ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT

EPA-330/2-78-010

Biological Impact of Discharges
Coffeen Generating Station
Central Illinois Public Service Company
Coffeen, Illinois

(NOVEMBER 15-19, 1977)

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

DENVER, COLORADO

JUNE 1978

Enviromental Protection Agency
Office of Enforcement
EPA-330/2-78-010

BIOLOGICAL IMPACT OF DISCHARGES
COFFEEN GENERATING STATION
CENTRAL ILLINOIS PUBLIC SERVICE COMPANY
COFFEEN, ILLINOIS

[November 15 - 19, 1977]

June 1978

National Enforcement Investigations Center
Denver, Colorado

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I. INTRODUCTION

In September 1974, National Pollutant Discharge Elimination System (NPDES) Permit No. IL0000108 was issued to the Central Illinois Public Service Company (CIPSCO) for discharge from the Coffeen Power Station to Lake Coffeen. From the date of permit issuance until July 1, 1977, the Company failed to report the quality of its effluents to EPA; since July 1, 1977, reported effluent quality frequently did not meet permit limitations. In addition, the permit required the installation of chemical control equipment by July 1, 1977; Company schedules indicate noncompliance with this requirement until 1979. The Environmental Protection Agency (EPA) Region V Enforcement Division filed a civil complaint against the Company with the U.S. District Court.

Region V expressed concern that the pollution abatement measures proposed by CIPSCO are inadequate to protect the biota of Lake Coffeen; even if mineralization was abated, the heat of the discharge could be damaging. The NEIC was requested to conduct a water quality investigation of Lake Coffeen to assess the impact of discharges from the Coffeen Power Station.

Lake Coffeen is a 445 hectare (1,100 acre) impoundment of McDavid Branch, a tributary to Shoal Creek in Montgomery County in southcentral Illinois [Figure 1]. The impoundment, constructed by the Central Illinois Public Service Company in the early 1960's to provide water for the Coffeen Power Station, is considered by the State of Illinois to be a public water. From 1965 into the early 1970's, the Station operated one unit which generated about 350 MWe

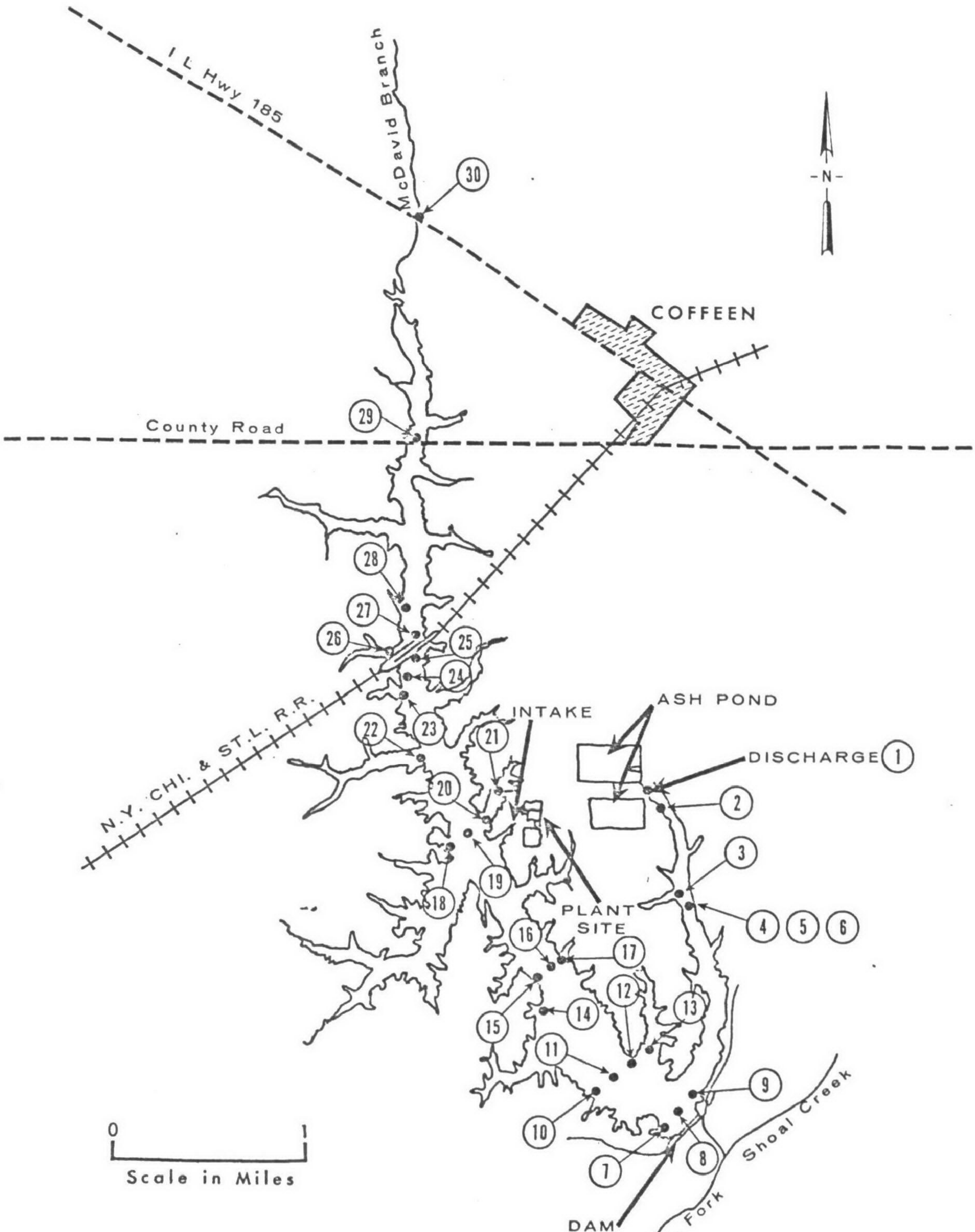

Figure 1. Lake Coffeen, Illinois, and Sampling Locations
November, 1977

of electric power. In 1975, a second unit was added which increased the plant capacity to 945 MWe. The Station withdraws water from a cove about one-third of the lake length, or about 1.5 mi (2.4 km) north of the dam, and discharges wastewaters to a cove near the dam. The distance from the discharge to the intake is about 4 mi (6.4 km). The potential exists for short-circuiting; wastewaters could be drawn into the intake without complete mixing with the northern portion of the lake. Also, an earth-fill railroad embankment that divides the lake may interfere with complete circulation.

Data submitted by the Company to the Illinois Pollution Control Board as part of a thermal demonstration,* document severe chemical quality deterioration of Lake Coffeen between 1965 and 1976, primarily since 1974. For example, alkalinity decreased from about 120 to 20 mg/l, and total dissolved solids increased from about 300 to more than 1,000 mg/l. Mineralization of Lake Coffeen can be attributed in part to evaporative losses aggravated by thermal additions of the power plant, and because there were no discharges over the spillway since the spring of 1975. Over the years, the Company has needed to use ever-increasing amounts of caustic soda and acid for demineralization.

Numerous problems have become apparent in the Lake Coffeen biota. The lake is reported to be the third most eutrophic among the Illinois lakes studied by EPA.[1] Blooms of blue-green algae have appeared as early as April. Company data[2] indicate a paucity of macroinvertebrates, and fish populations appear to be affected (younger fish in emaciated conditions, low numbers of important game fish, etc.).

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* Illinois Pollution Control Board Rules and Regulations, Chapter 3: Rule 203 (i) (10).

The Central Illinois Public Service Company intends to install dry processes for handling ash, a means of pumping make-up water from Shoal Creek, and other pollution controls at the Coffeen Power Station. The Company contends that by reversing Lake Coffeen mineralization, the biological problems will be abated.[2] They have requested the Illinois Pollution Control Board to establish thermal standards (water at the edge of a mixing zone not to exceed 98°F more than 8.2% of the time in any 12-month period and at no time exceeding 108°F) based upon reported operating conditions from 1965 through 1976.

The NEIC conducted an investigation at Lake Coffeen during the period November 15 to 19, 1977. Emphasis was placed on determining the effects of the power plant discharge on the fish and other aquatic biota of Lake Coffeen. This report discusses the findings of the NEIC investigation.

II. SUMMARY AND CONCLUSIONS

1. Water quality in Lake Coffeen was degraded by discharges from the Coffeen Generating Station. The entire lake was mineralized, with high conductivities, low alkalinities, and high concentrations of calcium, magnesium, sodium and sulfate. Boron concentrations (4.4 to 5.3 mg/l) were sufficiently high to make the water unsafe for irrigation of sensitive crops. Dissolved oxygen concentrations and pH values were suitable for fish and other aquatic life. Lake Coffeen temperatures were highest in the discharge arm, with a gradual decrease from south to north. There was a marked temperature decrease (2.5°C) between the waters immediately south and north of the railroad embankment.

2. Phytoplankton were dominated by bluegreen algae; this is considered to be an undesirable characteristic. The dominance by blue-green algae in November is an indication of unnaturally elevated lake temperatures.

3. The low numbers and diversities of benthic invertebrates reflected the poor quality of Lake Coffeen waters.

4. Lake Coffeen fish populations were influenced severely by the power plant discharges. Overall, there were relatively few important game fish, and most of the fish were thin and in poor condition. Fish inhabiting the area north of the railroad embankment were least affected by the discharges. There were more game fish in this area, and the fish were in better condition. It is concluded that the better condition of the fishery north of the railroad

embankment is the result of lower temperatures, and that the area north of the railroad embankment probably does not serve as a sanctuary for fish migrations from the southern portion of the lake.

III. RESULTS OF FIELD INVESTIGATION

WATER QUALITY

Locations at which samples were collected from Lake Coffeen are listed in Table 1 and illustrated in Figure 1. The quality of Lake Coffeen water was degraded by the power station discharge. Although runoff from McDavid Branch (estimated 10 cfs) on the sampling day appeared to dilute the mineral content at Station 29, all portions of the lake examined contained high concentrations of minerals [Table 2]. Concentrations of some chemicals were slightly lower in the portion of the lake north of the railroad embankment than those found in the southern portion, but the differences in concentration are insignificant. For example, concentrations of calcium, magnesium and sodium as high as 163, 27.1 and 177 mg/l, respectively, were detected in the northern portion, while in the southern portion concentrations of these chemicals ranged as high as 171, 28.9 and 188 mg/l. Sulfate concentrations ranged from 690 to 790 mg/l north of the railroad bridge and from 790 to 840 mg/l north of the railroad bridge and from 790 to 840 mg/l to the south. These values indicate that both the northern and southern portions of the Lake Coffeen are heavily mineralized. The mineralization of Lake Coffeen was reflected by the high conductivities which ranged from 1,450 to 1,850 μmho/cm. Alkalinities in the lake were low, ranging from 30.4 to 69.3 mg/l.

Boron concentrations ranged from 4.4 to 5.3 mg/l in the lake. Although these concentrations are in a range widely reported to be safe for aquatic biota (most investigators report toxicity of boron to fish when levels are in excess of 3,000 mg/l[3]), there is cause for concern. Recent investigations have developed evidence that boron

Table 1

SAMPLING LOCATIONS
LAKE COFFEEN, ILLINOIS
November 1977

Station No.	Water	Fish (Gill net & trap)	Fish (Electrofishing)	Benthos	Plankton
1	X				
2	X				X
3		X			
4	X				
5	X			X	X
6	X				
7	X				
8	X		X	X	X
9	X				X
10	X				
11	X				X
12	X				
13		X		X	
14		X		X	
15	X				
16	X				X
17	X				
18	X				
19	X				X
20	X	X			
21				X	
22		X		X	
23	X	X			
24	X		X		
25	X			X	X
26	X		X		
27	X			X	
28		X			
29	X	X			
30	x				

FIELD MEASUREMENTS AND ANALYTICAL DATA
LAKE COFFEEN, ILLINOIS
November 1977

Station	Date Nov.	Time	Depth M	Temp. °C	DO mg/l	pH	Specific Conductance µmho/cm	Total Alkalinity $CaCO_3$	NH_3-N mg/l	NO_2+NO_3-N mg/l	TKN mg/l	Total P mg/l	SO_4[a] mg/l	B mg/l	Na mg/l	Mg mg/l	Ca mg/l
1	18	1230	SS[b]	31.5	10.2	7.7	1,750		0.05	0.25	0.41	0.02	840	5.0	188	28.4	170
2	18	1205	SS	29.0	10.0	7.4	1,800	69.3	0.05	0.35	0.41	0.01	830	5.1	180	28.1	168
4	18	1245	SS	27.0	9.1	7.6	1,750	-	0.05	0.25	0.50	0.03	820	5.2	187	27.8	169
4	18	1245	7	16.5	8.0	6.9	1,850	-	0.05	0.25	0.41	0.01	860	5.0	181	27.8	166
5	18	1300	SS	28.0	7.9	7.4	1,700	30.4	0.05	0.25	0.41	0.02	830	5.2	187	27.8	171
5	18	1300	7.5	16.0	5.5	7.0	1,850	-	0.05	0.30	0.48	0.04	840	5.0	177	27.3	169
6	18	1330	SS	27.5	8.5	7.3	1,750	-	0.10	0.25	0.46	0.03	840	5.3	182	28.4	165
6	18	1330	6	16.0	7.0	7.1	1,800	-	0.05	0.30	0.40	0.03	820	5.1	181	27.5	162
7	18	1500	SS	19.5	7.5	7.3	1,800	-	0.05	0.30	0.49	0.03	820	5.3	187	28.9	169
7	18	1500	16	15.0	7.0	7.3	1,450	-	0.05	0.30	0.46	0.02	790	5.0	180	28.5	165
8	18	1445	SS	19.0	10.2	7.6	1,800	64.0	0.05	0.60	0.49	0.04	820	5.2	172	28.5	169
8	18	1445	14	15.5	7.0	7.2	1,650	-	0.05	0.25	0.49	0.03	810	5.1	171	27.9	165
9	18	1345	SS	20.5	8.2	7.3	1,650	50.4	0.05	0.25	0.49	0.03	810	5.2	173	28.9	171
9	18	1345	14	15.5	7.1	7.0	1,850	-	0.10	0.25	0.55	0.05	810	5.2	169	28.7	165
10	18	1515	SS	19.0	7.6	7.8	1,750	-	0.05	0.20	0.41	0.04	810	5.2	174	29.0	165
10	18	1515	15	15.0	7.1	7.2	1,800	-	0.05	0.25	0.55	0.06	820	5.2	173	28.4	167
11	18	1530	SS	19.0	8.1	7.7	1,800	57.8	0.10	0.36	0 46	0.03	810	4.9	180	28.3	165
11	18	1530	15	15.0	6.1	7.3	1,800	-	0.10	0.45	0.55	0.03	820	5.1	178	28.1	161
12	18	1545	SS	19.5	7.8	7.6	1,800	-	0.05	0.25	0.45	0.04	840	5.0	177	28.0	165
12	18	1545	3	17.0	7.5	7.5	1,800	-	0.05	0.25	0.48	0.03	830	¯ 0	178	28.3	166
15	18	1600	SS	17.0	7.2	7.3	1,700	-	0.05	0.20	0.41	0.02	810	4.9	172	27.3	165
15	18	1600	12	14.5	6.6	7.4	1,800	-	0.10	0.20	0.45	0.03	880	4.9	173	27.8	164
16	18	1610	SS	17.0	6.4	7.0	1,750	50.9	0.05	0.25	0.41	0.28	800	5.1	174	27.4	169
16	18	1610	10	15.0	6.2	7.0	1,800	-	0.10	0.30	0.41	0.04	820	5.0	175	27.3	166
17	18	1615	SS	17.0	6.4	7.3	1,650	-	0.10	0.20	0.45	0.03	820	5.2	175	28.3	170
17	18	1615	3.5	16.5	6.2	7.1	1,750	-	0.15	0.20	0.49	0.04	810	5.1	174	27.2	168
18	19	0915	SS	16.0	-	-	-	-	0.15	0.20	0.39	0.11	820	5.0	175	27.7	164
18	19	0915	10	14.0	-	-	-	-	0.25	0.20	0.60	0.05	800	5.0	171	27.6	161
19	19	0935	SS	16.0	-	-	-	53.6[c]	0.10	0.25	0.42	0.03	820	5.2	172	27.5	160
19	19	0935	11	13.5	-	-	-	-	0.10	0.25	0.39	0.03	790	4.0	170	27.2	163
20	19	0950	SS	16.0	-	-	-	-	0.05	0.25	0.31	0.02	810	5.0	174	27.9	169
20	19	0950	7	15.0	-	-	-	-	0.05	0.25	0.37	0.02	81C	5.3	175	27.4	168
21	18	1630	SS	16.0	6.8	7.5	1,800	-	0.05	0.30	0.42	0.03	840	5.0	174	27.6	165
21	18	1630	7	14.5	6.1	7.2	1,800	-	0.05	0.25	0.41	0.02	820	5.1	173	27.7	169
23	19	1010	SS	15.5	-	-	-	-	0.05	0.20	0.36	0.02	840	5.1	170	27.1	162
23	19	1010	6	14.0	-	-	-	-	0.05	0.25	0.31	0.02	820	5.0	173	27.4	161
24	19	1020	SS	15.5	-	-	-	-	0.05	0.25	0.37	0.02	820	5.0	177	28.2	164
24	19	1020	8	13.5	-	-	-	-	0.10	0.20	0.50	0.04	810	4.8	167	27.4	159
25	19	1035	SS	15.5	-	-	-	54.6[d]	0.05	0.25	0.31	0.02	820	4.9	176	27.8	167
25	19	1035	6	14.0	-	-	-	-	0.05	0.25	0.31	0.02	820	4.9	176	28.1	167
26	19	1055	SS	12.5	-	-	-	-	0.10	0.20	0.37	0.03	790	4.7	170	27.1	163
27	19	1100	SS	13.0	-	-	-	-	0.05	0.20	0.45	0.03	790	4.8	177	26.8	160
29	19	1135	SS	9.5	-	-	-	-	0.05	0.20	0.83	0.10	690	4.4	160	24.1	140
30	19	1130	SS	6.5	-	-	-	-	0.20	0.60	0.82	0.20	62	0.1	24	16.4	56

a *Sulfate analyses performed after recommended holding time.*
b *SS = Subsurface.*
c *Sample for alkalinity measurement collected November 18, 1977 at 1700.*
d *Sample for alkalinity measurement collected November 18, 1977 at 1705.*

concentrations as low as 0.2 mgd impair survival of embryonic and larval channel catfish.[4] The U.S. Department of Agriculture considers waters with more than 1.5 mg/l boron unsafe for irrigation of sensitive crops such as navy beans, apples, cherries and many others.[5]

The judgement of many investigators is that inorganic nitrogen should not exceed 0.3 mg/l and phosphorus 0.05 mg/l if nuisance plankton blooms are to be avoided in reservoirs.[6] Although these values were approached in Lake Coffeen, they were not generally exceeded [Table 2].

Dissolved oxygen concentrations exceeded 6 mg/l in all portions of Lake Coffeen, and the pH ranged from 6.9 to 7.8. Both of these conditions are suitable for the establishment of healthy communities of fish and other aquatic life.

Of the water quality constituents measured in Lake Coffeen, temperatures showed the greatest extreme in range and the most consistent pattern. Vertical temperature differences were pronounced in the discharge arm of the lake (12°C difference between surface and near-bottom), in the vicinity of Stations 4, 5 and 6 [Figure 1]. This is the area considered by CIPSCO to be the edge of the mixing zone, and it is apparent that complete mixing had not occurred. From the area of the dam northward, vertical temperature differences appeared to be depth-related; i.e., greater surface versus bottom temperature differences were found in deeper waters.

Horizontal temperature gradients were distinct in Lake Coffeen. Surface waters were warmest in the discharge arm (27 to 28°C at Stations 4, 5 and 6), about 7 to 9°C lower near the dam, and about 12°C lower on the south side of the railroad embankment. A distinct temperature difference also existed between surface waters immediately south of the railroad embankment (15.5°C) and surface waters immediately north (12.5 to 13°C); thus, it appears that the railroad embankment forms a barrier that interferes with water circulation between the north and south portions of Lake Coffeen.

On November 18, 1977, surface temperature gradients were measured by remote sensing techniques. Information obtained by remote sensing was similar to data obtained by on-site field measurements, but, provided a more detailed and comprehensive image of Lake Coffeen surface temperatures. Figures 2 and 3 (inside back cover) are synoptic isarthermal* maps of the lake, reconstructed from data obtained by an aircraft mounted infrared line scanner. From the remote sensing data, it is apparent that: 1) the largest area of the lake had surface temperatures ranging from 15°C to 20°C while the surface temperatures near the lake inlet were 7°C to 8°C; and 2) the railraod embankment interferes with circulation of surface water between the northern and southern portions of the lake.

PHYTOPLANKTON

Surface water samples were collected from eight locations in the southern portion of Lake Coffeen for plankton analyses [Table 1 and Figure 2]. Blue-green algae comprised 58 to 76% of the phytoplankton at each station, with lesser numbers of green algae and diatoms [Table 3]. The blue-green algae *Chroococcus*, *Merismopedia*, *Phormidium*, and *Schizothrix* were found at Station 2 nearest the power plant discharge. *Merismopedia* and *Schizothrix* were the only blue-green algae found at other stations. The predominance of blue-green algae in November (and in April as reported by CIPSCO) reflects the elevated

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* Isarthermal - area of constant or equal temperature.

Table 3

LAKE COFFEEN PHYTOPLANKTON
LAKE COFFEEN, ILLINOIS
November 1977

Type of Algae	Station							
	2	5	8	9	11	16	19	25
	Algal units/ml							
Blue-Green								
Chroococcus	33							
Merismopedia	199	232	99	66	99		99	199
Total	232	232	99	66	99		99	199
Filamentous Blue-Green								
Phormidium	33							
Schizothrix	3,740	4,700	5,130	3,277	4,667	4,667	2,979	3,674
Total	3,773	4,700	5,130	3,277	4,667	4,667	2,979	3,674
Coccoid Green								
Pediastrum		66						
Scenedesmus	265	463	1,423	430	397	298	199	364
Tetraedron	166	66					99	33
Total	431	595	1,423	430	397	298	298	397
Filamentous Green								
Rhizoclonium	166	99	33	199	232	397	397	298
Total	166	99	33	199	232	397	397	298
Green Flagellates								
Phacus	199	66	232	132	166	99	66	397
Total	199	66	232	132	166	99	66	397
Diatoms								
Pennate	2,085	1,059	662	463	728	794	496	761
Centric		33		66	33		33	99
Total	2,085	1,092	662	529	761	794	529	850
Total (No./ml)	6,886	6,784	7,579	4,633	6,322	6,255	4,368	5,825
Total (No. of kinds)	9	9	6	7	7	5	8	8

lake temperatures caused by the power station discharge. In lakes and reservoirs not influenced by artificial temperature inputs, blue-green algae may dominate during the summer months, but diatoms dominate in colder months.[7] The predominance of blue-green algae in the phytoplankton is considered to be an undesirable characteristic, and the presence of this condition in November and April is an indication of unnaturally elevated temperatures.

BENTHIC MACROINVERTEBRATES

Bottom-dwelling invertebrates collected at eight locations in Lake Coffeen reflected the generally poor water quality of Lake Coffeen. Phantom midges (*Chaoborus*), midges (*Chironomus*) and aquatic oligochaetes were the only organisms frequently collected in bottom samples [Table 4]. Benthic organisms were not abundant in any portions of the lake, and species diversity ($\bar{d}$) was extremely poor (ranging from 0.0 to 1.58 on a scale in which values greater than 3.0 are considered acceptable[8]).

FISH

Lake Coffeen fish populations were influenced severely by the power plant discharges. Overall, the fishery is characterized by relatively few important game fish such as largemouth bass and channel catfish, and large numbers of small sunfish [Tables 5 and 6]. In addition, most of the fish of Lake Coffeen were thin and in extremely poor condition. Condition factors were calculated and used as a method of describing the relative plumpness or well-being of the fish. The calculation involved the equation $K_{TL} = \frac{W\ 10^5}{L^3}$, where W is weight in grams, L is total length in millimeters and 10^5 is a factor to bring the value of K_{TL} near unity. Condition factors are influenced by many variables, such as the species and age of fish and

Table 4

BENTHIC MACROINVERTEBRATES
LAKE COFFEEN, ILLINOIS
November 1977

Organisms	Station							
	5	8	13	14	21	22	25*	27
	Numbers/m^2							
ANNELIDA								
Oligochaeta								
Naididae	474							
INSECTA								
Tripcotera								
Molannidae								
Molanna						43		
Diptera								
Chironomidae								
Chironomus	43		43	43				43
Eukiefferiella					86			43
Parachironomus								
Psectrocladius						43		
Nematocera								
Chaoborus	301	1,808	431		344			
MOLLUSCA								
Gastropoda								
Bulimidae								
Somatogyrus								43
Total No./m^2	818	1,808	474	43	430	86		129
No. of Kinds	3	1	2	1	2	2		3
$\bar{d}$**	1.21	0.0	0.438	0.0	0.721	0.999		1.58

* *No organisms*
** *Index of Diversity*

Table 5

LAKE COFFEEN FISH POPULATION
LAKE COFFEEN, ILLINOIS
November 1977

Station	Largemouth Bass				White Crappie				Channel Catfish				Black Bullhead				Yellow Bullhead				Carp			
	No.	Average Wt (g)	Average L (cm)	Average K_{TL}	No.	Average Wt (g)	Average L (cm)	Average K_{TL}	No.	Average Wt (g)	Average L (cm)	Average K_{TL}	No.	Average Wt (g)	Average L (cm)	Average K_{TL}	No.	Average Wt (g)	Average L (cm)	Average K_{TL}	No.	Average Wt (g)	Average L (cm)	Average K_{TL}
3					5	271	23	1.1	10	208	29	0.6												
8	2	1,362	42	1.8					3	140	26	0.7									2	1,702	50	1.4
13					2	120	21	1.0																
14	2	14	11.8	0.8	4	43	18	0.7	13	294	32	0.7	1	360	31	1.2					1	1,135	48	1.0
20					2	79	20	0.9																
22									1	454	40	0.7												
23					5	92	21	0.9	1	2,497	67	0.8												
24	1	1,816	48.5	1.6																				
26	7	822	32	1.6	7	252	26	1.5	1	132	26	0.8					1	136	22	1.4	5	1,999	54	1.2
28	1	36	15	1.1	5	397	25	1.4	5	620	34	0.9									1	481	32	1.4
29					5	32	14	1.2	5	603	36	0.9	2	193	24	1.4					1	1,085	42	1.5
Total	13				35				39				3				1				10			

Station	Orange Spot Sunfish				Green Sunfish				Longear Sunfish				Hybrid Sunfish				Gizzard Shad				Bluegill			
3									1	10	9	1.4	3	16	11	1.4	11	123	23	0.8	9	22	12	1.4
8	1	2	6	0.9					1	4	7	1.2	2	26	12	1.3	43	40	16	1.0	4	29	12	1.6
13	1	9	8.5	1.5	4	22	11	1.6	17	25	12	1.4	8	37	13	1.5					11	13.4	9.6	1.3
14	1	10	8.8	1.5					10	16	10	1.5	21	20	11	1.4	54	42	17	0.8	70	16.4	10.4	1.3
20	22	9.5	8.6	1.5	1	23	12	1.2	7	17	10	1.4	18	29	12	1.5					56	20	11	1.4
22	4	9.1	8.6	1.2	3	12	9	1.6	23	14	10	1.4	18	21	11	1.4	3	27	14	0.8	53	15.4	10.2	1.3
23	4	8	8.2	1.4					33	14	10	1.4	30	22	11	1.4	2	30	15	0.8	140	19.5	11.2	1.4
24					1	70	16	1.9	2	9	9	1.2	3	17	9	1.3	47	36	16	0.9	16	13.5	9.8	1.3
26					2	16	10	1.4	2	22	11	1.7	2	45	14	1.8	30	49	16	1.0	41	24.5	11.5	1.6
28									1	23	10	2.2	4	37	12	1.8	3	101	20	1.0	21	18.5	9.9	1.8
29	3	14	9.1	1.8													3	29	15	0.8	8	20.9	10.3	1.7
Total	16				11				97				109				196				437			

Table 6

LAKE COFFEEN FISH CONDITION FACTORS
LAKE COFFEEN, ILLINOIS
November 1977

Type of Fish	Station 3 No.	Station 3 Avg K_{TL}	Station 8 No.	Station 8 Avg K_{TL}	Station 13 No.	Station 13 Avg K_{TL}	Station 14 No.	Station 14 Avg K_{TL}	Station 20 No.	Station 20 Avg K_{TL}	Station 22 No.	Station 22 Avg K_{TL}	Station 23 No.	Station 23 Avg K_{TL}	Station 24 No.	Station 24 Avg K_{TL}	Station 26 No.	Station 26 Avg K_{TL}	Station 28 No.	Station 28 Avg K_{TL}	Station 29 No.	Station 29 Avg K_{TL}	Range No.	Range K_{TL}
Largemouth Bass			2	1.8			2	0.8							1	1.6	7	1.6			1	1.1	0-7	0.8-1.8
White Crappie	5	1.1			2	1.0	4	0.7	2	0.9			5	0.9			7	1.5	5	1.4	5	1.2	0-7	0.7-1.5
Channel Catfish	10	0.6	3	0.7			13	0.7			1	0.7	1	0.8			1	0.8	5	0.9	5	0.9	0-13	0.6-0.9
Black Bullhead							1	1.2													2	1.4	0-2	1.2-1.4
Yellow Bullhead																	1	1.4					0-1	1.4
Carp			2	1.4			1	1.0									5	1.2	1	1.4	1	1.5	0-5	1.0-1.5
Orange Spot Sunfish			1	0.9	1	1.5	1	1.5	2	1.5	4	1.2	4	1.4							3	1.8	0-4	0.9-1.8
Green Sunfish					4	1.6			1	1.2	3	1.6			1	1.9	2	1.4					0-4	1.2-1.9
Longear Sunfish	1	1.4	1	1.2	17	1.4	10	1.5	17	1.4	23	1.4	33	1.4	2	1.2	2	1.7	1	2.2			0-33	1.2-2.2
Hybrid Sunfish	3	1.4	2	1.3	8	1.5	21	1.4	18	1.5	18	1.4	30	1.4	3	1.3	2	1.8	4	1.8			0-21	1.3-1.8
Gizzard Shad	11	0.8	42	1.0			54	0.8			3	0.8	2	0.8	47	0.9	30	1.0	3	1.0	3	0.8	0-54	0.8-1.0
Bluegill	9	1.4	4	1.6	11	1.3	70	1.3	56	1.4	53	1.3	148	1.4	16	1.3	41	1.6	21	1.8	8	1.7	4-148	1.2-1.8
Total Fish	39		57		43		177		96		105		223		70		98		40		28		28-223	
Effort Units	2 trap days 3 gill net days		25 min. Electro-fishing		2 trap days 2 gill net days		2 trap days 3 gill net days		2 trap days 2 gill net days		2 trap days 2 gill net days		2 trap days 2 gill net days		25 min. Electro-fishing		20 min. Electro-fishing		1 trap day 1 gill net day		1 trap day 1 gill net day			

geographical location; thus, it is not possible to assign absolute values of acceptable condition factors. The values calculated for Lake Coffeen fish were in the lower range of values reported for fish in the southern Illinois.[9,10,11]

Fish populations in Lake Coffeen appeared to be affected to a large degree by temperature patterns. Population densities were lowest in the discharge arm, and highest in the area south of the railroad embankment (Station 23), where small sunfish were abundant [Table 5].

Fish inhabiting the area of Lake Coffeen north of the railroad embankment were least affected by the power plant discharges. In this area, there were more largemouth bass, white crappie and carp [Table 6]. The fish in this area did not appear stunted, and exhibited better color than did fish collected south of the railroad embankment. The condition factors of white crappie, channel catfish, black bullhead, orange spot sunfish, longear sunfish, bluegill and hybrid sunfish were better in fish collected north of the railroad embankment than in fish collected to the south. The chemical quality of water was not significantly better in the northern portion of the lake for the constituents measured; consequently it appears that the better condition of the fishery in this area is the result of lower temperatures.

The Central Illinois Public Service Company has reported that the northern portion of Lake Coffeen can serve as a refuge for fish when conditions are less than optimum in the main body of the lake.[2] This did not occur during the November 1977 survey. Surface temperatures were then in the 15 to 20°C range in most of the lake, an ideal temperature for most fish species, and the fish had not occupied these areas. Thus, it seems that the healthier fish populations occupy the cooler zones during the summer months, and not migrate in great numbers into the warmer zones when temperatures fall.

IV. METHODS

A network of thirty sampling stations was established in Lake Coffeen. Stations were located to provide a representative profile of the thermal and chemical patterns of the lake. Aquatic biota were collected from twenty representative locations to evaluate the influence of the thermal and chemical patterns.

Temperatures, dissolved oxygen, pH and conductivity were measured in the field, using methodology described in Standard Methods for the Examination of Water and Wastewater (14th Ed.).[12] Instruments used for these measurements were calibrated according to manufacturer specifications. Surface grab samples for alkalinity measurements were preserved on ice and analyzed using methodology described in Standard Methods.

On November 18, 1977 between 10:51 a.m. and 11:57 a.m., surface temperature gradients were measured by remote sensing techniques. Temperature measurements were made by a contractor-supplied aircraft equipped with an infrared line scanner, flying at 600 to 1,200 m (2,000 and 4,000 ft) above ground level. Temperature data were recorded on magnetic tape and subsequently processed by computer. The data generated, accurate to ± 0.5°C, were used to prepare isarthermal maps of Lake Coffeen. Field measurements were used to verify the validity and integrity of the remote sensing data.

Water samples were collected from Lake Coffeen using a Van Dorn bottle. Grab samples were taken from near the surface and approximately 1 meter above the lake bottom. Samples for calcium, magnesium, sodium and boron analyses were preserved with nitric acid.

Samples for nitrogen and phosphorus analyses were preserved with sulfuric acid. Sulfate analyses were performed on unpreserved water samples.

Sodium, magnesium and calcium were analyzed using flame atomic absorption on undigested samples. Boron analyses were done by inductively coupled argon-plasma emission spectroscopy on undigested samples. Ammonia and nitrite plus nitrate concentrations were determined using procedures described in the EPA manual Methods for Chemical Analyses of Water and Wastes.[13] The TKN and Total P values were obtained using the procedure described by Jirka, et al.[14] Sulfate concentrations were determined according to the procedure described in Standard Methods.

Surface grab water samples were collected and preserved with 5% formalin for plankton analyses. Algal counts were done using a Sedgwick-Rafter chamber. One strip of the chamber was examined for each count at a magnification of 160X. Taxonomic references used were: Smith, Freshwater Algae of the United States;[15] Prescott, How to Know the Freshwater Algae;[16] and FWPCA, A Guide to the Common Diatoms at Water Pollution Surveillance System Stations.[17]

Benthic macroinvertebrates were obtained by use of an Ekman grab. Bottom samples were washed in a U.S. Standard No. 70 sieve, and organisms and debris were preserved with ethyl alcohol. In the laboratory, organisms were manually separated from debris, identified and counted. Taxonomic references included Edmondson, Fresh-Water Biology[18] and Pennak, Freshwater Invertebrates of the United States.[19]

Fish were collected by use of rectangular trap nets, gill nets and an electroshocking device. Trap nets were set in shallow coves normally inhabited by small fish. Large-mesh gill nets were set near the bottom at the mouths of inlets to collect large bottom-dwelling fish. Electrofishing was done at selected locations usually inhabited by large game fish. Traps and gill nets were kept in place in comparable habitats for approximately one-day periods, after which fish were removed, sorted, weighed, measured, counted and returned alive to the lake. Electroshocking was done in similar habitats along the face of the dam and on both sides of the railroad bridge, using alternating current. All fish identifications were performed by Illinois Department of Conservation personnel.

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APPENDIX A

CHAIN OF CUSTODY PROCEDURES

(Partial Revision - June 1975)

ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

CHAIN OF CUSTODY PROCEDURES
June 1, 1975

GENERAL

The evidence gathering portion of a survey should be characterized by the minimum number of samples required to give a fair representation of the effluent or water body from which taken. To the extent possible, the quantity of samples and sample locations will be determined prior to the survey.

Chain of Custody procedures must be followed to maintain the documentation necessary to trace sample possession from the time taken until the evidence is introduced into court. A sample is in your "custody" if:

1. It is in your actual physical possession, or
2. It is in your view, after being in your physical possession, or
3. It was in your physical possession and then you locked it up in a manner so that no one could tamper with it.

All survey participants will receive a copy of the survey study plan and will be knowledgeable of its contents prior to the survey. A pre-survey briefing will be held to re-appraise all participants of the survey objectives, sample locations and Chain of Custody procedures. After all Chain of Custody samples are collected, a de-briefing will be held in the field to determine adherence to Chain of Custody procedures and whether additional evidence type samples are required.

SAMPLE COLLECTION

1. To the maximum extent achievable, as few people as possible should handle the sample.
2. Stream and effluent samples shall be obtained, using standard field sampling techniques.
3. Sample tags (Exhibit I) shall be securely attached to the sample container at the time the complete sample is collected and shall contain, at a minimum, the following information: station number, station location, data taken, time taken, type of sample, sequence number (first sample of the day - sequence No. 1, second sample - sequence No. 2, etc.), analyses required and samplers. The tags must be legibly filled out in ballpoint (waterproof ink).
4. Blank samples shall also be taken with preservatives which will be analyzed by the laboratory to exclude the possibility of container or preservative contamination.
5. A pre-printed, bound Field Data Record logbook shall be maintained to record field measurements and other pertinent information necessary to refresh the sampler's memory in the event he later takes the stand to testify regarding his actions during the evidence gathering activity. A separate set of field notebooks shall be maintained for each survey and stored in a safe place where they could be protected and accounted for at all times. Standard formats (Exhibits II and III) have been established to minimize field entries and include the date, time, survey, type of samples taken, volume of each sample, type of analysis, sample numbers, preservatives, sample location and field measurements such as temperature, conductivity,

DO, pH, flow and any other pertinent information or observations. The entries shall be signed by the field sampler. The preparation and conservation of the field logbooks during the survey will be the responsibility of the survey coordinator. Once the survey is complete, field logs will be retained by the survey coordinator, or his designated representative, as a part of the permanent record.

6. The field sampler is responsible for the care and custody of the samples collected until properly dispatched to the receiving laboratory or turned over to an assigned custodian. He must assure that each container is in his physical possession or in his view at all times, or locked in such a place and manner that no one can tamper with it.

7. Colored slides or photographs should be taken which would visually show the outfall sample location and any water pollution to substantiate any conclusions of the investigation. Written documentation on the back of the photo should include the signature of the photographer, time, date and site location. Photographs of this nature, which may be used as evidence, shall be handled recognizing Chain of Custody procedures to prevent alteration.

TRANSFER OF CUSTODY AND SHIPMENT

1. Samples will be accompanied by a Chain of Custody Record which includes the name of the survey, samplers' signatures, station number, station location, date, time, type of sample, sequence number, number of containers and analyses required (Fig. IV). When turning over the possession of samples, the transferor and transferee will sign, date and time the sheet. This record sheet allows transfer of custody of a group of samples in the field, to the mobile laboratory or when samples are dispatched to the NEIC - Denver laboratory. When transferring a portion of the samples identified on the sheet to the field mobile laboratory, the individual samples must be noted in the column with the signature of the person relinquishing the samples. The field laboratory person receiving the samples will acknowledge receipt by signing in the appropriate column.

2. The field custodian or field sampler, if a custodian has not been assigned, will have the responsibility of properly packaging and dispatching samples to the proper laboratory for analysis. The "Dispatch" portion of the "Chain of Custody Record shall be properly filled out, dated, and signed.

3. Samples will be properly packed in shipment containers such as ice chests, to avoid breakage. The shipping containers will be padlocked for shipment to the receiving laboratory.

4. All packages will be accompanied by the Chain of Custody Record showing identification of the contents. The original will accompany the shipment, and a copy will be retained by the survey coordinator.

5. If sent by mail, register the package with return receipt requested. If sent by common carrier, a Government Bill of Lading should be obtained. Receipts from post offices, and bills of lading will be retained as part of the permanent Chain of Custody documentation.

6. If samples are delivered to the laboratory when appropriate personnel are not there to receive them, the samples must be locked in a designated area within the laboratory in a manner so that no one can tamper with them. The same person must then return to the laboratory and unlock the samples and deliver custody to the appropriate custodian.

LABORATORY CUSTODY PROCEDURES

1. The laboratory shall designate a "sample custodian." An alternate will be designated in his absence. In addition, the laboratory shall set aside a "sample storage security area." This should be a clean, dry, isolated room which can be securely locked from the outside.

2. All samples should be handled by the minimum possible number of persons.

3. All incoming samples shall be received only by the custodian, who will indicate receipt by signing the Chain of Custody Sheet accompanying the samples and retaining the sheet as permanent records. Couriers picking up samples at the airport, post office, etc. shall sign jointly with the laboratory custodian.

4. Immediately upon receipt, the custodian will place the sample in the sample room, which will be locked at all times except when samples are removed or replaced by the custodian. To the maximum extent possible, only the custodian should be permitted in the sample room.

5. The custodian shall ensure that heat-sensitive or light-sensitive samples, or other sample materials having unusual physical characteristics, or requiring special handling, are properly stored and maintained.

6. Only the custodian will distribute samples to personnel who are to perform tests.

7. The analyst will record in his laboratory notebook or analytical worksheet, identifying information describing the sample, the procedures performed and the results of the testing. The notes shall be dated and indicate who performed the tests. The notes shall be retained as a permanent record in the laboratory and should note any abnormalties which occurred during the testing procedure. In the event that the person who performed the tests is not available as a witness at time of trial, the government may be able to introduce the notes in evidence under the Federal Business Records Act.

8. Standard methods of laboratory analyses shall be used as described in the "Guidelines Establishing Test Procedures for Analysis of Pollutants," 38 F.R. 28758, October 16, 1973. If laboratory personnel deviate from standard procedures, they should be prepared to justify their decision during cross-examination.

9. Laboratory personnel are responsible for the care and custody of the sample once it is handed over to them and should be prepared to testify that the sample was in their possession and view or secured in the laboratory at all times from the moment it was received from the custodian until the tests were run.

10. Once the sample testing is completed, the unused portion of the sample together with all identifying tags and laboratory records, should be returned to the custodian. The returned tagged sample will be retained in the sample room until it is required for trial. Strip charts and other documentation of work will also be turned over to the custodian.

11. Samples, tags and laboratory records of tests may be destroyed only upon the order of the laboratory director, who will first confer with the Chief, Enforcement Specialist Office, to make certain that the information is no longer required or the samples have deteriorated.

EXHIBIT I

EPA, NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

★ GPO

Station No.	Date	Time	Sequence No.

Station Location

_____ Grab
_____ Comp.

_____ BOD
_____ Solids
_____ COD
_____ Nutrients
_____ Metals
_____ Oil and Grease
_____ D.O.
_____ Bact.
_____ Other

Remarks/Preservative:

Samplers:

Front

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT
NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
BUILDING 53, BOX 25227, DENVER FEDERAL CENTER
DENVER, COLORADO 80225

Back

EXHIBIT II

FOR ______________________________ SURVEY, PHASE ______, DATE ______________

TYPE OF SAMPLE ______________________________

					ANALYSES REQUIRED																					
STATION NUMBER	STATION DESCRIPTION	TOTAL VOLUME	TYPE CONTAINER	PRESERVATIVE	NUTRIENTS	BOD	COD	TOC	TOTAL SOLIDS	SUSPENDED SOLIDS	ALKALINITY	DO	pH*	CONDUCTIVITY*	TEMPERATURE*	TOTAL COLIFORM	FECAL COLIFORM	TURBIDITY	OIL AND GREASE	METALS	BACTI	PESTICIDES	HERB	TRACE ORGANICS	PHENOL	CYANIDE

REMARKS

EXHIBIT III

Samplers: ______________________

____

____

____

FIELD DATA RECORD

STATION	NUMBER	DATE	TIME	TEMPERATURE °C	CONDUCTIVITY µmhos/cm	pH S.U.	D.O. mg/l	Gage Ht. or Flow Ft. or CFS

EXHIBIT IV

ENVIRONMENTAL PROTECTION AGENCY
Office Of Enforcement
NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
Building 53, Box 25227, Denver Federal Center
Denver, Colorado 80225

CHAIN OF CUSTODY RECORD

SURVEY	SAMPLERS: *(Signature)*

STATION NUMBER	STATION LOCATION	DATE	TIME	SAMPLE TYPE			SEQ. NO	NO OF CONTAINERS	ANALYSIS REQUIRED
				Water		Air			
				Comp	Grab				

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Relinquished by: *(Signature)*	Received by Mobile Laboratory for field analysis: *(Signature)*	Date/Time

Dispatched by: *(Signature)*	Date/Time	Received for Laboratory by:	Date/Time
Method of Shipment:			

Distribution: Orig — Accompany Shipment
1 Copy — Survey Coordinator Field Files

APPENDIX B

REVIEW OF PROCEDURES

REVIEW OF PROCEDURES

LAKE COFFEEN
COFFEEN, ILLINOIS

Records pertaining to the Lake Coffeen presurvey reconnaissance and survey were evaluated against established NEIC chain-of-custody procedures [Appendix A], records management practices and standardized methodology. Field data records, log books, sample tags, chain-of-custody records, laboratory bench sheets, etc. were reviewed to determine the nature and scope of any deviations from established procedures. If a deviation was discovered, an assessment was made of the impact of the deviation on the survey results. The following is the result of this evaluation.

Although all field instruments (dissolved oxygen meter, conductivity meter, pH meter) were calibrated daily or in accordance with manufacturer specifications, this information was not recorded in the bound field notebooks.

During one day of the survey (Nov. 16, 1978), one of the fish-collecting stations (designated 5 and 6 during the survey) was incorrectly labeled 11 and 12 in the field notebook; thus, there were collections from two separate locations recorded as Station 11 and 12 and no collections recorded for Station 5 and 6. However, differences existed in the type of sampling that was done at the two locations (fish samples were preserved for return to NEIC at Station 5 and 6 and not at Station 11 and 12) and it was possible to determine the correct locations from the field notebook. After the error was discovered, the improper information in the notebook was corrected.

Alkalinity samples were collected, tagged for identification purposes, documented in the field log, analyzed in the field, and discarded. Chain-of-custody records were not prepared because the samples remained in the custody of the same person(s) from the time of collection until completion of analysis. Fish and benthos samples were collected, tagged, documented in the field notebooks, and returned to NEIC for analysis. Chain-of-custody records were not prepared because the samples remained in the possession of the same person(s) from the time of collection until completion of analysis.

One sample intended for sulfate analysis and not preserved was incorrectly labeled for nutrient analysis. The mistake was discovered before the analysis occurred, and the sample was correctly analyzed for sulfate.

At two stations, sulfate and nutrient custody sheet sequence numbers were erroneously written as 01; they should have been written 02. The tags were correctly identified as sequence 02.

Some plankton and benthos sample tags were not completed with all of the information for which the tag has spaces. Collection times were not placed on some of the plankton tags, but were recorded in the field notebook. Collection times and sequence numbers were not recorded on tags or in notebooks for benthos samples; however, collection times and sequence numbers are not relevant to the interpretation of benthos data.

For continuity, it was necessary to renumber sampling locations for inclusion in the report. Thus, station numbers appearing in field notebooks do not always correspond with station numbers appearing in this report.

Sulfate analyses were performed beyond the recommended holding time of 7 days. The mechanism by which sulfate can be lost is through reduction by bacteria, in the absence of oxygen, with sulfide being produced. Since no black metallic sulfide compounds were formed and no odor due to sulfides was observed, reduction of sulfate in the samples did not occur. This result was expected as the samples did not contain enough organic matter to cause the samples to become anaerobic. Therefore, even though the samples were analyzed beyond the recommended holding time, the validity of the samples was maintained.

Blank samples were not submitted from the field to the laboratory for analysis. Other quality control procedures such as analysis of replicates and laboratory-prepared blanks were conducted.

Sulfuric acid to be used for preservation of nutrient samples inadvertently was not taken into the field. The Central Illinois Public Service Company supplied sulfuric acid for our use, but it may not have been of reagent grade. Results of nutrient analyses were in the range of values previously reported (moderate to low); therefore, it is our judgement that the nutrient results are valid, and, that nutrient samples were not contaminated by impurities in the preservative.

All of these deviations to established NEIC procedures, and the items requiring clarification are considered to be minor and, thereby, are considered to have no impact on the results or conclusions contained in this report.

PAGE NOT

AVAILABLE

DIGITALLY

PAGE NOT

AVAILABLE

DIGITALLY