CONCENTRATIONS OF METALS IN BED MATERIAL IN THE AREA OF CONGAREE SWAMP NATIONAL MONUMENT AND IN WATER IN CEDAR CREEK, RICHLAND COUNTY, SOUTH CAROLINA

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CONCENTRATIONS OF METALS IN BED MATERIAL IN THE AREA OF CONGAREE SWAMP NATIONAL MONUMENT AND IN WATER IN CEDAR CREEK, RICHLAND COUNTY, SOUTH CAROLINA

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ABSTRACT

The Congaree Swamp National Monument is a 15,135-acre flood-plain ecosystem in Richland County, South Carolina. It was officially established in 1976 by an Act of Congress to preserve the last significant tract of southern old-growth river-bottom forest. The Monument's ecosystem supports a wide variety of plant and animal life, and contains numerous trees that are among the largest of their species in the state and nation. This report describes the results of a study by the U.S. Geological Survey, in cooperation with the National Park Service, to document the occurrence of selected metals in bed material in the area of the Congaree Swamp National Monument and in the surface water of a major tributary, Cedar Creek. The study was prompted by concern that trace metals in this valuable flood-plain ecosystem could contaminate and endanger plant and animal life.

A total of 37 bed-material samples were collected at 28 sampling stations during two sampling periods (June 18, 1985, and May 28 to June 5, 1986). Results of chemical analyses indicated barium, iron, magnesium, and manganese, which occur naturally in soils in the basins, are present in a wide range of concentrations in the Cedar Creek and Toms Creek watersheds. The highest observed concentrations were 400; 68,000; 35,000; and 1,700 micrograms per gram, respectively. Beryllium, cadmium, lithium, and molybdenum were, if present, in concentrations no greater than minimum detection levels. Overall, concentrations in the Cedar Creek watershed are significantly higher than in the Toms Creek watershed. Relatively high concentrations in samples outside the influence of either Cedar Creek or Toms Creek indicate that the flood plain may act as a sink for certain metals.

Ten surface-water samples collected at a site on Cedar Creek were analyzed for selected metals. Concentrations of cadmium, which is a highly toxic element, equaled or exceeded the U.S. Environmental Protection Agency drinking water maximum-contaminant level of 10 micrograms per liter in three samples, with the highest concentration observed being 15 micrograms per liter. Concentrations of manganese equaled or exceeded the U.S. Environmental Protection Agency drinking water secondary maximum-contaminant level of 50 micrograms per liter in seven samples, with the highest observed concentration being 220 micrograms per liter. Copper, zinc, and lead were detected in concentrations less than the U.S. Environmental Protection Agency drinking water secondary maximum-contaminant level, with the highest observed concentrations being 51,270, and 35 micrograms per liter, respectively. Concentrations of barium, beryllium, chromium, cobalt, lithium, and molybdenum were, if present, equal to or less than the minimum detection levels.

INTRODUCTION

The Congaree Swamp National Monument was established in 1976 by an Act of Congress to preserve the last significant tract of southern old-growth river-bottom forest. The area supports a wide variety of plant and animal life, and contains trees that are among the largest of their species in the state and nation. The National Park Service administers the Monument and is concerned about the quality of water flowing into the Monument and, in particular, the concentrations of trace metals. In response to that concern, the U.S. Geological Survey, in cooperation with the National Park Service, measured the concentrations of selected metals in the area of the Monument.

Purpose and Scope

The purpose of this report is to document the results of an investigation to quantify the occurrence of selected metals in the Congaree Swamp National Monument and in streams flowing into the Monument. The report describes concentrations of selected metals in bed material in streams in the Monument and contributing watersheds, and in surface water in Cedar Creek.

Previous Investigations

Available data on concentrations of metals in the study area are limited. The most notable source of data on concentrations of selected metals in surface water in the Congaree Swamp National Monument is the work by Birch, (1985). That investigation consisted of a year-long water-quality monitoring program for water in the area.

Description of Study Area

The study area, approximately 120 mi^2 (square miles), includes the Congaree Swamp National Monument and the drainage areas of Cedar and Toms Creek. The Congaree Swamp National Monument is located approximately 20 miles southeast of Columbia, S.C. (fig. 1). Most of the 15,135 acre Monument is located in the flood plain of the Congaree River. Land-surface elevations in the area of the Monument range from about 80 to 120 feet above sea level. The southern boundary of the Monument is the Congaree River. Floodwaters inundate most of the Monument about once a year. Low-lying areas in the flood plain remain inundated about 25 percent of the time (Patterson and others, 1985).

When low and medium flows occur in the Congaree River, water elevations in the Monument are controlled by two main tributaries, Cedar Creek near the western boundary and Toms Creek near the eastern boundary (fig. 2). Headwaters for these tributaries are approximately 10 miles north of the Monument.

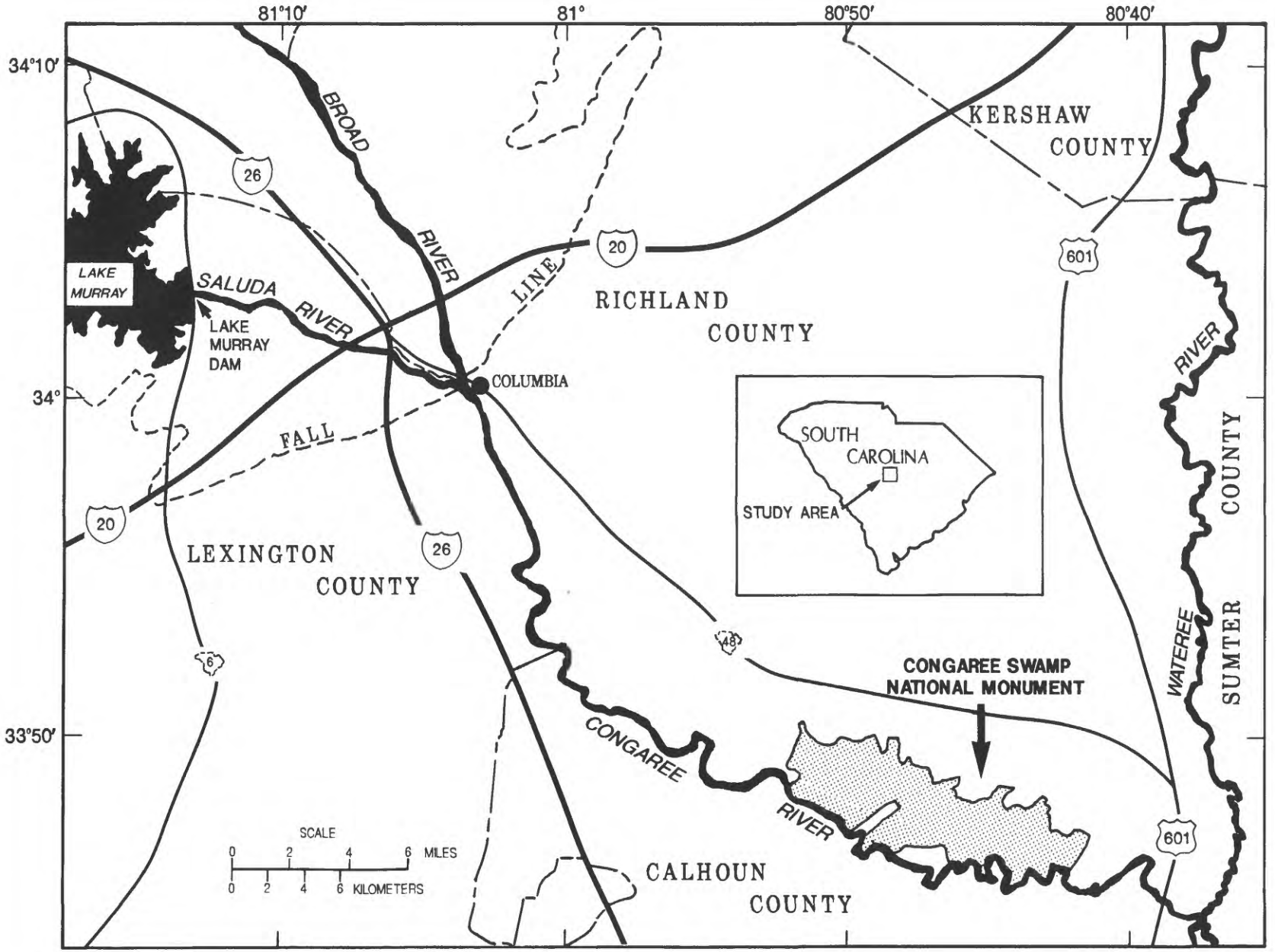

Figure 1.--Location of study area and Congaree Swamp National Monument.

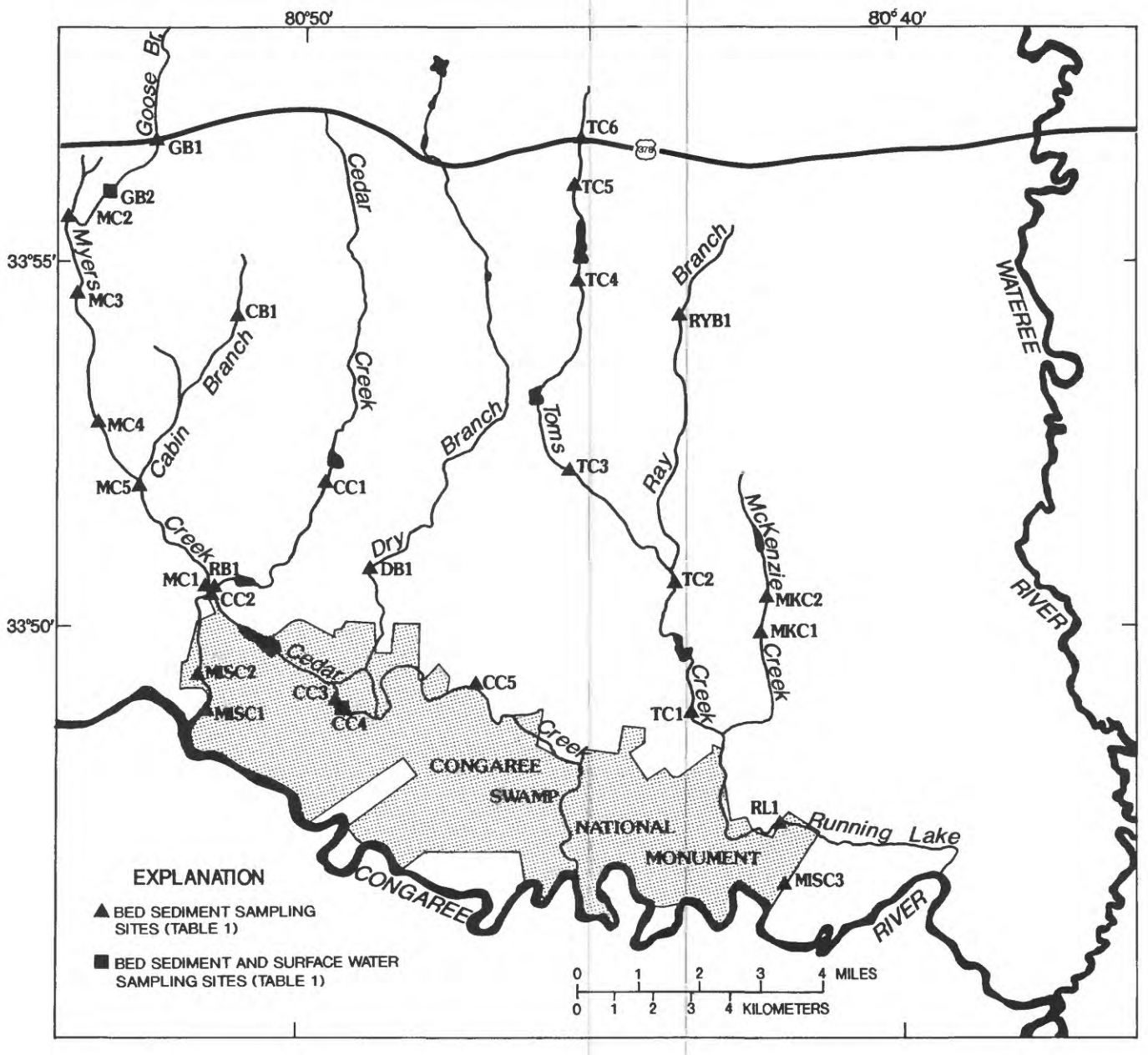

Figure 2--Location of sampling sites.

DATA COLLECTION

Bed-material Samples

Bed-material samples were collected for analysis of metals during two sampling periods. A total of 37 samples were collected at 28 selected sites (table 1) usually at the center of the channel to a depth of 10 to 12 cm (centimeters). The site numbers presented in table 1, in the left-most column, will be used throughout the remainder of this report to simplify station identification. The first sampling effort was on June 18, 1985, and consisted of collecting eight samples in the Cedar Creek watershed from sampling site CC4 upstream to sampling site GB1 (fig. 2). The second sampling effort, which extended from May 28 to June 5, 1986, consisted of collecting 16 samples in the Cedar Creek watershed, 10 samples in the Toms Creek watershed, and 3 samples at miscellaneous sites in the Monument. It should be noted that sampling sites MISC1, MISC2, and MISC3 are located in low-lying areas that frequently flood and remain inundated about 10 percent of the time (Patterson and others, 1985). The samples for sites MISC1, MISC2, and MISC3 were collected to determine background concentrations of selected metals in the Congaree River flood plain but outside the influence of the Cedar Creek and Toms Creek discharges. All bed-material samples were analyzed for particle-size distribution using methods outlined by Guy (1969, p. 50), and the relation between the concentration of the metals and particle-size was determined using regression analysis.

All samples collected during this study were analyzed for selected metals by the U.S. Geological Survey National Water Quality Laboratory using methods described by Skougstad and others (1979). Bed-material samples were analyzed for total recoverable barium, beryllium, cadmium, calcium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum. sodium, strontium, and zinc.

Surface-water Samples

Surface-water samples were collected for analysis of metals at the Cedar Creek Hunt Club gaging station (CC4) using an automatic sampler. The intake for the sampler was located at a fixed point in the channel (about mid-depth during normal flow conditions). Samples at CC4 were preserved as they were collected by depositing sufficient nitric acid in the sample bottles prior to automatic collection. A 6-hour sampling interval was maintained during the period June 25, 1985 to June 2, 1986. Four basic water-quality characteristics (specific conductance, pH, temperature, and dissolved oxygen) and discharge were monitored during that period. These data are published in U.S. Geological Survey Water-Data Reports (Bennett and others 1986; Bennett and others 1987). Ten surface-water samples were selected for analysis based on water quality and discharge data so that a range of hydrologic conditions was represented. Samples were analyzed for total recoverable barium, berylium, cadmium, calcium, chromium, cobalt, copper, lead, lithium, magnesium, manganese, molybdenum, sodium, and zinc.

Table 1.-- Sampling sites in the area of Congaree Swamp National Monument

Site number	U.S. Geological Survey station number	Station name	Latitude	Longitude
GB1	02169652	Goose Branch at U.S. Highway 378 near Horrell Hill	33°56'39"	80°52'31"
GB2	02169653	Goose Branch at S-40-223 near Horrell Hill	33°56'04"	80°53'19"
MC1	02169660	Myers Creek at S-40-734 near Hopkins	33°50'27"	80°51'36"
MC2	02169654	Myers Creek at S-40-222 near Hopkins	33°55'39"	80°54'03"
MC3	02169656	Myers Creek at S-40-1571 near Hopkins	33°54'36"	80°53'49"
MC4	02169657	Myers Creek at S-40-37 near Hopkins	33°52'46"	80°53'29"
MC5	02169658	Myers Creek at State Highway 48 near Gadsden	33°51'53"	80°52'46"
CC1	021696597	Cedar Creek at S-40-55 near Gadsden	33°51'56"	80°49'40"
CC2	02169670	Cedar Creek below Myers Creek near Hopkins	33°50'23"	80°51'38"
CC3	021696715	Cedar Creek above Cedar Creek Hunt Club	33°49'11"	80°49'24"

Table 1.-- Sampling sites in the area of Congaree Swamp National Monument--Continued

Site number	U.S. Geological Survey station number	Station name	Latitude	Longitude
CC4	02169672	Cedar Creek at Cedar Creek Hunt Club	33°48'58"	80°49'39"
CC5	02169675	Cedar Creek below S-40-1288 near Gadsden	33°49'07"	80°47'17"
TC1	021696966	Toms Creek below S-40-489 near Gadsden	33°48'41"	80°43'30"
TC2	021696962	Toms Creek at State Highway 48 near Gadsden	33°50'30"	80°43'54"
TC3	021696856	Toms Creek at S-40-1322 near Gadsden	33°52'07"	80°45'34"
TC4	021696851	Toms Creek at S-40-1307 near Eastover	33°54'46"	80°45'25"
TC5	021696842	Toms Creek at S-40-764 near Horrell Hill	33°56'04"	80°45'30"
TC6	021696840	Toms Creek at U.S. Highway 378 near Horrell Hill	33°56'43"	80°45 24"
MKC1	021696976	McKenzie Creek at S-40-489 near Gadsden	33°48'36"	80°42'18"
MKC2	021696971	McKenzie Creek at State Highway 48 near Gadsden	33°50'19"	80°42'21"

Table 1.-- Sampling sites in the area of Congaree Swamp National Monument--Continued

Site number	U.S. Geological Survey station number	Station name	Latitude	Longitude
RB1	021696699	Reeves Branch at S-40-734 near Hopkins	33°50'26"	80°51'38"
DB1	021696731	Dry Branch at S-40-734 near Gadsden	33°50'42"	80°48'58"
CB1	021696575	Cabin Branch at S-40-66 near Hopkins	33°54'16"	80°51'08"
RYB1	021696951	Ray Branch at S-40-764 near Eastover	33°54'13"	80°43'42"
RL1	3347110804206	Running Lake at CSNM boundary near Gadsden	33°47'11"	80°42'06"
MISC1	3348460805144	CSNM west of Wise Lake near Gadsden	33°48'46"	80°51'44"
MISC2	3349250805151	CSNM west of Weston Lake near Gadsden	33°49'25"	80°51'51"
MISC3	3346050804203	CSNM near lower boundary near Gadsden	33°46'05"	80°42'03"

Note: CSNM is Congaree Swamp National Monument

STREAMFLOW CONDITIONS

Discharge measurements were made at seventeen sites in the Cedar and Toms Creek watersheds in an effort to define discharge sources or sinks within the watersheds. Results of the discharge measurements, which are given in table 2, indicate that less than 20 percent of the flow that entered the Monument at CC2 on June 18, 1985, originated in the Myers Creek watershed. Due to the lack of rainfall in the weeks preceeding June 18, 1985, these discharges probably represent near base-flow conditions. Cedar Creek branches into several channels downstream of CC2, however, the majority of flow during low-flow conditions passes CC4.

Table 2.--Results of discharge measurements at sampling sites

[ft^3/s, cubic foot per second]

Cedar Creek			Toms Creek		
Site number	Date	Discharge (ft^3/s)	Site number	Date	Discharge (ft^3/s)
GB1	06/18/1985	No flow	TC6	06/09/1986	0.03
GB2	06/18/1985	0.11	TC4	06/09/1986	1.59
MC2	06/18/1985	.73	TC2	06/09/1986	6.03
MC3	06/18/1985	1.11	TC1	06/09/1986	16.0
MC4	06/18/1985	1.54	RL1	06/09/1986	No flow
MC5	06/18/1985	4.70	RYB1	06/09/1986	No flow
RB1	06/18/1985	14.7	MKC2	06/09/1986	No flow
CC2	06/18/1985	38.9	MKC1	06/09/1986	No flow
CC4	06/18/1985	28.0			

CONCENTRATIONS OF METALS IN BED MATERIAL

Results of chemical analyses for the 37 bed-material samples collected during the two sampling periods and the minimum detection level for each analysis are given in table 3. Barium, iron, magnesium, and manganese, which occur naturally in soils in the basins, are present in a wide range of concentrations in both the Cedar Creek and Toms Creek watersheds. Barium was detected in 28 samples with the highest concentration observed being 400 µg/g (micrograms per gram) in the sample collected at MC5 on June 18, 1985. Iron was detected in all samples with the highest observed concentration being 68,000 µg/g in the sample collected at MC2 on May 28, 1986. Magnesium was detected in 34 samples with the highest concentration observed being 35,000 µg/g in the sample collected at CC5 on June 4, 1986. Manganese was detected in 36 samples with the highest observed concentration being 1,700 µg/g in the sample collected at MC2 on May 28, 1986.

Copper, lead, and zinc also occur naturally in soils but are not present in great abundance. Copper was detected in 28 samples with the highest observed concentration being 30 µg/g in the samples collected at MC2 on May 28, 1986, MC5 on June 18, 1985, and CC3 on May 28, 1986. Lead was detected in 26 samples with the highest observed concentration being 350 µg/g in the sample collected at GB1 on June 18, 1985. Zinc was detected in 36 samples with the highest observed concentration being 130 µg/g in the sample collected at MC2 on May 28, 1986.

Beryllium, cadmium, cobalt, lithium, and molybdenum are either not present or present in such small quantities that almost all analyses indicate concentrations below minimum detection levels. Given below are general observations pertaining to the concentrations of metals in bed-material samples:

1. The concentrations of most metals at GB1 are similar to concentrations at GB2. Concentrations of lead and manganese are higher at the upstream station, which may be the result of contaminated runoff from U.S. Highway 378.
2. All concentrations in the sample collected at MC2 on May 28, 1986, are significantly higher than concentrations in the sample collected at the same site on June 18, 1985.
3. Concentrations of barium, copper, iron, lead, manganese, and zinc at CC3, CC4, and CC5 are significantly higher than at upstream sites.
4. Almost all concentrations in bed material from the Toms Creek watershed are significantly lower than in samples from the lower reaches of the Cedar Creek watershed.
5. Relatively high concentrations of most metals in the bed-material samples from MISC1, MISC2, and MISC3 indicate that the Congaree River flood plain may act as a sink for many metals.

The particle-size distributions of the 37 bed-material samples analyzed are given in table 4. Most samples were composed primarily of sand-size particles greater than 0.125 mm (millimeter) in diameter, although several samples contained a large percentage of silt or clay sizes (sediments less than 0.063 mm in diameter).

Table 3.--Results of chemical analyses of bed material

[Results are total recoverable concentrations, in micrograms per gram; <, less than]

Site number	Date	Barium	Beryllium	Cadmium	Calcium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Molybdemim	Sodium	Strontium	Zinc
		Minimum detection level, in micrograms per gram														
		10	1	1	10	50	1	1	10	10	10	1	0.1	10	1	1
GB1	06/18/85	40	<1	<1	300	<50	20	5,100	350	<10	60	77	0.5	20	1	30
GB1	05/28/86	<10	<1	<1	320	<50	2	2,700	30	<10	30	17	<.1	30	<1	10
GB2	06/18/85	10	<1	<1	20	<50	2	2,300	<10	<10	<10	<1	.1	20	<1	<1
GB2	05/28/86	<10	<1	<1	500	<50	1	6,800	<10	<10	50	10	<.1	50	<1	10
MC1	05/28/86	20	<1	1	80	<50	<1	950	10	<10	70	39	<.1	60	<1	10
MC2	06/18/85	10	<1	<1	90	<50	<1	760	<10	<10	30	19	.2	20	1	3
MC2	05/28/86	100	<1	11	340	<50	30	68,000	110	<10	70	1,700	2.9	50	20	130
MC3	06/18/85	<10	<1	<1	70	<50	<1	1,700	<10	<10	10	18	.3	20	1	5
MC3	05/28/86	70	<1	<1	800	<50	3	2,900	10	<10	190	320	<.1	60	9	10
MC4	06/18/85	130	<1	<1	50	<50	<1	250	<10	<10	<10	17	<.1	20	1	2
MC4	05/28/86	20	<1	<1	230	<50	3	1,400	20	<10	80	25	<.1	40	2	10
MC5	06/18/85	400	<1	<1	2,200	<50	30	6,300	90	<10	840	680	.1	40	30	50
MC5	05/28/86	90	<1	2	1,600	<50	8	2,600	40	<10	360	390	.2	410	10	10
CC1	06/05/86	<10	<1	1	100	<50	1	1,500	10	<10	40	42	.1	40	<1	10
CC2	06/18/85	10	<1	<1	50	<50	<1	680	<10	<10	20	22	.1	10	1	5
CC2	05/28/86	<10	<1	<1	50	<50	1	320	<10	<10	30	10	<.1	130	<1	10
CC3	05/28/86	190	<1	<1	2,000	50	30	18,000	30	<10	1,700	720	.3	190	30	70
CC4	06/18/85	30	1	<1	470	50	20	23,000	20	10	2,700	910	<.1	60	7	39
CC4	05/28/86	90	1	1	160	50	20	16,000	30	<10	2,300	95	<.1	120	1	50
CC4	06/04/86	120	1	<1	430	200	20	24,000	30	20	3,300	800	<.1	110	6	50

Table 3.--Results of chemical analyses of bed material--Continued

[Results are total recoverable concentrations, in micrograms per gram; <, less than]

Site number	Date	Barium	Beryllium	Cadmium	Calcium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Molybdemim	Sodium	Strontium	Zinc
		Minimum detection level, in micrograms per gram														
		10	1	1	10	50	1	1	10	10	10	1	0.1	10	1	1
CC5	06/04/86	70	1	<1	410	150	10	21,000	20	20	35,000	490	<.1	90	6	50
TC1	06/04/86	30	<1	<1	160	<50	4	6,900	10	<10	170	330	<.1	30	1	10
TC2	05/29/86	<10	<1	<1	20	<50	<1	120	<10	<10	<10	10	<.1	30	<1	10
TC3	05/29/86	<10	<1	<1	50	<50	<1	220	<10	<10	10	10	<.1	30	<1	10
TC4	05/29/86	20	<1	1	100	<50	3	280	10	<10	40	22	.3	40	<1	10
TC5	05/29/86	30	<1	<1	500	<50	3	6,000	<10	<10	50	37	<.1	20	6	20
TC6	05/29/86	20	<1	<1	270	<50	4	1,900	100	<10	380	10	.2	30	1	20
MKC1	06/02/86	80	<1	<1	520	<50	6	1,800	30	<10	360	130	.3	70	1	20
MKC2	06/02/86	90	<1	<1	490	<50	4	5,900	30	<10	190	180	<.1	50	5	20
RB1	05/28/86	20	<1	<1	140	<50	1	1,100	10	<10	70	32	<.1	40	<1	10
DB1	06/05/86	150	<1	2	1,300	50	9	8,500	20	<10	280	1,600	.2	130	10	50
CB1	06/05/86	<10	<1	<1	30	<50	<1	1,000	20	<10	10	25	<.1	30	<1	10
RYB1	06/04/86	<10	<1	<1	20	<50	<1	550	<10	<10	10	10	<.1	30	<1	10
RL1	06/04/86	120	<1	<1	710	150	10	1,700	10	<10	1,600	1,100	<.1	90	9	30
MISC1	06/05/86	130	<1	<1	1,000	100	20	1,200	20	<10	1,700	460	<.1	100	20	50
MISC2	06/05/86	170	1	<1	1,600	150	20	19,000	20	<10	1,200	830	<.1	30	30	50
MISC3	06/05/86	230	1	1	1,500	150	20	29,000	40	10	2,300	1,200	2.6	130	20	60

Table 4.--Particle-size distribution of bed material

Site number	Date	Percent less than (<), or greater than (>) indicated particle size, in millimeters					
		<0.063	<0.090	<0.125	<0.250	<0.500	>0.500
GB1	06/18/85	42	9	9	24	8	8
GB1	05/28/86	12	4	6	20	24	34
GB2	06/18/85	35	4	5	21	19	16
GB2	05/28/86	35	4	7	23	17	14
MC1	05/28/86	20	3	4	17	20	36
MC2	06/18/85	31	3	5	16	18	27
MC2	05/28/86	19	3	3	5	5	65
MC3	06/18/85	1	1	1	9	36	52
MC3	05/28/86	38	5	9	18	12	18
MC4	06/18/85	3	2	2	12	37	44
MC4	05/28/86	6	2	6	25	30	31
MC5	06/18/85	28	4	5	25	27	11
MC5	05/28/86	11	3	4	15	23	44
CC1	06/05/86	6	7	15	57	9	6
CC2	06/18/85	5	9	16	28	26	16
CC2	05/28/86	3	2	5	33	33	24
CC3	05/28/86	11	1	2	6	7	72
CC4	06/18/85	82	5	4	3	3	3
CC4	05/28/86	46	3	5	13	15	18
CC4	06/04/86	36	6	9	20	10	19
CC5	06/04/86	37	10	13	22	8	10
TC1	06/04/86	30	7	10	20	14	19
TC2	05/29/86	1	1	3	34	45	16
TC3	05/29/86	2	2	6	27	44	19
TC4	05/29/86	24	7	8	17	22	22
TC5	05/29/86	11	5	5	8	8	63
TC6	05/29/86	14	2	4	15	22	43
MKC1	06/02/86	27	3	4	27	17	22
MKC2	06/02/86	10	2	6	18	27	35
RB1	05/28/86	5	5	17	58	9	6
DB1	06/05/86	10	2	3	8	15	62
CB1	06/05/86	2	1	2	22	55	18
RYB1	06/04/86	6	2	2	14	50	26
RL1	06/04/86	71	4	4	8	5	8
MISC1	06/05/86	20	10	13	32	12	13
MISC2	06/05/86	16	4	5	19	27	29
MISC3	06/05/86	24	3	3	11	18	41

The four elements (barium, iron, magnesium, and manganese) found in a wide range of concentrations in both the Cedar Creek and Toms Creek watersheds were tested for correlation with percentage of sample finer than 0.063 mm and greater than 0.500 mm using regression analysis. The resulting correlation coefficients are given below. A value of 1.0 indicates a perfect positive relation, and a value near zero indicates little or no relation. The low correlation coefficients indicate little or no correlation between concentration and percentage of sample finer than 0.063 mm or greater than 0.500 mm. Variable metal concentrations may be the result of other variables, such as the irregular occurrence of organic matter and clay minerals. Iron, manganese and magnesium have a naturally lower affinity for organic matter than lead and copper (Horowitz, 1985). Although there is little or no correlation between concentration and percentage of sample finer than 0.063 mm, most of the metals measured in the bulk sample probably are concentrated in these finer particle sizes.

Trace metal	Correlation coefficient			
	Percent <0.063 millimeter		Percent >0.500 millimeter	
	Cedar Creek watershed (21 samples)	All sampling sites (37 samples)	Cedar Creek watershed (21 samples)	All sampling sites (37 samples)
Barium	0.01	0.02	0.02	0.03
Iron	.08	.06	.10	.10
Magnesium	.05	.05	.05	.03
Manganese	.09	.12	.09	.09

Note: < = less than
> = greater than

CONCENTRATIONS OF METALS IN SURFACE WATER IN CEDAR CREEK

Results of chemical analyses for the 10 surface-water samples collected at CC4 and the minimum detection level for each analysis are given in table 5. Two constituents, cadmium and manganese, exceeded U.S. Environmental Protection Agency (USEPA) drinking water standards. Cadmium is a highly toxic element that tends to accumulate in plants (Hem, 1985). Concentrations of cadmium equaled or exceeded the USEPA drinking water maximum-contaminant level of 10 µg/L (micrograms per liter) in three samples, with the highest concentration being 15 µg/L in samples collected on August 3, 1985, and May 19, 1986. It should be noted that the USEPA freshwater criteria for aquatic life for cadmium, based on a hardness of 100 mg/L (milligrams per liter) as calcium carbonate, is only 3.9 µg/L (USEPA, 1986). Manganese is an essential element for plant and animal life forms. Concentrations of manganese equaled or exceeded the USEPA drinking water secondary maximum-contaminant level of 50 µg/L in seven samples, with the highest concentration being 220 µg/L in the sample collected August 3, 1985.

Concentrations of lead approached the USEPA drinking water maximum-contaminant level of 50 µg/L, with the highest concentration being 35 µg/L in the sample collected on May 19, 1986. Concentrations of copper and zinc were more than an order of magnitude less than the secondary maximum contaminant levels (1 and 5 mg/L, respectively) established by the USEPA for drinking water (USEPA, 1986). The highest observed concentrations of copper and zinc were 51 and 270 µg/L, respectively. Concentrations of barium, beryllium, chromium, cobalt, lithium, and molybdenum were equal to or less than the minimum detection levels.

Table 5.--Results of chemical analyses of water samples collected at site CC4 on Cedar Creek

[ft, feet; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; mg/L milligrams per liter; °C, degrees Celsius; <, less than]

Date	Gage height (ft)	Discharge (ft^3/s)	Conductance (µS/cm)	Dissolved oxygen (mg/L)	Temperature (°C)	pH (standard units)	Barium (*)	Beryllium (*)	Cadmium (*)	Calcium (+)	Chromium (*)	Cobalt (*)	Copper (*)	Lead (*)	Lithium (*)	Magnesium (+)	Manganese (*)	Molybdenum (*)	Sodium (+)	Zinc Zn (*)
							Minimum detection level													
							100 µg/L	10 µg/L	1 µg/L	0.1 mg/L	10 µg/L	1 µg/L	1 µg/L	1 µg/L	10 µg/L	0.1 mg/L	10 µg/L	1 µg/L	0.1 mg/L	10 µg/L
08/03/85	3.42	54.1	164	4.6	24.5	5.1	<100	<10	15	2.0	<10	1	24	13	<10	1.0	220	1	3.0	270
09/10/85	3.03	25.5	50	3.6	27.0	5.4	<100	<10	6	4.0	<10	<1	16	8	<10	4.0	170	1	3.0	80
10/20/85	3.04	25.7	35	4.6	22.0	5.3	100	10	2	.8	10	1	17	3	10	6.0	80	1	3.0	50
11/23/85	5.63	ND	151	5.4	14.5	5.6	<100	<10	1	2.1	<10	<1	23	9	<10	1.1	50	1	4.0	190
01/01/86	3.39	47.1	28	10.5	5.5	5.4	<100	10	1	1.3	<10	<1	24	10	<10	.5	20	<1	3.3	40
02/12/86	3.73	190	30	8.8	9.5	5.8	<100	10	4	1.5	<10	<1	19	10	<10	.7	40	<1	3.6	70
03/03/86	2.68	45.7	24	10.5	11.0	6.3	<100	<10	3	1.1	<10	<1	28	11	<10	.5	30	<1	3.1	70
04/23/86	2.48	35.2	26	6.6	15.5	6.1	<100	<10	10	1.1	<10	<1	29	13	<10	.5	120	<1	2.9	80
05/19/86	2.29	26.9	26	4.8	23.5	6.0	<100	<10	15	.9	<10	<1	51	35	<10	.5	90	<1	2.3	120
05/28/86	2.18	22.8	27	5.2	25.0	5.9	<100	10	9	1.3	<10	<1	44	14	<10	.5	80	<1	2.5	100

* -- Total recoverable, in micrograms per liter (µg/L).
\+ -- Total recoverable, in milligrams per liter (mg/L).
ND -- Not determined, due to backwater effects of the Congaree River.

SUMMARY

A total of 37 bed-sediment samples were collected at 28 sampling stations during two sampling periods in an effort to quantify the occurrence of selected metals in the area of Congaree Swamp National Monument. Certain elements, such as barium, iron, magnesium, and manganese are present in a wide range of concentrations in both the Cedar Creek and Toms Creek watersheds. Other elements, such as beryllium, cadmium, lithium, and molybdenum are either not present or present in such small quantities that almost all analyses are below minimum detection levels. In general, the metal concentrations measured do not follow any discernable pattern, although most concentrations in the Toms Creek watershed are lower than concentrations in the Cedar Creek watershed. Relatively high concentrations in the MISC1, MISC2, and MISC3 samples indicate that the flood plain may act as a sink for certain trace metals.

Selected trace-metal concentrations were tested for correlation with particle size (percentage finer than 0.063 mm and percentage greater than 0.500 mm) using regression analysis to determine if the wide range of concentrations measured were the result of variations in particle-size distributions. Extremely low correlation coefficients indicate that there is no strong correlation between concentration and percentage of sample finer than 0.063 mm or greater than 0.500 mm.

Surface-water samples were collected for analysis of selected metals at the Cedar Creek at Cedar Creek Hunt Club gaging station using an automatic sampler. Ten samples were selected for analysis so that a variety of discharge and water-quality conditions were represented. Concentrations of cadmium, which is a highly toxic element, equaled or exceeded the U.S. Environmental Protection Agency (USEPA) drinking-water maximum contaminant level of 10 µg/L in three samples, with the highest concentration observed being 15 µg/L. Concentrations of manganese equaled or exceeded the USEPA drinking water secondary maximum-contaminant level of 50 µg/L in seven samples, with the highest observed concentration being 220 µg/L. Copper, zinc, and lead were found in concentrations less than the EPA drinking water secondary maximum-contaminant level. Concentrations of barium, beryllium, chromium, cobalt, lithium, and molybdenum were equal to or less than minimum detection levels.

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