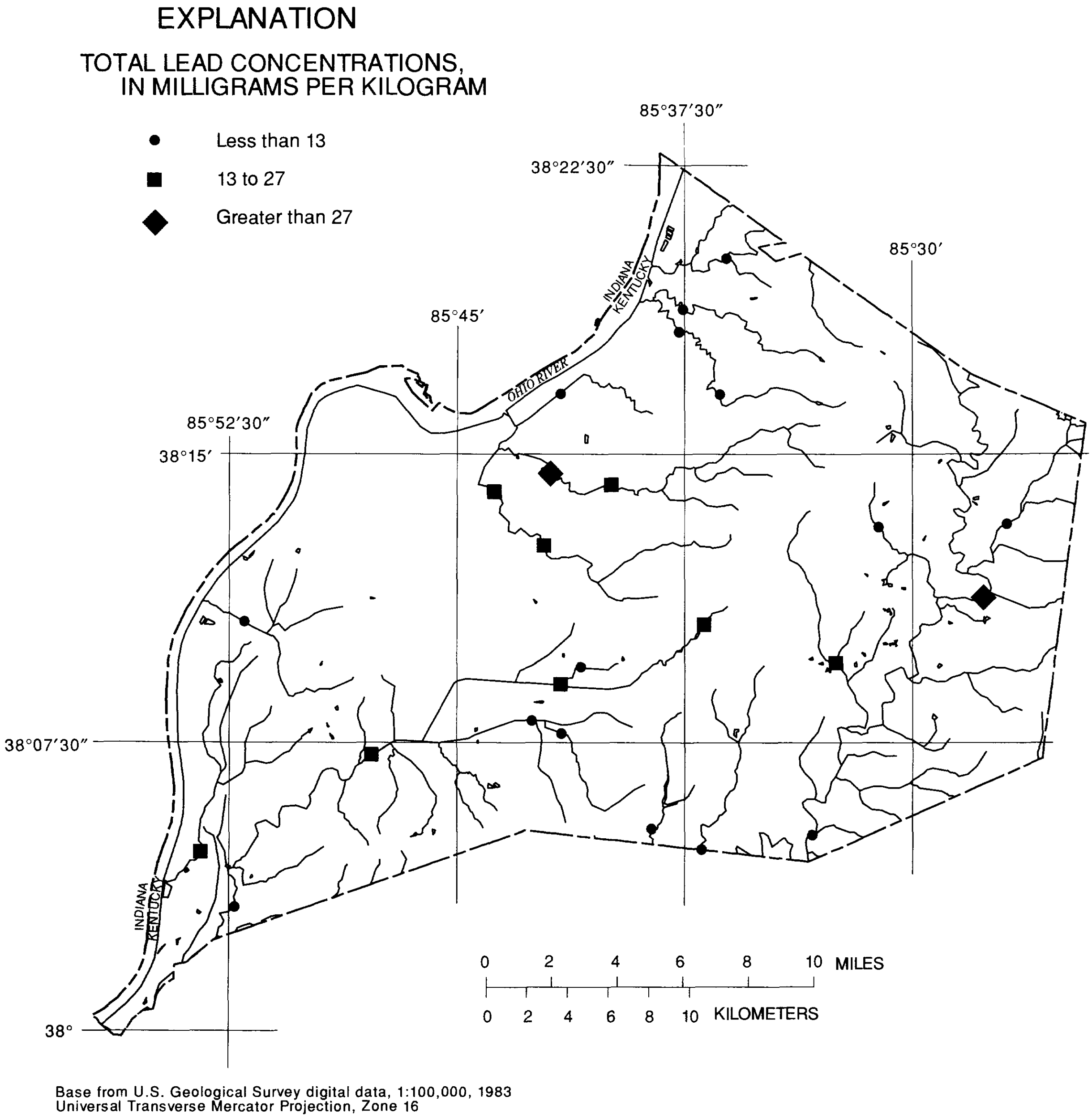


Figure 11. Total lead concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

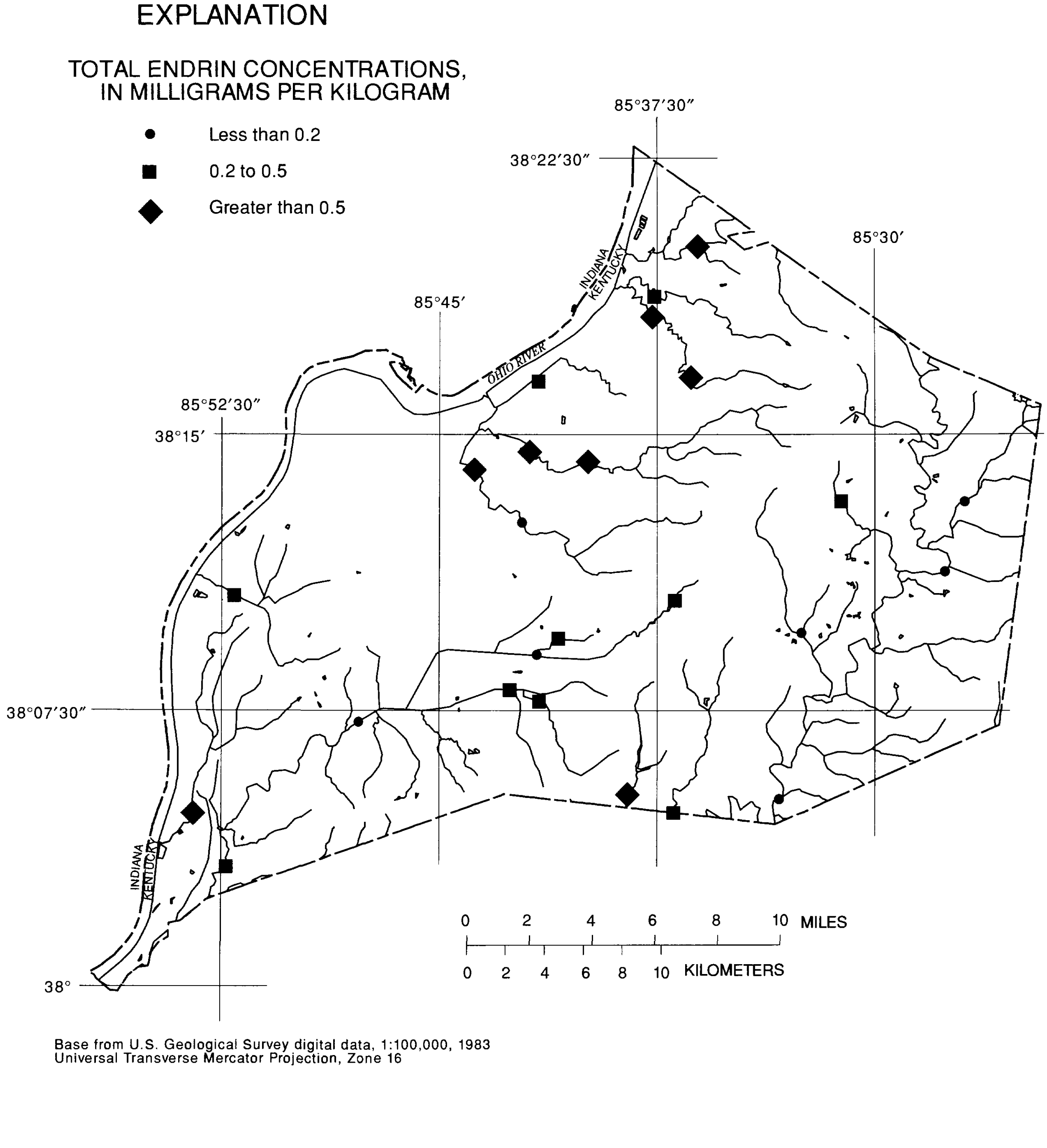


Figure 12. Total endrin concentrations in bottom sediments of selected streams in Jefferson County, Kentucky, April-July 1992.

SUMMARY

The Louisville and Jefferson County Metropolitan Sewer District (MSD) and the U.S. Geological Survey (USGS) sampled bottom sediment at 25 stream sites in Jefferson County, Ky., to evaluate the chemical quality of bottom sediments during April–July 1992. Bottom sediments were collected by hand during periods of low flow by MSD and USGS personnel. The MSD laboratory analyzed all of the samples for this study, except for the two quality-assurance samples, which were analyzed by the USGS National Water Quality Laboratory. Statistical high outliers were used as a measure of possible elevated concentrations.

The median concentration of total volatile solids in bottoms sediments of streams in Jefferson County was 5.6 mg/kg. The largest concentration of total volatile solids, 9.4 mg/kg, which was measured at the Pennsylvania Run site, was a statistical high outlier.

Analyses for nutrients in bottom sediments included nitrate plus nitrite, ammonia, organic nitrogen, and phosphorus. The median nitrate plus nitrite concentration was 2.9 mg/kg; statistical high outliers were measured at Pope Lick, Pennsylvania Run, and Mill Creek Cutoff. The median concentration of ammonia in bottom sediments of Jefferson County streams was 53 mg/kg, and a statistical high outlier was found at South Fork Beargrass Creek at Winter Avenue. The median organic nitrogen concentration in sediments was 558 mg/kg, and concentrations greater than 600 mg/kg were found at sites in Floyds Fork, Goose Creek, Middle Fork Beargrass Creek, Pennsylvania Run, and Pond Creek Basins. The median phosphorus concentration in bottom sediments of Jefferson County streams was 269 mg/kg, and statistical high outliers were found at Floyds Fork at former State Highway 155 and Long Run at State Highway 1531.

Results for major metals, trace elements, and miscellaneous inorganic compounds are summarized below:

Antimony............Less than 1.4 mg/kg at all sites, no statistical high outliers.
Arsenic ....Median, 0.6 mg/kg; no statistical high outliers.
Barium.................Median, 38 mg/kg; statistical high outlier at Northern Ditch.
Beryllium............Median, 0.2 mg/kg; statistical high outlier at Northern Ditch.
Cadmium............Median, 0.1 mg/kg; statistical high outlier at Northern Ditch and Spring Ditch.
Chromium ....Median, 5.2 mg/kg; statistical high outlier at Spring Ditch.
Copper.................Median, 8.3 mg/kg; statistical high outlier at Mill Creek at Orell Road.
Cyanide ....Median, 0.01 mg/kg; statistical high outlier at Muddy Fork, no data available for Goose Creek at Old Westport Road or Harrods Creek.
Iron......................Median, 5,830 mg/kg; no statistical high outliers.
Lead.....................Median, 10 mg/kg; no statistical high outliers.
Mercury...............Median, 0.02 mg/kg; statistical high outliers at Goose Creek at Old Westport Road and Chenoweth Run.
Nickel..................Median, 5.6 mg/kg; no statistical high outliers.
Selenium..............Less than 2.0 mg/kg; except at Spring Ditch, no statistical high outliers.
Silver...................Median, 0.2 mg/kg; statistical high outliers at Goose Creek at Old Westport Road, Chenoweth Run, and Southern Ditch at Minors Lane.
Thallium..............Less than 0.24 mg/kg; except at Spring Ditch, Northern Ditch, Floyds Fork at Bardstown Road, and Cedar Creek, no statistical high outliers.
Zinc ....Median, 26 mg/kg; no statistical high outliers.

Analyses for synthetic organic compounds included chlordane, endrin, lindane, methoxychlor, and toxaphene. Chlordane, lindane, methoxychlor, and toxaphene were not found above laboratory detection limits at any of the sampling sites. The median endrin concentration was 0.33 mg/kg, and the only statistical high outlier was found at Pennsylvania Run.

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