THREE-SIXTEEN
a & b
DEMONSTRATION

QUAD-CITIES NUCLEAR STATION
MISSISSIPPI RIVER

A Demonstration to

The United States

Environmental Protection Agency

by the

Commonwealth Edison Company,

Chicago, Illinois

1975

A DEMONSTRATION TO THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY BY THE COMMONWEALTH EDISON COMPANY UNDER SECTIONS 316a and b OF THE FEDERAL WATER POLLUTION CONTROL ACT FOR THE QUAD-CITIES NUCLEAR STATION AT CORDOVA, ILLINOIS ON THE MISSISSIPPI RIVER

February-April, 1975

PREFACE

The original 316a and b demonstration for the Quad-Cities Nuclear Station was submitted to the United States Environmental Protection Agency in loose-bound xerox form in two stages, the 316a demonstration (January, 1975) and then a 316a supplement, plus the 316b demonstration (April, 1975). Due to popular demand, the material here presented is printed and bound as a composite demonstration as follows:

1. Cover letter and summary for the original 316a submission (5 pages) Date: 28 February, 1975.
2. Original 316a Demonstration (264 pages) Date: January, 1975.
3. Cover letter for the 316a supplement and the 316b demonstration (2 pages) Date: 11 April, 1975.
4. Supplement to the 316a Demonstration (28 pages) Date: April, 1975.
5. Original 316b Demonstration (31 pages) Date: April, 1975.

Between the initial submission and the present time certain typographical errors and recommended minor changes have been pin-pointed and are printed in an errata list which follows this preface. In addition, several figures covering various facets of the aquatic biology data are presented which contain additional data not available for the 316a, but may also be considered as corrected versions of the figures originally presented.

4 November, 1975

Edited by:

Donald B. McDonald - D. B. McDonald Research Inc.

Harry F. Bernhard - Environmental Affairs Department,
Commonwealth Edison Company

William W. Sayre
and A. David Paar - Iowa Institute of Hydraulic Research,
University of Iowa

Robert M. Gerhold - Nalco Environmental Sciences (Formerly
Industrial Bio-Test Laboratories, Inc.)

Errata

316a and b Demonstration For The Quad-Cities Nuclear Generating Station, Commonwealth Edison Company.

(Includes recommended minor changes in the demonstration)

316a:

PAGE	LINE	CHANGE
6	26	change 77,00 to - 77,000
19	4	change BioTest to - Bio-Test
28	2	change BioTest to - Bio-Test
31	7	change BioTest to - Bio-Test
32	14	change tributaties to - tributaries
34	8	change is to - topics are
41	3	change eutropic to - eutrophic
49	8	change certainly to - certainty
56	5	change temperatures is to - temperature rise is
58	2	change nodules to - modules
59	17	change Izzak to Izaak
69	20	place comma between thermal and chemical
78	Note P	change mal-functioned to - malfunctioned
79	15	change Murry and Trettle to - Murray and Trettel
86	7	change 125 to - 1 foot per second
118	Table 20 (cont.)	substitute new table (following) with numbers not containing decimals.
109	Figure 25	change abcissa's title to read - Hours of Operation Per 24 Hour Day
140	Table 22	Hyphonate side-jet, No. 2 of middle column
143	8	change $.75^{10}-.056$ to - $.75^{10}=.056$

Errata

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Table 20 (Cont.)

Oxygen Saturation (%)

Date		Sampling Location			
	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	79	84	81	78	89
Sept.	88	87	93	93	92
Oct.	88	88	88	89	115
Nov.	92	88	91	92	122
Dec.	98	98	101	98	127
Jan. 1973	87	89	87	86	102
Feb.	85	83	85	91	115
Mar.	94	92	92	87	113
Apr.	98	94	97	95	117
May	95	88	97	96	112
June	82	75	82	80	96
July	74	77	79	76	95
Aug.	86	--	85	88	91
Sept.	78	--	80	78	96
Oct.	84	--	85	--	--
Nov.	95	--	95	--	--
Dec.	94	--	98	--	--
Jan. 1974	88	--	89	--	--
Feb.	86	--	86	--	--
Mar.	96	--	95	--	--
Apr.	102	--	104	--	--
May	95	--	98	--	--
June	79	--	83	--	--
July	85	--	86	--	--

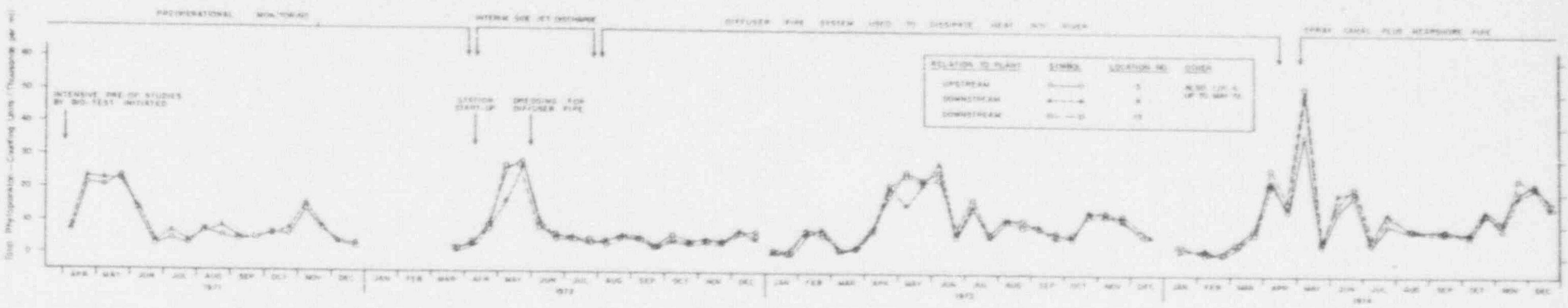

Figure 7.5. Comparison of mean phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station, April 1971 - December 1974.

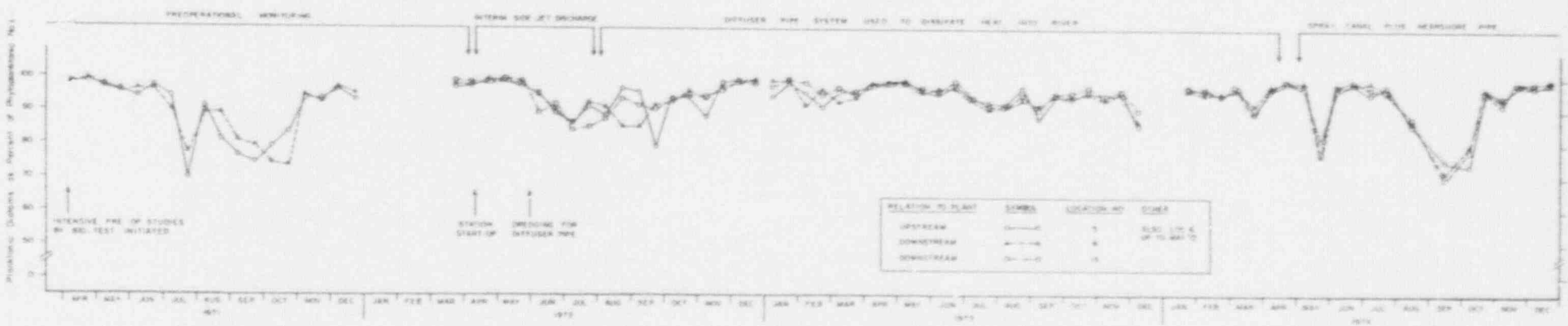

Figure 7.6. Comparison of planktonic diatoms as percent of total phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station, April 1971 - December 1974.

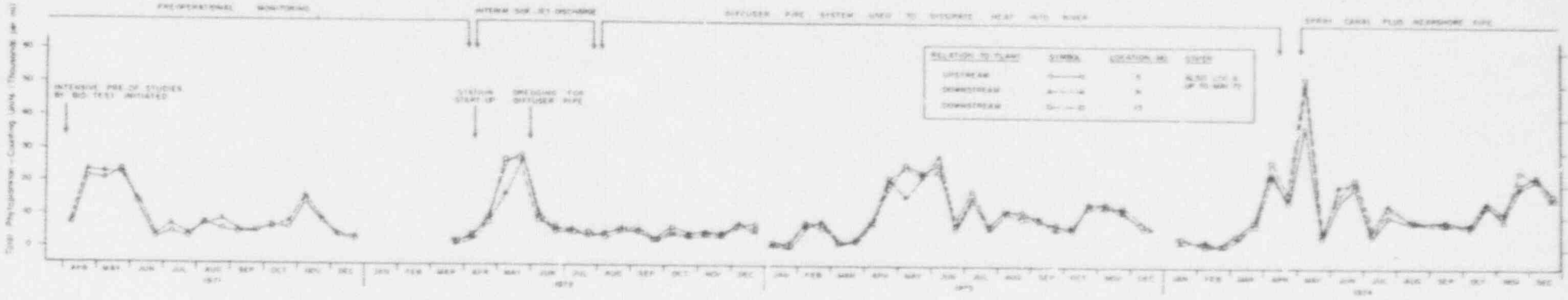

Figure 7.5. Comparison of mean phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station, April 1971 - December 1974.

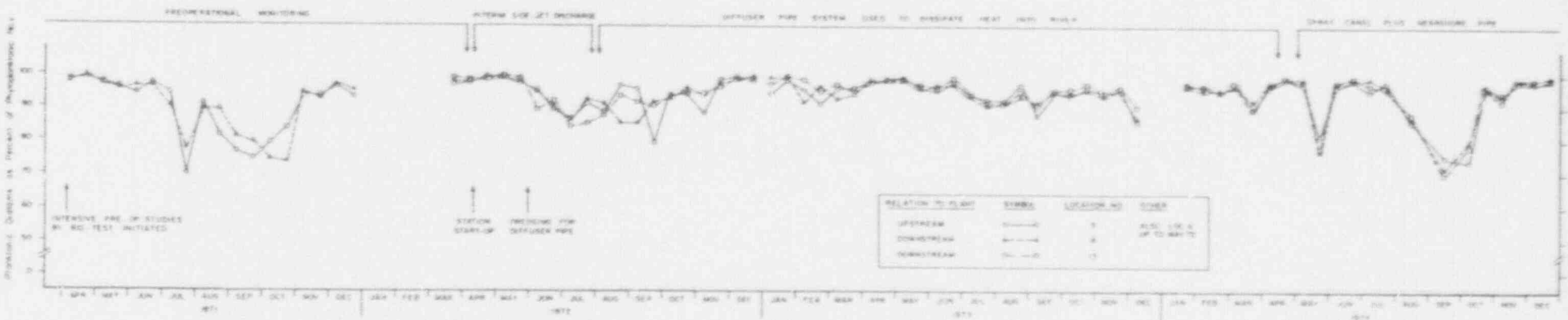

Figure 7.6. Comparison of planktonic diatoms as percent of total phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station, April 1971 - December 1974.

(316a e rata continued)

PAGE	LINE	CHANGE
141, 14	Figures 32, 33	original 316a graphs are updated by page 313 (Figures 7.5 and 7.6ff) taken from the latest semi-annual report to Commonwealth Edison on biological monitoring by Nalco Environmental Sciences. The following updated list of significant differences applies to Figure 7.5 of the semi-annual report, and Figure 32 of the 316a (p. 144):
		16 October, 1972 — 5>8 6 November, 1972 — 5>8 20 March, 1973 — 13>5 21 August, 1973 — 5>8; 5>13 2 May, 1974 — 8>5; 13>5 2 June, 1974 — 8>5 2 July, 1974 — 8>5; 13>5 15 July, 1974 — 8>5; 13>5 21 November, 1974 — 13>5
145	13	Change Ochener to - Ochsner
147	Figure 34	original 316a graph is updated by page 315 (Figure 7.7) from the latest semi-annual report which follows this section.
148	Figure 35	original 316a graph is updated by page 316 (Figure 7.8) from the latest semi-annual report which follows this section.
149	Figure 36	original 316a graph is updated by page 393 (Figure 9.3) from the latest semi-annual report which follows this section. The following list of significant differences applies to the updated 1974 portion of the Figure:
		1 April — 8>5; 13>5 17 May — 9>5 15 July — 5>8; 5>9; 5>13 6 August — 5>13; 8>13 11 September — 8>5 2 October — 13>5; 13>9 18 October — 13>5; 13>9 4 December — 8>9; 8>13

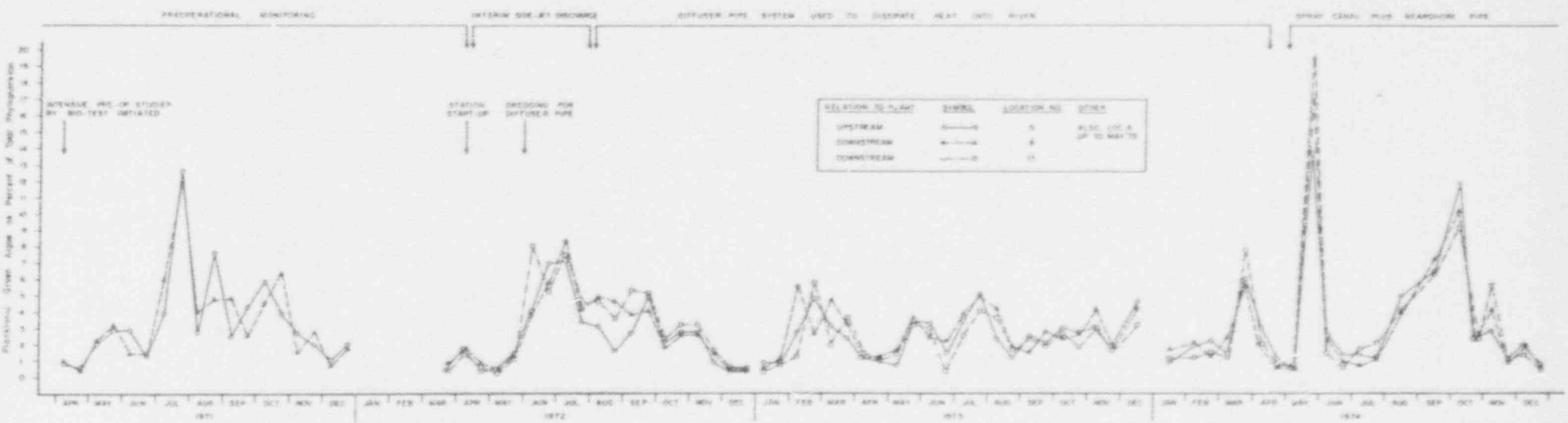

Figure 7.7. Comparison of planktonic green algae as percent of total phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station April 1971 - December 1974.

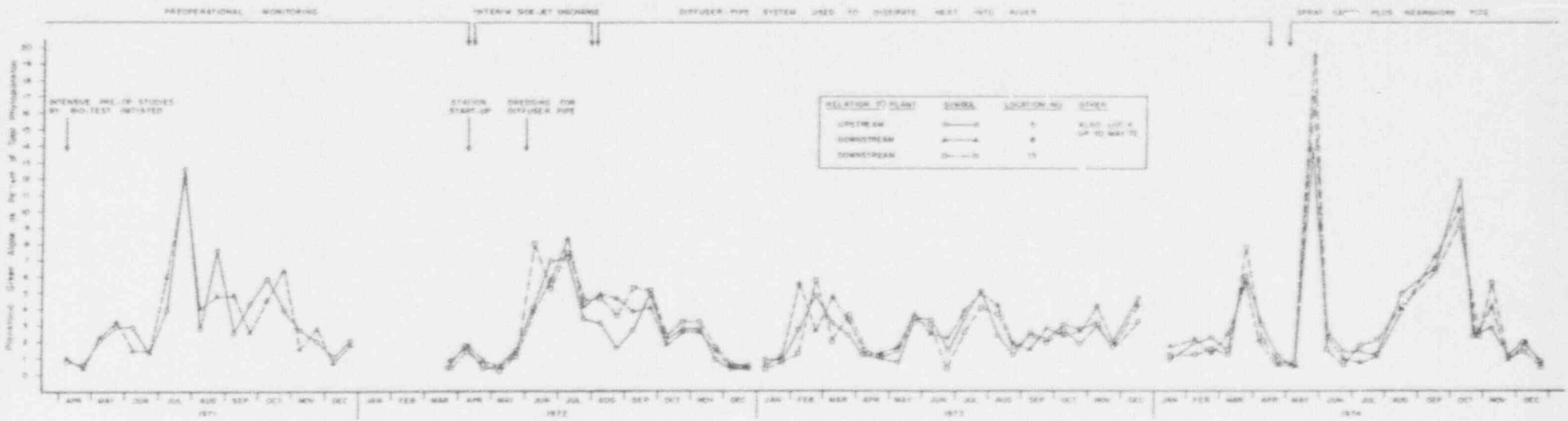

Figure 7.7. Comparison of planktonic green algae as percent of total phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station April 1971 - December 1974.

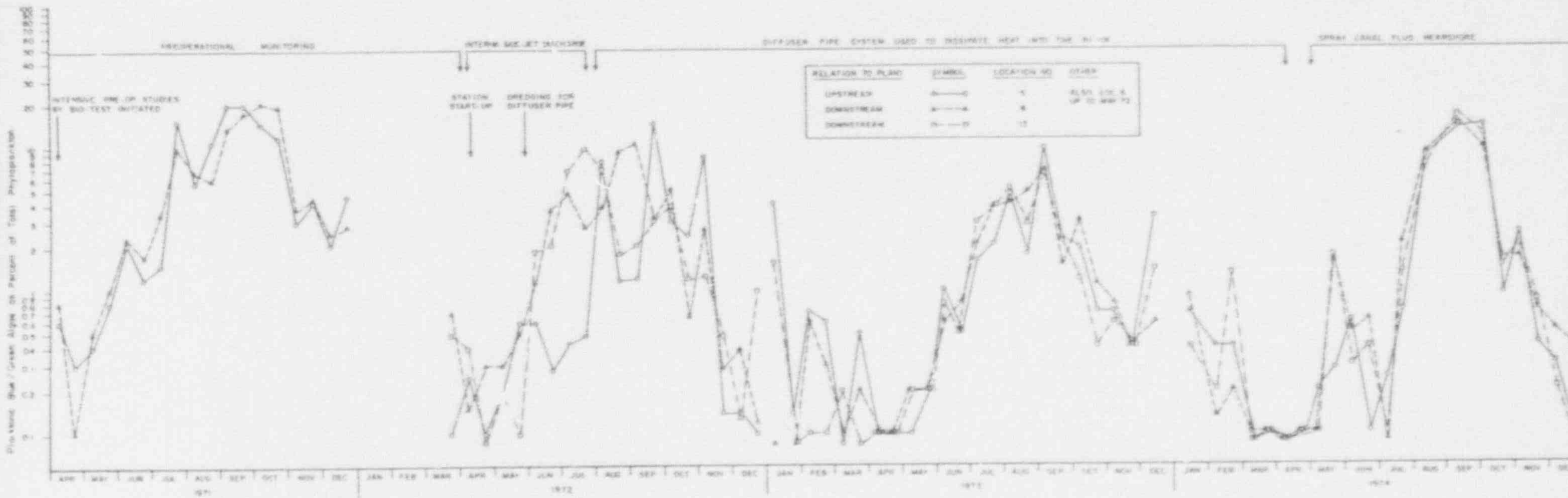

Figure 7.8. Comparison of planktonic blue-green algae as percent of total phytoplankton density at upstream Location 5 and downstream Locations 8 and 13 near the Quad-Cities Station April 1971 - December 1974.

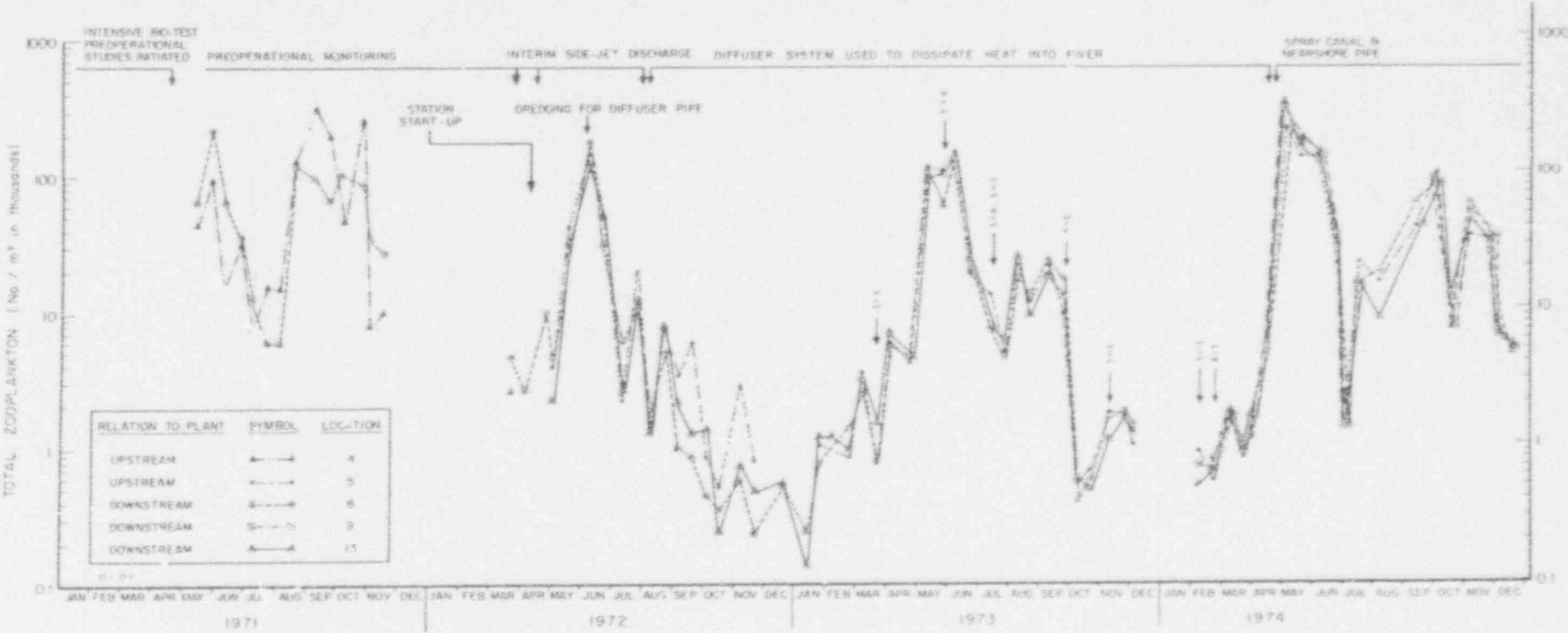

Figure 9.3. Density of total zooplankton in the vicinity of the Quad-Cities Station, 1971-1974.

(316a errata continued)

PAGE	LINE	CHANGE
150, 151, 152	Figures 37, 38, 39	Additional data is presented on the three major components of the zooplankton. However, the three curves that follow, (Figures 9.4, 9.5 and 9.6) taken from the latest semi-annual report are shown as numbers of organisms, rather than as percent of total zooplankton as was done originally for the 316a demonstration.
155	3	Eliminate quotation marks around the t
155	27	Change by to - bay
156	Figure 40	Original 316a graph is updated by page 345 (Figure 8.8) from the latest semi-annual report which follows this section but compares only upstream vs downstream. The original 316a Figure included a discharge bay station which was not a part of the river.
158	Figure 41	Original 316a graph is updated by page 344 (Figure 8.7) from the latest semi-annual report which follows this section but shows only the upstream/downstream comparisons. Additional periphyton data from the semi-annual report is also shown in forms not given in the original 316a demonstration: page 342, Figure 8.5 (periphyton biomass); and page 343, Figure 8.6 (periphyton biovolume).
163	Figure 45	Original 316a graphs are updated by page 429 (Figure 10.4) from the latest semi-annual report which follows this section.
164	Figure 46	Original 316a graphs are updated by page 430 (Figure 10.5) from the latest semi-annual report which follows this section.
165	Figure 47	Original 316a graph is updated by page 428 (Figure 10.3) from the latest semi-annual report which follows this section.
173	Last	Eliminate the word - Certain
176	First	Capitalize the first word - Other
176	11	Eliminate - It is likely that Capitalize - Under

(316a errata continued)

PAGE	LINE	CHANGE
150, 151, 152	Figures 37, 38, 39	Additional data is presented on the three major components of the zooplankton. However, the three curves that follow, (Figures 9.4, 9.5 and 9.6) taken from the latest semi-annual report are shown as numbers of organisms, rather than as percent of total zooplankton as was done originally for the 316a demonstration.
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163	Figure 45	Original 316a graphs are updated by page 429 (Figure 10.4) from the latest semi-annual report which follows this section.
164	Figure 46	Original 316a graphs are updated by page 430 (Figure 10.5) from the latest semi-annual report which follows this section.
165	Figure 47	Original 316a graph is updated by page 428 (Figure 10.3) from the latest semi-annual report which follows this section.
173	Last	Eliminate the word - Certain
176	First	Capitalize the first word - Other
176	11	Eliminate - It is likely that Capitalize - Under

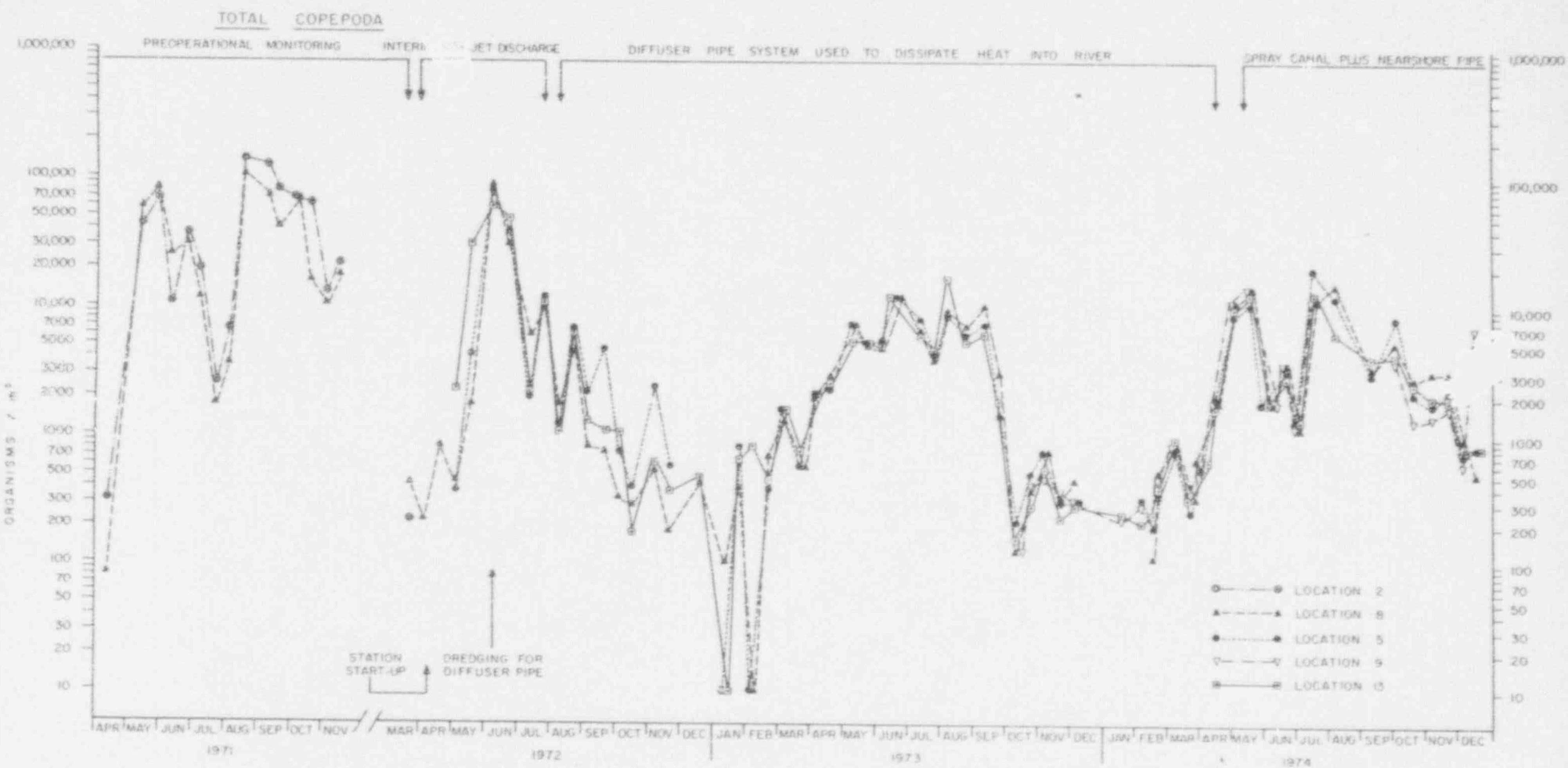


Figure 9.4. Density of total Copepoda in the vicinity of the Quad-Cities Station, 1971-1974.

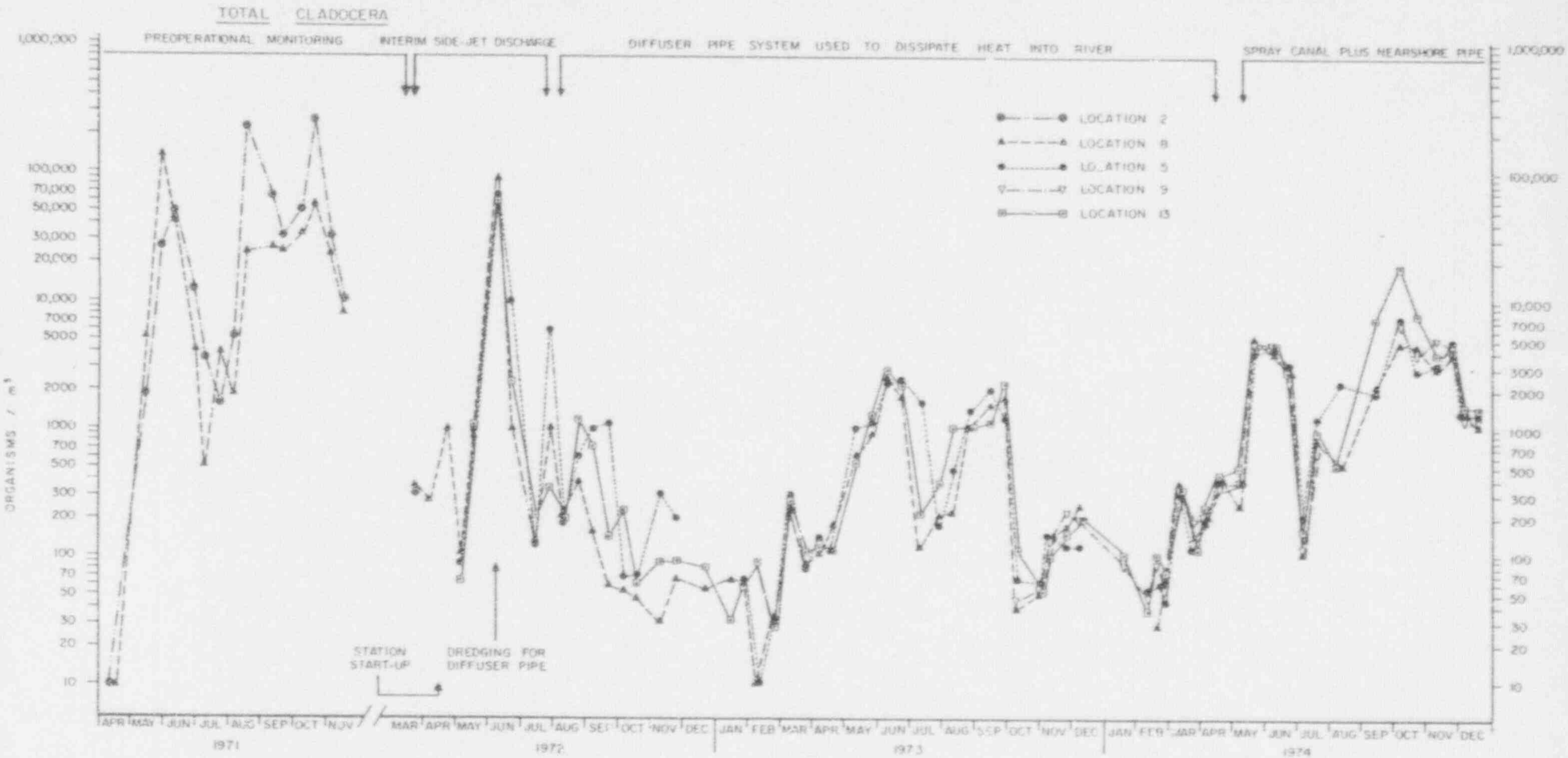


Figure 9.5. Density of total Cladocera in the vicinity of the Quad-Cities Station, 1971-1974.

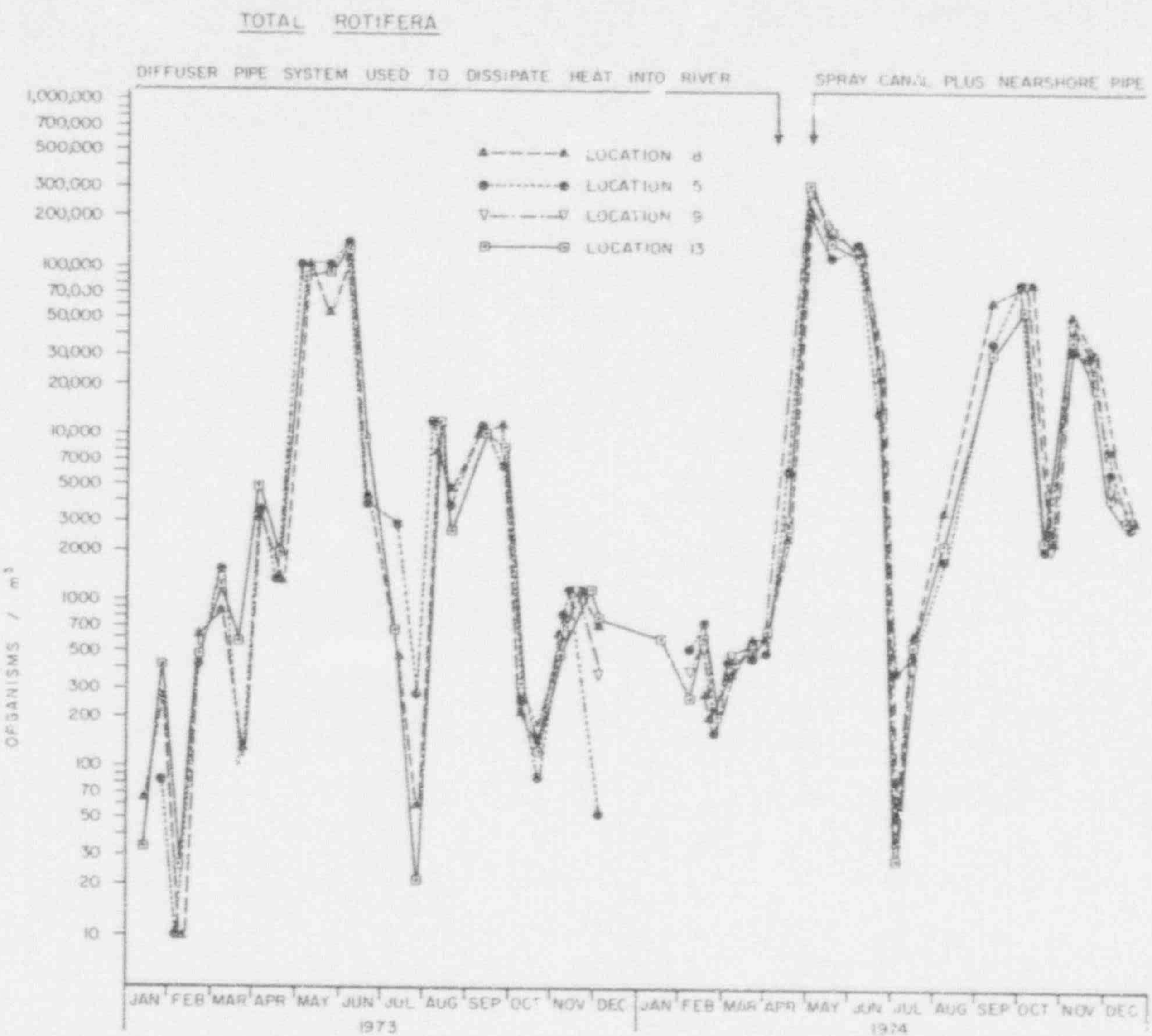


Figure 9.6. Density of total Rotifera in the vicinity of the Quad-Cities Station, 1973-1974.

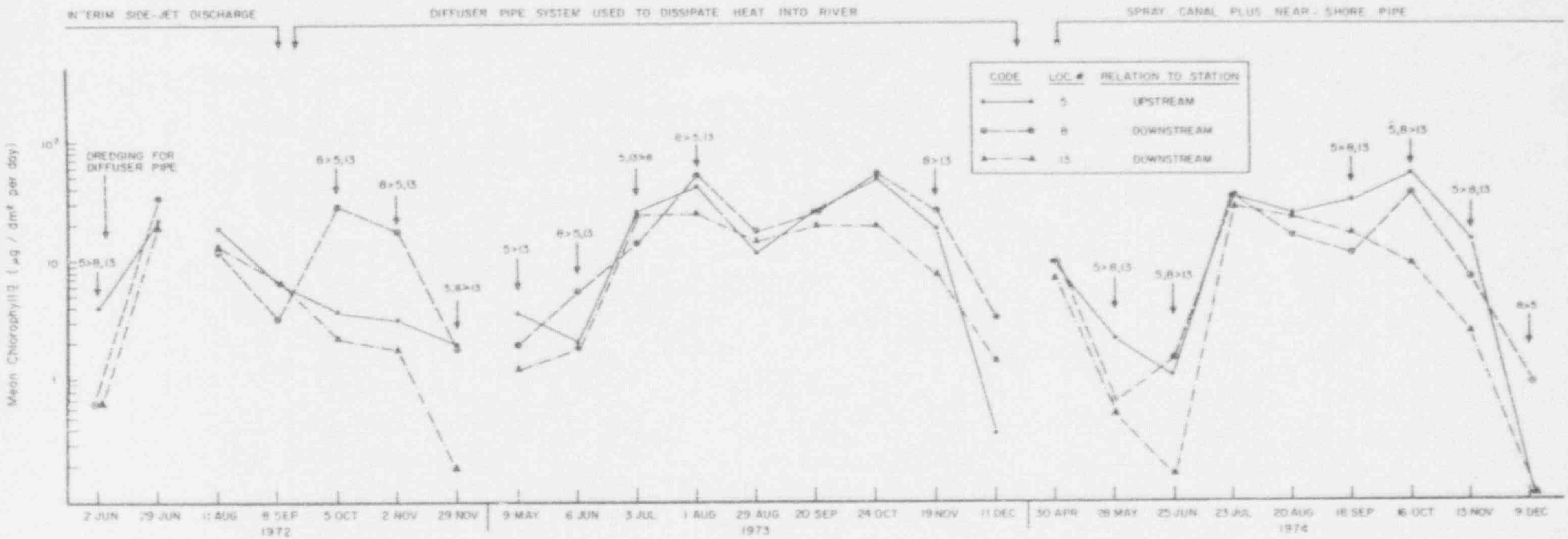


Figure 8.8. Mean chlorophyll a production of periphytic algae collected from plexiglass substrates in the Mississippi River near the Quad-Cities Station in the ice-free periods between June 1972 and December 1974.

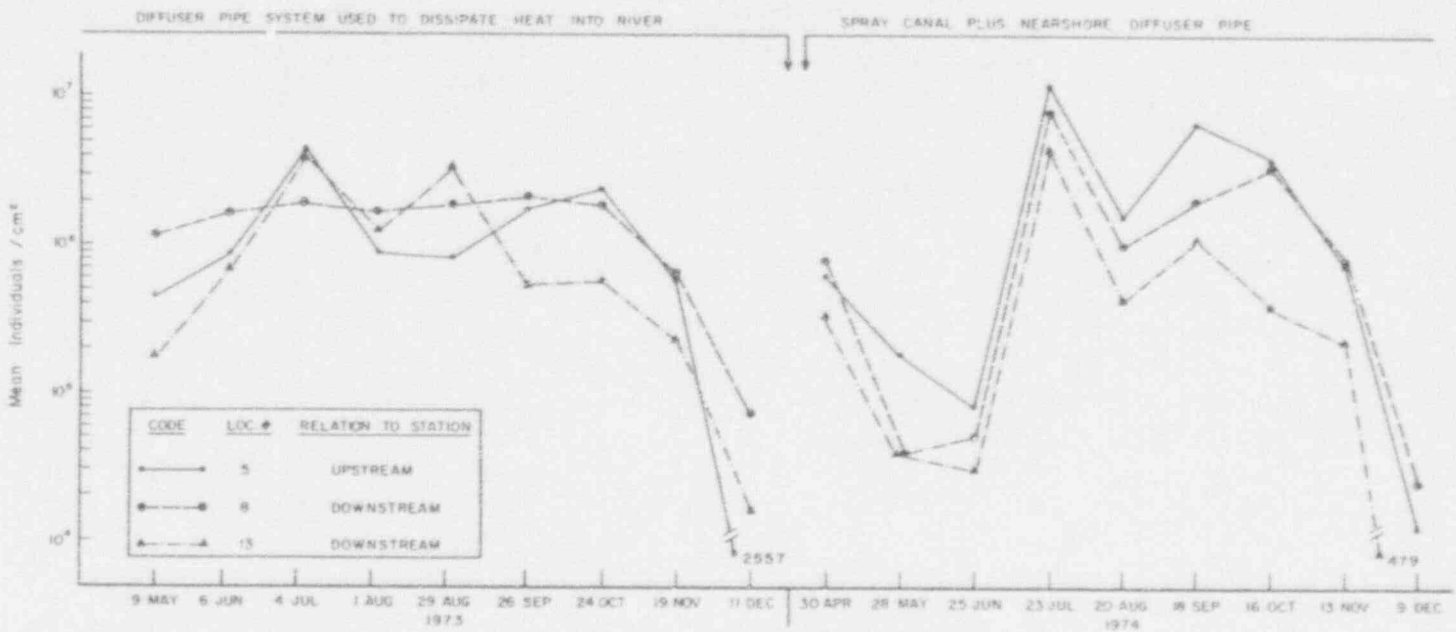


Figure 8.7. Mean number of individuals of periphytic algae collected from plexiglass substrates in the Mississippi River near the Quad-Cities Station in the ice-free periods between May 1973 and December 1974.

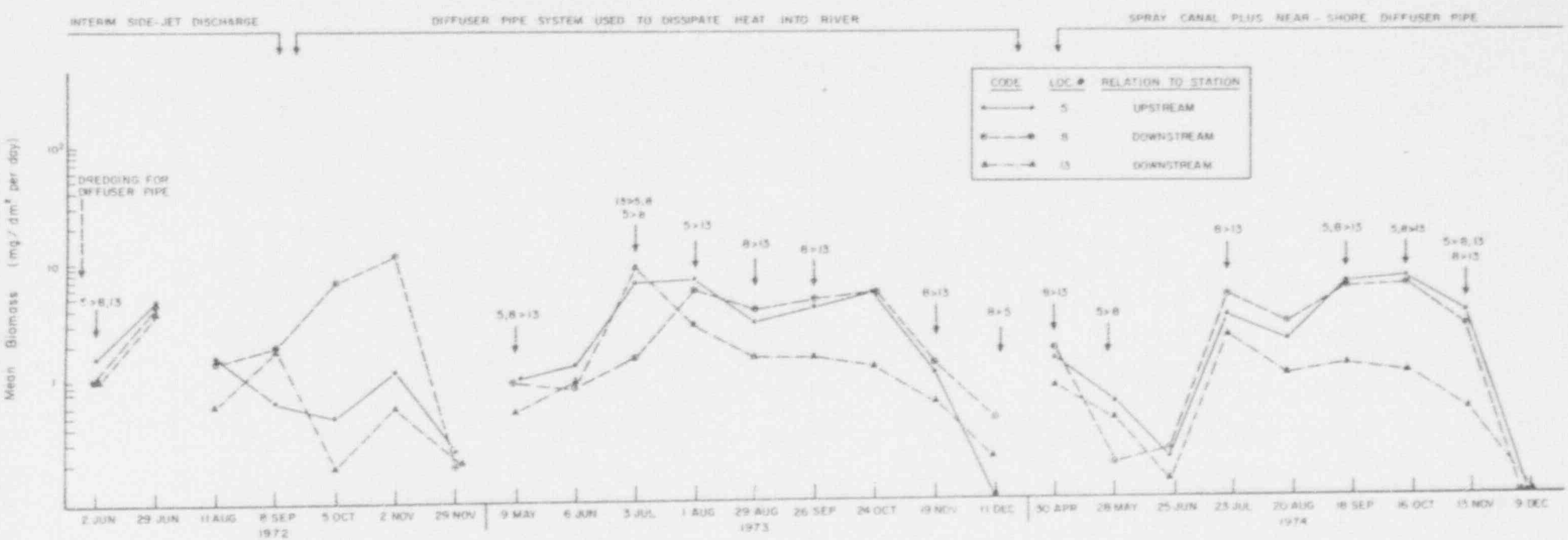


Figure 8.5. Mean biomass production of periphytic algae collected from artificial substrates in the Mississippi River near the Quad-Cities Station in the ice-free periods between June 1972 and December 1974.

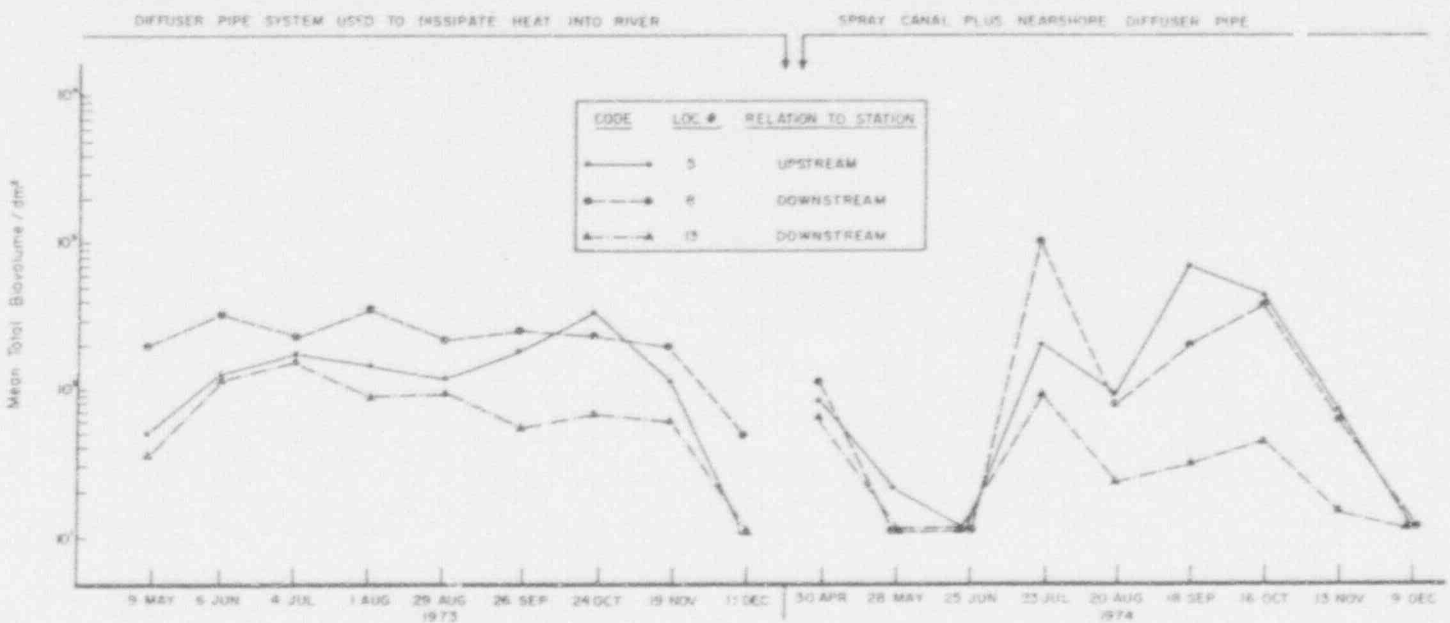


Figure 8.6. Mean total biovolume of periphytic algae collected from plexiglass substrates in the Mississippi River near the Quad-Cities Station in the ice-free periods between May 1973 and December 1974.

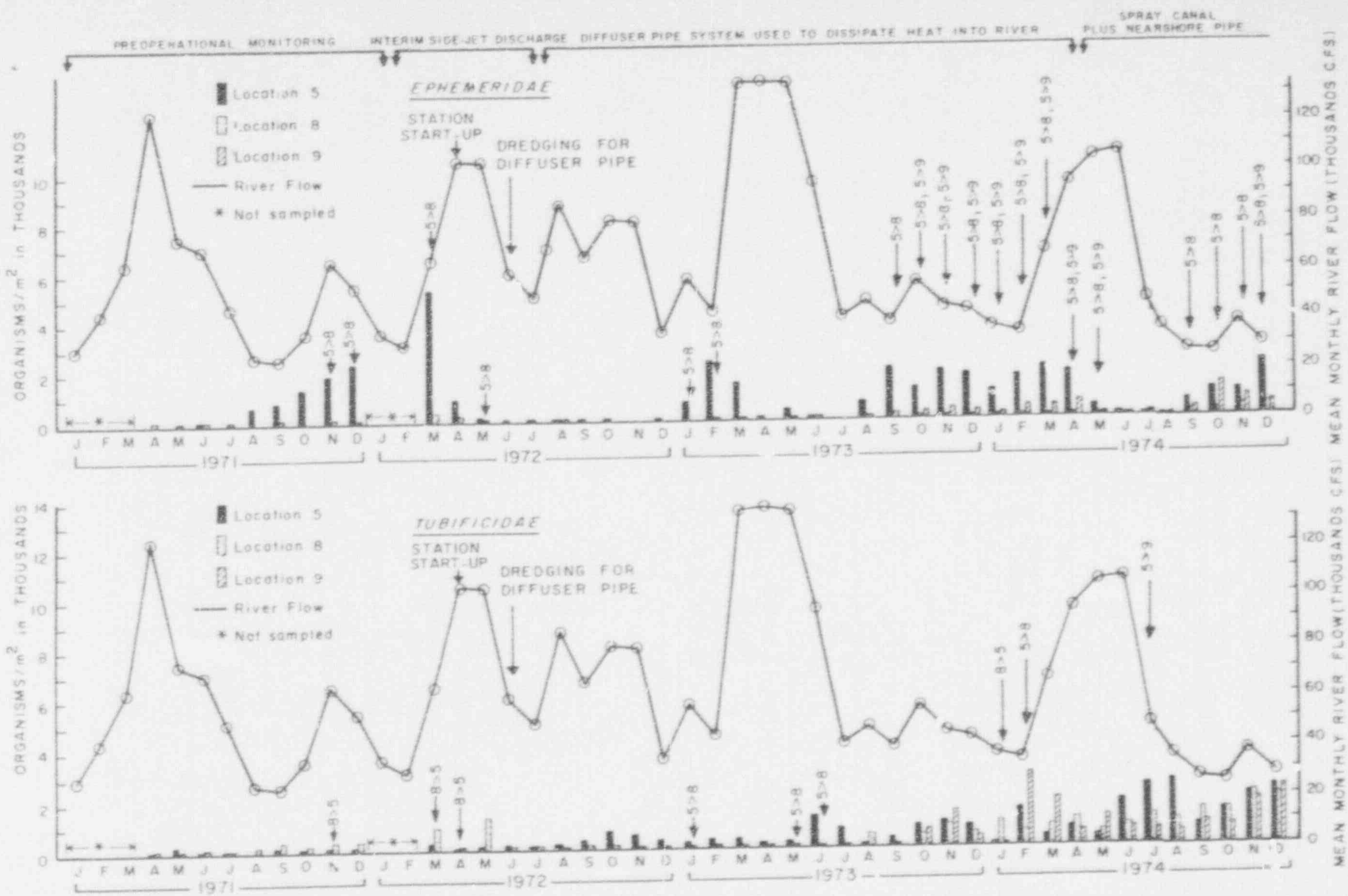
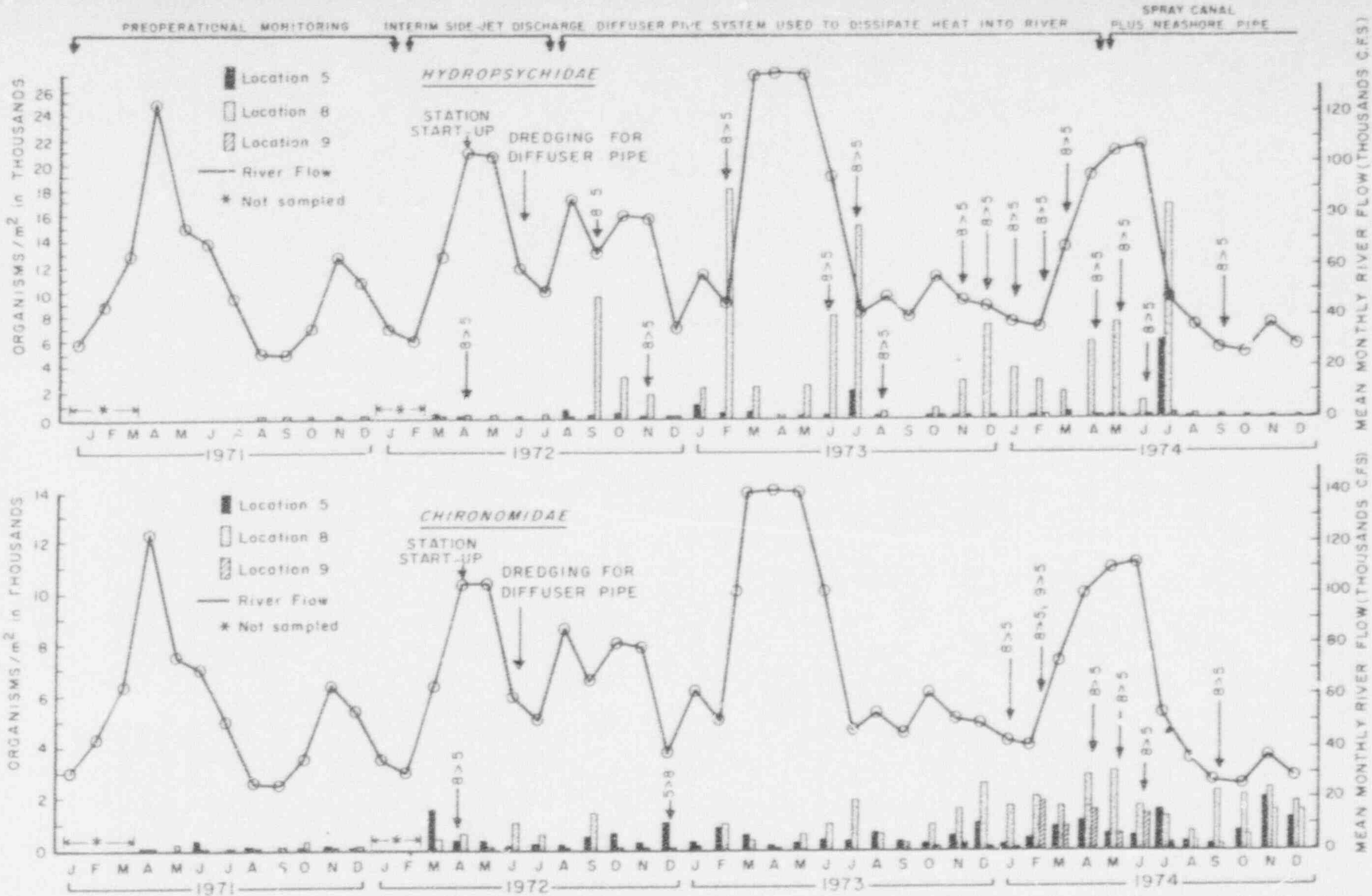


Figure 10.4. Density in numbers per square meter of Ephemeridae and Tubificidae collected near Quad-Cities Station during 1971, 1972, 1973 and 1974.



430

Figure 10.5. Density in numbers per square meter of Hydropsychidae and Chironomidae collected near Quad-Cities Station during 1971, 1972, 1973 and 1974.

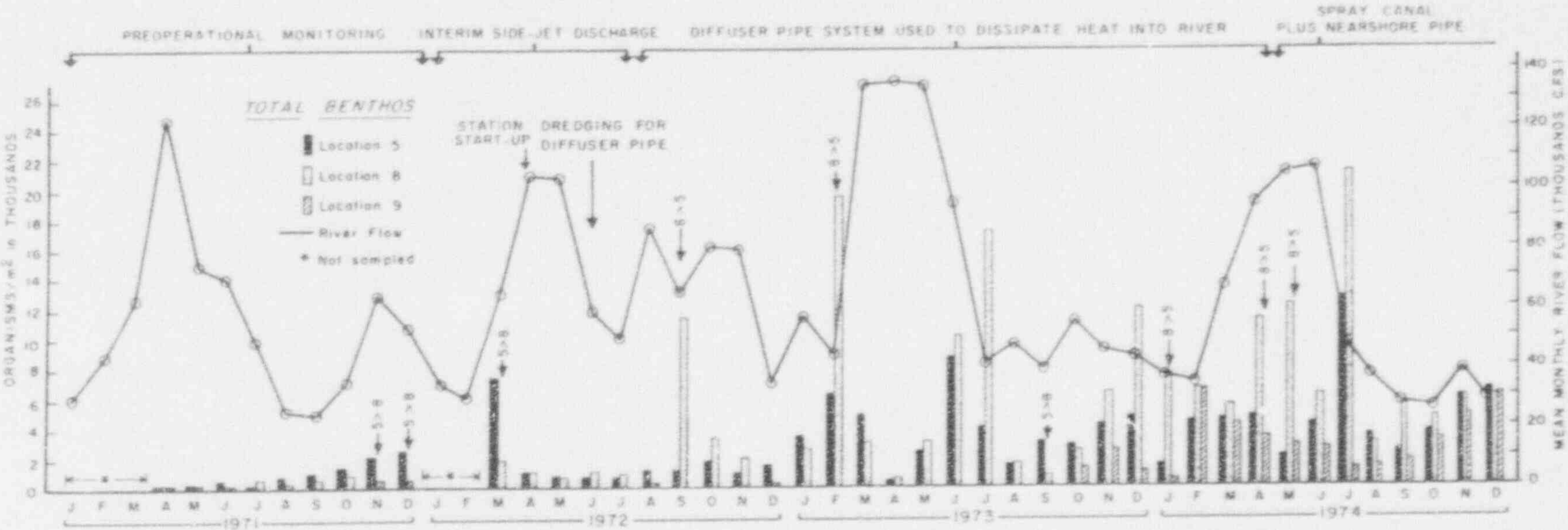


Figure 10.3. Density in numbers per square meter of total benthos collected near Quad-Cities Station during 1971, 1972, 1973 and 1974.

(316a errata continued)

PAGE	LINE	CHANGE
176	22	Eliminate the word - undoubtedly
177	3	Change fish shocking to - electrofishing
177	9	Change electrofishing to - electroshocking
177	18	Eliminate - additional, but very
177	Last	Change operator to - operated
178	4	Change electrofishing to - electroshocking
178	11	Eliminate - serious
178	13	Eliminate - very
178	16	Change predominate to - dominate
178	16-20	Eliminate the two sentences beginning with - Replicate, and ending with - suspect. (Replicate trawls can be made. Trammel netting was somehow confused with trawling in these two sentences.)
179	20	Change Island to - island
183	11	Change find to - fine
190	15	Change bluefill to - bluegill
190	16	Change was to - were
196	6-9	Eliminate last sentence of 1st paragraph (The young-of-the year were probably not spawned in the area of capture)
200	8,9	Change spot-tailed to - spottail
200	21	Change spot tailed to - spottail
201	1	Change spot tailed to - spottail
201	8	Change spot tailed to - spottail
210	Last	Eliminate - for

(316a errata continued)

PAGE	LINE	CHANGE
210	Last	Add - the between and - and fish, and - they between fish and caught
214	13	Change Meridosia to - Meredosia
214	16,17	Change consider-ably better to - higher
214	21	Change Table to Tables
215	Table 39	Change Maridosia to Meredosia (3 places)
216	Table 40	Table should be reduced to be accomodated on a single page
217	Table 41	Table should be reduced to be accomodated on a single page
221	5th Refer.	Change Plant to plant
261	18th Refer.	Change V Boon to U Boon

316a Supplement:

PAGE	LINE	CHANGE
5	25	Change Location to - Locations
9	14	Place a comma between biomass and chlorophyll
27	22	Change served to - were observed
27	26	Eliminate the word - however Eliminate the second comma

316b:

PAGE	LINE	CHANGE
3	3	Eliminate the word - species
4	23	Change August 31 to - May 29
4	25	Change (Table 11) to - (Table 3)
5	5	Change (Table 11) to - (Table 3)
5	11	Change (Table 9) to - (Table 1)
5	11	Change 128, 159 to - 122, 202
5	16	Change (Tables 12 and 13) to - (Tables 4 and 6)
6	Table 1	Corrected table follows -------
7	Table 1-continued	Corrected table follows -------
8	Table 1-continued	Corrected table follows -------
9	Table 1-continued	Corrected table follows -------
10	9	Change (Table 9 and 13) to - (Tables 1 and 5)
10	24	Change (Table 10) to - (Table 5)
11	14	Change Table 10 to - Table 2
11	14	Change 55,041 to - 55,048
12	Table 2	Corrected table follows -------
13	Table 2-continued	Corrected table follows -------
14	2	Change (Tables 10 and 13) to - (Tables 2 and 5)
14	6	Change (Tables 10 and 11) to - (Tables 2 and 5)
14	11	Change Tables 12, 13 and 14 to - Tables 4, 5, 6
14	11	Change 128,159 to - 122,202
14	12	Change 55,041 to - 55,048

Table 1. Numbers, total weight and percent occurrence of fishes removed from the traveling intake screens and deposited in the trash basket during 1973.

Species	Jan. large[a] (9)	Jan. small (0)	Feb. large (8)	Feb. small (0)	Mar. large (6)	Mar. small (0)	Apr. large (2)	Apr. small (4)	May large (4)	May small (5)	June large (5)	June small (2)	July large (6)	July small (2)
Silver lamprey	3	--[c]	1	--	1	--	0	3	0	1	2	1	0	0
American eel	0	--	0	--	0	--	0	0	0	0	0	0	0	0
Shovelnose sturgeon	0	--	0	--	0	--	0	0	0	0	0	0	3	0
Paddlefish	2	--	10	--	3	--	0	2	0	1	1	0	0	0
Longnose gar	3	--	4	--	6	--	4	3	3	1	2	1	7	6
Shortnose gar	3	--	8	--	11	--	4	0	0	1	1	0	5	2
Bowfin	0	--	0	--	0	--	1	2	0	3	0	63	8	2
Gizzard shad	1,017	--	265	--	82	--	22	700	8	27	180	1,933	1,186	2,053
Mooneye	33	--	121	--	178	--	15	176	77	114	70	6	18	26
Brown trout	0	--	0	--	0	--	0	0	0	0	1	0	0	0
Central mudminnow	0	--	0	--	2	--	0	1	0	2	1	1	1	1
Grass pickerel	0	--	1	--	0	--	0	3	0	1	1	0	3	0
Northern pike	1	--	1	--	1	--	2	0	0	2	8	23	20	9
Stoneroller	0	--	0	--	1	--	0	0	0	0	0	0	0	0
Carp	2	--	1	--	2	--	0	6	0	7	10	261	1,832	1,078
Silver chub	0	--	0	--	3	--	0	1	0	1	1	1	1	3
Golden shiner	0	--	0	--	0	--	0	2	[illegible]	0	1	2	3	2
Emerald shiner	0	--	0	--	0	--	0	0	0	4	1	10	4	7
River shiner	0	--	0	--	1	--	0	1	0	0	0	0	0	1
Spottail shiner	0	--	0	--	0	--	0	0	0	0	0	0	0	0
Sand shiner	0	--	0	--	0	--	0	0	0	1	0	0	0	0
Flathead minnow	0	--	0	--	0	--	0	0	0	0	0	0	0	0
River carpsucker	6	--	5	--	5	--	0	1	1	4	1	3	31	3
Quillback carpsucker	0	--	0	--	0	--	0	0	0	1	2	9	5	1
Highfin carpsucker	0	--	0	--	0	--	0	[illegible]	0	1	0	0	0	0
Blue sucker	0	--	0	--	0	--	0	0	0	0	0	1	0	0
Smallmouth buffalo	2	--	36	--	24	--	3	13	30	46	16	3	6	4
Bigmouth buffalo	1	--	3	--	1	--	1	2	1	1	78	323	0	3
Ictiobus sp. YOY	0	--	0	--	0	--	0	0	0	0	0	0	1,118	1,636

Table 1. continued.

Species	Jan. large[a] (9)	Jan. small (0)	Feb. large (8)	Feb. small (0)	Mar. large (6)	Mar. small (0)	Apr. large (2)	Apr. small (4)	May large (4)	May small (5)	June large (5)	June small (2)	July large (6)	July small (2)
Spotted sucker	0	--	0	--	0	--	0	0	1	1	0	0	0	0
Moxostoma sp.	0	--	1	--	0	--	0	2	0	14	28	146	1	1
Black bullhead	0	--	0	--	41	--	2	24	1	19	5	9	24	40
Yellow bullhead	0	--	0	--	0	--	0	0	0	1	0	0	0	0
Channel catfish	48	--	87	--	34	--	3	6	9	23	5	8	27	49
Stonecat	0	--	0	--	0	--	0	2	0	3	0	1	0	3
Tadpole madtom	0	--	0	--	1	--	0	5	0	2	1	0	0	0
Flathead catfish	0	--	0	--	1	--	1	1	0	1	0	0	2	1
Brook silverside	0	--	0	--	0	--	0	0	0	0	0	0	0	0
Yellow bass	0	--	0	--	0	--	0	7	2	15	1	0	1	0
White bass	15	--	12	--	22	--	8	66	13	44	10	2	0	1,479
Green sunfish	0	--	0	--	0	--	0	0	1	4	1	1	0	0
Pumpkinseed	0	--	0	--	0	--	0	0	0	2	1	0	0	0
Warmouth	0	--	0	--	0	--	0	0	1	4	1	0	0	0
Orangespotted sunfish	0	--	0	--	0	--	0	0	1	4	3	8	0	5
Bluegill	0	--	0	--	10	--	7	42	36	377	68	330	45	38
Largemouth bass	0	--	0	--	0	--	1	1	1	6	5	30	2	9
Smallmouth bass	0	--	0	--	0	--	0	0	0	0	0	1	0	0
White crappie	4	--	4	--	7	--	3	2	9	21	8	19	252	15
Black crappie	1	--	11	--	31	--	6	63	5	22	23	55	302	225
Pomoxis sp. YOY	0	--	0	--	0	--	0	0	0	0	0	0	0	915
Yellow perch	0	--	0	--	1	--	0	0	1	2	0	0	0	0
Logperch	0	--	0	--	2	--	0	1	0	1	1	0	1	0
River darter	0	--	0	--	0	--	0	2	0	2	0	0	1	0
Sauger	1	--	2	--	9	--	0	0	0	0	7	9	4	1
Walleye	0	--	0	--	2	--	0	0	0	0	1	1	1	0
Freshwater drum	212	--	400	--	424	--	192	2,081	166	237	97	23	204	673
Total No.	1,354	--	973	--	906	--	275	3,221	367	1,024	643	3,275	5,118	8,291
Avg. No./day	150	--	122	--	151	--	138	805	92	205	129	1,638	853	4,146
Total Wt.(kg)	--	--	44.8[d]	--	92.7	--	43.5	158.8	55.4	66.2	59.7	23.6	60.7	40.0
Avg. Wt./day(kg)	--	--	9.0[e]	--	15.5	--	21.8	79.4	13.9	13.2	11.9	11.8	10.1	20.0
Avg. Wt./fish(g)	--	--	122	--	102	--	158	49	151	64.7	93	7	12	10

Table 1. continued.

Species	Aug. large (7)	Aug. small (2)	Sept. large (5)	Sept. small (1)	Oct. large (5)	Oct. small (0)	Nov. large (1)	Nov. small (0)	Dec. large (6)	Dec. small (0)	Totals large (64)	Totals small (16)	Total (80)	Percent Occurrence
Silver lamprey	0	0	0	0	0	--	1	--	0	--	8	5	13	--f
American eel	0	0	1	0	0	--	0	--	0	--	1	0	1	--
Shovelnose sturgeon	0	0	0	0	0	--	0	--	0	--	3	0	3	--
Paddlefish	1	0	0	0	0	--	0	--	0	--	17	3	20	--
Longnose gar	4	3	0	4	33	--	2	--	0	--	68	19	87	0.1
Shortnose gar	4	3	3	0	51	--	0	--	0	--	90	6	96	0.1
Bowfin	1	1	0	0	0	--	0	--	0	--	10	71	81	0.1
Gizzard shad	2,077	4,684	9,611	14,509	8,845	--	1,136	--	43,501	--	67,930	23,906	91,836	75.2
Mooneye	28	59	28	50	28	--	5	--	6	--	607	431	1,038	0.8
Brown trout	0	0	0	0	0	--	0	--	0	--	1	0	1	--
Central mudminnow	0	0	0	0	0	--	0	--	0	--	4	5	9	--
Grass pickerel	0	0	0	0	0	--	0	--	0	--	5	4	9	--
Northern pike	1	1	0	0	2	00	0	--	2	--	38	35	73	0.1
Stoneroller	0	0	1	0	0	--	0	--	0	--	2	0	2	--
Carp	112	1,081	6	12	254	--	10	--	4	--	2,233	2,445	4,678	3.8
Silver chub	3	5	5	9	7	--	2	--	0	--	22	20	42	--
Golden shiner	0	2	0	2	2	--	0	--	0	--	6	10	16	--
Emerald shiner	3	4	2	5	14	--	1	--	0	--	25	30	55	--
River shiner	1	1	3	1	1	--	0	--	0	--	6	4	10	--
Spottail shiner	0	0	0	0	1	--	0	--	0	--	1	0	1	--
Sand shiner	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Flathead minnow	0	0	0	0	0	--	1	--	0	--	1	0	1	--
River carpsucker	2	11	1	6	25	--	1	--	7	--	85	28	113	0.1
Quillback carpsucker	0	0	0	0	0	--	0	--	0	--	7	2	9	--
Highfin carpsucker	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Blue sucker	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Smallmouth buffalo	11	105	20	45	49	--	3	--	9	--	209	216	425	0.3
Bigmouth buffalo	19	23	7	5	15	--	0	--	1	--	127	357	484	0.4
Ictiobus sp. YOY	0	0	0	0	0	--	0	--	0	--	1,118	1,636	2,754	2.3

Table 1. continued.

	Aug. large (7)	Aug. small (2)	Sept. large (5)	Sept. small (1)	Oct. large (5)	Oct. small (0)	Nov. large (1)	Nov. small (0)	Dec. large (6)	Dec. small (0)	Totals large (64)	Totals small (16)	Total (80)	Percent Occurrence
Spotted sucker	0	0	0	0	0	--	0	--	0	--	1	1	2	--
Moxostema sp.	3	0	0	0	4	--	0	--	0	--	37	163	200	0.2
Black bullhead	39	58	11	8	30	--	4	--	9	--	166	158	324	0.3
Yellow bullhead	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Channel catfish	231	187	179	149	57	--	1	--	10	--	691	422	1,113	0.9
Stonecat	1	3	1	1	1	--	0	--	0	--	3	13	16	--
Tadpole madtom	0	0	0	0	2	--	0	--	0	--	4	7	11	--
Flathead catfish	1	0	0	0	2	--	0	--	0	--	7	3	10	--
Brook silverside	0	0	0	0	0	--	0	--	0	--	0	0	0	--
Yellow bass	1	1	1	0	0	--	0	--	1	--	7	23	30	--
White bass	140	1,089	30	88	163	--	14	--	16	--	443	2,768	3,211	2.6
Green sunfish	0	0	0	0	0	--	0	--	0	--	2	5	7	--
Pumpkinseed	1	0	0	0	0	--	0	--	0	--	2	2	4	--
Warmouth	0	0	0	0	0	--	0	--	0	--	2	4	6	--
Orangespotted sunfish	0	1	0	1	2	--	2	--	0	--	8	19	27	--
Bluegill	9	24	8	14	91	--	1	--	0	--	275	825	1,100	0.9
Largemouth bass	2	3	3	0	5	--	8	--	5	--	32	49	81	0.1
Smallmouth bass	0	0	0	0	0	--	0	--	10	--	10	1	11	--
White crappie	20	19	8	19	51	--	7	--	22	--	395	95	490	0.4
Black crappie	32	30	30	26	116	--	3	--	0	--	560	421	981	0.8
Pomoxis sp. YOY	0	2,519	0	0	0	--	0	--	0	--	0	3,434	3,434	2.8
Yellow perch	0	0	0	0	0	--	0	--	0	--	2	2	4	--
Logperch	0	0	0	0	2	--	0	--	0	--	6	2	8	--
River darter	0	0	0	0	0	--	0	--	0	--	1	4	5	--
Sauger	0	0	1	0	5	--	1	--	2	--	32	10	42	--
Walleye	1	0	0	0	0	--	0	--	0	--	5	1	6	--
Freshwater drum	305	1,793	89	139	1,916	--	63	--	204	--	4,272	4,946	9,278	7.5
Total No.	3,053	11,710	10,049	15,094	11,774	--	1,266	--	43,809	--				
Avg. No./day	436	5,855	2,010	15,094	2,355	--	1,266	--	7,302	--				
Total Wt.(kg)	53.9	45.2	88.0	75.0	149.4	--	32.0	--	945.0	--				
Avg. Wt./day(kg)	7.7	22.6	17.6	75.0	29.9	--	32.0	--	157.5	--				
Avg. Wt./fish(g)	18	4	9	5	13	--	25	--	22	--				

[a] Large mesh basket
[b] Small mesh basket
[c] Not sampled
[d] Weight not recorded before Feb. 14
[e] 5 days of sampling - 366 fish
[f] Less than 0.1%

Table 2. Numbers, total weight and percent occurrence of fishes removed from the traveling intake screens and deposited in the trash basket during 1974.

	Jan. (5)	Feb. (7)	Mar. (5)	Apr. (6)	May (8)	June (8)	July (7)	Aug. (8)	Sep. (8)	Oct. (10)	Nov. (7)	Dec. (6)	Total	Percent Occurrence
Silver lamprey	0	1	1	0	0	0	0	0	0	0	0	0	2	--
Shovelnose sturgeon	0	0	0	0	1	0	0	0	0	0	0	0	1	--
Paddlefish	0	4	1	5	0	0	0	0	0	0	0	0	10	--
Longnose gar	2	3	12	31	15	4	13	3	0	11	6	1	101	0.2
Shortnose gar	5	5	6	13	4	3	6	5	1	5	1	1	55	0.1
Bowfin	0	0	0	0	3	0	6	1	0	0	0	0	10	--
Gizzard shad	9,095	4,527	644	296	203	43	80	221	289	3,590	13,820	2,372	35,180	63.9
Mooneye	14	63	94	105	32	31	14	11	6	22	3	6	401	0.7
Goldeye	1	1	0	0	0	1	0	0	0	0	0	1	4	--
Central mudminnow	0	2	0	1	0	0	0	0	0	0	0	0	3	--
Grass pickerel	0	0	7	0	0	2	1	0	0	0	0	0	10	--
Northern pike	0	0	0	2	9	7	17	0	2	0	0	0	37	
Creek chub	0	0	2	1	0	0	0	0	0	0	0	0	3	--
Stoneroller	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Carp	2	8	24	106	62	26	26	28	7	4	2	2	297	0.5
Silver chub	0	7	5	13	4	2	2	5	13	1	0	0	52	0.1
Golden shiner	0	0	1	4	3	0	1	0	0	0	0	0	9	--
Emerald shiner	2	2	2	1	9	0	7	2	8	4	5	0	42	--
River shiner	1	2	4	1	1	1	2	0	0	4	3	0	19	--
Spotfin shiner	0	0	1	0	0	0	0	0	0	0	0	0	1	--
Sand shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Bluntnose minnow	0	0	1	0	0	0	0	0	0	0	0	0	1	--
Fathead minnow	0	1	0	0	0	0	0	0	0	0	0	0	1	--
River carpsucker	3	22	16	17	12	1	6	12	1	2	1	1	94	0.2
Quillback carpsucker	1	0	1	0	1	1	1	0	0	0	0	0	5	--
White sucker	0	1	0	0	0	0	0	0	0	0	0	0	1	--
Blue sucker	0	0	0	0	0	0	0	0	0	0	1	0	1	--
Smallmouth buffalo	6	17	18	12	11	5	3	1	2	[illegible]	6	5	89	0.2
Bigmouth buffalo	0	8	6	4	6	0	4	0	0	0	0	1	29	--

Table 2. continued.

	Jan. (5)	Feb. (7)	Mar. (5)	Apr. (6)	May (8)	June (8)	July (7)	Aug. (8)	Sep. (8)	Oct. (10)	Nov. (7)	Dec. (6)	Total	Percent Occurrence
Spotted sucker	0	0	0	1	0	0	0	0	0	0	0	0	1	--
Moxostoma sp.	0	1	3	4	17	6	32	1	0	1	0	0	65	0.1
Black bullhead	5	14	26	233	66	9	11	14	1	0	3	0	382	0.7
Yellow bullhead	0	1	0	0	0	0	1	0	0	0	0	0	2	--
Channel catfish	79	101	80	46	39	8	146	206	192	18	16	15	946	1.7
Stonecat	0	0	0	4	0	0	9	0	4	0	0	1	18	--
Tadpole madtom	0	0	1	1	0	1	3	0	0	0	0	0	6	--
Flathead catfish	0	2	1	1	1	1	2	4	1	0	1	0	14	--
Yellow bass	0	3	1	19	3	1	0	0	0	1	1	0	29	--
White bass	25	47	51	165	55	17	119	155	23	80	51	25	813	1.5
Green sunfish	0	0	0	2	6	0	2	3	1	0	0	0	14	--
Pumpkinseed	0	0	0	4	3	0	1	0	0	0	0	0	8	--
Orangespotted sunfish	0	0	1	2	2	0	1	0	0	1	2	0	9	--
Bluegill	1	3	14	40	170	51	82	11	12	25	7	0	416	0.8
Largemouth bass	0	0	4	7	43	19	30	1	2	1	5	1	113	0.2
Smallmouth bass	0	0	0	0	0	0	1	10	0	0	1	0	12	--
White crappie	0	10	12	28	10	8	40	16	7	1	6	9	147	6.3
Black crappie	11	10	17	33	14	11	54	0	6	11	10	9	186	0.3
Yellow perch	0	0	2	2	0	0	1	0	0	0	0	0	5	--
Logperch	0	0	0	1	1	0	0	1	0	1	0	0	4	--
River darter	0	0	0	1	0	0	0	1	0	0	0	0	2	--
Sauger	0	0	1	6	10	4	7	0	0	1	1	0	30	--
Walleye	0	0	2	1	4	2	5	2	0	0	0	0	16	--
Freshwater drum	171	934	2,170	4,310	1,902	164	872	1,393	505	1,409	1,286	176	15,352	27.9
Total No.	9,424	5,860	3,232	5,523	2,722	429	1,608	2,107	1,083	5,196	15,238	2,626		
Avg. no./day	1,885	837	646	921	340	54	230	263	135	520	2,177	438		
Total wt.(kg)	502.0	348.6	188.6	211.6	118.1	38.0	59.5	39.5	28.8	84.1	253.8	118.1		
Avg. wt/day(kg)	100.6	49.8	37.7	35.3	14.8	4.8	8.5	4.9	3.6	8.4	36.3	19.7		
Avg. wt/fish(g)	53.4	59.5	58.4	38.3	43.4	88.7	37.0	18.7	26.6	16.2	16.7	45.0		

(316b errata continued)

PAGE	LINE	CHANGE
14	14	Change 4,752 to - 4,384
14	16	Change (Table 12) to - Table 4
15	Table 3	Corrected table follows ------
16	Table 3-continued	Corrected (reduced only) table follows ----
17	Table 3-continued	Corrected table follows ------
18	Table 4	Corrected table follows ------
19	Table 5	Corrected table follows ------
20	Table 5-continued	Corrected table follows ------
21	Table 6	Corrected table follows ------
22	2	Change (Table 14) to - (Table 6)
22	8	Change (Table 13) to - (Table 5)
23	5	Change Table 15 to - Table 7
23	11,12	Change (Table 16) to - (Tables 7 and 8)
23	13	Change Table 16 to - Table 8
26	7	Change Table 17 to - Table 9
26	9	Change Table 15 to - Table 7
26	13	Change Table 14 to - Tables 7 and 8
26	16	Change Table 16 to - Table 8
28	17	Change Table 17 to - Table 9
28	Last	Change Table 17 to - Table 9
30	2	Change Pun. to - Press

Table 3. Physical variables occurring during trash basket collection dates at Quad-Cities Station during 1974.

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers on Spray Canal on	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	Bubble Screen & spray canal not operating
March 1974								
No.sampling days	3	2	--	--	--	--	--	--
Total No. fish	1,844	1,388	--	--	--	--	--	--
Avg. no./day	615	694	--	--	--	--	--	--
Total wt. (g)	94,357	94,286	--	--	--	--	--	--
Avg.wt.(g)/day	31,452	47,143	--	--	--	--	--	--
Avg.wt./fish	51.2	67.9	--	--	--	--		
April 1974								
No.sampling days	4	2	--	--	--	--	--	--
Total No. fish	2,876	2,647	--	--	--	--	--	--
Avg. no./day	719	1,324	--	--	--	--	--	--
Total wt. (g)	122,500	89,143	--	--	--	--	--	--
Avg.wt.(g)/day	30,625	44,572	--	--	--	--	--	--
Avg.wt./fish	42.6	33.7	--	--	--	--		
May 1974								
No.sampling days	--	--	2	6	--	--	--	--
Total No. fish	--	--	156	2,566	--	--	--	--
Avg. no./day	--	--	78	428	--	--	--	--
Total wt. (g)	--	--	11,843	106,223	--	--	--	--
Avg.wt.(g)/day	--	--	5,922	17,704	--	--	--	--
Avg.wt./fish	--	--	75.9	41.4	--	--		

Table 3. continued.

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers off Spray Canal off	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	Bubble Screen & spray canal not operatin
June 1974								
No. sampling days	--	--	--	--	6	2	--	--
Total No. fish	--	--	--	--	403	29	--	--
Avg. no./day	--	--	--	--	67	15	--	--
Total wt. (g)	--	--	--	--	35,159	2,885	--	--
Avg.wt.(g)/day	--	--	--	--	5,860	1,443	--	--
Avg.wt./fish	--	--	--	--	87.2	99.5	--	--
July 1974								
No. sampling days	--	--	--	--	5	2	--	--
Total No. fish	--	--	--	--	1,578	30	--	--
Avg. no./day	--	--	--	--	316	15	--	--
Total wt. (g)	--	--	--	--	54,895	4,615	--	--
Avg.wt.(g)/day	--	--	--	--	10,979	2,308	--	--
Avg.wt./fish	--	--	--	--	34.9	153.8	--	--
August 1974								
No. sampling days	--	--	--	--	6	--	2	--
Total No. fish	--	--	--	--	1,728	--	379	--
Avg. no./day	--	--	--	--	288	--	190	--
Total wt. (g)	--	--	--	--	27,976	--	11,493	--
Avg.wt.(g)/day	--	--	--	--	4,663	--	5,747	--
Avg.wt./fish	--	--	--	--	16.2	--	30.3	--
September 1974								
No. sampling days	--	--	--	--	4	--	3	1
Total No. fish	--	--	--	--	112	--	714	257
Avg. no./day	--	--	--	--	28	--	238	257
Total wt. (g)	--	--	--	--	10,695	--	14,725	3,380
Avg.wt.(g)/day	--	--	--	--	2,674	--	4,908	3,380
Avg.wt./fish	--	--	--	--	95.5	--	20.6	13.2

Table 3. continued.

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers off Spray Canal off	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	Bubble Screen & spray canal not operating
October 1974								
No.sampling days	--	--	--	--	7	3	--	--
Total No. fish	--	--	--	--	345	4,851	--	--
Avg. no./day	--	--	--	--	49.3	1,617	--	--
Total wt. (g)	--	--	--	--	19,345	64,774	--	--
Avg.wt.(g)/day	--	--	--	--	2,764	21,591	--	--
Avg.wt./fish	--	--	--	--	56.1	13.4	--	--
November 1974								
No.sampling days	--	--	--	--	4	2	1	--
Total No. fish	--	--	--	--	1,705	13,365	168	--
Avg. no./day	--	--	--	--	426	6,683	168	--
Total wt. (g)	--	--	--	--	49,448	198,198	6,165	--
Avg.wt.(g)/day	--	--	--	--	12,362	99,099	6,165	--
Avg.wt./fish	--	--	--	--	29.0	7.4	36.7	--
December 1974								
No.sampling days	--	--	--	--	4	2	--	--
Total No. fish	--	--	--	--	1,524	1,102	--	--
Avg. no./day	--	--	--	--	381	551	--	--
Total wt. (g)	--	--	--	--	86,235	31,81[illegible]	--	--
Avg. wt.(g)/day	--	--	--	--	21,559	15,908	--	--
Avg.wt./fish	--	--	--	--	56.6	28.9	--	--

Table 4. Comparison of numbers and weights of fishes collected by large and small mesh tra .. baskets during 1973 and 1974.

Year	Mesh	No. days	Total No. Jan-Dec	Avg.no. day Jan-Dec	Total wt.(lbs) Jan-Dec	Avg.wt. day Jan-Dec	No. days	Total No. Mar-Dec	Avg.no. day Mar-Dec	Total wt.(lbs) Mar-Dec	Avg.wt. day Mar-Dec	No. days	Total No. Apr-Sep	Avg.no. day Apr-Sep	Total wt.(lbs) Apr-Sep	Avg.wt. day Apr-Sep
1973	large	64	79,587	1,244	--	--	47	77,260	1,644	3,483.9	74.1	29	19,505	6,726	796.3	27.2
	small	16	42,615	2,663	--	--	16	42,615	2,663	900.4	56.3	16	42,615	2,663.4	900.4	56.3
	Total	80	122,202	1,528	--	--	63	119,875	1,903	4,384.3	69.6	45	62,120	1,380.4	1,696.7	37.7
1974	large	85	55,048	648	4,383	51.6	73	39,764	545	2,507.6	34.4	45	13,472	299.4	1,091.4	24.3

Table 5. Number, weight and percent occurrence of the most common fish collected in trash baskets.

Species	1973 Month	Number	(g) Weight	Percent Occurrence	1974 Month	Number	(g) Weight	Percent Occurrence
Gizzard shad	Jan.	1,017	--	78	Jan.	9,095	479,825	97
	Feb.	265	--	27	Feb.	4,527	278,040	77
	Mar.	82	7,180	9	Mar.	644	50,580	20
	Apr.	722	19,395	21	Apr.	296	7,205	5
	May	35	1,535	3	May	203	7,215	8
	June	2,113	6,715	54	June	43	2,325	10
	July	3,239	6,650	24	July	80	5,280	5
	Aug.	6,761	22,180	44	Aug.	221	1,795	11
	Sep.	24,120	115,270	96	Sep.	289	3,500	27
	Oct.	8,845	70,905	75	Oct.	3,590	54,770	69
	Nov.	1,136	25,390	93	Nov.	13,820	228,655	91
	Dec.	43,501	908,525	99	Dec.	2,372	102,595	90
Total		91,836				35,180	1,221,785	
Mar.-Dec. Total		90,554	1,183,745			21,558	463,920	
Freshwater drum	Jan.	212	--	14	Jan.	171	9,985	2
	Feb.	400	--	41	Feb.	994	42,205	17
	Mar.	424	50,060	47	Mar.	2,170	105,530	67
	Apr.	2,273	138,550	65	Apr.	4,310	153,300	78
	May	403	40,521	29	May	1,902	53,290	70
	June	120	14,175	3	June	164	6,245	38
	July	877	5,760	7	July	872	7,050	54
	Aug.	2,098	9,445	14	Aug.	1,393	11,730	66
	Sep.	228	7,365	1	Sep.	505	7,245	47
	Oct.	1,916	33,207	16	Oct.	1,409	16,795	27
	Nov.	63	1,810	5	Nov.	1,286	17,370	8
	Dec.	204	14,210	--	Dec.	176	5,835	7
Total		9,218				15,352	436,580	
Mar.-Dec. Total		8,606	315,103			14,187	384,390	
Channel catfish	Jan.	48	--	2	Jan.	79	2,628	1
	Feb.	87	--	9	Feb.	101	1,615	2
	Mar.	34	1,885	4	Mar.	80	3,475	2
	Apr.	9	2,363	-	Apr.	46	1,000	1
	May	32	2,432	2	May	39	958	1
	June	13	940	--	June	8	143	2
	July	76	4,614	--	July	146	7,570	5
	Aug.	418	33,954	3	Aug.	206	9,445	10
	Sep.	328	20,205	1	Sep.	192	8,260	18
	Oct.	57	4,905	--	Oct.	18	907	0.3
	Nov.	1	6	--	Nov.	16	585	0.1
	Dec.	10	823	--	Dec.	15	1,025	0.6
Total		1,113				946	37,611	
Mar.-Dec. Total		978	72,127			766	33,368	

Table 5. continued.

Species	1973 Month	Number	(g) Weight	Percent Occurrence	1974 Month	Number	(g) Weight	Percent Occurrence
White bass	Jan.	15	--	1	Jan.	25	396	--
	Feb.	12	--	1	Feb.	47	3,140	1
	Mar.	22	1,893	2	Mar.	51	1,310	2
	Apr.	74	4,363	2	Apr.	165	3,525	3
	May	57	2,505	4	May	55	1,217	2
	June	10	2,605	--	June	17	500	4
	July	1,479	4,255	13	July	119	2,980	7
	Aug.	1,229	5,820	8	Aug.	155	1,295	7
	Sep.	118	2,060	--	Sep.	23	1,995	2
	Oct.	163	1,952	1	Oct.	80	2,020	2
	Nov.	14	180	1	Nov.	51	1,245	0.3
	Dec.	16	220	--	Dec.	25	725	1
Total		3,211				813	20,348	
Mar.-Dec. Total		3,184	25,853			741	16,812	
Additional fishes	Jan.	62	--	5	Jan.	54	10,146	<1
	Feb.	209	--	22	Feb.	191	23,620	3
	Mar.	344	47,293	38	Mar.	787	27,761	9
	Apr.	418	37,634	12	Apr.	706	44,813	13
	May	865	74,610	62	May	523	55,412	10
	June	1,662	58,794	42	June	197	28,831	46
	July	7,738	79,421	56	July	391	36,635	25
	Aug.	4,257	27,756	31	Aug.	132	15,204	6
	Sep.	349	18,044	2	Sep.	74	7,800	7
	Oct.	793	38,461	7	Oct.	99	9,630	2
	Nov.	52	2,763	4	Nov.	65	5,956	0.2
	Dec.	78	21,252	<1	Dec.	38	8,110	1.5
Total		16,827				2,757	273,918	
Mar.-Dec. Total		16,556	406,028			2,512	240,152	

Table 6

COMPARISON OF NUMBERS OF THE MOST COMMON SPECIES COLLECTED IN TRASH BASKETS DURING 1973-1974

Species	Year	Large Mesh	Small Mesh	Total	Difference[a]
Gizzard Shad	1973	67,930	23,906	91,836	56,656
	1974	35,180	--	35,180	
Crappies	1973	955	3,950	4,905	+ 4,572
	1974	333	--	333	
Carp	1973	2,233	2,445	4,678	+ 4,381
	1974	297	--	297	
Buffaloes	1973	1,454	2,209	3,663	+ 3,545
	1974	118	--	118	
White Bass	1973	443	2,768	3,211	+ 2,398
	1974	813	--	813	
Mooneye	1973	607	431	1,038	+ 637
	1974	401	--	401	
Bluegill	1973	275	825	1,1[illegible]	+ 684
	1974	416	--	416	
Freshwater Drum	1973	4,272	4,946	9,218	- 6,134
	1974	15,352	--	15,352	

[a] Difference between numbers in 1973 and 1974

Cover Letter for 316a

February 28, 1975

(5 pages)

Commonwealth Edison
72 West Adams Street, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

February 28, 1975

Mr. A. H. Manzardo
Chief, Permit Branch
Region V
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604

Subject: Evidence to Support a 316(a) Demonstration for Quad Cities Station

Dear Mr. Manzardo:

Enclosed is a report by Commonwealth Edison Company in support of its application for an alternate effluent limitation under 316(a) of the Federal Water Pollution Control Act. Commonwealth Edison Company believes that sufficient data are presented in the report demonstrating that open cycle operation of the Quad Cities Station does not harm aquatic communities in the Mississippi River in the vicinity of the Station.

The alternate effluent limitation requested on the basis of this material is a discharge from the large diffuser (discharge 001) of not more than 5.86×10^9 B.T.U./hr. to the Mississippi River. This effluent limitation would allow a discharge equal to that of one of Quad Cities' two units. Discharge from the second unit would be limited to blowdown from operation of the spray canal.

According to your suggestion that we supplement this report with a report of impingement effects, we are currently completing a 316(b) demonstration and expect to have it in your hands within two weeks as an addendum to this report.

We also request a modification of the permit to delay the effective date of Special Condition #b (7) of the permit (limiting the thermal discharge to 2.0×10^9 BTU/hr.) from May 1, 1975 to November 1, 1975. Your letter to us of January 24, 1975 indicates that you have a significant backlog of 316(a) applications which may delay consideration of the Quad Cities application. As you know, the NPDES permit requires that both units be in closed cycle operation on May 1, 1975. As indicated in our letter of November 4, 1974 to William J. Scott, Attorney General of Illinois, the Quad Cities spray canal does not presently have sufficient capacity to handle the discharge of both units.

On the basis of tests performed on the spray canal in December 1974, we believe that two unit closed cycle operation of the spray canal during the summer of 1975 will result in a loss of

400 megawatts of capacity during a significant portion of the summer, and a loss of 700 megawatts of capacity during the most humid portions of the summer. The total loss of capacity is estimated at 600 million kilowatt hours. Replacement of that capacity by oil and coal fired capacity will require the burning of 35 million gallons of oil and 169,000 tons of coal. The total increase in cost to Commonwealth Edison and its co-owner, Iowa-Illinois Gas & Electric Company, resulting from this loss of capacity over the summer is estimated at $16.2 million. These very substantial problems -- requiring the waste of scarce resources and of money -- can be avoided by allowing a plant delay in the effective date of the two unit closed cycle requirement. The Station would continue to operate at least one unit on the spray canal during this period.

The date of May 1, 1975 was incorporated in the permit simply because it was already required by Edison's agreement with the Attorney General. Both the Company and Region V expected that the spray canal would be completed by that date. We regard the present inability of the spray canal to handle both units as a condition (beyond the reasonable control of Edison) which has caused a delay in the completion date of the spray canal, within the meaning of paragraph 6 of the Agreement with the Attorney General.

The regulations issued under §§301 and 304 of the FWPCA allow until July 1, 1981 for the completion of closed cycle cooling facilities. The Quad Cities permit requires a date 6 years earlier. We do not propose a 6 year delay in the effective date; we believe, however, that a short delay in the effective date of the two unit closed cycle requirement is readily justifiable in view of the much later date specified in the regulations. We do not disagree with the general policy of setting compliance dates in terms of the expected construction time of a facility. Such a policy must, however, have some flexibility when construction delays occur or when, as is the case at Quad Cities, initial testing of the facility indicates that it does not operate as designed. The Quad Cities spray canal is a state of the art facility and allowance of an additional period for testing and for curing its deficiencies is not unreasonable.

While we do not know whether or not the spray canal can be operated at full capacity by November 1, 1975, the extension until that date will allow Edison to complete and to analyze the results of additional tests of the canal which will be performed this summer. Those tests should indicate, far more precisely than can now be done, the nature of the difficulty with the spray canal, and the availability and extent of a cure. In addition, the delay will allow adequate time to determine the pending application under §316(a).

<u>The 316(a) Report</u>

The data presented in the enclosed report are the results of the studies conducted in the Mississippi River since 1968. Intensive pre-operational studies were first undertaken in July 1970 and continued until the station became operational in January 1972. During the entire operational period, intensive studies of all important aquatic ecosystems have been conducted in the River both

upstream and downstream of the station. The reports of these studies to date are summarized in Table 22, page 140 of the attached demonstration.

Operational History

The Quad Cities Station operated with an open cycle condenser cooling system from April 1972 until May 1974, with the exception of a short period of time (April to July 1972) when an interim side jet discharge was utilized. Since July, 1972, heated condenser water has been discharged into the River through a multiport diffuser system consisting of two 16 foot diameter manifolds buried in the river bed. During the period of side jet operation, plume temperatures as measured at the edge of the 600 foot mixing zone were as much as 12.5°F greater than ambient river temperatures and temperatures in the Illinois island area immediately downstream from the side jet discharge were as much as 15.1°F higher than ambient. A maximum temperature of 91°F was observed in this area during the period of side jet operation. Operational history is summarized in Figure 8 (p. 68) of the demonstration.

Effects of Side Jet Discharge

Intensive studies of the Illinois island area during the period of side jet discharge indicated a transient reduction in periphyton productivity, but this effect appeared to be due more to chlorination of the condensers for slime control than to increased temperatures. The side jet discharge did not appear to have any practical effect on macroinvertebrate populations that developed on artificial substrates in the River below the station. Seasonal and hydrological influences were definitely greater than any thermal effects attributable to station operation. Neither zooplankton nor phytoplankton populations in the river appeared to be noticeably affected by the side jet discharge.

Benthic organisms under the influence of the side-jet plume appeared to be affected to a greater extent by the prior dredging operation for the installation of the diffuser pipe system than by operation of the side jet discharge itself. During the period of side jet operation, the populations of many of the important species of fish in the Illinois island area were similar in number to those documented in earlier studies. However, crappie were much less abundant than in 1971; and during late July when increases in water temperatures due to station operation were greatest, the numbers of juvenile and adult bluegill decreased in the island area and no largemouth bass were collected in the island area although both species had been common previously. Similar decreases in numbers of these fish were not observed at other sampling locations and, with the exception of the Illinois island area, side jet operation appeared to have no influence on the fishery of the River.

Diffuser Pipe System

Biological Monitoring

Following start up of the diffuser pipe system in August 1972, virtually complete mixing of the heated effluent of the plant with the river water was achieved and the changes in the periphytic, benthic and fishery communities observed during the period of side jet operation quickly disappeared. Those species of fish which had been displaced from the Illinois island area in June and July of 1972 were quickly reestablished in the area.

Since that time, none of the intensive biological studies which have been conducted during the period of diffuser pipe operation have shown evidence of any negative effect from the thermal discharges from the Quad Cities Station on any of the aquatic communities in the Mississippi River in the vicinity of the station. This is not surprising when the relatively insignificant temperature change within the river due to station discharge is considered.

Comparisons of total phytoplankton, major algal divisions, and dominant species at locations upstream and downstream from the side-jet discharge area or of the diffuser pipe heat dissipation systems indicated that neither mode of waste heat discharge had any detectable effect upon phytoplankton numbers or community composition. Phytoplankton monitoring above and below the Station is summarized in pages 143-145 of the demonstration.

Comparisons of total zooplankton and the three major taxonomic groups of zooplankters prior to and during all phases of Station operation at locations upstream and downstream from the station did not reveal any differences attributable to operation of the facility (see page 145).

Periphyton populations and chlorophyll production upstream and downstream of the Station were generally equivalent throughout the period of the study (pages 154-157).

Analysis of the data collected to date has indicated no discernable effects on the benthic communities relative to the thermal discharges from the Quad Cities Station (pages 157-166).

No consistent effects on the drifting macroinvertebrate populations were attributable to operation of the diffuser-pipe mode of heat dissipation (pages 167-169).

Likewise, intensive studies of the pool 14 fisheries both above and below the Station during diffuser system operation have not demonstrated any negative effects of Station operation (pages 169-259).

Temperature Monitoring

Since the start up of the diffuser pipe system, numerous temperature surveys have been conducted in the River, 500' downstream

from the diffuser pipes. At no time have downstream river temperatures exceeded 85°F and maximum local temperature increases have never exceeded 3.8°F, well below the allowable 5° maximum. In addition, the diffuser pipe discharge differs from conventional plumes in that heated effluent is diffused as jets from a series of ports spaced along the length of the buried diffuser pipes. This results in rapid mixing with the river water, and thus only a very small portion of the river is subjected to temperature increases of 5°F or more above ambient. The zone of passage between diffuser ports has been in excess of 86% throughout the entire course of the study. When the entire width of the River is considered, the zone of passage is considerably greater than the minimum 86% when both diffuser pipes are operating due to the absence of diffuser ports in the shallow water areas on each side of the river. Our tagging and recapture studies have clearly demonstrated that fishes have no apparent difficulty in movement either upstream or downstream across the diffuser system. (See pages 201-204.) Refer to pages 87 to 114 for details of diffuser system engineering, operation and zone-of-passage monitoring studies.

In view of the above findings obtained during two unit operation, which are documented in detail in the attached demonstration, it is obvious that continued open cycle operation of only one unit certainly will have no adverse impact on the river and will be both ecologically and economically desirable due to the substantial conservation of energy possible with continued open cycle cooling.

If additional information or discussion is desired regarding this submittal for Quad Cities, please call me at (312) 294-8074 or Harry Bernhard at (312) 294-2939.

Very truly yours,

John H. Hughes

John H. Hughes
Director of Water Quality

Attachment

cc: Dr. Richard A. Briceland, Director
Illinois Environmental Protection Agency

316a Demonstration

January, 1975

(264 pages)

AN EVALUATION OF THE

QUAD-CITIES STATION

OF COMMONWEALTH EDISON CO.

FOR A 316 (a) DEMONSTRATION

Prepared by:

Commonwealth Edison Co.
Chicago, Illinois

January 1975

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

1. Introduction

This report presents a review of the physical, chemical and biological considerations related to the once-through operation of Commonwealth Edison's Quad-Cities Generating Station. The purpose of this report is to provide as much information and documentation as possible within a limited time framework to permit an evaluation by the U. S. EPA Region V for a 316(a) application under the FWPCA Act.

A commitment was made by Commonwealth Edison, prior to any operational monitoring studies, to convert to a completely closed-cycle cooling system by mid-1975. Commonwealth Edison Company now contends that sufficient physical, chemical and biological data have been collected during intensive studies conducted over the past two years in the Mississippi River at Quad-Cities Station to demonstrate that open cycle operation of the station has not caused appreciable harm to any aquatic communities in the Mississippi River in the vicinity of the Quad-Cities Station.

2. The Site

The Quad-Cities Station is located in Rock Island County on the east bank of the Mississippi River in Pool 14 about 3 miles north of Cordova, Illinois and about 20 miles northeast of the Rock Island, Moline, Davenport, Bettendorf area and about 7 miles southwest of Clinton, Iowa (Figure 1). Pool 14 is about 29 miles in length and encompasses the area of the Mississippi River between lock and dam 14 at river mile 493.3 about 5 miles north of Bettendorf, Iowa and lock and dam 13 at river mile 522.5, about 2 miles north of Clinton, Iowa. The total acreage of the pool is approximately 12,200 acres.

The Mississippi River at Clinton, Iowa has a drainage area of

FIGURE 1. LOCATION MAP OF QUAD CITIES STATION

approximately 85,600 square miles. The topography of the basin upstream from the Quad-Cities area consists primarily of gently rolling agricultural land, and in the northern section, forest and lake areas. Prior to 1940, 13 locks and dams were constructed by the U. S. Army Corps of Engineers on the Mississippi River upstream of Clinton, Iowa. These navigation dams are operated to maintain a constant pool elevation during periods of medium and low flows.

Land along the river shore in the vicinity of the Station is devoted to residences, industrial plants, a wildlife refuge, and recreational sites. Major land areas in this vicinity are under agricultural usage including vegetable growing and livestock. The boundaries of the Station extend about 3/4 mile along the river and irregularly one mile inland.

2.1 General Characterizations of the Mississippi River and Biota Near Quad-Cities Station

The condition of the Mississippi River in the vicinity of Quad-Cities Station is described as generally good and essentially unchanged over the 5 year period of the preoperational and operational monitoring programs.

The water quality of the Mississippi River in Pool 14 is generally good although serious pollution problems exist immediately downstream from some major cities and towns bordering the river, and there are periods of degraded water quality due to upstream industrial discharge and runoff from agricultural lands. The major industrial development in the Pool is located in and around Clinton, Iowa and a variety of municipal and industrial effluents enter the river in this area. A recent survey indicated that, in general, the Iowa reach of the Mississippi River contains water of excellent quality. Water quality data considered to be representative of the Upper Mississippi River are presented in Table 1.

Table 1

Typical water chemistry of the Iowa portion of the Mississippi River.[1/]

Parameter	Typical values[2/]
Alkalinity (Phenolphthalein)	2
Alkalinity (Total)	160
Bicarbonate	190
BOD	4
Calcium	51.2
Carbonate	2.4
COD	33.4
Chloride	12
Fluoride	0.2
Hardness (as $CaCO_3$)	200
Magnesium	17.5
Manganese	<0.05
Nitrogen (Organic)	1.1
Nitrogen (Ammonia)	0.07
Nitrogen (Nitrate)	0.2
pH	8.2 units
Phosphate (Soluble, as PO_4)	0.2
Phosphate (Total, as PO_4)	0.5
Potassium	2.6
Silica (as SiO_2)	1.0
Solids (Total)	230
Solids (Dissolved)	178

Table 1 Continued

Parameter	Typical values 2/
Solids (Suspended)	52
Specific Conductance	420 micromhos
Sulfates	52

1/ From Gakstatter and Morris (1970).

2/ Values are in mg/l, except as noted.

The results of water quality studies conducted by Commonwealth Edison prior to and after operation of Quad-Cities Station provide comparable conclusions about the river water quality as well as evidencing that station operation has not affected the river water quality. These data are discussed further in section 4.3 of this report.

Pool 14 encompasses a variety of aquatic habitats and communities in the vicinity of the Station (Sternberg 1971). The various habitats are chiefly defined and classified according to location, depth, bottom material and vegetation. Extensive running and closed sloughs, side channel and island lake habitats support a variety of benthic organisms and are significant spawning and nursery areas for several important species of sport and commercial fish. Directly below the station along the Illinois shore are several small islands with adjacent relatively quiet shallow water areas. Further downstream from the Station west of the main channel are slough habitats (Figure 2). The 16 mile portion of the pool above the Station contains a variety of these habitat types. In addition, there are main channel and channel border habitats throughout the area These habitats do not, however, support prolific aquatic life due to the scoured sand bottom resulting from higher river velocities and maintenance dredging for navigational purposes conducted periodically by the U. S. Corps of Engineers.

Although the Corps of Engineers has compiled information relating to the silt ranges of many pools in the river, Pools 12, 13 and 14 are notable exceptions. The average sediment load of the upper Mississippi River increases from 500 tons per day at St. Paul to 11,000 tons per day at East Dubuque, and subsequently to 77,00 tons per day at Hannibal (UMRCC 1970). Sedimentation in the river contributes to the loss of

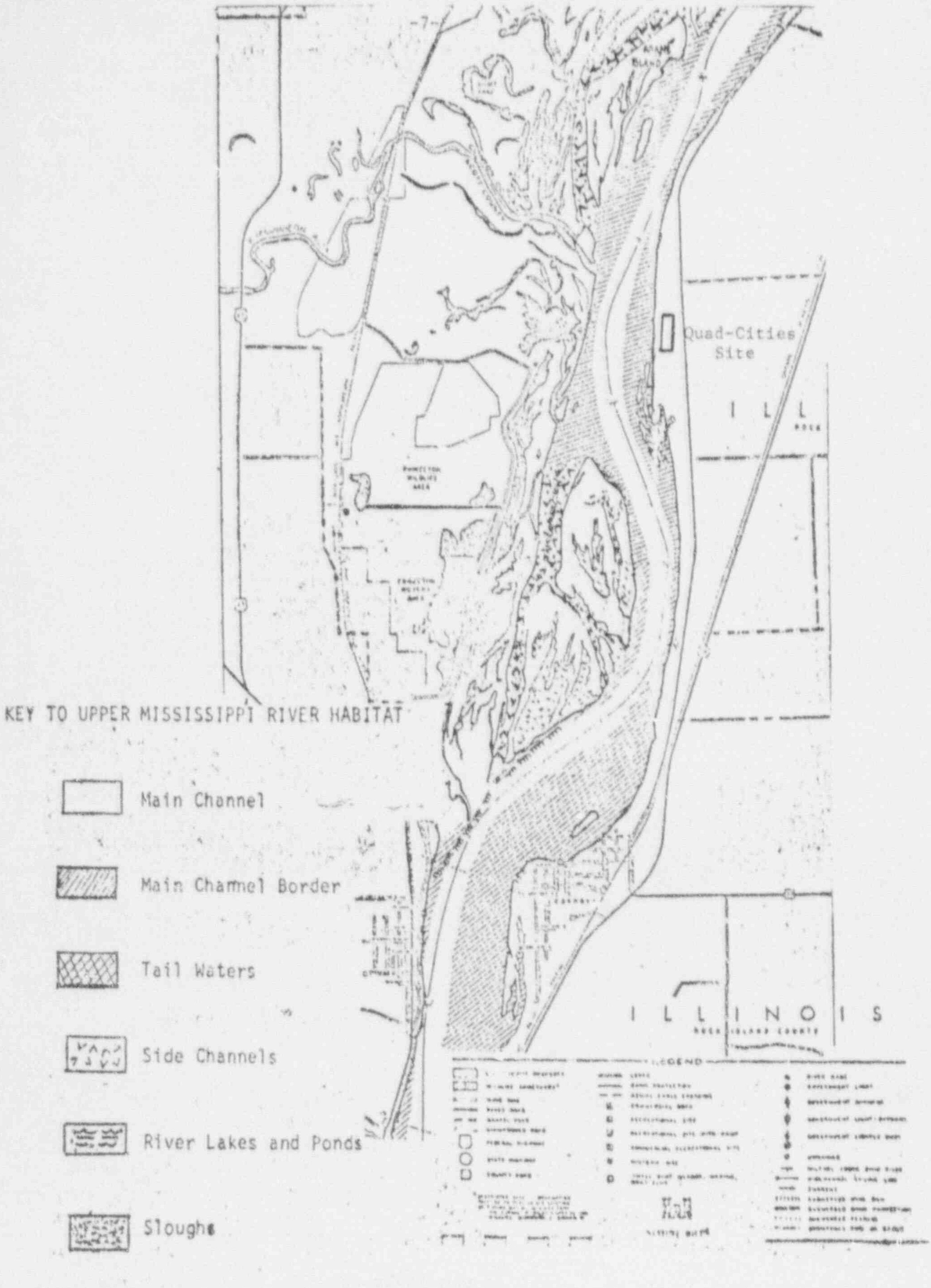


Figure 2 Location of Major Mississippi River Habitats Near Quad Cities Station.

habitat for fish, fur bearers, migratory birds and benthic organisms. In addition, the continuous shifting of bottom deposits contribute to the general periodic depreciation of water quality.

Biological studies in Pool 14 and various other pools in the river have established the existence of relatively diverse and productive planktonic,periphytic and benthic communities which support commercial and sports fisheries.

Prior to channelization of the river, Reinhard's (1931) study of the phytoplankton (free-floating algae) communities from Minneapolis (Pool 2) to Winona (Pool 16) revealed an average population comprised of approximately 70 percent diatoms, 6 percent blue-grean algae, and 3 percent green algae.

The major phytoplankton communities of the river in the vicinity of East St. Louis, Burlington, Dubuque and St. Paul were studied by Williams in 1962. Studies conducted for Commonwealth Edison by Bio-Test Laboratories Inc. (1970 a, b) documented similar populations in the vicinity of the Quad-Cities Station. The results of these studies demonstrated that the most prevalent phytoplankton genera were Cyclotella, Melosira, and Stephanodiscus. Even in summer samples, diatoms were the most common organisms and blue-green algae seldom comprised 10 percent of the population.

Total cell counts ranged from 4,360 to 74,220 organisms/ml in July 1970 and from 650 to 20,530 organisms/ml in October 1970. Similar ranges were reported in the previous study with 2,300 to 8,720 and 2,750 to 20,400 organisms/ml reported for August and November 1969 respectively. The high value of 74,200 organisms/ml in July 1970 was due to a blue-green algal bloom, comprised primarily of Microcystis and Oscillatoria

species (5 percent) at one station located in a slough away from the main channel.

The temperature range was 75.2 F to 84.2 F in July and 53.8 F to 58.5 F in October. These temperatures were within the preferred range for diatoms but outside the preferred ranges for other algae. In general, diatoms prefer temperatures of 65 to 85 F; green algae 86 to 95 F; and blue-green algae of 95.0 to 104 F, with individual species having different tolerances. In addition to temperature, chemical and physical parameters (nitrates as N, Ortho PO_4, BOD, DO, current velocity, turbidity) that influence algal growth are discussed in other sections of this report. Diatom species reported to be associated with organically enriched waters were found in October, 1970. These include Melosira ambigua, Cyclotella meneghiniana and Stephanodiscus hantzschii.

Gale and Lowe (1971) documented the phytoplankton communities inhabiting Pool 19. This investigation found that the abundance of blue-green algae, even at peak density, was less than that of either green algae or diatoms. Gale and Lowe further reported that Cyclotella, Melosira, Stephanodiscus and Scenedesmus were the most prevalent genera in Pool 19. Also, these authors reported that the fingernail clam, Sphaerium transversum, derives most of its food from diatoms and green algae.

The phytoplankton populations in the river are influenced by a variety of chemical, physical and biological factors which can be best understood in terms of river hydrology and hydrography (Reinhard 1931).

Although physical and chemical alterations of the Mississippi River have occurred in the last 40 years, as a result of dam construction, channel improvement, human population increases and agricultural and industrial development, the basic phytoplankton composition does not

appear to have changed drastically since the first major plankton study in 1931. Although changes in the exact species composition may have occurred, insufficient historial data prevents adequate comparisons. Recent studies indicate that the organisms present between river mile 501 and 509 in the Mississippi River are characteristic of a somewhat enriched habitat and, although seasonal variations exist, the phytoplankton composition has been relatively stable.

Species lists of typical phytoplankton species found near Quad-Cities Station during the periods March through July 1972 and August 1972 through January 1973 are given in Tables 2 and 3.

Growth of periphyton occurs upon many submerged substrates in the Mississippi River. Studies conducted for Commonwealth Edison by Industrial Bio-Test Laboratories, Inc. (1970 a, b) in Pool 14 indicate that periphytic growths are common on logs and rocks in slack-water locations. Cladophora was the principal genus in the periphyton of Pool 14, although a variety of other forms (Oscillatoria, Melosira, Stigeoclonium and Lyngbya) were common. During July, abundant growths of blue-green algae (Aphanizomenon) were collected on substrata at two locations. Also, Microcystis was found to be abundant at one location and Plectonema at one location from this monitoring. A species list of typical periphytic algae found in the vicinity of Quad-Cities Station during May-June 1972 monitoring by Industrial Bio-Test Laboratories Inc. is given in Table 4. These data, along with other biological data, are discussed further in section 4.4 of this report.

The nature and distribution of zooplankton populations in the Mississippi River, particularly for Pool 14, has not been well documented with the exception of the work that has been conducted for Commonwealth

Table 2

Phytoplankton species found in the Mississippi River
near Quad-Cities Station
March through July 1972[1]

BACILLARIOPHYTA

Centrales
- Coscinodiscus sp. Ehrenberg
- Cyclotella Kuetz.
  - atomus Hustedt
  - meneghiniana Kuetz.
  - michiganiana Skvortzow
  - pseudostelligera Hustedt
  - sp.
  - stelligera Cl. u. Grun.
- Melosira Ag.
  - ambigua (Grun.) O. Muell.
  - distans (Ehrenberg) Kuetz.
  - granulata (Ehrenberg) Ralfs
  - granulata var. angustissima Muell.
  - islandica Muell.
  - sp.
  - varians Ag.
- Microsiphona potamos Weber
- Rhizosolenia eriensis H. S. Smith
- Stephanodiscus Ehrenberg
  - alpinus Hustedt ex Huber-Pestalozzi
  - astraea (Ehrenberg) Grun.
  - binderanus (Kuetz.) Krieger
  - hantzschii Grun.
  - hantzschii-tenuis Grun.-Hustedt and Skabitschewsky
  - invisitatus Hohn and Hellerman
  - minutus Grun. ex Cl. and Moll.
  - niagarae Ehrenberg
  - sp.
  - sp. 2
  - sp. 3
  - tenius Hustedt
- unidentified centrics

Pennales
- Achnanthes Bory
  - exigua Grun.
  - lanceolata Breb.
  - lanceolata var. dubia Grun.
  - lanceolata var. rostrata Hustedt
  - minutissima Kuetz.
  - sp.

Table 2 Continued

Amphiprora ornata Bailey
Amphora Ehrenberg
    ovalis var. pediculus Kuetz.
    sp.
Asterionella
    formosa Hassall
    gracillima (Hantzsch) Heiberg
Caloneis
    amphisbaena (Bory) Cl.
    bacillum (Grun.) Mereschkowsky
    lewisii var. inflata (Schultze) Patr.
Cocconeis Ehrenberg
    diminuta Pant.
    disculus Schum.
    pediculus Ehrenberg
    placentula Ehrenberg
    placentula var. euglypta (Ehrenberg) Cl.
    placentula var. lineata (Ehrenberg) Cl.
    sp.
Cymatopleura solea (Breb.) W. Smith
Cymbella Ag.
    affinis Kuetz.
    prostrata (Berk.) Cl.
    sp.
    ventricosa Kuetz.
Diatoma DeCandelle
    sp.
    tenue var. elongatum Lyngbye
    vulgare Bory
Epithemia intermedia Fricke
Fragilaria Lyngbye
    capucina Desmazieres
    capucina var. mesolepta (Rabh.) Grun
    construens (Ehrenberg) Grun.
    crotonensis Kitton
    crotonensis var. oregona Sov.
    intermedia Grun.
    leptostauron (Ehrenberg) Hustedt
    pinnata Ehrenberg
    sp.
    vaucheriae var. capitellata (Grun.) Patr.
Gomphonema Ag.
    acuminatum var. coronata (Ehrenberg) Rabh.
    angustatum (Kuetz.) Rabh.
    olivaceum (Lyngbye) Kuetz.
    parvulum (Kuetz.) Kuetz.
    sp.
Gyrosigma Hassall
    scalproides (Rabh.) Cl.
    sp.
    spencerii (W. Smith) Cl.

Table 2 Continued

Meridion circulare Ag.
Navicula Bory
    capitata Ehrenberg
    capitata var. hungarica (Grun.) Ross
    cryptocephala Kuetz.
    cryptocephala var. intermedia Grun.
    cryptocephala var. veneta (Kuetz.) Rabh.
    cuspidata (Kuetz.) Kuetz.
    decussis Ostr.
    exigua (Gregory) O. Muell.
    exigua var. capitata Patr.
    gastrum (Ehrenberg) Kuetz.
    gracilis Ehrenberg
    hungarica (Grun.) Ross
    lanceolata (Ag.) Kuetz.
    laterostrata Hustedt
    menisculus Schum.
    mutica Kuetz.
    protracta Grun.
    pupula Kuetz.
    pygmaea Kuetz.
    radiosa Kuetz.
    reinhardtii Grun.
    reinhardtii var. elliptica Herib.
    rhynchocephala Kuetz.
    salinarum Grun. in Cl. and Grun.
    salinarum var. intermedia (Grun.) Cl.
    sp.
    viridula Kuetz.
    viridula var. rostellata (Kuetz.?) Cl.
Neidium sp. Pfitzer
Nitzschia Hassall
    acicularis W. Smith
    closterium (Ehrenberg) W. Smith
    dissipata Grun.
    fonticola Grun.
    palea (Kuetz.) W. Smith
    paleacea Grun.
    sp.
    sp. 1
    tryblionella Hantzsch
Opephora martyi Herib.
Pinnularia sp. Ehrenberg
Rhoicosphenia curvata (Kuetz.) Grun.
Stauroneis sp. Ehrenberg
Surirella Turp.
    angusta Kuetz.
    ovalis Breb.
    ovata Kuetz.
    sp.

Table 2 Continued

Synedra Ehrenberg
acus Kuetz.
filiformis Grun.
nana Meister
parasitica var. subconstricta Grun.
rumpens Kuetz.
sp.
ulna (Nitzsch) Ehrenberg
unla var. chaseana Thomas
unla var. contracta Ostr.
unidentified pennates

CHLOROPHYTA

Non-Filamentous
Actinastrum hantzschii var. fluviatile Schroeder
Ankistrodesmus
falcatus (Corda) Ralfs
falcatus var. mirabilis West and West
spiralis (Turner) Lemm.
Chlamydomonas sp. Ehrenberg
Chlorogonium
elongatum Dang.
euchlorum Ehrenberg
Chodatella
quadriseta Lemm.
wratislawiensis (Schroeder) Ley
Closteriopsis
longissima Lemm.
longissima var. tropica West and West
Closterium sp. Nitzsch
Coelastrum
cambricum Archer
microporum Naegeli
sphaericum Naegeli
Cosmarium sp. Corda
Crucigenia
apiculata (Lemm.) Schmidle
fenestrata Schmidle
irregularis Wille
lauterbornii Schmidle
quadrata Morren
rectangularis (A. Braun) Gay
tetrapedia (Kirch.) West and West
Dictyosphaerium
ehrenbergianum Naegeli
pulchellum Wood
Elakatothrix
gelatinosa Wille
viridis (Snow) Printz
Errerella bornhemiensis Conrad

Table 2 Continued

Franceia
- droescheri (Lemm.) G. M. Smith
- ovalis (France) Lemm.
- tuberculata G. M. Smith

Gloeocystis gigas (Kuetz.) Lag.
Golenkinia radiata (Chodat) Wille
Gonium pectorale Muell.
Kirchneriella
- contorta (Schmidle) Bohlin
- lunaris (Kirch.) Moebius
- obesa (W. West) Schmidle

Lagerheimia
- ciliata (Lag.) Chodat
- subsalsa Lemm.

Micractinium
- pusillum Fresenius
- pusillum var. elegans G. M. Smith
- quadrisetum (Lemm.) G. M. Smith

Nephrocytium agardhianum Naegeli
Oocystis
- borgei Snow
- lacustris Chodat
- parva West and West
- pusilla Hansgirg

Pandorina morum (Muell.) Bory
Pediastrum
- boryanum (Turp.) Meneghini
- boryanum var. longicorne Raciborski
- duplex Meyen
- duplex var. clathratum (A. Braun) Lag.
- simplex (Meyen) Lemm.
- simplex var duodenarium (Bailey) Rabh.
- tetras (Ehrenberg) Ralfs

Platydorina caudata Kofoid
Polydriopsis spinulosa Schmidle
Ptermonas aculeata Lemm.
Scenedesmus
- abundans (Kirsch.) Chodat
- acuminatus (Lag.) Chodat
- arcuatus Lemm.
- arcuatus var. platydisca G. M. Smith
- bernardii G. M. Smith
- bijuga (Turp.) Lag.
- bijuga var. alternans (Reinsch) Hansgirg
- carinatus (Lemm.) Chodat
- denticulatus Lag.
- dimorphus (Turp.) Kuetz.
- incrassatulus Bohlin
- intermedius Chodat
- longispina Chodat

Table 2 Continued

longus Meyen
longus var. naegelii (Breb.) G. M. Smith
obliquus (Turp.) Kuetz.
opoliensis P. Richter
quadricauda (Turp.) Breb.
quadricauda var. maximus West and West
quadricauda var. westii G. M. Smith
Schizochlamys compacta Prescott
Schoederia setigera (Schroeder) Lemm.
Selenastrum
gracile Reinsch
minutum (Naegeli) Collins
westii G. M. Smith
Sphaerocystis schroeteri Chodat
Spermatozoopsis exultans Korsch
Staurastrum sp. Meyen
Tetraedron Kuetz.
caudatum (Corda) Hansgirg
caudatum var. longispinum Lemm.
hastatum var. palatinum (Schmidle) Lemm.
limneticum Borge
minimum (A. Braun) Hansgirg
muticum (A. Braun) Hansgirg
pentaedricum West and West
regulare Kuetz.
regulare var. granulata Prescott
regulare var. incus Teiling
sp.
trigonum (Naegeli) Hansgirg
trigonum var. gracile (Reinsch) DeToni
verrucosum G. M. Smith
Tetrallantos lagerheimii Teiling
Tetraspora lamellosa Prescott
Tetrastrum
elegans Playfair
heterocanthum (Nordst) Chodat
staurogeniaeforme (Schroeder) Lemm.
Treubaria
setigerum (Archer) G. M. Smith
triappendiculata Bernard
Volvox globator Linnaeus

Filamentous
Radiofilum irregulare (Wille) Brunnthaler

Table 2 Continued

CHRYSOPHYTA

Dichotomococcus lanatus Fott.
Dinobryon
    bavaricum Imhof
    cylindricum Imhof
    divergens Imhof
    sociale Ehrenberg
Mallomonas
    acaroides Perty
    caudata Iwanoff
    producta (Zacharias) Iwanoff
    tonsurata Teiling
Monosiga sp. S. Kent
Ophiocytium
    capitatum Wolle
    capitatum var. longispinum (Moebius) Lemm.
Synura uvella Ehrenberg

CYANOPHYTA

Non-Filamentous
    Aphanocapsa Naegeli
        elachista W. and G. Smith
        pulchra (Kuetz.) Rabh.
        sp.
    Aphanothece
        castagnei Breb.
        clathrata G. S. West in West and West
        nidulans P. Richter
    Chroococcus turgidus (Kuetz.) Naegeli
    Coelosphaerium naegelianum Unger
    Dactylococcopsis fascicularis Lemm.
    Gomphosphaeria
        aponina Kuetz.
        lacustris Chodat
    Merismopedia
        convoluta Breb. in Kuetz.
        punctata Meyen
    Microcystis
        aeruginosa Kuetz.
        incerta Lemm.
    Stichosiphon sp. Geitler

Filamentous
    Anabaena Bory
        circinalis Rabh.

Table 2 Continued

sp.
spiroides Klebahn
Aphanizomenon flos-agrae (Lemm.) Ralfs
Lyngbya sp. Ag.
Oscillatoria Vaucher
amoena (Kuetz.) Gomont
limnetica Lemm.
sp.
tenuis Ag.
Phormidium mucicola Naumann and Huber-Pestalozzi in Huber-Pestalozzi and Naumann
Plectonema Thuret
notatum Schmidle
sp.

EUGLENOPHYTA

Euglena Ehrenberg
acus Ehrenberg
acus var. rigida Huebner
deses Ehrenberg
minuta Prescott
polymorpha Dang.
proxima Dang.
rostrifera Johnson
sp.
sp. (encysted form)
spirogyra Ehrenberg
Lepocinclis
acuta Prescott in Prescott, Silva, and Wade
fusiformis (Carter) Lemm.
glabra Drezepolski
ovum (Ehrenberg) Lemm.
playfairiana Deflandre
Phacus Dujardin
caudatus Huebner
caudatus var. ovalis Drezepolski
crenulata Prescott
longicauda (Ehrenberg) Dujardin
orbicularis Huebner
sp.
Trachelomonas Fhrenberg
crebea (Kellicott) Deflandre
dubia (Swir.) Deflandre
hispida (Perty) Stein
sp.
tambowika Swir.
varians (Lemm.) Deflandre
volvocina Ehrenberg

Table 2 Continued

PYRRHOPHYTA

Certium cornutum (Ehrenberg) Claparede and Lachmann
Glenodinium sp. (Ehrenberg) Stein
Peridinium sp. Ehrenberg

1 Studies conducted by Industrial BioTest Laboratories, Inc.

Table 3

Phytoplankton species found near the Quad-Cities Station, Cordova, Illinois August 1972 through January 1973[1]

BACILLARIOPHYTA (Diatoms)

Achnanthes Bory
- *clevei* Grunow
- *exigua* Grunow
- *exigua* var. *constricta* Torka
- *exigua* var. *heterovalva* Krasske
- *haukiana* Grunow
- *lanceolata* Brebisson
- *lanceolata* var. *dubia* Grunow
- *lanceolata* var. *rostrata* Hustedt
- *minutissima* Kuetz.
- *wellsiae* Reim
- sp.

Amphora Ehrenberg
- *ovalis* Kuetz.
- *ovalis* var. *pediculus* Kuetz.
- sp.

Asterionella Hassall
- *formosa* Hassall
- *gracillima* (Hantzsch) Heiberg

Caloneis Cleve
- *bacillum* (Grunow) Mereschkowsky
- *hyalina* Hustedt
- sp.

Capartogramma crucicula (Grunow *ex* Cleve) Ross

Cocconeis Eherenberg
- *diminuta* Pant.
- *disculus* Schum.
- *pediculus* Ehrenberg
- *placentula* Ehrenberg
- *placentula* var. *euglypta* (Ehrenberg) Cleve
- *placentula* var. *lineata* (Ehrenberg) Cleve

Coscinodiscus sp. Ehrenberg

Cyclotella Kuetz.
- *atomus* Hustedt
- *meneghiniana* Kuetz.
- *meneghiniana* var. *plana* Fricke
- *michiganiana* Skvortzow
- *ocellata* Pant.
- *pseudostelligera* Hustedt
- *stelligera* Cleve u. Grunow
- sp.

Cymatopleura solea (Brebisson) W. Smith

Cymbella Agardh
- *affinis* Kuetz.
- *microcephala* Grunow

Table 3 Continued

- prostrata (Berkeley) Cleve
- sinuata Gregory
- tumida (Brebisson) Van Heurck
- turgida (Gregory) Cleve
- ventricosa Kuetz.
- sp.

Diatoma DeCandolle
- tenue var. elongatum Lyngbye
- vulgare Bory

Diploneis pseudovalis Hustedt

Fragilaria Lyngbye
- brevistriata Grunow
- brevistriata var. inflata (Pantocsk) Hustedt
- capucina Desmazieres
- capucina var. mesolepta (Rabh.) Grunow
- construens (Ehrenberg) Grunow
- construens var. binodis (Ehrenberg) Grunow
- consaruens var. pumila Grunow
- crotonensis Kitton
- intermedia Grunow
- pinnata Ehrenberg
- vaucheriae (Keutz.) Peters
- sp.

Gomphonema Agardh
- abbreviatum Kuetz.
- angustatum (Kuetz.) Rabh.
- lanceolatum var. insignis (Gregory) Cleve
- olivaceum (Lyngbye) Kuetz.
- parvulum Kuetz.
- sp.

Gyrosigma Hassall
- scalproides (Rabh.) Cleve
- spencerii (W. Smith) Cleve
- sp.

Hantzschia Grunow
- amphioxys (Ehrenberg) Grunow

Melosira Agardh
- ambigua (Grunow) O. Mueller
- distans (Ehrenberg) Kuetz.
- granulata (Ehrenberg) Ralfs
- granulata var. angustissima O. Mueller
- islandica O. Mueller
- italica (Ehrenberg) Kuetz.
- varians Agardh

Meridion circulare Agardh

Microsiphona potamos Weber

Navicula Bory
- anglica Ralfs
- capitata Ehrenberg
- capitata var. hungarica (Grunow) Ross

Table 3 Continued

confervacea var. peregrina (W. Smith) Grunow
cryptocephala Kuetz.
cryptocephala var. veneta (Kuetz.) Grunow
cuspidata (Kuetz.) Kuetz.
decussis Ostr.
exigua var. capitata Patr.
gastrum (Ehrenberg) Kuetz.
gracilis Ehrenberg
gregaria Donkin
halophila fo. tenuirostris Hustedt
hambergii Hustedt
hungarica Grunow
laevissima Kuetz.
lanceolata (Agardh) Kuetz.
menisculus Schum.
mutica Kuetz.
mutica var. undulata (Hilse) Grunow
pupula Kuetz.
pupula var. capitata Hustedt
pygmae [illegible]uetz.
rhynch[illegible]ala Kuetz.
salinarum Grunow
salinarum var. intermedia (Grunow) Cleve
scutelloides W. Smith
subhamulata Grunow
tripunctata (O. Mueller) Bory
viridula Kuetz.
sp.

Neidium sp. Pfitzer

Nitzschia Hassall
acicularis W. Smith
apiculata (Gregory) Grunow
closterium (Ehrenberg) W. Smith
dissipata (Kuetz.) Grunow
fonticola Grunow
frustulum Kuetz.
frustulum var. perpusilla (Rabh.) Grunow
holsatica Hustedt
palea (Kuetz.) W. Smith
paleacea Grunow
tryblionella Hantzsch
sp.

Opephora martyi Heribaud

Pinnularia Ehrenberg
borealis Ehrenberg
sp.

Rhizosolenia eriensis H. L. Smith

Rhoicosphenia curvata (Kuetz.) Grunow

Stauroneis anceps Ehrenberg
anceps fo. gracilis (Ehrenberg) Cleve

Stephanodiscus Ehrenberg

Table 3 Continued

- *alpinus* Hustedt ex Huber - Pestalozzi
- *astraea* (Ehrenberg) Grunow
- *binderanus* (Kuetz.) Krieger
- *hantzschii* Grunow
- *hantzschii-tenuis* Grunow-Hustedt and Skabitschewsky
- *invisitatus* Hohn and Hellerman
- *minutus* Grunow *ex* Cleve and Moll.
- *niagarae* Ehrenberg
- *tenuis* Hustedt
- sp.

Surirella Turpin
- *angusta* Kuetz.
- *ovalis* Brebisson
- *ovata* Kuetz.

Synedra Ehrenberg
- *acus* Kuetz.
- *delicatissima* W. Smith
- *delicatissima* var. *angustissima* Grunow
- *filiformis* Grunow
- *parasitica* var. *subconstricta* Grunow
- *rumpens* Kuetz.
- *ulna* (Nitzsch) Ehrenberg
- *ulna* var. *contracta* Ostr.
- sp.

Tabellaria flocculosa (Roth) Kuetz.

Thalassiosira fluviatilis Hustedt.
- sp.

unidentified centrics

CHLOROPHYTA (Green Algae)

Actinastrum hantzschii var. *fluviatile* Schroeder

Ankistrodesmus Corda
- *falcatus* (Corda) Ralfs
- *falcatus* var. *mirabilis* (West and West) G. S. West
- *falcatus* var. *stipitatus* (Chod.) Lemm.
- *spiralis* (Turner) Lemm.

Chlamydomonas sp. Ehrenberg

Chlorogonium Ehrenberg
- *elongatum* (Dang.) Franze
- *euchlorum* Ehrenberg

Chodatella Lemm.
- *quadriseta* Lemm.
- *subsalsa* Lemm.
- *wratislawiensis* (Schroeder) Ley

Closteriopsis Lemm.
- *longissima* Lemm.
- *longissima* var. *tropica* West and West

Closterium sp. Nitzsch

Coelastrum Naegeli

Table 3 Continued

cambricum Archer
microporum Naegeli
sphaericum Naegeli
Cosmarium sp. Corda
Crucigenia Morren
apiculata (Lemm.) Schmidle
fenestrata Schmidle
lauterbornii Schmidle
quadrata Morren
rectangularis (A. Braun) Gay
tetrapedia (Kirch.) West and West
Dictyosphaerium pulchellum Wood
Elakatothrix Wille
gelatinosa Wille
viridis (Snow) Printz
Errerella bornhemiensis Conrad
Franceia Lemm.
ovalis (France) Lemm.
tuberculata G. M. Smith
Gloeocystis ampla (Kuetz.) Lag.
Golenkinia radiata (Chod.) Wille
Kirchneriella Schmidle
lunaris (Kirch.) Moebius
lunaris var. *irregularis* G. M. Smith
ofesa (W. West) Schmidle
Lagerheimia ciliata (Lag.) Chod.
Micractinium Fresenius
pusillum Fresenius
quadrisetum (Lemm.) G. M. Smith
Oocystis Naegeli
borgei Snow
lacustris Chod.
pusilla Hansgirg
solitaria Wittrock
Pandorina morum (O. Mueller) Bory
Pediastrum Meyen
boryanum (Turp.) Meneghini
duplex Meyen
duplex var. *clathratum* (A. Braun) Lag.
simplex (Meyen) Lemm.
simplex var. *duodenarium* (Bailey) Rabh.
tetras (Ehrenberg) Ralfs
Platydorina caudata Kofoid
Polyedriopsis spinulosa Schmidle
Pteromonas aculeata Lemm.
Scenedesmus Meyen
abundans (Kirch.) Chod.
acuminatus (Lag.) Chod.
arcuatus Lemm.
arcuatus var. *platydisca* G. M. Smith
bernardii G. M. Smith
bijuga (Turp.) Lag.

Table 3 Continued

bijuga var. alternans (Reinsch) Hansgirg
brasiliensis Bohlin
carinatus (Lemm.) Chod.
denticulatus Lag.
dimorphus (Turp.) Kuetz.
incrassatulus Bohlin
intermedius Chod.
longispina Chod.
longus Meyen
longus var. naegelii (Brebisson) G. M. Smith
obliquus (Turp.) Kuetz.
opoliensis P. Richter
quadricauda (Turp.) Brebisson
quadricauda var. westii G. M. Smith
Schizochlamys Braum
compacta Prescott
gelatinosa A. Braun in Kuetz.
Schroederia setigera (Schroeder) Lemm.
Selenastrum Reinsch
gracile Reinsch
minutum (Naegeli) Collins
westii G. M. Smith
Spermatozoopsis exultans Korshikov
Sphaerocystis schroeteri Chod.
Staurastrum Meyen
natator var. crassum W. and G. S. West
sp.
Tetraedron Kuetz.
caudatum (Corda) Hansgirg
caudatum var. longispinum Lemm.
hastatum var. palatinum (Schmidle) Lemm.
muticum (A. Braun) Hansgirg
regulare var. incus Teiling
trigonum (Naegeli) Hansgirg
trigonum var. gracile (Reinsch) DeToni
Tetrallantos lagerheimii Teiling
Tetraspora lamellosa Prescott
Tetrastrum Chodat
elegans Playfair
heterocanthum (Nordst) Chod.
staurogeniaeforme (Schroeder) Lemm.
Treubaria triappendiculata Bernard
Volvox tertius A. Meyer

CHRYSOPHYTA (Golden-Brown Algae)

Aulomonas sp. Lackey
Cladomonas Stein
fruticulosa Stein
sp.

Table 3 Continued

Codonosiga botrytis (Ehrenberg) S. Kent
Dichotomococcus lunatus Fott.
Dinobryon Ehrenberg
- bavaricum Imhof
- cylindricum Imhof ex Ahlstrom
- divergens Imhof
- sertularia Ehrenberg
- sociale Ehrenberg

Mallomonas Perty
- acaroides Perty
- caudata Iwanoff
- producta (Zacharias) Iwanoff
- tonsurata Teiling
- sp.

Monosiga sp. S. Kent
Ophiocytium Naegeli
- capitatum Wolle
- capitatum var. longispinum (Moebius) Lemm.

Poteriodendron petiolatum Stein
Stipitococcus urceolatus West and West
Synura uvella Ehrenberg
Uroglenopis americana (Calkins) Lemm.

CYANOPHYTA (Blue-Green Algae)

Anabaena Bory
- circinalis Rabh.
- spiroides Klebahn
- sp.

Aphanizomenon flos-aquae (L.) Ralfs
Aphanocapsa elachista W. and G. Smith
Aphanothece nidulans P. Richter
Chroococcus Naegeli
- dispersus (Keissl.) Lemm.
- limneticus Lemm.

Coelosphaerium naegelianum Unger
Dactylococcopsis fascicularis Lemm.
Lyngbya sp. Agardh
Merismopedia Meyen
- punctata Meyen
- tenuissima Lemm.

Microcystis Kuetz.
- aeruginosa Kuetz.
- incerta Lemm.

Oscillatoria Vaucher
- amoena (Kuetz.) Gomont
- limnetica Lemm.
- tenuis Agardh
- sp.

Phormidium muciocola Nauman and Huber-Pestalozzi

Table 3 Continued

Plectonema notatum Schmidle
Stichosiphon sp. Geitler

EUGLENOPHYTA

Euglena Ehrenberg
- acus Ehrenberg
- acus var. rigida Huebner
- elongata Schewiakoff
- gracilis Klebs
- minuta Prescott
- polymorpha Dangeard
- proxima Dangeard
- rostrifera Johnson
- spirogyra Ehrenberg
- sp.

Lepocinclis Perty
- acuta Prescott
- fusiformis (Carter) Lemm.
- glabra Drezepolski
- ovum (Ehrenberg) Lemm.
- playfairiana Deflandre

Phacus Dujardin
- caudatus Huebner
- crenulata Prescott
- curvicauda Swirenko
- longicauda (Ehrenberg) Dujardin
- orbicularis Huebner
- sp.

Trachelomonas Ehrenberg
- crebea (Kellicott) Deflandre
- hispida (Perty) Stein
- tambowika Swirenko
- varians (Lemm.) Deflandre
- sp.

PYRRHOPHYTA

Ceratium Schrank
- hirundinella (O. Mueller) Dujardin
- sp.

Glenodinium (Ehrenberg) Stein
- quadridens (Stein) Schiller
- sp.

Peridinum Ehrenberg
- sp.

Table 3 Continued

MISCELLANEOUS

Rhodomonas sp. Karsten

1. Studies conducted by Industrial BioTest Laboratories, Inc.

Table 4. Species list of periphytic algae collected in the vicinity of the Quad-Cities Station, May-June, 1972.[1]

Achnanthes lanceolata Breb
Achnanthes minutissima Kutzing
Amphora ovalis Kutz
Amphora ovalis v. *pediculus* Kütz
Amphora perpusilla Grun
Caloneis bacillum (Grun.) Mereschkowsky
Caloneis lewisii Patr.
Caloneis lewisii v. *inflata* (Schultze) Patr. comb. nov.
Caloneis sp.
Cladophora sp.
Closterium acerosum (Schrank) Ehrenberg
Closterium sp.
Cocconeis diminuta Pant.
Cocconeis pediculus Ehr.
Cocconeis placentula (Ehr.) Cleve
Cosmarium sp.
Cymbella cymbiformis (Agardh? Kutz.) v. Heurck
Cymbella sinuata Gregory
Cymbella tumida (Breb.) v. Heurck
Cymbella ventricosa Kütz.
Diatoma tenue v. *elongatum* Lyngb.
Diatoma vulgare v. *linearis* Grunow
Epithemia sp.
Fragilaria capucina Desmazieres
Fragilaria construens (Ehr.) Grunow
Fragilaria crotonensis Kitton
Fragilaria intermedia Grunow
Fragilaria pinnata Ehrenberg
Fragilaria spp.
Gomphonema acuminatum Ehr.
Gomphonema anustatum (Kutz.) Rabh.
Gomphonema augar Ehr.
Gomphonema lanceolatum Ehr.
Gomphonema lanceolatum v. *insignis* (Gregory) Cleve
Gomphonema olivaceum (Lyngbye) Kutz.
Gomphonema parvulum Kutz.
Gyrosigma acuminatum (Kütz.) Rabh.
Gyrosigma kutzingii (Grun.) Cleve
Gyrosigma scatproides (Rabh.) Cleve
Gyrosigma spencerii (W. Smith) Cleve
Melosira binderana Kütz.
Melosira distans (Ehr.) Kutz.
Melosira granulata (Ehr.) Ralfs.
Melosira herzogii
Melosira islandica O. Mull.
Melosira italica (Ehr.) Kütz.
Melosira varians C. A. ag.
Melosira spp.
Navicula accomoda Hust.
Navicula anglica Ralfs

Table 4 Continued

Navicula atomus (Naeg) Grun.
Navicula cryptocephala Kütz.
Navicula cuspidata Kutz.
Navicula cuspidata v. *ambigua* (Ehr.) Cleve
Navicula gracilis Ehr.
Navicula graciloides A. Mayer
Navicula heufleri Grun.
Navicula hungarica Grun.
Navicula hungarica v. capitata (Ehr.) Cleve
Navicula inflata Donkin
Navicula integra (W. Smith) Ralfs
Navicula multigramme Hohn and Hellerm.
Navicula notha Wallace
Navicula pupula Kutz.
Navicula pygmea Kutz.
Navicula reinhardtii Grun.
Navicula tripunctata (O. F. Mull.) Bory
Navicula viridula Kütz.
Navicula vitabunda Hust.
Navicula zanoni Hust.
Navicula spp.
Nitzschia acicularis W. Smith
Nitzschia acuta Hantzsch
Nitzschia amphibia Grun.
Nitzschia angustata (W. Smith) Grun.
Nitzschia dissipata (Kutz.) Grun.
Nitzschia filiformis (W. Smith) Hust.
Nitzschia fonticola Grun.
Nitzschia gracilis Ehr.
Nitzschia hantzschiana Rabh.
Nitzschia holsatica Hust.
Nitzschia hungarica Grun.
Nitzschia ignorata Krasske
Nitzschia linearis W. Smith
Nitzschia palea (Kütz.) W. Smith
Nitzschia recta Hantzsch
Nitzschia sublinearis Hust.
Nitzschia vermicularis (Kutz.) Grun.
Nitzschia spp.
Oedgonium sp.
Opephora martyi Heribaud
Ophiocytium sp.
Palmella cf. *miniata* Leibl.
Phormiduim tenue (Menegh.) Gomont
Pinnularia braunii v. *amphicephata* (A. Meyer) Hustedt
Pinnularia spp.
Plectonema sp.
Scenedesmus sp.
Stigeoclonium sp.
Surirella angustata Kutz.
Surirella ovata Kutz.

Table 4 Continued

<u>Synedra</u> <u>acus</u> Kutz.
<u>Synedra</u> <u>rumpens</u> Kutz
<u>Synedra</u> <u>ulna</u> (Nitzsch) Ehr.
<u>Synedra</u> <u>ulna</u> v. <u>oxyrhynchus</u> Kutz.
<u>Synedra</u> <u>ulna</u> v. <u>oxyrhynchus</u> fo. <u>contracta</u>
<u>Synedra</u> spp.

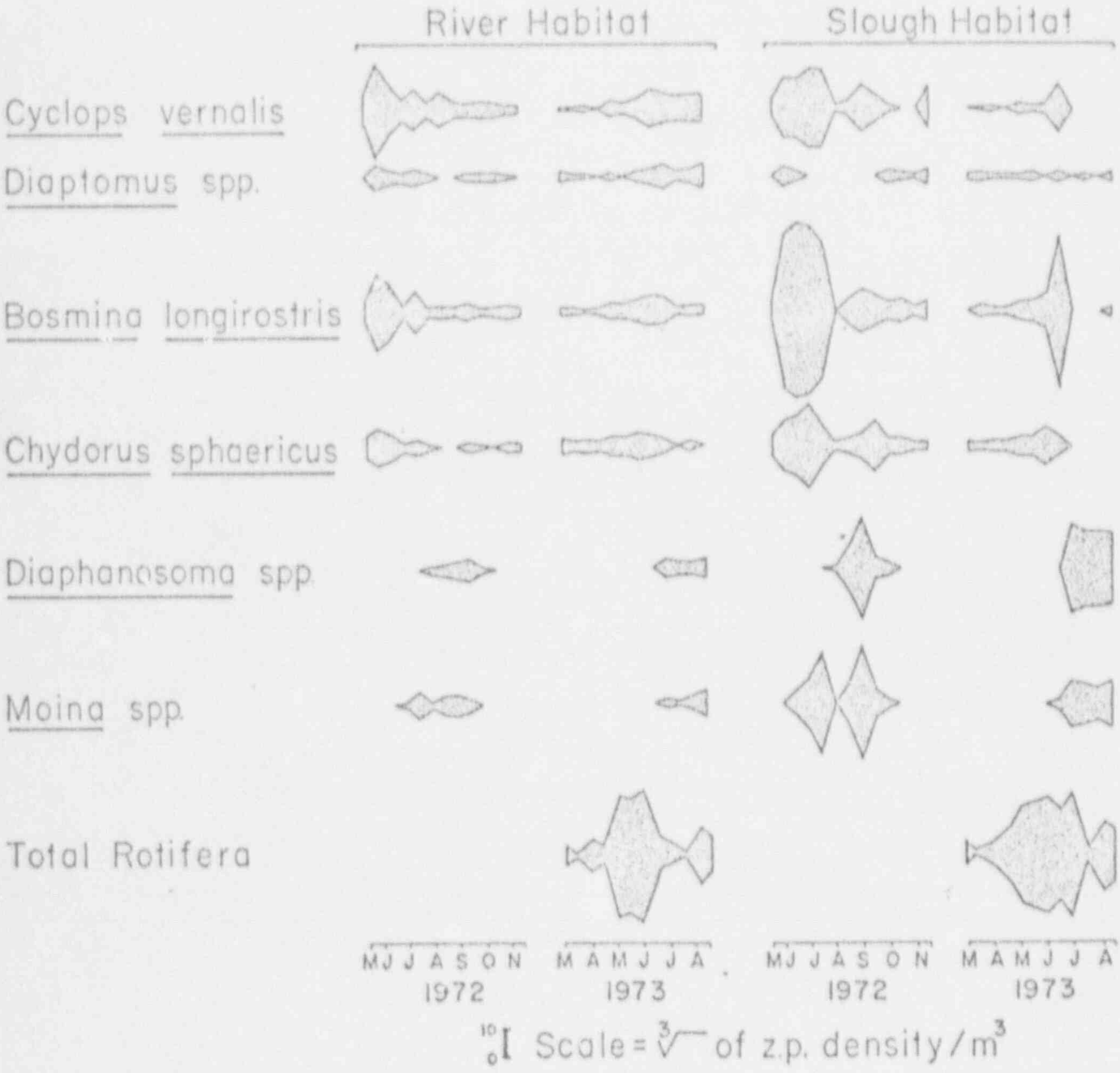
1. Studies conducted by Industrial BioTest Laboratories, Inc.

Edison Company by Industrial Bio-Test Laboratories, Inc. Studies in other river systems in North America, however, have described the nature of these organisms and examined the problem of survival in relationship to a variety of factors. The relationship between species richness and abundance in streams appears to be largely due to changes in flow rate and specific habitats with a specific river system. Studies in Pool 14 substantiate this finding. It appears that one of the major factors affecting variations in zooplankton density and community composition at locations with similar habitats are the hydrological conditions in the river. Densities were found to be inversely related to flow conditions while the species richness observed on a particular sampling date was directly related to flow. The dynamic nature of the Mississippi River with its variable flow and water levels as well as the contribution from its many tributaties enhances the randomness of zooplankton distribution.

The zooplankton community in Pool 14 is dominated by several true planktonic species such as Cyclops vernalis, Cyclops bicuspidatus thomasi, Diaptomus siciloides, and Bosmina longiorstris. Additional dominant taxa are total Rotiferia and the tycohoplankter Chydorus sphaericus. Other species such as Diaphanosoma spp. and Moina spp. demonstrate seasonal pulses. Remaining species are considered incidental forms which are present as a result of fluctuating hydrologic conditions.

The abundance of the total zooplankton in the river versus the slough habitats during 1972 through 1973 studies is shown in Figure 3. Abundance was generally greatest in warmer slow-flowing slough areas, particularly after early summer. Values ranged from approximately 1,606 organisms/m^3 to almost 600,000 organisms/m^3 in 1972 while in 1973 they ranged from 2,000 organisms/m^3 to just under 150,000 organisms/m^3.

Figure 3. Comparison of dominant zooplankton taxa collected from Mississippi River and slough locations near Cordova, Illinois. Data are presented as cube root transformations of zooplankton densities from 16 May through 21 November 1972 and 6 March through 21 August 1973.[1]



[1]Industrial Bio-Test Laboratories, Inc.

The marked fluctuations in population appear to be related to differences in river flow in a given season. Figures 4 and 5 show the seasonal variations of the zooplankton community in the Mississippi River from February 1973 to January 1974.

Table 5 is a species list of the typical representative planktonic crustaceans collected in the Mississippi River by Industrial Bio-Test Laboratories, Inc. during the period August 1973 through January 1974. Additional zooplankton is discussed in further detail in section 4.4.1.2 of this report.

Studies of the benthic organisms in the Mississippi River by various investigators indicate a varied and diverse community exists which is related to substrate and habitat type and general water quality conditions in the river.

A study from 1959-1963 by Carlander (1967) in Pool 19 indicated tremendous populations of Hexagenia naiads with alternate years of abundance. Soft mud provided the major habitat. Hexagenia were not found in either sand or gravel habitats. Large populations of mayflies indicate good water quality because they are sensitive to low levels of chemical pollutants and to low concentrations of dissolved oxygen. Mayflies have been eliminated by the polluted conditions of the Mississippi River below the Twin Cities and St. Louis (Fremling 1964), the Illinois River (Mills et al. 1966) and in Lake Erie (Britt 1963).

Although large hatches of mayflies are an annoyance in river towns, the insects are an important food source for fish, birds, and other animals. A study by Hoopes (1960) revealed that mayflies comprised over 50 percent of the summer food of channel catfish, drum,

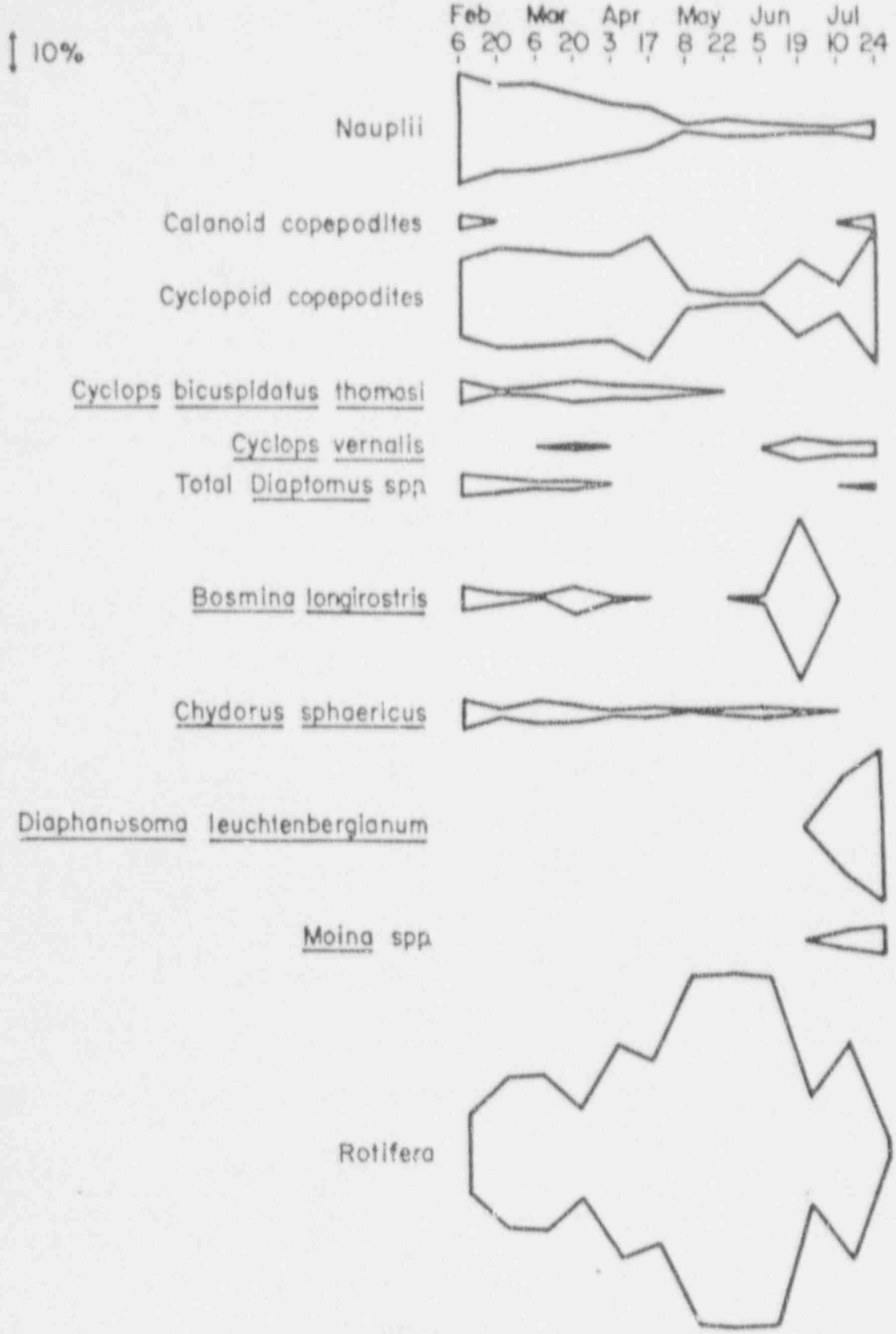


Figure 4. Seasonal variation of the Zooplankton community composition in the Mississippi River near the Quad-Cities Station, February-July 1973.[1]

[1]Industrial Bio-Test Laboratories, Inc.

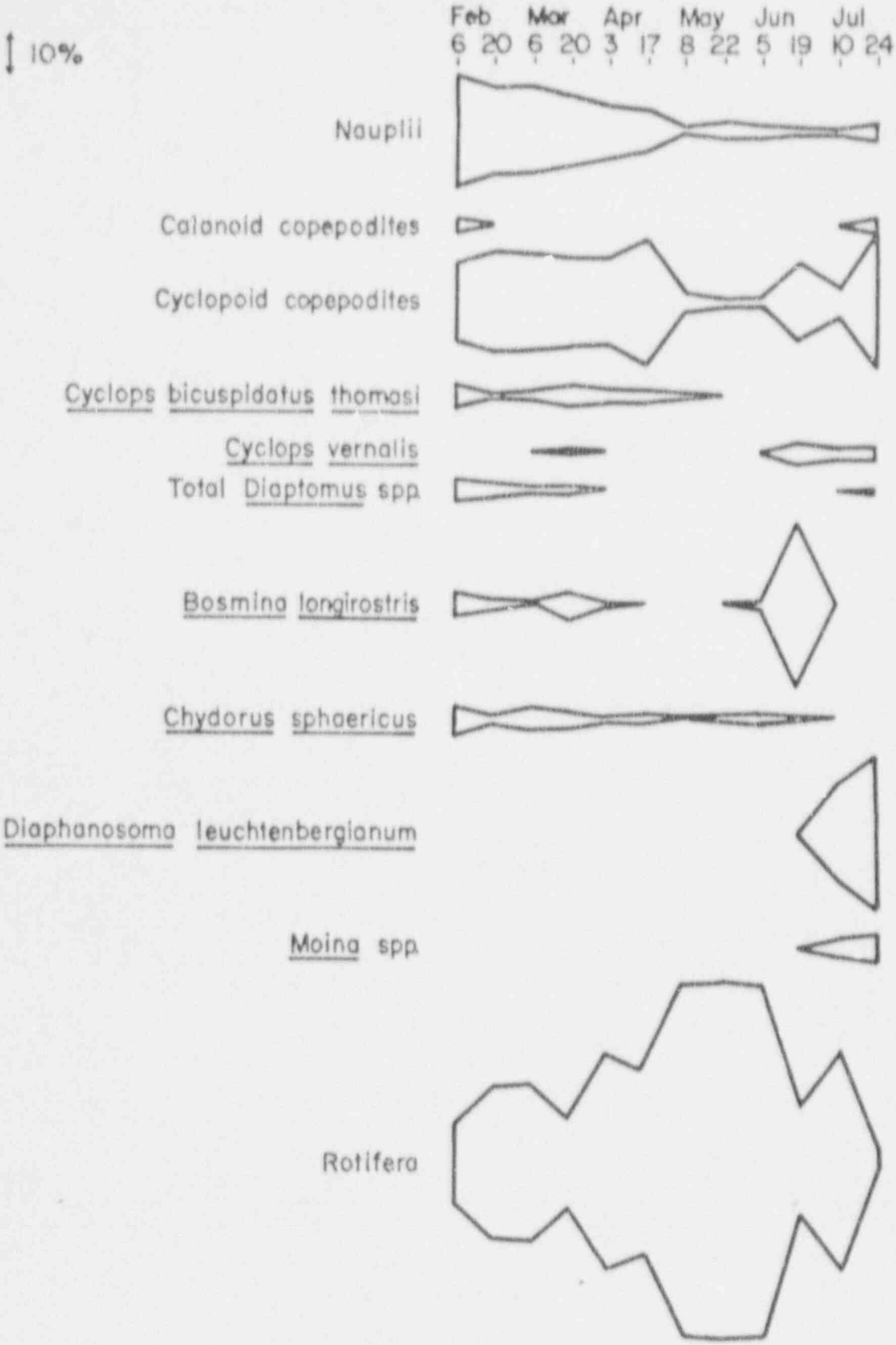


Figure 4. Seasonal variation of the Zooplankton community composition in the Mississippi River near the Quad-Cities Station, February-July 1973.[1]

[1]Industrial Bio-Test Laboratories, Inc.

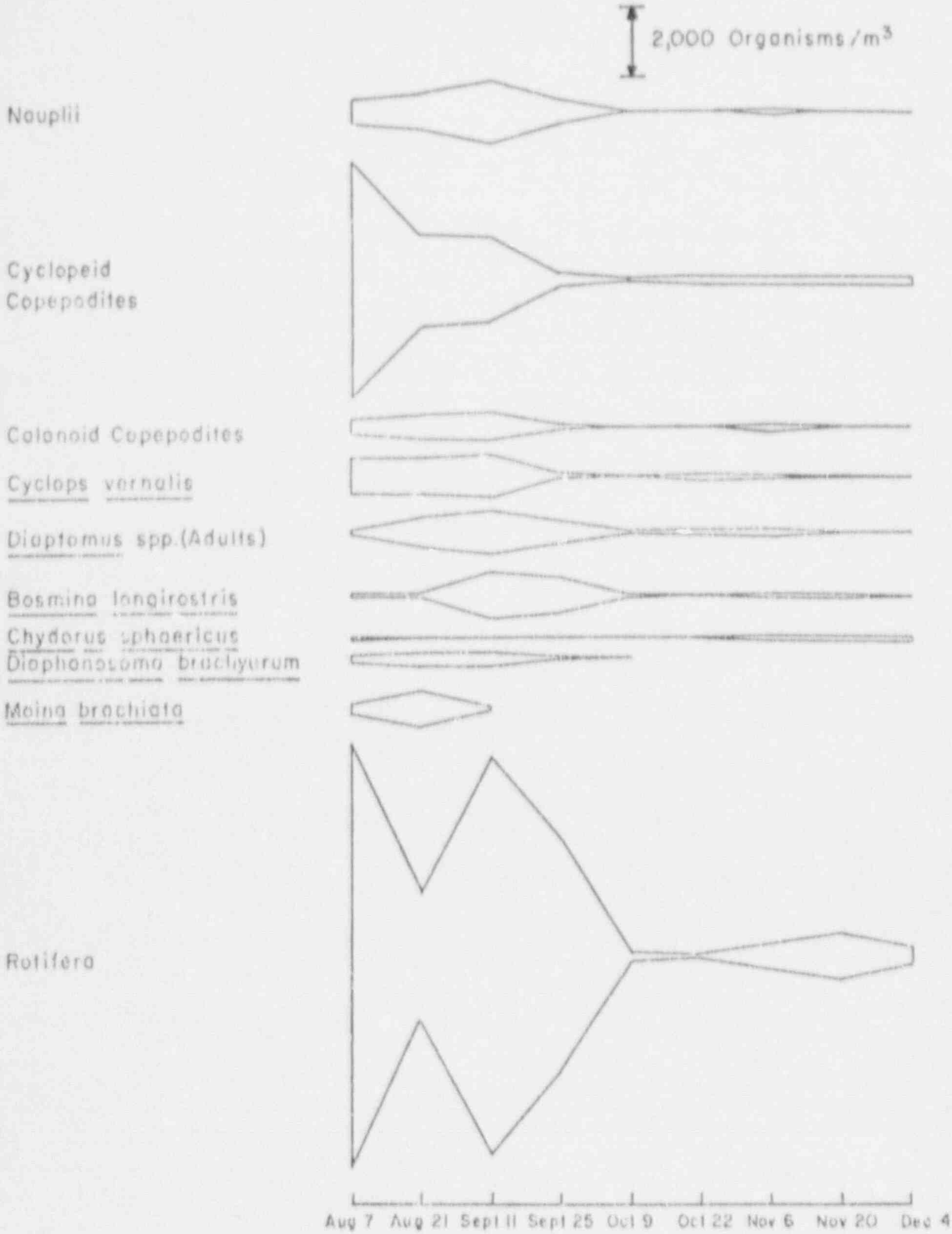


Figure 5. Seasonal variation of the zooplankton community in the Mississippi River near the Quad-Cities Station, August 1973-January 1974.[1]

Table 5. List of planktonic crustacean species collected in the Mississippi River near the Quad-Cities Station, August 1973-January 1974.[1]

Species

COPEPODA

Cyclops bicuspidatus thomasi S. A. Forbes
Cyclops varicans rubellus Lilljeborg
Cyclops vernalis Fischer
Diaptomus clavipes Schacht
Diaptomus minutus Lilljeborg
Diaptomus oregonensis Lilljeborg
Diaptomus pallidus Herrick
Diaptomus siciloides Lilljeborg
Ectocyclops phaleratus (Koch)
Ergasilus chautauquaensis Fellows
Eucyclops agilis (Koch)
Eucyclops prionophorus Kiefer
Eucyclops speratus (Lilljeborg)
Macrocyclops albidus (Jurine)
Mesocyclops edax (S. A. Forbes)
Orthocyclops modestus E. B. Forbes
Paracyclops fimbriatus poppei (Rehberg)
Tropocyclops prasinus mexicanus Kiefer

CLADOCERA

Alona costata Sars
Alona guttata Sars
Alona rectangula Sars
Alona quadrangularis (O. F. Muller)
Alonella acutirostris (Birge)
Alonella nana (Baird)
Bosmina longirostris (O. F. Muller)
Ceriodaphnia lacustris Birge
Ceriodaphnia quadrangula (O. F. Muller)
Chydorus sphaericus (O. F. Muller)
Daphnia galeata mendotae Birge
Daphnia parvula Fordyce
Daphnia retrocurva Forbes
Diaphanosoma brachyurum (Lieven)
Diaphanosoma leuchtenbergianum Fischer
Eubosmina coregoni (Baird)
Eurycercus lamellatus (O. F. Muller)
Graptoleberis testudinaria (Fischer)
Holopedium gibberum Zaddach
Holocryptus sordidus (Lieven)
Kurzia latissima (Kurz)
Leptodora kindtii (Focke)
Leydigia quadrangularis (Leydig)
Macrothrix laticornis (Jurine)

[1]Industrial Bio-Test Laboratories, Inc.

Table 5 Continued

Moina brachiata (Jurine)
Pleuroxus denticulatus Birge
Pleuroxus hamulatus Birge
Pleuroxus procurvus Birge
Polyphemus pediculus (Linne')
Scapholeberis kingi Sars
Sida crystallina (O. F. Muller)
Simocephalus serrulatus (Koch)
Simocephalus vetulus Schodler

BRANCHIURA
Argulus sp.

mooneyes, goldeyes, and white bass in the upper Mississippi River. Carlander et al. (1967) suggested that the abundance of Hexagenia naiads in the Keokuk area is probably greater today than it was in 1913. They reasoned that the increase in sedimentation since the construction of the dam has enlarged the habitat for mayflies. In this instance, siltation may have had a desirable effect upon an important member of the food chain.

During the summers of 1960 and 1961, Carlson (1968) collected over 1,400 benthos samples from eight sampling locations near the Illinois shore just upstream of Dam 19. The fingernail clam (Sphaerium transversum) was the most abundant organism collected at each sampling location. Hexagenia (mayflies) naiads were the most abundant insects at each sampling location in 1960 and Tendipes (midges) in 1961. Coelotanypus, Stenochironomus, Oligochaetes, Campeloma, Lioplax subcarinata, Somayogyrus depressus and Onecetis were also common. Based on comparisons with earlier data, Carlson concluded that the major elements of the benthos possessed the characteristics of a climax community and seem to have changed very little.

Gakstatter and Morris in 1970 reported that the only parts of the Iowa portion of the Mississippi River where pollution appeared to have deleteriously affected the benthic communities were just below the outfalls of several cities and towns. For example, they found a serious reduction in the number of benthic organisms for three miles downstream from Clinton, Iowa. As expected, they found that an increase in fecal coliform organisms was usually accompanied by a decrease in benthic organisms. The effects of the Clinton outfalls were not detected in the

southern section of Pool 14.

In the July 1969-June 1970 study by Industrial Bio-Test Laboratories, Inc. the benthic organisms were found to be composed mainly of "facultative" forms (adaptable to a wide range of conditions). The dominant organisms were insects of the orders Ephemeroptera (mayflies), Trichoptera (caddisflies), and Diptera (family Chironomid or midge-flies). Oligochaete worms were present in some of the organically rich sediments. Samples from the main channel contained few organisms probably because of a combination of two factors: (1) scouring action of the current and (2) the presence of sandy substrates which are regarded as being an unsuitable habitat for aquatic animals (Hynes, 1970). In areas such as wing dams, sloughs, and shorelines, which are protected from the current and where more suitable substrates occur, a greater abundance and diversity of invertebrates were observed. In July, 1970, Chironomus (Chironomus) and C. Cryptochironomers (midges) and Limnodrilus orvix and L. hoffmeisteri (sludgeworms) were the two most abundant groups present, comprising 34.7 and 41.1 percent of the 297 organisms collected (Industrial Bio-Test Laboratories, Inc., 1971). Other groups such as crustacea, amphipods (Hyallela azteca), caddisflies, trichoptera and leeches comprised three percent or less of the total organisms found during this period. Mollusks were found in very small numbers and generally exhibited no consistent pattern of distribution.

The benthic invertebrates which have been reported as tolerant of organic pollution include the midges, Chironomus (Chironomus), Chironomus (Cryptochironomus), and Procladius; and the sludgeworms, Limnodrilus hoffmeisteri, L. cervix, and Tubifex tubifex (Brinkhurst

1966, 1968, 1970, Carr 1965, Hiltunen 1970). According to Brinkhurst sludgeworms may be the only benthic invertebrates present in highly eutropic (nutrient-rich) waters.

In October, 1970, a total of 914 specimens were collected, with mayflies, tubificids, and midges comprising 44.1, 35.9 and 14.3 percent respectively of the benthic fauna in the samples. The low mayfly population in July corresponds with data obtained by Carlander (1967) who studied Hexagenia naiad populations in Pool 19 of the Mississippi River from 1959 to 1963.

Mayflies of the genus Hexagenia are considered to be intolerant of organic pollution and resultant low dissolved oxygen concentrations (Carlander 1967). The other forms of benthic fauna of the river were characterized as being comprised primarily of facultative forms which are indicative of clean to moderately enriched waters.

A species list of typical benthic invertebrates collected in the Mississippi River near the Quad Cities Station during the periods of February - July 1973 and August 1973 - January 1974 is shown in Table 6 and Table 7 respectively. The dominant organisms in this list, along with other data obtainedduring the operational phase of Quad Cities Station are discussed in greater detail in Section 4.4.1.4 of this report.

Sampling for drifting macroinvertebrates was conducted by Industrial Bio-Test Laboratories, Inc. in 1971 in the Quad-Cities Station area. The dominant forms comprising typical drift organisms during the period April through December 1971 are shown in Table 8. Subsequent to that time sampling for drifting macroinvertebrates was conducted near the area of the diffuser pipe discharge in May 1972 and continued until November.

Table 6. A checklist of benthic invertebrates collected in the Mississippi River near the Quad-Cities Station, February-July 1973.[1]

- Aschelminthes
  - Nematoda
- Coelenterata
  - Hydrozoa
    - Hydroida
      - Hydridae
        - *Hydra*
- Platyhelminthes
  - Turbellaria
    - Tricladida
      - Planariidae
        - *Dugesia tigrina* (Girard)
    - Rhabdocoelida
- Annelida
  - Oligochaeta
    - Plesiopora
      - Glossoscolecidae
        - *Sparganophilus* Benham
      - Enchytraeidae
      - Naididae
        - *Arcteonais lomondi* (Martin)
        - *Dero digitata* (Müller)
        - *Nais* sp.
        - *N. behningi* Michaelson
        - *N. bretscheri* Michaelson
        - *N. communis* Piguet
        - *Paranais frici* (Hrabe)
        - *Piguetiella michiganensis* Hiltunen
        - *Pristina longiseta leidyi* Smith
        - *Specaria josinae* (Vejdovsky)
        - *Vejdovskyella intermedia* (Bretscher)
      - Tubificidae
        - *Aulodrilus limnobius* Bretscher
        - *A. pigueti* Kowalewski
        - *Branchiura sowerbyi* Beddard
        - *Ilyodrilus templetoni* (Southern)
        - *Limnodrilus cervix* Brinkhurst
        - *L. claparedianus* Ratzel
        - *L. hoffmeisteri* Claparede
        - *L. maumeensis* Brinkhurst and Cook
        - *L. spiralis* Eisen
        - *L. udekemianus* Claparede
        - *Peloscolex multisetosus multisetosus* (F. Smith)
        - *Potamothrix moldaviensis* Vejdovsky and Mrazek
        - Immature w/ capilliforms
        - Immature w/o capilliforms
    - Prosopora
      - Lumbriculidae
        - *Stylodrilus heringianus* Claparede
  - Hirudinea
    - Rhynchobdellida
      - Glossiphoniidae
        - *Helobdella stagnalis* (Linnaeus)
- Arthropoda
  - Arachnida
    - Acari
  - Crustacea
    - Isopoda
      - Asellidae
        - *Asellus* Geoffrey St. Hillaire
    - Amphipoda
      - Talitridae
        - *Hyalella azteca* (Saussure)
      - Gammaridae
        - *Crangonyx* Bate
        - *Gammarus* Fabricius
  - Insecta
    - Plecoptera
      - Perlodidae
        - *Isoperla* Banks
    - Ephemeroptera
      - Ephemeridae
        - *Hexagenia* Walsh
        - *Potamanthus* Pictet
      - Baetiscidae
        - *Baetisca* Walsh
      - Caenidae
        - *Caenis* Stephens
        - *Tricorythodes* Ulmer
      - Baetidae
        - *Baetis* Leach
        - *Isonychia* Eaton
        - *Siphlonurus* Eaton
      - Heptageniidae
        - *Stenonema* Traver
    - Odonata
      - Coenagrionidae
        - *Lestes* Leach
    - Hemiptera
      - Pleidae
        - *Plea striola* Fieber
      - Corixidae
    - Megaloptera
      - Sialidae
        - *Sialis* Latreille
    - Trichoptera
      - Hydropsychidae
        - *Cheumatopsyche* Wallengren
        - *Hydropsyche orris* Ross
        - *Potamyia flava* (Hagen)
      - Psychomyiidae
        - *Neureclipsis* McLachlan
      - Leptoceridae
        - *Athripsodes* Billberg
        - *Leptocella albida* (Walker)
        - *L. candida* (Hagen)

[1] Industrial Bio-Test Laboratories, Inc.

Table 6. Continued.

Leptocerus americanus (Banks)
Oecetis McLachlan
Coleoptera
Elmidae
Dubiraphia Sanderson
Stenelmis Dufour
Diptera
Psychodidae
Psychoda alternata Say
Chaoboridae
Chaoborus punctipennis (Say)
Simuliidae
Chironomidae
Ablabesmyia Joh.
Chironomus (Meig.)
Clinotanypus Kieff.
Coelotanypus Kieff.
Corynoneura (Winn.)
Cryptochironomus Kieff.
Cryptocladopelma Lenz
Demicryptochironomus (Townes)
Endochironomus Kieff.
Epoicocladius (Mall.)
Glyptotendipes Kieff.
Harnischia (Kieff.)
Heterotrissocladius Sparck
Microcricotopus (Mall.)
Micropsectera Kieff.
Monodiamesa Kieff.
Orthocladius (v.d. Wulp.)
Paracladopelma Harn.
Parakiefferiella (Thein.)
Paralauterborniella Lenz
Polypedilum (Fallax Grp.) Kieff.
Polypedilum (Tripodura Grp.) Kieff.
Procladius Skuse
Rheocricotopus Thien. et Harn.
Rheotanytarsus (Bause)
Stictochironomus Kieff.
Tanypus Meig.
Tanytarsus v.d. Wulp.
Thienemanniinyia Grp. Fittk.
Trissocladius (Kieff.)
Xenochironomus (Anceus) Roback
near Demicryptochironomus cf. monstrosus A (Tschern)
near D. B
near Paratendipes Kieff.
Ceratopogonidae
Empididae
Mollusca
Gastropoda
Pulmonata
Lymnaeidae
Lymnaea Lamarck
Physidae
Physa Draparnaud
Ancylidae
Ferrissia Walker
Ctenobranchiata
Amnicolidae
Amnicola Gould and Haldeman
Horatia Bourguignat
Somatogyrus Gill
Pelecypoda
Heterodonta
Sphaeriidae
Pisidium Pfeiffer
Sphaerium Scopoli
Sphaerium striatinum (Lamarck)
S. transversum (Say)
Corbiculidae
Corbicula manilensis Phillipi
Schizodonta
Unionidae
Fusconaia undata (Barnes)
Leptodea fragilis (Raf.)
Megalonais gigantea (Barnes)
Quadrula nodulata (Raf.)
Q. quadrula (Raf.)
Truncilla donaciformis (Lea)
T. truncata Raf.
Immature unionids

Table 7. A checklist of benthic invertebrates collected in the Mississippi River near the Quad-Cities Station, August 1973 - January 1974.[1]

- Aschelminthes
  - Nematoda
- Coelenterata
  - Hydrozoa
    - Hydroida
      - Clavidae
        - Cordylophora lacustris Allman
      - Hydridae
        - Hydra
- Platyhelminthes
  - Turbellaria
    - Tricladida
      - Planariidae
        - Dugesia tigrina (Girard)
    - Rhabdocoelida
- Annelida
  - Oligochaeta
    - Plesiopora
      - Enchytraeidae
      - Naididae
        - Dero digitata (Muller)
        - Nais sp.
        - N. behningi Michaelson
        - Paranais frici (Hrabe)
        - Piguetiella michiganensis Hiltunen
        - Pristina breviseta Bourne
        - P. cf. synclites Stephenson
        - Vejdovskyella intermedia (Bretscher)
      - Tubificidae
        - Aulodrilus limnobius Bretscher
        - A. pigueti Kowalewski
        - Branchiura sowerbyi Beddard
        - Ilyodrilus templetoni (Southern)
        - Limnodrilus sp. Claparede
        - L. cervix Brinkhurst
        - L. hoffmeisteri Claparede
        - L. maumeensis Brinkhurst and Cook
        - L. spiralis Eisen
        - L. udekemianus Claparede
        - Peloscolex freyi Brinkhurst
        - P. multisetosus multisetosus (F. Smith)
        - Rhyacodrilus cf. subterraneus
        - Immature w/ capilliforms
        - Immature w/o capilliforms
  - Hirudinea
    - Rhynchobdellida
      - Glossiphoniidae
        - Helobdella stagnalis (Linnaeus)
    - Arhynchobdellida
      - Erpobdellidae
- Arthropoda
  - Arachnida
    - Acari
  - Crustacea
    - Amphipoda
      - Talitridae
        - Hyalella azteca (Saussure)
      - Gammaridae
        - Crangonyx Bate
    - Decapoda
      - Astacidae
        - Orconectes Cope
  - Insecta
    - Collembola
    - Plecoptera
      - Taeniopterygidae
        - Taeniopteryx Pictet
      - Perlodidae
        - Isoperla Banks
    - Ephemeroptera
      - Ephemeridae
        - Hexagenia Walsh
        - Pentagenia vittigera (Walsh)
        - Potamanthus Pictet
      - Baetiscidae
        - Baetisca bajkovi Neave
      - Caenidae
        - Brachycercus Curtis
        - Caenis Stephens
        - Tricorythodes Ulmer
      - Baetidae
        - Baetis Leach
      - Heptageniidae
        - Stenonema Traver
    - Odonata
      - Gomphidae
        - Dromogomphus Selys
        - Gomphus Leach
    - Hemiptera
      - Corixidae
    - Neuroptera
      - Sisyridae
        - Climacia areolaris (Hagen)
    - Trichoptera
      - Hydropsychidae
        - Cheumatopsyche Wallengren
        - Hydropsyche orris Ross
        - Potamyia flava (Hagen)
      - Hydroptilidae
        - Agraylea multipunctata Curtis
        - Hydroptila Dalman

[1] Industrial Bio-Test Laboratories, Inc.

Table 7. Continued.

Psychomyiidae
Cyrnellus marginalis (Banks)
Neureclipsis McLachlan
Leptoceridae
Athripsodes Billberg
Neureclipsis McLachlan
Polycentropus Banks
Leptoceridae
Athripsodes Billberg
Leptocella albida (Walker)
L. candida (Hagen)
Oecetis inconspicua (Walker)
Coleoptera
Elmidae
Dubiraphia Sanderson
Stenelmis Dufour
Diptera
Chaoboridae
Chaoborus punctipennis (Say)
Simuliidae
Chironomidae
Ablabesmyia Joh.
Chironomus (Meig.)
Clinotanypus Kieff.
Coelotanypus Kieff.
Cryptochironomus Kieff.
Demicryptochironomus Lenz
Endochironomus Kieff.
Epoicocladius (Mall.)
Glyptotendipes Kieff.
Harnischia (Kieff.)
Leptochironomus Pagast
Microcricotopus (Mall.)
Microtendipes Kieff.
Orthocladius (v. d. Wulp)
Parachironomus Lenz
Parakiefferiella (Thein.)
Paralauterborniella Lenz
Polypedilum Kieff.
Procladius Skuse
Rheotanytarsus (Bause)
Stenochironomus Kieff.
Stictochironomus Kieff.
Tanypus Meig.
Thienemannimyia Grp. Fittk.
Trissocladius (Kieff.)
Xenochironomus (Anceus) Roback
near *Demicryptochironomus*
near *Paratendipes* Kieff.
Ceratopogonidae
Empididae
Mollusca
Gastropoda
Pulmonata
Ancylidae
Ferrissia Walker
Ctenobranchiata
Viviparidae
Campeloma Raf.
Amnicolidae
Amnicola Gould and Haldeman
Somatogyrus Gill
Pelecypoda
Heterodonta
Sphaeriidae
Pisidium Pfeiffer
Sphaerium striatinum (Lamarck)
S. transversum (Say)
Corbiculidae
Corbicula manilensis Phillipi
Schizodonta
Unionidae
Amblema plicata (Say)
Fusconaia undata (Barnes)
Leptodea fragilis (Raf.)
Megalonaias gigantea (Barnes)
Plagiola lineolata (Raf.)
Proptera alata Say
Quadrula nodulata (Raf.)
Q. quadrula (Raf.)
Truncilla donaciformis (Lea)
T. truncata Raf.
Immature unionids

Table 8 Summary of the most abundant drift organisms collected in Pool 14 (April-December 1971) 1

Date	Location 1* Taxa	#/m²	%[1]	Location 3 Taxa	#/m²	%	Location 6 Taxa	#/m²	%	Location 7 Taxa	#/m²	%
4-29-71	-[2]	-	-	-		-	Hexagenia	*	43	Hyalella	*	57
							Hyalella	*	41	Hexagenia	*	17
							Chironomidae	*	11	Chaoboridae/ Chironomidae	*	13
5-12-72	Hexagenia	*[3]	78	Hyalella	*	35	Hyalella	*	28	Hexagenia	*	56
	Acari	*	7	Hexagenia	*	27	Hexagenia	*	26	Hyalella	*	14
	Chaoborus	*	6	Acari	*	19	Acari	*	19	Chironomidae	*	13
5-26/28-71	Acari	*	40	Hyalella	*	25	Hexagenia	*	29	Acari	*	61
	Hexagen/a	*	20	Adult Diptera	*	23	Acari	*	28	Adult Diptera	*	10
	Hyalella	*	10	Acari	*	18	Adult Diptera	*	16	Hyalella	*	8
6-9-71	Acari	*	39	Acari	*	47	Hyalella	*	61	Hyalella	*	41
	Adult Diptera	*	24	Hyalella	*	21	Hydropsychidae	*	11	Stenelmis	*	
	Hyalella	*	17	Chironomidae	*	13	Stenelmis	*	10	Acari	*	14
6-30/7-1-71	Hyalella	2.07	34	Hyalella	*	87	Hydropsychidae	6.85	38	Hexagenia	3.81	40
	Hexagenia	1.35	22	Chironomidae	*	9	Hexagenia	4.67	26	Stenelmis	2.49	26
	Stenelmis	1.10	18	Hexagenia	*	2	Hyalella	2.74	16	Hyalella	1.51	16
7-14/15-71	Acari	*	39	Chaoborus	*	34	Acari	3.75	47	-	-	-
	Hyalella	*	19	Hyalella	*	29	Hyalella	1.63	21			
	Chaoborus	*	14	Chironomidae	*	9	Cha .borus	1.50	19			
7-38/30-71	Hyalella	*	63	Hyalella	*	63	Hyalella	*	42	Chaoborus	*	57
	Chaoborus		16	Baetis	*	14	Chaoborus	*	30	Hydropsychidae	*	23
	Hydropsychidae	*	12	Hydropsychidae	*	13	Hydropsychidae	*	7	Hyalella	*	6
8-11-71	Hydropsychidae	7.69	67	Baetis	*	35	Hyalella	*	58	Hydropsychidae	5.24	85
	Hyalella	1.71	15	Hyalella	*	19	Chaoborus	*	10	Chaoborus	*	5
	Chaobor; s	1.61	14	Chironomidae	*	12	Hydropsychidae	*	14	Hyalella	*	4
8-25-71	Hexagenia	1.70	66	Hexagenia	*	49	Hexagenia	17.87	74	Hexagenia	61.75	97
	Hyalella		23	Hyalella	*	25	Hyalella	5.20	22	Hyalella	*	2
	Chironomidae	*	4	Chaoborus	*	16	Hydropsychidae	*	2	Chaoborus	*	0.7
9-8/9-71	Chaoborus	*	50	Chaoborus	*	31	Chaoborus	2.08	53	Chaoborus	4/13	67
	Hyalella	*	9	Hyalella	*	28	Adult Diptera	*	17	Adult Diptera	*	14
	Acari	*	8	Adult Diptera	*	18	Hyalella	*	13	Hyalella	*	9
9-22/23-71	Hexagenia	*	33	Hyalella	*	75	Hyalella	3.32	66	Hexagenia	*	29
	Hyalella	*	23	Hexagenia	*	8	Hexagenia	*	16	Hyalella	*	28
	Stenonema	*	17	Hydropsychidae	*	7	Acari	*	14	Hydropsychidae	*	20
10-6-71	Hyalella	*	36	Hyalella	*	88	Chaoborus	*	29	Hexagenia	*	45
	Acari	*	21	Hydropsychidae	*	12	Hexagenia	*	18	Hyalella	*	21
	Hexagenia	*	14				Acari	*	14	Chaoborus	*	7
10-20-71	Hexagenia	1.20	50	Hyalella	*	38	Hexagenia	2.01	31	Hexagenia	1.77	54
	Chaoborus	*	27	Chironomidae	*	25	Hyalella	1.31	23	Hydropsychidae	*	20
	Hyalella	*	7	Chaoborus	*	10	Chaoborus	*	18	Adult Diptera	*	7
11-3-71	Hexagenia	2.54	74	Hexagenia	*	61	Hyalella	2.07	49	Hexagenia	1.47	68
	Hyalella	*	19	Hyalella	*	29	Hexagenia	1.75	41	Hyalella	*	8
	Acari	*	3	Acari	*	3	Corixidae	*	4	Acari	*	2
11-17-71	Hexagenia	13.76	96	Hexagenia	2.32	85	Hexagenia	5.35	91	Hexagenia	8.02	95
	Chironomidae	*	0.7	Hyalella	*	3	H, lla	*	3	Acari	*	0.5
	Acari	*	0.6	Chironomidae	*	2	Cha .borus	*	2	Hyalella	*	0.8
12-4-71	Hexagenia	*	62	Hexagenia	*	43	Hexagenia	*	75	Hexagenia	*	42
	Chironomidae	*	12	Aelosomatidae	*	31	Chironomidae	*	25	Chironomidae	*	21
	Aelosomatidae	*	11	Chironomidae	*	12				Acari	*	10
12-16-71	Hexagenia	1.52	98	Hexagenia	1.71	99	Hexagenia	*	86	Hexagenia	1.36	96
	Chironomidae	*	2	Chironomidae	*	1	Hydropsychidae	*	10	Chaoborus	*	2
	Chaoborus	*	0.9				Corixidae	*	3	Corixidae	*	0.9

1/ Percent organisms collected per station per date.
2/ No sample.
3/ Indicates less than one organism/m².

*Location 1 is located upstream of plant intake
Location 3 is located in Adams Slough
Location 6 is located in the area of intake
Location 7 is located downstream of intake

Table 8 Continued.

Date	Location 8 Taxa	#/m²	%	Location 1F Taxa	#/m²	%	Location 11 Taxa	#/m²	%	Location 13 Taxa	#/m²	%
4-29-71	Hexagenia	5.13	73	Hyalella	*	47	-	-	-	Hyalella/ Chironomidae	*	28
	Hyalella	1.15	16	Hexagenia	*	25				Hexagenia	*	17
	Chironomidae	*	7.1	Chironomidae	*	16.9				Hydropsychidae	*	10
5-12-71	Hexagenia	*	54	Hyalella	*	19	-	-	-	-	-	-
	Hyalella	*	14	Hexagenia	*	6						
	Chironomidae	*	9	Chironomidae	*							
5-26/28-71	Acari	*	28	Hyalella	*	25	Hyalella	*	47	Adult Diptera	*	52
	Hexagenia	*	24	Acari	*	24	Baetis	*	14	Acari	*	35
	Hyalella	*	23	Baetis	*	17	Adult Diptera	*	13	Chironomidae	*	8
6-9-71	Hyalella	1.49	39	Acari	*	45	Acari	*	34	Chironomidae	*	46
	Hydropsychidae	*	23	Chironomidae	*	30	Hyalella	*	32	Hyalella	*	21
	Acari	*	17	Hyalella	*	16	Chironomidae	*	19	Acari	*	6
6-30/7-1-71	Hydropsychidae	4.06	74	Hyalella	*	47	Hyalella	*	48	Hydropsychidae	*	33
	Hexagenia	*	13	Hydropsychidae	*	17	Hydropsychidae	*	24	Hyalella	*	32
	Hyalella	*	3	Stenelmis	*	15	Hexagenia	*	9	Stenelmis	*	13
7-14/15-71	Chaoborus	1.49	29	Hexagenia	*	23	Stenelmis	*	45	Hydropsychidae	*	28
	Stenelmis	*	17	Hyalella	*	17	Hexagenia	*	20	Hexagenia	*	18
	Acari	*	16	Stenelmis	*	16	Chironomidae	*	10	Hyalella	*	17
7-28/30-71	Chaoborus	*	83	Hyalella	*	50	Hyalella	*	50	Hydropsychidae	*	65
	Hyalella	*	17	Chaoborus	*	50	Chaoborus	*	19	Chaoborus	*	14
8-11-71	Hydropsychidae	12.34	68	Hexagenia	*	20	Hydropsychidae	1.21	68	Hydropsychidae	*	67
	Chaoborus	3.59	19	Chaoborus	*	16	Hyalella	*	9	Stenonema	*	11
	Chironomidae	*	8	Chironomidae	*	15	Baetis	*	8	Chironomidae	*	6
8-25/26-71	Hexagenia	6.15	89	Hexagenia	6.22	79	Hexagenia	42.43	86	Hexagenia	4.32	77
	Hyalella	*	3	Chironomidae	*	7	Hyalella	4.21	9	Caenis	*	4
	Chaoborus	*	2	Hyalella	*	3	Chaoborus	1.35	3	Hyalella	*	3
9-8/9-71	Chaoborus	*	48	Hexagenia	1.20	64	Hyalella	8.10	78	Hexagenia	*	35
	Hyalella	*	22	Hyalella	*	16	Chaoborus	1.08	10	Hyalella	*	23
	Hexagenia	*	19	Chaoborus	*	10	Hydropsychidae	*	5.5	Chaoborus	*	16
9-22/23-71	Hyalella	*	37	Hexagenia	*	40	Hyalella	*	45	Hexagenia	*	43
	Hexagenia	*	21	Chironomidae	*	30	Acari	*	17	Hydropsychidae	*	33
	Cyrnellus	*	16	Hyalella	*	20	Hydropsychidae	*	16	Potamanthus	*	7
10-6-71	Hexagenia	*	59	Hexagenia	*	38	Hexagenia	*	49	Hexagenia	*	67
	Hydropsychidae	*	13	Chaoborus	*	25	Hyalella	*	45	Acari	*	22
	Acari	*	10	Acari	*	24	Acari	*	2	Baetis	*	11
10-20-71	Hexagenia	*	46	Hexagenia	*	33	Hyalella	*	51	Hexagenia	*	39
	Hydropsychidae	*	14	Chironomidae	*	20	Hexagenia	*	27	Hyalella	*	18
	Hyalella	*	9	Chaoborus	*	14	Hydropsychidae	*	12	Chaoborus	*	9
11-3-71	Hexagenia	*	67	Hexagenia	*	51	Hexagenia	3.39	91			
	Hyalella	*	12	Chironomidae	*	21	Hyalella	*	3	-	-	-
	Adult Diptera	*	10	Adult Diptera	*	20	Adult Diptera	*	2			
11-17-71	Hexagenia	14.63	97	Hexagenia	1.96	82	Hexagenia	3.55	96	Hexagenia	2.00	68
	Acari	*	0.7	Acari	*	7	Chaoborus	*	1	Hydropsychidae	*	6
	Chaoborus	*	0.5	Chironomidae	*	3	Hyalella	*	0.8	Ischnura	*	2
12-2-71	Hexagenia	*	78	Hexagenia	*	72	Hexagenia	*	71	Hexagenia	*	29
	Hydropsychidae	*	5	Chironomidae	*	15	Chaoborus	*	14	Corixidae	*	16
	Chironomidae	*	4	Acari	*	5	Acari	*	5	Acari	*	10
12-16-71	Hexagenia	1.50	94	Hexagenia	*	80	Hexagenia	*	80	Hexagenia	*	35
	Chaoborus	*	2	Aelosomatidae	*	7	Chironomidae	*	9	Aphididae	*	15
	Hydropsychidae	*	1	Chironomidae	*	6	Hydropsychidae	*	4	Chironomidae	*	10

[1]Industrial Bio-Test Laboratories

The amphipod Hyalella azteca was the most abundant drifting invertebrate reaching a peak of 16.5 organisms/m^3 in August. Hexagenia spp. nymphs were the second most abundant, reaching a peak of 4.8 organisms/m^3 in May 1972. Chaoborus punctipennis was the third most abundant organism averaging 0.3 organisms/m^3. Other important organisms reaching high seasonal peaks were hydropsychids, Cheumatopsyche, Potamyia flava, and Hydropsyche orris; the caenid and baetid mayflies, Caenis spp., Brachycercus sp., Tricorythodes spp., Baetis spp., Baetisca spp., and Isonychia spp., water mites, Acari, and a diverse population of Chironomidae. These data are discussed in greater detail in Section 4.4.1.5.

The fishery in the Upper Mississippi River and in Pool 14 has been characterized by a number of investigators. Their results in all cases indicate that the river supports a diverse and productive warm water fishery due largely to the variety of habitat types present. Crappie and bluegill are by far the most abundant species of sport fish. Northern pike, sauger and walleye are taken, especially in the northern areas. It is likely that the increased silt load on the river, silting above the dams, and the draining of adjoining bottom land lakes has contributed towards reducing the potentialities of the river as a sport fishery, although the river is still recognized as one of the major sport fisheries in the midwest.

Studies authorized by Smith, Lopinot and Pflieger (1971) for the Illinois Natural History Survey from Pool 1 downstream to the Ohio River identified 134 species of fish. Of these, 30 species are probably accidental in the Mississippi River. They state that

despite the steady decline in the number of commercial fishermen, and despite highly publicized references to the Mississippi River as a sewer, the evidence available indicates that the Mississippi River has a rich fish fauna and that it supports good populations of most of the native species. With the exception of the muskellunge, no indigeneous species of fish are known to have been exterminated in recent times. Several species appear to be less generally distributed and less common than formerly. The decline cannot be attributed with certainly to increased pollution. It is probable that drainage of marginal lakes and sloughs, construction of flood control levees, destruction or modification of habitat through efforts to maintain the navigational channel and excessive siltation have been the major cause of observable changes in the numbers and distribution of fish.

A check list of the fish known to occur in the Upper Mississippi River and Pool 14 is shown in Table 9.

Barnickol and Starrett (1951) used a variety of sampling techniques to collect sport and commercial fish at 31 locations from Pools 12 - 19 during April - September 1946. Commercial species comprised the majority of the total poundage collected, with the top four species being carp (Cyprinus carpio), buffalo (Ictiobus spp.) catfish (Ictalurus spp.) and drum (Aplodinotus grunniens). Shovelnose sturgeon (Scaphirhynchus platorynchus), lake sturgeon (Acipense fulvescens), paddlefish (Polyodon spathula) and eel (Anguilla [illegible]trata) were much less abundant than they had been prior to 1931, probably due both to over-exploitation by man and to habitat changes resulting from construction of the lock and dam system on the river.

TABLE 9

Check List of Fish Species Known to
Occur in the Upper Mississippi River - Adapted
from Smith, Lopinot & Pflieger, 1971

*denotes presence in river probably accidental

Ichthyomyzon cataneus - Chestnut Lamprey
Ichythyomyzon unicuspis - Silver Lamprey
Acipenser fulvescens - Lake Sturgen
Scaphirhynchus albus - Pallid Sturgeon
Scaphirhynchus platorynchus - Shovelhose Sturgeon
Polyodon spathula - Paddlefish
Lepisosteus osseus - Longnose Gar
Lepisosteus platostomus - Shortnose Gar
Lepisosteus spatula - Alligator Gar
Amia calva - Bowfin
Anguilla rostrata - American Eel
Alosa alabamae - Alabama Shad
Alosa chrysochloris - Skipjack Herring
Dorosoma cepedianus - Gizzard Shad
Dorosoma petense - Threadfin Shad
Hiodon alosoides - Goldeye
Hiodon tergisus - Mooneye
*Salmo gairdneri - Rainbow Trout
*Umbra limi - Mudminnow
*Esox americanus - Grass Pickerel
Esox lucius - Northern Pike
Campostoma anomalum - Stoneroller
*Dionda nubila - Ozark Minnow
Cyprinus carpio - Carp
*Ctenopharyngodon idella - Grass Carp
Ericymba buccata - Silverjaw Minnow
Hybognathus argyritis -
Hybognathus hankinson - Brassy Minnow
Hybognathus nuchalis - Silvery Minnow
Hybognathus placitus - Plains Minnow
Hybopsis aestivalis - Speckled Chub
Hybopsis gelida - Sturgeon Chub
Hybopsis gracilis - Flathead Chub
Hybopsis meeki - Sicklefin Chub
Hybopsis storeriana - Silver Chub
Hybopsis x-punctata - Gravel Chub
*Nocomis biguttatus - Horneyhead Chub
Notemigonus crysolevcas - Golden Shiner
Notropis amnis - Pallid Shiner
*Notropis anogenus - Pugnose Shiner
Notropis atherionoides - Emerald Shiner
Nitropis blennius - River Shiner
*Notropis boops - Bigeye Shiner
Notropis buchanani - Ghost Shiner
*Notropis chrysocephalvs - Striped Shiner
Notropis cornutus - Common Shiner
Notropis dorsalis - Big Mouth Shiner
Notropis emiliae - Pugnose Minnow
Notropis hudsonius - Spottail Shiner
Notropis lutrensis - Red Shiner
*Notropis rubellus - Rosy face Shiner
Notropis shumardi - Silverband Shiner
Notropis spilopterus - Spotfin Shiner
Notropis stramineus - Sand Shiner
Notropis texanus - Weed Shiner
*Notropis venustus - Blacktail Shiner
Notropis volucellus - Mimic Shiner
Phenacobius mirabilis - Suckermouth Minnow
*Phoxinus erythrogaster - Southern Redbelly Dace
Pimephales notatus - Bluntnose Dace
Pimephales promelas - Fathead Minnow
Pimephales vigilax- Bullhead Minnow
*Semotilus atromaculatus - Creek Chub
*Semotilus margarita - Pearl Dace
Carpiodes carpio - River Carpsucker
Carpiodes cyprinus - Quillback
Carpiodes velifer - Highfin Carpsucker
Castostomus commersoni - White Sucker
Cycleptus elongatus - Blue Sucker
Hypentelium nigricans - Northern Hog Sucker
Ictiobus bubalus - Smallmouth Buffalo
Ictiobus cyprinellus - Bigmouth Buffalo
Ictiobus higer - Black Buffalo
Minytrema melanops - Spotted Sucker
Moxostoma anisurum - Silver Redhorse
Moxostoma erythrurum - Golden Redhorse
Moxostoma macrolepidotum - Shorthead Redhorse
Moxostoma valenciennesi - Greater Red horse

Table 9 Continued

*Ictalurus catus - White Catfish
Ictalurus furcatus - Blue Catfish
Ictalurus melas - Black Bullhead
Ictalurus natalis - Yellow Bullhead
Ictalurus nebulosus - Brown Bullhead
Ictalurus punctatus - Channel Catfish
Noturus flavus - Stonecat
Noturus gyrinus - Tadpole Madtom
Noturus nocturnus - Freckled Madtom
Pylodictis olivaris - Flathead Catfish
*Aphredoderus sayanus - Pirate Perch
Percopsis omiscomaycus - Trout Perch
Lota lota - Burbot
*Fundulus notti - Starhead Topminnow
Fundulus notatus - Blackstripe Topminnow
*Fundulus olivaceus - Black spotted Topminnow
Gambusia affinis - Mosquitofish
Lapidesthes sicculus - Brook Silverside
Menidia audens - Mississippi Silverside
*Culaea inconstans - Brook Stickleback
Morone chrysops - White Bass
Morone mississippiensis - Yellow Bass
Ambloplites rupestris - Rock Bass
*Centrarchus macropterus - Flier
Lepomis cyanellus - Green Sunfish
Lepomis gibbosus - Pumpkinseed
Lepomis gulosus - Warmouth
Lepomis humilis - Orangespotted Sunfish
Lepomis macrochirus - Bluegill
Lepomis megalotis - Longear Sunfish
*Lepomis microlophus - Redear Sunfish
Micropterus dolomievi - Smallmouth Bass
*Micropterus punctulatus - Spotted Bass
Micropterus salmoides - Largemouth Bass
Pomoxis annularis - White Crappie
Pomoxis nigromaculatus - Black Crappie
Ammocrypta asprella - Crystal Darter
Ammocrypta clara - Western Sand Darter
Etheostoma aspringene - Mud Darter
*Etheostoma caeruleum - Rainbow Darter
Etheostoma chlorosomum - Bluntnose Darter
*Etheostoma exile - Iowa Darter
*Etheostoma flabellare - Fantail Darter
Etheostoma nigrum - Johnny Darter
*Etheostoma spectabile - Orangethroat Darter
*Etheostoma zonale - Banded Darter
Perca flavescens - Yellow Perch
Percina caprodes - Logperch
*Percina naculata - Blackside Darter
Percina phoxocephala - Slenderhead Darter
*Percina sciera - Dusky Darter
Percina shumardi - River Darter
Stizostedion canadense - Sauger
Stizostedion vitreum - Walleye
Aplodinotus grunniens - Freshwater Drum
*Cottus carolinae - Banded Sculpin

Bluegills (Lepomis macrochirus) and crappies (Pomoxis spp.) were the most abundant sport species sampled, with most being collected from backwaters, bottomland lakes adjoining the river, and immediately downstream of the dams. Northern pike (Esox lucius), sauger (Stizostedion canadense) and walleye (S. vitreum) were taken only in limited numbers. They concluded that northern pike and yellow perch were too scarce downstream of Pool 13 to be of much importance to the sport fishery. Sauger were the most abundant of the perch family (Percidae) and were significant to the sport fishery.

White bass (Roccus chrysops) and yellow bass (Morone interrupta) were widely distributed, with white bass predominant in northern pools and yellow bass predominant in southern pools. Overall, white bass were about three times as abundant as yellow bass. Bowfins (Amia calva) and gars (Lepisosteus sp.) were quite abundant throughout the study area, with bowfins predominant in northern pools and gars predominant in southern pools. Minnows (Cyprinidae) and gizzard shad (Dorosoma cepedianum) were abundant forage fish collected.

Barnickol and Starrett concluded that the river's fishery had declined before 1951 for the following reasons:

1. Poor land management which resulted in erosion;
2. Increased siltation due to the lock and dam system;
3. Channelization of the river;
4. Levees which eliminated spawning and rearing grounds; and
5. Municipal and industrial wastes.

Helms (1966) reported that the habitats with the lowest catch rates included tailwaters, main channel borders, and the main channel.

Ranthum (1969) reported that, in Pool 19, the shallow river and flat habitats yielded the greatest number of species of food organisms for fish. The slough habitats ranked next in importance, and the channel habitat ranked lowest of all habitats.

Recent studies by Industrial Bio-Test Laboratories, Inc. (1970 through 1974) of Pool 14 have indicated that its fishery is generally quite similar to that reported for Pool 13. The most abundant sport and commercial fish collected from Pool 14 were crappies, bluegills, carp, buffalo, drum and channel catfish. Preferred habitats included side channels, sloughs, and island areas. These studies are discussed in detail in Section 4.4.1.6.

Wright (1970) reported the results of a 1967-1968 creel census of the sport fishery of Pools 4, 5, 7, 11, 13, 18, and 26. Table 10 summarizes the sport catch from Pools 7, 11, 13, 18, and 26.

Seventy-nine percent of the 2,819 anglers censused on Pool 13 (a northern pool) were from Illinois, with most of the remaining 21 percent being from Iowa. Of the anglers, 66 percent sought bluegills and crappies, 10 percent sought any species, 7 percent sought walleye or sauger, and 7 percent sought catfish. Although the catch rates for Pool 13 during the summer (0.98 fish/man-hr) and fall (1.26 fish/man-hr) were the highest for the seven pools, its overall catch rate of 1.05 fish/man-hr ranked third. Bluegills, crappies, drum, white bass, and catfish comprised 88 percent of the total catch. Although Pool 13 is considered to be one of the better pools for production of walleye and northern pike, these species comprised only 0.62 percent and 0.09 percent, respectively, of the catch. Total catch per acre averaged 0.57 lb/acre/month.

Table 10. Summary of species composition of sport catch taken in Pools 7, 11, 13, 18, and 26 of the Mississippi River (1967-1968).[1/]

Species		Pool 7	11	13	18	26
Bluegill	No.	8,955	2,470	2,230	858	443
	%	44.8	20.0	33.8	14.5	20.7
Crappie	No.	4,805	4,605	2,097	695	209
	%	24.1	37.2	31.8	11.7	9.8
Drum	No.	332	3,219	932	794	565
	%	1.7	26.0	14.1	13.4	26.3
Sauger	No.	1,193	449	1	354	4
	%	6.0	3.6	tr.	6.0	0.2
Channel Catfish	No.	257	848	340	2,506	324
	%	1.3	6.8	5.2	42.3	15.1
White Bass	No.	654	132	742	570	552
	%	3.3	1.1	11.3	9.6	25.8
Walleye	No.	917	205	47	52	12
	%	4.6	1.7	0.7	0.9	0.6
Largemouth Bass	No.	914	439	140	97	32
	%	4.6	3.5	2.1	1.6	1.5
Yellow Perch	No.	1,429	-	58	-	-
	%	7.2	-	0.9	-	-
Northern Pike	No.	477	12	7	1	-
	%	2.4	0.1	0.1	tr.	-
TOTAL:	No.	19,933	12,379	6,594	5,927	2,141
	%	100.0	100.0	100.0	100.0	100.0

1/ From Wright (1970).

Sixty-one percent of the 12,618 anglers censused on Pool 18 (a southern pool) were from Illinois, with most of the remaining 39 percent being from Iowa. Of the anglers, 49 percent sought channel catfish, 40 percent sought any species, 8 percent sought bluegills and crappies, and 6 percent sought walleye and sauger. The catch rates were 0.98 fish/man-hr during the summer, 0.88 fish/man-hr during the fall, and averaged 0.95 fish/man-hr overall, a rate comparable to that from Pool 13. Catfish, bluegills,drum, crappies, and white bass comprised 84 percent of the total catch of Pool 18. Both walleye and northern pike comprised less than 1 percent of the catch. Total catch per acre averaged 0.90 lb/acre/mo, indicating that the sport fishery of Pool 18 was somewhat more productive than that of Pool 13.

Additional creel surveys were conducted by Commonwealth Edison Co. during varying intervals from 1972 through 1974. The results of these surveys are discussed in section 4.1.1.6.

3. The Station

3.1 General Description

Quad-Cities Station is a nuclear fueled steam electric generating facility that began operation in 1972. Each reactor has a thermal output of 2,511 megawatts thermal (MWt) with a net electrical output of 809 megawatts net electrical (MWe). Each unit utilizes a single cycle forced circulation boiling water reactor producing steam for direct use in the steam turbines. The mechanical, thermal, hydraulic and nuclear design of these reactors is comparable to several other boiling water reactors. The total condenser water flow at full pump capacity is 942,480 gallons per min. (gpm) or ca. 2,100 cubic feet per second (cfs). The total discharge including house service is ca. 2,265 cfs.

The maximum designed water temperature rise from intake to discharge (ΔT) is 23 F (12.8 C), with a maximum heat rejection of 11.7×10^9 BTU per hour. At a lower station power level, the temperature rise is proportionately lower as long as the station cooling water flow remains at 2,270 cfs (e.g., at 50% of full power, temperatures is ca. 11.5 F; at 20% of full pwer, temperature rise is ca. 4.6 F). While the original design of the reactor and steam-electric plant (including the condenser and its cooling water system) has been retained, the means by which the heat is dissipated to the environment has undergone several changes. These changes are discussed in greater detail in section 3.2 of this report.

The station operated with an open-cycle condenser cooling system from April 1972 until May 1974. With the exception of a short period of time (April -July 1972) when an interim side-jet discharge was utilized (discussed in Section 3.2), all of the heated condenser water was discharged into the river through a multi-port diffuser system consisting of two 16 foot diameter manifolds buried in the river bed with ports installed at intervals along the length of the manifolds. The location and position of the pipes in the river are shown in Figure 6.

A new system of cooling was initiated at Quad-Cities Station in May, 1974, pursuant to which approximately 53% of the heated condenser effluent (Unit 1) is cooled by a spray canal system and the remaining 47% (Unit 2) is discharged into the river through the south diffuser pipe. The spray canal is approximately 14,000 feet long, 185 feet wide and nine feet deep, and is designed to accommodate a flow of about one million gpm. Six lift pumps, each with a capacity of 167,000 gpm, move the heated effluent from the discharge bay into the canal where it is

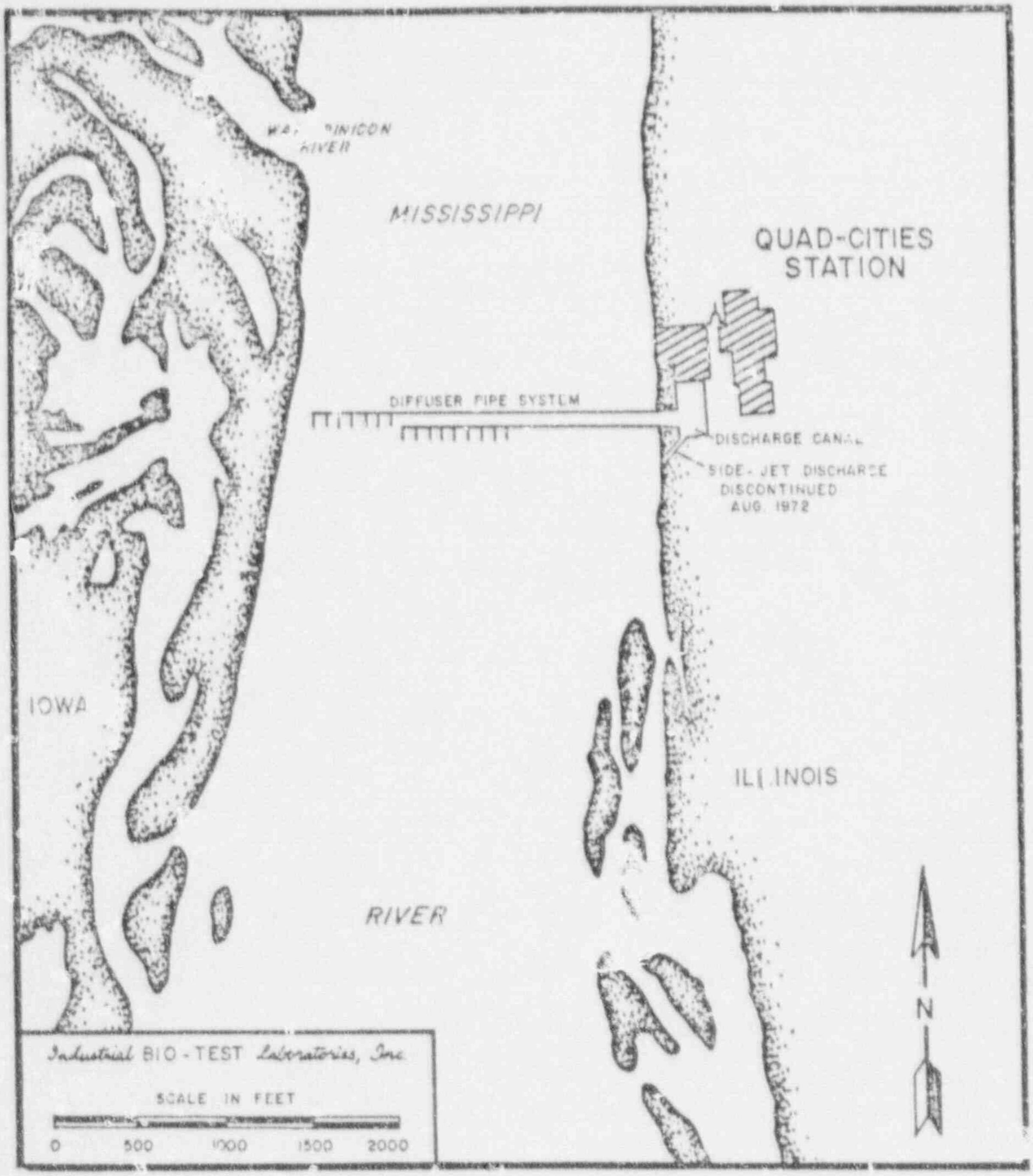


Figure 6 Location map of diffuser pipe system at The Quad-Cities Station

cooled by the evaporative action of approximately 300 floating spray modules. The cooled water returns to the intake bay and is recirculated through the condensers.

3.2 Evolution of Condenser Cooling Water Discharge Systems

The original condenser water discharge design for Quad-Cities Station in 1968 proposed that the discharge water be returned to the east bank of the river by means of a channel and then conveyed into the deeper, higher velocity region of the river's main channel along a straight wing dam extending 1,200 ft. from the east bank and inclined approximately 70 degrees from the downstream shore. However, a thermal-hydraulic study predicted that this method of open-cycle discharge would violate the State of Illinois thermal criteria, limiting the maximum rise above ambient river temperature to 5 F at the edge of the 600 ft. radius mixing zone.

Model studies conducted by the Iowa Institute of Hydraulic Research to determine the optimum method for rapid water mixing narrowed the alternative methods of discharge to some type of multi-port diffuser system (Jain 1971). Since sufficient time was not available to adequately test, design and install a multi-port diffuser system prior to the scheduled station start-up date, an interim side-jet system for discharging [illegible] cooling water was developed. The side-jet was formed by [illegible] sheet metal piling to block the open end of the discharge canal except for a 35 foot wide opening in the center of the canal. The water velocity through the opening at 2,270 cfs is about 4.4 feet per second and this relatively high velocity aided in mixing the discharged condenser cooling water with the river water.

The side-jet system operated from the time of plant start-up

in January 1972 until August 1972, when the diffuser pipe system was placed in operation.

This system consists of a multi-port discharge at the bottom of the main channel of the river. The diffuser pipe extends across the main channel and lies below the 18 foot maximum depth required for navigation. No heated water is dischargedto the shallow off-channel portions of the river, since the lower velocity in the shallows does not provide effective dilution. Each of the 51 jets are 29-in. in diameter and can be made smaller if desired. The jets are in two groups with a 19.7 foot spacing (on centers) for one group and 39.3 foot spacing for the other group. The design of the diffuser system is illustrated in Figure 7. Mixing of the heated water with river water to give a temperature rise not exceeding 5 F has been shown to occur within 500 ft. downstream of the diffuser pipes (see section 4.2.8).

In the spring of 1972, Commonwealth Edison settled a lawsuit which had been brought by the Attorney General of the State of Illinois and by the Izzak Walton League to enjoin operation of the plant. The settlement provided that the Company would construct an off-stream spray canal system for cooling the condenser water discharge from the plant and that one unit of the plant would be placed on the canal system in mid-1974 and the other unit in mid-1975.

Nonetheless, comprehensive biological and limnological monitoring conducted during diffuser pipe operation has conclusively shown that there has been no detectable effect on any biotic or abiotic component in the river.

The diffuser pipe system was in operation from August 1972 until May 1974 for both units of the plant and subsequently for one unit.

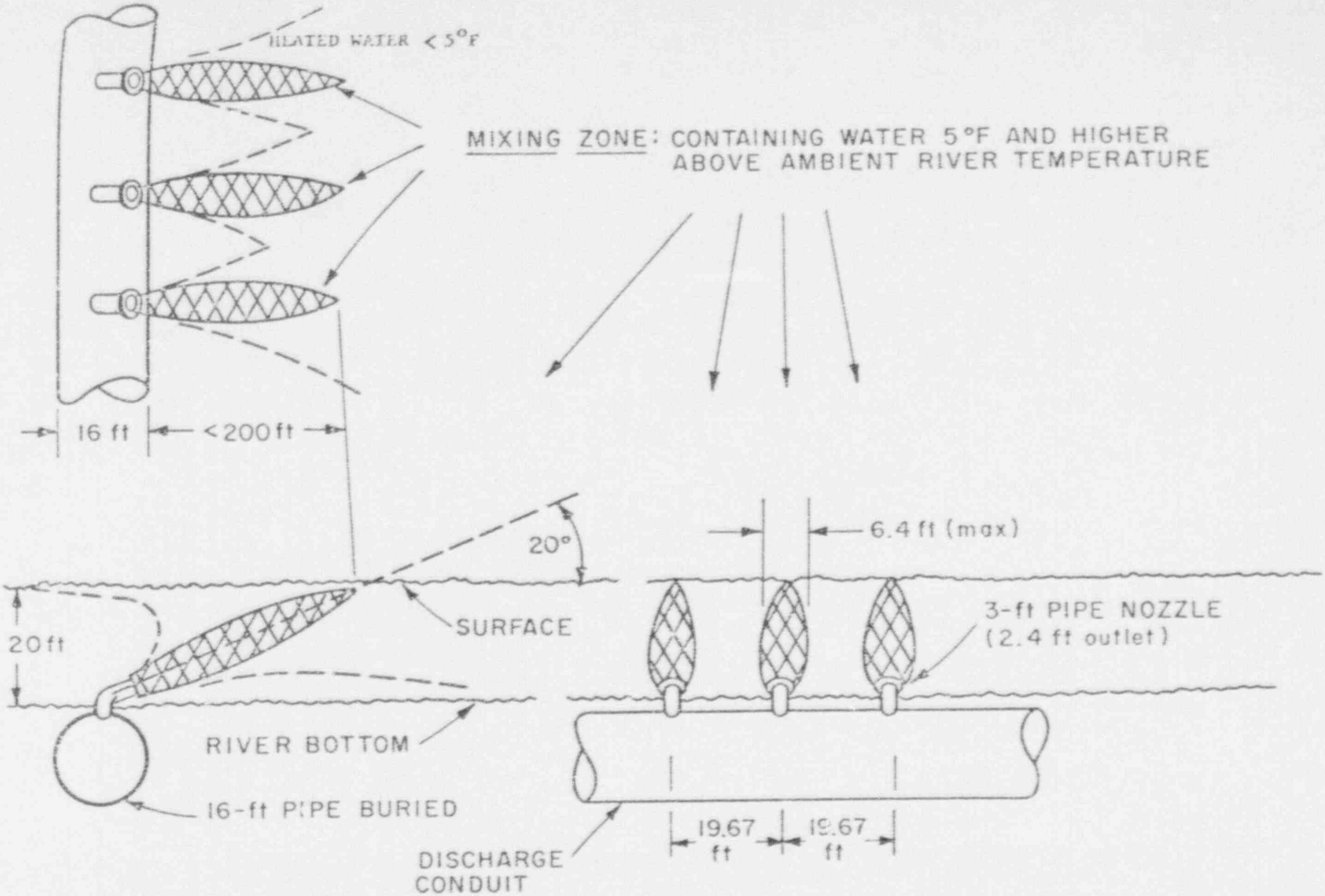


Figure 7. Diffuser Pipe System and Thermal Plumes (not to scale)

4. Environmental Effects of Station Operation

4.1 Operational History

4.1.1 Evidence of Compliance with Water Quality Standards

The Illinois and Iowa water quality criteria applicable to the Mississippi River in the vicinity of the Quad-Cities Station are shown in Table 11. The physical-chemical and bacteriological characteristics of the Mississippi River near the Quad-Cities Station are attributable to a complex of natural and cultural factors including river flow, dilutic , runoff, seasonal changes and upstream municipal and industrial discharges. During the period August 1971 to July 1974 concentrations of several of the chemical parameters observed in the Mississippi River were occasionally found to be in excess of the applicable water quality criteria. However, these high levels occurred both upstream and downstream of the Quad-Cities Station and could not be attributed to the operation of the station.

Examination of the water quality data presented in Table 20 of Section 4.3 indicates that, with the exception of chlorine residuals, at no time did the operation of the Quad-Cities Station result in significant changes in any of the chemical parameters listed in the water quality critera.

Residual chlorine from the chlorination of the station's condenser cooling water was detected in the Mississippi River downstream of the discharge on only one occasion during the operation of the interim side-jet discharge system on July 27, 1972. Residual chlorine has never been detected in the Mississippi River below the Quad-Cities Station during the period of diffuser pipe operation. A summary of chlorine determinations at Quad-Cities Station is given in Table 21 of Section 4.3.

During the interim side-jet period, plume temperatures measured at the downstream edge of the 600 ft. mixing zone were as much as 12.5 F

Table 11. Illinois and Iowa water quality criteria applicable to Pool 14 of the Mississippi River.

Parameter	Criteria	Authority
Ammonia nitrogen	1.5 mg/l	a
	2.0 mg/l	d
Cyanide	0.025 mg/l	a, c, d
	0.01 mg/l	b
Copper	0.02 mg/l	a, d
Dissolved oxygen	Dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time.	a
	Dissolved oxygen shall not be less than 5.0 mg/l during at least 16 hours of any 24 hour period, nor less than 4.0 mg/l at any time. (warm water areas)	c
	Dissolved oxygen shall not be less than 7.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time. (cold water areas)	d
Fecal coliform	Based on a minimum of five samples taken over not more than a 30-day period, fecal coliforms shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30-day period, exceed 400 per 100 ml.	a
	Numerical bacteriological limits of 200 fecal coliforms per 100 ml for primary contact recreational waters are exceeded during low flow periods when such bacteria can be demonstrated to be attributed to pollution by sewage.	e
Iron (total)	1.0 mg/l	a
	0.3 mg/l	b

Table 11. Continued.

Parameter	Criteria	Authority
Lead (total)	0.1 mg/l 0.05 mg/l	a, d b, c
Manganese (total)	1.0 mg/l 0.05 mg/l	a b
Mercury	0.0005 mg/l	a
Metals	A maximum of 5.0 mg/l for the entire heavy metal group shall not be exceeded.	d
Nitrates plus nitrites	10.0 mg/l	a
Oil (Hexane-solubles or equivalent)	0.1 mg/l	b
pH	pH shall be within the range of 6.5 to 9.0 except for natural causes. pH shall be within the range of 6.8 to 9.0.	a d
Phenols	0.1 mg/l, except for natural causes 0.001 mg/l	a b, c, d
Phosphorus	Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake, or in any stream at the point where it enters any reservoir or lake.	a
Temperature	(a) There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions. (b) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.	a a

Table 11 ...inued.

Parameter	Criteria	Authority
Temperature (continued)	(c) The maximum temperature rise above natural temperatures shall not exceed 5°F.	a
	(d) In addition, the water temperature at representative locations in the main river shall not exceed the maximum limits in the following table during more than one percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits of the following by more than 3°F.	a
	(e) (Temperature - Mississippi River, Iowa Border to Alton Lock and Dam) Jan. 45°F (7.2°C), Feb. 45°F (7.2°C), Mar. 57°F (13.9°C), Apr. 68°F (20.0°C), May 78°F (25.6°C), June 86°F (30.0°C), July 88°F (31.1°C), Aug. 88°F (31.1°C), Sept. 86°F (30.0°C), Oct. 75°F (23.9°C), Nov. 65°F (18.3°C), Dec. 52°F (11.1°C).	a
	(f) Not to exceed a 90°F (32.2°C) maximum temperature from the Wisconsin border to the Missouri border nor a 5°F (2.8°C) change from background or natural temperature in the Mississippi River.	d
Total Dissolved Solids	1000 mg/l 500 mg/l	a b
Zinc	1.0 mg/l	a, d

[a] Illinois Pollution Control Board. 1972. General standards. Water pollution regulations of Illinois. State of Illinois, the Environmental Protection Agency. March 7, 1972.

Table 11 Continued.

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[b] Illinois Pollution Control Board. 1972. Public and food processing water supply standards. Water pollution regulations of Illinois. State of Illinois, the Environmental Protection Agency. March 7, 1972.

[c] Iowa Water Pollution Control Commission. 1971. Public water supply standards. Rules and regulations. Water quality standards. June 8, 1971.

[d] Iowa Water Pollution Control Commission. 1971. Aquatic life standards. Rules and Regulations. Water quality standards. June 8, 1971.

[e] Iowa Water Pollution Control Commission. 1971. Recreation standards. Rules and Regulations. Water quality standards. June 8, 1971.

greater than ambient river temperatures. Temperature data to substantiate these conclusions are given in Table 16 of Section 4.2.4. Although during the period of interim side-jet operation from April to August 1972, Illinois thermal standards were occasionally exceeded, heated discharges from the Quad-Cities Station did not result in any violations of the applicable Iowa or Illinois thermal standards during the period of diffuser pipe operation.

4.1.2 Records of Shut-Downs and Effects

Periods of plant shut-downs in excess of 100 hours are listed in Table 12. Although intensive studies have been consistently conducted at Quad-Cities Station throughout the entire operational period, no evidence of deleterious environmental effects due to the shut-downs were observed. The effects of station operation on aquatic biota are discussed in detail in Section 4.4.1.

4.1.3 Communications with Regulatory Agencies

During the period of side-jet operation chlorine concentrations in the discharge exceeded the values allowed by the AEC Technical Specifications for the Quad-Cities Station. The AEC granted a waiver extending the time period allowed to correct these high chlorine levels. Agreement was reached with the State of Illinois during the period of interim side-jet operation to allow a variance from the thermal standards.

Since operation of the Quad-Cities Station has not resulted in violation of applicable state water quality standards, there has been no communication with state regulatory agencies concerning violations.

4.1.4 Chronology and Status of Environmental Monitoring Programs

Studies to determine the physical, chemical and biological characteristics of the Mississippi River in the vicinity of the Quad-Cities Station have been conducted since 1968 (Figure 8). These studies included preoperational surveys to determine baseline ecological conditions in the river prior to

Table 12

Major Outages (100 hours or more) at Quad-Cities Station
June 1973-July 1974

Date	Unit	Duration Hrs.	Duration Mins.	Cause
Aug. 1, 1973	1	114	25	Starter Node >15% Power
Sept. 22	1	196	51	Scheduled Maintenance
July 29	2	110	11	Control Blade Testing
Oct. 17	2	117	26	Scheduled Maintenance
Jan. 1, 1974	1	137	15	Condenser Tube Leak
Mar. 31	1	2,184	00	Refueling Outage
Mar. 23	2	188	13	Recombiner Cut Over; LPCI Valve Out of Service
June 10	2	160	55	Min. Feed Waterflow Line Severed

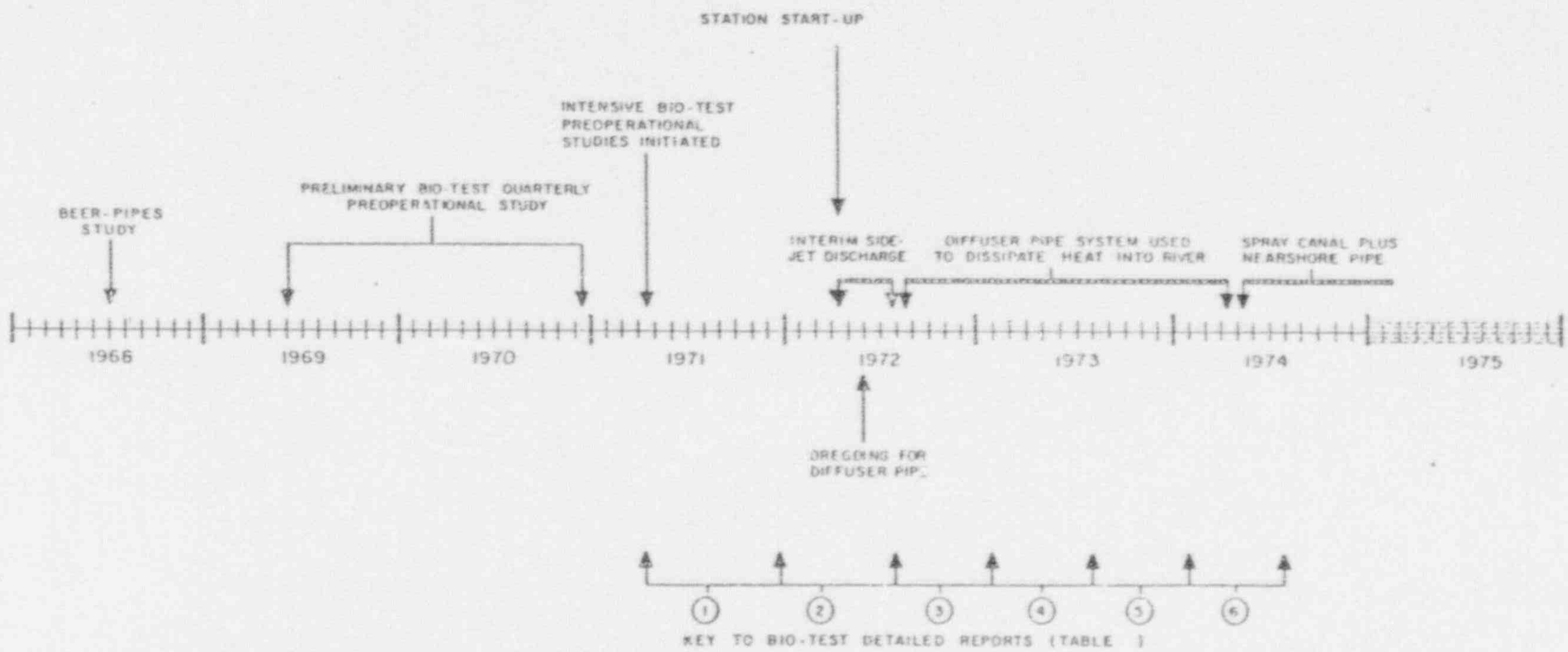


Figure 8. Chronology of plant operation, and key to environmental monitoring program reports for the Quad-Cities Station.

station start-up and operational studies of the environmental impact of the discharge of condenser cooling water into the river. Operational studies were carried out during the period of operation of the interim side-jet discharge from January to July 1972 and continued from start-up of the diffuser pipe discharge system in August 1972 to the present time.

The first preliminary preoperational survey of the Mississippi River in the vicinity of the Quad-Cities Station was reconnaissance in nature and was conducted during the summer of 1968 by Commonwealth Edison (Beer & Pipes, 1968). From June 1969 to December 1970 a quarterly monitoring program was conducted by Industrial Bio-Test Laboratories, Inc. under a contract with Commonwealth Edison (Industrial Bio-Test Laboratories 1970, 1971). Intensive studies to establish the preoperational physical, chemical and biological characteristics of the Mississippi River in the vicinity of the Quad-Cities Station were implemented on a continuous basis in April 1971 (Industrial Bio-Test Laboratories, 1972a).

Station start-up and testing was commenced in January 1972 and operational studies have been conducted on a continuous basis since that time (Industrial Bio-Test Laboratories, 1972b, 1973a, b; 1974a, b). These studies were designed to assess the impact of the heated discharge from a side-jet and twin diffuser discharge system on the thermal chemical and biological characteristics of the Mississippi River. The results of this monitoring are discussed in detail in sections 4.2 to 4.4 of this report.

4.2 Hydrology and Engineering

4.2.1 Hydrological Characteristics of the Mississippi River

The Mississippi River in the vicinity of the Quad-Cities Station has a drainage area of approximately 85,000 square miles. The flow distribution in the river is distinctly seasonal. Annual high flows usually occur between April and June and the annual low flows occur between December and February. A minimum daily flow of 6,500 cfs was reported in December of 1933. The average flow for the period of record (1864 to 1969) is 47,000 cfs.

The seven-day 10-year low flow as determined by the U. S. Geological Survey at Clinton, Iowa, a short distance upstream from the Quad-Cities Station for the period 1864 to 1969 was 9,400 cfs. Following the construction of navigation dams which resulted in a leveling of river flow, the 7-day 10-year low increased slightly. During the period 1939 to 1968 the 7-day 10-year low flow was 13,200 cfs. Maximum, minimum and average monthly flows for the period of record (1864 to 1969) are given in Table 13.

4.2.2 Current Data

Current velocities in the Mississippi River in the vicinity of the Quad-Cities Station vary both spatially and temporally. In general, maximum current velocities occur in the main channel with substantially lower velocities occurring in channel edge and side-channel areas. Little or no water movement occurs in slough areas.

Current velocities in the main channel are influenced primarily by river stage. In general, greatest current velocities occur during the April-June period when river flow is at a maximum. Maximum current velocities of 1.7 meters/sec have been observed at mid-channel locations during this period. Lowest current velocities usually occur during the fall and winter months. Monthly minimum, average and maximum current velocities observed in the river channel and channel edge areas during the period February 1973-July 1974 are shown in Table 14.

4.2.3 Stratification Characteristics

With the exception of the slough areas, which may exhibit pronounced thermal and chemical stratification during the summer months, little stratification occurs in the river in the vicinity of the Quad-Cities Station. Intermittent thermal stratification has been observed on the Iowa side of the river due to inflow from the Wapsipinicon River and upstream discharges in the vicinity of Clinton, Iowa. However, temperature differentials were transitory and rarely exceeded 2 F. Little evidence of thermal stratification has been observed in the main river channel.

Table 13

Summary of 1864-1969 Mississippi River Discharges*

Month	Average Flow (cfs)	Max. Daily Flow (cfs)	Min. Daily Flow (cfs)
Jan.	24,185	107,000	8,000
Feb.	26,375	100,000	9,000
Mar.	47,289	164,400	7,000
Apr.	86,563	307,000	17,400
May	79,662	284,000	18,100
June	69,421	250,000	14,600
July	55,463	215,000	11,900
Aug.	36,791	116,000	10,500
Sept.	36,733	176,000	10,500
Oct.	39,508	237,000	12,500
Nov.	36,570	213,000	10,000
Dec.	25,443	90,400	6,500

*U.S.G.S. Data from Clinton, Iowa

Table 14

Summary of Current Velocities in the Mississippi River
Near Quad-Cities for the Period February 1973-August 1974*
(Current velocities in meters/sec)

	1973			1974		
	Low	Average	High	Low	Average	High
Jan.				0.1	0.2	0.5
Feb.	0.1	0.4	0.6	0.1	0.1	0.2
Mar.	0.7	0.7	1.4	0.1	0.2	0.4
Apr.	0.4	1.0	1.6	0.2	0.4	1.0
May	0.3	0.9	1.4	0.1	0.4	1.1
June	0.2	0.7	1.0	0.1	0.9	1.7
July	0.1	0.3	0.8	0.2	0.2	0.6
Aug.	0.1	0.2	0.5			
Sept.	0.1	0.2	0.3			
Oct.	0.1	0.3	0.6			
Nov.	0.1	0.2	0.3			
Dec.	0.1	0.2	0.5			

*Date collected by Industrial Bio-Test Laboratories

4.2.4. Ambient Temperature of the Receiving Waters

Prior to the implementation of studies at the Quad-Cities Station, only a limited amount of information concerning ambient river temperature in the vicinity of the site was available. The United States Geological Survey established a temperature recording station near Fulton, Illinois in 1969 but earlier data are not available.

However, a good deal of long-term temperature data are available from the Davenport, Iowa water plant, approximately 22 miles downstream from the Quad-Cities Station, and these data are believed to be representative of the thermal characteristics of Pool 14. Monthly maximum, average maximum and average water temperatures recorded at the Davenport water plant during the period 1962 to 1970 are given in Table 15. Maximum temperatures generally occur during July and have not been reported to exceed 86 F. in the main channel. It has been reported that the river temperature at Davenport has been measured at 85 F. or higher only about 1/10th or 1 percent of the time (Ryckman, Edgerley, Tomlinson & Associates, 1971).

Continuous monitoring of water temperatures upstream and 600 feet downstream from the Quad-Cities Station was initiated in October 1971. The results of these determinations are summarized in Table 16. In general, average ambient river temperatures determined from October 1971 through July 1974 were similar to comparable seasonal temperatures reported by Ryckman, Edgerley, Tomlinson & Associates (1971). With the exception of May 1972 and September 1973, maximum monthly temperatures were lower than those compiled by Ryckman, Edgerley, Tomlinson & Associates from the Davenport water treatment plant records during the 1962-1971 period. During the October 1971-July 1974 period a maximum ambient river temperature of 83.3 F. was recorded by the upstream river sensor in July of 1974.

During the period of interim side-jet operation (April-August 1972) plume temperatures measured at the downstream edge of the 600 ft. mixing

Table 15

Monthly Average and Monthly Maximum Temperatures
in the Mississippi River at the Davenport
Water Treatment Plant - July 1962 - February 1971*

Month	Maximum Observed Temp.	Average Temp.
Jan.	37	33.1
Feb.	38	33.3
Mar.	54	37.0
Apr.	63	49.2
May	73	62.5
June	81	72.8
July	85	77.8
Aug.	83	76.6
Sept.	80	68.9
Oct.	69	57.4
Nov.	55	44.0
Dec.	42	34.3

*Compiled by RETA 1971

TABLE 16

Summary of Mississippi River Temperatures (^{o}F) by Continuous Monitoring Upstream and 600' Downstream of the Quad Cities Station Oct. 1971-July 1974.

DATE (Week Ending)	UPSTREAM TEMP. Min.	Max.	Mean	DOWNSTREAM TEMP. Min.	Max.	Mean	Footnote
Oct. 23 1971	61.6	62.6	61.9		62.9	62.1	A, E, F, H, V
Oct. 30 1971	58.0	62.3	60.6		62.5	60.7	A, E, F, H
Nov. 6 1971	42.0	59.6	51.1		60.4	51.8	A, E, F, H
Nov. 13 1971	37.1	41.8	38.8		43.6	40.6	A, E, F, H
Nov. 20 1971	44.6	45.7	43.5		47.4	44.9	A, E, F, H, R
Nov. 27 1971	34.0	38.2	36.7		41.0	39.0	A, E, F, H, T
Dec. 4 1971	32.3	35.4	33.7		38.1	34.1	A, E, F, H
Dec. 11 1971	32.6	37.1	34.6		41.5	35.3	A, E, F, H, S
Dec. 18 1971	32.1	36.6	34.7		40.0	37.6	A, E, F, H
Dec. 25 1971	32.4	33.6	32.8		37.2	35.5	A, E, F, H
Jan. 1 1972	32.1	34.5	32.8		37.5	35.4	A, E, F, H
Jan. 8 1972	33.7	35.8	34.1		38.2	35.5	A, E, F, H
Jan. 15 1972	33.9	35.0	34.3		37.2	35.7	A, E, F, H
Jan. 22 1972	34.0	34.6	34.3		36.6	35.9	A, B, E, F, G, H
Jan. 29 1972	34.0	34.5	34.3		36.5	35.7	A, B, E, F, G, H
Feb. 5 1972	33.2	34.4	33.7		36.6	35.6	A, B, E, F, G, H
Feb. 12 1972	32.1	33.6	32.8		36.6	33.1	A, B, E, F, G, H
Feb. 19 1972	32.4	32.7	32.5		34.1	32.5	A, B, E, F, G, H
Feb. 26 1972	32.3	33.0	32.6		33.3	32.6	A, B, E, F, G, H
Mar. 4 1972	32.4	33.5	32.7		36.5	32.7	A, B, E, F, G, H
Mar. 11 1972	32.4	35.0	33.0		34.6	33.0	A, B, E, F, G, H
Mar. 18 1972	32.4	35.7	33.8		40.0	34.8	A, B, E, F, G, H
Mar. 25 1972	33.9	39.9	37.3		45.4	38.6	A, B, E, F, G, H
Apr. 1 1972	33.7	39.3	35.8		42.7	36.0	A, B, E, F, G, H, T
Apr. 8 1972	33.3	37.9	35.5		32.9	35.7	A, B, C, E, F, G, H, K
Apr. 15 1972	35.5	46.4	41.6		50.2	42.1	A, B, E, F, G, H
Apr. 22 1972	45.2	51.6	48.5		54.2	48.5	A, B, E, F, G, H
Apr. 29 1972	45.1	51.3	47.8		53.6	47.9	A, B, E, F, G, H
May 6 1972	51.4	57.7	54.4				A, B, F, G, H, I
May 13 1972	50.5	62.9	56.5		66.3	59.0	A, B, E, F, G, H, L
May 20 1972	61.6	73.2	66.8		78.8	69.4	A, B, E, F, G, H, L
May 27 1972	72.5	77.6	75.8		79.3	75.1	A, B, E, F, G, H, L
June 3 1972	66.8	77.4	71.4		89.9	77.6	A, B, E, F, G, H, L
June 10 1972	69.5	75.4	72.9		80.4	74.8	A, B, E, F, G, H
June 17 1972	67.7	75.0	71.5		85.6	73.7	A, B, E, F, G, H, J
June 24 1972	67.2	72.9	69.9		81.2	75.9	A, B, E, F, G, H, L
July 1 1972	69.0	78.5	74.8		90.5	82.1	A, B, E, F, G, H
July 8 1972	71.0	77.6	74.0		88.3	78.1	A, B, E, F, G, H, K
July 15 1972							X
July 22 1972							X
July 29 1972							X
Aug. 5 1972	71.5	75.0	73.4		77.1	73.8	B, F, G, H, W

Table 16 (Cont.)

Summary of Mississippi River Temperatures (^{o}F) by Continuous Monitoring Upstream and 600' Downstream of the Quad Cities Station Oct. 1971-July 1974.

DATE	UPSTREAM TEMP.			DOWNSTREAM TEMP.			
(Week Ending)	Min.	Max.	Mean	Min.	Max.	Mean	Footnote
Aug. 12 1972	67.5	71.0	69.4		73.0	70.2	B,F,G,H,S
Aug. 19 1972	71.0	83.0	78.7		84.5	78.2	B,F,G,H,T
Aug. 26 1972	72.0	79.9	77.3		80.4	76.1	B,F,G,H,U
Sep. 2 1972	71.0	77.5	74.9		78.0	74.2	B,F,G,H,T
Sep. 9 1972	68.5	71.5	69.7		73.2	70.2	B,F,G,H
Sep. 16 1972	68.0	71.5	69.4		73.0	69.8	B,F,G,H
Sep. 23 1972	65.0	68.5	67.1		70.5	67.7	B,F,G,H,P
Sep. 30 1972	58.0	67.0	63.0		69.0	63.5	B,F,G,H,S
Oct. 7 1972	57.5	59.5	58.5		61.5	58.8	B,F,G,H
Oct. 14 1972	55.0	58.5	56.2		60.0	57.2	B,F,G,H
Oct. 21 1972	45.0	55.5	49.1		57.5	49.6	B,F,G,H
Oct. 28 1972	44.5	47.5	45.9		49.5	46.4	B,F,G,H
Nov. 4 1972	44.5	46.9	45.9		50.0	46.5	B,F,G,H
Nov. 11 1972	43.0	46.2	44.1		47.4	44.4	B,F,G,H
Nov. 18 1972	37.5	43.5	40.3		43.8	40.3	B,F,G,H
Nov. 25 1972	34.9	39.0	36.0		40.2	36.4	B,F,G,H
Dec. 2 1972	32.5	36.5	34.1		38.6	34.9	B,F.G,H
Dec. 9 1972	32.0	33.0	32.2		35.0	33.5	B,F,G,H
Dec. 16 1972	32.0	32.5	32.3		34.9	33.3	B,F,G,H
Dec. 23 1972	32.0	32.5	32.3		34.8	33.1	B,F,G,H
Dec. 30 1972	32.0	32.3	32.2		34.9	33.1	B,F,G,H,R
Jan. 6 1973	32.0	32.3	32.1		32.6	32.2	B,F,G,H,Q
Jan. 13 1973	32.0	32.3	32.0		33.3	32.3	B,F,G,H
Jan. 20 1973	32.0	32.3	32.0		32.9	32.2	B,F,G,H
Jan. 27 1973	32.0	32.5	32.1		34.3	32.5	B,F,G,H
Feb. 3 1973	32.0	32.9	32.2	32.3	34.3	32.7	B,G,M
Feb. 16 1973	32.0	32.7	32.3	32.0	34.1	32.6	B,G
Feb. 17 1973	32.0	32.8	32.1	32.0	34.9	33.1	B,G
Feb. 24 1973	32.0	33.1	32.3	32.0	36.0	33.3	B,G
Mar. 3 1973	32.0	36.7	33.9	32.0	36.9	34.7	B,G
Mar. 10 1973	36.4	42.0	39.3	36.5	42.5	39.5	B,G
Mar. 17 1973	40.5	46.0	43.0	40.5	46.5	42.9	B,G
Mar. 24 1973	39.5	42.5	41.1	39.5	42.7	41.4	B,G
Mar. 31 1973	41.7	46.5	44.3	41.7	46.8	44.4	B,G
Apr. 7 1973	44.0	48.5	46.1	44.1	48.8	46.3	B,G
Apr. 14 1973	38.5	48.0	41.5	38.5	48.5	41.7	B,G
Apr. 21 1973	44.5	56.0	50.9	44.4	56.4	50.9	B,G
Apr. 28 1973	56.5	58.0	57.2	56.4	58.4	57.3	B,G,T
May 5 1973	54.0	57.5	55.9	53.8	57.6	55.9	B,G
May 12 1973	54.7	57.8	56.3	54.7	58.1	56.4	B,G
May 19 1973	57.2	60.5	58.2	57.1	60.7	58.3	B,G
May 26 1973	60.0	63.7	62.5	60.0	64.4	62.7	B,G
June 2 1973	59.8	67.8	62.5	59.7	69.7	62.7	B,G
June 9 1973	67.0	76.5	70.5	67.9	76.9	70.8	B,G
June 16 1973	76.0	80.5	77.6	76.1	80.5	77.9	B,G
June 23 1973	72.4	77.0	74.7	72.4	77.6	74.9	B,G
June 30 1973	74.0	76.0	74.8	74.0	76.6	75.3	B,G

Table 16 (Cont.)

Summary of Mississippi River Temperatures (^{o}F)
by Continuous Monitoring Upstream and 600' Downstream of the Quad Cities Station Oct. 1971-July 1974.

DATE	UPSTREAM TEMP.			DOWNSTREAM TEMP.			
(Week Ending)	Min.	Max.	Mean	Min.	Max.	Mean	Footnote
July 7 1973	74.5	79.7	77.7	74.5	80.9	78.5	B,G
July 14 1973	79.0	82.8	80.9	79.6	84.4	82.1	B,G
July 21 1973	77.4	79.6	78.3	77.7	81.5	79.9	B,G
July 28 1973	73.9	78.8	76.0	74.1	80.2	77.4	B,G
Aug. 4 1973	72.9	77.6	75.8	72.9	78.7	76.1	B,G
Aug. 11 1973	75.5	80.0	77.3	75.3	80.7	78.3	B,G
Aug. 18 1973	76.3	80.2	78.0	76.8	81.3	79.1	B,G
Aug. 25 1973	71.4	78.7	75.1	71.7	80.6	76.2	B,G
Sep. 1 1973	72.5	80.7	77.5	73.2	82.1	78.7	B,G
Sep. 8 1973	74.5	80.4	77.3	74.8	81.4	78.2	B,G
Sep. 15 1973	67.2	74.4	70.0	68.3	75.9	71.0	B,G
Sep. 22 1973	61.2	68.0	63.4	62.0	68.9	64.5	B,G
Sep. 29 1973	62.4	67.5	65.5	62.7	68.6	66.1	B,G
Oct. 6 1973	62.0	66.0	64.2	62.2	66.5	65.0	B,G
Oct. 13 1973	61.4	65.6	63.8	61.9	66.9	64.7	B,G
Oct. 20 1973	55.9	64.0	59.5	56.0	66.0	60.1	B,G
Oct. 27 1973	55.3	58.0	56.5	55.9	58.5	57.1	B,G
Nov. 3 1973	46.4	55.0	50.3	46.5	57.0	51.2	B,G
Nov. 10 1973	37.4	46.5	42.0	37.6	48.3	43.0	B,G
Nov. 17 1973	37.8	41.1	39.7	38.0	42.5	40.4	B,G
Nov. 24 1973	40.0	43.3	42.2	40.3	44.2	47.3	B,G
Dec. 1 1973	38.5	43.2	41.3	39.0	44.2	42.0	B,G
Dec. 8 1973	34.3	41.1	37.8	34.3	41.7	38.4	B,G
Dec. 15 1973	32.0	34.0	32.2	32.0	35.0	33.2	B,G
Dec. 22 1973	32.0	32.4	32.1	32.0	34.2	33.1	B,G
Dec. 29 1973	32.0	32.2	32.0	32.0	35.2	32.7	B,G
Jan. 5 1974	32.0	32.3	32.0	32.0	34.0	32.4	B,G
Jan. 12 1974	32.0	32.1	32.0	32.0	33.5	32.4	B,G
Jan. 19 1974	32.0	32.2	32.1	32.0	35.1	33.0	B,G
Jan. 26 1974	32.0	32.8	32.3	32.0	34.4	32.9	B,G
Feb. 2 1974	32.0	32.7	32.0	32.0	33.5	32.4	B,G,N
Feb. 9 1974	32.0	32.5	32.1	32.0	34.3	33.0	B,G,N
Feb. 16 1974	32.0	32.8	32.1	32.0	35.6	33.4	B,G,N
Feb. 23 1974	32.0	33.4	32.5	32.4	35.6	34.1	B,G,N,O
Mar. 2 1974	32.0	34.5	32.9	33.0	36.1	34.2	B,G,O
Mar. 9 1974	34.5	39.6	37.3	34.2	40.8	37.6	B,G,O
Mar. 16 1974	37.5	39.7	38.7	37.2	41.1	38.9	B,G,O
Mar. 23 1974	34.2	39.1	37.7	34.5	40.3	38.3	B,G,O
Mar. 30 1974	31.9	38.7	35.8	32.6	39.4	36.4	B,G,O
Apr. 6 1974	37.5	45.9	42.0	37.5	45.2	42.0	B,G
Apr. 13 1974	42.0	49.4	45.0	41.5	50.0	45.1	B,G
Apr. 20 1974	47.7	54.1	50.1	47.4	56.4	50.5	B,G
Apr. 27 1974	50.4	57.5	53.9	50.4	57.9	54.2	B,G
May 4 1974	57.5	62.4	60.4	57.4	63.0	60.7	B,G
May 11 1974	53.5	62.1	56.9	53.1	63.0	57.5	B,G
May 18 1974	53.0	57.2	55.3	53.2	60.2	55.7	B,G
May 25 1974	56.4	67.2	62.7	56.3	67.9	62.9	B,G

Table 16(Cont.)

Summary of Mississippi River Temperatures (^{o}F) by Continuous Monitoring Upstream and 600' Downstream of the Quad Cities Station Oct. 1971-July 1974.

DATE	UPSTREAM TEMP.			DOWNSTREAM TEMP.			
(Week Ending)	Min.	Max.	Mean	Min.	Max.	Mean	Footnote
June 1 1974	63.9	66.8	65.1	63.9	68.0	65.6	B,G
June 8 1974	69.5	72.4	71.1	66.5	73.5	70.8	B,D,G
June 15 1974	67.0	71.5	69.0	67.0	72.0	69.3	B,G
June 22 1974	66.2	72.9	69.4	66.0	73.2	69.7	B,G
June 29 1974	67.7	73.4	70.4	67.9	74.1	70.6	B,G
July 6 1974	72.8	78.6	75.9	73.0	79.6	76.3	B,G
July 13 1974	79.0	83.0	81.1	79.5	85.0	81.9	B,G,T
July 20 1974	79.5	83.3	81.4	80.3	83.9	82.1	B,G
July 27 1974	77.6	82.7	79.8	78.5	83.8	80.7	B.G

Notes pertaining to upstream only:

A - Upstream temperatures taken at intake
B - Upstream mean values represent averages of daily means
C - Upstream values based on 5 days of data. Instrument malfunction.
D - Upstream values based on 6 days of data. Instrument malfunction.

Notes pertaining to downstream only:

E - Downstream temperatures taken at edge of 600 ft. mixing zone
F - Downstream maximum and mean values computed by adding ΔT to upstream maximum and mean temperatures respectively.
G - Downstream mean values are averages of daily means
H - Downstream minimum temperatures not recorded
I - Downstream temperatures not recorded because of sensor malfunction
J - Downstream values based on 3 days of data. Sensors malfunctioned.
K - Downstream values based on 4 days of data. Sensors malfunctioned.
L - Downstream values based on 6 days of data. Sensors malfunctioned.
M - Value for average minimum downstream temperatures computed from daily means for February 1, 2 and 3
N - Date from 2 February through 21 February 1974 are not based on infrequent individual readings due to non-functioning sensors downstream.
O - Downstream data from 22 February through 28 February 1974 are based on hourly readings from sensors C and D only. Downstream sensors A and B were still non-functional.

Notes pertaining to upstream and downstream:

P - All values based on two days of data. Sensors mal-functioned.
Q - All values based on 3 days of data. Sensors malfunctioned.
R - All values based on 4 days of data. Sensors malfunctioned.
S - All values based on 5 days of data. Sensors malfunctioned.
T - All values based on 6 days of data. Sensors malfunctioned.
U - All values based on 2 days of data
V - All values based on 4 days of data
W - All values based on 5 days of data
X - No data available

zone were as much as 12.5 F greater than ambient river temperatures and temperatures in the Illinois Island area immediately downstream from the station reached a maximum of 91 F. With the exception of this period, however, maximum temperatures recorded by the downstream sensors 600 feet below the diffuser pipes have never exceeded 85 F. Thermal plume characteristics are discussed in detail in section 4.2.1.

Slough temperatures may be considerably higher than main channel temperatures. Observations in Pool 14 have shown that temperatures in sloughs may exhibit diurnal variations of as much as 12 F and in one study conducted in June 1971, slough temperatures 18 F higher than main channel temperatures were reported (Ia. Geol. Surv., 1971). These waters are unaffected by diffuser pipe operation of the plant.

4.2.5 Meterological Characteristics of Site and Data

The regional meteorological characteristics of the Quad-Cities region have been summarized by Murry and Trettle (consulting meteorologists, Northfield, Illinois). They indicate that the site is located in rolling prairie terrain, typical of much of Illinois and there are apparently no topographical features which would have a significant effect on the local meteorology.

Data gathered from on-site meteorological towers and from the Summary of Hourly Surface Observation, Moline, Illinois, by the U. S. Weather Bureau show a rather uniform distribution of wind direction which is typical of mid-continent locations. The most frequent wind directions are from the southwest and northwest sectors. (A sector is defined as 22½ degrees.) The highest velocity of wind officially reported at various locations around the site area is 85 mph at Chicago and 75 mph at Peoria. Higher gusts are reported unofficially, up to 109 mph, during heavy thunderstorms and scattered tornadic activity.

Severe winds in the form of tornadoes have been reported in the Quad-Cities region. Thom (1963), using data from 1948-1965, records 18 tornadoes occurring within the one-degree square (2.3 million acres) encompassing the site. Using this method, a mean recurrence interval for a tornado striking a point in this area was calculated to be 1,250 years.

In the 52-year period, 1914-1965, 8 tornadoes have been reported in Rock Island County, Illinois. Within Illinois, a total of 140 were reported during that same 52-year period with 52 being classified as "destructive;" i.e., causing $50,000 damage or more and/or at least one death. In general, a tornado covers an average area of about 8 square miles once it touches down. Widths of tornado paths range from about 100 feet to a maximum of about 4 miles. Tornadoes have been known to touch down repetitively in erratic patterns with path lengths ranging from about 1 mile to 163 miles, which is the longest ever recorded.

Surface temperature and humidity data for Moline reflect the continental-type climate of the area. Extreme high and low temperatures have been 106 F and -26 F respectively. There are an average of 23 days per year with temperatures of 90 F or higher, and 20 days per year when temperatures reach 0 F or lower. There are substantial changes in temperature regimes, typically at 3 to 4-day intervals. Mean annual relative humidity at noon is about 60 percent.

Fog may be classified into three categories: (1) heavy fog reducing visibility to ¼ mile or less; (2) fog reducing visibility to ½ mile or less; and (3) light fog with visibility of 1 mile or less. Weather data show heavy fog is expected in the Quad-Cities area 50 hours per year occurring on 20 days during the year (average duration of fog equals 2½ hours). Approximately 61 hours of moderate fog and 150 hours

of light fog are expected per year in the area. Fog usually occurs during the hours from 3:00 a.m. to 7:00 a.m. There has been no observed increase in the incidence of fog resulting from operation of the station with either the side-jet or the diffuser pipe system. The spray canal will predictably increase the incidence somewhat.

Meteorological data at the Quad-Cities Station site has been collected and summarized by Commonwealth Edison since 1971. The data were obtained from the 35 foot level of the meteorological tower located on station property.

Since the tower is only instrumental for ambient temperature, dew point temperature, wind speed and wind direction, data concerning wet bulb temperature, cloud cover, long wave radiation, short wave radiation and evapotranspiration data are not available from the site. The data collected from this installation is shown in Table 17.

The numbers in parenthesis to the right of the monthly averages in each of the tables indicate the number of hours of data used to calculate average values. For example, during the month of January, 739 hourly observations of ambient temperature out of a possible 744 were used to determine the average.

The seasons have been defined as December through February (winter), March through May (spring), June through August (summer) and September through November (fall).

4.2.6 Characteristics of the Intake Structure

Cooling-water intake for the condensers of both units is provided by an intake canal extending into the river. The dimensions of the canal are approximately 235 ft. long, 180 ft. wide, and 12 ft. deep at the point of juncture with the river (see Figure 8). For once-through operation with either the side-jet or the diffuser, the full flow requirements of the condensers are obtained directly from the river via this intake canal. For closed-cycle operation of one or both units the

Meteorological Data

QUAD 1971 MONTHLY AVERAGES

	Ambient Temp.	Dew Point Temp.	35 Ft. Wind Speed	
January	I	I	I	(N = 0 0 0)
February	I	I	I	(N = 0 0 0)
March	I	I	I	(N = 0 0 0)
April	I	I	I	(N = 0 0 0)
May	I	I	I	(N = 0 0 0)
June	75.7	64.5	6.2	(N = 370 370 370)
July	69.1	61.0	5.8	(N = 730 730 730)
August	70.3	59.7	5.5	(N = 687 687 687)
September	66.8	56.1	5.8	(N = 669 669 669)
October	60.3	52.1	6.2	(N = 423 423 423)
November	38.5	31.5	7.3	(N = 532 532 532)
December	26.7	23.8	3.1	(N = 129 129 129)

QUAD 1971 SEASONAL EXTREMES

	Ambient Temp.		Dew Point Temp.		35 Ft. Wind Speed and Associated Direction			
	Max.	Min.	Max.	Min.	Max.	(Dir)	Min.	(Dir)
Winter	34.1	12.4	34.1	9.7	10	(132)	0	Calm
Spring								
Summer	92.5	47.0	78.5	46.5	22	(179)	0	Calm
Autumn	91.5	16.8	73.0	5.4	22	(190)	C	Calm

Table 17 (Cont.)

QUAD 1972 MONTHLY AVERAGES

	Ambient Temp.	Dew Point Temp.	35 Ft. Wind Speed	
January	15.3	5.3	9.0	(N = 455 455 395)
February	19.8	10.9	6.6	(N = 596 596 596)
March	I	I	I	(N = 0 0 0)
April	46.2	34.9	9.1	(N = 242 242 241)
May	63.4	50.5	5.7	(N = 668 670 670)
June	67.3	56.3	5.8	(N = 719 719 719)
July	72.0	64.2	4.7	(N = 726 730 733)
August	72.8	64.3	4.8	(N = 737 743 743)
September	65.8	55.8	6.3	(N = 697 697 697)
October	49.5	40.5	5.6	(N = 743 743 743)
November	37.0	31.6	6.3	(N = 637 637 636)
December	21.6	18.3	10.3	(N = 707 707 625)

QUAD 1972 SEASONAL EXTREMES

	Ambient Temp.		Dew Point Temp.		35 Ft. Wind Speed and Associated Direction			
	Max.	Min.	Max.	Min.	Max.	(Dir)	Min.	(Dir)
Winter	60.5	-17.7	65.9	-33.4	40	(165)	0	Calm
Spring	87.0	31.9	66.0	17.3	21	(97)	0	Calm
Summer	91.7	40.0	83.1	9.0	21	(205)	0	Calm
Autumn	88.7	18.3	75.8	13.1	25	(37)	0	Calm

Table 17 (Cont.)

QUAD 1973 MONTHLY AVERAGES

	Ambient Temp.	Dew Point Temp.	35 Ft. Wind Speed	
January	28.2	22.1	7.8	(N = 735 735 578)
February	31.1	23.4	8.8	(N = 629 629 672)
March	44.9	38.4	9.6	(N = 724 724 730)
April	50.3	42.1	10.7	(N = 655 655 664)
May	57.2	I	9.2	(N = 742 0 743)
June	71.6	59.4	8.6	(N = 709 579 668)
July	74.5	66.3	6.6	(N = 744 744 742)
August	74.6	67.2	5.9	(N = 744 744 744)
September	63.8	57.7	6.0	(N = 590 590 588)
October	58.1	49.4	6.2	(N = 644 644 622)
November	39.8	28.6	7.1	(N = 674 343 562)
December	23.5	18.3	8.4	(N = 744 716 744)

QUAD 1973 SEASONAL EXTREMES

	Ambient Temp.		Dew Point Temp.		35 Ft. Wind Speed and Associated Direction			
	Max.	Min.	Max.	Min.	Max.	(Dir)	Min.	(Dir)
Winter	64.6	- 5.5	54.4	-15.3	27	(49)	0	Calm
Spring	74.8	25.6	67.8	13.5	37	(51)	0	Calm
Summer	93.4	56.3	80.7	46.0	36	(342)	0	Calm
Autumn	89.9	18.7	74.6	7.1	23	(113)	0	Calm

Table 17 (Cont.)

QUAD 1974 MONTHLY AVERAGES

	Ambient Temp.	Dew Point Temp.	35 [illegible] Wind Speed			
January	21.7	15.4	5.7	(N =	739 739	641)
February	26.2	19.8	7.6	(N =	665 665	460)
March	37.6	26.[illegible]	8.3	(N =	735 [illegible]	715)
April	52.9	35.9	8.7	(N =	632 [illegible]	720)
May	57.2	44.5	8.0	(N =	634 634	729)
June	68.4	52.7	8.2	(N =	698 698	601)
July	77.2	58.8	6.2	(N =	528 528	707)
August	70.8	60.4	6.0	(N =	666 668	744)
September	60.0	48.1	7.1	(N =	686 686	720)
October	53.9	39.8	7.6	(N =	718 728	743)
November	I	I	I	(N =	0 0	0)
December	I	I	I	(N =	0 0	0)

QUAD 1974 SEASONAL EXTREMES

	Ambient Temp.		Dew Point Temp.		35 Ft. Wind Speed and Associated Direction			
	Max.	Min.	Max.	Min.	Max.	(Dir)	Min.	(Dir)
Winter	53.9	-17.9	41.8	-28.0	19	(299)	0	Calm
Spring	80.5	2.8	67.6	-13.9	29	(199)	0	Calm
Summer	94.[illegible]	52.6	74.0	35.9	28	(299)	0	Calm
Autumn	80.7	31.5	68.6	0.0	25	(189)	0	Calm

intake canal is partially closed off from the river by a wall of piling and recycle water from the exit of the spray canal is conducted into the inlet canal near where it connects with the forebay of the screenhouse, where screens and pumps are located as part of the water intake system for the condensers.

At the maximum station cooling water flow rate of 2,270 cfs, the entrance velocity to the intake canal is approximately 0.8 feet per second. A floating boom which extends 23 inches beneath the surface is provided at the mouth of the canal to deflect floating material. Between the floating boom and the condensers there is a trash rack composed of vertical metal bars spaced 2½ inches apart which extend from about 20 feet above the water line to the bottom of the intake canal. Immediately behind the trash rack are the traveling screens with a mesh size of 3/8 inch. At low river flow with all six intake pumps operational, maximum intake velocity at the traveling screens would be approximately 1.85 feet per second. At higher river flows or with operation of fewer intake pumps intake velocities are correspondingly lower. Calculated mean intake velocity with all intake pumps operating is 1.55 feet per second.

4.2.7. Outfall Configuration and Operation

Since the Quad-Cities Station employs a diffuser pipe system as the means of discharging and mixing heated condenser cooling water, there is no outfall in the usual sense of the word. Heated water from the condensers passes directly from the discharge canal into the two 16 foot diameter diffuser pipes which are buried in the bottom of the river. The river in this area is approximately 2,200 feet wide. The main river channel is on the west side and is approximately 800 feet wide and 25 feet deep. The remainder of the channel has an average depth of ca. 8 feet. About 75%-80% of the river flow passes through the main channel.

Effluent from the diffuser pipes is discharged as jets from a series of risers that are spaced along the pipes. Beginning ca. 840 ft. from the Illinois shore, ten 24 inch risers are spaced at intervals of ca. 39 feet across the remainder of the shallow water region and extend 400 feet into the navigation channel. Forty 36 inch diameter ports are spaced at intervals of ca. 20 feet across the deep water region spanning the next 780 feet. Each riser is inclined at an angle of 20 degrees with the port pointing in the downstream direction. Discharge velocity from the jets is approximately 10 feet per second. The characteristics of the thermal plume from these ports is discussed in the next section. The general diffuser pipe configuration and location of discharge ports is shown in Figure 6.

Section 4.2.8. Thermal Plume Characteristics

The thermal plume at the Quad-Cities Station is unusual in that heated condenser cooling water is discharged into the Mississippi River by means of a diffuser pipe system which was designed to distribute the condenser cooling water across the river more or less in proportion to the transverse distribution of the ambient river discharge in such a way that complete mixing is achieved within a short distance. The diffuser pipe system is described in detail in Section 4.2.7.

Numerous temperature surveys have been conducted to determine the distribution of the temperature rise in the river 500 ft. downstream from the diffuser pipes. The surface area of the reach of the river between the diffuser pipes and the 500 ft. downstream cross-section is 24.9 acres, slightly less than the 26 acres allowed as a mixing zone. To determine the temperature rise due to the effluent, ambient temperatures 200 ft. upstream from the diffuser pipe were measured, both before

and after the 500 ft. downstream survey. Thus, the temperature rise at a point in the channel was estimated as the difference between the measured temperature at a point in the 500 ft. downstream cross-section and the ambient temperature at the corresponding point in the 200 ft. upstream cross-section.

From July 23, 1973 to January 16, 1974 nine temperature surveys were conducted by the Iowa Institute of Hydraulic Research (Sayre 1974 and Parr 1974) at river discharges ranging from 31,400 to 58,300 cfs. The results of these surveys are shown in Figures 9-17. Background river flow and plant effluent data are given in Table 18.

Analysis of the cross-sectional distribution of temperatures upstream and 500 ft. downstream from the diffuser pipes give rise to the following conclusions:

1. Maximum local temperature increases (ΔT) ranging from 1.6 F to 3.8 F were found in the seven surveys. These corresponded to dilutions at the point of least mixing ranging from about 6 to 14.

2. In five of the surveys the highest excess temperatures were found in a region about 200 to 300 meters from the Illinois shore. The highest excess temperatures were found at the bottom of the channel on November 14 and December 21 of 1973 and near the water surface on the other days.

3. The velocity distribution measurements indicate that the transverse distribution of river discharge differs somewhat from the previously estimated distribution that was based on measurements obtained in 1970, although the difference appears to be less for lower river discharges. Comparison between transverse distributions of river discharge 200 feet upstream and 500 feet downstream from the diffuser pipe

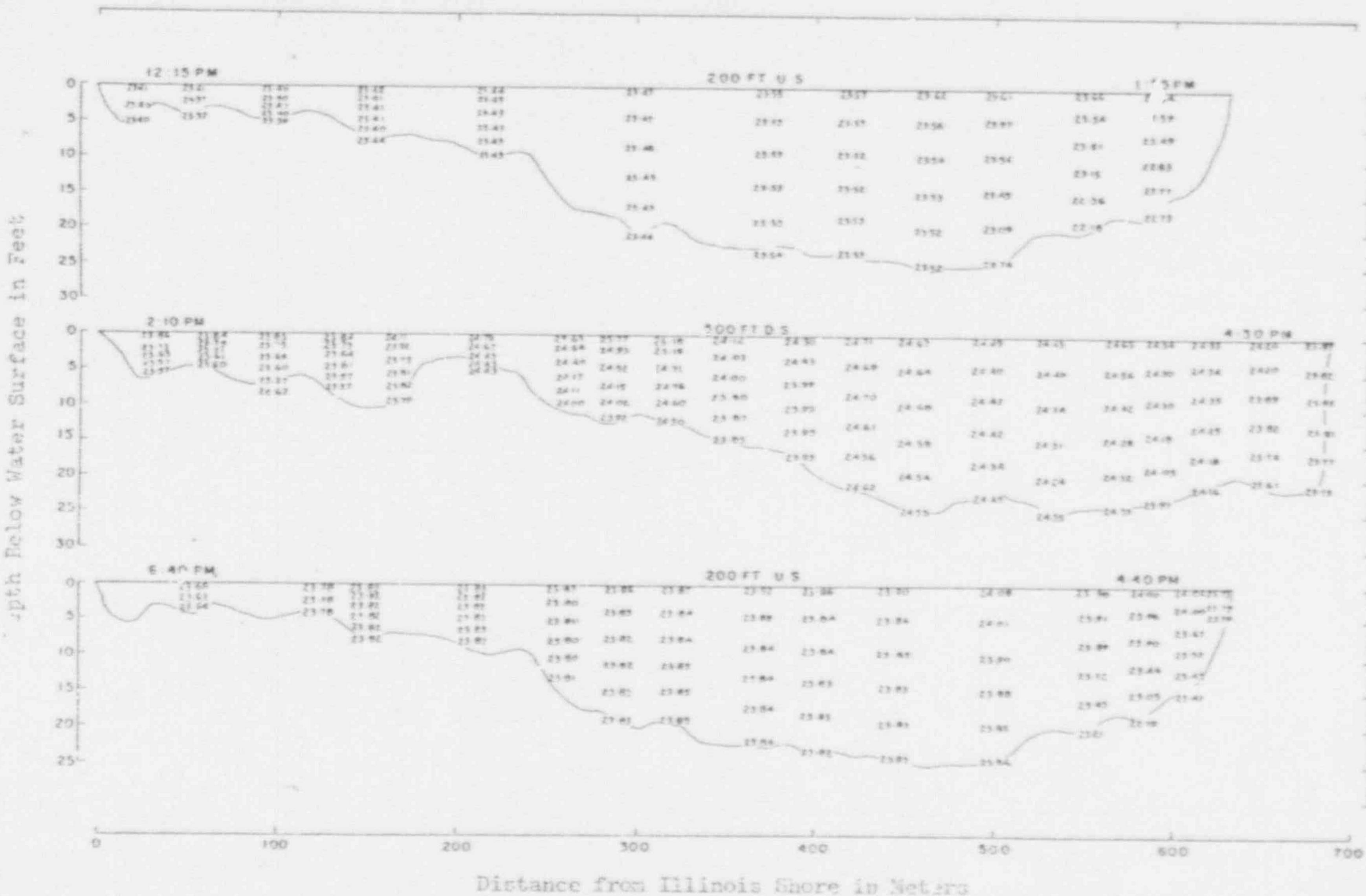


Figure 9. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on July 23, 1973.

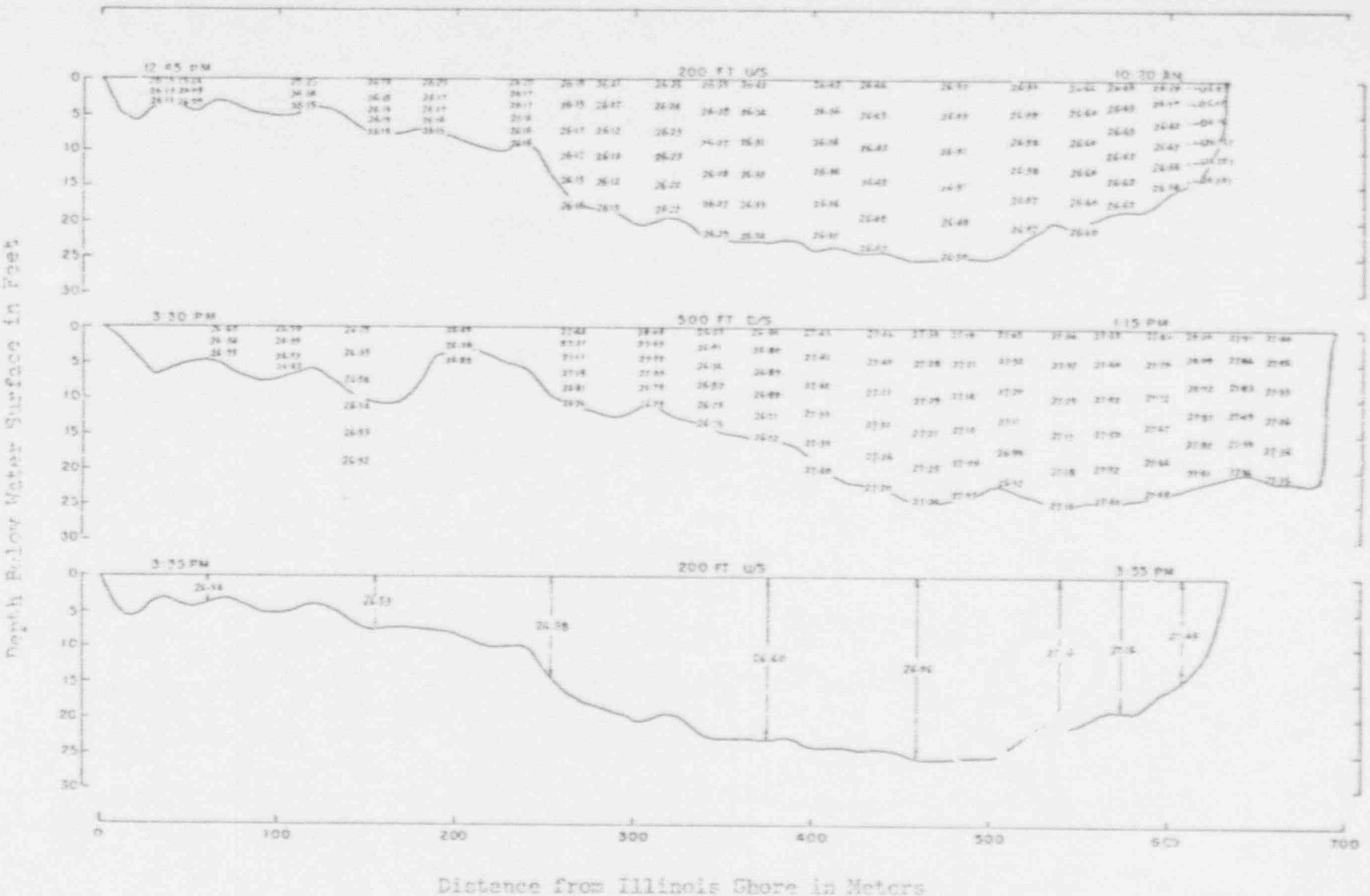


Figure 10. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on August 30, 1973.

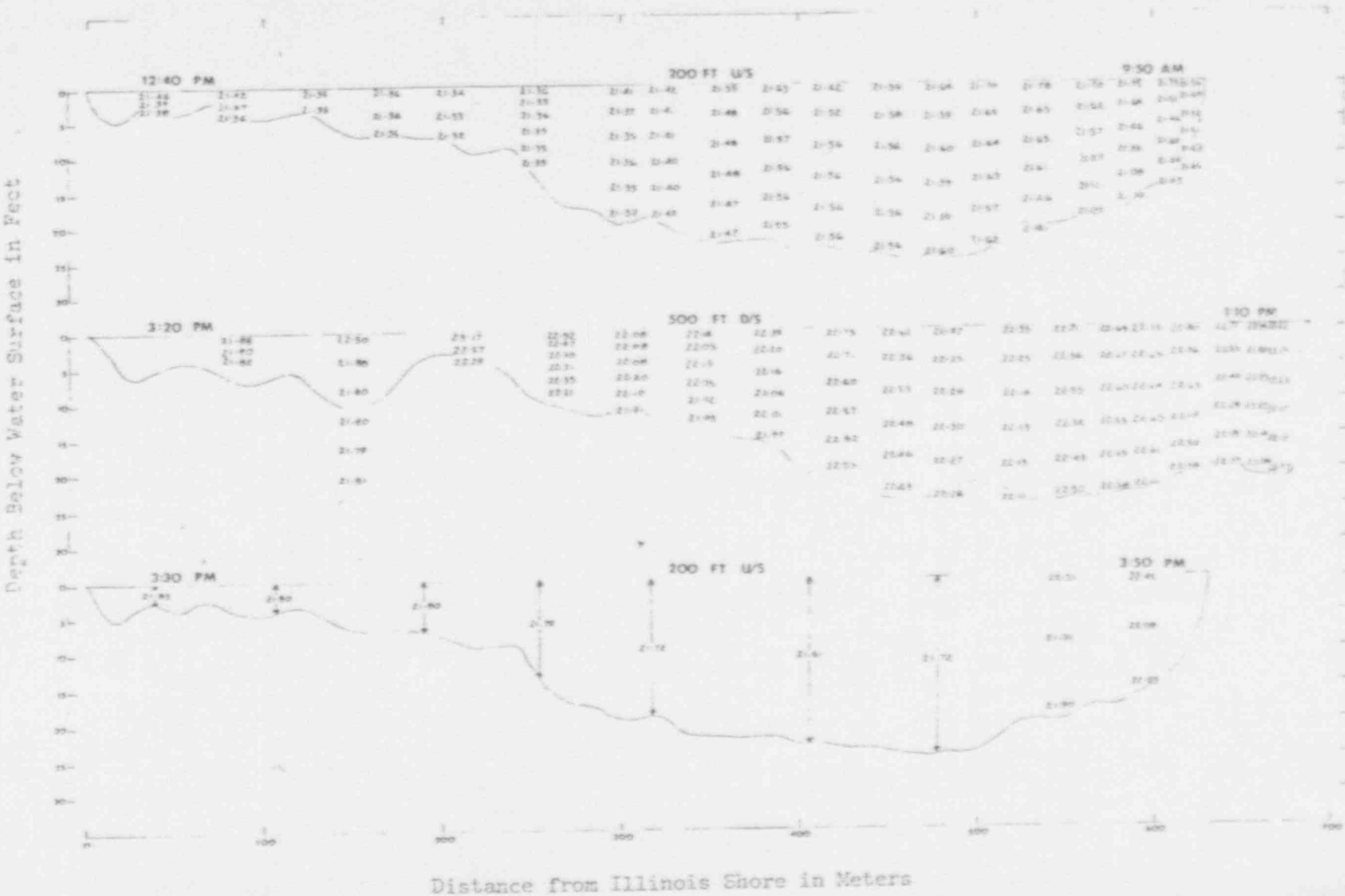


Figure 11. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on September 12, 1973.

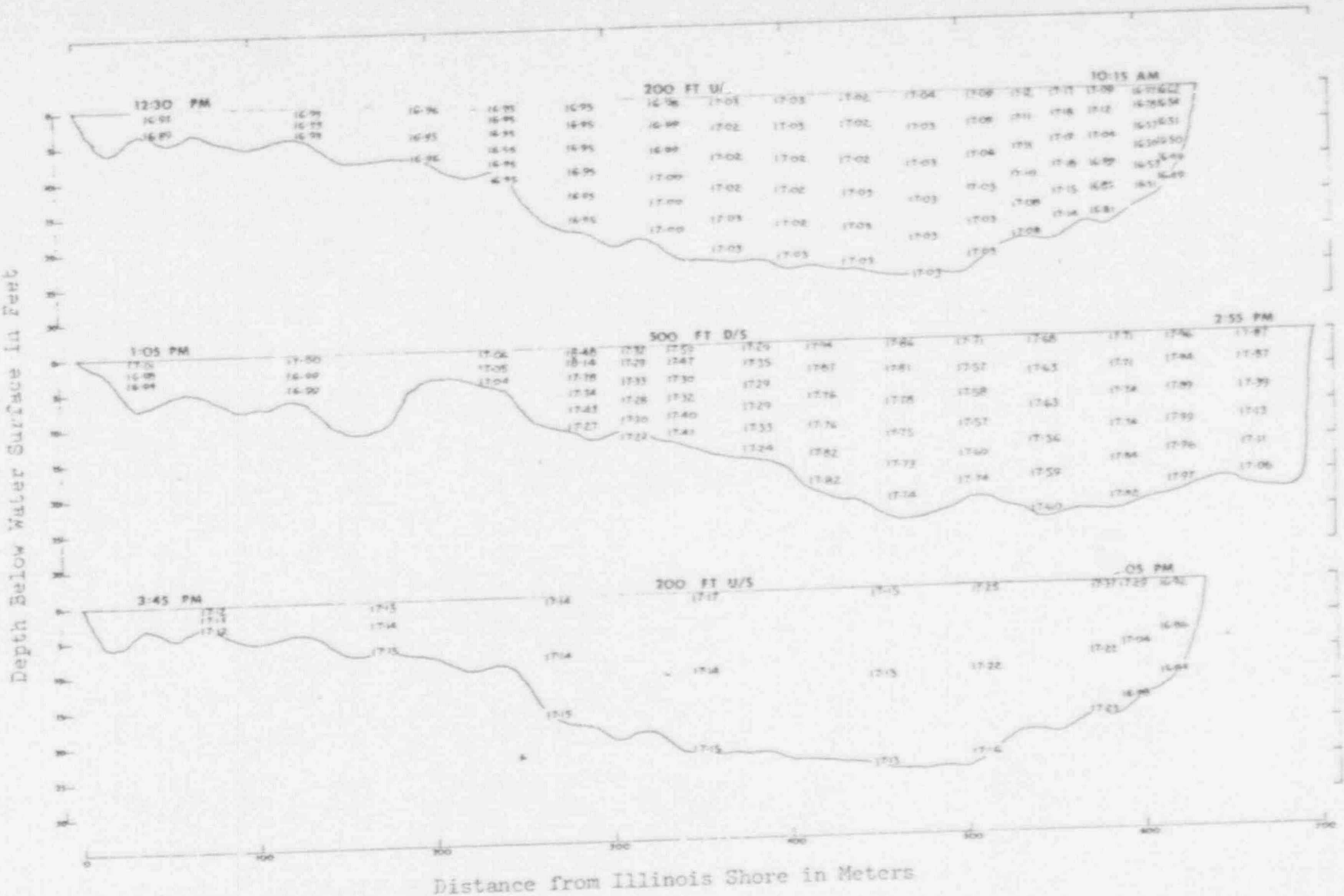


Figure 12. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on October 8, 1973.

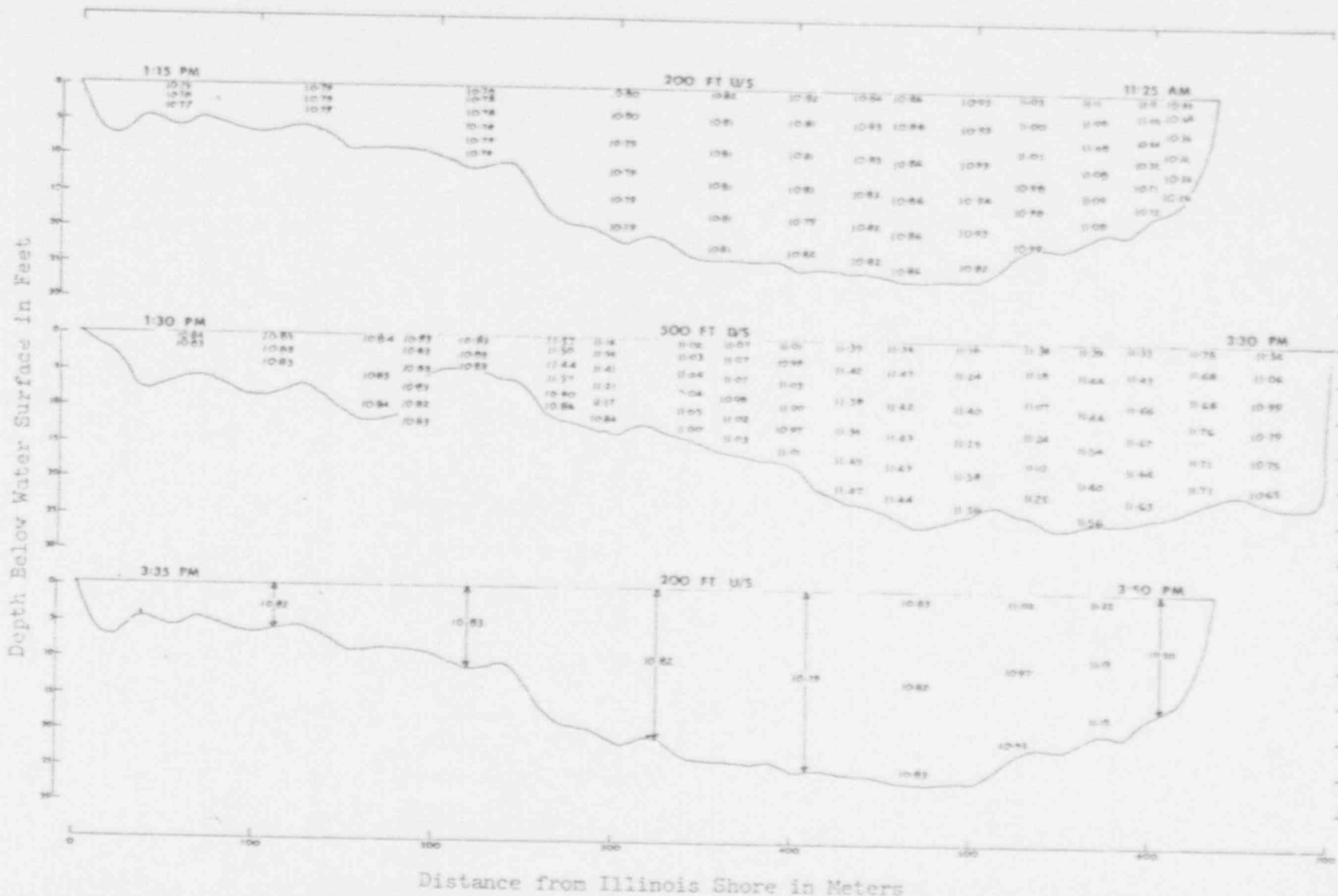


Figure 13. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on October 31, 1973.

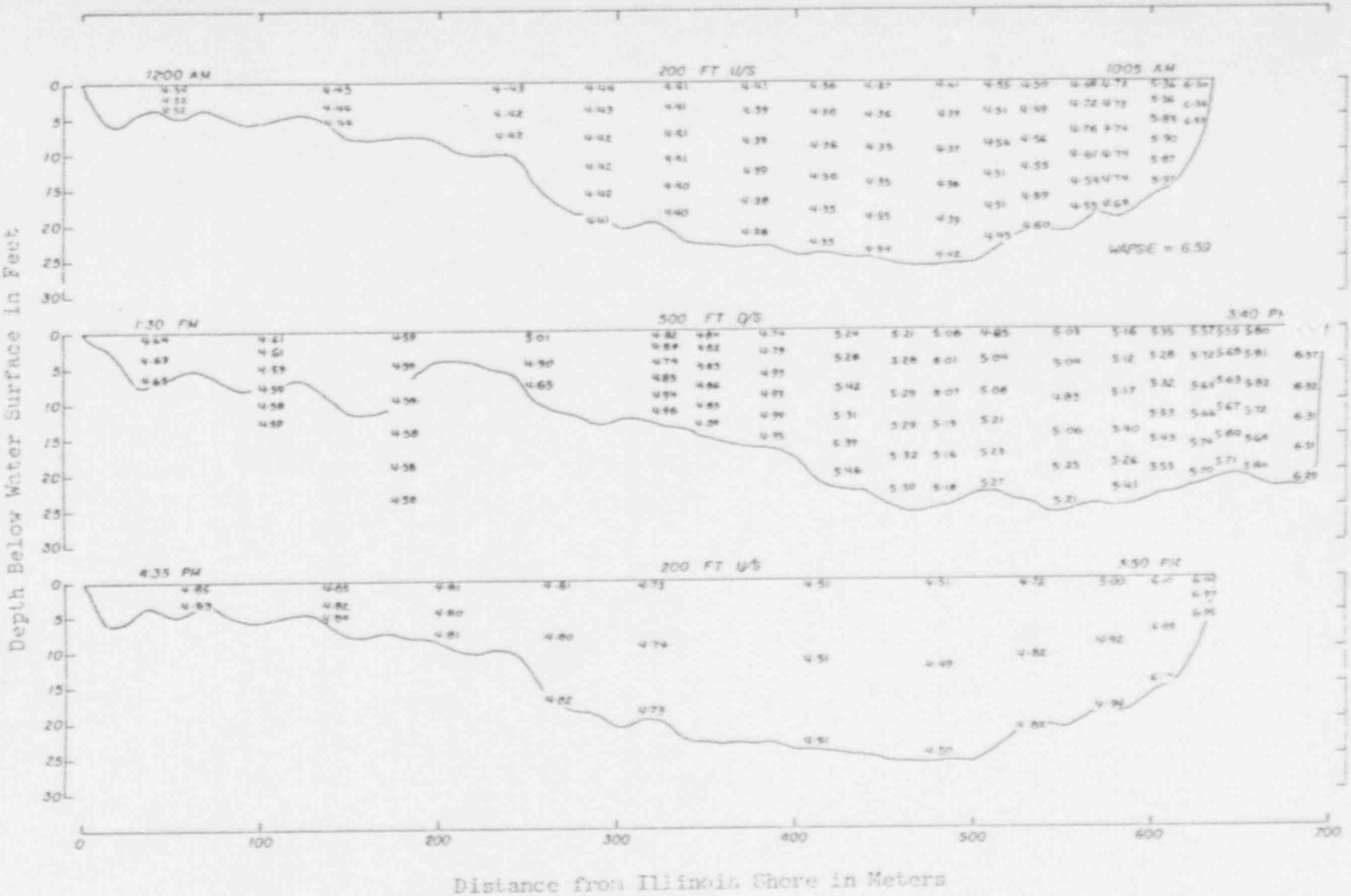


Figure 14. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on November 14, 1973.

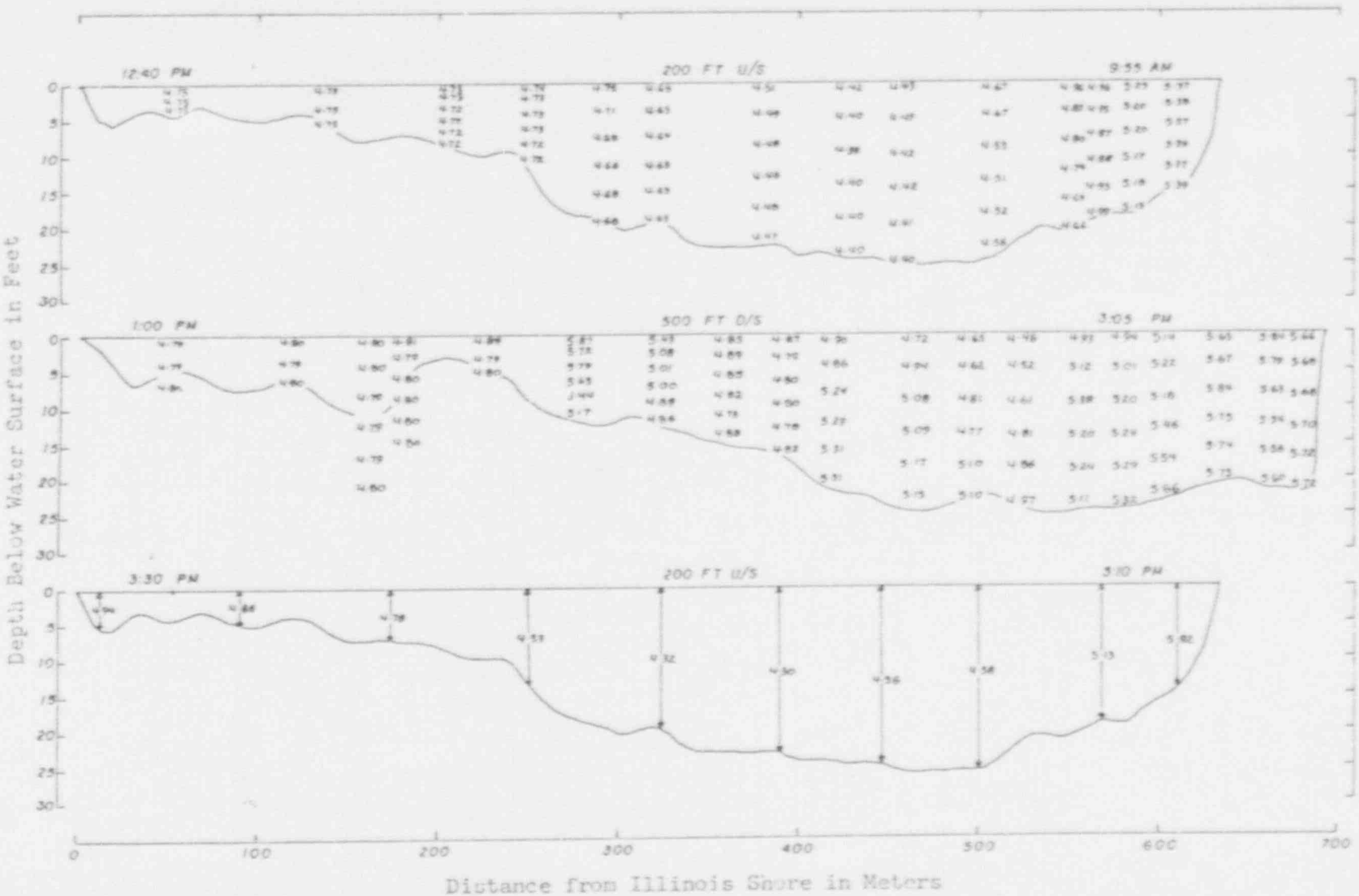


Figure 15. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on December 3, 1973.

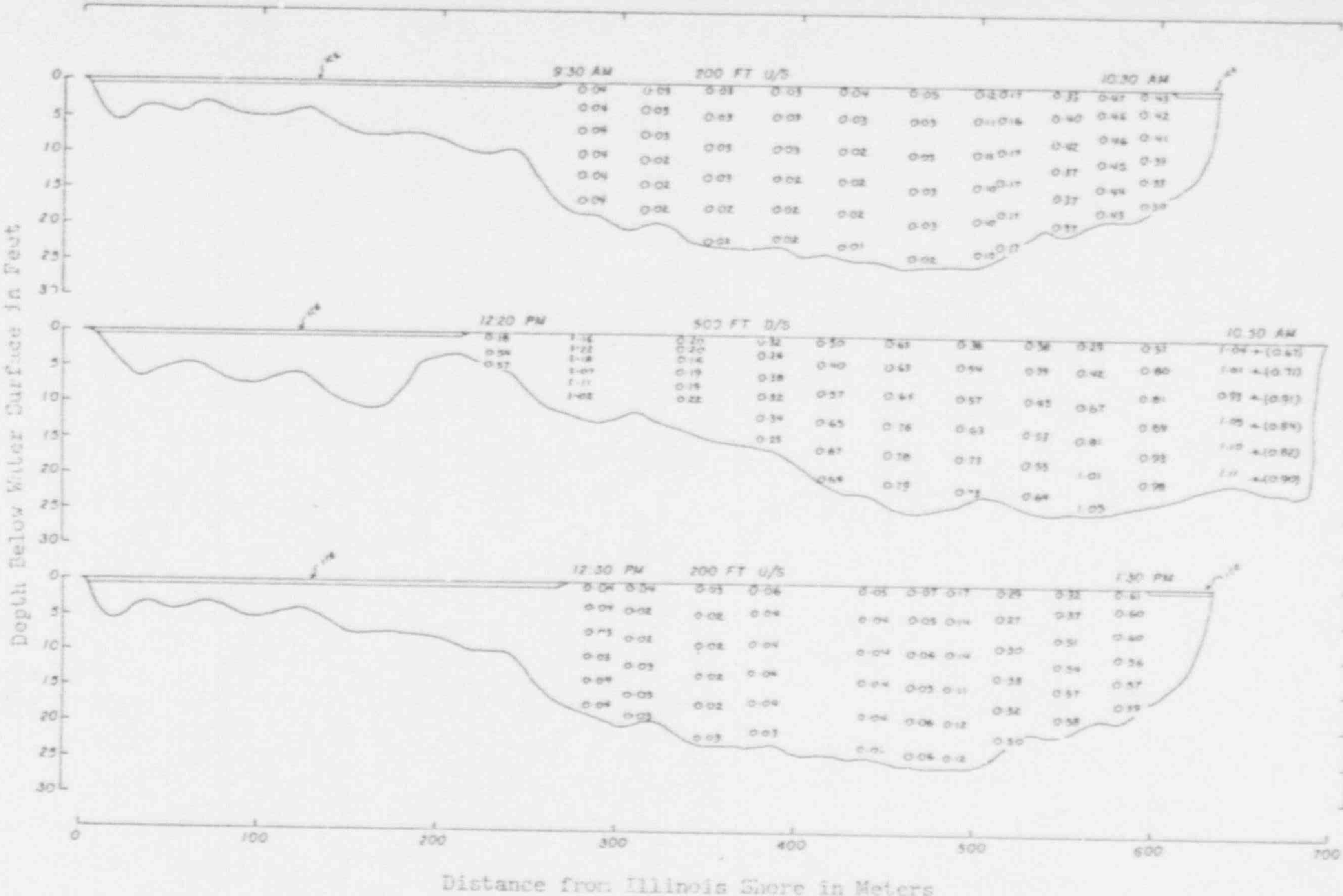


Figure 16. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on January 16, 1974.

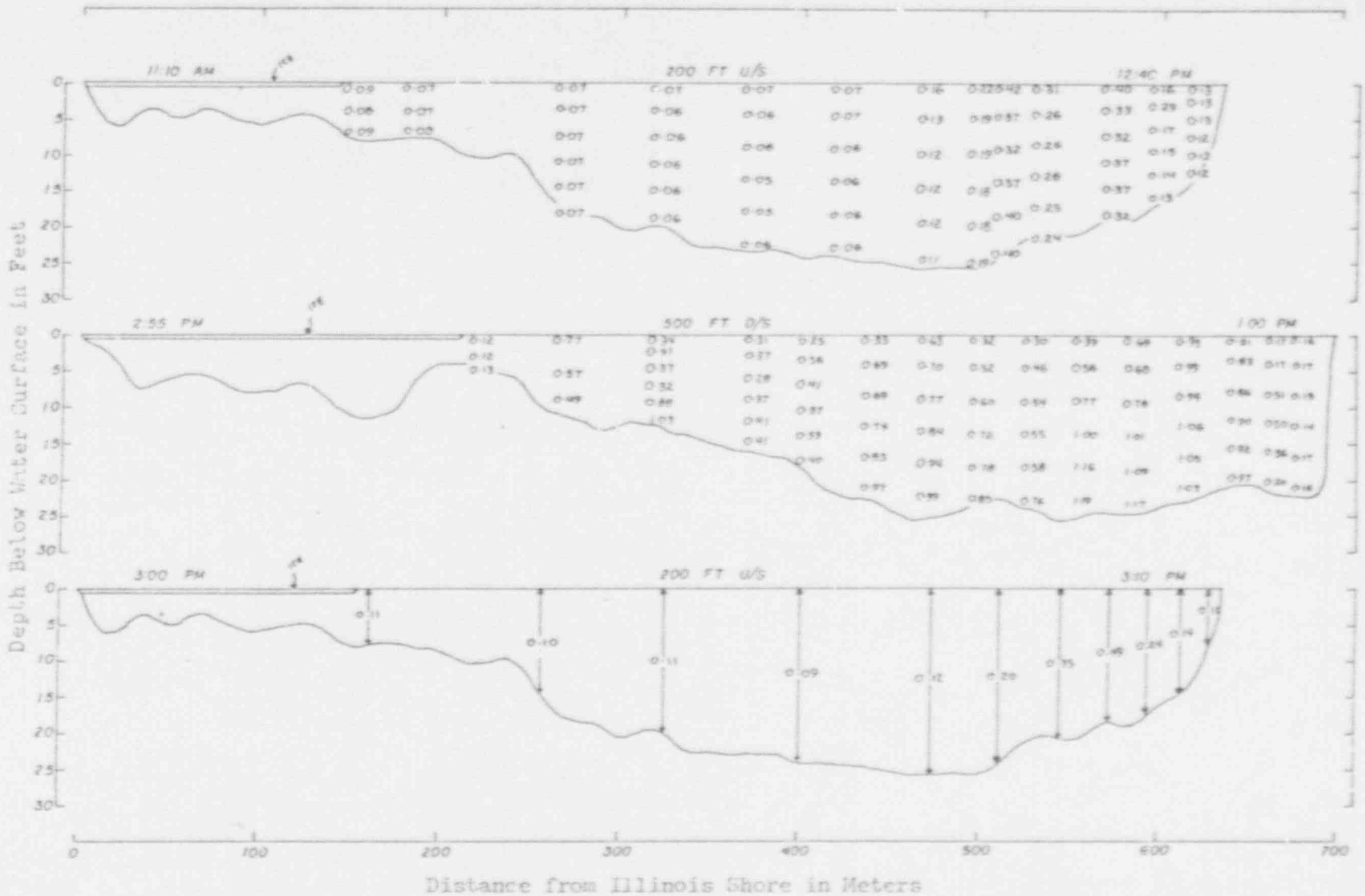


Figure 17. Observed temperatures in °C 200 ft. upstream and 500 ft. downstream from diffuser pipe on January 21, 1974.

TABLE 18--Background River Flow and Plant Effluent Data[1]

Date	River Discharge cfs	Average Ambient Temperature °C	Plant Intake Temperature °C	Plant Effluent Temperature °C	Percent of Full Plant Load	No. of Pumps Running	Estimated Plant Effluent Discharge cfs	Estimated Mixed Temperature Rise ΔT_m
7-23-73	34,600	23.6	23.5	35.2	94	6	2340	0.79
8-30-73	42,000	26.7	26.0	37.8	93	6	2290	0.64
9-12-73	37,108	21.7	21.4	31.7	85.5	6	2485	0.69
10- 8-73	47,536	17.1	18.0	28.8	85.0	6	2299	0.52
10-31-73	58,273	10.9	10.9	21.6	77.8	6	2125	0.39
11-14-73	39,111	4.57	4.69	16.4	79.4	6	1970	0.59
12- 3-73	55,680	4.62	4.95	18.8	89.0	6	1850	0.46
1-16-74	31,392	0.14	0.01	10.0	47.5	6	1380	0.44
1-21-74	41,865	0.17	0.04	11.5	82.5	6	2080	0.57

[1] From Sayre 1974 and Farr 1974

showed no appreciable effect due to the operation of the diffuser pipe system. However, there could be an effect at lower river discharges.

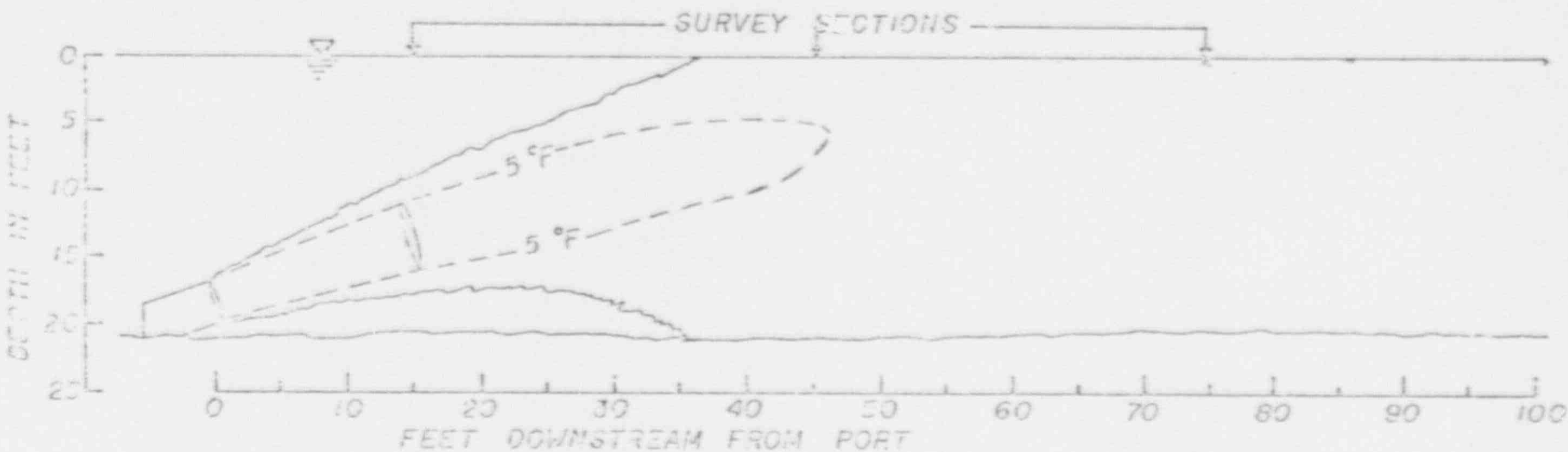
4. The total measured excess temperature flux in the cross-section 500 feet downstream from the diffuser pipes agreed closely with the total calculated excess heat input from the diffuser pipe system.

5. The transverse distribution of river velocity tended to approach the estimated distribution upon which the diffuser pipe design was based as river flow decreases. If this tendency persists for river flows lower than those measured to date, the distribution of excess temperature should become more uniform throughout the channel as the river discharge is reduced.

Studies were conducted to determine the extent of the 5 F temperature rise isotherm as required by the National Pollutant Discharge Elimination System Permit No. IL0005037. It is important to bear in mind that the diffuser pipe discharge differs from conventional plumes in that the heated effluent is discharged as jets from a series of 50 ports spaced along the length of the two buried diffuser pipes. At normal river flows the configuration of the 5 F isotherm arising from each port may be defined as sausage-shaped, a few feet in diameter and extending approximately 50 feet downstream from the port as shown in Figure 18. The diameter and length of the 5 isotherm "sausages" arising from each of the fifty ports varies inversely with the river discharge. Studies were conducted during the period November 1973-October 1974 to determine the configuration of the plumes from single ports. The results of these studies are illustrated in Figure 19 to 24. Each point on the figures represents a measurement point. Background data relative to river discharge, ambient river and plant effluent temperatures, maximum

FIGURE 18

TYPICAL 5°F EXCESS TEMPERATURE ISOTHERM



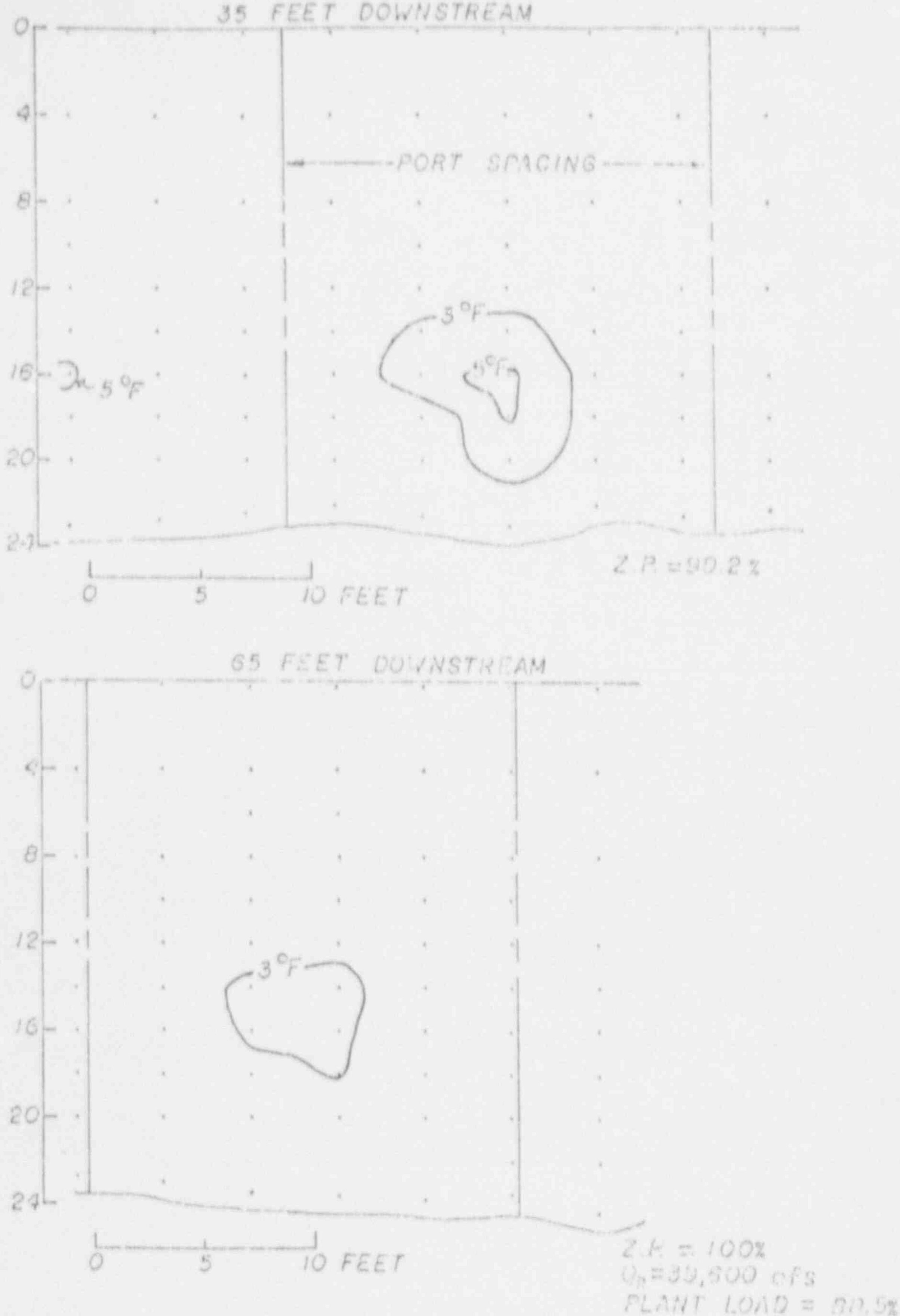


Figure 19. Excess Temperature Isotherms in °F Measured 35 and 65 feet Downstream from a Main Channel Diffuser Pipe Port on November 16, 1973.

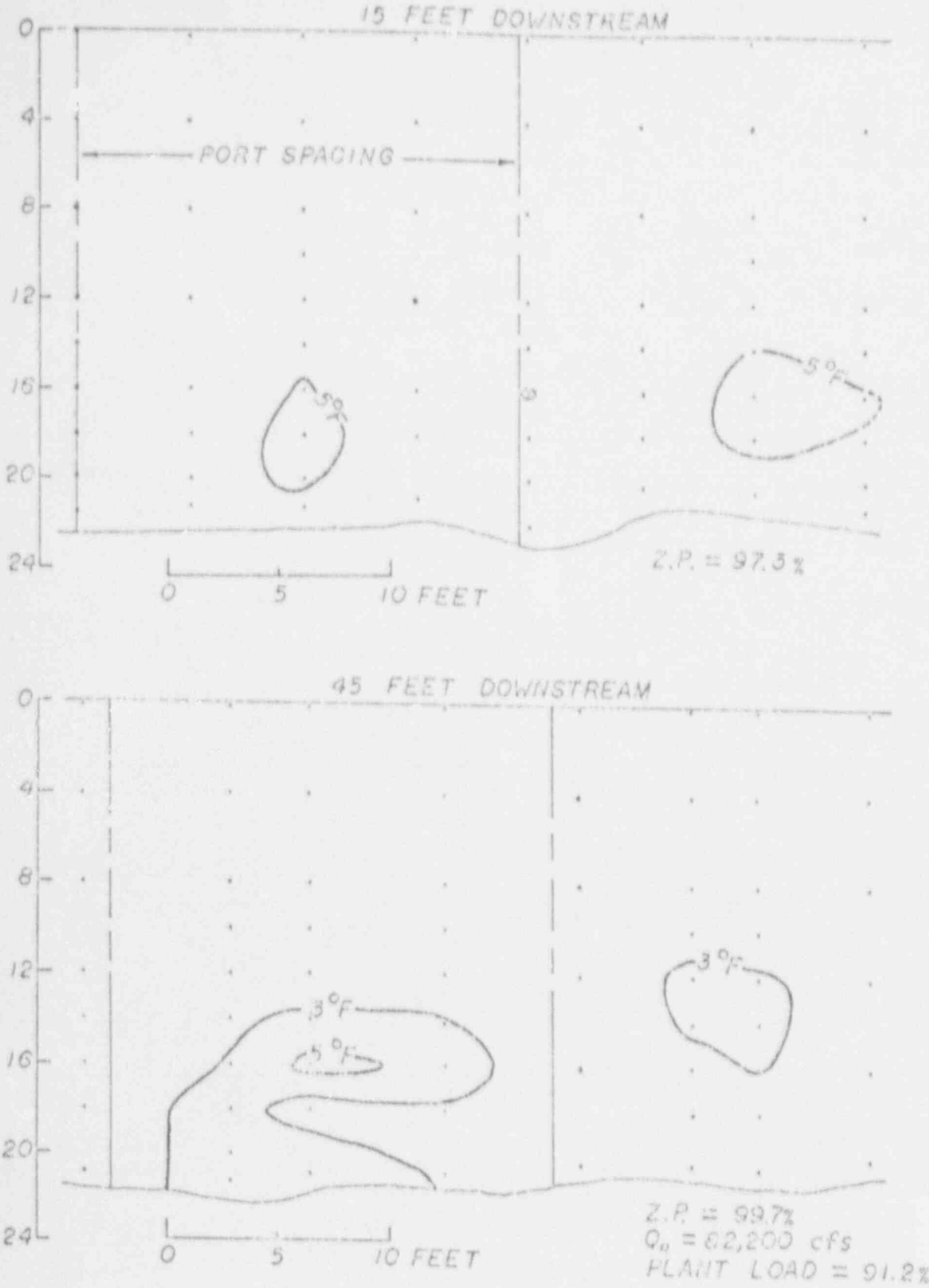


Figure 20. Excess Temperature Isotherms in °F Measured 15 and 45 feet Downstream from a Main Channel Diffuser Pipe Port on March 12, 1974.

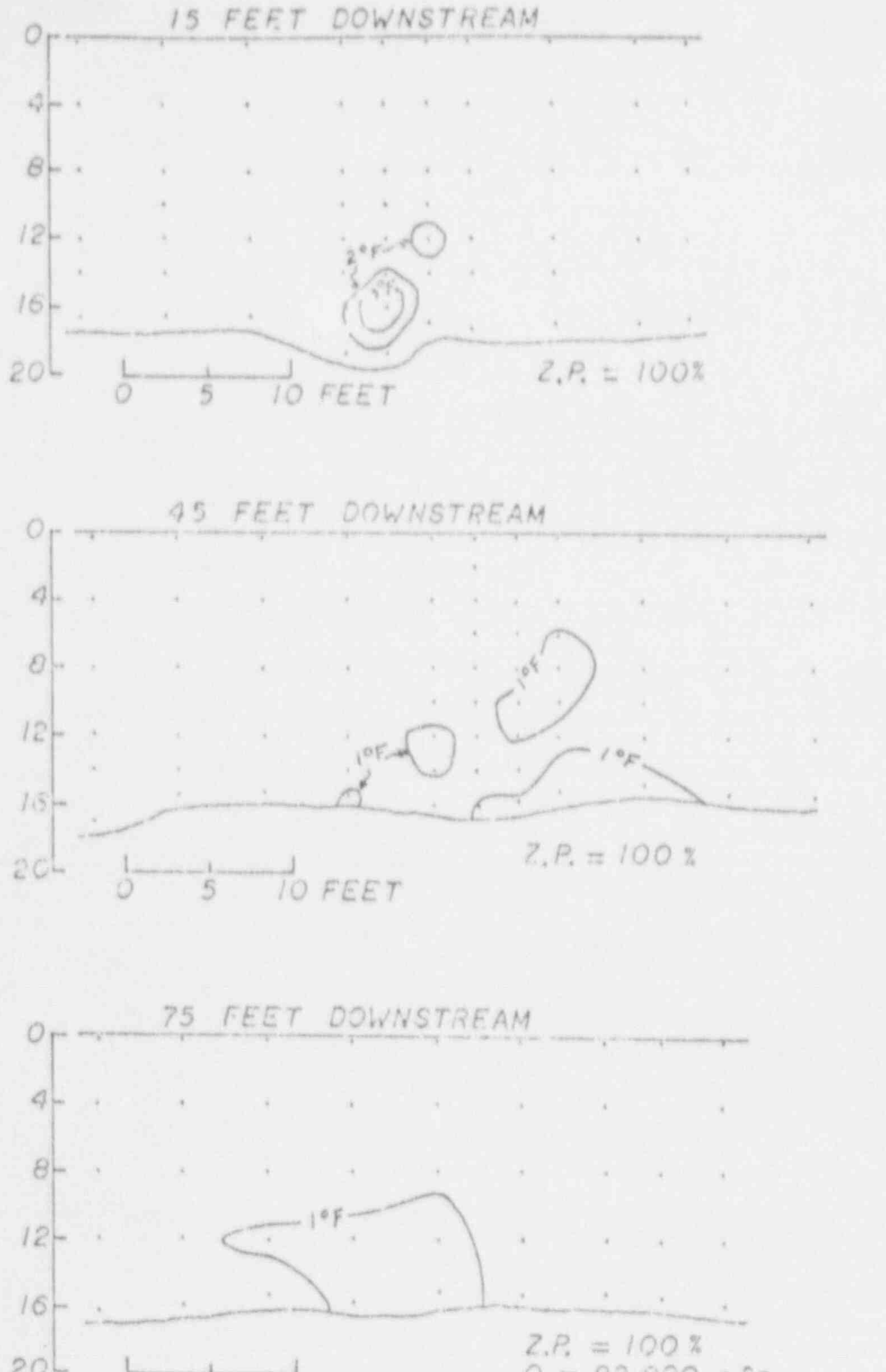


Figure 21. Excess Temperature Isotherms in °F Measured 15, 45, and 75 feet Downstream from a Shallow Channel Diffuser Pipe Port on March 13, 1974.

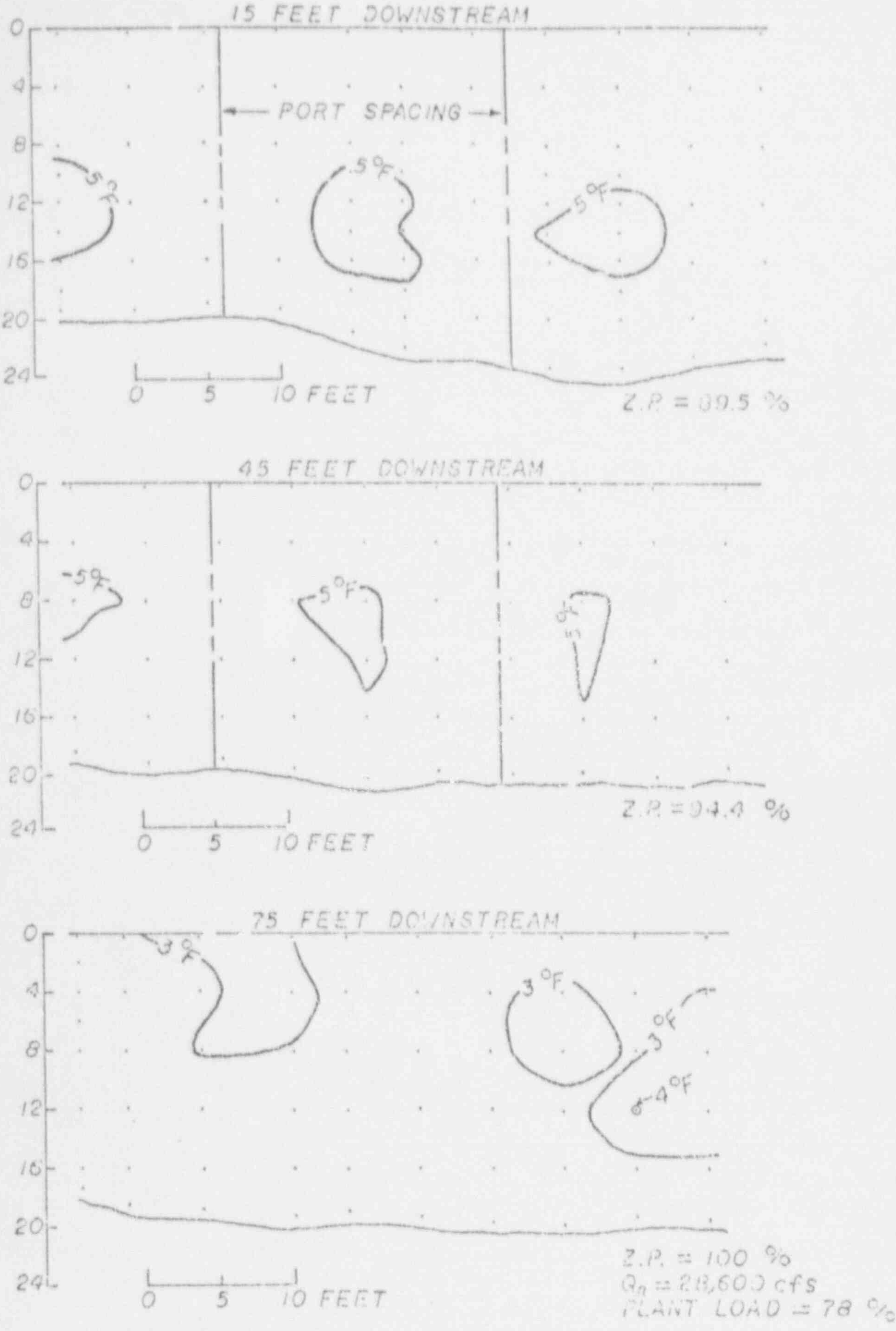


Figure 22. Excess Temperature Isotherms in °F Measured 15, 45, and 75 feet Downstream from a Main Channel Diffuser Pipe Port on October 1, 1974.

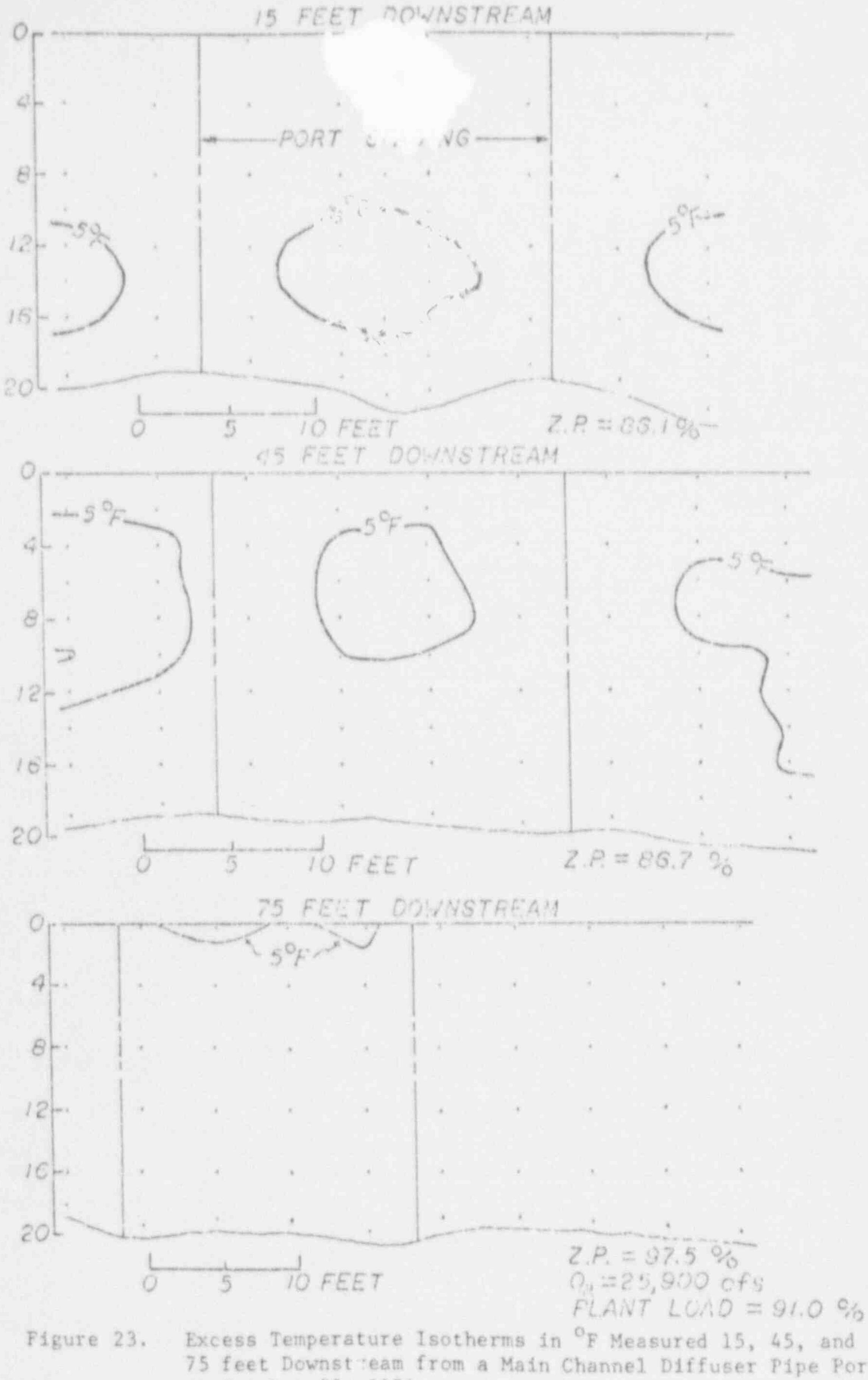


Figure 23. Excess Temperature Isotherms in °F Measured 15, 45, and 75 feet Downstream from a Main Channel Diffuser Pipe Port on October 25, 1974.

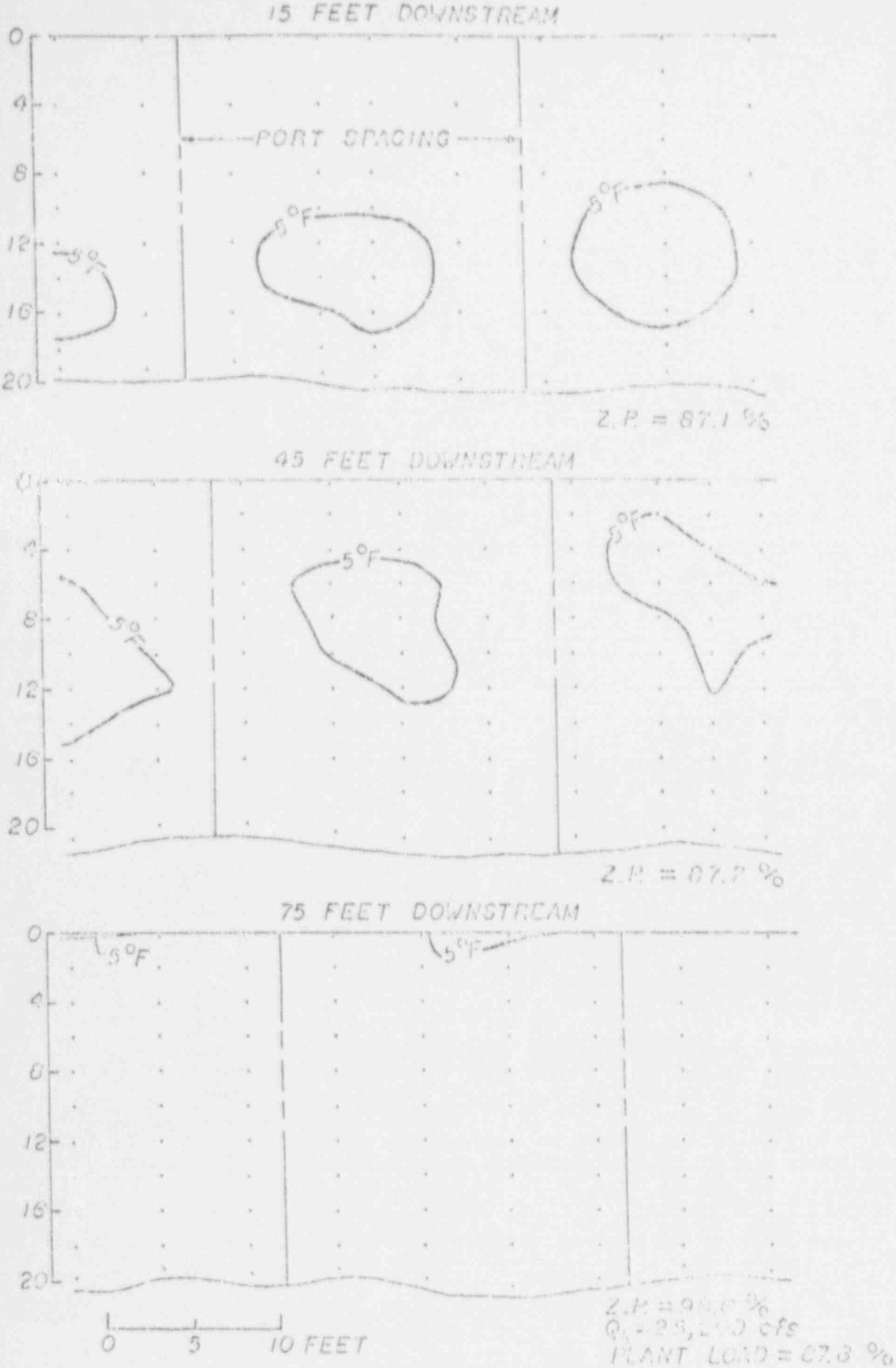


Figure 24. Excess Temperature Isotherms in °F Measured 15, 45, and 75 feet Downstream from a Main Channel Diffuser Pipe Port on October 30, 1974.

observed temperature rise, and other plant operational data during the period of the single port studies is given in Table 19.

It is evident from these studies that the heated discharge from the diffuser is rapdily mixed with the river water and that only a small portion of the river is subjected to temperature increases of 5 F or more above ambient. Based upon the generally recognized assumption that temperature increases of less than 5 F above ambient do not constitute a thermal barrier for the migration of aquatic forms, the zone of passage (ZP) between diffuser ports was in excess of 86% throughout the course of the study (Table 19). When the entire width of the river is considered, the zone of passage is considerably greater due to the absence of diffuser ports in the shallow water areas on each side of the river.

4.2.9 Total Heat Discharge As A Function Of Time

Heat rejected to the Mississippi River is shown in Figures 25 and 26. Figure 25 shows heat rejection during summer months when high load factors are expected. Figure 26 shows heat rejection during plant operation at 80% load factor.

4.2.10 Time Temperature Data

The circulating water temperature rise versus time of passage is shown for each diffuser pipe in Figures 27 and 28. The temperature profile begins at the intake structure and terminates when the cooling water temperature has approached ambient river temperature for each diffuser port. Graphs showing the probability of a specific particle residence time in each diffuser pipe are included in Figures 29 and 30. Residence times are calculated from the moment a particle enters the diffuser pipe. It should be noted that the residence times do not take into consideration dispersion effects due to passage through the circulating water system.

Table 19. Background Data and Results of Single Port Field Studies in 1973 and 1974[1]

Date	River Discharge (Q_R) cfs	Dist. from Ill. Shore Feet	Dist. Downstream from Port Feet	Percent of Full Plant Load %	Local Ambient Temperature °F	Plant Effluent Temperature °F	Estimated Plant Effluent Discharge cfs	Estimated Velocity from Single Port fps	Maximum Observed Temperature Rise °F	Zone of Passage %
11-16-73	39,600	1744	35 65	88.5	40.2	65.5	1878	7.3	5.4 3.6	99.2 100.0
3-12-74	82,210	1345	15 45	91.2	37.2	61.4	2079	8.2	7.7 5.6	97.3 99.7
3-13-74	82,900	968	15 45 75	89.5	38.1	61.4	2068	7.8	4.4 1.7 1.4	100.0 100.0 100.0
10-1-74	28,600	1273	15 45 74	78.0	57.2	96.0	688	5.4	14.8 6.7 4.0	89.5 94.4 100.0
10-25-74	25,900	1293	15 45 75	91.0	53.5	104.5	688	5.4	19.0 8.9 6.0	86.1 86.7 97.5
10-30-74	25,200	1351	15 45 75	87.8	56.1	106.8	688	5.5	20.0 8.7 5.7	87.1 87.2 98.6

[1] From Sayre 1974

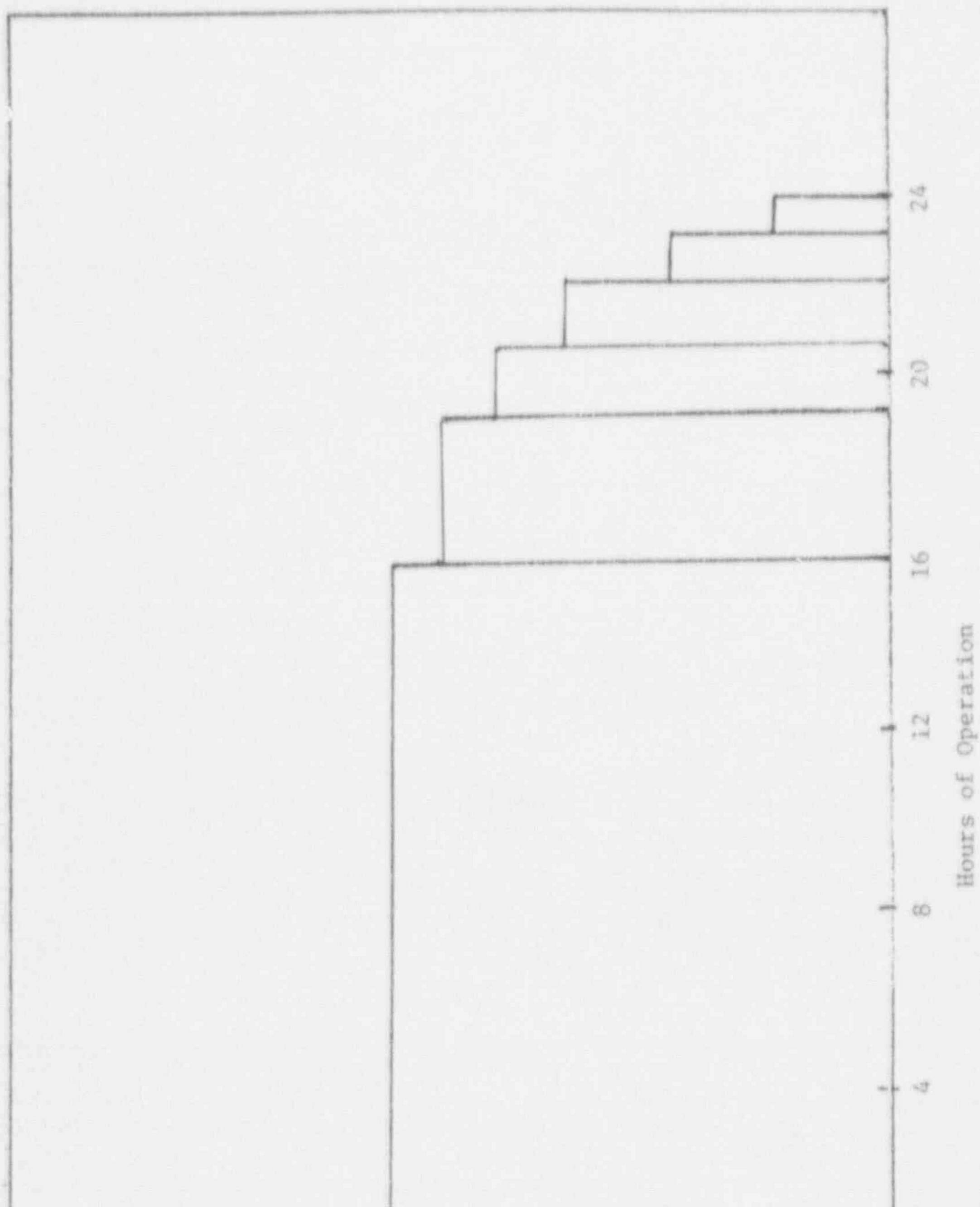


Figure 25

HEAT REJECTED VIA DISCHARGE
SUMMER LOAD MODEL

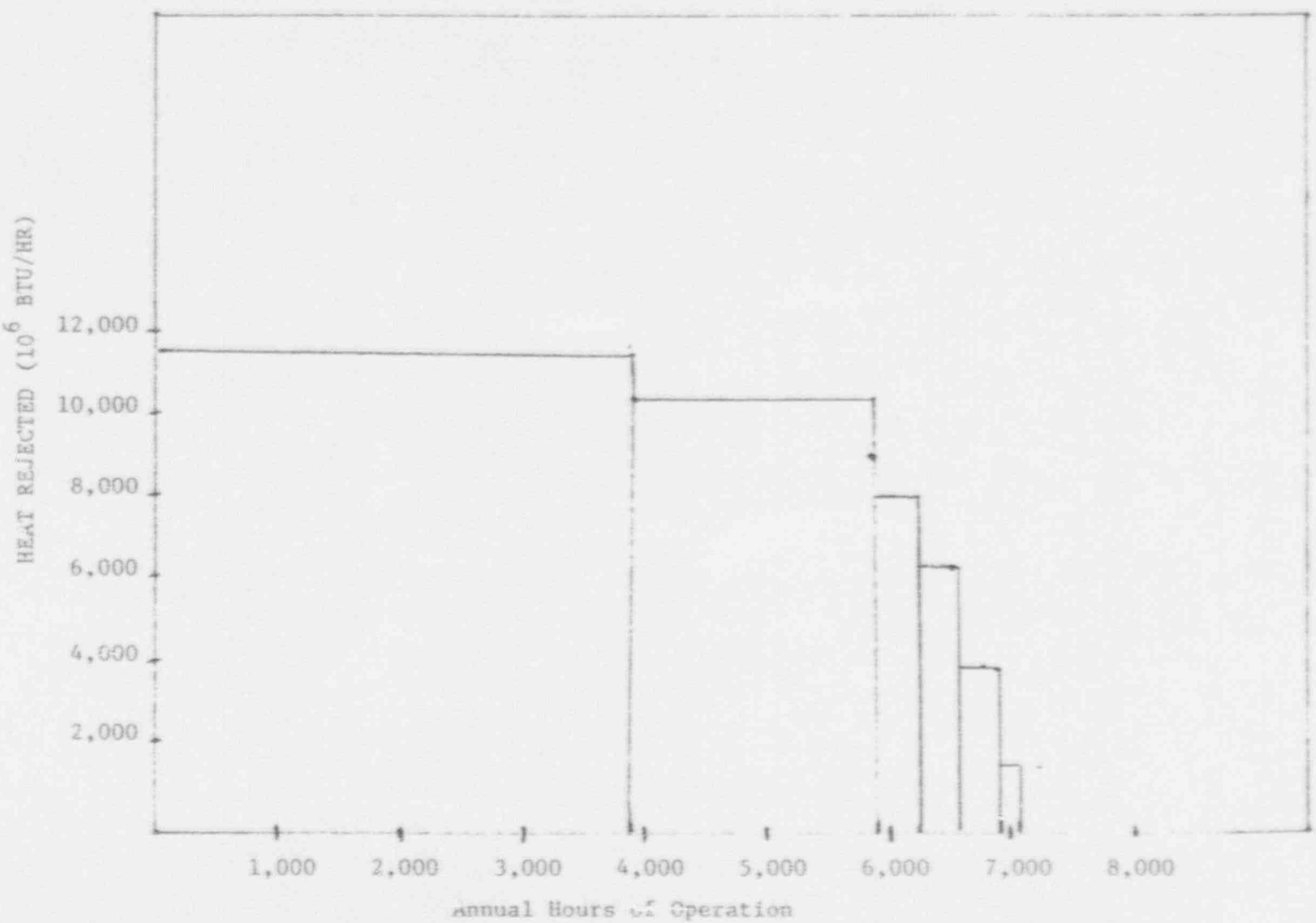


Figure 26

HEAT REJECTED VIA DISCHARGE

Figure 27

Temperature Rise Vs. Time of Passage
Circulating Water System
Long Diffuser Pipe (North Pipe)

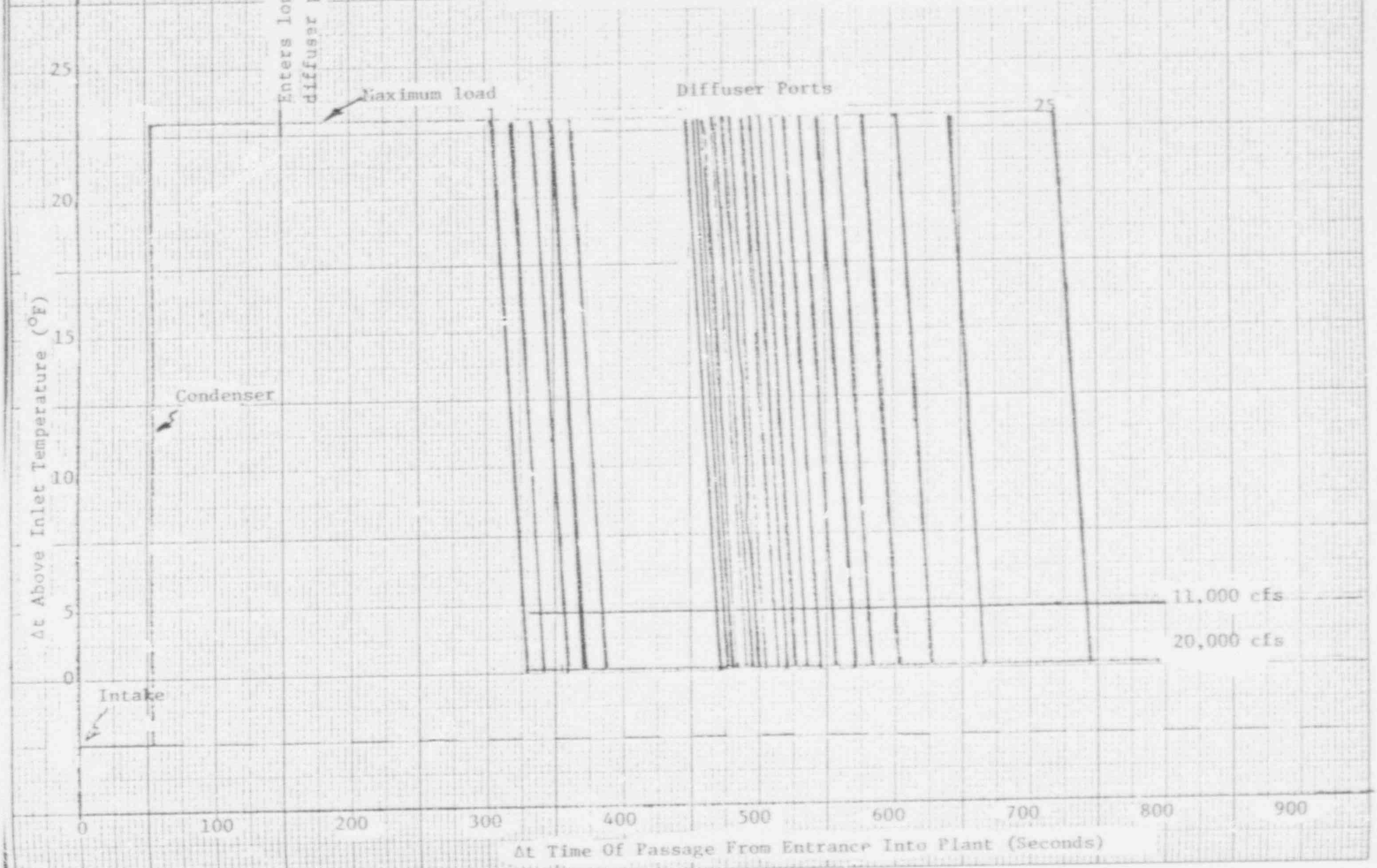


Figure 28
Temperature Rise Vs. Time of Passage
Circulating Water System-Short Diffuser Pipe
(South Pipe)

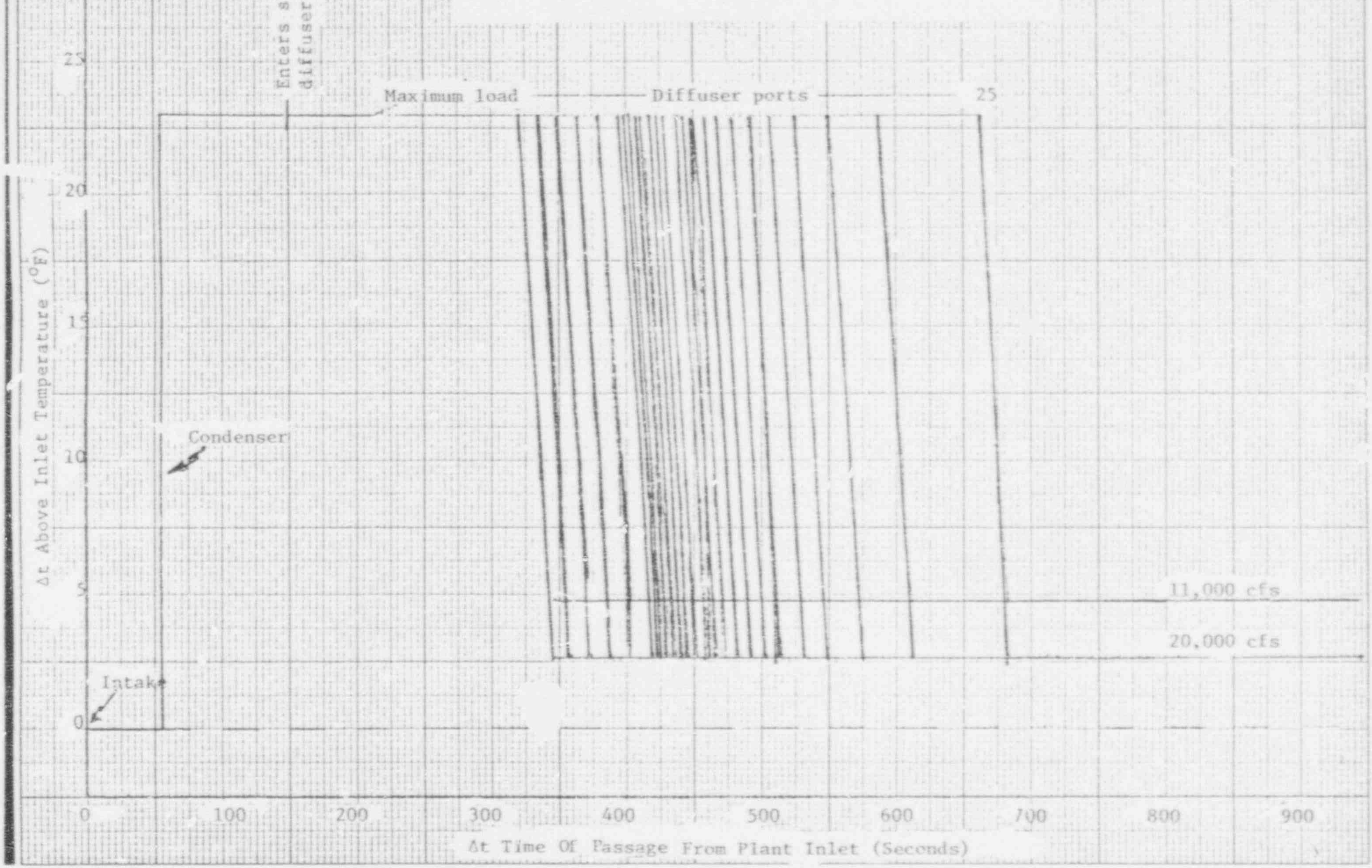
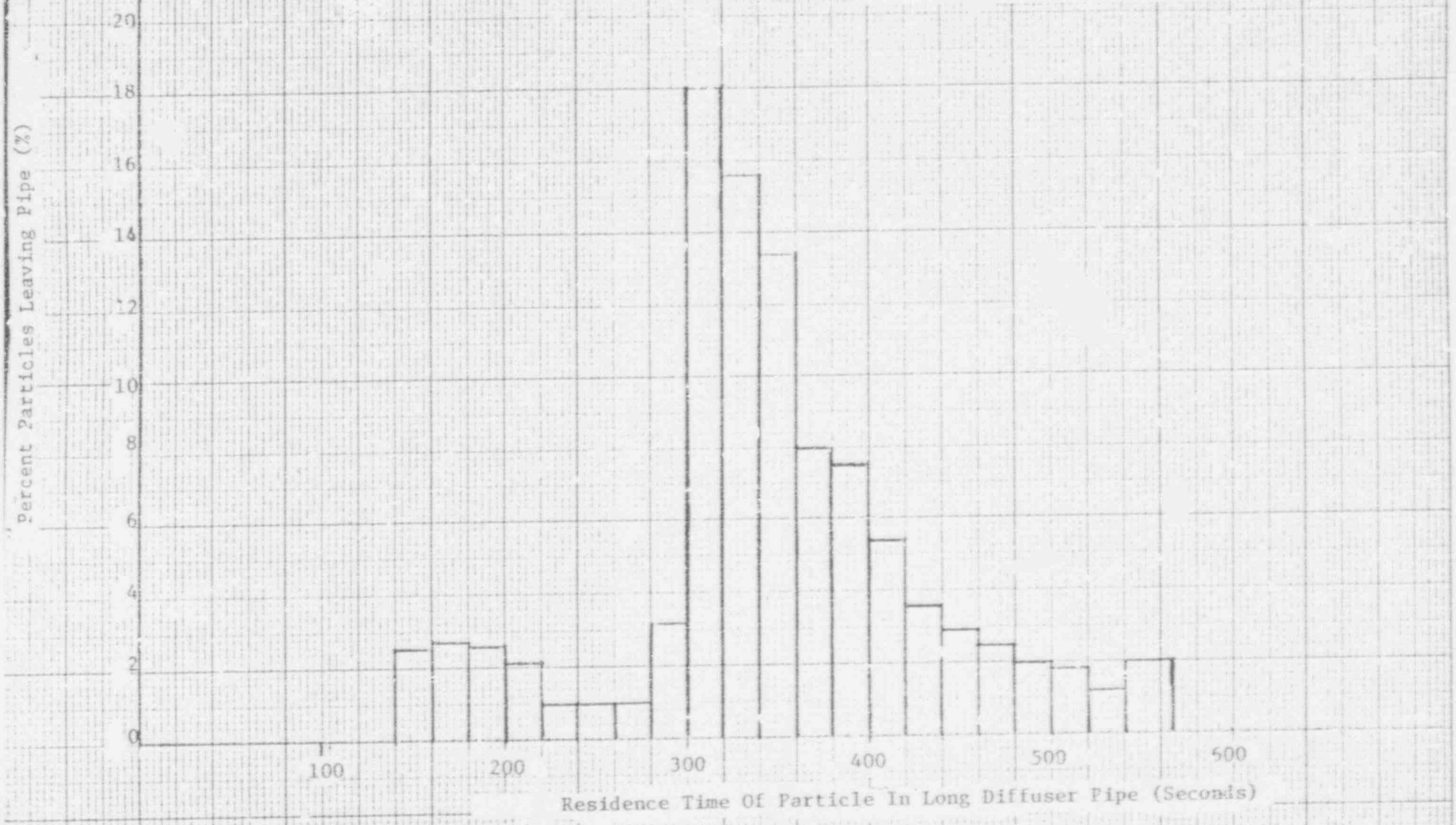


Figure 29
Probability Distribution of Particle Residence Times In Long Diffuser Pipe (North Pipe) For Maximum Flow



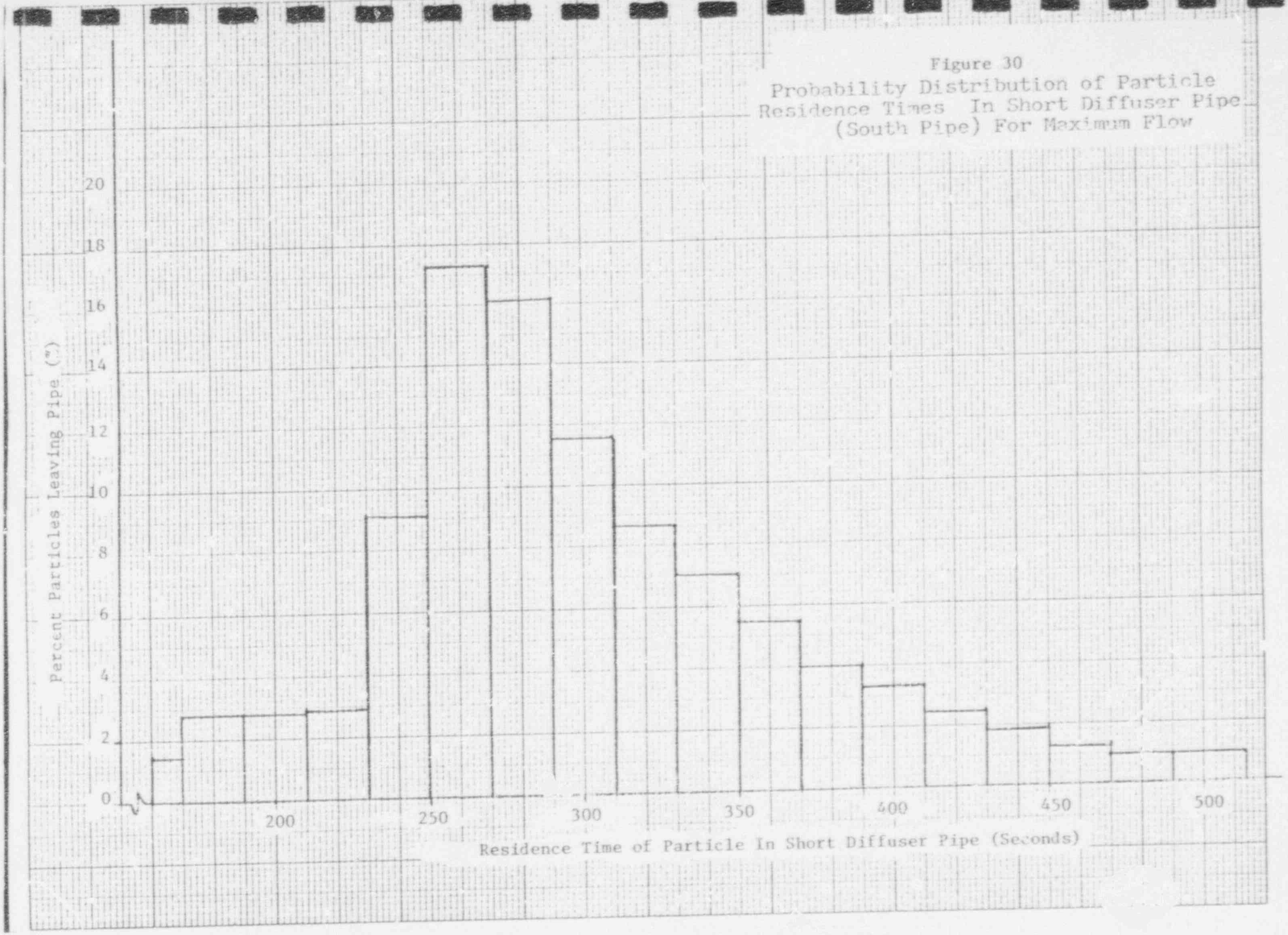


Figure 30
Probability Distribution of Particle Residence Times In Short Diffuser Pipe (South Pipe) For Maximum Flow

4.3 Effects of Station Operation on Chemical Water Quality

Monitoring of water quality in the Mississippi River near the Quad-Cities Station has been carried out at regular intervals since 1969 to establish the normal seasonal fluctuations in chemical parameters (preoperational phase) as well as to determine the effects, if any, of station operation on the limnology of the river. Sampling was initially conducted on a seasonal (quarterly) basis. This was increased to twice monthly in August 1971 and then to weekly in February, 1972. Dissolved oxygen has been monitored continuously on an hourly basis since 1973. In order to determine the effects of station operation on the water quality of the Mississippi River, samples have been taken at locations upstream and downstream of the station as well as in the intake and discharge bays.

The water quality in this area of the Mississippi River is by nature highly variable and is significantly influenced by climatic and hydrological conditions. Extensive agricultural activity in the upstream drainage basin provides abundant nutrients to the river. The amount of nutrient present can be correlated with hydrological conditions since surface runoff from agricultural land provides the source of soil-bound nutrients which are carried in suspension or solution. Specific conductance measurements were found to be inversely proportional to river flow and hence to the amount of water runoff. In addition, high river flows frequently resulted in increased turbidity and true color values and increased concentrations of total iron and total suspended solids. Concentrations of the majority of the remaining water quality parameters studied were also influenced by variation in the river flow. For example, coliform bacteria; indicators of organic enrichment such as

biochemical oxygen demand, chemical oxygen demand and total carbon; trace metals and industrial waste parameters such as phenol, cyanide and hexane-soluble materials all showed considerable variability depending on river hydrology. Industrial discharges in the vicinity of Clinton, Iowa also occasionally influenced downstream water quality, although in general the water quality of the Mississippi River is relatively good.

Since the nature of the area at Quad-Cities is such that chemical changes were more dependent on river flow than on other parameters, correlations of river flow and chemical parameters were determined. In addition, standard statistical summaries of all parametric values were compiled. Since little difference could be seen above and below the station, statistical testing of these data were omitted.

The results of operational studies indicate that with the exception of oxygen saturation, which is slightly higher in the discharge bay than in the river, station operation appears to have no effect on the chemical water quality of the Mississippi River. Comparisons between the water quality at intake and discharge and upstream and downstream river are shown in Table 20.

Chlorination of the Quad-Cities Station condenser cooling water system is accomplished by adding approximately four gallons per minute of a 15 percent sodium hypochlorite solution for a twenty or forty minute period three times per day.

A summary of total chlorine data obtained by amperometric titration from the Mississippi River near the Quad-Cities Station and the intake and discharge bays (locations 6, 7, 8 and 13) from July 27, 1972 to July 9, 1974 is presented in Table 21. During periods of station

TABLE 20

Comparar on of Selected Chemical Parameters
Upstream vs Downstream (Locations 5 vs 8 & 13) and
Intake vs Discharge (Locations 6 vs 7)
August 1972 - July 1974

Dissolved Oxygen (mg/1)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	6.6	6.9	6.8	6.6	6.9
Sept.	8.3	7.8	8.2	8.3	7.8
Oct.	9.9	9.9	9.9	10.0	10.5
Nov.	12.0	11.5	11.9	12.0	11.9
Dec.	14.2	14.1	14.5	13.6	11.6
Jan. 1973	12.3	12.2	12.2	11.2	9.6
Feb.	12.3	12.1	12.2	12.8	11.7
Mar.	12.3	12.3	11.9	11.1	10.9
Apr.	11.2	12.0	11.2	11.1	10.9
May	9.7	8.9	9.9	9.8	9.7
June	7.1	6.5	7.0	6.8	6.9
July	6.3	6.6	6.6	6.4	6.5
Aug.	7.3		6.7	6.8	6.4
Sept.	7.2		7.4	7.2	7.4
Oct.	8.6		8.7		
Nov.	12.0		12.1		
Dec.	13.3		13.8		
Jan. 1974	12.9		13.1		
Feb.	12.4		12.5		
Mar.	13.0		12.9		
Apr.	11.8		12.0		
May	9.6		9.9		
June	7.2		7.5		
July	7.0		7.0		

All values in these table. re mean monthly values calculated from data obtained in the Mississippi River near the Quad-Cities Station.

August 1972 - July 1974

Table 20 (Cont.)

Oxygen Saturation (%)

Date	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
		Sampling Location			
Aug. 1972	7.9	8.4	8.1	7.8	8.9
Sept.	8.8	8 7	9.3	9.3	9.2
Oct.	8.8	8.8	8.8	8.9	11.5
Nov.	9.2	8.8	9.1	9.2	12.2
Dec.	9.8	9.8	10.1	9.8	12.7
Jan. 1973	8.7	8.9	8.7	8.6	10.2
Feb.	8.5	8.3	8.5	9.1	11.5
Mar.	9.4	9.2	9.2	8.7	11.3
Apr.	9.8	9.4	9.7	9.5	11.7
May	9.5	8.8	9.7	9.6	11.2
June	8.2	7.5	8.2	8.0	9.6
July	7.4	7.7	7.9	7.6	9.5
Aug.	8.6		8.5	8.8	9.1
Sept.	7.8		8.0	7.8	9.6
Oct.	8.4		8.5		
Nov.	9.5		9.5		
Dec.	9.4		9.8		
Jan. 1974	8.8		8.9		
Feb.	8.6		8.6		
Mar.	9.6		9.5		
Apr.	10.2		10.4		
May	9.5		9.8		
June	7.9		8.3		
July	8.5		8.6		

Table 20 (Cont.)

Ammonia (mg/l - N)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	0.17	0.10	0.10	0.15	0.14
Sept.	0.08	0.05	0.04	0.06	0.06
Oct.	0.05	0.04	0.03	0.05	0.0[illegible]
Nov.	0.12	0.10	0.09	0.11	0.11
Dec.	0.06	0.06	0.06	0.06	0.07
Jan. 1973	0.43	0.27	0.3[illegible]	0.43	0.41
Feb.	0.47	0.46	0.40	0.44	0.42
Mar.	0.35	0.35	0.32	0.35	0.32
Apr.	0.07	0.05	0.05	0.06	0.06
May	0.09	0.05	0.05	0.08	0.08
June	0.13	0.10	0.08	0.11	0.11
July	0.31	0.10	0.10	0.23	0.18
Aug.	0.25		0.09	0.28	0.18
Sept.	0.22		0.08	0.20	0.15
Oct.	0.22		0.09		
Nov.	0.18		0.04		
Dec.	0.21		0.14		
Jan. 1974	1.1		0.63		
Feb.	0.95		0.39		
Mar.	0.89		0.43		
Apr.	0.35		0.09		
May	0.43		0.21		
June	0.39		0.19		
July	0.38		0.07		

Table 20 (Cont.)

Nitrate (mg/l-N)

Date	U/S ([illegible])	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	0.90	0.95	0.96	0.92	[illegible]
Sept.	0.72	0.74	0.72	0.73	[illegible]
Oct.	0.68	0.73	0.71	0.65	[illegible]
Nov.	0.87	0.86	0.72	0.91	[illegible]
Dec	1.6	1.8	1.6	1.7	[illegible]
Jc	1.6	1.6	1.4	1.5	[illegible]
Fet	1.3	1.5	1.2	1.3	[illegible]
Mar.	1.1	0.92	1.1	1.2	1.1
Apr.	1.5	1.4	1.8	1.6	1.6
May	0.75	1.1	0.66	0.70	[illegible]
June	0.66	0.87	0.71	0.64	[illegible]
July	0.82	0.84	0.69	0.74	[illegible]
Aug.	0.54		0.45	0.50	0.50
Sept.	0.64		0.62	0.66	0.61
Oct.	0.81		0.80		
Nov.	0.95		0.95		
Dec.	1.1		1.2		
Jan. 1974	1.5		1.5		
Feb.	1.5		1.4		
Mar.	1.2		0.98		
Apr.	0.90		0.95		
May	0.83		0.84		
June	1.2		1.4		
July	1.5		1.4		

Table 20 (Cont.)

Nitrite (mg/1-N)

Date	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
	Sampling Location				
Aug. 1972	0.042	0.042	0.042	0.042	0.045
Sept.	0.031	0.029	0.030	0.030	0.029
Oct.	0.012	0.012	0.011	0.012	0.012
Nov.	0.0068	0.0064	0.0062	0.0067	0.0058
Dec.	0.0072	0.0067	0.0067	0.0069	0.0073
Jan. 1973	0.014	0.015	0.015	0.016	0.018
Feb.		0.0086			
Mar.		0.011			
Apr.		0.024			
May		0.013			
June		0.032			
July		0.035			
Aug.					
Sept.					
Oct.					
Nov.					
Dec.					
Jan. 1974					
Feb.					
Mar.					
Apr.					
May					
June					
July					

Table 20 (Cont.)

Orthophosphate, Soluble (mg/1-P)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	0.12	0.12	0.12	0.12	0.12
Sept.	0.11	0.11	0.10	0.11	0.11
Oct.	0.081	0.077	0.080	0.081	0.079
Nov.	0.062	0.060	0.062	0.063	0.061
Dec.	0.075	0.060	0.058	0.10	0.077
Jan. 1973	0.19	0.19	0.17	0.17	0.17
Feb.	0.10	0.11	0.10	0.11	0.11
Mar.	0.075	0.082	0.073	0.077	0.092
Apr.	0.050	0.041	0.044	0.048	0.048
May	0.041	0.042	0.033	0.041	0.040
June	0.054	0.050	0.052	0.052	0.059
July	0.073	0.060	0.065	0.073	0.072
Aug.	0.11		0.10	0.12	0.11
Sept.	0.11		0.10	0.11	0.11
Oct.	0.086		0.083		
Nov.	0.066		0.050		
Dec.	0.084		0.071		
Jan. 1974	0.15		0.13		
Feb.	0.13		0.11		
Mar.	0.081		0.080		
Apr.	0.043		0.040		
May	0.038		0.037		
June	0.052		0.053		
July	0.078		0.087		

Table 20 (Cont.)

Phosphorous, total (mg/l-P)

Date		Sampling Location				
	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)		Intake (6)	Discharge (7)
Aug. 1972	0.24	0.25	0.25		0.22	0.25
Sept.	0.26	0.24	0.23		0.25	0.25
Oct.	0.2[illegible]	0.22	0.22		0.22	0.22
Nov.	0.25	0.22	0.24		0.24	0.25
Dec.	0.16	0.16	[illegible]		0.18	0.17
Jan. 1973	0.26	0.22	[illegible]		0.26	0.26
Feb.	0.24	0.26	[illegible]		0.23	0.23
Mar.	0.26	0.46	0.27		[illegible]	0.27
Apr.	0.21	0.21	0.20		[illegible]	0.20
May	0.20	0.23	0.20		[illegible]	0.21
June	0.29	0.31	0.29		[illegible]	0.30
July	0.21	0.17	0.16		[illegible]	0.19
Aug.	0.22		0.19		0.21	0.21
Sept.	0.21		0.18		0.21	0.21
Oct.	0.21		0.21			
Nov.	0.15		0.13			
Dec.	0.15		0.14			
Jan. 1974	0.33		0.30			
Feb.	0.18		0.16			
Mar.	0.23		0.22			
Apr.	0.24		0.22			
May	0.26		0.20			
June	0.44		0.43			
July	0.26		0.25			

Table 20 (Cont.)

Total Coliform Bacteria (No/100 ml)

Date		Sampling Location U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug.	1972	220,000	50,000	73,000	99,000	580,000
Sept.		680,000	210,000	93,000	240,000	200,000
Oct.		13,000	12,000	14,000	26,000	34,000
Sept.		58,000	30,000	34,000	44,000	52,000
Dec.		34,000	35,000	26,000	45,000	35,000
Jan.	1973	30,000		30,000	35,000	60,000
Feb.		21,000		6,300	12,000	13,000
Mar.		3,400		2,500	3,900	1,500
Apr.		14,000		6,900	13,000	8,400
May		360,000		250,000	340,000	270,000
June		26,000		18,000	23,000	19,000
July		15,000		6,000	9,000	10,000
Aug.		4,700		15,000	3,000	2,300
Sept.		5,900		3,200	4,600	25,000
Oct.		8,200		7,500		
Nov.		4,100		5,200		
Dec.		1,200		1,400		
Jan.	1974	7,600		6,900		
Feb.		1,400		1,400		
Mar.		570		290		
Apr.		690		510		
May		550		210		
June		2,300		1,200		
July		1,900		2,300		

Table 20 (Cont.)

Fecal Coliform Bacteria (No/100 ml)

Date		Sampling Location			
	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	910	730	670	660	13,000
Sept.	850	890	850	810	7,000
Oct.	750	620	680	630	810
Nov.	250	300	330	270	250
Dec.	330	240	220	230	330
Jan. 1973	540	510	510	520	540
Feb.	150		130	140	150
Mar.	170		140	130	44
Apr.	390		340	340	420
May	640		570	660	550
June	1,900		1,700	1,600	1,800
July	2,500		1,600	1,600	3,700
Aug.	640		1,300	610	410
Sept.	1,900		1,700	1,800	3,700
Oct.	1,900		2,500		
Nov.	990		1,000		
Dec.	830		790		
Jan. 1974	2,400		3,000		
Feb.	560		310		
Mar.	140		97		
Apr.	280		240		
May	290		250		
June	6,700		6,700		
July	750		560		

Table 20 (Cont.)

Biochemical Oxygen Demand (mg/1)

Date		Sampling Location			
	U/S (5)	D/S 600' (8)	D/S 2 mi. ([illegible])	Intake (6)	Discharg (7)
Aug. 1972					
Sept.					
Oct.	3.2	3.1	3.0	3.1	3.5
Nov.	3.9	3.6	3.6	3.4	3.3
Dec.	3.1	2.4	2.6	2.9	1.8
Jan. 1973	5.6		6.0	5.2	5.3
Feb.	4.3		4.0	3.8	3.3
Mar.	3.2		3.3	3.3	2.7
Apr.	4.3		4.2	4.2	4.3
May	4.4		4.0	4.0	4.3
June	4.4		3.0	3.8	3.5
July	4.0		2.8	3.7	2.9
Aug.	2.7		2.2	2.8	2.3
Sept.	3.4		2.2	3.0	2.7
Oct.	3.7		3.3		
Nov.	5.2		5.0		
Dec.	3.5		3.3		
Jan. 1974	5.5		5.7		
Feb.	4.1		4.1		
Mar.	4.0		4.8		
Apr.	4.4		4.5		
May	5.1		5.0		
June	5.2		4.2		
July	4.0		2.9		

Table 20 (Cont.)

pH

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	7.7	7.7	7.7	7.7	7.7
Sept.	7.8	7.8	7.8	7.9	7.9
Oct.	7.6	7.6	7.5	7.6	7.6
Nov.	7.7	7.7	7.7	7.7	7.7
Dec.	8.0	8.0	8.1	8.0	8.1
Jan. 1973	7.7	7.7	7.7	7.6	7.6
Feb.	7.7	7.7	7.7	7.7	7.7
Mar.	7.7	7.7	7.7	7.6	7.6
Apr.	7.9	8.0	7.9	7.9	7.9
May	8.2	8.2	8.2	8.2	8.2
June	8.0	8.1	8.0	8.0	8.0
July	7.9	7.9	8.0	8.0	8.0
Aug.	7.8		7.8	7.8	7.8
Sept.	7.8		7.8	7.8	7.9
Oct.	7.8		7.8		
Nov.	8.1		8.1		
Dec.	8.2		8.2		
Jan. 1974	7.7		7.7		
Feb.	7.8		7.8		
Mar.	8.0		8.1		
Apr.	8.2		8.2		
May	8.2		8.1		
June	8.0		8.0		
July	8.0		8.0		

Table 20 (Cont.)

Specific Conductance (umhos/cm at 25C)

Date		Sampling Location U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug.	1972	274	275	275	276	274
Sept.		289	284	287	288	288
Oct.		277	277	276	277	277
Nov.		285	288	284	285	287
Dec.		388	387	389	394	389
Jan.	1973	352	313	345	347	345
Feb.		352		344	346	345
Mar.		277		277	276	283
Apr.		310		308	311	312
May		311		306	309	309
June		315		321	321	323
July		374		372	369	375
Aug.		361		357	360	362
Sept.		337		333	337	337
Oct.		340		340		
Nov.		322		322		
Dec.		356		356		
Jan.	1974	366		372		
Feb.		385		384		
Mar.		347		342		
Apr.		342		339		
May		330		336		
June						
July		374		369		

Table 20 (Cont.)

Copper (mg/1)

Date		Sampling Location			
	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	0.0043	0.0034	0.0041	0.0036	0.012
Sept.	0.0076	0.0043	0.0037	0.0041	0.0051
Oct.	0.0047	0.0034	0.0034	0.0040	0.0052
Nov.	0.0046	0.0041	0.0037	0.0041	0.0059
Dec.	0.0032	0.0020	0.0026	0.0017	0.0026
Jan. 1973	0.0038		0.0037	0.0039	0.0074
Feb.	0.0033		0.011	0.0034	0.0046
Mar.	0.0039		0.0047	0.0054	0.011
Apr.	0.0042		0.0038	0.0051	0.0062
May	0.0027		0.0040	0.0069	0.0048
June	0.0052		0.0028	0.0036	0.0053
July	0.0055		0.0037	0.0022	0.0042
Aug.	0.0039		0.0032	0.0031	0.0028
Sept.	0.0063		0.0038	0.0049	0.067
Oct.	0.0033		0.0026		
Nov.	0.0030		0.0022		
Dec.	0.0032		0.0025		
Jan. 1974	0.0028		0.0030		
Feb.	0.0027		0.0041		
Mar.	0.0038		0.0038		
Apr.	0.010		0.0040		
May	0.014		0.011		
June	0.0				
July	0.0058		0.0046		

Table 20 (Cont.)

Iron, total (mg/1)

Date	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
		Sampling Location			
Aug. 1972	2.1	2.1	2.1	2.1	2.1
Sept.	2.6	2.6	2.3	2.5	2.6
Oct.	1.3	1.3	1.2	1.3	1.2
Nov.	3.5	3.9	3.4	3.5	3.8
Dec.	0.57	0.47	0.48	0.43	0.44
Jan. 1973	2.9		2.8	2.9	3.0
Feb.	0.66		0.67	0.67	0.67
Mar.	2.1		2.2	2.2	2.2
Apr.	1.6		1.4	1.3	1.4
May	2.5		2.6	2.6	2.6
June	2.4		2.6	2.6	2.6
July	1.1		0.79	0.89	0.79
Aug.	1.3		1.1	1.3	1.3
Sept.	1.1		0.97	1.1	1.2
Oct.	1.6		1.4		
Nov.	0.65		0.64		
Dec.	0.46		0.48		
Jan 1974	0.99		0.88		
Feb.	0.46		0.44		
Mar.	0.85		0.69		
Apr.	1.9		2.0		
May	2.4		2.6		
June	11.8		12.5		
July	1.0		0.97		

Table 20 (Cont.)

Lead (mg/l)

Date	U/S (5)	D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
		Sampling Location			
Aug. 1972	0.003	0.003	0.003	0.003	0.013
Sept.	0.004	0.003	0.002	0.002	0.003
Oct.	0.003	0.002	0.001	0.002	0.002
Nov.	0.007	0.005	0.004	0.004	0.006
Dec.	0.002	0.004	0.002	<0.001	0.003
Jan. 1973	0.007		0.006	0.006	0.009
Feb.	0.001		<0.001	0.009	0.005
Mar.	0.003		0.003	0.003	0.004
Apr.	0.005		0.002	<0.001	0.001
May	0.002		0.005	0.006	0.007
June	0.014		0.004	0.004	0.006
July	0.009		0.004	0.001	0.004
Aug.	0.029		0.012	0.018	0.038
Sept.	0.003		<0.001	0.003	0.003
Oct.	0.004		0.002		
Nov.	0.007		0.002		
Dec.	0.003		0.002		
Jan. 1974	0.002		0.002		
Feb.	0.001		0.001		
Mar.	0.001		0.001		
Apr.	0.002		0.001		
May	0.005		0.005		
June	0.017		0.018		
July	0.002		0.002		

Table 20 (Cont.)

Manganese, total (mg/l)

Date		U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug.	1972	0.20	0.19	0.19	0.20	0.23
Sept.		0.25	0.22	0.20	0.22	0.24
Oct.		0.14	0.14	0.13	0.13	0.14
Nov.		0.31	0.38	0.33	0.32	0.35
Dec.		0.090	0.066	0.059	0.074	0.064
Jan.	1973	0.15		0.15	0.15	0.16
Feb.		0.11		0.10	0.10	0.11
Mar.		0.17		0.17	0.18	0.18
Apr.		0.20		0.18	0.16	0.18
May		0.24		0.26	0.25	0.25
June		0.32		0.28	0.35	0.36
July		0.26		0.19	0.22	0.22
Aug.		0.13		0.11	0.13	0.13
Sept.		0.19		0.15	0.19	0.21
Oct.		0.16		0.13		
Nov.		0.079		0.077		
Dec.		0.063		0.062		
Jan.	1974	0.13		0.11		
Feb.		0.11		0.097		
Mar.		0.10		0.10		
Apr.		0.22		0.23		
May		0.34		0.38		
June		0.72		0.80		
July		0.21		0.16		

Table 20 (Cont.)

Mercury (mg/1)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	0.00097	0.00061	0.00056	0.00045	0.00073
Sept.	0.00093	0.00025	0.00010	0.00033	0.00013
Oct.	0.00023	0.00011	0.00011	0.00010	0.00012
Nov.	0.00026	0.00029	0.00085	0.00028	0.00030
Dec.	0.00039	0.00006	0.00011	< 0.00005	0.00005
Jan. 1973	0.00032		0.00011	0.00022	0.00020
Feb.	0.00006		0.00006	< 0.00005	0.00008
Mar.	0.00005		0.00009	0.00012	0.00014
Apr.	< 0.00005		< 0.00005	< 0.00005	< 0.00005
May	0.00008		< 0.00005	0.00007	< 0.00005
June	0.00012		0.00013	0.00012	0.00010
July	0.00008		0.00031	< 0.00005	< 0.00005
Aug.	< 0.00005		0.00006	< 0.00005	< 0.00005
Sept.	< 0.00005		< 0.00005	< 0.00005	0.00008
Oct.	0.00043		0.00019		
Nov.	0.00006		0.00009		
Dec.	0.00010		0.00008		
Jan. 1974	< 0.00005		< 0.00005		
Feb.	0.00009		0.00010		
Mar.	0.00005		< 0.00005		
Apr.	0.00014		0.00008		
May	< 0.00005		< 0.00005		
June	0.00028		0.00023		
July	0.00022		0.00018		

Table 20 (Cont.)

Zinc (mg/1)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	<.001	<.001	<.001	<.001	<.001
Sept.	<.001	<.001	<.001	0.002	0.003
Oct.	0.002	0.004	0.001	0.002	0.005
Nov.	<.001	<.001	0.002	0.002	0.003
Dec.	0.010	0.010	0.009	0.006	0.012
Jan. 1973	0.023		0.005	0.023	0.010
Feb.	0.002		<0.001	<0.001	0.001
Mar.	0.004		0.004	0.008	0.011
Apr.	0.012		0.013	0.007	0.011
May	0.027		0.015	0.023	0.015
June	<0.001		<0.001	<0.001	<0.001
July	<0.001		<0.001	<0.001	<0.001
Aug.	0.016		0.015	0.016	0.020
Sept.	0.024		0.008	0.011	0.027
Oct.	0.010		0.008		
Nov.	0.012		0.005		
Dec.	0.008		0.006		
Jan. 1974	0.009		0.008		
Feb.	0.008		0.011		
Mar.	0.012		0.008		
Apr.	0.035		0.010		
May	0.043		0.039		
June	0.082		0.092		
July	0.016		0.008		

Table 20 (Cont.)

Hexane soluble materials (mg/1)

Date	U/S (5)	Sampling Location D/S 600' (8)	D/S 2 mi. (13)	Intake (6)	Discharge (7)
Aug. 1972	1.7	0.1	5.2	0.6	0.7
Sept.	0.3	0.3	0.7	< 0.1	0.2
Oct.	0.9	0.4	1.1	0.5	0.6
Nov.	< 0.1	< 0.1	0.8	0.2	0.9
Dec.	0.5	0.6	0.3	0.1	0.1
Jan. 1974	0.5		< 0.1	< 0.1	0.7
Feb.	< 0.1		< 0.1	< 0.1	< 0.1
Mar.	0.2		< 0.1	< 0.1	< 0.1
Apr.	0.8		0.8	0.3	0.6
May	0.7		1.3	0.6	1.2
June	< 0.1		< 0.1	< 0.1	< 0.1
July	< 0.1		0.7	0.1	0.3
Aug.	1.8		0.9	0.7	1.3
Sept.	< 0.1		0.4	< 0.1	< 0.1
Oct.					
Nov.					
Dec.					
Jan. 1974					
Feb.					
Mar.					
Apr.					
May					
June					
July					

Table 21

Summary of Chlorine Determinations at the Quad-Cities Station July, 1972 - July 1974

	Station 6 - Intake Bay			Station 7 - Discharge Bay			Station 21 - Miss. River mid channel 600' downstream			Station 8 Miss River E. side 800' downstream		
Date	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l total Cl)	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l Total Cl)	Number of Samples Analyze	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l total Cl)	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l Total Cl
27 July 1972				17	10	0.21				17	8	0.16
1 August 1972	2	0	< 0.01							2	0	< 0.01
8 August 1972	2	0	< 0.01	2	1	0.03				2	0	< 0.01
15 August 1972	2	0	< 0.01	2	0	<0.01				2	0	< 0.01
22 August 1972	2	0	< 0.01	2	0	<0.01				2	0	< 0.01
29 August 1972	4	0	< 0.01	4	0	<0.01				4	0	< 0.01
5 September 1972	2	0	< 0.01	2	2	0.05				2	0	< 0.01
12 September 1972	2	0	< 0.01	2	0	<0.01				2	0	< 0.01
19 September 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
26 September 1972	4	0	< 0.01	4	0	< 0.01				4	0	< 0.01
3 October	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
10 October 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
17 October 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
24 October 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
31 October 1972	4	0	< 0.01	4	0	< 0.01				4	0	< 0.01
7 November 1972												
14 November 1972	4	0	< 0.01	4	0	< 0.01				4	0	< 0.01
19 November 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
28 November 1972	2	0	< 0.01	2	2	0.18				2	0	< 0.01
5 December 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
12 December 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
17 December 1972	4	0	< 0.01	4	0	< 0.01				4	0	< 0.01
27 December 1972	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
3 January 1973	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
9 January 1973	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
16 January 1973	2	0	< 0.01	2	0	< 0.01				2	0	< 0.01
23 January 1973	2	0	< 0.01	2	0	< 0.01						
31 January 1973	2	0	< 0.01	2	2	0.83						
13 February 1973	3	0	< 0.01	3	1	0.32	2	0	<0.01			
20 February 1973	3	0	< 0.01	3	0	< 0.01	2	0	<0.01			
13 March 1973	3	1	0.11	3	1	0.34	3	0	<0.01			
20 March 1973	3	0	< 0.01	3	1	0.23	3	0	<0.01			
27 March 1973	3	0	< 0.01	3	1	0.41	3	0	<0.01			
3 April 1973	3	0	< 0.01	3	1	0.28	3	0	<0.01			
9 April 1973	3	0	< 0.01	12	3	0.37	3	0	<0.01			
16 April 1973	3	0	< 0.01	4	2	0.36	3	0	<0.01			
1 May 1973	3	0	< 0.01	5	1	0.04	3	0	<0.01			
15 May 1973	3	0	< 0.01	7	4	0.13	3	0	<0.01			
30 May 1973	3	0	< 0.01	7	4	0.25	3	0	<0.01			
5 June 1973	3	0	< 0.01	10	4	0.11	3	0	<0.01			
12 June 1973	3	0	< 0.01	8	4	0.05	3	0	<0.01			
18 June 1973	3	0	< 0.01	12	4	0.17	3	0	<0.01			
25 June 1973	3	0	< 0.01	7	2	0.05	3	0	<0.01			
2 July 1973	3	0	< 0.01	3	1	0.17	3	0	<0.01			
16 July 1973	3	0	< 0.01	7	5	0.34	3	0	<0.01			
31 July 1973	3	0	< 0.01	5	3	0.10	3	0	<0.01			
27 August 1973	3	0	< 0.01	6	2	0.15	3	0	<0.01			
5 September 1973	3	0	< 0.01	6	3	0.14	3	0	<0.01			
11 September 1973	3	0	< 0.01	7	2	0.60	3	0	<0.01			
24 September 1973	3	0	< 0.01	5	3	0.07	3	0	<0.01			
2 October 1973	3	0	< 0.01	8	4	0.67	3	0	<0.01			
23 October 1973	3	0	< 0.01	6	5	0.52	3	0	<0.01			
6 November 1973	3	0	< 0.01	6	0	< 0.01	3	0	<0.01			

Table 21 (Cont.)

	Station 6 - Intake Bay			Station 7 - Discharge Bay			Station 21 - Miss. River mid channel 600' down-stream			Station 8 Miss. River E. side 800' down-stream		
	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l total Cl)	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l Total Cl)	Number of Samples Analyze	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l total Cl	Number of Samples Analyzed	No. of Samples >0.01 mg/l Total Cl	Max Conc. (mg/l Total Cl
4 December 1973	3	0	< 0.01	6	0	< 0.01	3	0	< 0.01			
3 January 1974	3	0	< 0.01	12	6	0.46						
9 January 1974	3	0	< 0.01	8	5	0.31						
15 January 1974	3	0	< 0.01	9	1	0.25						
22 January 1974	3	0	< 0.01	7	2	0.05	3	0	< 0.01			
19 February 1974	3	0	< 0.01	11	0	< 0.01	3	0	< 0.01			
26 February 1974	3	0	< 0.01	12	4	0.34	3	0	< 0.01			
26 March 1974	3	0	< 0.01	13	11	2.10	3	0	< 0.01			
2 April 1974	2	0	< 0.01	15	10	1.18	2	0	< 0.01			
9 April 1974	3	0	< 0.01	10	2	1.09	3	0	< 0.01			
15 April 1974	3	0	< 0.01	8	1	0.06	3	0	< 0.01			
25 April 1974				7	6	0.58						
30 April 1974	2	0	< 0.01	17	10	0.34	2	0	< 0.01			
7 May 1974	1	0	< 0.01	8	1	0.06	1	0	< 0.01			
14 May 1974	2	0	< 0.01	8	1	0.13	2	0	< 0.01			
21 May 1974	3	0	< 0.01	8	5	0.26	3	0	< 0.01			
27 May 1974	3	0	< 0.01	21	9	0.10	3	0	< 0.01			
4 June 1974	3	0	< 0.01	8	1	0.02	3	0	< 0.01			
18 June 1974	3	0	< 0.01	8	0	< 0.01	3	0	< 0.01			
9 July 1974	3	0	< 0.01	8	0	< 0.01	3	0	< 0.01			

chlorination total chlorine was detected outside of the discharge bay (location 7) only on two occasions, July 27, 1972 at location 8 and March 13, 1973 at location 6. On July 27, 1972, during the operation of interim side-jet discharge, total chlorine was detected in eight of seventeen samples at location 8 about 800 feet downstream from the discharge during the period of chlorination. Total chlorine concentrations dropped below the analytical detection limit (0.01 mg/l) shortly after completion of the chlorination cycle.

Total chlorine was detected in the intake bay (location 6) on March 13, 1973 during station chlorination and was attributed to recirculation from the discharge to the intake by operation of the station's ice melt system.

Total chlorine was never detected in the intake bay or in the main channel of the Mississippi River on any other occasion.

Beginning on February 13, 1973, samples were collected before, during and after chlorination at location 6, 7 and 13. From April 9, 1973 to July 9, 1974 samples were collected at approximately five to ten minute intervals at location 7 to determine variability of total chlorine in the discharge bay during chlorination.

Total chlorine concentrations in excess of 1.0 mg/l were observed in the discharge bay (location 7) on only three occasions: March 26, 1973 (2.10 mg/l), April 2, 1973 (1.18 mg/l), and April 9, 1973 (1.09 mg/l) during periods of increased flow rate of sodium hypochlorite into the chlorination system.

4.4 Effects of Station Operation on Existing Biota

4.4.1. Aquatic Biota

The detailed results of the biological monitoring program which

justify the conclusions contained in this section of the application are documented in six reports prepared by Industrial Bio-Test Laboratories, Inc. These reports consist of a total of fourteen volumes spanning nearly four years of study and are briefly described in Table 22.

All the important aquatic communities present in the Mississippi River above and below the Quad-Cities station were investigated during the course of these studies and are discussed below. Sampling locations for these studies are shown in Figure 31.

Various statistical procedures were used for the analysis of the Quad-Cities biological data. Two basic approaches can be made toward the statistical design of environmental river-monitoring programs. One method, the formal approach, is to perform an intensive initial study of all the myriad components of the various habitats that comprise a river system. From such a study precise knowledge of sample size and sample replication requirements can be determined so that each monitoring event can show relevent environmental differences with sufficient power. This approach will lead to greater statistical sensitivity for each monitoring event yet can be quite expensive when applied routinely over a long period of time. Because of the complexity of the Mississippi River ecosystem, the vast and obvious impact of seasonal fluctuations and hydraulic changes on the biotic system and the practical budgetary and personnel constraints, this formal approach was not selected for monitoring at Quad-Cities.

A second approach, the one applied at the Quad-Cities station, is one that lends itself well to the tripartite considerations of grossly differing habitats within the study area; rapid shifts in the flow regime and vast seasonal temperature extremes; and a requirement for

Table 22

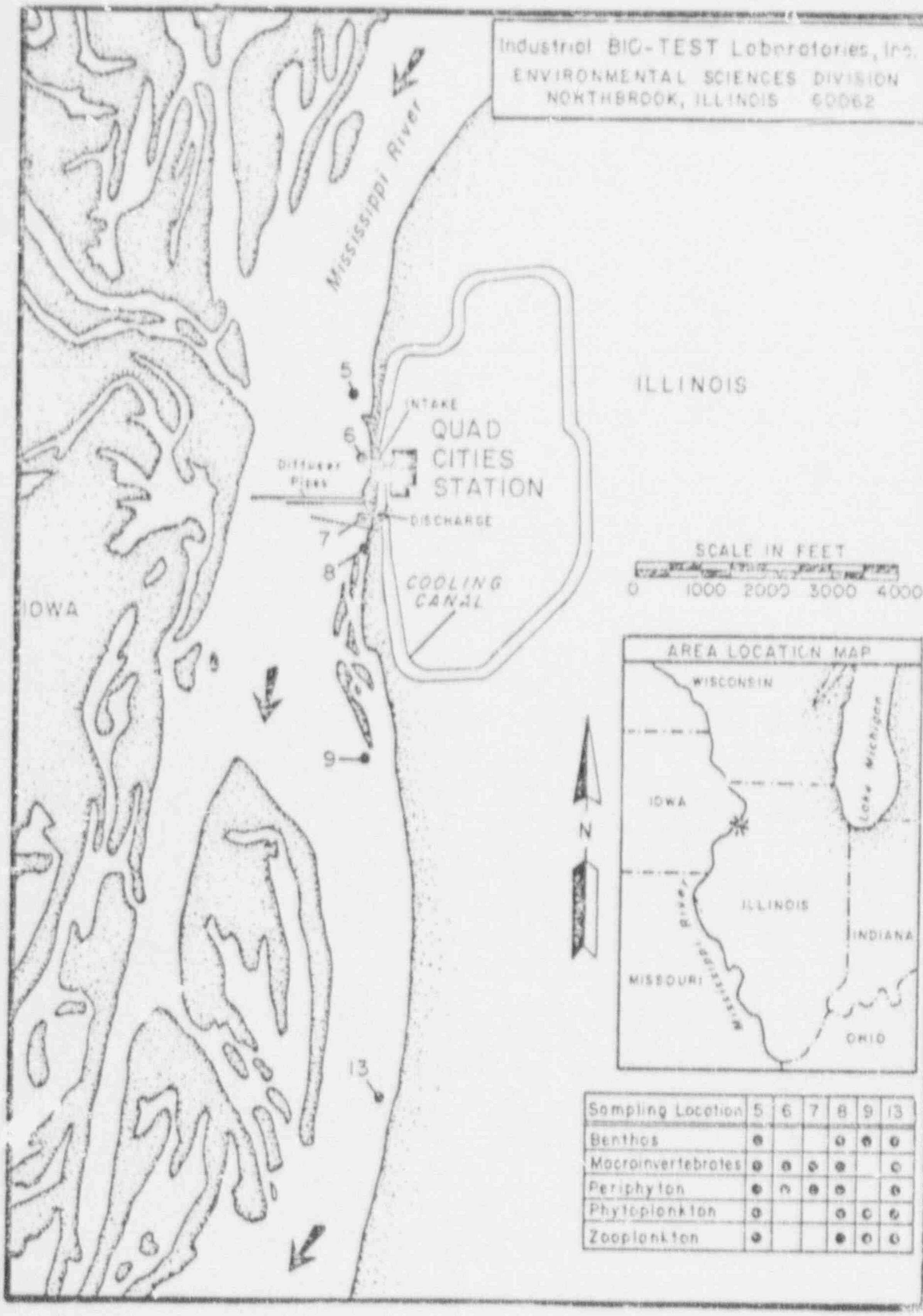
List of detailed reports by Industrial Bio-Test Laboratories, Inc. to the Commonwealth Edison Company for the Quad-Cities Station.

No.	Title	Preoperational or Operational Period Covered	Volume	Contents
1	Determination of thermal effects in the Mississippi River Near Quad-Cities Station	April to December 1971 (preoperational monitoring	I	Limnology, temperature, water quality
			II	Quad-Cities: Pesticides, fish physiology, artificial substrate studies, fish populations. Riverside: Thermal effects
			III	Quad-Cities: Thermal effects
2	Determination of thermal effects in the Mississippi River near Quad-Cities Station	April to July 1972 (period of interim side jet discharge monitoring	I	Temperature, water quality
			II	Artificial substrates, thermal effects, fisheries: entrainment
3	Determination of thermal effects in the Mississippi River near Quad-Cities Station	August 1972 through January 1973 (period of diffuser pipe system monitoring	I	Text
			II	Appendixes (Tables)
4	Operational environmental monitoring in the Mississippi River near Quad-Cities Station	February 1973 through July 1973 (period of diffuser pipe system monitoring	I	Text
			II*	Appendix tables, temperature, D.O., water quality chlorine
			III*	Appendix tables, periphyton, macroinvertebrates phytoplankton, zooplankton, benthos, particle size, fish populations, entrainment

* The initial printing of this report incorporated both appendices into one volume. The second printing divided appendices into two separate volumes.

Table 22 (Cont.)

No.	Title	Preoperational or Operational Period Covered	Volume	Contents
5	Operational environmental monitoring in the Mississippi River near Quad-Cities Station	August 1973 through January 1974 (period of diff[illegible]pe system mor[illegible]	I	Text
			II	appendices
6	Operational environmental monitoring in the Mississippi River near Quad-Cities Station	February 1974 through July 1974 (period covering end of two-pipe system into period of nearshore diffuser pipe plus sp[illegible] canal operational m[illegible]itoring	I	Text
			II	Appendices



Sampling Location	5	6	7	8	9	13
Benthos	●			●	●	●
Macroinvertebrates	●	●	●	●		●
Periphyton	●	●	●	●		●
Phytoplankton	●			●	●	●
Zooplankton	●			●	●	●

Figure 31. Sampling locations for the biological monitoring studies at Quad-Cities Station.

long-term monitoring. Although sample size and sample replication at each sampling was small, the combined effect of the many samplings increases the power of the study to an acceptable level. For example, suppose at any one sampling the probability of detecting a biologically significant change is .25 and the probability of claiming there is no change when there has been a change of biological significance is 1 - .25 = .75. If ten independent samplings take place the probability of claiming no change when there has been one is now $.75^{10}$ - .056 and the probability of detecting a biologically significant change is now 1 - .056 = .944, an acceptable power.

The details of statistical analyses that were conducted for the various biological studies are discussed in the appropriate sections.

4.4.1.1 Phytoplankton

Comparisons of total phytoplankton, major algal divisions, and dominant species at locations upstream and downstream from the side-jet discharge area or of the diffuser pipe heat dissipation systems indicated that neither mode of heat discharge had any detectable effect upon phytoplankton numbers or community composition. Statistically significant differences ($P = \leq .05$) were found infrequently; however, these small differences were random in nature and were not indicative of effect of Station operation.

Total phytoplankton numbers at both upstream and downstream locations achieved annual peaks in the spring months: May and June in 1971 and 1972; April, May and June in 1973; and in 1974 a major peak during April and May, plus a second peak during June. Minor pulses also occurred in early November 1971; December of 1972; and October and November 1973 (Figure 32). Similar seasonal phytoplankton pulses are typical of other flowing waters (Hynes 1970).

Careful examination of Figure 32 revealed no consistent differences between the upstream locations (5 or 6) and the downstream locations (8 and 13).

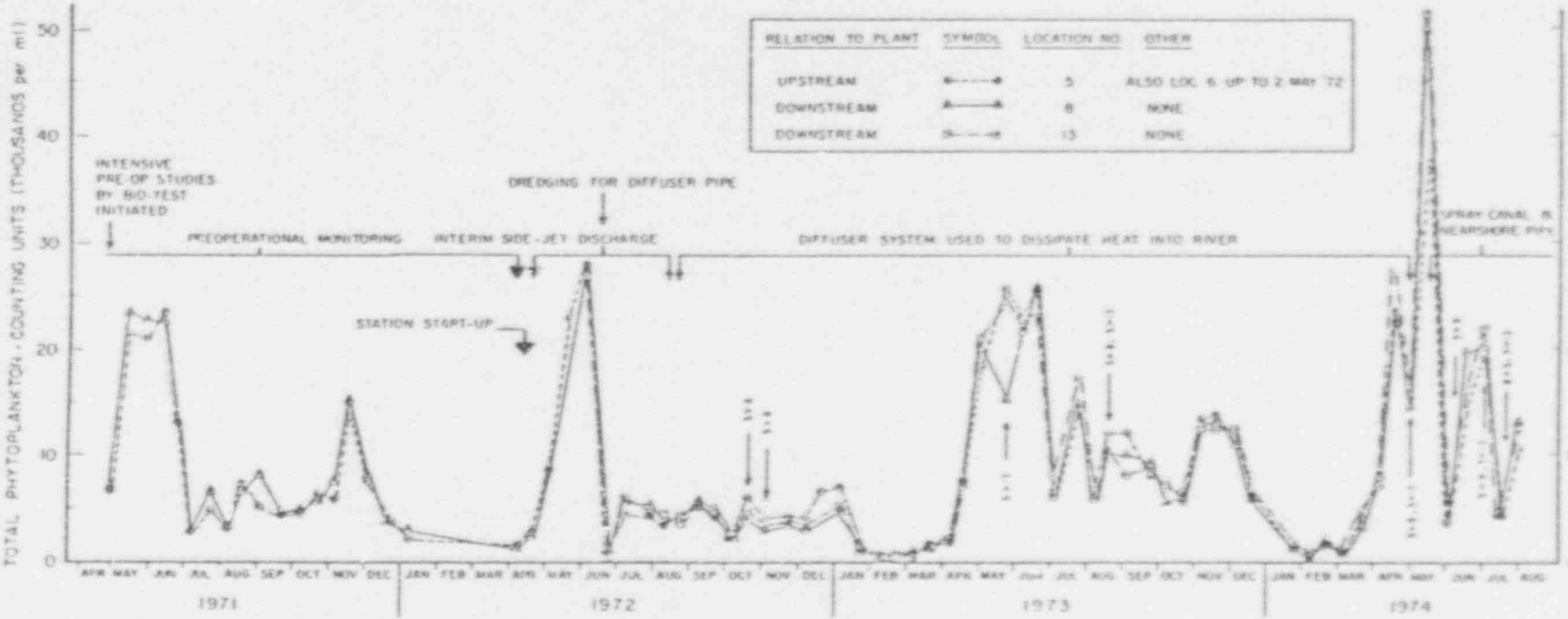


Figure 32. Total phytoplankton counts compared above and below Quad-Cities Station, April 1971 through July 1974.

Likewise, when the three major algal groups were plotted as a percent of the total algal numbers (Figures 33, 34, 35) no consistent differences between upstream and downstream locations were apparent and no effects could be attributed to the various waste heat systems employed since December 1971. Additional perspective was added in comparing the normal variation in the phytoplankton by comparison of the preoperational data up to December 1971 (Figures 33-35) with the operational data from 1972 to the present.

Phytoplankton counts were statistically analyzed by one-way analyses of variance. Justification of this normal parametric procedure is as follows:

1. Raw counts of phytoplankton can often be modeled as Poisson random variables (McCaughran and Ochener, 1974) since the organisms are well mixed in river conditions.

2. The mean counts of phytoplankton taxa analyzed were high; thus, the underlying distribution is approximately normal.

To stabilize variances, the square root transformation was applied to the data prior to ANOVA. Tukey's or Scheffe's multiple comparison was used to test for specific differences between locations.

It was obvious that the differences between upstream and downstream locations were not great and that greater phytoplankton numbers were sometimes exhibited upstream and sometimes downstream. In addition, the overall magnitude of differences between locations was similar for preoperational or operational periods.

4.4.1.2 Zooplankton

Comparisons of total zooplankton (Figure 36) and the three major groups of zooplankters (Figures 37, 38, 39) prior to and during all phases

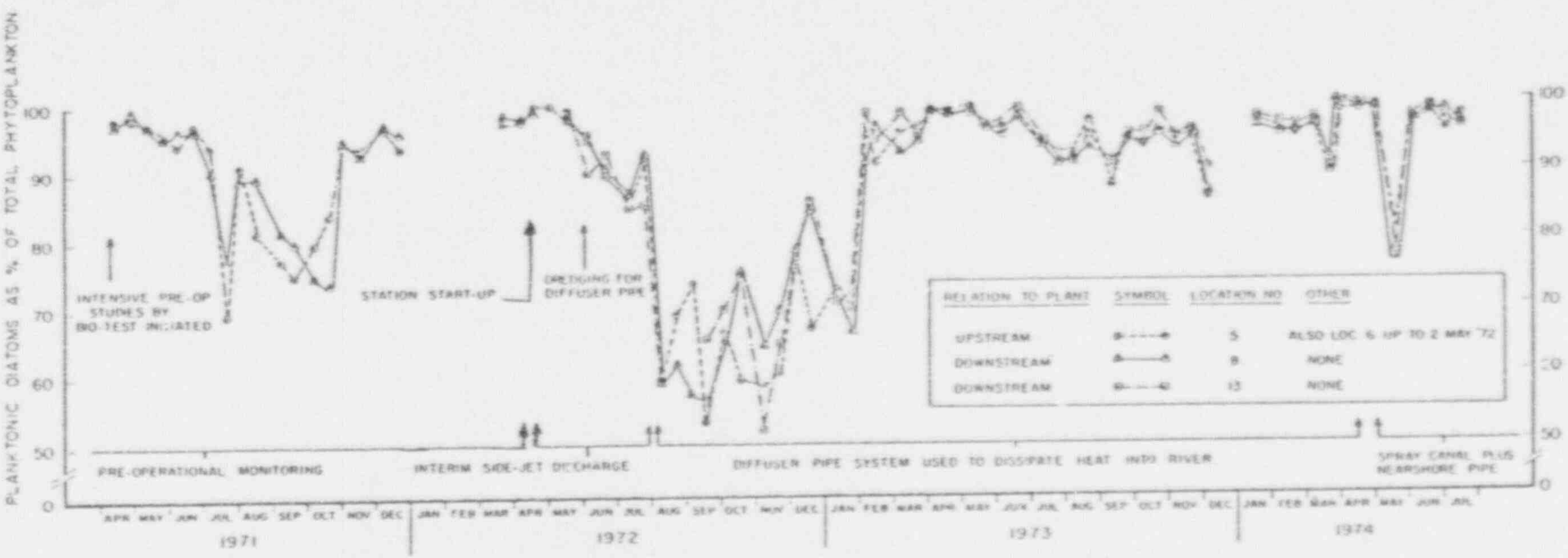


Figure 33. Planktonic diatoms as a percent of total phytoplankton compared above and below Quad-Cities St ation, April 1971 through July 1974.

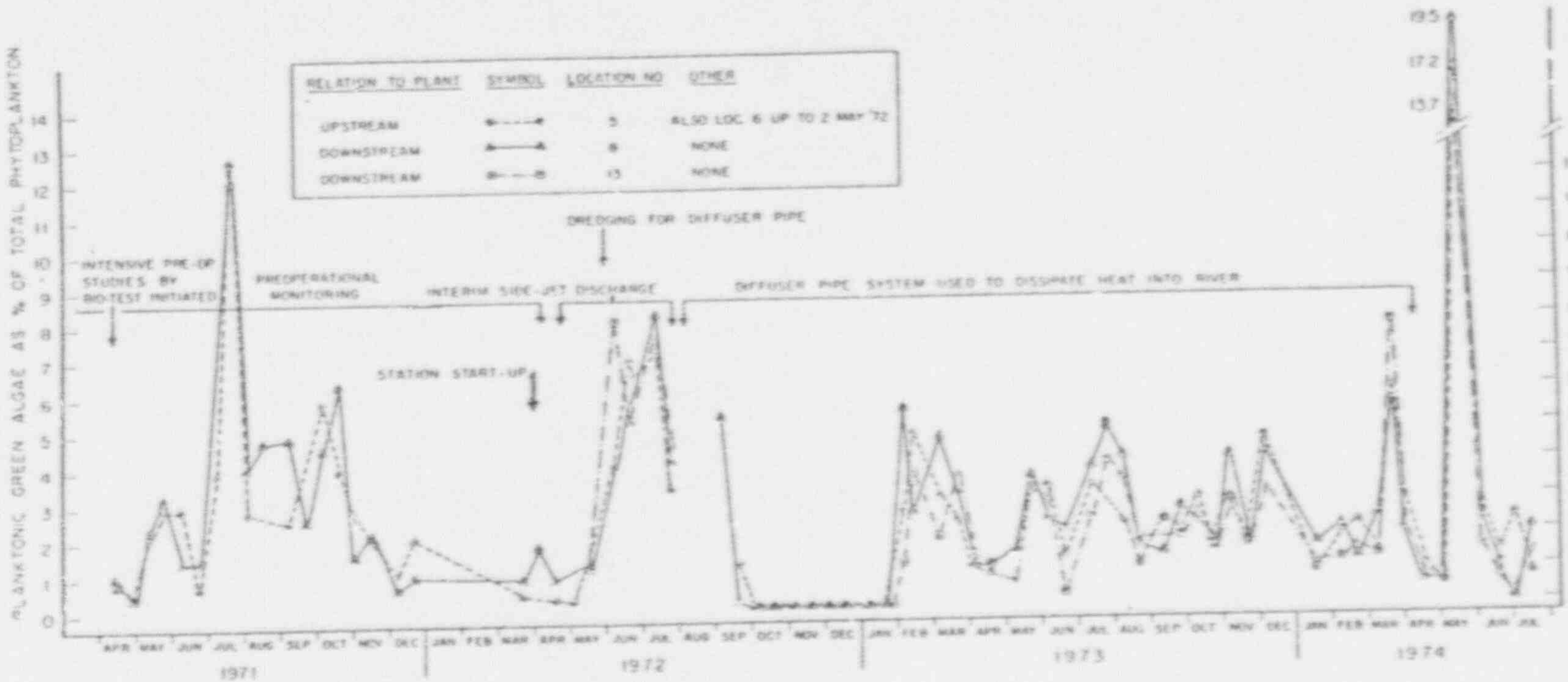


Figure 34. Planktonic green algae as a percent of total phytoplankton compared above and below Quad-Cities Station, April 1971 through July 1974.

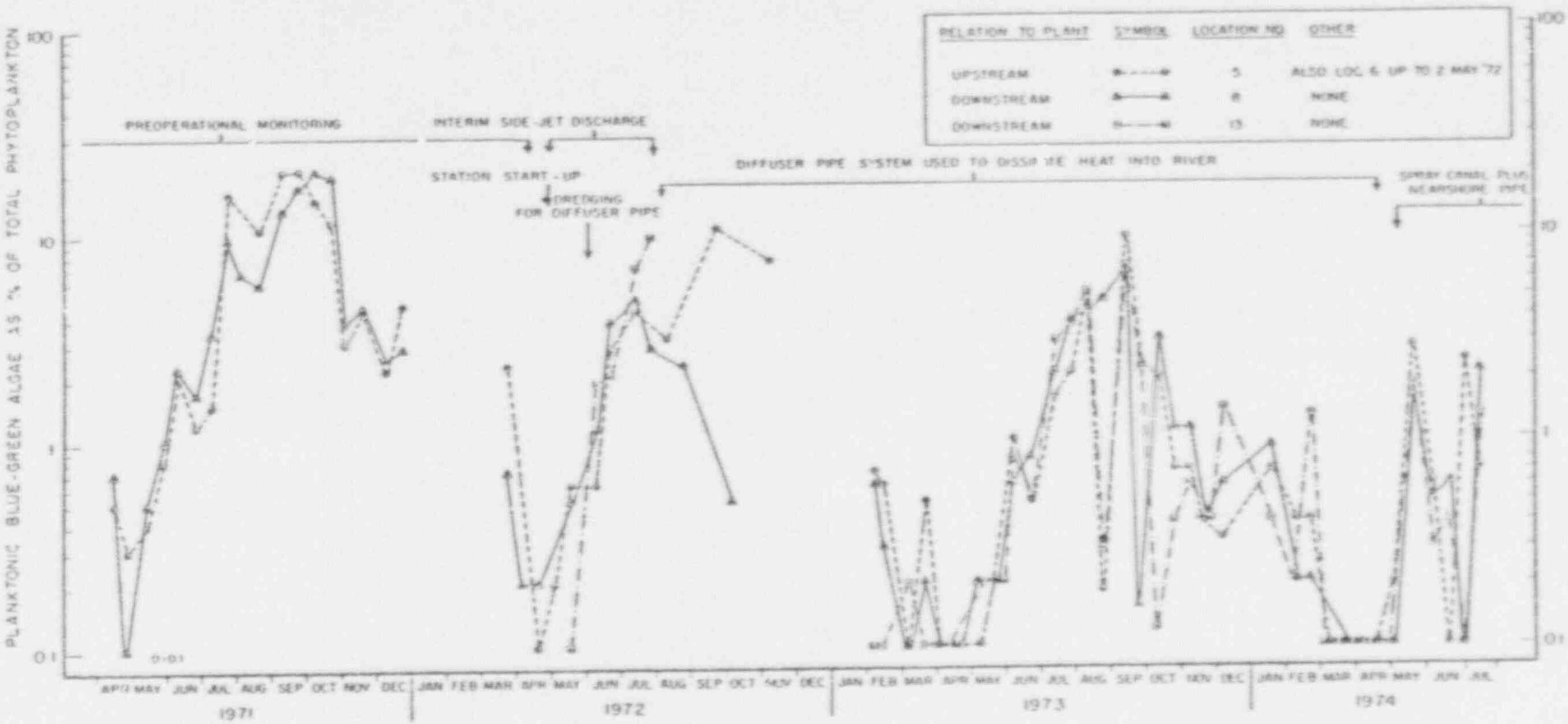


Figure 35. Planktonic blue-green algae as a percent of total phytoplankton compared above and below Quad-Cities Station, April 1971 through July 1974.

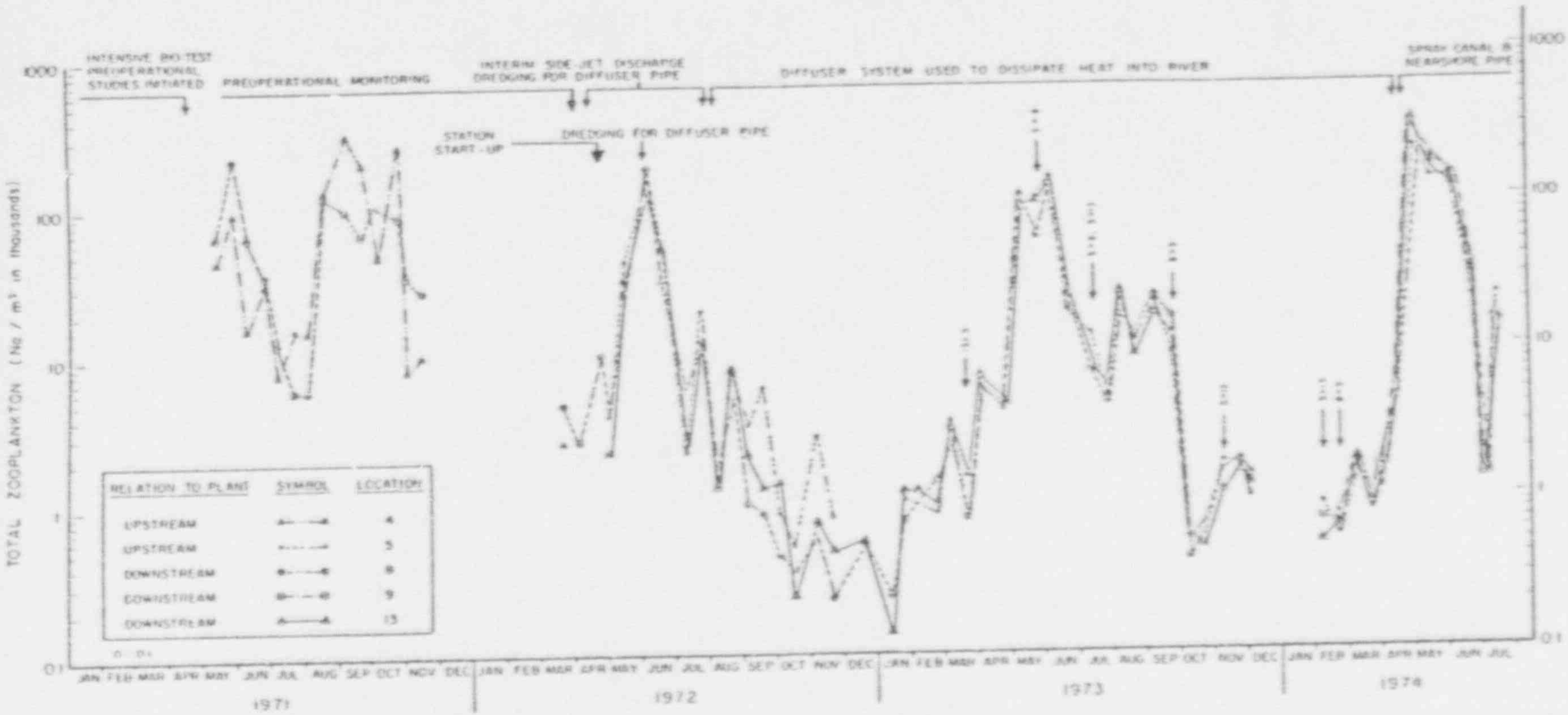


Figure 36. Total zooplankton counts compared above and below Quad-Cities Station, May 1971 through July 1974.

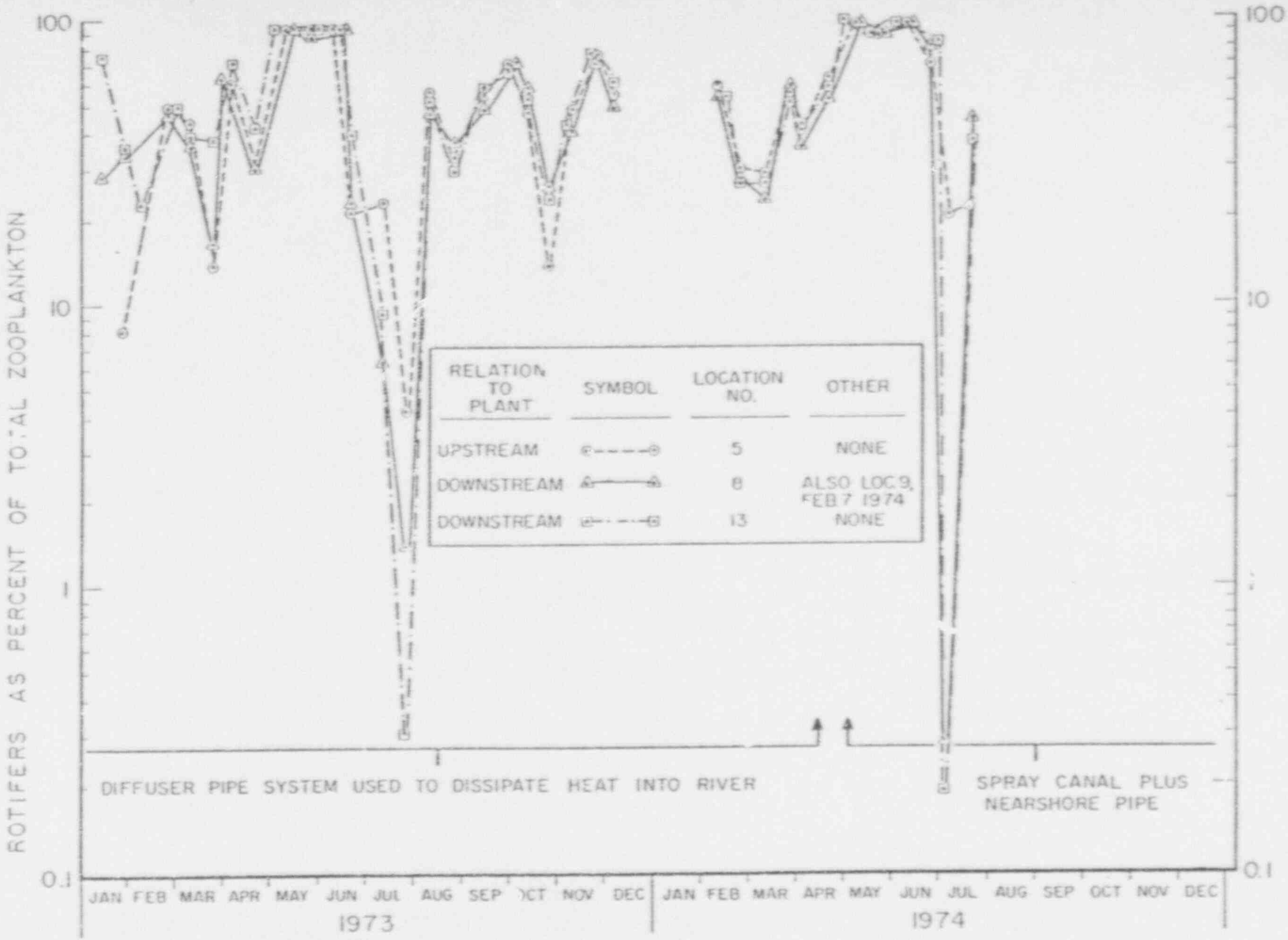


Figure 37. Rotifers as a percent of total zooplankton compared above and below Quad-Cities Station, January 1973 through July 1974.

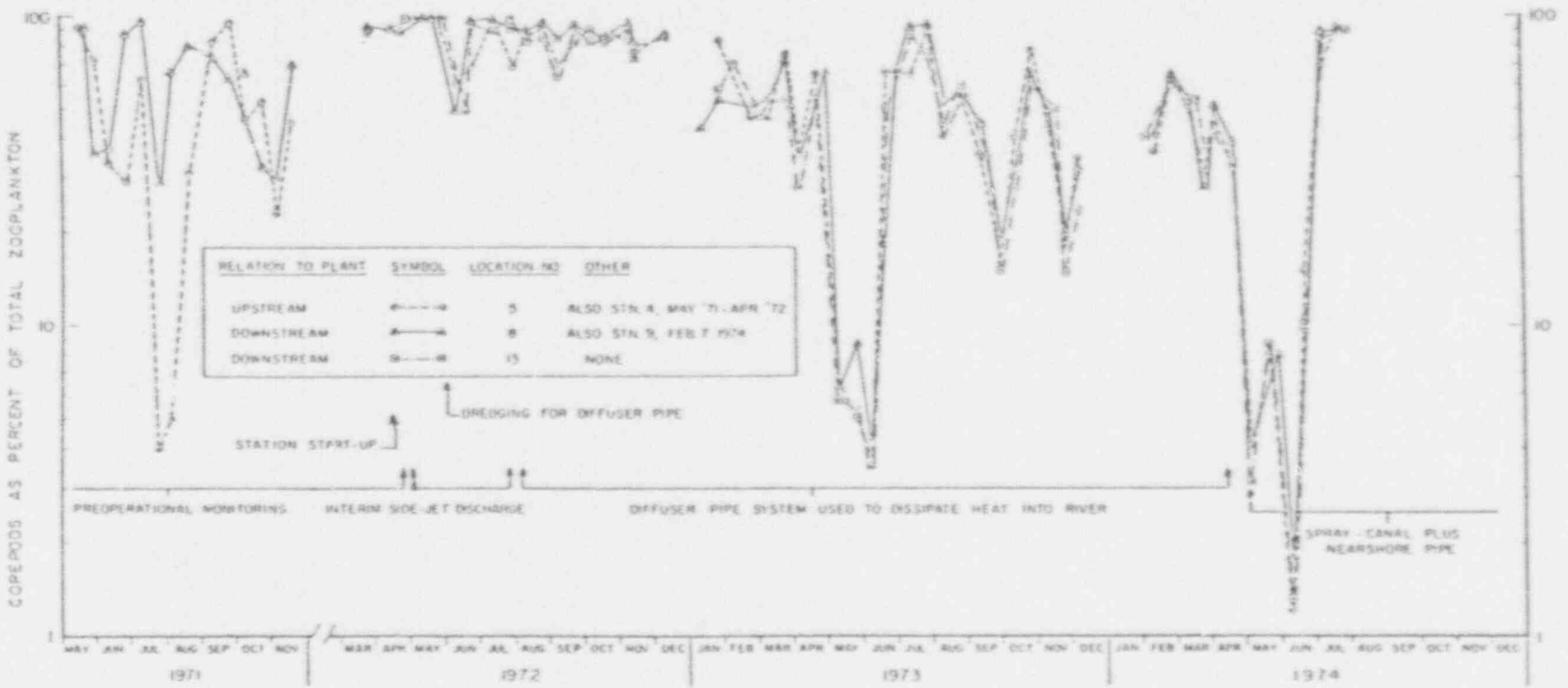


Figure 38. Copepods as a percent of total zooplankton compared above and below Quad-Cities Station, May 1971 through July 1974.

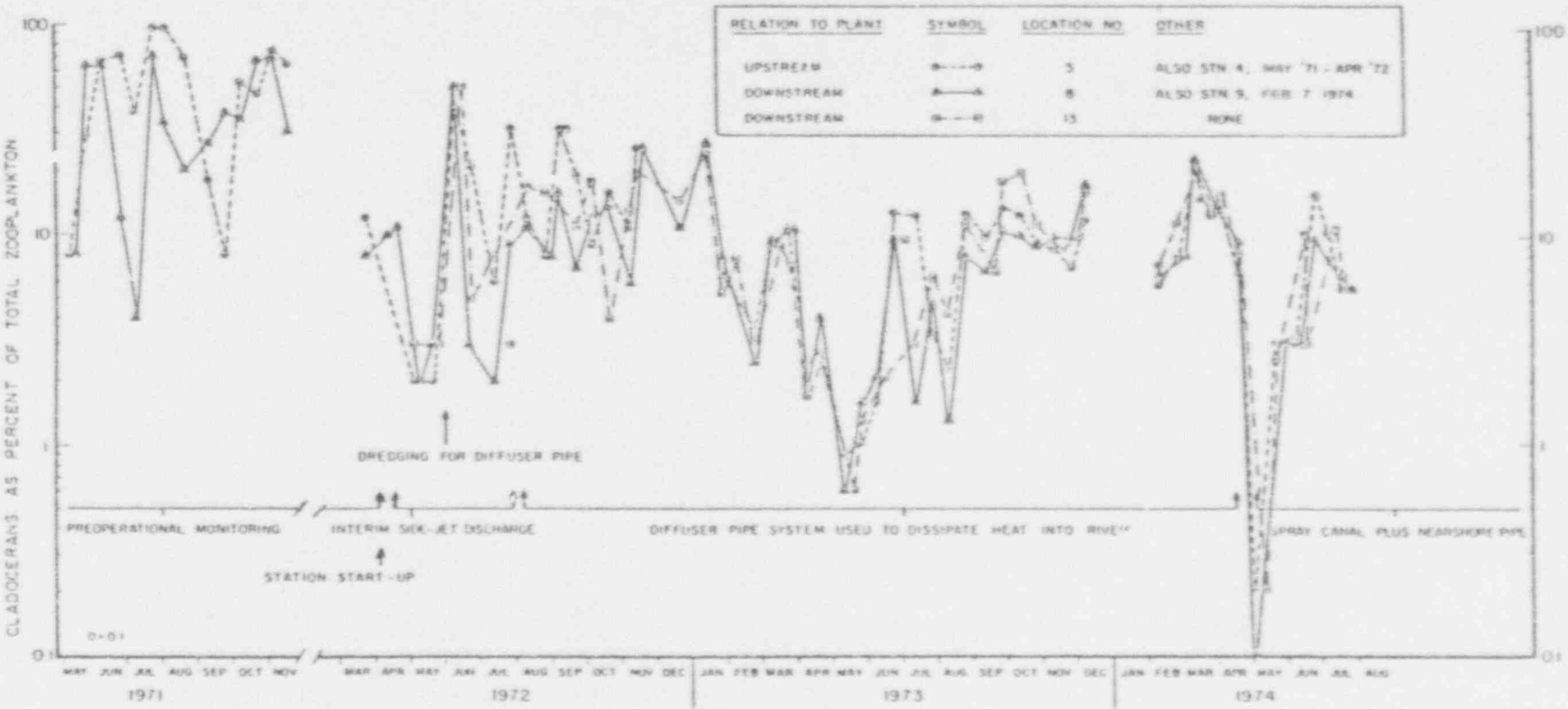


Figure 39. Cladocerans as a percen of total zooplankton compared above and below Quad-Cities Station, May 1971 through July 1974.

of station operation at locations upstream and downstream from the Quad-Cities Station from early 1971 to the present time did not reveal any differences attributable to plant operations.

Non-parametric procedures (Mann-Whitney U test for two sample comparisons and Kruskal-Wallis for K-sample comparisons) were performed as well as the analysis of variance. These analyses were employed primarily as a back-up to the normal parametric procedures. The Mann-Whitney and Kruskal-Wallis tests are distribution-free, and are therefore more conservative.

Total numbers of zooplankton were influenced by seasonal changes. In addition, several periods of decreased abundance were related to periods of high river flow (Czajkowski and Carpenter, 1974).

Statistically significant differences between total zooplankton numbers (Figure 36) upstream and downstream of the diffuser pipe system were occasionally observed but highest counts did not consistently occur at either upstream or downstream locations.

The sampling locations employed from May 1972 to the present time are indicated in Figure 31. The upstream control station (Location 4) in the slough area on the Iowa side of the river was employed only between May 1971 and April 1972.

Total zooplankton numbers at both upstream and downstream locations consistently peaked in the spring during May and June. A late summer and fall pulse occurred in 1971 and to a lesser extent during 1973 (Figure 36). Careful examination of Figure 36 revealed no consistent differences between upstream locations (Nos. 4 and 5) and the downstream locations (8, 9 and 13) that were attributed to plant operation. The differences that occurred during the 1971 preoperational monitoring period appeared to be greater than differences during any of the operational periods.

Since total numbers of zooplankton can give an indication of community structure, the percent composition of the three major zooplankton groups were compared on the basis of the sampling locations upstream and downstream from the Quad-Cities Station. Neither the percent rotifers (Figure 37), copepods (Figure 38), nor Cladocerans (Figure 39) indicated any consistent relationship to sampling location. Although major shifts in community structure occurred at various intervals, these data indicated that no changes in community structure occurred after station start-up as compared to the preoperational monitoring period that could be attributed to station operations.

4.4.1.3. Periphyton

Periphyton populations and production rates upstream and downstream of the station were generally equivalent throughout the period of the study. Periphyton productivity, as indicated by species diversity, biomass and chlorophyll-a concentrations was significantly reduced in the Illinois Island area 600 feet below the station during the period of side-jet operation. However, periphyton populations rapidly recovered to their baseline levels following start-up of the diffuser pipe system. The quick recovery indicated that no permanent changes in the physical or chemical environment occurred due to side-jet discharge operation.

No consistent differences between upstream and downstream periphyton colonizing the artificial substrates were attributable to diffuser pipe operation (Clark 1974). All changes in periphytic algal communities or chlorophyll-a production were related to seasonal fluctuations or other hydrological conditions and were not affected by operation of the Quad-Cities Station during the diffuser pipe mode of discharge.

Since biomass and chlorophyll-a are commonly modeled as normal random variables, normal parametric procedures were employed for statistical analysis. When comparing two locations, a Student's "t" test was used. For comparison of three or more locations, a one-way analysis of variance, with Tukey's multiple comparison procedure was used. In the case of unequal replication, Scheffe's procedure, instead of Tukey's followed the analysis of variance.

At different points in the studies, occasional variations occurred between the periphyton parameters such as community structure, ash-free dry weight and chlorophyll-a at several locations. All differences that were found between locations were attributable to conditions such as total river flow rates, current velocities over substrates, scouring that occurred only at certain locations, patchy colonization by the diatoms which were the dominant periphytic organisms throughout the study, varying silt loads that collected along with developing algal colonies, natural seasonal changes in water temperature, and grazing of the substrates by algae-eating benthic macroinvertebrate organisms were found to be responsible for those statistically significant differences that were observed between locations.

The variable of plant operation cannot be isolated as the only variable influencing the course of attached algal community development over a 28-day period (Hohn, 1970).

The seasonal nature of periphytic chlorophyll-a production is illustrated in Figure 40 which covers the period of interim side-jet discharge, total use of the diffuser pipe system, and three months of near-shore diffuser pipe use. Data relating to chlorophyll-a production from substrates located in the discharge by was included to show that at times (e.g. July to November 1973) periphyton populations at this location were

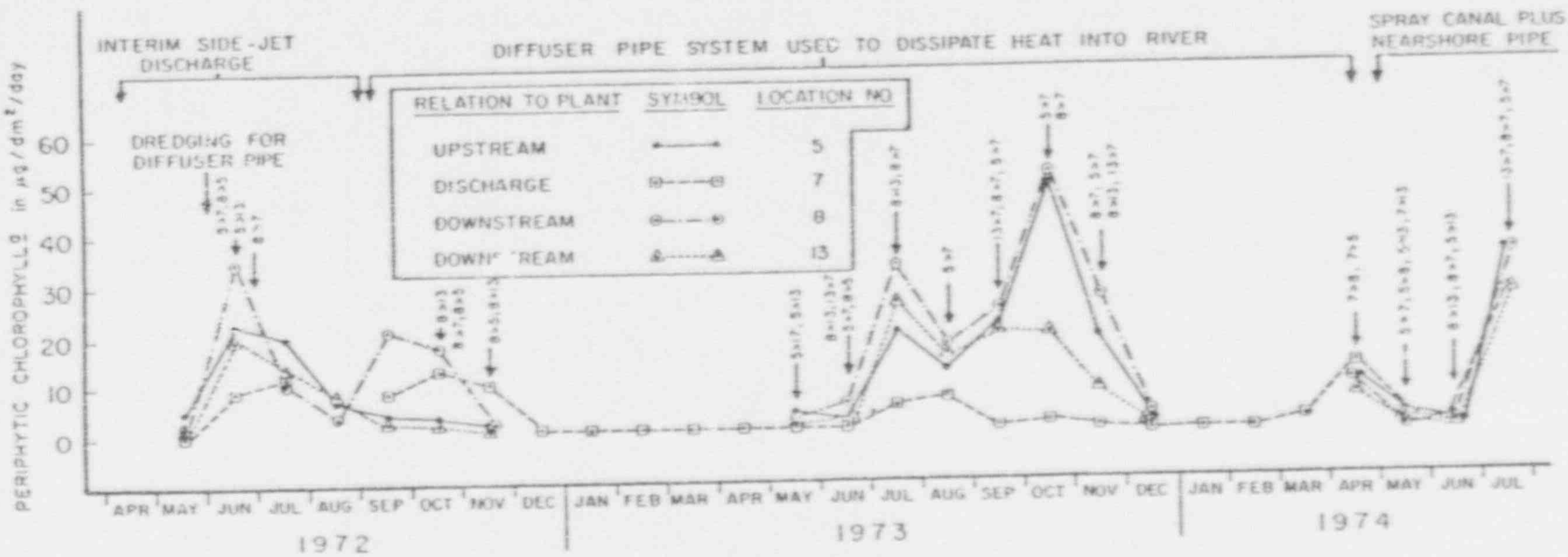


Figure 40. Periphytic chlorophyll-a developed on artificial substrates compared above and below Quad-Cities Station and including discharge bay location, May 1972 through July 1974.

markedly reduced as compared with other locations. This effect is understandable because of the stresses of intermittent chlorination, high temperatures, and increased current velocity. At other periods discharge bay (Location 7) chlorophyll-a values were similar to those found at other locations (e.g. May and July 1972; May, June and December 1973; and April through July 1974).

When upstream and downstream locations were compared for chlorophyll-a production (Figure 40) it was obvious that at times all three locations were similar and that no consistent relationships occurred. The reduced chlorophyll-a values obtained from substrates at downstream Location 13 during October and November appeared to be the result of scouring of substrates by unusually high river currents prior to the end of each 28-day period of colonization.

Total periphyton abundance in 1973 and 1974 during the period of diffuser pipe system operation and three months of spray canal plus near-shore diffuser pipe operation (Figure 41) also indicated no consistent differences between upstream and downstream locations.

The three major groups forming the artificial substrate periphyton communities (diatoms, green algae, and blue-green algae) are compared as a percent of the total periphyton for the same period shown in Figure 41 for total abundance (Figures 42-44). The diatoms, with very few exceptions, formed the dominant algal division. Careful examination of the graphed data for diatoms (Figure 42), green algae (Figure 43), and the blue-green algae (Figure 44) revealed no consistent effect on the pattern of community composition that could be attributed to plant operation.

4.4.1.4. Benthos

The total benthic invertebrates and dominant species were compared at locations upstream and downstream from the side-jet discharge and diffuser pipe system. By examination of means and variances of benthic

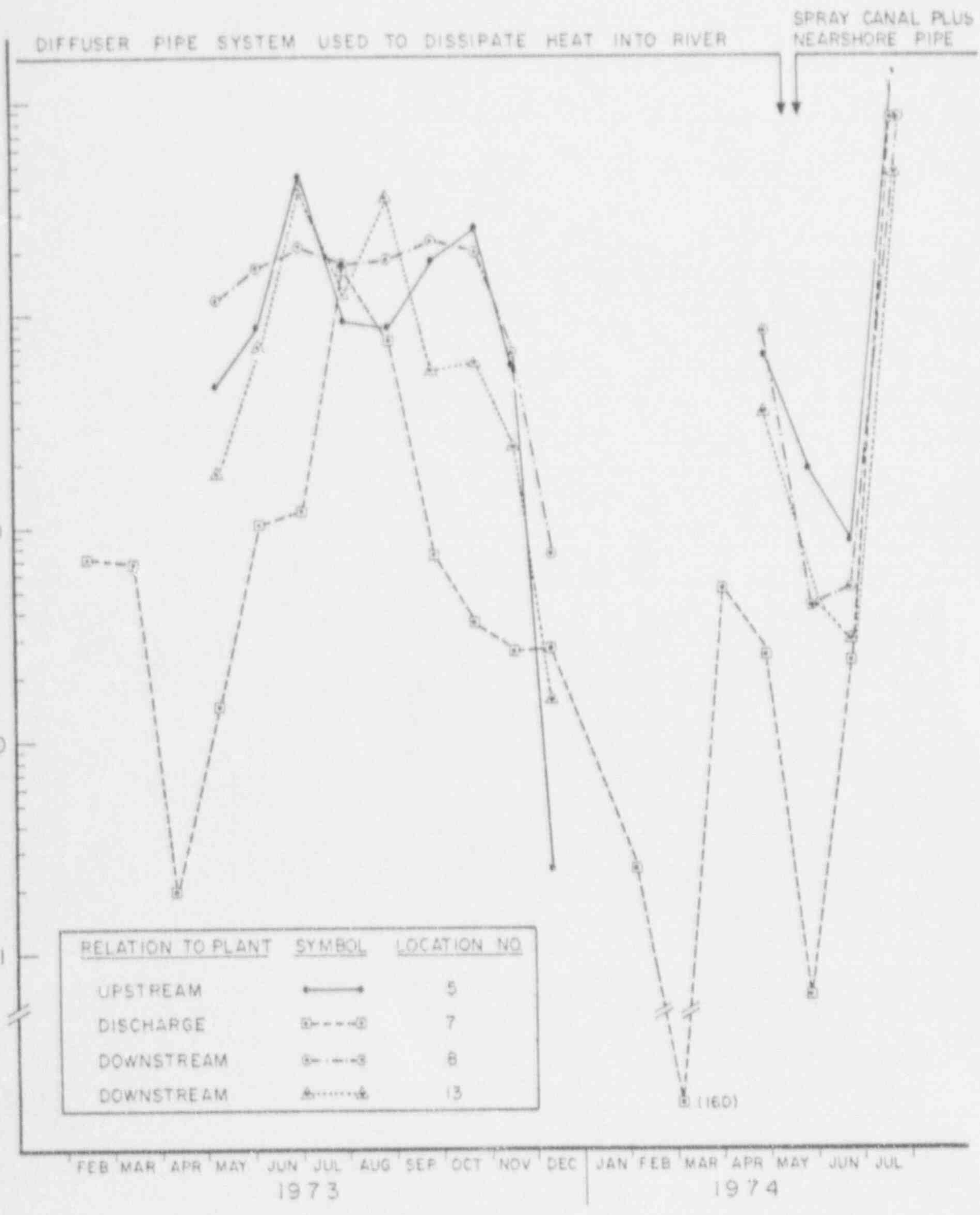


Figure 41. Periphyton total abundance developed on artificial substrates compared above and below Quad-Cities Station and including discharge bay locations, February 1973 through July 1974.

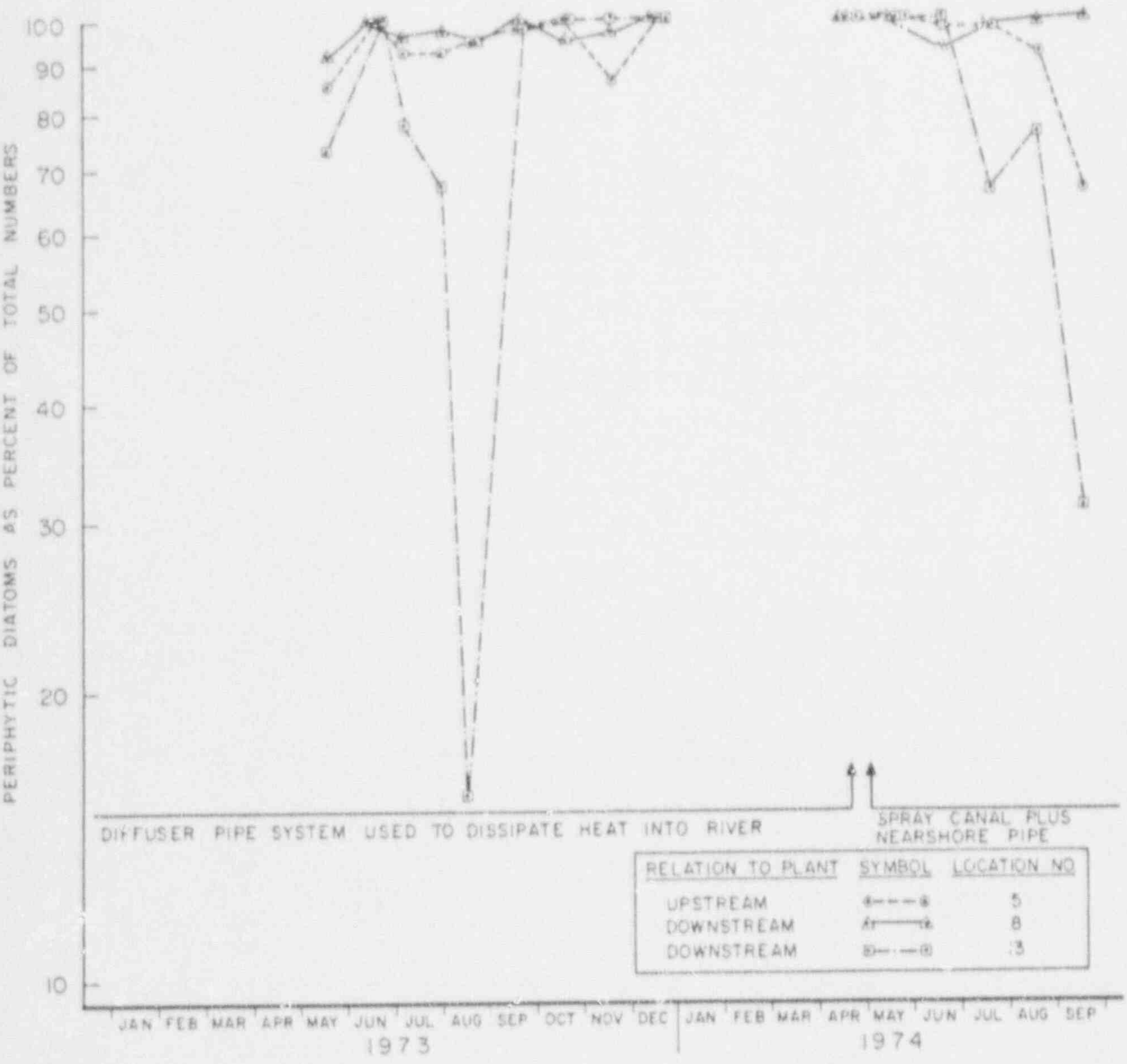


Figure 42. Periphytic diatoms as a percent of total periphyton developed on artificial substrates compared above and below Quad-Cities Station May 1973 through September 1974.

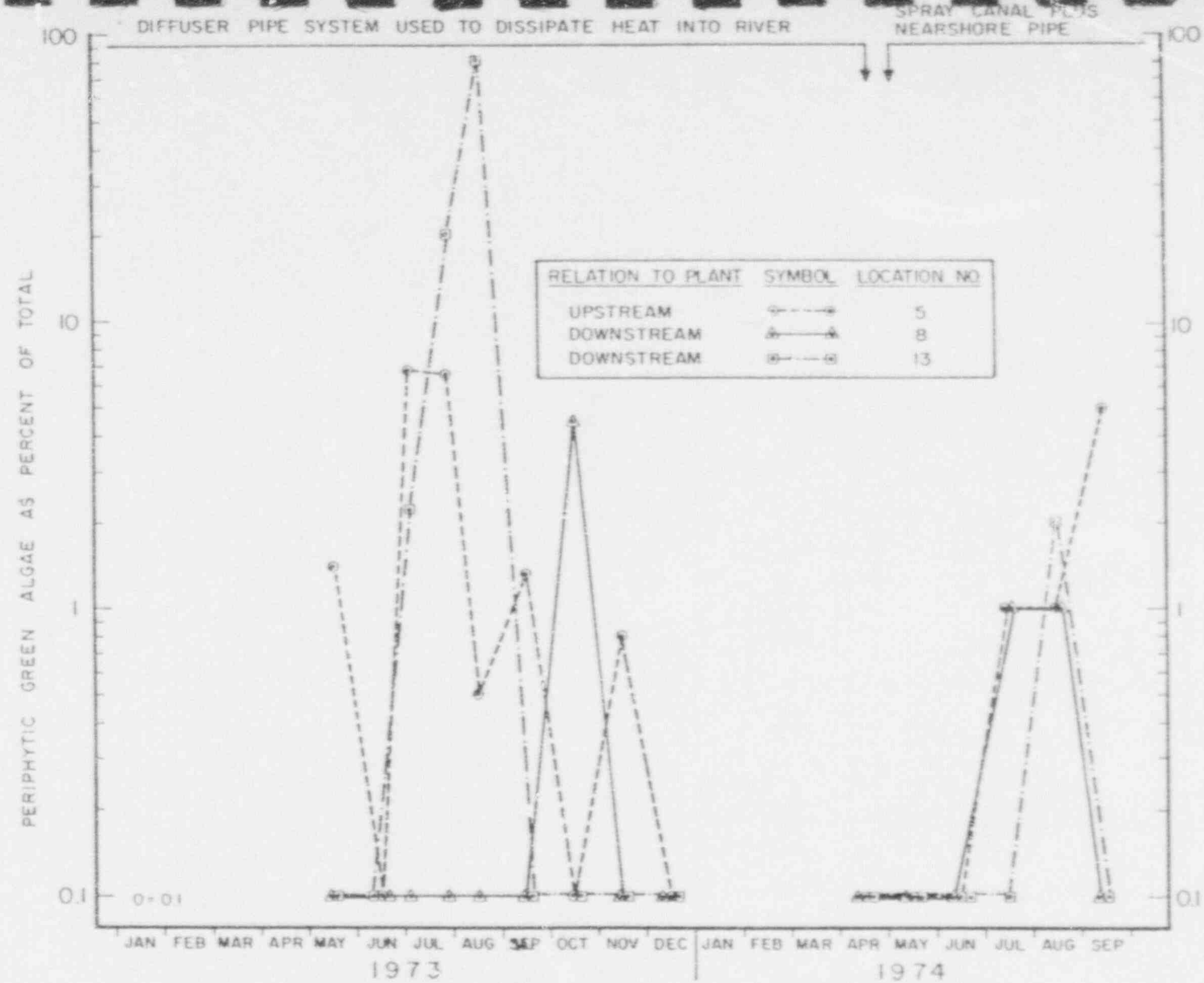


Figure 43. Periphytic greer algae as a percent of total periphyton developed on artificial substrates comp.red above and below Quad-Cities Station, May 1973 through September 1974.

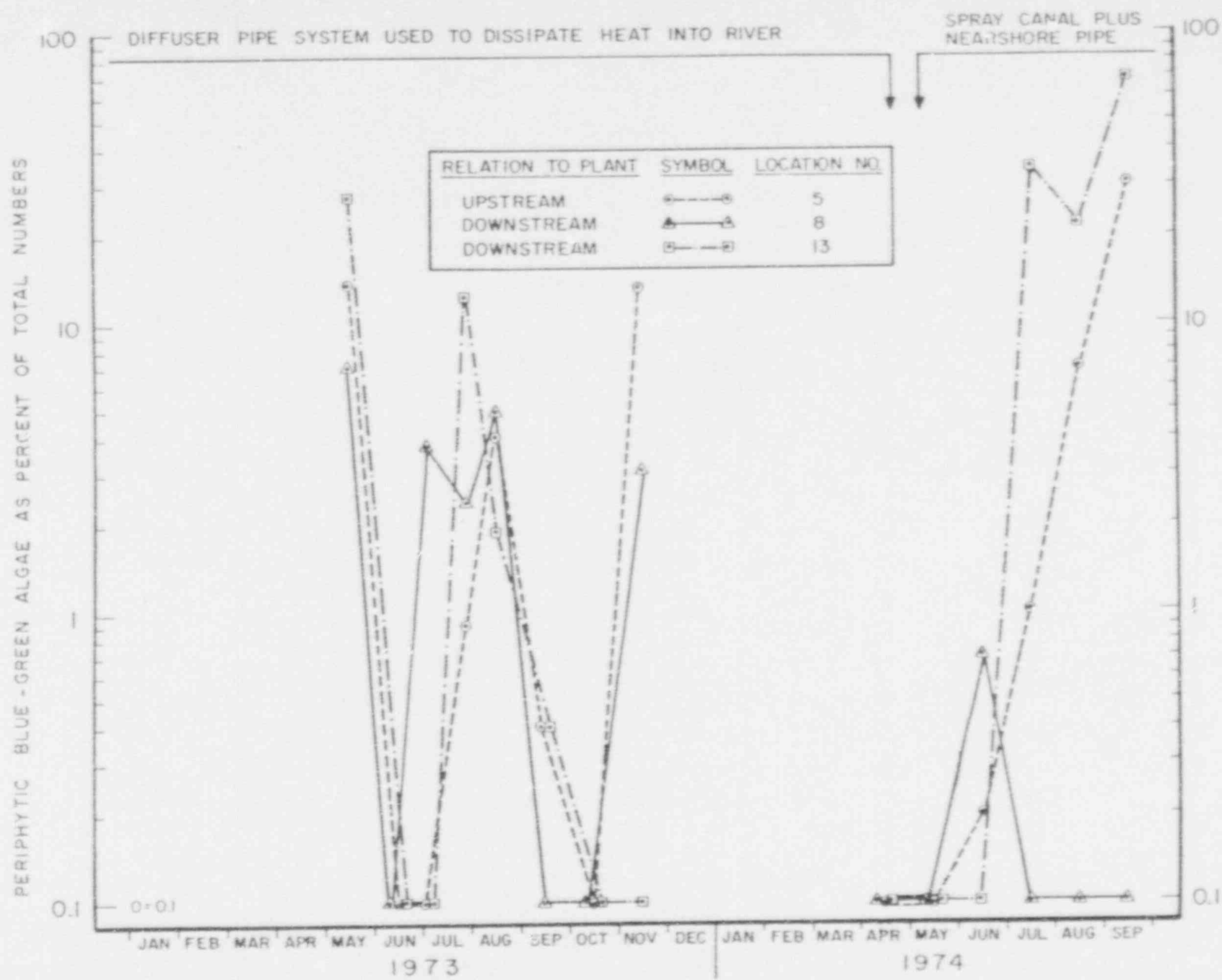


Figure 44. Periphytic blue-green algae as a percent of total periphyton developed on artificial substrates compared above and below Quad-Cities Station, May 1973 through September 1974.

organism counts it was found that benthic invertebrate counts could be modeled as a negative binomial, which is a more contageous spatial distribution than Poisson. Reliance on large mean counts which converge to the normal, justified the use of analysis of variance. The appropriate transformation was used to stabilize variances prior to analysis. Tukey's or Scheffe's multiple comparison procedure was employed to test for specific differences.

Analysis of the data indicated no discernible effects on the benthos relative to the thermal discharge from Quad-Cities Station. The benthos data compiled during the four years of the study are presented in summary figures which indicate the variation of the major organisms between locations due to seasonal fluctuations, substrate differences and changes in river flow (Figures 45 through 47).

The dominant benthic invertebrates collected during the 1971-1974 monitoring periods near Quad-Cities Station were primarily Tubificidae, Ephemeridae, Hydropsychidae and Chironomidae. The seasonal changes in populations were not easily distinguished because of fluctuations in river flow and subsequent changes in substrates. Locations 5 and 9 (Figure 31) had silty substrates which provided ideal habitats for Ephemeridae (burrowing mayflies) and Tubificidae (sludge worms). Location 8, characterized by gravel substrates and constant current, was colonized primarily by Hydropsychidae (net-spinning caddisflies). Low river flow usually resulted in greater deposition of silt at all locations and subsequently led to greater numbers of Ephemeridae and Tubificidae (Figures 45 and 47). High river flow resulted in faster current which scoured the substrates with the degree of scouring dependent upon location. The substrate at Location 9, near the main channel, was changed during

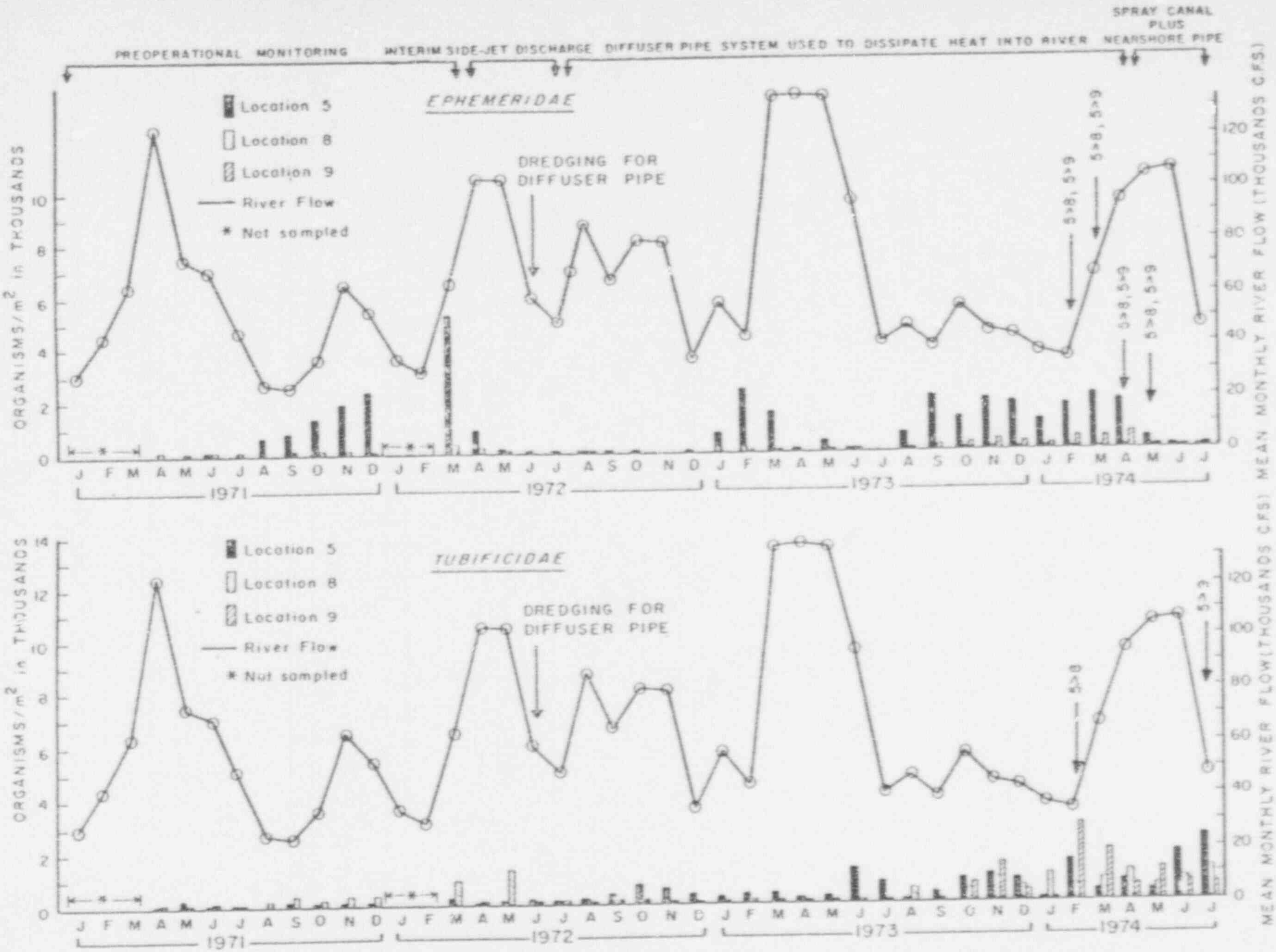


Figure 45. Mean monthly counts of Ephemeridae and Tubificidae in bottom samples compared above and below Quad-Cities Station and including mean monthly river flow rates, January 1971 through July 1974.

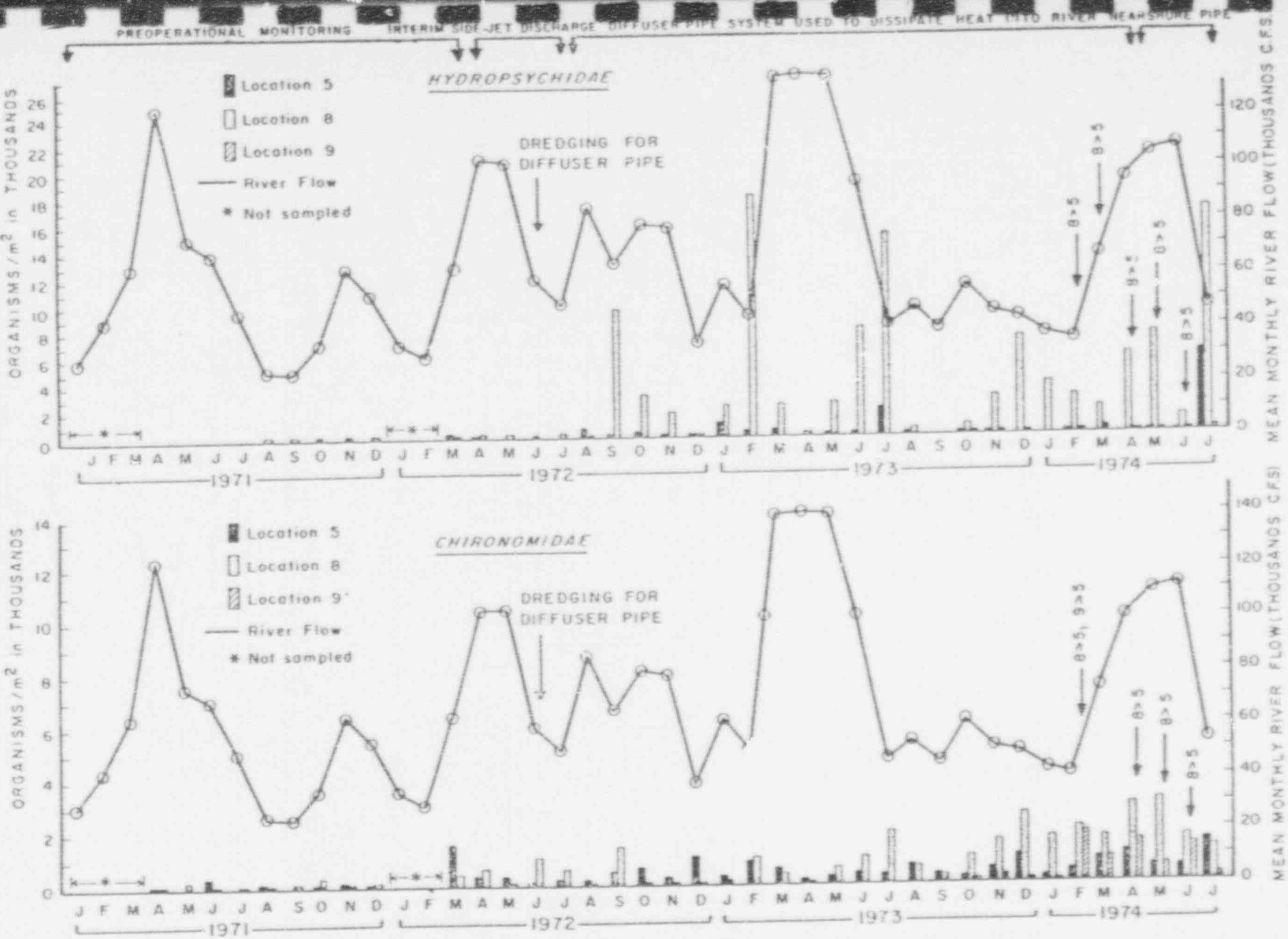


Figure 46. Mean monthly counts of Hydropsychidae and Chironomidae in bottom samples compared above and below Quad-Cities Station and including mean monthly river flow rates, January 1971 through July 1974.

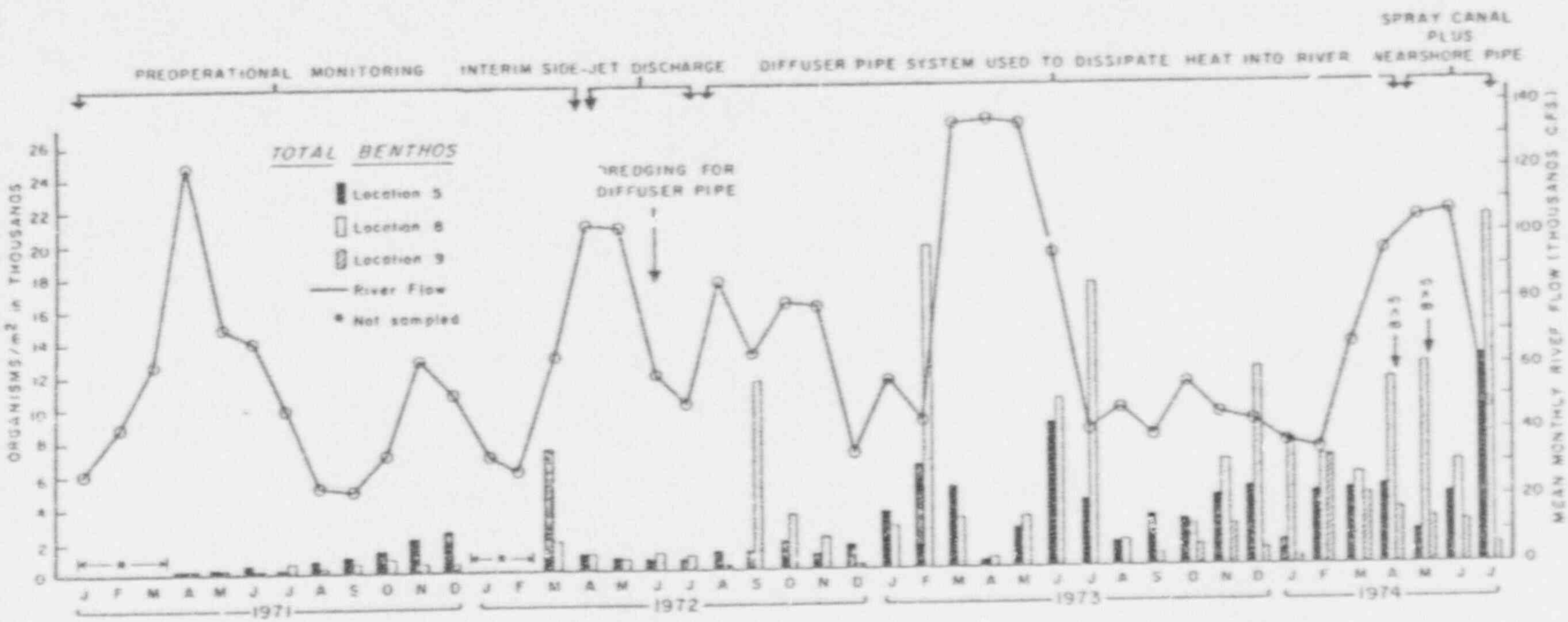


Figure 47. Mean monthly total benthic organism counts in bottom samples compared above and below Quad-Cities Station and including mean monthly river flow rates, January 1971 through July 1974.

periods of high flow to nearly pure sand which contained few benthic organisms. The gravel substrate at Location 8, located in a side-channel area, was flushed free of silt during high flow and this usually resulted in increased numbers of Hydropsychidae (Figure 46), which require a steady current and silt-free habitat (Fremling 1960). The total benthos was usually greater at Location 8 than at Location 5, primarily due to the large number of hydropsychids at Location 8 (Figure 47).

The fluctuations of the benthic populations at the locations upstream and downstream from Quad-Cities appeared to be related to seasonal and hydrological changes and/or substrate conditions that could not be attributed to station operation.

4.4.1.5 Drifting Macroinvertebrate Organisms

No consistent effects on the drifting macroinvertebrate populations were attributable to operation of the diffuser-pipe mode of heat dissipation.

During 1973, when the diffuser-pipe system was employed to dissipate heat into the river, a series of twelve experiments were conducted in which upstream net collections were compared with downstream net collections. The dead macroinvertebrate organisms were evaluated as a fraction of the total numbers present in each collection. T n experiments were conducted each month for six months. Each experiment consisted of upstream versus downstream collections taken (a) 300 to 400 feet from the Illinois shore, and (b) 300 to 400 feet from the Iowa shore.

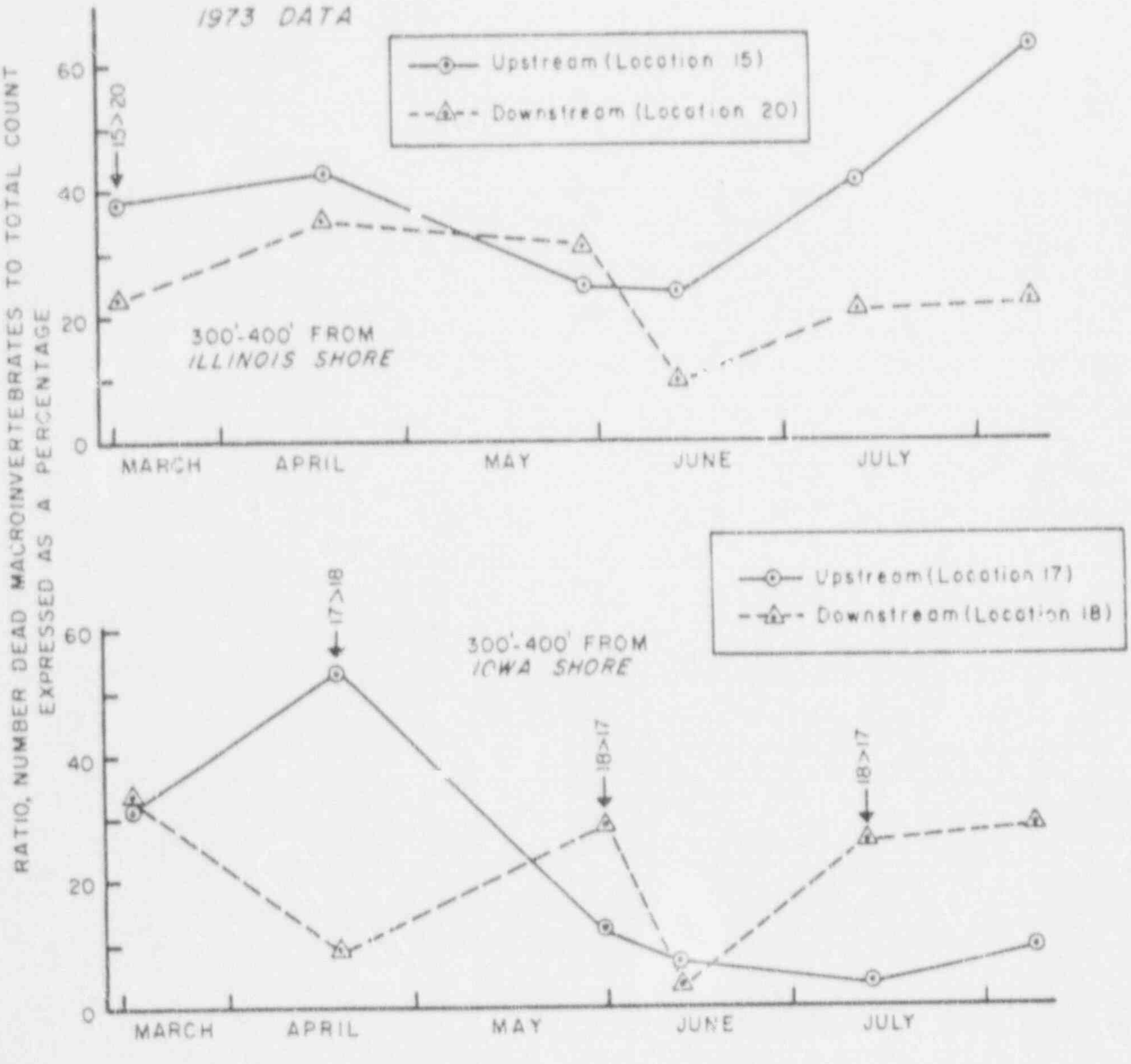
Fewer than half of the twelve experiments indicated that mortality in the collections was greater below the diffuser pipe. These results (Table 23 and Figure 48) suggest that the combined effects of dissipated heat and mechanical stress during entrainment plus any post-entrainment residual thermal effects were not detectable in the river. The mean of upstream mortalities (29.8%) exceeded the mean

Table 23. Summary of twelve experiments conducted from March through August 1973 to determine the effect of diffuser-pipe operation on macroinvertebrate drift populations in the Mississippi River at the Quad-Cities Station.

(Upstream and downstream locations were sampled on the same day, but locations near the Illinois shore were sampled 1-2 days apart from locations near the Iowa shore. A total of 2,589 organisms were identified and counted in the twenty-four net collections taken during the experimental series)

	Locations 300' - 400' from Illinois shore	Locations 300' - 400' from Iowa shore	
Fraction of Experiments Where Downstream Mortality Exceeded Upstream Mortality:			
	1/6	4/6	(5/12 overall)
Ratio, dead organisms in the samples divided by the total numbers counted, expressed as the percent dead:			
Collected Upstream from diffuser approximately 400 feet	37.4	17.6	(29.8 grand mean based on 1,334 organisms counted in twelve experiments)
Collected Downstream from diffuser approximately 400 feet	26.8	21.7	(23.8 grand mean based on 1,255 organisms counted in twelve experiments)

Figure 48. Summary of twelve experiments conducted from March through August 1973 to determine the effect of diffuser-pipe operation on macroinvertebrate drift populations in the Mississippi River at the Quad-Cities Station.



of downstream mortalities (23.8%). If the diffuser pipe system were exerting a practical effect on the viability of the drifting macroinvertebrates, a consistently greater downstream mortality would have been found.

When the near-Illinois-shore mortalities (mean 33.3%) were compared with the near-Iowa-shore mortalities (mean 20.0%) the data suggests that the differences between experimental locations were related more to the near shore or main channel current than to the river sampling location above or below the diffuser pipe (see also Illinois column of Table 23).

4.4.1.6 Fish

4.4.1.6.1 General Description of Existing Community

The Mississippi River in the vicinity of the Quad-Cities Station has historically supported a diverse and productive warm water fishery (Barnickol and Starrett 1951, Schoumacher 1965, and Smith et al. 1971). Thorough fishery studies have been conducted within the vicinity of the Quad-Cities Station (river mile 504-river mile 509) since April 1971. During the period April 1971 through July 1974, 75 species of fish have been collected from Pool 14 of the Mississippi River (Industrial Bio-Test Laboratories, Inc. 1972a p. A1-A3; 1972b p. A1-A2; 1973a p. 170; 1973b p. 241-242; 1974a p. 204-205; 1974b p. 282-283). A check list of the species collected during this period is given in Table 24. Scientific and common names of all species reported follow Bailey (1970). Only common names will be used throughout the remainder of this report.

Forage fish such as river shiner, gizzard shad, emerald shiner and silver chub are generally the most abundant in the collections. Most frequently collected commercial species are carp, channel catfish,

Table 24

Checklist of Fishes Collected From the Mississippi River (Pool 14) near Quad-Cities Station, April 1971 - July 1974

Family and Scientific Name	Common Name
Petromyzontidae (lampreys)	
Ichthyomyzon castaneus	Chestnut lamprey
Ichthyomyzon unicuspis	Silver lamprey
Acipenseridae (sturgeons)	
Scaphirhynchus platorynchus	Shovelnose sturgeon
Polyodontidae (paddlefishes)	
Polydon spathula	Paddlefish
Lepisosteidae (gars)	
Lepisosteus osseus	Longnose gar
Lepisosteus platostomus	Shortnose gar
Amiidae (bowfins)	
Amia calva	Bowfin
Anguillidae (freshwater eels)	
Anguilla rostrata	American eel
Clupeidae (herrings)	
Alosa chrysochloris	Skipjack herring
Dorosoma cepedianum	Gizzard shad
Hiodontidae (mooneyes)	
Hiodon alosoides	Goldeye
Hiodon tergisus	Mooneye
Salmonidae (trouts)	
Salmo trutta	Brown trout
Umbridae (mudminnows)	
Umbra limi	Central mudminnow
Esocidae (pikes)	
Esox americanus	Grass pickerel
Esox lucius	Northern pike

Table 24 (Cont.)

Family and Scientific Name	Common Name
Cyprinidae (minnows and carps)	
Campostoma anomalum	Stoneroller
Cyprinus carpio	Carp
Hybognathus nuchalis	Silvery minnow
Hybopsis aestivalis	Speckled chub
Hybopsis storeriana	Silver chub
Nocomis biguttatus	Hornyhead chub
Notemigonus crysoleucas	Golden shiner
Notropis atherinoides	Emerald shiner
Notropis blennius	River shiner
Notropis buchanani	Ghost shiner
Notropis emiliae	Pugnose minnow
Notropis hudsonius	Spottail shiner
Notropis spilopterus	Spotfin shiner
Notropis stramineus	Sand shiner
Phenacobius mirabilis	Suckermouth minnow
Pimephales notatus	Bluntnose minnow
Pimephales promelas	Fathead minnow
Pimephales vigilax	Bullhead minnow
Semotilus atromaculatus	Creek chub
Catostomidae (suckers)	
Carpiodes carpio	River carpsucker
Carpiodes cyprinus	Quillback
Carpiodes velifer	Highfin carpsucker
Catostomus commersoni	White sucker
Cycleptus elongatus	Blue sucker
Ictiobus bubalus	Smallmouth buffalo
Ictiobus cyprinellus	Bigmouth buffalo
Minytrema melanops	Spotted sucker
Moxostoma anisurum	Silver redhorse
Moxostoma erythrurum	Golden redhorse
Moxostoma macrolepidotum	Shorthead redhorse
Ictaluridae (freshwater catfishes)	
Ictalurus melas	Black bullhead
Ictalurus natalis	Yellow bullhead
Ictalurus punctatus	Channel catfish
Noturus flavus	Stonecat
Noturus gyrinus	Tadpole madtom
Pylodictis olivaris	Flathead catfish
Atherinidae (silversides)	
Labidesthes sicculus	Brook silverside

Table 24 (Cont.)

Family and Scientific Name	Common Name
Percichthyidae (temperate basses)	
Morone chrysops	White bass
Morone mississippiensis	Yellow bass
Centrarchidae (sunfishes)	
Ambloplites rupestris	Rock bass
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis gulosus	Warmouth
Lepomis humilis	Orangespotted sunfish
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
Percidae (perches)	
Ammocrypta clara	Western sand darter
Etheostoma asprigene	Mud darter
Etheostoma nigrum	Johnny darter
Perca flavescens	Yellow perch
Percina caprodes	Logperch
Percina phoxocephala	Slenderhead darter
Percina shumardi	River darter
Stizostedion canadense	Sauger
Stizostedion vitreum	Walleye
Sciaenidae (drums)	
Aplodinotus grunniens	Freshwater drum

freshwater drum, and carpsucker. The most abundant sport fish species are black and white crappies, bluegill, and largemouth bass. The wide variety of species present in the pool is due primarily to the variety of existing habitat types and the availability of the water area to a number of species. Five distinct habitat types as described by the Upper Mississippi River Conservation Committee (Sternberg 1971) are present in Pool 14 (see Table 25). Ten shallow water and three mid-channel locations were selected for collecting juvenile and adult species. These locations are representative of all of the UMRCC habitat types except lake-type habitat. Similar habitat types occur both upstream and downstream from the station within the study area. Sampling locations are shown in Figure 49.

Shallow, vegetated slough and slough-like habitats are considered the most productive in terms of total numbers and diversity of fish (Industrial Bio-Test Laboratories, Inc., 1972a p. 14) and are also important nursery areas for several species of sport and commercial significance (Industrial Bio-Test Laboratories, Inc. 1972a, p. 14,15). Unprotected sand beaches and main channel areas are generally the least productive habitats (Industrial Bio-Test Laboratories, Inc., 1973a p. 169).

The fish sampling techniques employed at the Quad-Cities Station on the Mississippi River since 1971 were designed to yield the most representative sample under the environmental conditions encountered within the study area.

During the period of study, some collection techniques have been added (trawling, trammel netting) and some dropped (wing netting) in order to improve the quality and efficiency of collections. Certain

Table 25. Habitat types of fish sampling locations near Quad-Cities Station, April-July 1974.

U.M.R.C.C. habitat type	Locations upstream from diffuser pipe	Locations downstream from diffuser pipe
Main channel	1T[a], 15	6T, 13T
Main channel border	4, 5	8, 9, 13
Side channel	2	11
Slough	3	10
Station intake bay[b]	6	

[a] Trawling and trammel netting location.
[b] Not a U.M.R.C.C. habitat distinction.

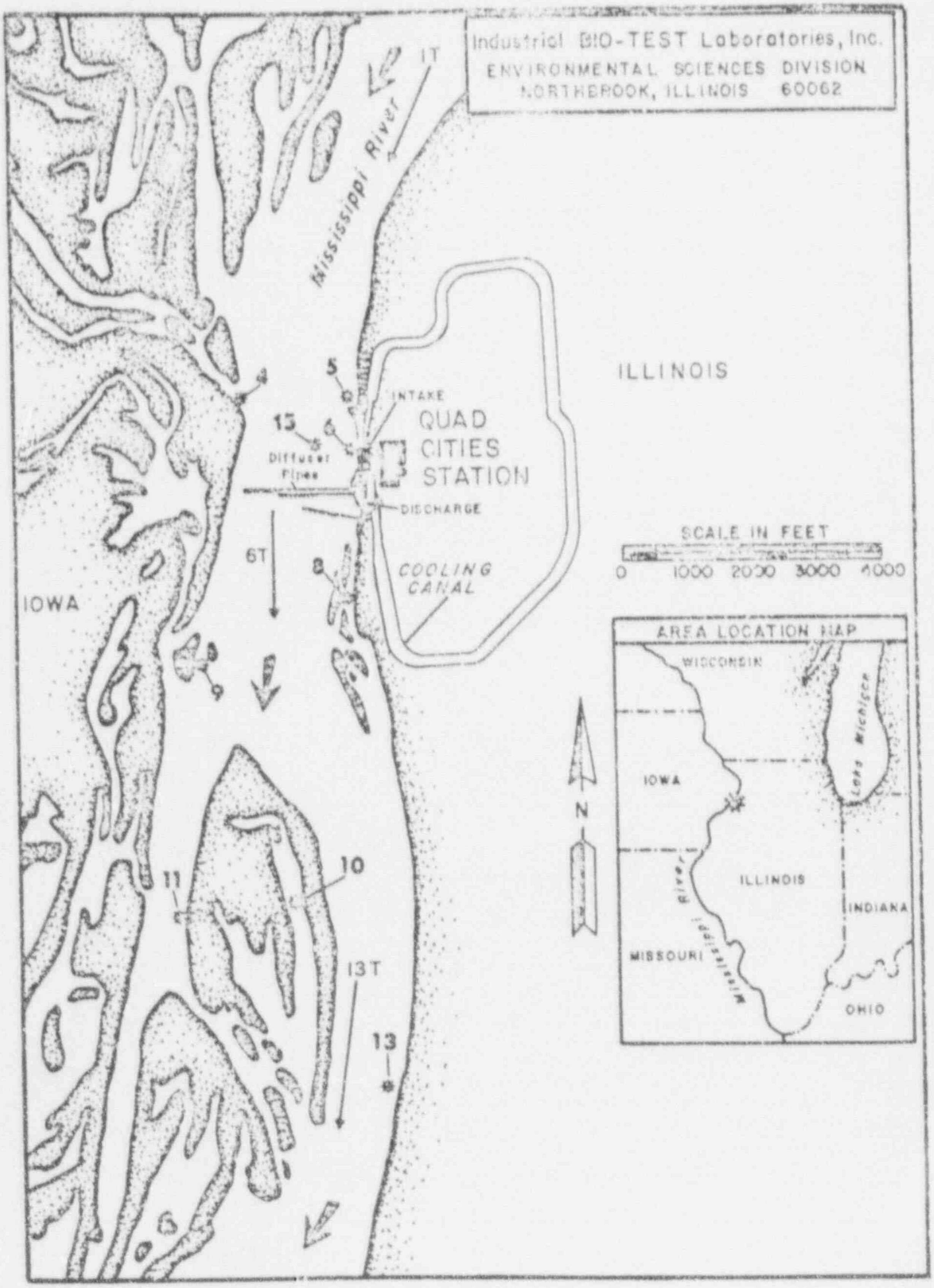


Figure 49. Fish sampling locations near Quad-Cities Station.

other devices, such as gill netting, were evaluated and found lacking in applicability.

For the past three years, collections have included those sampling techniques which have been most useful in the study of the various river habitats.

The kinds of fish collection equipment which were used are all selective in regard to the environment in which they can be successfully used. The use of the several techniques presently employed (seining, trawling, trammel netting and electrofishing) give a reasonable and practical representation of the fish population.

It is likely that under other habitat conditions, such as pools or lakes, sampling devices such as larger trawls and variable mesh gill nets would yield collection data that may be more directly useful to statistical comparison; however, such devices are not practical for use in the Mississippi River in the vicinity of the Quad-Cities Station.

The devices used in the study are prone to be somewhat selective, **and may affect the distribution** and behavior of fish in the collection location for a limited period of time. These considerations are addressed in each technique which follows:

Electrofishing

This is undoubtedly the most successful fish sampling technique in terms of numbers of species collected within the study area. This technique has the added benefit of allowing the release of fish back into the same location from which they were collected in relatively good condition, an important prerequisite in tagging and recapture studies. It also permits the collection of accurate live weight and length

measurements and also insures that stomach contents are in optimum condition for stomach sample analysis.

Success of fish shocking is related directly to water temperature and conductivity. Although conductivity is not an important variable within the study area, water temperatures exhibit marked seasonal fluctuations. Thus, if the results are to be compared, such comparisons must be made on sampling periods with similar temperatures.

The wide range of river levels encountered also affects the success of electrofishing. Rarely are river levels the same from one period to the next, and since significant changes in river level and flow rate result in changes in the distribution of fishes, fish may be displaced from their customary habitat and be unavailable to collection even though water temperatures may be ideal for shocking.

Every effort is made to standardize electroshocking collections (use of the same kind of shocker, the same collectors, and the same time unit of effort). This does not however, totally overcome the built-in bias and selectivity that is inherent both in the mechanical device and in the operator. One additional, but very important limitation, is the fact that some fish may sink after being stunned by electricity. Because of the turbid water, fish must float quite near the surface in order to be seen for collection with a dip net, and sinking fish will rarely be collected. The tendency for fish to float or sink when stunned varies not only with environmental conditions, but also with species and size.

Fish also quickly develop an "avoidance" reaction to electroshocking once the boat has operator within sensing distance. This avoidance

behavior may be retained up to several days and greatly limits the possibility of making successful short-term replicate collections within the same collection location.

The data presented within this report show that electrofishing samples include nearly all of the 75 species of fish which have been taken during the studies and cover all except the mid-channel habitat locations.

Trawling

Trawling has been conducted at three mid-channel locations since 1971. Trawling has been found useful in sampling in locations where electrofishing has not been successful; however, there are serious limitations with this technique. Although trawling is relatively free of operator bias, it is very selective for species and sizes of fish. Only four or five species are taken in numbers allowing a basis for comparison from year to year and, with each of these species, young-of-the-year and yearlings predominate the catch. Replicate trawl tows are subsequently not of the same time duration because of the frequent snagging. Therefore, it is nearly impossible to make identical tows of seven minutes each at 2-3 mph. For this reason, the use of "replicates" for the purpose of statistical evaluation is highly suspect. Temperature and water level, along with seasonal changes in abundance of young fish, also influence the catch success of trawling.

Seining

Seining was confined to shallow areas at those few locations in the study area exhibiting a firm, unobstructed bottom. Seining is the best device for collecting young or small fish in the littoral zone; however, due to habitat limitations it is selective. Only four locations

in the study area were sampled continuously throughout the last four years of study. Quantitative comparisons of seine haul collections are of little use, even though the effort is kept as uniform as possible. Its primary usefulness is in providing a rough indication of success of reproduction of certain species and the species composition of the forage fish population.

Distribution of fish taxa and numbers both above and below the Quad-Cities Station appear to be most strongly influenced by the river flow, season, and habitat type. In general, catch per unit effort (CPE) among locations upstream and downstream from the diffuser pipes were similar during the operation of the diffuser pipe as well as prior to its use. During the period of side-jet discharge when the heated effluent tended to hug the Illinois shore as far as 6.3 miles downstream from the station and plume temperatures as measured at the end of the 600 ft. mixing zone were as much as 15.1 F higher than ambient river temperatures, several species of fish were displaced at that time from the Illinois Island area (location 8) downstream from the station (Industrial Bio-Test Laboratories, Inc., 1972b p. 11, 14, 18). The abundance of crappie and bluegills decreased and no largemouth bass were collected, although those species were previously common in this Island area. Similar decreases in numbers of these fishes were not observed at other sampling locations and with this exception station operation appeared to have no influence on the fishery of the river. Following start-up of the diffuser pipe system the Illinois Island area was reinhabited by the displaced species when river temperatures in this area again returned to ambient levels (Industrial Bio-Test Laboratories, Inc., 1973a p. 183, 166). Abundance and distribution of important sport and commercial fish for 1971, 1972 and 1973 upstream and downstream of the diffuser pipes as

measured by electroshocking, trawling and seining are summarized in section 4.4.1.6.3.

Although certain species were consistently more abundant upstream of the station and others downstream, these differences were consistent prior to and during operation of the diffuser pipe system and are not attributable to diffuser pipe operation. Catch per unit effort (CPE) was consistently higher in the slough-like habitat than in side channel or main channel border habitats. Catch per unit effort was also generally greater during the summer months than during the spring and late fall periods. Sampling during high flow periods was less effective than during periods of low river flow and for this reason catch per unit effort was consistently reduced at all river stations when flows were high. No effect from operation of the diffuser pipe on migration of fish within the river was observed (see section 4.4.1.6.4).

4.4.1.6.2 <u>Species Composition and Abundance</u>

The abundance of all species collected within the study area prior to and during the period of diffuser operation is given in Table 26. When changes in abundance occurred they were noted upstream as well as downstream prior to and after diffuser pipe operation.

The State of Illinois lists five Representative Important Species (RIS), all of which have been collected within the study area (McSwiggen, 1974). The forms listed by the State of Illinois as RIS species are the gizzard shad, bluntnose minnow, channel catfish, bluegill and largemouth bass. The largemouth bass is listed as common within the study area and the bluntnose minnow is listed as scarce (only one specimen collected during the entire study). The gizzard shad, channel catfish and bluegill were abundant prior to and during diffuser pipe operation.

Table 26. Abundance of fish species collected in Pool 14 during pre-operation and operation of the diffuser pipe discharge system near Quad-Cities Station, Mississippi River, 1971-1974.

Species	Classification[a]		Preoperational April - November 1971				Operational April 1972 - April 1974			
			Upstream of Diffuser Abundance[b]		Downstream of Diffuser Abundance		Upstream of Diffuser Abundance		Downstream of Diffuser Abundance	
			April-July	August-November	April-July	August-November	April-July	August-November	April-July	August-November
Chestnut lamprey	P		NC	ND	NC	S	NC	NC	NC	NC
Silvery lamprey	P		NC	NC	NC	S	UC	S	NC	NC
Shovelnose sturgeon	C		S	UC	S	S	UC	UC	S	UC
Paddlefish	C		S	S	S	S	S	NC	NC	NC
Longnose gar	C-CI		S	S	S	S	UC	UC	UC	UC
Shortnose gar	C-CI		UC	S	UC	S	UC	S	UC	
Bowfin	C-CI		S	UC	S	UC	UC	UC	UC	UC
American eel	C		NC	NC	NC	NC	NC	S	NC	NC
Skipjack herring	F		NC	S	NC	NC	NC	S	NC	NC
Gizzard shad	F	RIS	A	A	A	A	A	A	A	A
Goldeye	F-C		NC	NC	NC	NC	S	NC	NC	NC
Mooneye	F-C		UC	UC	UC	UC	C	C	UC	C
Brown trout	S		NC	NC	NC	NC	S	NC	NC	NC
Central mudminnow	F		NC	NC	NC	NC	S	NC	NC	NC
Grass pickerel	CI		NC	NC	S	UC	NC	NC	S	UC
Norther pike	S		UC	UC	UC	UC	UC	UC	UC	UC
Carp	S-C		A	A	A	A	A	A	A	A
Silvery minnow	F		UC	NC	NC	UC	NC	NC	NC	NC
Speckled chub	F		NC	S	NC	S	NC	UC	NC	UC
Silver chub	F		C	A	C	A	A	A	A	A
Golden shiner	F		S	NC	UC	UC	UC	UC	UC	UC
Emerald shiner	F		A	A	A	A	A	A	A	A
River shiner	F		A	A	A	A	C	A	A	A
Ghost shiner	F		NC	S	NC	NC	NC	NC	NC	NC
Pugnose minnow	F		NC	NC	NC	NC	NC	NC	S	NC
Spottail shiner	F		UC	UC	UC	UC	UC	UC	C	UC
Spotfin shiner	F		UC	UC	A	UC	UC	NC	UC	UC
Sand shiner	F		NC	NC	NC	NC	NC	NC	NC	S
Suckermouth minnow	F		NC	NC	NC	NC	S	NC	S	UC
Bluntnose minnow	F	RIS	NC	S	NC	NC	NC	NC	NC	UC
Fathead minnow	F		NC	NC	NC	NC	S	NC	S	NC
Bullhead minnow	F		NC	NC	UC	UC	S	NC	UC	C
Creek chub	F		NC	NC	NC	NC	S	NC	NC	NC
River carpsucker	C		C	C	C	C	C	C	C	C
Quillback	C		UC	UC	UC	UC	S	UC	NC	NC
Highfin carpsucker	C		NC	NC	NC	NC	UC	S	UC	NC

Table 26 (continued)

Species	Classification[a]	Preoperational April - November 1971: Upstream of Diffuser, Abundance[b], April-July	Preoperational: Upstream, August-November	Preoperational: Downstream of Diffuser, Abundance, April-July	Preoperational: Downstream, August-November	Operational April 1972 - April 1974: Upstream of Diffuser, Abundance, April-July	Operational: Upstream, August-November	Operational: Downstream of Diffuser, Abundance, April-July	Operational: Downstream, August-November
White sucker	C	NC	NC	NC	S	S	NC	NC	NC
Blue sucker	C	NC	NC	NC	NC	S	S	NC	S
Smallmouth buffalo	C	UC	C	UC	C	C	C	UC	UC
Bigmouth buffalo	C	UC	UC	UC	UC	C	C	UC	UC
Spotted sucker	C	NC	C	S	S	S	NC	NC	S
Silver redhorse	C	NC	S	NC	NC	S	S	S	S
Shorthead redhorse	C	UC	UC	UC	UC	UC	UC	UC	UC
Black bullhead	C-S	UC	S	UC	S	S	S	NC	S
Yellow bullhead	C-S	NC	NC	NC	S	S	NC	NC	NC
Channel catfish	C-S RIS	A	A	A	A	A	A	A	A
Stonecat	CI	S	S	S	S	S	UC	NC	S
Tadpole madtom	CI	NC	NC	NC	NC	UC	S	NC	S
Flathead catfish	C-S	UC	S	UC	S	UC	UC	S	S
Brook silverside	F	S	UC	S	UC	NC	NC	UC	C
White bass	S	C	C	C	C	UC	C	UC	UC
Yellow bass	S	NC	NC	NC	NC	S	S	S	NC
Rock bass	S	NC	NC	S	NC	UC	NC	NC	NC
Green sunfish	S	S	S	S	S	NC	UC	S	S
Pumpkinseed	S	S	UC	NC	UC	S	UC	S	UC
Warmouth	S	NC	NC	S	NC	UC	UC	UC	UC
Orangespotted sunfish	CI	UC	UC	UC	UC	UC	UC	UC	UC
Bluegill	S RIS	C	A	C	A	A	A	A	A
Smallmouth bass	S	UC	UC	UC	UC	NC	S	NC	S
Largemouth bass	S RIS	C	C	C	C	C	A	C	A
White crappie	S	A	A	A	A	C	A	C	A
Black crappie	S	A	A	A	A	C	A	C	A
Western sand darter	R&E	S	NC	NC	NC	NC	NC	NC	NC
Johnny darter	F	UC	UC	UC	UC	NC	S	UC	UC
Yellow perch	S	NC	NC	UC	UC	S	NC	NC	UC
Log perch	F	UC	UC	UC	UC	S	UC	UC	UC
River darter	F	NC	UC	NC	UC	S	UC	S	S
Slenderhead darter	F	NC	NC	NC	NC	NC	S	NC	NC
Sauger	S	C	C	C	C	C	C	UC	C
Walleye	S	C	C	C	C	UC	UC	S	UC
Freshwater drum	C-S	C	C	C	C	C	C	C	C

[a] - Classification; C-commercial, CI-community integrity, F-forage, P-parasitic, R&E-rare and endangered (Iowa), RIS-representative important species (Illinois), S-sport.

Abundance: A-abundant (≥ 5% of the total catch); C-common (50 individuals to ≤ 5% of total catch); UC-uncommon (5-50 individuals); S-scarce (< 5 individuals); NC-not collected.

No species classified as rare and endangered by the State of Illinois have been collected in the study area. The State of Iowa to date has not issued a list of Representative Important Species. Of the rare and endangered species listed in Iowa (Miller, 1972) only the western sand darter has been collected during the study (1 specimen in 1971). A limited amount of information concerning the western sand darter is available in reference to its life history (reproductive periods or associated temperatures). Starrett (1950), Harlan and Speaker (1951), and Cross (1967) have found that the western sand darter is primarily a fish of deep channel habitat with a preference for coarse sand or find gravel bottoms. Starrett (1950) found the western sand darter to be most active in mid-summer and probably spawns at that time.

4.4.1.6.3 Results of Specific Sampling Techniques

Electroshocking

Tables 27, 28 and 29 summarize the catch per unit effort as fish per hour of the principal and important sport and commercial fish species collected by electroshocking during 1971, 1972 and 1973. The CPE values for all species collected by electroshocking 1971-1973 are listed in the appendices, Tables A-1, A-2, A-3, A-4 and A-5 (Industrial Bio-Test Laboratories, Inc., 1972a pp. 44-45, 1973 a pp. 1971, 1973b pp. 243-244, 1974a pp. 206-207). Sampling locations for electroshocking are shown in Figure 49. The UMRCC habitat types present at these locations are given in Table 25. Even though no two similar habitats are exactly comparable, general trends in diversity and abundance are apparent and will be discussed. It should be stressed that while similar habitat types above and below the diffuser pipes may be expected to produce similar CPE data, a number of factors unrelated to diffuser pipe

Table 27. Summary of average catch per unit of effort ($\bar{X}$ CPE - fish/hour) by electroshocking at all locations near the Quad-Cities Station, Mississippi River, March-November, 1971. (Preoperational)

Species	Locations 2	11	3[a/]	10	4[a/]	9	8	5[a/]	13	Locations (2,3,4,5) $\bar{X}$ CPE Upstream	Locations (8,9,10,11,13) $\bar{X}$ CPE Downstream
Gizzard shad	10.3	8.3		23.1		13.8	22.3		11.8	10.3	15.8
Carp	33.5	21.5		19.8		24.2	22.3		2.3	33.5	18.0
Buffalo	7.5	1.0		12.8		7.3	1.8		0	7.5	4.5
Channel catfish	1.7	1.3		0.2		6.0	1.4		1.5	1.7	2.0
Bluegill	2.8	3.5		31.4		3.9	5.5		0.6	2.8	8.9
Largemouth bass	2.1	2.7		15.6		2.5	7.5		3.6	2.1	6.3
White crappie	2.2	3.8		13.8		4.0	12.0		2.1	2.2	7.1
Black crappie	7.0	5.8		31.5		11.7	6.2		2.0	7.0	11.4
Sauger	4.8	11.0		0.4		4.5	6.8		20.7	4.8	8.6
Walleye	2.7	0.5		0		0	0.8		1.9	2.7	0.6
Freshwater drum	7.4	6.6		7.8		5.9	15.1		6.9	7.4	8.4

[a/] Electroshocking not conducted.

Table 28. Summary of average catch per unit of effort ($\overline{X}$ CPE - fish hour) by electroshocking at all locations near Quad-Cities Station, Mississippi River, April-November, 1972. (Last half of side-jet and first three months of diffuser pipe operation)

Species	Locations 2	11	3	10	4	9	8	5	13	Locations (2,3,4,5) $\overline{X}$ CPE Upstream	Locations (8,9,10,11,13) $\overline{X}$ CPE Downstream
Gizzard shad	5.3	18.8	18.9	25.5	15.3	8.8	23.0	5.4	10.8	11.2	17.4
Carp	13.1	11.9	13.9	9.2	19.6	18.0	12.1	2.9	1.2	12.4	10.5
Buffalo	4.2	0.9	5.4	4.3	2.1	3.5	3.2	0.4	0.6	3.0	2.5
Channel catfish	0.8	0.7	0.4	0.2	1.4	3.1	1.2	0.2	0	0.7	1.0
Bluegill	7.2	5.5	55.2	65.6	1.7	5.6	9.7	1.5	0.2	16.4	17.3
Largemouth bass	2.2	3.0	9.[illegible]	17.6	1.4	2.2	6.6	1.9	1.2	3.7	6.1
White crappie	1.8	1.2	10.7	16.2	5.2	5.2	8.5	0.8	0.4	4.6	6.3
Black crappie	3.8	4.0	12.2	22.8	2.6	6.5	3.7	0.8	0.7	4.9	7.5
Sauger	4.2	5.5	1.3	0.6	2.4	2.4	7.1	10.3	11.5	4.6	5.4
Walleye	1.2	1.8	0.2	0	0.4	0.6	0.6	2.7	6.1	1.1	1.8
Freshwater drum	8.7	5.7	3.4	1.4	19.3	12.8	9.4	7.7	7.8	9.8	7.4

Table 29. Summary of average catch per unit of effort ($\overline{X}$ CPE - fish/hour) by electroshocking at all locations near Quad-Cities Station, Mississippi River, April-November, 1973. (Diffuser pipe operation)

Species	Locations 2	11	3	10	4	9	8	5	13	Locations (2,3,4,5) $\overline{X}$ CPE Upstream	Locations (8,9,10,11,13) $\overline{X}$ CPE Downstream
Gizzard shad	25.0	18.8	38.7	19.3	31.1	19.9	29.6	28.9	15.2	30.9	20.6
Carp	11.7	8.4	31.0	15.4	8.5	10.2	11.3	12.0	4.3	15.8	9.9
Buffalo	2.7	0.5	8.5	3.8	2.6	1.2	0.7	3.3	0.3	4.2	1.3
Channel catfish	1.3	0.6	0	0.2	2.1	6.0	3.0	1.5	0	1.2	1.9
Bluegill	20.5	6.4	29.8	83.9	9.6	5.3	13.2	2.3	4.1	15.5	22.5
Largemouth bass	3.0	6.0	7.7	18.0	7.5	5.4	8.7	3.2	2.3	5.3	8.0
White crappie	4.3	2.3	7.3	14.5	4.2	3.9	3.6	2.3	1.8	4.5	5.2
Black crappie	8.9	3.6	8.6	11.6	4.5	4.5	6.4	1.5	1.0	5.8	5.4
Sauger	1.9	0.4	0	0.2	1.9	0.8	2.3	6.2	2.8	2.5	1.3
Walleye	0.4	0.4	0	0	0.4	0	0.4	0.9	0.2	0.4	0.2
Freshwater drum	1.7	1.5	2.7	3.4	2.7	2.6	5.5	7.9	2.6	3.7	3.1

operation are also responsible for CPE variat .s. Some factors affecting CPE values include water temperature, turbidity, river velocity, depth, season, bottom type and availability for electro-shocking.

Mean CPE values for carp, buffalo and to a lesser degree the walleye were greater or equal at locations upstream from the diffuser pipes compared to equivalent downstream locations during the entire period (1971-1973), (Tables 27, 28 and 29). The overall CPE value of these forms in 1972 was generally less than in 1971 and 1973 except for the walleye (CPE slightly greater in 1972), due primarily to higher river flows in 1972 which decreased sampling efficiency and availability of fish (Industrial Bio-Test Laboratories, Inc., 1973 b p. 234; 1974a p. 197). CPE values for all three species were lower in 1973 than in 1971 but the decrease was observed upstream as well as downstream of the diffuser pipes (Table 30).

Channel catfish, bluegill, largemouth bass and white crappie exhibited higher mean CPE values downstream from the diffuser pipes during all three years. Greater CPE values for channel catfish at the downstream locations appear to be due to the greater number of wing dams present in the downstream sampling locations. The greater mean CPE value of largemouth bass and white crappie at the downstream locations as compared to the upstream locations was due primarily to the large number of these species taken at location 10 where aquatic vegetation is more extensive than at location 3 (the comparable upstream location), apparently attracting a greater number of these two species. Increased CPE values for bluegill in 1972 and 1973 was attributed to a strong year class (successful spawn) for the species

Table 30. Summary of average catch per unit of effort ($\overline{X}$ CPE, fish/hour) by electroshocking of all locations upstream and downstream of the Quad-Cities Station, Mississippi River, 1971-1973.

Species	1971		1972		1973	
	$\overline{X}$ CPE[a] Upstream	$\overline{X}$ CPE Downstream	$\overline{X}$ CPE Upstream	$\overline{X}$ CPE Downstream	$\overline{X}$ CPE Upstream	$\overline{X}$ CPE Downstream
Gizzard shad[b]	10.3	15.8	11.2	17.4	30.9	20.6
Carp[c]	33.5	18.0	12.4	10.5	15.8	9.9
Buffalo[c]	7.5	4.5	3.0	2.5	4.2	1.3
Channel catfish[d]	1.7	2.0	0.7	1.0	1.2	1.9
Bluegill[d]	2.8	8.9	16.4	17.3	15.5	22.5
Largemouth bass[d]	2.1	6.3	3.7	6.1	5.3	8.0
White crappie[d]	2.2	7.1	4.6	6.3	4.5	5.2
Black crappie[b]	7.0	11.4	4.9	7.5	5.8	5.4
Sauger[b]	4.8	8.6	4.6	5.4	2.5	1.3
Walleye[e]	2.7	0.6	1.1	1.8	0.4	0.2
Drum[f]	7.4	8.4	9.8	7.4	3.7	3.1

a CPE = fish collected/hour of electroshocking.
b = $\overline{X}$ CPE Greater downstream during 1971, 1972
c = $\overline{X}$ CPE Greater upstream during all years
d = $\overline{X}$ CPE Greater downstream during all years
e = $\overline{X}$ CPE Greater upstream during 1971, 1973
f = $\overline{X}$ CPE Greater upstream during 1972, 1973

in 1971 (Industrial Bio-Test Laboratories, Inc., 1973 a p. 169).

Gizzard shad, black crappie and sauger also exhibited similar trends in mean CPE values. Catch per unit effort values for these species were greater downstream in 1971 and 1972 (Tables 27, 28 and 29). In 1973 the CPE values were greater upstream for gizzard shad and only slightly greater for black crappie and sauger (Table 29). The mean CPE for freshwater drum was greater at the upstream locations during 1972 and 1973, while in 1971 the mean CPE was greater at the downstream locations.

Data from the electroshocking collections suggest that diffuser pipe discharge operation does not adversely affect fish distribution and abundance at sampling locations downstream from the station. In most cases where changes in CPE values for a given species occurred downstream similar changes were realized upstream, indicating that the changes were due to natural causes and were not the result of temperature increases related to the diffuser pipe discharge. In addition, differences between CPE values at locations upstream compared to those downstream of the diffuser pipe were frequently unrelated to temperature changes. Locations 8 and 9, located approximately 1,000 feet below the diffuser pipes, were the most likely to be influenced by diffuser pipe operation, yet sampling locations upstream from the diffuser pipes often exhibited higher water temperatures than those measured at locations 8 or 9 at the same time (Industrial Bio-Test Laboratories, Inc., 1973a p. 167; 1973b p. 236; 1974a p. 202). This indicates that natural temperature variations between locations may be greater than increases due to the operation of the diffuser pipe discharge. Tables 27, 28 and 29 show that at locations 8 and 9 CPE values

have increased from 1971 to 1973 for gizzard shad, channel catfish, bluegill, and largemouth bass. At these same locations CPE values have decreased from 1971 to 1973 for carp, buffalo, sauger and freshwater drum. The CPE value for walleye has remained similar throughout the period. The CPE value for white crappie decreased at location 8 from 1971 and 1973 and remained essentially the same at location 9 during the same period, while the CPE value for black crappie increased slightly at location 8 from 1971 to 1973 and decreased at location 9 for the same period.

Electroshocking data collected at Quad-Cities from April 1972 through April 1974 was analyzed statistically by means of a factorial analysis of variance (ANOVA). Following the ANOVA, Tukey's multiple comparison procedure was applied to detect significant differences between locations. Only data relating to the seven most abundant species of fish (gizzard shad, carp, largemouth bass, bluefill, white crappie, black crappie and drum) was subjected to analysis. A number of statistically significant differences were noted but these differences were expected and were not related to station operation. For example, catch per unit effort (CPE) values at location 3 and 10, both slough locations, were significantly greater than at side channel locations 4, 5, 9 and 13. Comparable locations upstream and downstream from the Quad-Cities Station rarely exhibited significant differences.

Monthly comparisons of electroshocking data indicated that significant differences in CPE values existed between months at each location but these differences were less apparent than in the case of trawling data. Comparison of data from locations with differing habitats resulted in a number of significant differences. However, significant

differences in CPE values between similar habitats upstream and downstream of the diffuser pipe discharge were only rarely observed. Since higher CPE values were not consistently observed at either upstream or downstream locations, it is unlikely that these differences are the result of diffuser pipe operation. A summary of the results of statistical analysis of the electroshocking data are given in Table 31.

Trawling

Table 32 presents the CPE (catch per unit effort as fish per hour) of the principal species of fish collected by trawling (shovelnose sturgeon, silver chub, channel catfish and freshwater drum) during 1971, 1972 and 1973. With the exception of three sampling dates no fish were collected during the April and May collections. This is usually a period of high river flows and it is probable that at these times small fishes experience difficulty negotiating the current and do not remain in mid-channel areas where they would be available for collection.

A total of 24 species of fish have been collected by trawling over the three year period. Trawling data for all species is shown in the appendices (Tables A-6, A-7, A-8, A-9 and A-10). The channel catfish, and to a lesser extent, the freshwater drum, have been the predominant species collected (Industrial Bio-Test Laboratories, Inc., 1972a p. 48; 1973a p. 184; 1973b pp. 259-260; 1974a p. 215). The number of species has generally been similar at all locations throughout the study. The highest total CPE occurred at location 1T (upstream) during 1971, location 13T (downstream) during 1972, and was nearly equal at all locations during 1973 (Figure 49).

Table 31

Summary of statistically significant differences between CPE values ($p \geq 0.05$) obtained by Tukey's Analysis during electroshocking studies April 1972 - April 1974

*Indicates significant differences between comparable locations upstream vs. downstream locations (4 & 5 vs. 9 & 13, 3 vs. 10)

Differences Between Locations

Species	Month	Locations Showing Significant Differences
Gizzard Shad	July 1972	4 - 3
	"	4 - 9*
	"	13 - 3
	"	13 - 9
	October 1972	3 - 13
	November 1973	4 - 5
	"	9 - 5*
Carp	September 1973	3 - 13
	October 1973	3 - 13
Largemouth Bass	June 1972	10 - 4
	July 1972	10 - 13
	September 1972	10 - 5
	"	10 - 13
Bluegill	June 1972	10 - 4
	"	10 - 13
	"	10 - 5
	"	3 - 4
	"	3 - 13
	"	3 - 5
	July 1972	10 - 13
	"	10 - 4
	"	10 - 5
	"	3 - 13
	September 1972	10 - 5
	"	10 - 13
	"	10 - 4
	"	3 - 5
	"	3 - 13
	October 1972	10 - 4
	"	10 - 5
	"	10 - 9
	"	10 - 13
	"	3 - 4
	"	3 - 5
	"	3 - 9
	"	3 - 13

Table 31 (Cont.)

Species	Month	Locations Showing Significant Differences
Bluegill (Cont.)	November 1972	3 - 4
	"	3 - 5
	"	3 - 9
	"	3 - 13
	"	10 - 4
	"	10 - 5
	"	10 - 9
	"	10 - 13
	April 1973	10 - 4
	"	10 - 13
	August 1973	10 - 5
	"	10 - 9
	"	10 - 4
	"	3 - 5
	September 1973	10 - 13
	"	10 - 5
	"	10 - 9
	"	4 - 13*
	"	3 - 13
	October 1973	10 - 4
	"	10 - 5
	"	10 - 9
	"	10 - 13
	November 1973	10 - 4
	"	10 - 5
	"	10 - 9
	"	10 - 13
	"	3 - 4
	"	3 - 5
	"	3 - 9
	"	3 - 13
White Crappie	May 1972	10 - 5
	"	10 - 9
	"	10 - 13
	July 1972	9 - 5*
	"	9 - 13*
	"	10 - 4
	"	10 - 13
	"	10 - 9
	"	3 - 4
	"	3 - 13
	April 1973	10 - 3*
	"	10 - 5
	"	10 - 13
	August 1973	10 - 13
	October 1973	10 - 13

Table 31 (Cont.)

Species	Month	Locations Showing Significant Differences
White Crappie (Cont.)	November 1973	3 - 4
	"	3 - 5
	"	3 - 9
	"	3 - 13
	"	10 - 4
	"	10 - 5
	"	10 - 13
Black Crappie	June 1972	9 - 5*
	"	9 - 13
	July 1972	10 - 13
	September 1972	10 - 5
	"	3 - 5
	October 1972	10 - 4
	"	10 - 5
	"	10 - 13
	"	10 - 9
	"	3 - 4
	"	3 - 5
	October 1973	10 - 5
	"	10 - 13
	"	3 - 5
	"	3 - 13
	"	4 - 5
	"	4 - 13*
Freshwater Drum	June 1972	4 - 10

Differences Between Months

Species	Location	Months Showing Significant Differences
Gizzard Shad		No Differences
Carp		No Differences
Largemouth Bass		No Differences
Bluegill	10	May 1972 vs. July, September, October 1972 and July, Aug-use, September, November 1973
White Crappie		No Differences
Black Crappie	10	October 1972 vs. August 1972 and May 1973
Freshwater Drum		No Differences

Table 32. Summary of the dominant species of fish collected by trawling (CPE = Fish/hour) near Quad-Cities Station, Mississippi River 1971-1973.

		Locations								
		1T			6T			13T		
Species	Month	1971	1972	1973	1971	1972	1973	1971	1972	1973
Shovelnose sturgeon	Apr	-[a]	0	0	-	0	0	-	0	0
	May	-	6.4	0	-	0	0	-	0	0
	Jun	8.6	2.1	0	0	2.1	0	0	4.3	0
	Jul	0	2.1	0	4.3	2.1	17.1	4.3	0	6.4
	Aug	4.3	0	4.3	4.3	0	25.7	8.6	0	8.6
	Sep	4.3	0	10.7	4.3	6.4	25.7	4.3	2.1	2.1
	Oct	4.3	0	2.1	4.3	0	2.1	4.3	2.1	12.9
	Nov	0	2.1	4.3	8.6	2.1	2.1	0	0	2.1
X̄ CPE		3.58	1.58	2.67	4.30	1.58	9.08	3.58	1.06	4.01

		Locations								
		1T			6T			13T		
Species	Month	1971	1972	1973	1971	1972	1973	1971	1972	1973
Channel catfish	Apr	-	0	0	-	0	0	-	0	0
	May	-	6.4	0	-	0	0	-	4.3	0
	Jun	175.7	57.9	4.3	12.9	17.1	0	34.3	47.1	6.4
	Jul	715.7	259.3	192.9	162.9	105.0	263.6	124.3	902.1	240.0
	Aug	55.7	6.4	120.0	158.6	10.7	289.3	68.6	81.4	235.7
	Sep	141.4	107.1	312.9	8.6	79.3	529.3	47.1	107.1	143.6
	Oct	205.7	42.9	220.7	68.6	12.9	113.6	12.9	81.4	100.7
	Nov	60.0	2.1	122.1	115.7	0	51.4	55.7	2.1	53.6
X̄ CPE		225.70	60.26	121.61	87.88	28.12	155.90	57.15	153.18	97.5

		Locations								
		1T			6T			13T		
Species	Month	1971	1972	1973	1971	1972	1973	1971	1972	1973
Silver chub	Apr	-	0	0	-	0	0	-	0	0
	May	-	0	0	-	0	0	-	0	0
	Jun	34.3	4.3	4.3	4.3	0	0	0	0	0
	Jul	0	0	0	0	2.1	0	0	0	0
	Aug	12.9	2.1	0	0	0	0	0	0	0
	Sep	4.3	12.9	0	4.3	6.4	0	0	6.4	0
	Oct	8.6	12.9	4.3	8.6	2.1	12.9	4.3	0	0
	Nov	25.7	4.2	64.3	25.7	0	12.9	17.1	2.1	4.3
X̄ CPE		14.30	4.55	9.11	7.15	1.32	3.22	3.56	1.06	0.53

		Locations								
		1T			6T			13T		
Species	Month	1971	1972	1973	1971	1972	1973	1971	1972	1973
Freshwater drum	Apr	-	0	0	-	0	0	-	0	0
	May	-	0	0	-	0	0	-	0	0
	Jun	0	38.6	0	0	27.9	0	0	203.6	0
	Jul	7.29	8.6	47.1	34.3	2.1	38.6	12.9	4.3	31.4
	Aug	8.6	0	72.9	17.1	0	107.1	17.1	0	87.9
	Sep	12.9	0	23.6	0	0	70.7	0	0	21.4
	Oct	8.6	2.1	2.1	4.3	2.1	4.3	4.3	6.4	2.1
	Nov	0	0	4.3	0	0	51.4	4.3	0	6.4
X̄ CPE		17.16	6.16	18.75	9.28	4.01	34.01	6.43	26.78	21.15

[a] - Trawling not attempted

Channel catfish were collected in greatest numbers at location 1T (upstream) during 1971, and location 13T (downstream) during 1973 and in lesser but nearly equal numbers at all three locations during 1973 (Table 31). The same general pattern of abundance among the sampling locations for the three years was also observed for the freshwater drum. Since ca. 90% of the individuals of both of these species were young-of-the-year, it is possible that differences in abundance among sampling stations during 1971 and 1972 could be the results of differential spawning success at these locations.

Warmer water temperatures and low river flows are probable reasons for the large catch in 1973. In 1972 cooler water temperatures and high river flows were experienced in association with low CPE values (Industrial Bio-Test Laboratories, Inc., 1973b p. 234; 1974a p. 197, 252). Higher flows were experienced in the spring of 1973 as compared to 1971 although similar flows occurred in both years during the late summer and fall months.

Shovelnose sturgeon and silver chub exhibited trends similar to those observed for the channel catfish and freshwater drum. Greater numbers of shovelnose sturgeon were consistently collected at location 6T (downstream) than at either location 1T or 13T (Table 32). It does not appear, however, that the greater CPE values for this species at 6T are due to the slightly warmer water temperatures since the CPE was greatest at location 6T in 1971 (prior to diffuser operation). The greater numbers of shovelnose sturgeon collected at location 6T (downstream) during all three years suggests that a more suitable habitat type is available at this location. The higher CPE value in 1973 compared to 1971 suggests the appearance of a strong year class during 1973. The

low CPE values observed in 1972 were apparently related to high river flows. The same general trends observed in the shovelnose sturgeon catch are also applicable to the silver chub.

Using these four species of fish, especially the channel catfish and freshwater drum, as indic ns, it is apparent that the small temperature differentials measured (max ΔT 2.9F) between trawling locations during the collections were not adversely affecting the abundance and distribution of fish collected by trawling below the diffuser pipes (Industrial Bio-Test Laboratories, Inc., 1973a p. 168; 1973b, p. 239; 1974a pp. 202-203).

The results of trawling studies at one location above the plant (location 1T) and two locations below the plant (locations 6T and 1 T) were compared statistically by means of a nested factorial analysis of variance followed by Tukey's multiple comparison procedure. All of these locations were sampled in duplicate twice a month for a total of 17 months; from April through July 1972 prior to diffuser operation and from August through November 197 April through August 1973 and April 1974 during operation of the diffuser pipe system.

In order to insure adequate sample size, catch per unit effort data (CPE) for only two species of fish, channel catfish and drum, were subjected to statistical analysis. Analysis of the trawling data indicated that there were no significant differences between locations during the same month. 11 locations, however, showed significant differences in catch per unit effort results during different months. In other words, the catch per unit effort for September compared to the CPE for April showed a significant difference. The results of the statistical comparisons of trawling data are summarized in Table 33.

Table 33

Summary of statistically significant differences between CPE values ($p \geq 0.05$) obtained by Tukey's Analysis during trawling studies April 1972 - April 1974

Monthly Comparisons

Species	Location	Significant Differences
Channel Catfish	1T	September 1973 vs. April, May, August, November 1972 & April, May, June 1973
	1T	July 1973 vs. April, November 1972 & April, May, June 1973
	1T	October 1973 vs. April, November 1972 & April, May, June 1973
	6T	September 1973 vs. April, May, June, August, October, November 1972 & April, May, June 1973 & April 1974
	6T	August 1973 vs. April, May, August, October, November 1972 & April, May, June 1973 & April 1974
	6T	July 1973 vs. April, May, November 1972 & April, May, June 1973 & April 1974
	13T	July 1972 vs. April, May, June, August, October, November 1972 & April, May, June, November 1973 & April 1974
	13T	August 1[illegible] vs. April, May, November 1972 & April, May, 1973 & April 1974
	13T	July 197[illegible] vs. November 1972 & April, May 1973 & April 1974
	13T	September 1973 vs. April, May 1973

Table 33 (Cont.)

Species	Location	Significant Differences
Freshwater Drum	1T	October 1973 vs. April, August, September, October, November 1972 & April, May, June 1973
	1T	November 1973 vs. April, May, August, September, October, November 1972 & April, May, June 1973
	6T	August 1973 vs. April, May, July, August, September, October, November 1972 & April, May, June 1973 & April 1974
	6T	September 1973 vs. April, May, August, September, November 1972 & April, May, June 1972 & April 1974
	13T	August 1973 vs. April, May, August, September, November 1972 & April, May, June 1973 & April 1974

Location Comparisons

Species	U/S vs D/S Comparison	Significant Differences
Channel Catfish	1T vs. 6T	No Differences
Channel Catfish	1T vs. 13T	No Differences
Channel Catfish	6T vs. 13T	No Differences
Freshwater Drum	1T vs. 6T	No Differences
Freshwater Drum	1T vs. 13T	No Differences
Freshwater Drum	6T vs. 13T	No Differences

Seining

During the period 1971-1973, 51 species of fish have been collected by shoreline seining within the study area. Location 8 has consistently been the most productive in terms of species collected and total numbers of fish during each of the three years. The shoreline seining data for all years is shown in the appendices (Tables A-11, A-12, A-13, A-14 and A-15).

During 1971 river shiner, emerald shiner, spotfin shirer, spottailed shiner and gizzard shad, all forage fish, were the predominant species collected at all locations (Industrial Bio-Test Laboratories, Inc., 1972a, p. 49). Location 8 produced three times the number of fish than any other location. Young-of-the-year carpsucker, bluegill, largemouth bass, black and white crappie were collected at location 8, indicating this is an existing and/or potential nursery area. Location 5 was second in abundance and diversity.

During 1972 numbers of species and abundance was generally less than in 1971 at all stations, both upstream and downstream of the diffuser pipes. Increased river flows with associated decreased effort were the probable reasons for these decreases. Principal species collected at all locations were similar to 197 collections with emerald shiner, river shiner, silver chub and spot led shiner abundant. Young-of-the-year bluegills, largemouth bass, white and black crappie were again abundant at location 8 (Industrial Bio-Test Laboratories, Inc., 1973a pp. 183-184).

During 1973 all locations produced the highest abundance and numbers of fish species to date (Industrial Bio-Test Laboratories, Inc., 1973b p. 255; 1974a pp. 223-224). Fish abundance s similar between locations 5, 11 and 13 with gizzard shad, emerald shiner, river shiner

and spot tailed shiner predominating. The gizzard shad population exhibited marked increases in 1973 over the levels observed in 1971 and 1972. Increased gizzard shad catches were noted at all locations, particularly locations 8 and 5. This increase appeared to be the result of a successful spawn during 1973 as the majority of the shad collected were young-of-the-year. A slight increase was also observed in the emerald shiner population, especially at location 13. Slight decreases occurred in numbers of river shiner and spot tailed shiner at all locations. Location 8, as in the past, supported many young-of-the-year species. During the late summer and fall 16% of the catch at this location was composed of centrarchids (Industrial Bio-Test Laboratories, Inc., 1974a p. 226).

Location 8 is the most susceptible of all seining locations to the possible effects of the heated effluent from the diffuser pipes. However, the consistent diversity and abundance of fish species collected at location 8 during all years of the study (1971-1973) evidences no appreciable adverse effect from diffuser pipe operation. The consistently high numbers of young-of-the-year centrarchids collected by seining indicates that the heated effluent from the diffuser pipe has had no effect on the nursery potential at location 8. No adverse effects have been noted at locations 11 and 13 for the three year period as species diversity and abundance have remained constant.

4.4.1.6.4 Fish Movements (tagging and recapture studies)

Tagging of selected sport and commercial fish species was implemented in September 1971 and has continued throughout this study. Tagging studies have been conducted to determine the pattern and extent of fish movement in the study area, and to ascertain whether fishes would

move across the temperature differential created by the diffuser pipe system.

The number of fishes tagged during each year and the number recaptured which have moved across the diffuser pipe discharge are summarized in Table 34. All other data resulting from tagging and recapture efforts are listed in the appendices (Tables A-16, A-17, A-18, A-19, A-20 and A-21). From April 1972 - July 1974 a total of 15 tagged fish have traveled across and/or around the diffuser pipes. Ten of these fish have traveled upstream across and/or around the diffuser pipes and 5 fish traveled downstream. Of the 10 fish traveling upstream across and/or around the diffuser pipe, 4 were black crappie, 3 were channel catfish, 2 were sauger and 1 was a largemouth bass. Of the 5 fish traveling downstream across the diffuser pipe area 2 were white crappie, 2 were largemouth bass and one was a bigmouth buffalo.

The possibility that fish traveled across and/or around the diffuser pipes during periods when the station was not discharging heated effluent must be considered. In addition, the diffuser pipes do not discharge heated water across the entire width of the river (Industrial Bio-Test Laboratories, Inc., 1973b pp. 347-355; 1974b pp 317-338) and a thermally unobstructed zone of passage does exist at both ends of the diffuser pipes. During 1973 three species of fish (largemouth bass, channel catfish and black crappie) did travel around and/or over the diffuser pipe discharge as shown by the tagging and recapture studies. The largemouth bass was tagged at river mile 508 on May 22, 1973 and was recaptured by Industrial Bio-Test Laboratories, Inc. personnel at location 8 on July 10, 1973. The channel catfish was tagged at location 9 on August 9, 1973 and subsequently recaptured by commercial fishermen

Table 34

Number of Fishes Tagged and Recaptured and Occurrence of Movement of Recaptured Species in the Vicinity of Quad-Cities Station April 1972-July 1974

	1972	1973	1974[c]
No. of fishes tagged	1092	1323	482
No. of recaptures			
1972	39	-a	-
No. of traveling recaptures[b]	6	-	-
No. traveling across diffuser	2	-	-
Movement upstream across diffuser	1	-	-
Movement downstream across diffuser	1	-	-
No. of recaptures			
1973	15	60	-
No. of traveling recaptures	8	8	-
No. traveling across diffuser	4	3	-
Movement upstream across diffuser	3	2	-
Movement downstream across diffuser	1	1	-
No. of recaptures			
1974	8	25	6
No. of traveling recaptures	2	14	1
No. traveling across diffuser	0	6	0
Movement upstream across diffuser	-	4	-
Movement downstream across diffuser	-	2	-

a - Not applicable

b - Recaptured other than where released

c - Through July only

at river mile 513.5 on October 8, 1973. The black crappie was tagged at location 8 on August 30, 1973 and recaptured by sport fishermen at river mile 509 on November 11, 1973. Both units of the Quad-Cities Station were operating on the diffuser pipes during this period. Although the three fish which did travel around and/or across the diffuser pipe represent a small fraction of the fishery, these data show that the diffuser pipes do not act as an impassable barrier to fish movements either upstream or downstream.

In 1973 the station operated with one unit on one diffuser pipe and the second unit on the spray canal (closed cycle) and no heated effluent was discharged on the west side of the river. During this period 8 fish (tagged and subsequently recaptured) traveled across and/or around the diffuser pipes. These species include shovelnose sturgeon (2), channel catfish (4), largemouth bass (1) and sauger (1) (Industrial Bio-Test Laboratories, Inc., 1974b pp. 204-308).

Tagging and recapture data concerning the centrarchids show that these species have a general tendency to remain within the original sampling location. If movement occurs it is for a short distance (less than 3 miles) or laterally across the river (Industrial Bio-Test Laboratories, Inc., 1973a pp. 192, 199; 1973b p. 264, 269; 1974 a pp. 136-240; 1974b pp. 304-308). Sauger and walleye recaptures have shown a strong tendency for these species to migrate to the tailwaters of lock and dam 13 and in one case as far as lock and dam 12, ca. 50 miles upstream. Channel catfish are less prone to inhabit an exclusive location as none have been recaptured at their original release locations. Data concerning other species of fish tagged and recaptured is so limited that discussion of trends and movements of these species is unwarranted at this time.

4.4.1.6.5 Reproduction Periods and Larval Fish

The reproductive periods and associated water temperatures of the most common sport and commercial fish species collected within the study area are shown in Table 35. Reproductive characteristics of these fish are also discussed in Industrial Bio-Test Laboratories, Inc. 1972a, pp. 23-29. Since essentially complete mixing of the heated effluent occurs within ca. 600 feet of the diffuser pipes, only very limited areas of main channel and main channel border habitat types would be under the influence of temperatures of 5F or more above ambient. Potential species which might select this limited area of main channel and main channel border habitat type for reproduction would be shovelnose sturgeon, gizzard shad, carp, channel catfish and freshwater drum; however, main channel and main channel border habitat in this area have not been found to be significant reproductive and nursery areas for these species (Industrial Bio-Test Laboratories, Inc., 1972a pp. 14-15; 1973a pp. 183-192; 1973b pp. 253-256, 264; 1974a pp. 219-232). Figure 50 shows known reproductive and nursery areas downstream from the diffuser pipe discharge area.

Data concerning drifting larval fish within the study area has shown that gizzard shad, carp, Notropis sp. (minnows) and freshwater drum comprised 94.2% of the total catch in 1971; 93.1% in 1972; and 91.5% in 1973 (Industrial Bio-Test Laboratories, Inc., 1972a pp. 21-23, 61-62; 1973a pp. 210-213; 1973b pp. 335-338; 1974a pp. 249-255). Highest densities of mooneye, sauger and walleye generally occur from mid-March through mid-April. All other larval species collected within the study area reached a peak density between mid-May and mid-June (Industrial Bio-Test Laboratories, Inc., 1974a p. 251). Average river flows during this period are in excess of 50,000 cfs.

Table 35

Reproductive Periods and Associated Temperatures (°C) of the Most Common Sport and Commercial Fish Species in Pool 14, Mississippi River, near Quad-Cities Station

Species	Mar	Apr	May	June	July	Aug	Spawning Temp(°C)	Incubation Time-days	Incubation Temp (°C)	Data Source[1]
Shovelnose sturgeon		XXXX	XXXX	X			13-21	3-7	13-21	1,2,3,4,5,6,7,8
Gizzard shad[a]			XXXX	XXXX	XX		19-29	2-7	16-20	9,10,11,12,13,14
Carp	XX	XXXX	XXXX	XXXX	XXXX	XX	16-26	4-10	16-22	15,16,17,18
Bluntnose minnow[a]			X	XXXX	XXXX	XX	21-26	8-12	21-26	19,20,21,22,23
Smallmouth buffalo		XXXX	XXXX	X			14-21	4-14	14-21	24,25,26
Bigmouth buffalo		XX	XXXX	X			15-19	8-14	15-19	27,28,29,30
Channel catfish[a]			X	XXXX	XXXX		21-27	6-10	16-28	31,32,33,34,35,36
Bluegill[a]			XX	XXXX	XXXX		19-27	2-5	19-27	37,38,39,40,41
Largemouth bass[a]			XXX	XX			16-24	3-7	16-24	42,43,44,45,46,47
White crappie			XXX	XX			13-23	2-4	13-23	48,49,50,51,52
Black crappie			XXX	XX			12-18	5-10	12-18	53,54
Western sand darter[b]					XXXX		c			55,56,57
Sauger		XXXX	XX				6-10	9-21	8-15	58,59,60,61,62,63
Walleye	X	XXXX	XX				4-10	12-18	4-13	64,65,66,67,68
Freshwater drum			XX	XXXX	XXXX		18-22	1-3	18-26	69,70,71,72,73,74

[a]Representative Important Species (as classified by the State of Illinois, 1974)

[b]Rare and Endangered Species (as classified by the State of Iowa, 1972)

[c]Specific spawning temperatures and incubation periods unknown

[1]See Appendix Table A-22

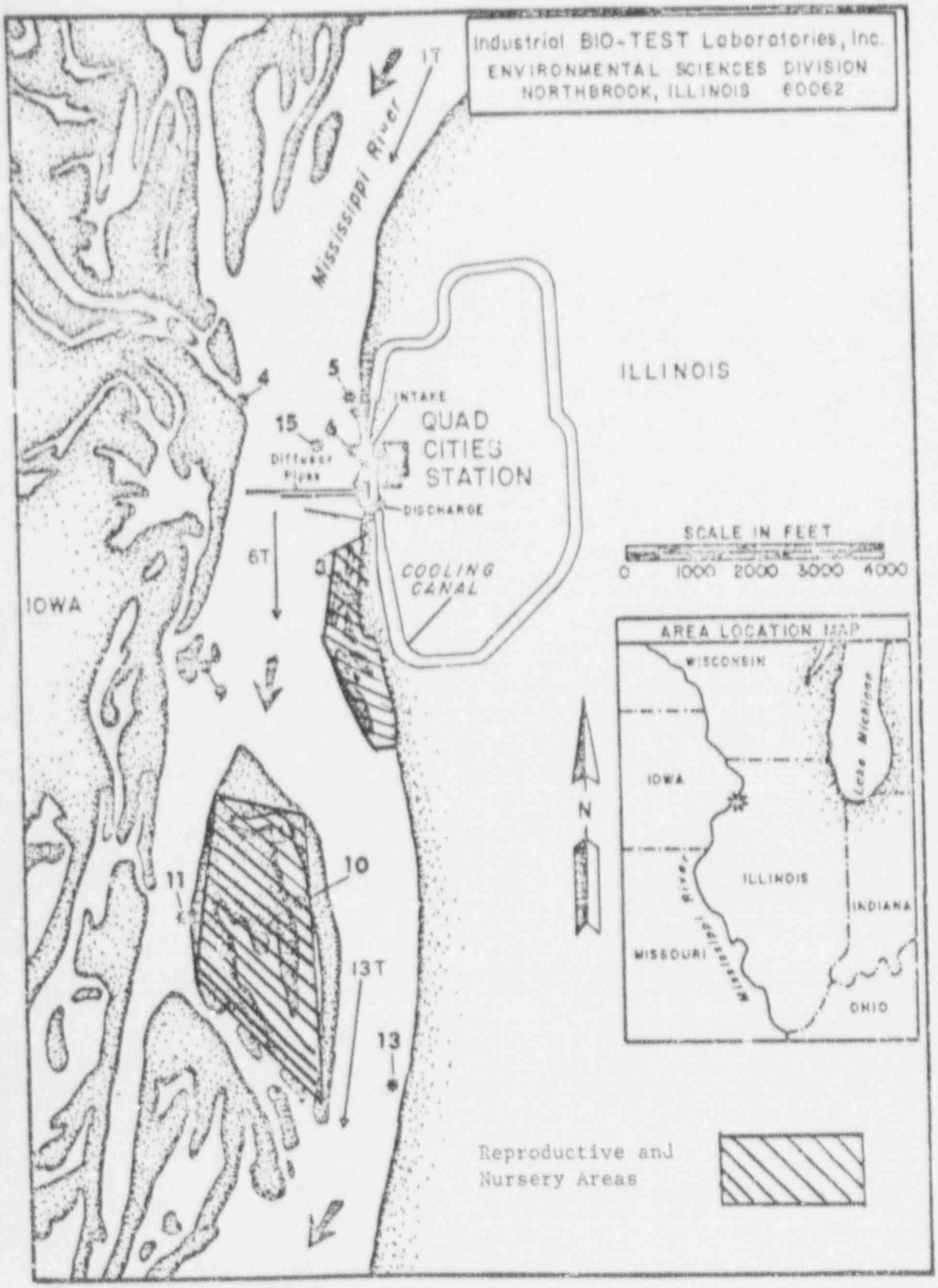


Figure 50. Reproductive and nursery areas in relation to fish sampling locations near Quad-Cities Station.

Less than 30 of the 75 fish species collected during the study have been found in the larval drift. There are a number of possible reasons for their absence. One obvious reason may be that the species does not reproduce within the general location of the Quad-Cities Station. Second, the nature of the species reproductive habits and larval behavior may be such that they are not introduced into the main stream drift and thus are not available to collection gear. The appearances of larval fish in the drift and the time that they appear is highly specific. As shown in the data (Industrial Bio-Test Laboratories, Inc., 1972a pp. 60-61; 1973a p. 212; 1974a, p. 254), the larvae of many species appear in the drift only for a period of a month or less. Fishes which exhibit this relatively brief drift period include walleye, sauger, Esox species, white bass, and several of the sucker species. It is possible that hatching of these species occurs over a short period of time and the larval fish soon attain independent swimming capabilities and are no longer present in the drift. Other species displaying unusually long periods of larval drift are carp, freshwater drum, and gizzard shad. In these species it is likely that both spawning and hatching occur over a long period of time (May through July) and that larval fish may not develop independent swimming capabilities as quickly as other species.

4.4.1.6.6 Commercial and Sport Catch Data

Table 36 summarizes total commercial catch data for pools 12-16 for 1971 and 1972 (UMRCC 1973, 1974). Total poundage and total catch (pounds per acre) has increased within all pools (1971-1972) and has generally been increasing over the past 10 years. Total commercial catch data has not been summarized and therefore is not available for

Table 36. Total commercial catch (lbs.) by pools in the upper Mississippi River 1971 and 1972.

	Pool Numbers									
	12		13		14		15		16	
Species	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972
Carp	62,426	116,285	214,065	308,256	[illegible]	89,627	40,822	53,457	86,467	145,365
Buffalo	173,424	205,375	253,739	354,992	139,506	162,271	36,996	61,033	112,490	159,488
Freshwater Drum	16,724	28,989	66,186	82,502	26,460	46,563	5,622	17,421	33,499	66,797
Catfish	23,581	38,159	109,369	110,792	63,172	87,230	9,132	10,905	15,864	34,816
Bullhead	838	600	3,588	998	233	448	20	155	640	771
Carpsucker	100	250	1,600	2,550	2,100	740	0	0	10,000	26,752
Redhorse & sucker	707	2,934	4,167	1,384	316	1,005	0	1,078	21	397
Sturgeon	8,884	5,781	2,642	438	1,319	[illegible]	2,548	3,433	2,417	3,166
Paddlefish	1,263	5,040	4,278	10,989	2,266	[illegible]	15	3,697	15,648	12,578
Gar	672	59	0	3,479	400	247	90	0	0	1,339
Bowfin	0	0	200	50	0	0	0	0	0	112
American Eel	0	6	0	0	0	40	4	0	0	59
Turtle	200	0	0	6,900	0	244	0	0	200	332
Mooneye & goldeye	0	2,079	0	1,273	0	16	0	35	0	6,538
Other	0	30	0	0	0	0	0	0	138	0
Total Poundage	288,819	405,587	659,774	884,603	331,483	396,522	95,249	151,214	277,384	458,510
Area of Pool (acres)	12,840		30,000		12,200		3,725		14,200	
Total Catch (lbs/acre)	22.5	31.6	22.0	29.5	27.2	32.5	25.6	40.6	19.5	[illegible]

comparison from the UMRCC for 1973 and 1974.

In Pool 14 the buffalo has been the dominant species collected in terms of poundage and channel catfish in terms of commercial value in both 1971 and 1972. Fluctuations realized within a given species are the result of many factors other than year to year abundance of that species. Variations in market demand, market value, physical factors (river flow, weather), and number of commercial fishermen with associated applied effort all affect the composition of the commercial catch. Because of these diverse factors it is difficult to determine the effect, if any, of the diffuser pipe discharge upon the commercial fishery in pool 14.

Creel survey studies in pool 14 of the Mississippi River were conducted from mid-June through September 1972 by Commonwealth Edison Company in cooperation with the Iowa Conservation Commission. A winter creel census study was conducted from December 1972 through February 1973. In addition summer creel census studies were conducted from May through September in 1973 and 1974.

In order to facilitate estimation of the pattern of fishing activity the pool was divided into four sections as shown in Figure 51. Sections I and II were located upstream of the station while sections III and IV were located downstream. The format for the creel census procedures was furnished by the Iowa Conservation Commission.

The results of the summer 1972 creel census studies are summarized in Tables 37 and 38. During this period the catch rate was higher in areas I and II above the Quad-Cities Station (0.762 fish per hour) than in areas III and IV downstream of the station (0.644). The total numbersof fishermen and fish caught were far higher above the station

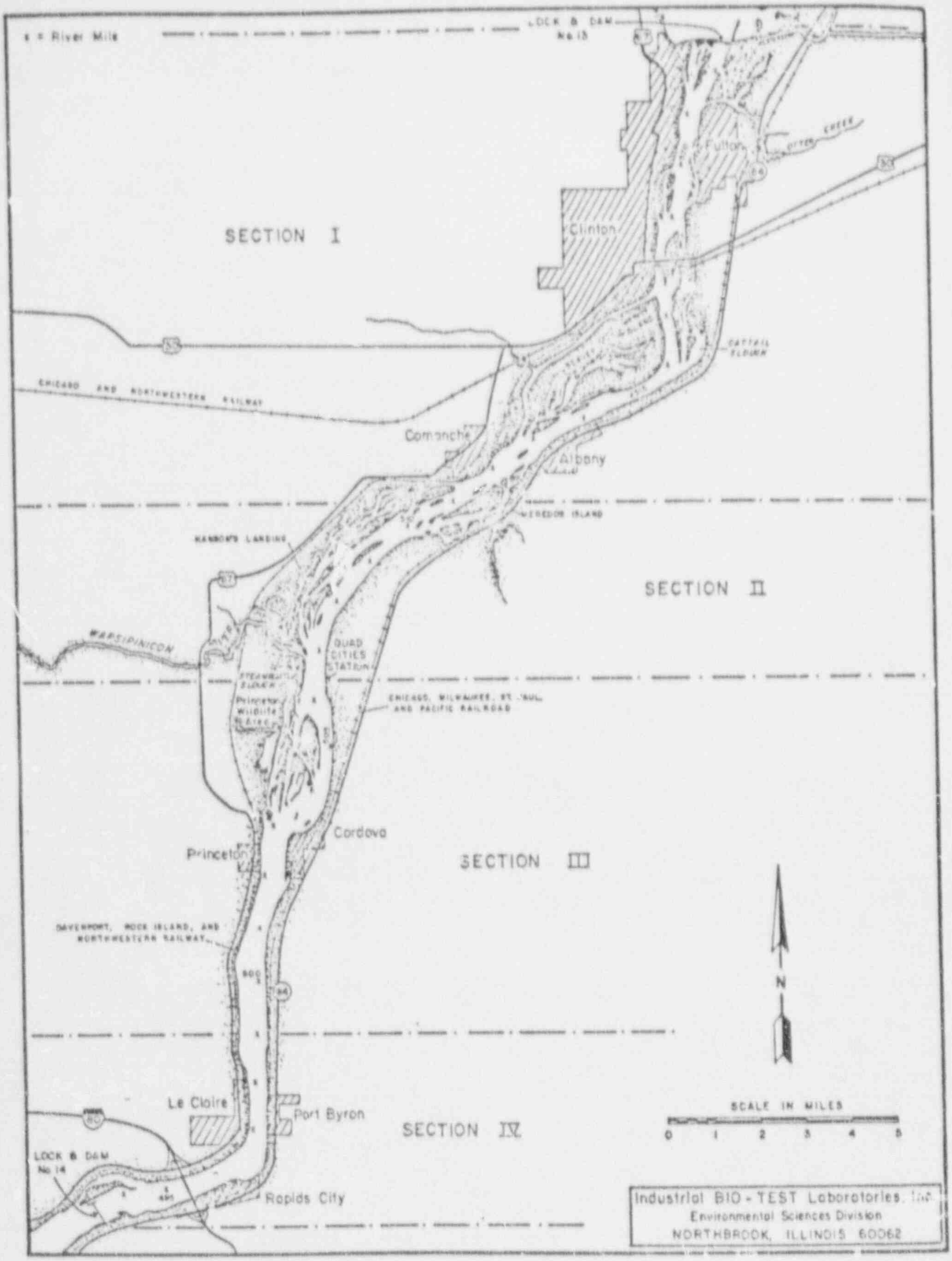


Figure 51. Location of Creel Census Areas

Table 37

SUMMARY OF EXPANDED CREEL CENSUS DATA-1972
(Estimated Totals Above Station - Areas I & II)

	June			July			August			September			October			Total Period			
	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	%
No. of Fishermen	1,416	601	2,017	347	576	923	297	248	545	279	144	423	183	158	341	2,522	1,727	4,249	
Hrs. Fished	3,318	1,320	4,638	960	1,864	2,824	869	536	1,405	1,199	350	1,549	800	424	1,724	7,146	4,494	11,640	
Fish/hour	0.551	0.672	0.657	838	664	723	0.639	0.847	0.718	0.876	1.183	0.945	1.249	0.734	1.070	0.779	0.735	0.762	
L.M. Bass	173	0	173	0	20	20	0	0	0	6	0	6	12	10	12	191	20	211	2.38
Bluegill	314	52	366	11	79	90	0	0	0	303	104	407	143	4	147	771	239	1,010	11.38
Crappie	945	516	1,461	163	84	247	80	41	121	217	112	329	457	98	555	1,862	851	2,713	30.58
Channel Catfish	362	0	362	427	174	601	185	64	249	97	98	195	81	53	134	1,152	389	1,541	17.37
White Bass	39	0	39	52	446	498	130	308	438	225	7	242	170	132	302	616	903	1,519	17.12
Drum	91	140	231	115	359	474	120	41	161	59	40	92	57	10	67	435	590	1,025	11.55
Bullhead	198	66	264	11	59	70	40	0	40	140	25	165	47	14	61	436	164	600	6.76
Walleye/ Sauger	39	22	61	0	0	0	0	0	0	5	0	5	30	0	30	74	22	96	1.08
Carp	0	91	91	16	17	33	0	0	0	4	18	22	2	0	2	22	126	148	1.67
Mooneye	0	0	0	9	0	9	0	0	0	0	0	0	0	0	0	9	0	9	0.10
Flathead	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0.01
Total Fish	2,161	887	3,048	804	1,238	2,042	555	454	1,009	1,050	414	1,464	999	311	1,310	5,569	3,304	[illegible]	100

Table 38

SUMMARY OF EXPANDED CREEL CENSUS DATA-1972
(Estimated Totals Below Station - Areas III & IV)

	June			July			August			September			October			Total Period			%
	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	
Estimated No. of Fishermen	235	637	872	75	49	124	141	152	293	37	61	98	122	79	201	610	978	1,588	
Estimated Hrs. Fished	756	1,180	1,936	266	140	406	425	417	842	79	142	221	368	227	595	1,894	2,106	4,000	
Fish/hour	0.247	1.102	0.769	0.282	0.157	0.239	0.718	0.417	0.569	0.405	0.690	0.588	0.726	0.511	0.644	0.457	0.812	0.644	
Estimated Catch L.M. Bass	33	72	105	10	15	25	3	9	12	0	0	0	6	16	22	52	112	164	6.36
Bluegill	0	38	38	0	0	0	0	41	41	0	23	23	0	0	0	0	102	102	3.96
Crappie	74	144	218	10	0	10	0	0	0	0	23	23	48	51	99	132	218	350	13.58
Channel Catfish	9	72	81	47	7	54	240	98	338	32	36	68	154	24	178	482	237	719	27.90
White Bass	0	900	900	0	0	0	0	0	0	0	0	0	0	0	0	0	900	900	34.92
Drum	19	0	19	8	0	8	50	13	63	0	0	0	33	11	44	110	24	134	5.20
Bullhead	52	0	52	0	0	0	9	13	22	0	8	8	13	14	27	74	35	109	4.23
Walleye/ Sauger	0	75	75	0	0	0	3	0	3	0	0	0	0	0	0	3	75	78	3.03
Carp	0	0	0	0	0	0	0	0	0	0	8	8	13	0	13	13	8	21	0.82
Total Fish	187	1,301	1,488	75	22	97	305	174	479	32	98	130	267	116	383	866	1,711	2,577	100

than downstream. This higher catch rate appeared to be due largely to the presence of better access in the upstream areas.

Crappie, channel catfish and white bass were the species most frequen taken during the 1972 summer period. There appeared to be a diffe.ence between the kinds of fish taken upstream and downstream of the station. In areas I and II, crappie accounted for ca. 30% of the total catch while channel catfish and white bass each accounted for ca. 17% of the catch. In areas III and IV downstream of the station white bass and channel catfish accounted for 35% and 28% of the catch respectively.

Results of the December 1972-February 1973 winter creel census studies are summarized in Table 39. Nearly all of the winter fishing was confined to the Hanson, Meridosia, and Cattail Slough areas in areas I and II. There was virtually no fishing in areas III and IV below the station. Although the total number of fishermen was relatively small, fishing success in terms of fish per hour was considerably better in the winter than during the summer period. The average winter success rate was 1.95 fish per hour. Crappie and bluegill were the dominant fish taken during the winter period.

Results of the May-September 1973 creel census studies are summarized in Table 40 and 41. During this period fishing success was highest downstream from the Quad-Cities Station. This was in contrast to the 1972 summer period when the success rate was slightly greater upstream of the station. During the summer of 1973 the overall success rate in areas III and IV (downstream) was 0.752 fish per hour compared to a rate of 0.681 fish per hour in the upstream areas (areas I and II).

Table 39

RESULTS OF WINTER CREEL CENSUS INTERVIEWS
December 1972-February 1973

	Area	No. of Fishermen	Hours	Mean Trip Length	Fish/Hr.	Bluegill	Crappie	L.M. Bass	Green Sunfish	Total Fish
December 1972	Hansen	93	260.0	3.01	2.82	138	593	0	1	732
	Maridosia	18	59.0	2.50	1.05	13	49	0	0	62
	Cattail Slough	15	34.5	2.65	6.61	2	226	0	0	228
January 1973	Hansen	190	597.7	3.19	1.60	525	424	9	0	958
	Maridosia	30	85.0	-	1.47	5	119	1	0	125
	Cattail Slough	4	3.0	-	7.00	0	21	0	0	21
Feb. 1973	Haasen	70	181.7	3.03	1.41	85	166	5	0	256
	Maridosia	11	12.7	-	1.80	0	23	0	0	23

Table 40

SUMMARY OF EXPANDED CREEL CENSUS DATA-1973
(Estimated Totals Above Station - Areas I & II)
1973

	May			June			July			August			September			Total Period			
	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	%
No. of Fishermen	234	1,204	1,438	679	802	1,481	238	257	495	1,416	854	2,270	928	787	1,715	3,495	3,904	7,399	
Hrs. Fished	808	3,404	4,212	2,037	2,182	4,219	761	771	1,532	5,584	3,311	8,895	3,071	1,966	5,037	12,261	11,634	23,895	
Fish/hour	0.116	0.857	0.715	0.338	0.450	0.396	0.966	1.047	1.006	1.003	0.402	0.779	0.836	0.278	0.618	0.790	0.566	0.681	
Channel Catfish	10	0	10	35	40	75	620	39	659	809	161	970	974	107	1,081	2,448	347	2,795	17.2
Bullhead	39	411	450	139	40	179	0	0	0	61	0	61	0	0	0	239	451	690	4.2
Crappie	45	582	627	301	75	376	56	111	167	1,273	406	1,679	696	0	696	2,371	1,174	3,545	21.8
Bluegill	0	1,675	1,675	14	56	70	42	578	620	2,724	615	3,339	321	0	321	3,101	2,924	6,025	37.0
White Bass	0	0	0	0	175	175	0	20	20	72	0	72	0	0	0	72	195	267	1.6
L.M. Bass	0	0	0	0	22	22	9	0	9	34	0	34	34	0	34	77	22	99	0.6
Rock Bass	0	0	0	0	0	0	0	0	0	31	0	31	0	0	0	31	0	31	0.2
Walleye/ Sauger	0	0	0	77	172	249	0	0	0	56	0	56	34	0	34	167	172	339	2.1
Northern Pike	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drum	0	0	0	122	97	219	4	39	43	505	26	531	255	439	694	886	601	1,487	9.1
Carp	0	248	248	0	286	286	4	20	24	10	124	134	252	0	252	266	678	944	5.8
Bowfin	0	0	0	0	0	0	0	0	0	10	0	10	0	0	0	10	0	[illegible]	0.1
Flathead	0	0	0	0	18	18	0	0	0	14	0	14	0	0	0	14	18	32	0.2
Total Fish	94	2,916	3,010	688	981	1,669	735	807	1,542	5,599	1,332	6,931	2,566	546	3,112	9,682	6,582	16,264	100

Table 41

SUMMARY OF EXPANDED CREEL CENSUS DATA-1973
(Estimated Totals Below Station - Areas III & IV, 1973)

	May			June			July			August			September			Total Period			%
	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	Boat	Shore	Tot.	
No. of Fishermen	395	2,186	2,581	338	613	951	524	344	868	396	289	685	96	267	[illegible]	1,749	3,699	5,448	
Hrs. Fished	789	4,653	5,442	919	1,533	2,452	1,896	1,348	3,244	1,118	721	1,839	587	666	1,253	5,309	8,921	14,230	
Fish/hour	0.522	0.608	0.596	0.274	0.509	0.421	0.961	0.431	0.741	0.828	3.105	1.721	1.235	0.356	0.768	0.779	0.748	0.752	
Channel Catfish	157	26	183	0	0	0	502	12	514	558	20	578	488	86	574	1,705	144	1,849	17.1
Bullhead	0	219	219	19	201	220	243	25	268	0	0	0	0	0	0	262	445	707	6.5
Crappie	177	1,294	1,471	64	59	123	430	203	633	34	1,261	1,295	31	35	66	736	2,852	3,588	33.2
Bluegill	0	720	720	93	303	396	168	0	168	204	938	1,142	0	0	0	465	1,961	2,426	22.5
White Bass	0	341	341	38	103	141	151	25	176	0	0	0	20	22	42	209	491	700	6.5
L.M. Bass	0	13	13	0	0	0	9	316	325	0	0	0	0	0	0	9	329	338	3.2
Rock Bass	0	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13	0.1
Walleye/ Sauger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	0	0	0	19	51	70	9	0	9	0	0	0	0	0	0	28	51	79	0.7
Drum	78	148	226	0	13	13	264	0	264	34	0	34	186	94	280	562	255	817	7.6
Carp	0	44	44	19	51	70	9	0	9	96	20	116	0	0	0	124	115	239	2.2
Bowfin	0	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13	0.1
Flathead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sand Sturgeon	0	0	0	0	0	0	37	0	37	0	0	0	0	0	0	37	0	37	0.3
Total Fish	412	2,831	3,243	252	781	1,033	1,822	581	2,403	926	2,239	3,165	725	237	962	4,137	6,669	10,806	100

In spite of the slightly higher success rate downstream of the station, the total number of fishermen and total number of fish caught continued to be greater in the upstream areas in 1973. Bluegill, crappie, and channel catfish were the forms most frequently taken during the summer catch. Bluegills were the dominant form taken from the upstream areas while crappie predominated in the downstream catch. The major difference between the species composition of the June through October 1972, and the May to September 1973 creel studies was the unusually high white bass catch during the 1972 period. During the 1972 period white bass accounted for 20% of the total catch as compared to 4% during 1973. The high percentage of white bass in the 1972 catch was considered unusual in light of the fisheries studies which have been conducted. Another significant difference between the 1972 and 1973 creel studies was the increased percentage of bluegill in the 1973 catch.

The results of the May through September 1974 creel studies have not as yet been analyzed but they do not appear to differ significantly from earlier studies.

None of the creel census studies conducted to date indicate that the operation of the diffuser pipe is influencing either fishing patterns or fishing success.

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APPENDIX A

TABLES FOR
FISHERY
SECTION

Table A-1. Relative abundance of fish collected by both electroshocking and wire netting at each sampling location (April - December 1971)

Species	Location number											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Chestnut lamprey	0	0	0	0	0	1	0	0	0	0	0	1
Silver lamprey	0	0	0	0	0	1	0	0	0	0	0	0
Paddlefish	2	1	0	0	0	0	0	0	0	0	2	1
Longnose gar	0	0	0	0	0	1	0	0	0	2	0	1
Shortnose gar	2	2	49	1	2	9	4	3	5	1	1	0
Bowfin	0	0	3	0	2	5	2	4	12	0	0	2
Gizzard shad	142	82	53	73	104	71	57	37	111	57	219	65
Mooneye	11	2	6	23	9	5	9	3	0	5	4	2
Grass pickerel	0	0	0	0	6	0	0	2	0	1	0	0
Northern pike	4	1	1	2	5	2	1	1	3	0	2	0
Carp	23	32	163	29	109	122	108	86	90	11	47	63
Silvery minnow	1	1	0	3	1	2	0	0	6	7	6	3
Silver chub	55	50	10	16	4	6	10	0	0	81	25	4
Golden shiner	0	0	2	0	0	0	0	0	28	0	1	0
Emerald shiner	57	10	1	20	6	8	42	2	1	8	9	3
River shiner	10	0	2	3	3	3	2	0	0	24	2	0
Spottail shiner	0	0	1	0	3	0	0	0	0	0	2	1
Spotfin shiner	0	0	0	0	5	0	0	0	0	0	0	0
Fathead minnow	0	0	0	0	1	0	[illegible]	0	0	0	0	0
River carpsucker	21	25	72	22	90	30	21	52	89	12	31	6
Quillback	4	4	2	2	7	0	0	0	0	6	2	0
White sucker	0	0	0	0	0	1	0	0	0	0	0	0
Smallmouth buffalo	2	3	23	0	5	32	3	12	49	0	6	6
Bigmouth buffalo	0	11	17	1	3	1	4	5	12	0	0	5
Spotted sucker	0	0	0	0	0	0	0	1	5	0	1	0
Shorthead redhorse	0	1	1	4	2	4	4	0	0	2	1	0
Black bullhead	1	2	0		1	0	1	0	2	0	0	2
Yellow bullhead	0	0	0	0	0	0	0	0	0	0	2	0
Channel catfish	7	11	8	6	8	36	8	3	2	6	14	45
Flathead catfish	0	0	0	1	0	1	1	0	0	0	0	1
Brook silverside	0	0	0	1	1	0	0	0	3	1	0	0
White bass	31	29	18	38	5	16	12	2	5	26	12	7
Rock bass	0	0	0	0	0	1	0	0	0	0	0	0
Green sunfish	0	0	0	1	0	0	0	0	0	0	0	1
Pumpkinseed	0	0	0	0	0	1	0	0	0	0	0	0
Warmouth	0	0	0	0	1	0	0	0	0	0	0	0

Table A-1 Continued

Species	Location number I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Orangespotted sunfish	3	0	2	2	14	1	1	5	10	0	5	10
Bluegill	4	6	15	8	31	20	16	42	168	22	24	35
Smallmouth bass	0	0	0	0	0	0	0	[illegible]	0	2	1	4
Largemouth bass	3	2	10	9	38	11	[illegible]	[illegible]	80	[illegible]	43	59
White crappie	65	23	26	59	[illegible]	[illegible]	49	154	107	54	37	54
Black crappie	46	49	59	109	78	83	54	91	209	92	66	100
Yellow perch	0	0	0	0	0	0	0	0	7	0	2	0
Logperch	0	0	0	2	1	0	1	0	0	5	3	3
Sauger	95	42	31	67	32	26	50	25	0	93	77	23
Walleye	4	2	14	2	5	0	2	1	0	12	3	2
Drum	63	25	34	30	76	31	34	17	39	31	37	46
Total Number of Individuals	656	416	623	535	760	571	509	572	1046	590	687	555
Total Number of Species	24	24	26	28	33	30	26	22	23	[illegible]	31	29

Table A-2. Numbers of each species collected by electroshocking and wing netting at Locations Nos. 8, 10 and 13, April-July (1971 vs. 1972).

Species	Location 8 1971	8 1972	10 1971	10 1972	13 1971	13 1972
Paddlefish	0	1	0	0	0	1
Longnose gar	0	7	0	0	0	0
Shortnose gar	2	12	3	6	1	1
Bowfin	0	1	2	3	0	1
Gizzard shad	45	61	40	34	18	37
Mooneye	1	8	0	1	2	36
Grass pickerel	1	0	0	0	0	0
Northern pike	2	0	2	1	0	0
Carp	44	37	51	24	3	4
Silvery minnow	0	0	0	0	3	0
Silver chub	0	1	0	0	48	32
Golden shiner	0	2	6	11	0	0
Emerald shiner	6	39	3	0	1	19
River shiner	3	2	0	0	8	5
Spottail shiner	1	0	0	0	0	0
Fathead minnow	1	0	0	0	0	0
River carpsucker	46	39	46	33	7	7
Quillback	1	0	0	0	5	4
Smallmouth buffalo	2	14	14	10	0	0
Bigmouth buffalo	1	1	8	6	0	3
Golden redhorse	2	0	0	0	1	0
Shorthead redhorse	0	2	0	0	0	1
Black bullhead	2	7	0	1	0	1
Channel catfish	6	6	0	0	5	1
Brook silverside	0	0	2	0	0	0
White bass	3	2	0	1	23	11
Warmouth	1	0	0	9	0	1
Orangespotted sunfish	1	7	0	3	0	0
Bluegill	14	32	55	128	14	4
Largemouth bass	0	0	0	0	1	0
Smallmouth bass	0	0	0	0	1	0
White crappie	55	11	51	59	51	63
Black crappie	61	13	84	48	81	57
Logperch	0	0	0	0	1	5

Table A-2 Continued.

Species	Location 8		Location 10		Location 13	
	1971	1972	1971	1972	1971	1972
Yellow perch	0	0	1	4	0	0
Mud darter	0	0	0	2	0	0
Sauger	13	7	0	2	50	40
Walleye	1	3	0	0	3	30
Drum	26	41	10	3	21	13

Table A-2. Numbers of each species collected by electroshocking and wing netting during each sampling period at Location No. 8, April-July 1972.

Species	April I	April II	May I	May II	June I	June II	July I	July II
Paddlefish	0	0	0	1	0	0	2	0
Longnose gar	0	2	3	2	0	0	0	0
Shortnose gar	0	0	0	0	2	8	1	1
Bowfin	0	0	0	0	0	0	0	1
Gizzard shad	0	0	0	1	0	2	35	23
Mooneye	0	6	1	0	0	1	0	0
Carp	0	1	0	11	15	8	1	1
Silver chub	0	0	0	0	0	0	1	0
Golden shiner	0	0	0	0	0	1	1	0
Emerald shiner	0	0	0	0	38	0	1	0
River shiner	0	0	0	0	2	0	0	0
River carpsucker	0	0	0	4	6	4	8	17
Smallmouth buffalo	0	0	0	3	1	2	3	5
Bigmouth buffalo	0	0	0	0	1	0	0	0
Shorthead redhorse	0	0	0	0	0	2	0	0
Black bullhead	0	7	0	0	0	0	0	0
Channel catfish	0	0	0	0	0	4	2	0
White bass	0	0	1	0	0	0	0	1
Pumpkinseed	0	0	0	0	0	0	1	0
Orangespotted sunfish	0	0	0	0	5	1	1	0
Bluegill	0	0	0	0	10	8	11	3
Largemouth bass	0	0	0	0	1	5	6	0
White crappie	0	2	0	1	0	4	2	2
Black crappie	0	1	0	7	1	3	1	0
Sauger	0	2	0	0	1	3	1	0
Walleye	0	0	0	0	0	0	3	0
Drum	0	8	2	1	4	18	0	6

Table A-2. Numbers of each species collected by electroshocking and wing netting during each sampling period at Location No. 10, April-July 1972.

Species	April I	April II	May I	May II	June I	June II	July I	July II
Shortnose gar	0	0	0	3	1	1	1	0
Bowfin	0	0	0	1	0	2	0	0
Gizzard shad	0	0	0	1	11	4	2	11
Mooneye	0	0	1	0	0	0	0	0
Northern pike	0	0	0	0	0	1	0	0
Carp	1	4	0	6	3	6	4	0
Golden shiner	0	0	3	5	0	0	1	2
River carpsucker	0	5	0	0	9	10	8	1
Smallmouth buffalo	0	3	0	1	1	5	0	0
Bigmouth buffalo	1	1	0	0	2	2	0	0
Black bullhead	0	1	0	0	0	0	0	0
White bass	0	1	0	0	0	0	0	0
Rock bass	0	0	0	0	1	0	0	0
Pumpkinseed	0	0	0	0	0	0	2	5
Warmouth	0	0	2	0	0	1	2	4
Orangespotted sunfish	0	0	1	0	0	1	0	1
Bluegill	0	1	0	3	25	26	31	42
Largemouth bass	0	0	0	0	10	8	23	8
White crappie	3	17	6	10	10	6	7	2
Black crappie	1	10	5	4	4	5	8	10
Yellow perch	0	1	0	0	1	0	2	0
Sauger	0	0	0	0	2	0	0	0
Drum	0	3	0	0	0	0	0	0

Table A-2. Numbers of each species collected by electroshocking and wing netting during each sampling period at Location No. 13, April-July 1972.

Species	April I	April II	May I	May II	June I	June II	July I	July II
Paddlefish	0	0	1	0	0	0	0	0
Shortnose gar	0	0	0	0	0	0	1	0
Gizzard shad	0	0	0	0	0	0	16	21
Mooneye	0	23	1	0	0	0	4	7
Carp	0	0	0	2	2	0	0	0
Silver chub	0	0	0	0	10	7	4	11
Emerald shiner	0	0	0	1	1	0	8	9
River shiner	0	0	0	1	0	2	1	2
River carpsucker	0	0	0	1	4	0	1	1
Quillback	0	0	0	0	1	3	0	0
Bigmouth buffalo	0	1	1	0	0	1	0	0
Shorthead redhorse	0	0	0	0	0	1	0	0
Black bullhead	0	1	0	0	0	0	0	0
Channel catfish	0	0	0	0	0	0	0	1
White bass	0	0	0	0	0	3	1	7
Warmouth	0	0	0	0	0	1	0	0
Bluegill	0	0	0	0	0	0	0	4
Largemouth bass	0	0	0	0	3	0	1	0
White crappie	0	0	13	19	0	9	0	22
Black crappie	0	0	3	6	0	15	0	33
Logperch	0	0	0	3	1	0	0	1
Sauger	0	0	0	3	19	2	0	13
Walleye	0	0	0	0	0	0	6	24
Drum	0	4	0	0	3	1	1	7

Table A-2. Numbers of each species collected by electroshocking and wing netting at each sampling location, April-July 1972.

Species	Sampling Location 1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Paddlefish	1	0	0	1	0	0	0	1	0	0	0	0	1	4
Longnose gar	0	0	0	2	1	1	0	7	0	0	0	0	0	11
Shortnose gar	1	0	11	4	1	4	0	12	2	6	0	1	1	43
Bowfin	0	6	2	5	0	6	0	1	1	3	0	2	1	27
Gizzard shad	41	19	0	47	17	28	9	61	1	34	43	10	37	347
Mooneye	4	2	0	5	6	14	7	8	17	1	7	5	36	112
Northern pike	1	0	0	0	2	3	0	0	0	1	0	0	0	7
Carp	17	40	41	47	14	25	2	37	35	24	20	34	4	340
Silver chub	36	7	0	0	18	0	0	1	2	0	12	0	32	180
Golden shiner	0	0	5	2	1	0	0	2	0	11	1	1	0	23
Emerald shiner	8	10	0	2	5	2	13	39	3	0	17	2	19	120
River shiner	6	2	0	0	12	0	0	2	1	0	2	2	6	33
Spotfin shiner	0	1	0	0	0	0	0	0	0	0	0	0	0	1
River carpsucker	25	20	31	42	26	2	4	39	16	33	19	24	7	288
Quillback	0	0	0	0	2	1	0	0	0	0	0	1	4	8
White sucker	25	20	31	42	26	2	4	39	16	33	19	24	7	288
Blue sucker	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Smallmouth buffalo	5	6	17	7	0	1	1	14	9	10	2	3	0	75
Bigmouth buffalo	1	4	7	2	2	1	0	1	0	6	0	0	2	26
Spotted sucker	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Golden redhorse	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Shorthead redhorse	13	0	0	1	4	0	1	2	2	0	3	0	2	28
Black bullhead	2	0	4	1	0	0	0	7	0	1	0	1	1	17
Channel catfish	2	7	1	4	4	12	8	6	7	0	0	3	1	55
Flathead catfish	0	0	0	0	0	1	0	0	1	0	1	0	0	3
White bass	13	4	0	7	3	6	3	2	2	1	1	2	11	55
Rock bass	0	1	0	0	0	0	0	0	0	1	0	0	0	2
Green sunfish	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Pumpkinseed	0	0	1	1	0	0	0	1	0	7	0	3	0	13
Warmouth	0	0	0	0	0	0	0	0	0	9	0	0	1	10
Orangespotted sunfish	2	2	6	0	0	0	0	7	4	3	0	9	0	33
Bluegill	7	29	81	2	7	32	4	32	15	128	26	70	4	437
Smallmouth bass	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Largemouth bass	6	8	19	5	9	14	2	12	8	49	9	14	4	159

Table A-2 Continued.

Species	Sampling Location 1	2	3	4	5	6	7	8	9	10	11	12	13	Total
White crappie	20	13	18	19	6	10	4	11	23	53	15	61	63	316
Black crappie	18	8	21	10	4	29	1	13	18	48	18	34	57	279
Mud darter	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Yellow perch	0	0	1	0	0	0	0	0	0	4	0	0	0	5
Logperch	4	1	0	0	1	0	0	0	1	0	0	0	4	11
Sauger	41	14	0	9	40	0	5	7	7	2	22	3	40	190
Walleye	9	3	0	1	12	1	0	3	3	0	7	1	30	70
Drum	121	35	11	89	18	6	2	41	39	4	11	9	13	399
Total no. of species	25	23	18	24	26	22	17	27	23	24	19	23	25	
Total no. of fish	404	242	278	315	218	200	68	369	217	441	236	295	381	

Table A-3. Catch per unit of effort (fish collected per hour of electroshocking) of each species at each sampling location, with sampling locations grouped by habitat type, August-November 1972.

Species	Habitat Group and Sampling Locations: A[a]			B[b]		C[c]		D[d]		E[e]		F[f]
	1	5	13	4	9	2	11	3	10	8	12	6
Longnose gar	0.9	1.3	-[g]	-	-	-	0.4	-	-	1.7	-	1.7
Shortnose gar	-	-	-	-	-	0.4	-	-	0.9	0.9	0.4	2.6
Bowfin	-	-	-	-	0.4	0.9	-	2.1	1.3	0.9	0.4	0.9
Gizzard shad	8.1	4.3	7.7	12.9	17.1	3.4	21.4	37.7	38.6	23.1	21.4	6.4
Mooneye	15.6	8.6	15.6	7.3	8.6	5.6	2.6	-	0.9	1.7	2.6	10.7
Grass pickerel	-	-	-	-	0.4	-	-	-	-	0.4	0.4	-
Northern pike	0.4	-	-	-	-	0.9	-	-	-	2.6	0.9	2.1
Carp	1.7	0.9	0.9	23.1	23.1	11.1	16.7	12.4	9.4	10.3	5.6	5.1
Silver chub	12.4	13.3	5.6	0.9	-	0.4	1.3	-	-	0.4	-	3.4
Golden shiner	-	-	-	-	-	-	-	1.3	4.3	-	-	-
Emerald shiner	0.9	0.4	-	-	0.9	4.3	1.3	0.9	-	1.7	1.3	0.9
River shiner	3.0	1.7	3.0	-	-	0.4	1.3	-	-	-	-	-
Spottail shiner	-	-	-	-	-	-	-	-	-	0.4	-	-
Spotfin shiner	-	-	-	-	-	-	-	-	-	0.9	-	0.4
River carpsucker	6.9	3.9	3.4	18.4	9.0	10.3	3.0	27.0	20.6	12.4	14.6	0.9
Quillback	-	-	-	-	-	-	-	0.4	-	-	-	0.4
Smallmouth buffalo	-	-	-	3.0	4.7	6.4	0.4	2.6	5.1	1.3	0.9	0.9
Bigmouth buffalo	0.4	-	-	1.3	1.7	5.6	1.3	0.9	0.9	-	0.4	-
Shorthead redhorse	0.4	0.9	-	0.9	-	-	0.4	-	-	0.9	0.9	-
Channel catfish	1.3	0.4	-	1.3	3.9	-	1.3	0.4	0.4	-	0.9	4.3
Flathead catfish	-	-	-	-	-	-	0.4	-	-	-	-	-
Brook silverside	-	-	-	-	-	-	-	-	0.4	0.4	0.4	-
White bass	4.3	6.9	2.1	3.0	0.4	3.4	1.3	0.4	-	0.9	0.4	7.3
Green sunfish	-	-	-	-	-	-	-	-	-	-	-	1.3
Pumpkinseed	-	-	-	-	-	-	-	1.7	2.1	0.4	-	0.4
Warmouth	0.4	-	-	-	-	-	-	0.4	4.7	-	0.9	0.4
Orangespotted sunfish	-	-	-	0.4	0.4	0.4	0.4	3.0	1.7	4.3	4.3	0.4
Bluegill	0.4	0.4	0.4	2.6	4.3	3.4	2.6	81.4	86.6	7.3	16.3	17.2
Smallmouth bass	0.4	-	-	-	-	-	-	-	-	-	-	-
Largemouth bass	-	0.4	1.3	0.9	1.7	1.3	2.6	12.0	16.7	8.6	5.6	4.7
White crappie	0.9	0.4	0.4	3.9	4.7	2.1	1.3	18.0	20.6	15.0	29.6	8.6
Black crappie	2.6	0.4	0.9	2.1	6.9	6.0	3.9	18.4	32.1	5.1	3.0	11.7
Yellow perch	-	-	-	-	-	-	-	-	1.3	0.4	-	-
Logperch	1.3	0.9	0.9	-	-	-	0.4	-	-	-	-	-
Sauger	13.7	6.0	9.0	1.3	2.1	3.0	2.6	2.6	0.4	11.6	2.6	2.6
Walleye	3.4	0.9	0.9	0.4	-	1.3	0.9	0.4	-	0.4	-	2.1
Drum	4.3	8.6	11.1	5.6	11.6	4.3	6.0	2.6	1.7	3.4	3.4	1.7
No. of Species	22	19	15	18	18	21	23	21	21	27	23	26
No. of Individuals	194	141	147	208	238	175	172	529	585	274	273	231

a Sand and gravel beach habitat along the main channel.
b Main channel border habitat other than sand and gravel beaches.
c Side channel habitat.
d Slough habitat.
e Slough-like habitat, but also has characteristics of other habitats.
f Station intake canal.
g No fish collected.

Table A-4. Average catch per unit of effort (number of fish collected per hour) of each species collected by electroshocking near the Quad-Cities Station, April-July 1973.

	Habitat Groups and Sampling Locations												
	A[a]			B[b]		C[c]		D[d]		E[e]		F[f]	
	1	5	13	4	9	2	11	3	10	8	12	6	mean
Paddlefish	0.4	0	0	0	0	0	0	1.1	0	0	0	0	0.12
Longnose gar	1.1	0.4	0	0.7	0	0.4	0.4	0.7	0	1.5	0.7	1.1	0.58
Shortnose gar	0	0	0	1.5	0	0	0	1.5	0.4	0	0	0	0.28
Bowfin	0.4	0.4	0	1.5	1.5	0.4	0	3.0	0.7	0	1.5	3.4	1.07
Gizzard shad	25.1	18.4	12.4	6.7	5.6	24.4	13.1	21.4	14.2	23.6	3.7	14.2	15.23
Mooneye	1.5	1.9	0	3.7	1.1	1.9	0	1.1	0.4	1.9	0.4	11.6	2.12
Brown trout	0	0	0	0	0	0	0	0	0	0	0	0.4	0.03
Grass pickerel	0	0	0	0	0	0	0	0	0	0.4	0	0	0.03
Northern pike	0	0.4	0	0.4	0.4	0	0	0.4	0.4	1.1	0	1.9	0.42
Carp	11.6	11.2	8.2	15.7	4.9	9.0	3.7	12.4	17.6	13.5	9.0	11.2	10.67
Silver chub	0	1.5	0.4	0	0	0	0	0	0	0.4	0	0	0.19
Golden shiner	0.4	0	0.7	0.4	0	0	0	1.1	3.7	0.4	0.4	0.7	0.65
Emerald shiner	0	1.1	0	0	0	0.4	0.4	0	0	0.7	0	2.2	0.40
River shiner	0.4	0	0	0	1.1	0	0.7	0	0	0.4	0	0	0.22
Spottail shiner	0	0	0	0	0	0	0	0	0	0.4	0.4	0	0.06
Bullhead minnow	0	0	0	0	0	0	0	0	0	0.4	0	0	0.03
River carpsucker	1.1	1.9	3.7	13.1	3.7	3.4	0	3.4	3.0	4.1	5.2	0	3.55
Highfin carpsucker	0	0	0	0	0.4	0	0	0	0	0.4	0	0.7	0.65
Smallmouth buffalo	0.4	2.6	1.1	4.9	3.7	1.1	1.1	5.6	2.6	1.1	1.9	1.9	2.33
Bigmouth buffalo	3.7	4.5	0	2.2	0.7	1.9	0.7	6.4	6.0	0.7	0.4	0.7	2.32
Spotted sucker	0.4	0	0	0	0	0	0	0	0.4	0	0	0	0.06
Silver redhorse	0	0.4	0.4	0.4	0	0	0	0	0	0	0	0	0.10

Table A-4 Continued.

	Habitat Groups and Sampling Locations												
	A[a]			B[b]		C[c]		D[d]		E[e]		F[f]	
	1	5	13	4	9	2	11	3	10	8	12	6	mean
Shorthead redhorse	1.5	3.4	1.5	0	0	0.4	0.4	0	1.1	5.6	0.4	0	1.19
Black bullhead	0.4	0	0	0	0	0	0	0.4	0	0	0	0	0.06
Channel catfish	0	0.7	0	0.4	1.1	0.7	0	0	0	3.4	1.1	0.4	6.65
Flathead catfish	0	0	0	0	0	0	0.4	0	0	0	0	0	0.03
Brook silverside	0	0	0	0	0	0	0	0	1.5	0	0	0	0.12
White bass	1.9	1.1	0.4	1.5	0.4	0	0	0	0	0.7	0	1.1	0.59
Yellow bass	0.7	0	0	0.4	0	0	0	0	0	0.4	0	0	0.12
Rock bass	0	0	0	0	0	0	0	0	0	0	0	1.9	0.16
Green sunfish	0	0	0	0	0	0	0	0	0	0	0	0.4	0.03
Pumpkinseed	0	0	0	0	0	0	0	0	0.7	0	0	1.5	0.18
Warmouth	0	0	0	0	0	0	0	0.7	4.9	0	0	1.9	0.62
Orangespotted sunfish	1.1	0.4	0	0.4	0	0.7	0	2.6	4.1	0.4	0.4	7.5	1.47
Bluegill	2.6	3.7	2.2	5.6	4.9	18.4	1.9	20.6	43.9	12.0	18.4	30.7	13.74
Largemouth bass	2.6	2.6	0.7	4.1	2.2	1.5	4.9	1.9	16.9	4.5	4.5	7.5	4.49
White crappie	1.9	1.9	0	1.9	2.2	4.1	0.4	1.1	9.0	3.0	9.4	4.9	3.32
Black crappie	1.1	2.6	1.1	2.2	3.7	1.9	1.1	2.6	7.9	10.1	3.0	14.6	4.32
Logperch	0.4	0	0.4	0	0	0	0	0	0	0	0	0	0.06
Sauger	7.9	9.0	5.2	2.6	0.7	3.4	0.4	0	0.4	4.1	0.4	0.7	2.90

Table A-5. Catch per unit of effort (number of fishes collected per hour) and relative abundance of each species collected by electroshocking at each sampling location near Quad-Cities Station, August-November 1973.

Species	2	11	3	10	4	5	8	9	13	6[a]	No. of Fish	Relative Abundance (% of total catch)	Avr. No.
Longnose gar	0	0	0	0	0.4	0.4	0	0.4	0	0.5	4	-[b]	0.2
Shortnose gar	0	0	0.4	0	0	0	0	0	0	1.0	3	-	0.1
Bowfin	0	0	4.9	1.9	0.8	0	0	1.1	0	4.0	31	1	1.3
Gizzard shad	25.5	24.4	55.9	40.9	55.5	39.4	35.6	34.1	18.0	24.5	927	28	35.4
Mooneye	0	0.4	0	0	0	0	0	0	0.4	1.0	3	-	0.2
Grass pickerel	0	0	0	0	0	0	1.1	0	0.8	0	5	-	0.2
Northern pike	0.4	0	0	0.4	0.4	0	0.8	0	0	1.5	8	-	0.4
Carp	14.3	13.1	49.5	13.1	14.3	12.8	9.0	15.4	0.4	7.5	393	12	14.9
River carpsucker	3.4	0.4	4.9	3.4	16.5	2.6	1.9	6.8	0.4	0	107	3	4.0
Quillback carpsucker	0	0	0	0	0	0	0	0	0	0.5	1	-	0.1
Smallmouth buffalo	0.8	0	10.5	4.1	2.3	4.9	0.8	0.4	0	0	64	2	2.4
Bigmouth buffalo	7.1	0	11.3	2.3	0.8	1.1	0	0	0	0.5	61	2	2.3
Spotted sucker	0	0	0	0	0	0	0.4	0.4	0	0	2	-	0.1
Silver redhorse	0	0	0	0	0.4	0.8	0.8	0	0	0	5	-	0.2
Shorthead redhorse	1.1	0.4	0	0	3.4	1.9	1.1	0	0	0	21	1	0.8
Black bullhead	0	0	1.1	0.4	0	0.4	0	0	0	0	5	-	0.2
Channel catfish	1.9	1.1	0	0.4	3.8	2.3	2.6	10.9	0	0	61	2	2.3
Flathead catfish	0	0	0	0	0.8	0	0.4	0	0	0	3	-	0.2
White bass	2.6	1.5	1.5	0.4	1.9	2.3	0	0.8	0.4	14.0	58	2	2.5
Yellow bass	0.4	0	0	0	0	0	0	0	0	0.5	2	-	0.1
Green sunfish	0	0	0	0.4	0	0	0.8	0	0	3.0	9	-	0.4
Pumkinseed	0	0	0	1.9	0	0	0	0	0	0.5	6	-	0.2
Warmouth	0	0	2.3	5.6	0	0	0	0	0	1.5	24	1	0.9
Orangespotted sunfish	0.4	0	0.4	1.1	0.4	0.8	1.1	0	0.4	4.0	20	1	0.9
Bluegill	22.5	10.9	39.0	123.8	13.5	0.8	14.3	5.6	6.0	39.5	709	21	27.6
Smallmouth bass	0	0.4	0	0	0	0	0	0	0.4	0	2	-	0.1
Largemouth bass	4.5	7.1	13.5	19.1	10.9	3.8	12.8	8.6	3.8	27.0	278	8	11.1
White crappie	4.5	4.1	13.5	19.9	6.4	2.6	4.1	5.6	0	3.5	169	5	6.4
Black crappie	15.8	6.0	14.6	15.8	6.8	0.4	2.6	5.3	0.8	12.5	206	6	8.0
Yellow perch	0	0	0	0.4	0	0	0	0	0	0	1	-	-
Logperch	0	0	0	0	0	0.4	0	0	0	0	1	-	-
Sauger	0.4	0.4	0	0	1.1	3.4	0.4	0.8	0.4	0	18	1	0.7
Walleye	0.8	0.8	0	0	0	1.1	0	0	0.4	0	8	-	0.3

Table A-5 . Continued.

Species	2	11	3	10	4	5	8	9	13	6[a]	No. of Fish	Relative Abundance (% of total catch)	Avr. No.
Freshwater drum	2.6	2.3	3.8	6.4	3.4	9.8	5.3	4.1	1.1	2.5	108	3	4.1
No. of species	18	15	16	20	20	20	19	15	14	20	34		
No. of fishes	290	195	605	697	382	244	255	267	89	299	3323		
Total catch/hour	108.8	73.1	226.9	261.4	143.3	91.5	95.6	100.1	33.4	149.5	128.4		
Relative Abundance (%)	9	6	18	21.	11	7	8	6	3	9			

[a] Location not sampled Oct[illegible] 22-24 and November 5-6.
[b] Less than 1%.

Table A-6. Relative abundance of fish collected at the mid-channel trawling locations (April - December 1971)

Species	Upstream from the station	At the station	Downstream from the station	Total
Shovelnose sturgeon	5	6	5	16
Gizzard shad	1	2	2	5
Mooneye	3	1	3	7
Carp	0	3	0	3
Silvery minnow	0	1	[illegible]	2
Silver chub	40	10	[illegible]	57
Emerald shiner	5	0	2	7
River shiner	0	0	1	1
Silver redhorse	1	0	0	1
Shorthead redhorse	0	1	1	1
Channel catfish	316	114	91	521
Stonecat	1	3	1	5
Tadpole madtom	0	0	1	1
Flathead catfish	0	1	1	2
White bass	0	1	0	1
Orangespotted sunfish	0	1	0	1
Black crappie	0	1	0	1
Sauger	2	0	1	3
Walleye	1	0	0	1
Drum	25	14	9	48
Total Number of Individuals	400	159	126	685
Total Number of Species	11	14	14	20

Table A-7. Numbers of each species collected by mid-channel bottom trawling at each location, April-July (1971 vs. 1972).

Species	Upstream from station		Adjacent to station		Downstream from station	
	1971	1972	1971	1972	1971	1972
Shovelnose sturgeon	2	5	1	2	1	2
Carp	0	2	1	1	0	0
Silvery minnow	0	2	1	1	0	0
Silver chub	8	2	1	1	0	0
Emerald shiner	5	0	0	1	2	1
River shiner	0	1	0	2	0	1
River carpsucker	0	0	0	1	0	0
Channel catfish	202	151	41	57	37	445
Stonecat	1	1	1	3	0	0
Flathead catfish	0	0	1	0	0	0
White bass	0	0	0	1	0	0
Walleye	1	0	0	0	0	0
Drum	17	22	8	14	3	97
Total no. of species	7	8	8	11	4	5
Total no. of fish	242	185	55	84	43	546

Table A-8. Comparison of average numbers of fish collected per seven minute tow at each location sampled by mid-channel bottom trawling during August-November (1971 vs. 1972).

Species	Location 1T		Location 6T		Location 13T	
	1971	1972	1971	1972	1971	1972
Shovelnose sturgeon	0.4	*[a]	0.6	0.3	0.5	0.1
Gizzard shad	0.1	-[b]	0.3	0.4	0.4	-
Mooneye	-	*	-	-	-	0.1
Carp	-	-	0.1	-	-	-
Speckled chub	-	*	-	*	-	*
Silver chub	1.5	*	1.1	*	0.6	*
Emerald shiner	-	-	-	*	-	*
River carpsucker	-	-	-	-	-	*
Silver redhorse	0.1	*	-	-	-	-
Channel catfish	13.4	4.6	9.1	3.0	6.5	7.9
Stonecat	-	0.2	0.7	-	-	0.1
Flathead catfish	-	-	-	*	0.1	-
White bass	-	*	0.1	-	-	-
Sauger	-	-	-	-	-	*
Drum	0.9	*	0.7	*	0.7	0.2

[a] Less than 0.1 fish collected per tow.

[b] Not collected.

Table A-9. Catch per unit of effort (fish collected per seven minute tow) of fish collected at each mid-channel sampling location by bottom trawling near the Quad-Cities Station April-July 1971, 1972, and 1973.

	Sampling Locations									
	1T			6T			13T			
	1971	1972	1973	1971	1972	1973	1971	1972	1973	mean
Shovelnose sturgeon	0.5	0.3	0	0.2	0.1	0.5	0.2	0.1	0.2	0.2
Carp	0	0.1	0.1	0.2	0.1	0.2	0	0	0	0.1
Silvery minnow	0	0.1	0	0.2	0.1	0	0	0	0	-[a]
Silver chub	2.0	0.1	0.2	0.2	0.1	0	0	0	0	0.3
Emerald shiner	1.2	0	0	0	0.1	0	0.5	0.1	0	0.2
River shiner	0	0.1	0	0	0.1	0	0	0.1	0	-
River carpsucker	0	0	0	0	0.1	0	0	0	0	-
Channel catfish	50.5	10.8	6.5	10.2	4.1	7.7	9.2	31.8	8.7	15.5
Stonecat	0.2	0.1	0.1	0.2	0.2	0.1	0	0	0	0.1
Flathead catfish	0	0	0.1	0.2	0	0	0	0	0.1	-
White bass	0	0	0	0	0.1	0	0	0	0	-
White crappie	0	0	0	0	0	0.1	0	0	0	-

Table A-9 Continued.

	Sampling Locations									
	IT			6T			13T			
	1971	1972	1973	1971	1972	1973	1971	1972	1973	mean
Walleye	0.2	0	0	0	0	0	0	0	0	-
Drum	4.2	1.6	1.4	2.0	1.0	1.1	0.7	6.9	1.2	2.2
No. of species	7	8	6	8	11	6	4	5	4	
Total fish per tow	58.8	13.2	8.4	13.4	6.1	9.7	10.6	39.0	10.2	18.8

[a] Less than 0.1 fish/tow.

Table A-10. Catch per unit of effort (number of fishes collected per hour) and relative abundance of each species collected by bottom trawling at each sampling location near Quad-Cities Station, August-November 1973.

Species	Location 1T	Location 6T	Location 13T	Average Catch/Hour	Relative Abundance (% of total catch)
Shovelnose sturgeon	5.4	13.9	6.4	8.6	3
Gizzard shad	0	9.6	0.5	3.4	1
Mooneye	0	1.1	0	0.4	-[a]
Carp	2.7	0.5	0.5	1.2	-
Speckled chub	2.1	2.1	1.6	1.9	1
Silver chub	17.1	7.0	1.1	8.4	3
River shiner	13.9	6.4	2.7	7.7	3
River carpsucker	0.5	0.5	0	0.3	-
Channel catfish	177.3	245.9	133.4	185.5	72
Stonecat	4.3	1.6	1.1	2.3	1
Flathead catfish	0.5	0	0	0.2	-
White bass	0.5	0	0	0.2	-
Bluegill	0	0	0.5	0.2	-
White crappie	0	0	0.5	0.2	-
Sauger	0.5	0	0	0.2	-
Freshwater drum	25.7	58.4	29.5	37.9	15
				Total No.	
Total No. Fishes	468	648	332	1448	
Total No. Species	12	11	11	16	
				Average	
Fishes/Hour	250.7	347.1	177.9	258.6	
Relative Abundance	32%	45%	23%		

[a] Less than 1%.

Table A-11. Relative abundance of fish collected by minnow seining at each sampling location (April - December 1971)

Species	Location number						
	I	II	IV	V	VII	VIII	X
Longnose gar	0	1	1	1	0	0	0
Skipjack herring	0	0	0	0	1	0	0
Gizzard shad	6	4	10	12	2	26	6
Mooneye	4	21	1	0	1	0	11
Carp	0	6	0	1	0	6	0
Silvery minnow	0	1	0	9	0	16	2
Speckled chub	1	0	0	0	3	0	0
Silver chub	62	12	66	78	32	100	28
Golden shiner	0	0	0	1	0	0	0
Emerald shiner	105	136	59	220	54	109	39
River shiner	179	223	298	767	95	597	171
Ghost shiner	0	0	0	1	0	0	0
Spottail shiner	2	6	9	49	11	49	1
Spotfin shiner	1	2	2	267	4	32	4
Bluntnose minnow	0	0	0	0	1	0	0
Bullhead minnow	0	0	0	41	3	80	1
River carpsucker	0	1	5	23	0	54	0
Quillback	0	0	1	2	0	0	0
Smallmouth buffalo	0	0	0	0	0	1	1
Channel catfish	12	1	6	4	19	1	28
Brook silverside	0	0	0	1	0	25	0
White bass	3	59	10	9	6	1	4
Green sunfish	0	0	1	0	0	2	0
Orangespotted sunfish	0	0	3	3	0	16	1
Bluegill	8	0	1	134	3	80	0
Smallmouth bass	0	0	1	0	3	1	0
Largemouth bass	0	0	0	18	0	14	0
White crappie	1	3	4	4	1	26	2
Black crappie	0	1	1	1	0	16	0
Western sand darter	0	1	0	0	0	0	0
Johnny darter	3	0	1	6	7	1	0
Yellow perch	0	0	0	1	0	1	0
Logperch	3	0	14	1	3	0	2
River darter	5	0	2	0	1	0	0
Sauger	3	5	4	0	3	2	1
Walleye	4	3	0	5	0	4	2
Drum	23	3	6	11	0	10	0
Total Number of Individuals	419	483	500	1655	247	1244	298
Total Number of Species	18	19	23	27	20	26	17

Table A-12. Numbers of each species collected by shoreline seining at each location, May-July 1972.

Species	Sampling Location 1	5	8	11	12	13	Total
Longnose gar	0	0	1	0	0	0	1
Gizzard shad	3	6	103	7	7	1	127
Mooneye	3	4	0	1	0	14	22
Carp	1	0	0	0	0	0	1
Silvery minnow	2	5	327	40	6	0	380
Silver chub	26	20	179	98	120	44	487
Golden shiner	1	0	4	1	0	3	9
Emerald shiner	114	142	370	245	43	141	1055
River shiner	86	55	613	124	36	68	982
Spottail shiner	14	13	255	7	41	32	362
Spotfin shiner	1	0	207	19	14	1	242
Ghost shiner	0	0	0	0	1	0	1
Southern redbelly dace	0	0	1	0	0	0	1
Bluntnose minnow	0	0	1	1	18	0	20
Fathead minnow	1	0	1	0	0	0	2
Bullhead minnow	0	0	2	1	51	0	54
Pearl dace	0	0	1	0	0	0	1
River carpsucker	1	1	267	4	99	0	372
Blue sucker	0	0	1	0	0	0	1
Smallmouth buffalo	0	0	162	0	1	0	163
Bigmouth buffalo	0	1	936	0	8	10	955
Shorthead redhorse	0	0	0	0	0	1	1
Channel catfish	0	0	0	2	0	1	3
Tadpole madtom	1	0	0	0	0	0	1
White bass	7	27	3	2	12	33	84
Green sunfish	1	0	0	0	0	0	1
Orangespotted sunfish	0	0	5	0	24	0	29
Bluegill	1	3	28	0	16	1	49
Largemouth bass	0	0	21	0	10	1	32
White crappie	3	22	1	0	36	4	66
Black crappie	0	5	1	1	24	0	31
Johnny darter	0	0	1	0	1	0	2
Yellow perch	0	1	1	0	0	0	2
Logperch	2	0	1	0	0	2	5

Table A-12 Continued.

Species	Sampling Location 1	5	8	11	12	13	Total
River darter	1	1	0	0	0	1	3
Sauger	3	2	4	6	11	0	26
Walleye	1	2	2	6	3	6	20
Drum	0	3	6	4	2	0	15
Total no. of species	21	18	30	18	23	18	
Total no. of fish	273	313	3505	569	584	364	

Table 4-13. Numbers of each fish species collected by shoreline seining at each location sampled. August-November 1972.

Species	Sampling Locations 1	5	8	11	12	13	Total
Gizzard shad	1	3	27	2	1	0	34
Skipjack herring	0	1	0	0	0	0	1
Mooneye	9	5	1	0	2	25	42
Silvery minnow	4	1	59	7	0	3	74
Speckled chub	1	0	0	0	0	0	1
Silver chub	21	70	18	12	5	49	175
Emerald shiner	45	74	102	38	33	80	372
River shiner	24	62	117	22	11	33	269
Spottail shiner	3	18	78	0	19	2	120
Spotfin shiner	0	0	6	2	1	0	9
Bullhead minnow	0	2	64	2	57	0	125
River carpsucker	0	1	1	1	1	0	4
Smallmouth buffalo	0	0	1	0	0	0	1
Silver redhorse	0	0	1	0	0	0	1
Shorthead redhorse	0	0	1	0	0	0	1
Channel catfish	0	0	3	0	0	1	4
Tadpole madtom	0	0	0	0	1	0	1
Brook silverside	0	0	5	0	2	0	7
White bass	0	1	1	0	1	5	8
Orangespotted sunfish	0	0	6	0	94	1	101
Bluegill	4	4	82	1	40	1	132
Largemouth bass	2	0	16	0	7	0	25
White crappie	0	4	2	0	11	0	17
Black crappie	1	2	10	0	3	0	16
Johnny darter	1	1	4	0	12	0	16
Slenderhead darter	1	1	0	0	0	0	2
River darter	4	0	1	0	0	0	5

Table A-14. Relative abundance (percent of total catch) of each fish species collected at each sampling location by shoreline seining, June and July 1973.

Species	Sampling Locations					
	1	5	8	11	12	13
Longnose gar	0	0	0.4	1.1	0.4	0
Shortnose gar	0	0	0	0	0.7	0
Gizzard shad	51.3	38.3	45.1	16.6	13.4	33.2
Mooneye	0	0	0.1	3.2	0	2.9
Grass pickerel	0	0	0	0	0.4	0
Northern pike	0	0	0.1	0	0	0
Carp	0.3	0	0.8	0.5	4.5	0.4
Silver chub	10.1	3.1	4.8	14.4	11.6	5.7
Golden shiner	0	0.8	2.6	1.1	0	0
Emerald shiner	4.1	28.1	0.9	11.2	1.9	34.8
River shiner	1.6	0.8	6.0	15.5	0.7	2.9
Pugnose minnow	0	0	0	0	0	0.4
Spottail shiner	0	1.6	0.8	11.8	1.1	1.6
Spotfin shiner	1.6	0	1.3	0.5	0	0
Suckermouth minnow	0.3	0.8	0	0.5	0	0
Fathead minnow	0	0	0.1	0	0	0
Bullhead minnow	0.3	0	2.6	4.8	6.3	0
River carpsucker	0	0	4.1	0.5	11.6	0
Smallmouth buffalo	0	0	0.4	0	0.4	0
Bigmouth buffalo	0.9	0.8	0.5	0	0.7	0
Silver redhorse	0	0	0.8	0	0	0
Shorthead redhorse	2.8	0.8	0.3	0	0	1.6
Brook silverside	0	0	0.5	0	0.4	0.4
White bass	5.4	2.3	0.7	1.6	0	4.1
Orangespotted sunfish	0	0	0.4	0	3.0	0
Bluegill	7.0	2.3	14.7	1.1	23.9	3.7
Largemouth bass	0.6	0.8	7.2	0.5	7.5	0.8
White crappie	11.1	12.5	1.5	1.6	2.6	3.3
Black crappie	1.3	7.0	2.0	0.5	1.9	3.3
Johnny darter	0	0	0	2.1	0.4	0
Logperch	0.3	0	0.1	1.1	0	0.8
River darter	0.6	0	0.3	0	0	0
Stizostedion spp.	0	0	0.1	0.5	0	0
Sauger	0	0	0.1	0	0.7	0
Drum	0.3	0	0.4	9.1	6.0	0
No. of species	18	14	30	22	22	16
Total No. of fish	316	128	753	187	268	244

Table A-15. Number and relative abundance of each species collected at each location by shoreline seining near Quad-Cities Station during August-November 1973.

Species	Station 5		Station 8		Station 11		Station 13		Total No. of Fish	Relative Abundance (% of total catch)
	No. of Fish	Relative Abundance (%)	No. of Fish	Relative Abundance (%)	No. of Fish	Relative Abundance (%)	No. of Fish	Relative Abundance (%)		
Longnose gar	0		0		1	-	0		1	-[a]
Gizzard shad	69	14	407	35	19	4	36	7	531	20
Northern pike	1	-[a]	0		0		0		1	-
Carp	4	1	1	-	3	1	0		8	-
Speckled chub	0		0		1	-	0		1	-
Silver chub	67	14	59	5	87	19	12	2	225	9
Golden shiner	6	1	10	1	0		0		16	1
Emerald shiner	152	31	156	14	148	32	394	78	850	32
River shiner	36	7	152	13	75	16	37	7	300	11
Spottail shiner	20	4	16	1	27	6	5	1	68	3
Spotfin shiner	0		9	1	1	-	0		10	-
Sand shiner	0		2	-	0		0		2	-
Suckermouth minnow	0		1	-	1	-	0		2	-
Bluntnose minnow	0		14	1	0		0		14	1
Bullhead minnow	0		54	5	4	1	2	-	60	2
River carpsucker	0		12	1	6	1	0		18	1
Smallmouth buffalo	1	-	0		0		0		1	-
Bigmouth buffalo	1	-	1	-	0		0		2	-
Silver redhorse	1	-	0		0		0		1	-
Black bullhead	108	22	0		0		0		108	4
Channel catfish	2	-	0		53	11	1	-	56	2
Tadpole madtom	0		0		1	-	0		1	-
Brook silverside	0		77	7	0		1	-	78	3
White bass	3	1	0		5	1	0		8	-
Green sunfish	0		0		0		1	-	1	-
Bluegill	5	1	117	10	5	1	4	1	131	5
Largemouth bass	9	2	22	2	2	-	2	-	35	1

T[redacted]e A-[redacted] Co[redacted]ue[redacted]

Species	Station 5 No. of Fish	Station 5 Relative Abundance (%)	Station 8 No. of Fish	Station 8 Relative Abundance (%)	Station 11 No. of Fish	Station 11 Relative Abundance (%)	Station 13 No. of Fish	Station 13 Relative Abundance (%)	Total No. of Fish	Relative Abundance (% of total catch)
White crappie	2	-	20	2	4	1	1	-	27	1
Black crappie	0		23	2	5	1	0		28	1
Johnny darter	1	-	1	-	4	1	1	-	7	1
Logperch	1	-	0		0		4	1	5	-
River darter	3	-	0		0		0		3	-
Sauger	0		0		2	-	0		2	-
Freshwater drum	1	-	0		13	3	1	-	15	1
Total	493		1154		467		502		2616	
Number of Species	21		20		22		15		34	
Relative Total Abundance (%)		19		44		18		19		

[a] Less than 1%.

Table A-16. Summary of the number of fish marked and subsequently recaptured (September - December 1971).

Location No.	Marking technique: Fin clips	Marking technique: Anchor tags	Recaptures: Fin clips	Recaptures: Anchor tags	Percent recapture
I	68	3	1	0	1.4
II	58	0	3	0	5.2
III	175	17	0	1	0.5
IV	0	0	0	0	0.0
V	137	5	8	0	5.6
VI	143	2	1	0	0.7
VII	127	1	4	0	3.1
VIII	162	16	7	0	3.9
IX	210	23	7	2	3.9
X	71	0	1	0	1.4
XI	75	12	1	0	1.1
XII	86	16	0	0	0.0
Totals	1312	95	33	3	2.6

Table A-17. Locations and dates of mark and recapture of fish recovered, April-July 1972.

Species	Marked		Recaptured	
	Location[a]	Date	Location	Date
Smallmouth buffalo	river mile 5060	1971	8	5/16/72
River carpsucker	downstream from station	1971	12	6/21/72
River carpsucker	downstream from station	1971	10	6/21/72
Bluegill	10	11/19/71	10	6/ 9/72
Bluegill	3	6 20/72	3	[illegible]/72
Bluegill	12	6/7/72	12	[illegible]/72
Largemouth bass	11	6/7/72	11	6/8/72
Largemouth bass	downstream from station	1971	10	7/12/72
Largemouth bass	6	7/13/72	6	7/27/72
Largemouth bass	9	6/6/72	9	7/18/72
White crappie	10	11/3/71	10	5/3/72
White crappie	downstream from station	1971	12	6/7/72
White crappie	12	6/16/72	12	6/21/72
White crappie	11	6/21/72	11	7/12/72
White crappie	12	7/12/72	12	7/26/72
White crappie	12	6/7/72	12	7/26/72
White crappie	12	6/16/72	12	7/26/72
White crappie	2	6/21/72	12	7/26/72
Black crappie	downstream from station	1971	4	7/26/72
Black crappie	9	6/6/72	10	4/18/72
Black crappie	11	7/12/72	9	6/21/72
Sauger	downstream from station	1971	1	6/6/72
Sauger	downstream from station	1971	5	6/17/72
Sauger	[illegible]	6/6/72	1	6/20/72
Sauger	[illegible]	6/20/72	1	6/22/72
Sauger	1	6/20/72	1	6/21/72
Drum	upstream from station	1971	9	4/18/72
Drum	downstream from station	1971	4	6/20/72

[a] The marking location of fish marked by fin clips in 1971 is listed as upstream or downstream of the station, since the exact location and date of tagging are not retrievable.

Table A-18. Date and location of marking and recovery of tagged fish recaptured, November 1972.

Species	Tagged: Date	Tagged: Sampling Location	Recaptured: Date	Recaptured: Sampling Location
Largemouth bass	July 27	6	August 8	6
	July 27	6	August 23	6
	July 26	11	August 23	11
	September 6	8	September 19	8
White crappie	September 6	12	September 20	12
	September 6	12	October 2	12
	June 21	12	October 4	12
	July 26	12	October 4	12
	June 21	3	October 17	3
	October 4	10	October 18	10
	October 17	3	November 7	3
Black crappie	September 5	6	September 18	6
	September 7	9	September 18	12
	September 18	6	October 2	6
	October 2	10	October 4	10
Sauger	August 22	8	September 6	8
	September 6	1	October 3	1
	October 3	8	October 17	8

Table A-19. Tagging and recapture information on all tagged fish recaptured between September 1971 and July 1973 near the Quad-Cities Station.

	Tagged		Recaptured		Direction and Distance
	Date	Location	Date	Location	Traveled
Bluegill	11-19-71	10	6-19-72	10	-[a]
	6-20-72	13	7-10-72	13	
	6-7-72	12	7-12-72	12	
	6-6-72	8	7-5-72	9	Across river
	6-20-72	8	7-5-72	8	
Largemouth bass	10-20-71	10	11-17-71	10	
	6-7-72	11	6-8-72	11	
	7-13-72	6	7-27-72	6	
	6-6-72	9	7-18-72	9	
	7-27-72	6	8-8-72	6	
	7-27-72	6	8-23-72	6	
	7-26-72	11	8-23-72	11	
	9-6-72	8	9-19-72	8	
	6-7-72	11	6-8-72	11	
	5-22-73	1	7-10-73	8	Downstream 3.0 miles
	6-19-73	10	7-11-73	10	
	9-20-72	12	7-12-73	12	
	7-10-73	6	7-27-73	6	
	7-12-73	12	7-26-73	12	
White crappie	11-3-71	10	11-17-71	10	
	11-3-71	10	5-3-72	10	
	6-16-72	12	6-21-72	12	
	6-21-72	11	7-12-72	11	
	7-12-72	12	7-26-72	12	
	6-7-72	12	7-26-72	12	
	6-16-72	12	7-26-72	12	
	6-21-72	2	7-26-72	4	Downstream 1.0 mile

Table A-19. Continued.

Species	Tagged		Recaptured		Direction and Distance Traveled
	Date	Location	Date	Location	
White crappie	9-6-72	12	9-20-72	12	
	9-6-72	12	10-2-72	12	
	6-21-72	12	10-4-72	12	
	7-26-72	12	10-4-72	12	
	6-21-72	3	10-17-72	3	
	10-4-72	10	10-18-72	10	
	10-17-72	3	11-7-72	3	
	6-21-72	12	7-21-72	8	Upstream 0.5 miles and across river
	10-4-72	12	7-12-73	12	
	7-12-73	12	7-26-73	12	
Black crappie	6-6-72	9	6-21-72	9	
	7-12-72	11	7-25-72	11	
	9-5-72	6	9-18-72	6	
	9-7-72	9	9-18-72	12	Downstream 1.2 miles
	9-18-72	6	10-2-72	6	
	10-2-72	10	10-4-72	10	
	7-13-72	6	12-18-72	Hanson slough	Upstream 1.5 miles and across river
	9-19-72	10	3-1-73	Near 10	Within same slough complex
	4-19-72	5	5-21-72	Hanson slough	Across river
	9-20-72	4	4-10-73	4	
	6-19-73	10	7-26-73	10	

Table A-19 Continued.

Species	Tagged		Recaptured		Direction and Distance Traveled.
	Date	Location	Date	Location	
Sauger	10-20-71	Cordova	11-2-72	2	Upstream 4.0 miles
	10-20-71	2	2-26-72	Lock and Dam 13	Upstream 15.0 miles
	6-6-72	1	6-20-72	1	
	6-20-72	1	6-22-72	1	
	6-20-72	1	6-21-72	1	
	8-22-72	8	9-6-72	8	
	9-6-72	1	10-3-72	1	
	10-3-72	8	10-17-72	8	
	10-2-72	6	2-24-73	Lock and Dam 13	Upstream 15.5 miles
	9-19-72	8	4-3-73	Lock and Dam 12	Upstream 50.5 miles
Walleye	9-6-72	2	1-6-73	Lock and Dam 13	Upstream 14.5 miles

[a] fish recaptured at same location as tagged.

Table A-20. Number of fishes tagged and recaptured at each sampling location, and occurrence of movement of each species in the vicinity of Quad-Cities Station during 1973.

Species	Location 1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Largemouth bass																
Number tagged	3	0	4	10	36	7	17	0	43	27	42	17	6	2	0	214
Number recaptured	1[a]	0	1	0	4	0	7	0	9	3	2	2	1	0	0	30

1972 recaptures - Two tagged during 1972 were recaptured in 1973 where tagged.

a - traveled across diffuser to downstream Location 8.

Species	1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Bluegill																
Number tagged	1	0	23	38	30	0	28	0	41	21	90	7	4	0	0	283
Number recaptured	0	0	0	1	[illegible]	0	0	0	3	1[b]	5	0	0	0	0	11

1972 recaptures - two tagged during 1972 were recaptured in 1973 where tagged.

b - traveled downstream 1.4 miles.

Species	1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Black crappie																
Number tagged	1	0	25	13	22	1	27	0	28	17	7	8	1	2	1	153
Number recaptured	0	0	1[c]	1[d]	0	1	0	2[e]	0	2	0	0	0	0	0	7

1972 recaptures - one of four tagged in 1972 was recaptured in 1973 where tagged.[f]

c - traveled upstream 1.0 miles.
d - traveled upstream 1.8 miles.
e - one traveled across diffuser, upstream 3.0 miles.
f - one of three traveled across diffuser, upstream 5.6 miles.

Species	1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
White crappie																
Number tagged	0	0	9	16	34	1	1	0	41	12	19	7	12	0	1	153
Number recaptured	0	0	0	0	1	0	0	0	3	1	0	0	1	0	0	6

1972 recaptures - two of three tagged in 1972 were recaptured in 1973 where tagged.[g]

g - one traveled across diffuser, downstream 1.3 miles.

Species	1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Channel catfish																
Number tagged	0	0	6	0	12	15	0	6	20	70	1	3	3	0	6	142
Number recaptured	0	0	0	0	0	1[h]	0	0	0	1[i]	0	0	0	0	0	2

h - traveled upstream 7.0 miles
i - traveled across diffuser, upstream 6.9 miles.

Species	1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Bowfin																
Number tagged	0	0	0	4	0	0	5	0	1	6	0	0	0	0	0	16
Number recaptured	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
Northern pike																
Number tagged	0	0	0	0	2	0	2	0	3	0	2	0	0	0	0	9
Number recaptured	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

Table A-20 Continued.

Species	Locations 1	1T	2	3	4	5	6	6T	8	9	10	11	12	13	13T	Total
Walleye																
Number tagged	1	0	1	0	3	3	1	0	1	0	0	0	0	0	0	10
Number recaptured	0	0	0	0	1[j]	0	0	0	0	0	0	0	0	0	0	1
1972 recaptures - one tagged during 1972 moved[k,l]																

j - traveled upstream 2.0 miles.

k - traveled upstream 15.5 miles.

l - traveled upstream 14.5 miles. (across diffuser)

Total fishes - 1973																
Number tagged	11	29	78	83	254	53	85	35	240	178	162	42	20	8	45	1,323
Number recaptured	1	0	2	1	8	1	10	0	17	7	9	2	2	0	0	60
Movement	1	0	1	0	2	1	0	0	1	2	0	0	0	0	0	8
Movement across diffuser	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3
Movement 1972 recaptures	1	0	1	0	0	0	1		1	0	3	0	0	0	0	7
1972 recaptures across diffuser	1	0	0	0	0	0	0		1	0	2	0	0	0	0	4

[x] tagged 72, recaptured 73

Table A-21. Recapture information on all tagged fishes recaptured and reported during 1974.

Species	Tagged			Recaptured			Comment
	Date	Length (mm)	Location	Date	Length (mm)	Location	
Carp	10/9/73	320	8	7/11/74	370	8	
Bigmouth buffalo	9/10/73	340	2	1/28/74	-	9	
Bluegill	11/30/73	175	10	4/25/74	185	10	
Largemouth bass	10/17/72	215	3	7/12/74	295	4	
	7/25/73	295	8	6/7/74	310	8	
	8/7/73	255	3	7/12/74	290	4	
	8/9/73	450	4	5/16/74	-	3	
	6/20/73	290	9	7/22/74	300	9	
	9/11/73	400	10	4/1/74	410	10	
	9/11/73	280	10	7/11/74	290	10	
	9/25/73	320	11	8/6/74	-	Albany	River mile 514.0
	6/7/74	280	8	7/25/74	285	8	
	7/12/74	315	4	7/22/74	315	4	
	7/12/74	345	4	7/25/74	340	4	
	7/12/74	315	4	7/24/74	315	4	
White crappie	4/18/72	310	10	4/1/74	330	10	
	5/16/72	330	10	4/17/74	370	Near 10	
	6/20/72	260	4	7/11/74	280	4	
	9/5/72	220	10	4/1/74	265	10	
	10/7/72	280	10	4/25/74	310	10	
	10/17/72	290	3	9/?/73	305	Schricker's Slough	River mile 508.5
	11/7/72	310	3	7/12/74	310	4	
	4/24/73	250	10	4/25/74	280	10	
	8/20/7?	215	2	4/?/74	-	Sand pit	River mile 510.5
	9/1?/73	260	4	7/24/74	305	4	
	10/22/73	260	3	4/25/74	265	10	
	11/5/73	295	3	6/6/74	290	3	
Black crappie	5/22/73	235	3	4/22/74	-	Hansen's Slough	River mile 508.5
	6/19/73	220	8	4/19/74	-	Clinton Slough	River mile 516.0
	8/20/73	205	6	3/21/74	205	6	Trash basket
	9/11/73	240	10	7/24/74	245	Princeton Slough	River mile 503.0
	10/22/73	235	2	4/21/74	-	Pond Lily Slough	River mile 510.0
	6/7/74	215	4	7/12/74	210	4	
	6/7/74	215	4	7/25/74	215	Swan Slough	River mile 511.0
Channel catfish	8/9/73	300	9	5/19/74	-	River mile 527.0	
	8/20/73	240	9	7/12/74	275	9	
	8/20/7?	260	9	7/25/74	-	Wapsi River	Approx. 3.5 miles
	9/12/73	360	9	4/14/74	-	Rock Creek	River mile 509.5
Sauger	10/9/73	280	9	4/20/74	-	Lock & Dam 15	River mile 483.0

TABLE A-22

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Cover Letter for: 316a Supplement

and

316b Demonstration

April 11, 1975

(2 pages)

Commonwealth Edison
72 West Adams Street, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

April 11, 1975

Mr. A. H. Manzardo
Chief, Permit Branch
Region V
U. S. Environmental Protection
Agency
230 South Dearborn Street
Chicago, IL 60604

Subject: NPDES No. IL0005037 Transmittal of 316(a) Supplement and 316(b) Demonstration

Dear Mr. Manzardo:

In further response to your letter of January 24, 1975, Commonwealth Edison Company herewith encloses a supplement, respecting entrainment to its 316(a) demonstration for its Quad Cities Station, located on Pool 14 of the Mississippi River.

The zooplankton entrainment studies were conducted from mid-September, 1972 through August, 1973, a period during which both units of the Station were operating in the open-cycle cooling mode. Comparison of samplings made at the station's intake with those made in the discharge bay show zooplankton mortalities ranging from 4.6% to 31%, during periods of non-chlorination, up to approximately 95% during periods of chlorination of the condensers for slime control necessary to Station operation. However, comparisons of samplings made immediately upstream of the Station with those made immediately downstream of the diffuser pipe discharge show zooplankton mortality averaging only 1.2%.

This value is consonant with the average zooplankton mortality of less than 5% not affected by Station operation, shown by comparison of downstream samplings with upstream samplings. The maximum mortality observed in this comparison was 7.3% on one sampling date in July when stresses due to high river temperature and low river flow were greatest.

The rapid regeneration time of zooplankton organisms and the relatively small proportion affected by condenser passage, assures that the zooplankton entrainment resulting from the operating of Quad Cities Station has no significant adverse environmental impact.

Phytoplankton entrainment studies covered approximately the same period as did the zooplankton studies. Measurable inhibitory effects of entrainment of phytoplankton were generally confined to the discharge bay and occurred most

frequently during periods of condenser chlorination. Comparison of productivity data (chlorophyll a and carbon fixation rate) collected during periods of both chlorination and non-chlorination at locations upstream from the station with downstream locations indicated that phytoplankton productivity was frequently stimulated downstream of the diffuser pipe.

Thus, phytoplankton entrainment resulting from the operation of Quad Cities Station has no significant adverse environmental impact. We believe the supplement demonstrates that entrainment resulting from the Station's operation, even in an open-cycle cooling mode does not result in any significant adverse environmental impact.

We also enclose, as a 316(b) demonstration, a report on fish impingement at the Station's intake. The data presented in the report are the results of studies conducted at the Station during the period September, 1972 through December, 1974. Intensive fish impingement studies were initiated in January, 1973. Both units of the Station were in the open-cycle cooling mode until May, 1974, and one unit thereafter.

The fish found to be impinged in the greatest quantity by the Station's intake structure was gizzard shad, a non-commercial and non-sportfish species. Even so, the amount of gizzard shad impinged is estimated to have been less than 1.3% of its total standing crop in Pool 14. The aggregate of all species impinged was less than 0.5% of the estimated standing crop, and most of these were juveniles or young-of-the-year which are characterized by high natural mortality rates and low commercial value. Even channel catfish, one of the most commercially valued species of Pool 14, had less than 0.5% of its estimated standing crop impinged, in contrast to the up to 47% of the estimated annual standing crop which was commercially harvested.

These findings support the conclusion that no significant adverse environmental impact results from the Station's intake structure, during open-cycle cooling water operation.

If additional information is needed, please phone me at (312) 294-8074 or Mr. Harry Bernhard at (312) 294-2939.

Very truly yours,

John H. Hughes
Director of Water Quality

JHH:HB:gm
attachments

cc: Dr. Briceland

Supplement 316a Demonstration

April, 1975

(28 pages)

Supplement to Quad Cities

316(a) Demonstration

Entrainment

Prepared by:

Commonwealth Edison Co.

Chicago, Illinois

April 1975

Table of Contents

ENTRAINMENT

A. Zooplankton Entrainment

Zooplankton entrainment studies at the Quad-Cities Station were conducted from mid-September 1972 through early August 1973, a period during which the full thermal, mechanical and chemical stresses of entrainment could be assessed, since both reactor units were in operation in the open cycle cooling mode with two diffuser pipes employed to diffuse waste heat into the river.

Samples were collected with a filter-pump system (Icanberry 1973) near the surface from the Station intake (Location 6) and from the discharge bay (Location 7) where condenser water entered the diffuser pipes. River locations were sampled upstream (Locations 15, East; and 17, West) and downstream (Locations 20, East; and 18, West) of the diffuser pipes (Figure 1).

Motile and immotile zooplankton were examined under a stereozoom microscope within 20 minutes and at four hours after sample collection. Zooplankton observed during the first (20 minute) period were initially recorded as motile or immotile rather than living or dead to allow for possible recovery from temporary shock resulting from condenser passage. However, since there was no clear indication of delayed mortality or recovery from the immediate effects of condenser passage throughout the study, those organisms observed to be immotile 20 minutes after collection were reported as dead. The percentage of dead zooplankton due to condenser passage was calculated by subtracting the percent intake or upstream mortalities from the percent discharge or downstream mortalities. The zooplankton were preserved in 3% formalin after analysis for later determination of species composition (Brooks 1957, and Wilson and Yeatman, 1959).

1. Intake (Location 6) - Discharge (Location 7) Comparisons

Zooplankton mortality attributed to condenser passage ranged from 4.6% to 31.0% during periods of non-chlorination (Table 1). Highest

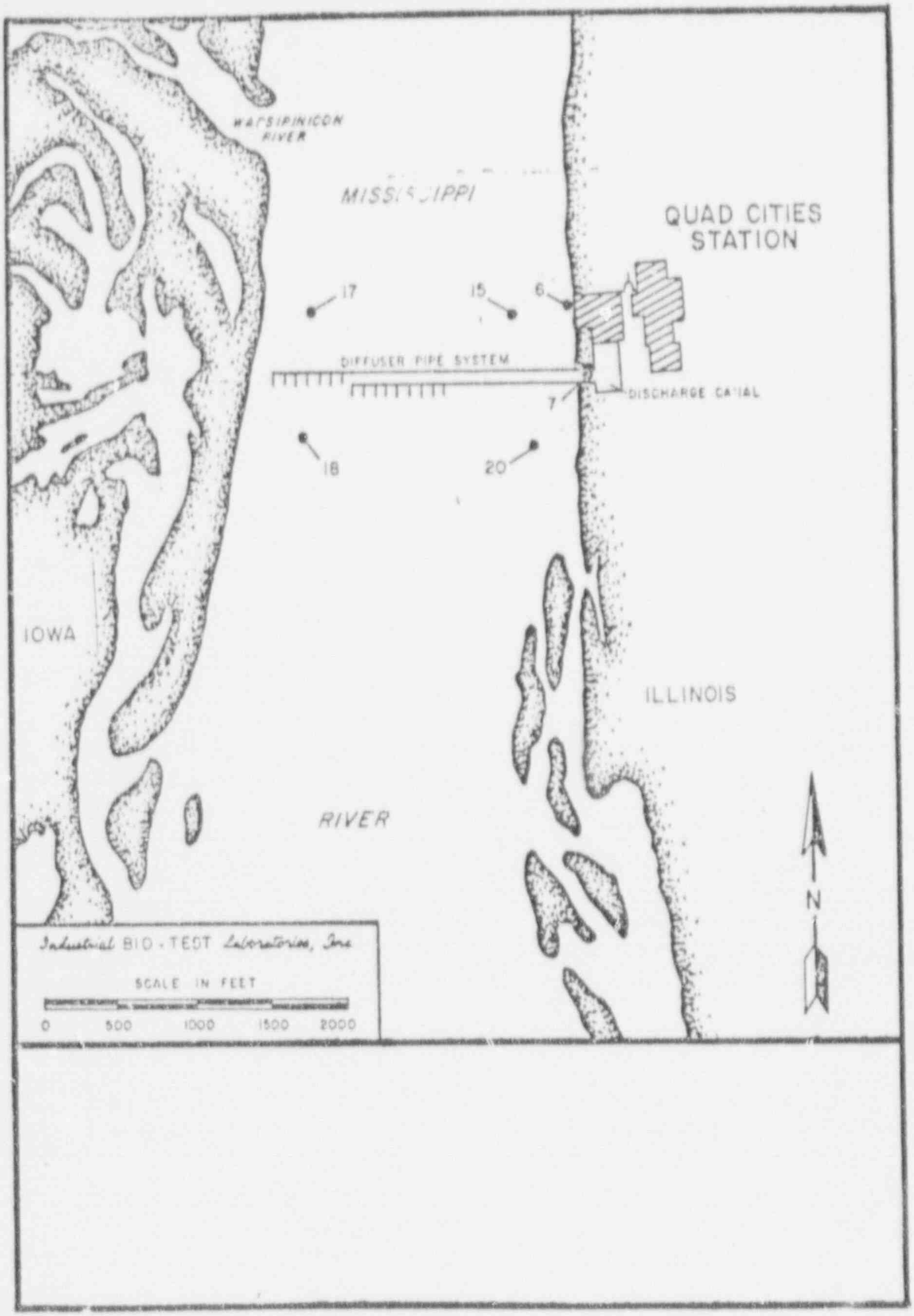

Figure 1. Sampling locations for zooplankton and phytoplankton entrainment studies, Quad-Cities Station, September 1972 through August 1973.

Table 1. The viability of zooplankton before and after condenser passage at Locations 6, 7, 15, 17, 18 and 20 at Quad-Cities Station, September 1972-August 1973.

	Percent Mortality Difference Between Locations			Temperature (°C)						Total Chlorine (mg/l)
	7vs6	20vs15 (East)	18vs17 (West)	7	6	20	15	18	17	7
Non-Chlorination										
19 September 1972	7.0	3.9	5.4	34.5	23.0	22.0	23.2	23.2	23.2	0.00
17 October	4.6	0.0	5.5	23.5	11.5	12.5	11.3	11.3	11.8	0.00
7 November	8.5	0.0	1.0	19.5	8.3	8.7	8.3	9.0	8.7	0.00
18 December	14.0	6.4	0.0	13.0	0.0	0.2	0.2	0.2	0.2	0.00
23 January 1973	11.3	-	-	18.0	1.3	-	-	-	-	0.00
20 February	10.1	0.0	0.7	16.5	0.5	0.5	0.5	0.5	0.5	0.00
6 March	5.6	2.7	0.6	19.5	3.1	4.2	3.0	4.0	4.0	0.00
10 April	10.2	1.2	0.1	18.0	4.5	4.5	4.5	4.5	4.5	0.00
22 May	5.8	0.0	0.0	25.0	17.2	17.2	17.2	17.2	17.2	0.00
26 June	23.7	2.3	0.0	35.0	23.6	23.6	23.6	24.1	23.6	0.00
24 July	12.3	14.7	8.4	35.0	23.9	25.5	23.9	25.5	23.9	0.00
7 August	31.0	0.0	4.9	36.7	24.5	25.5	24.5	25.5	24.5	0.00
Chlorination										
5 September 1972	9.2	13.1	0.0	27.7	21.5	21.3	21.3	22.0	21.5	0.09
3 October	9.0	0.0	4.0	19.7	15.2	15.0	15.0	15.0	15.0	0.06
28 November	10.9	0.0	0.0	17.3	1.0	1.2	1.0	2.3	1.5	0.18
6 December	1.7	-	-	15.0	0.3	-	-	-	-	0.05
9 January 1973	7.4	23.4	0.0	20.0	9.0	0.0	0.0	0.0	0.0	0.05
13 February	32.4	0.0	1.5	16.7	0.3	0.5	0.5	0.0	1.0	0.51
20 March	6.6	0.1	0.0	12.5	4.5	4.5	4.5	4.8	4.8	0.07
3 April	22.2	4.5	2.5	20.8	8.7	9.0	8.7	8.7	9.6	0.37
8 May	11.6	2.5	0.0	18.8	12.5	12.5	12.5	12.5	12.5	0.10
5 June	10.4	5.0	6.6	28.2	20.3	20.3	20.3	20.3	17.2	0.03
10 July	94.7	3.2	5.8	39.5	27.4	29.0	27.2	29.0	27.2	0.26
21 August	51.0	0.0	1.3	37.2	24.5	26.1	24.5	26.1	24.7	0.09

Mortalities at upstream locations (15 or 17) that were equal to or greater than downstream locations (18 or 20) are reported as 0%. The actual numbers on which these percentages are based were reported in Industrial Bio-Test Laboratories, Inc. reports (1973a; 1973b; and 1974a).

mortalities were observed during the summer. Zooplankton mortalities averaged 18.0% in June and July when discharge temperature was 35.0 C. When the discharge water temperature was 36.7 C in August the mortality was 31.0%

Condenser passage was found to be less detrimental when discharge temperatures were below critical levels for most zooplankton. Condenser water temperatures were below 35 C from September through May and resulted in an average mortality of 8.6%. From January through March, when water temperatures were lowest, mortalities remained low averaging 9%, although temperature rise (ΔT) across the condensers was the highest (16.4 C) observed during the study. Similar intake-discharge studies at Milliken Station on Lake Cayuga, New York and at Waukegan Generating Station on southwestern Lake Michigan, showed that zooplankton were not adversely affected by entrainment when temperature rise (ΔT) across the condensers ranged from 5 C to 18 C (Youngs 1969 and Restaino 1972).

The effects of condenser passage on zooplankton during periods of non-chlorination and low thermal stress ($\leq$35.0 C) were apparently due largely to mechanical damage. Entrained organisms which exceeded 1.35 mm in length (i.e., Daphnia pulex and Diaptomus spp. female) exhibited a 14.0% higher mortality than nonentrained organisms, while an increase in mortality of only 5.4% was observed in organisms of 0.4 mm or less (i.e., copepod nauplii and Chydorus sphaericus). Binomial regression analysis ($P\leq0.05$) showed that mortality of entrained

zooplankton was a linear function of species size (Figure 2), suggesting that mechanical damage is an important factor in evaluating the effects of condenser passage on a given zooplankton population. Although this does not exclude the possibility that larger zooplankton species are less tolerant of higher temperatures, other studies have indicated similar size/effect relationships even when no heat was being exchanged across the condensers (Restaino 1972).

The effects of condenser chlorination on entrained zooplankton during periods of low thermal stress (September through May) were related to the concentrations of chlorine. Chlorine concentrations of 0.50 mg/1 in February and 0.37 mg/1 in April at Location 7 resulted in mortalities of 32.4% and 22.2%, respectively (Table 1). When chlorine levels were lower than 0.2 mg/1, mortalities were similar to those observed during periods of non-chlorination of the condensers. Similar studies have demonstrated zooplankton mortalities exceeding 50% when chlorine concentrations were $\geq$0.5 mg/1 (Davies 1972).

Zooplankton mortality rates were greatest during periods of chlorination in the summer when discharge temperatures reached maximum levels. The combined effect of 0.26 mg/1 of chlorine and temperatures of 39.5 C in the discharge water in July, resulted in zooplankton mortality of 94.7%. Zooplankton mortality in August was 51.0% when chlorine level was 0.09 mg/1 and discharge temperature was 37.2 C.

2. <u>Upstream (Location 15 and 17) - Downstream (Locations 18 and 20) Comparisons</u>

Total chlorine values were below the analytical detection limit of 0.01 mg/1 immediately downstream of the diffuser pipe during condenser chlorination (Locations 18 and 20) throughout the course of

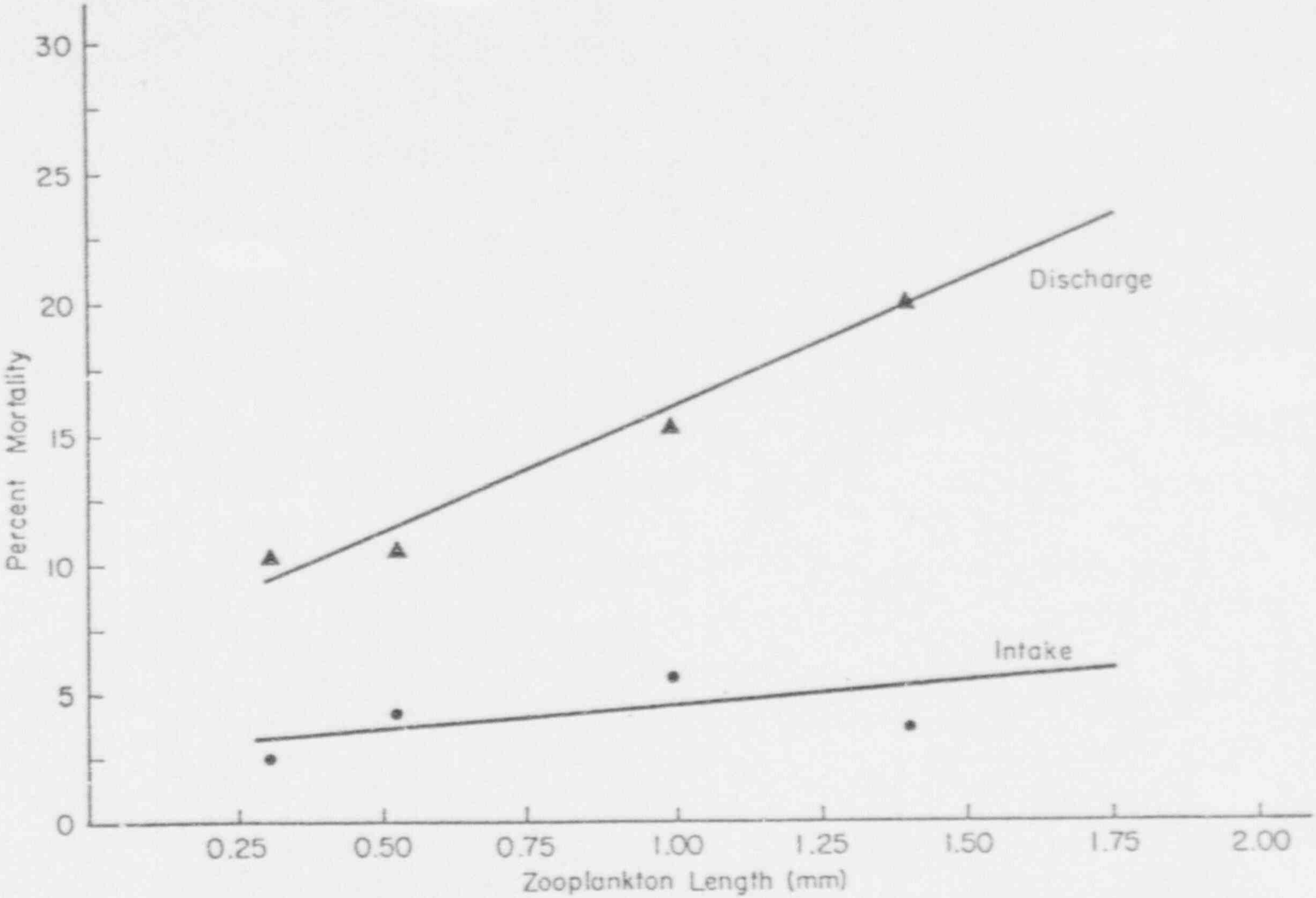

Figure 2. Binomial regression analyses (size vs. mortality) for zooplankton subjected to condenser passage without chlorination during low thermal stress at Quad-Cities Station, September 1972 through June 1973. Dots indicate intake mortality and triangles indicate discharge mortality.

the study. No significant differences ($P \leq 0.05$) in zooplankton viability were observed among river locations upstream and downstream of the diffuser pipes during periods of chlorination and non-chlorination (Table 1). The difference in mortality between east downstream versus east upstream locations averaged 4.7% and 2.8% during chlorination and non-chlorination periods respectively. Mortality differences between west downstream and west upstream averaged 2.0% during chlorination and 2.4% during non-chlorination.

A comparison of observed zooplankton mortality data collected downstream of the Station with data from upstream locations indicated slightly higher mortality downstream of the diffuser pipe. A maximum observed mortality of 7.3% downstream of the Station was measured in July when water temperatures in the discharge bay reached the highest levels. Observed mortality downstream was similar to predicted mortality and corresponded to lethal temperatures, low river flow, and high chlorine concentrations.

3. Calculated impact on total river population

The average rate of water flow through the Station during the 12 month study was 3.7% of total river flow (Table 2). Assuming even distribution of river zooplankton, mean condenser mortality (based on Location 7) was predicted to be 0.8% of the total river population flowing by the Station. Maximum predicted mortality was 4.0% on July 10 during low river flow when chlorine concentrations and discharge water temperatures were highest.

B. Phytoplankton Entrainment

Phytoplankton entrainment studies covered approximately the same period as the zooplankton studies, and were conducted from August 1972 through August 1973. During this period both reactor units of

Table 2. Predicted and observed effects of Quad-Cities Station on total viability of Mississippi River zooplankton passing the Station, September 1972 through August 1973. The total effect of the Station on zooplankton was predicted by multiplying the condenser mortalities in the discharge bay by the fraction of river flow passing through the Station.

Date	Average River Flow at Lock and Dam #14 (cfs)	% River Flow through Quad-Cities Station	% Zooplankton Mortality Predicted by % Volume of River Passing through the Station a/	% Zooplankton Mortality at Downstream Locations when compared with Upstream Locations b/
1972				
5 September	81,300	2.5	0.3	0.1
19 September	57,800	3.6	0.8	0.1
3 October	88,000	2.4	0.1	0.0
17 October	59,500	3.5	0.0	0.0
7 November	75,900	2.8	0.2	0.0
28 November	59,400	3.5	0.0	0.0
6 December	23,300	9.0	0.0	- c/
18 December	34,100	6.2	0.5	0.6
1973				
9 January	47,000	4.5	0.2	0.0
23 January	67,500	3.1	0.3	-
13 February	41,700	5.0	2.1	0.0
20 February	34,100	6.2	2.7	0.2
6 March	61,600	3.4	0.2	0.5
20 March	181,400	1.2	0.2	0.4
3 April	135,800	1.5	0.3	2.0
10 April	124,500	1.7	0.0	2.8
8 May	125,400	1.7	0.0	2.6
22 May	124,200	1.7	0.0	0.0
5 June	134,600	1.6	0.2	1.7
26 June	65,200	3.2	0.7	0.8
10 July	47,300	4.4	4.0	1.8
24 July	36,500	5.8	3.1	7.3
7 August	33,200	6.3	1.3	3.7
21 August	42,600	4.9	2.8	1.7
Mean	74,246	3.7	0.8	1.2

a/ Based on condenser effect at Location 7.
b/ Based on actual data from Locations 15 and 17 vs. Locations 18 and 20 (See footnote, Table 1).
c/ Not sampled due to ice conditions.

the Quad-Cities Station were in operation in the open cycle mode with both diffuser pipes employed to dissipate waste heat into the Mississippi River.

The same sampling locations were used for both the zooplankton and phytoplankton entrainment studies (Figure 1). Phytoplankton samples were taken from a 24-liter composite water sample collected near the surface with a 6-liter Kemmerer sampler. Each composite sample was placed in a translucent carboy and maintained at ambient river temperature. Samples collected on August 8, 22, September 5, 19 and October 3, 1972 were processed in the field for the determination of chlorophyll a concentration and rate of carbon fixation (mg $C/m^3/hr$) at intervals of 3, 7, 24, 48 and 72 hours after collection. Following collection and preservation, samples were transported to a Northbrook, Illinois laboratory for abundance, biomass chlorophyll a and carbon fixation rate determinations. An analysis of variance was performed to identify differences in phytoplankton productivity between the intake location and the discharge location and between river locations above and below the diffuser pipe discharge system.

1. Intake (Location 6) - Discharge (Location) Comparisons

Phytoplankton abundance and biomass at intake and discharge locations (Locations 6 and 7) are summarized in Table 3, covering the period from August 1972 to January 1973, and Table 4 covering the period from February to August 1973. In general, carbon fixation rate, chlorophyll a concentration and phytoplankton abundance were found to be directly related.

Measurable inhibitory effects of trainment on phytoplankton were generally confined to the discharge bay and occurred most often during periods of chlorination.

Table 3. [illegible] counts [illegible] and cell volumes of phytoplankton collected from [illegible] (intake) and 7 (discharge) during chlorination (C) and non-[illegible] (NC) at Quad-Cities Station, August 1972-January 1973.

	Time After Collection			
	3 Hours		72 Hours	
[illegible]	Units/ml	Cell Volumes (µl/l)	Units/ml	Cell Volumes (µl/l)
1972:				
Aug 8 (C)				
6	[illegible]19	2.1[illegible]3	8825	3.670
7	[illegible]859	2.616	3021	1.447
Aug 22 (NC)				
6	4673	1.939	24052	8.208
7	4975	1.731	32804	8.441
Sept [illegible]				
6	2815	1.785	18798	6.999
7	3743	1.792	3512	2.284
Sept 15 (NC)				
6	2165	1.354	8057	2.084
7	2263	1.080	12785	2.907
Oct [illegible] (C)				
6	5[illegible]	1.880	13148	3.443
7	[illegible]695	3.227	4858	1.838
Oct 17 (NC)				
6	5243	2.940	10389	6.[illegible]41
7	5435	2.648	11165	4.8[illegible]0
Nov 7 (NC)				
6	3975	1.840	6016	2.647
7	3086	1.479	4591	2.102
Nov 27 (C)				
6	3654	1.958	6601	2.[illegible]
7	4426	2.254	3688	2.069
Dec 6 (C)				
6	5[illegible]04	2.645	10606	[illegible]
7	7000	2.892	7394	[illegible]
Dec 18 (NC)				
6	5217	2.147	7847	3.421
7	4489	1.990	7465	[illegible].422
1973:				
Jan 9 (C)				
6	1521	0.594	2232	0.867
7	[illegible]	0.518	[illegible]264	0.497
Jan 23 (NC)				
6	555	0.214	785	0.340
7	697	0.291	738	0.315

Table 4

Abundance and biovolume of phytoplankton collected from Locations 6 (intake) and 7 (discharge) during chlorination (C) and non-chlorination (NC), Quad-Cities Station, February-August, 1973.

Date Collected & Location	Time After Collection					
	7 Hours		24 Hours		72 Hours	
	Reporting Units/ml	Biovolume (1/1)	Reporting Units/ml	Biovolume (1/1)	Reporting Units/ml	Biovolume (1/1)
13 Feb. (C)						
6	608	0.320	611	[illegible]	691	0.357
7	642	0.330	642	0.411	1,233	0.527
20 Feb. (NC)						
6	531	0.249	[illegible]	0.361	985	0.403
7	560	0.248	615	0.255	1,146	0.601
6 Mar. (NC)						
6	1,730	0.825	2,022	0.983	3,601	1.815
7	1,364	0.784	2,450	1.274	4,166	2.188
20 Mar. (C)						
6	1,802	1.068	2,418	1.081	3,063	1.417
7	1,723	0.759	2,041	1.090	2,749	1.196
[illegible] Apr. (C)						
6	7,934	3.909	12,635	5.948	28,414	12.827
7	7,432	3.502	7,918	4.269	7,363	3.526
10 Apr. (NC)						
6	15,213	6.715	23,008	10.401	61,947	23.672
7	18,170	8.295	21,936	7.676	55,396	19.292
8 May (C)						
6	37,145	17.861	34,650	15.605	43,977	20.201
7	26,674	12.541	27,630	13.216	26,300	11.455
22 May (NC)						
6	20,323	10.025	15,952	10.217	55,949	[illegible]
7	[illegible]	6.576	[illegible]	10.793	57,579	22.149
5 June (C)						
6	21,637	17.983	27,367	13.720	52,935	37.715
7	27,372	15.979	32,172	16.548	47,915	20.117
26 June (NC)						
6	11,363	8.406	15,749	14.140	24,754	29.953
7	11,924	8.500	14,498	10.204	37,675	23.032
10 July (C)						
6	57,553	15.933	30,217	10.364	74,977	20.717
7	12,992	3.990	19,758	4.667	16,244	4.784

Table 4 (Cont.)

Date Collected & Location	Time After Collection: 7 Hours Reporting Units/ml	7 Hours Biovolume (1/1)	24 Hours Reporting Units/ml	24 Hours Biovolume (1/1)	72 Hours Reporting Units/ml	72 Hours Biovolume (1/1)
24 July (NC)						
6	12,030	2.732	12,956	[illegible].165	73,387	14.030
7	10,885	3.144	11,933	2.746	95,112	17.763
7 Aug. (NC)						
6	14,422	3.951	23,108	4.775	113,391	13.991
7	13,192	4.522	19,551	5.376	187,450	23.707
21 Aug. (C)						
6	8,491	2.144	17,035	4.434	110,752	15.715
7	6,204	3.094	7,328	1.998	10,625	2.797

During periods of chlorination, phytoplankton productivity (carbon fixation rate) and chlorophyll a concentrations were significantly reduced in the discharge bay compared with the intake during periods of chlorination (Table 5, 6 and 7) (Figures 3 and 6). Phytoplankton abundance and biomass also decreased (Tables 3 and 4). The mean percent reduction (August 1972 - January 1973) for phytoplankton productivity, chlorophyll a concentration, and phytoplankton abundance at Location 7 compared with Location 6 was 92%, 44% and 53% respectively. These results are in keeping with similar studies by Morgan and Stross (1969) and Brook and Baker (1972) which indicated inhibition of phytoplankton productivity and reduction of chlorophyll a concentration, suggesting destruction of algal cells due to chlorination and with other entrainment studies (Industrial Bio-Test Laboratories, Inc. 1973 a, b) which have documented destruction of algal cells at the discharge location.

During periods of non-chlorination, the effects of condenser passage on entrained phytoplankton were not consistent. In August, September and December of 1972 increases in phytoplankton productivity were observed in the discharge bay at 72 hours after collection, when compared with intake samples as determined by carbon fixation rate, chlorophyll a concentrations (Table 5) and phytoplankton abundance and biomass (Table 4). In January of 1973 inhibition of phytoplankton productivity (carbon fixation) was observed in the discharge bay samples over the 72 hour period, (Table 3) although phytoplankton abundance and chlorophyll a concentrations were generally similar between the intake and discharge. Neither stimulation nor inhibition were noted in October and November 1972. Average discharge/intake (D/I) values for phytoplankton productivity, chlorophyll a concentrations and phytoplankton abundance for the period August 1972 - January 1973 demonstrated no significant effect of condenser passage (Figure 3)

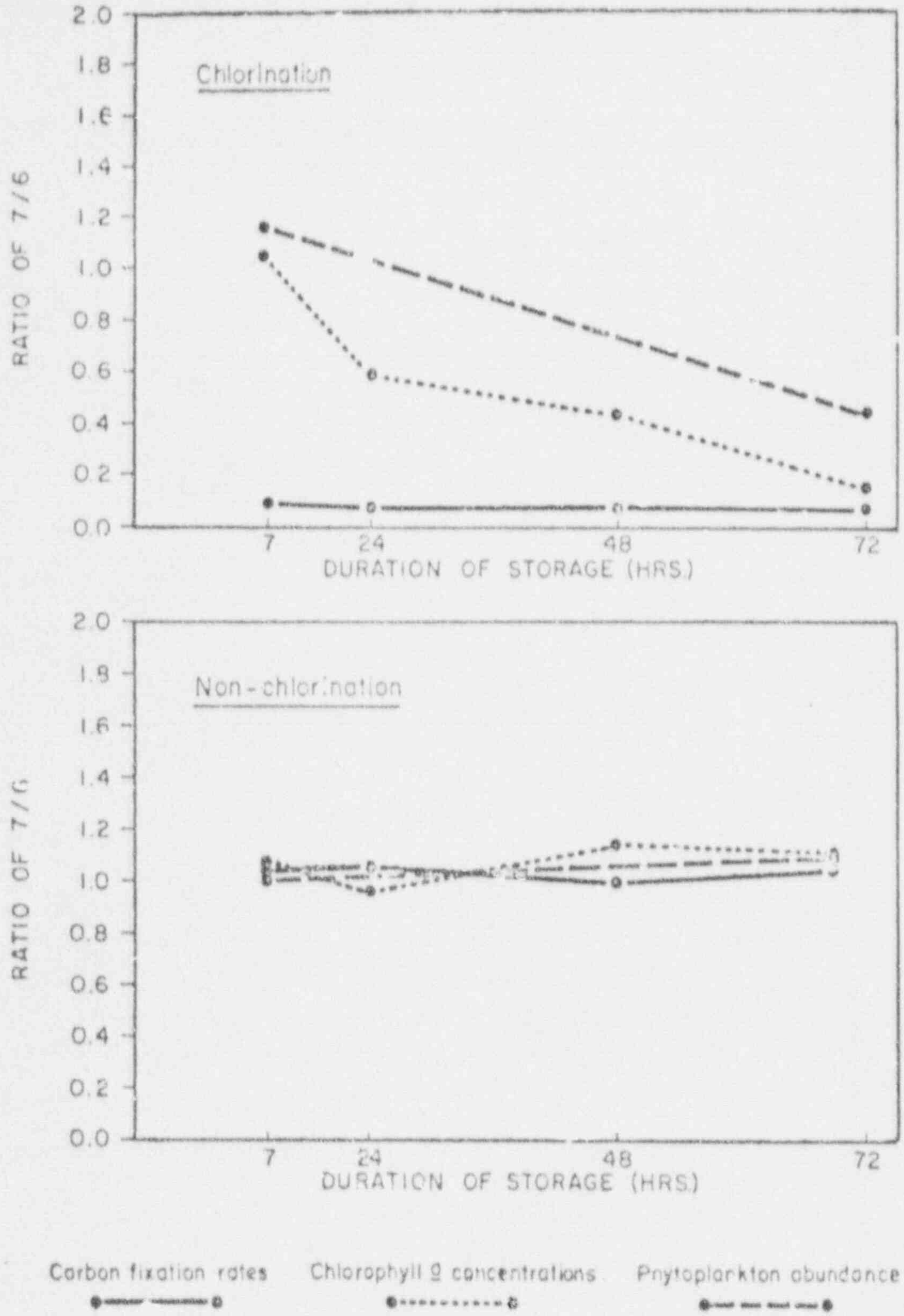

Figure 3. Mean values for phytoplankton productivity (carbon fixation rate), chlorophyll a concentration and phytoplankton abundance as ratios for Location 7 (discharge) / 6 (intake) at Quad-Cities Station, August 1972- January 1973.

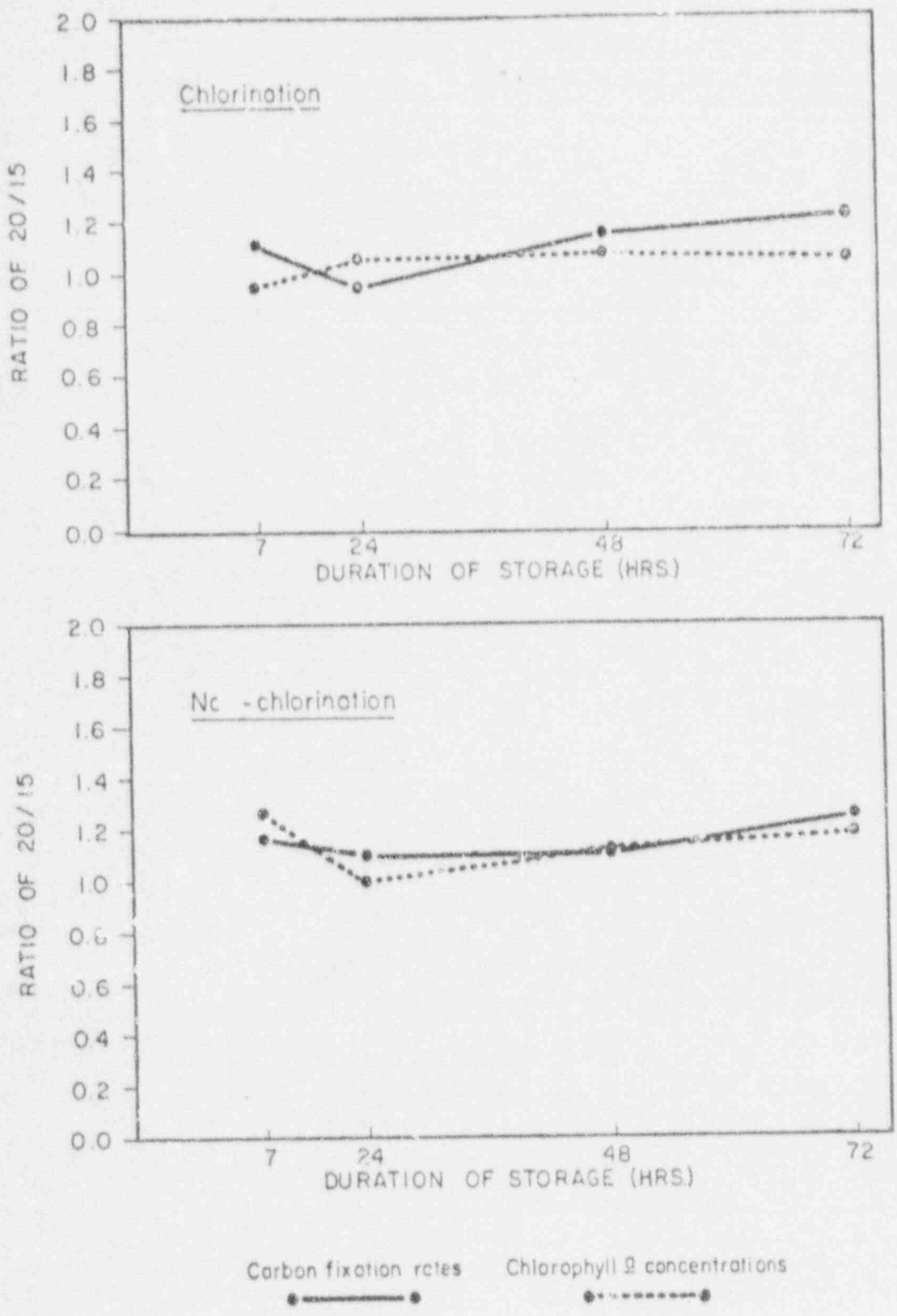

Figure 4. Mean values for phytoplankton productivity (carbon fixation rate) and chlorophyll a concentration as ratios for Location 20 (east downstream) / 15 (east upstream) at Quad-Cities Station, August 1972- January 1973.

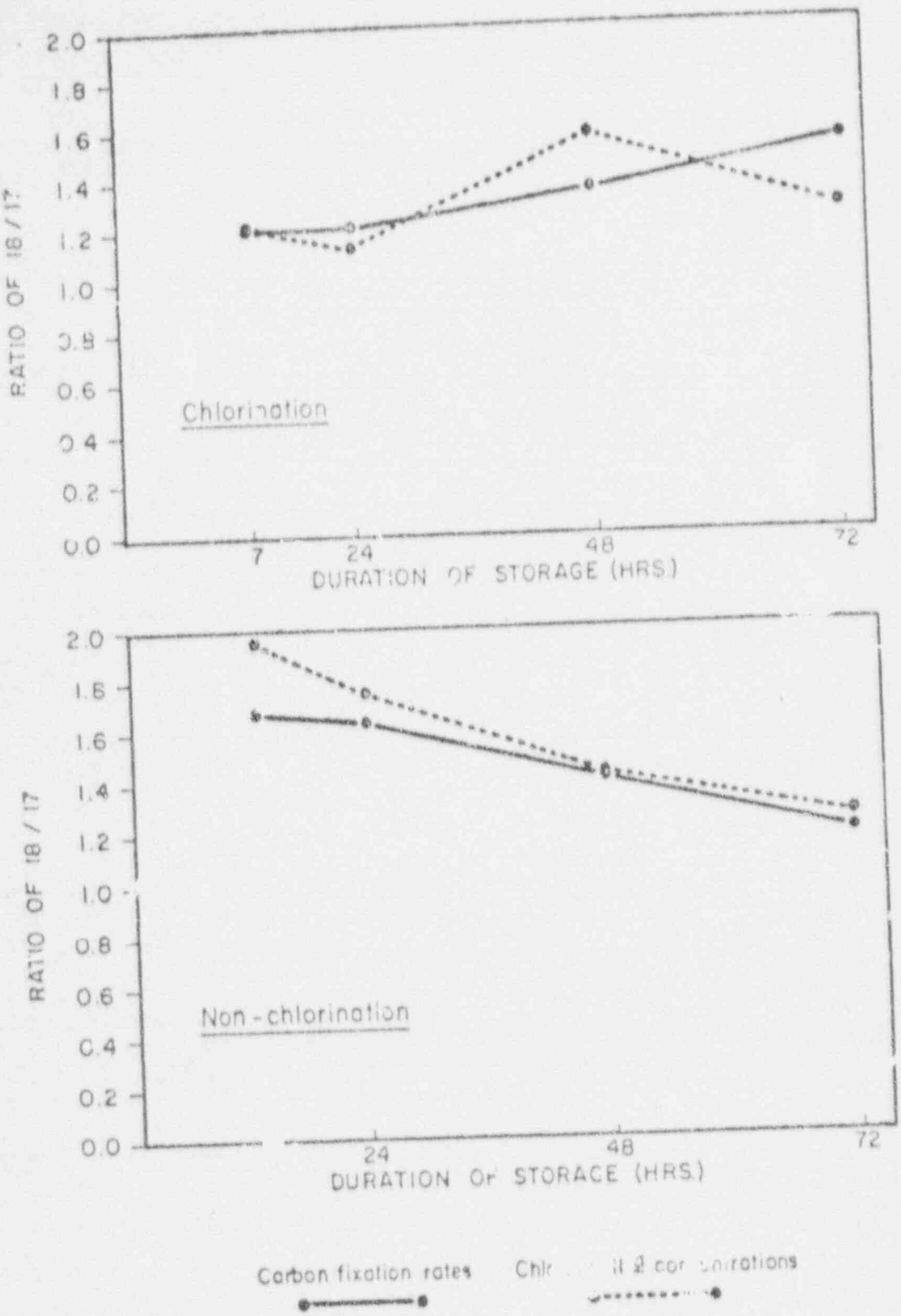

Figure 5. Mean values for phytoplankton productivity (carbon fixation rate) and chlorophyll a concentration as ratios for Location 18 (west downstream) / 17 (west upstream) at Quad-Cities Station, August 1972- January 1973.

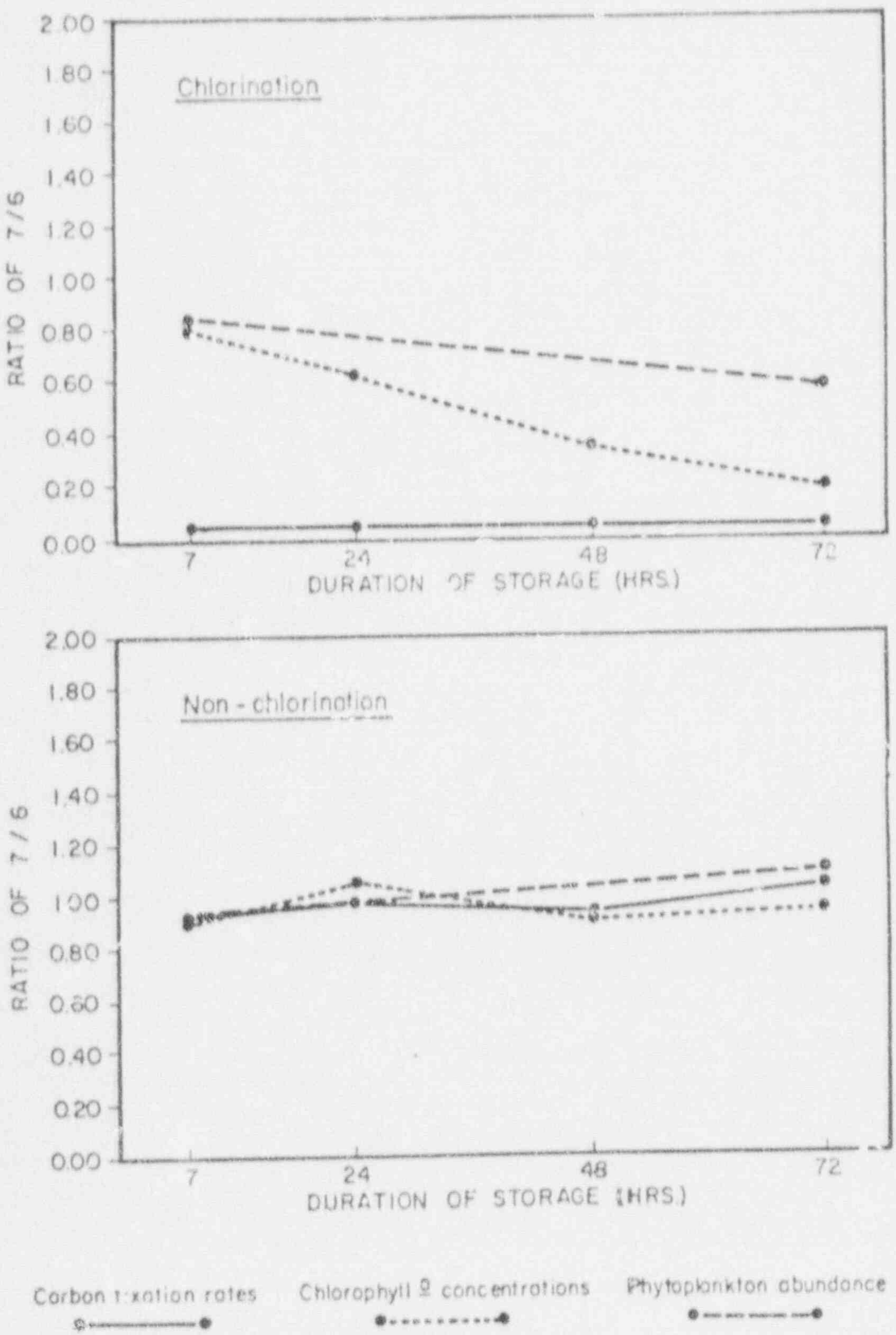

Figure 6. Mean ratios of phytoplankton productivity (carbon fixation rate), chlorophyll a concentration and phytoplankton abundance for Location 7 (discharge)/ 6 (intake), Quad-Cities Station, February-July 1973.

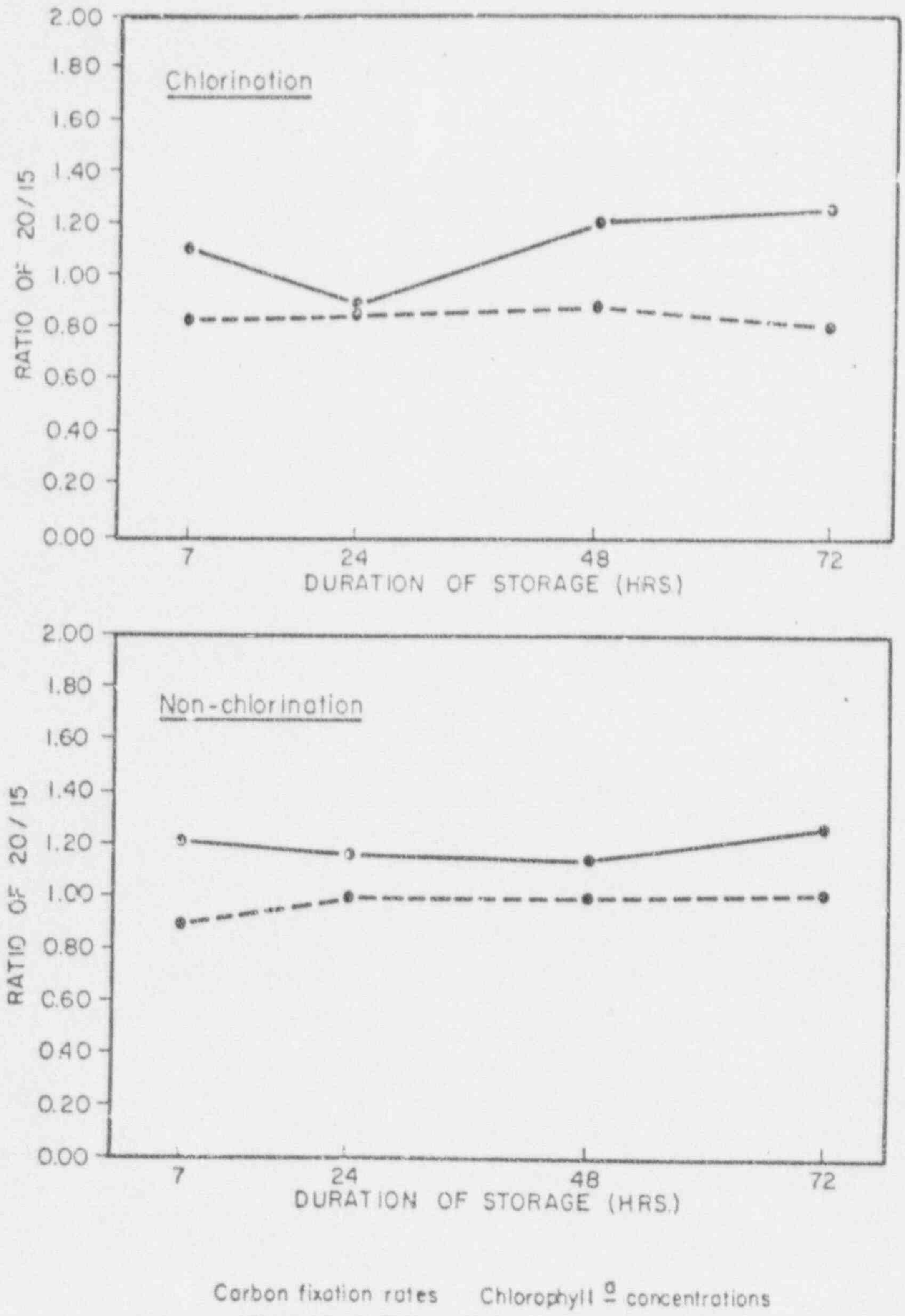

Figure 7. Mean ratios of phytoplankton productivity (carbon fixation rate) and chlorophyll a concentration for Location 20 (east downstream)/ 15 (east upstream), Quad-Cities Station, February-July 1973.

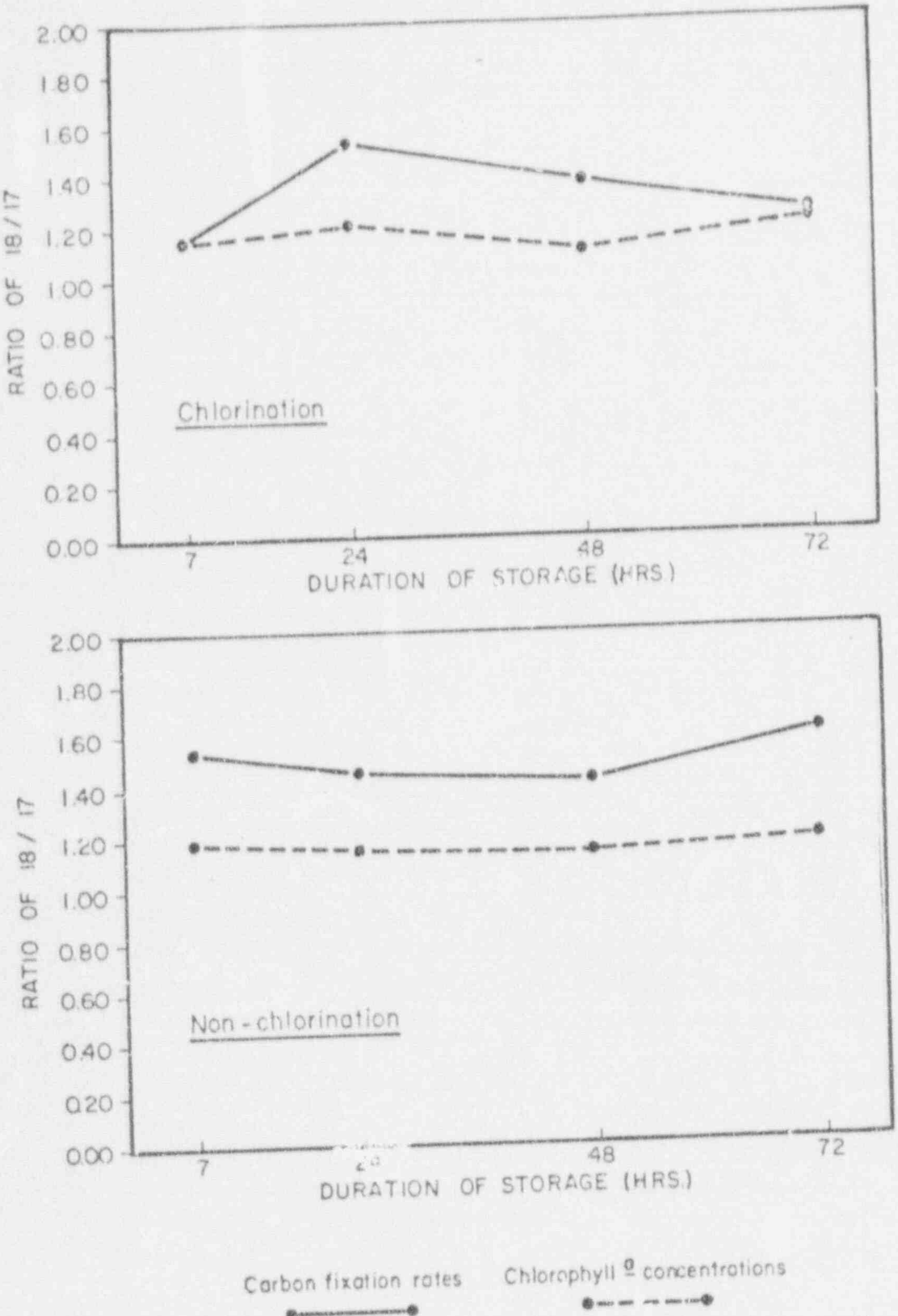

Figure 8. Mean ratios of phytoplankton productivity (carbon fixation rate) and chlorophyll a concentration for Location 18 (west downstream)/ 17 (west upstream), Quad-Cities Station, February-July 1973.

Table 5. Comparison of mean carbon fixation rates and chlorophyll a concentrations between sampling locations at Quad-Cities Station, August 1972-January 1973.

	Hour	4 (Intake)	7 (Discharge)	Significant (P < 0.05)	15 (East Upstream)	16 (East Downstream)	Significant (P < 0.05)	17 (West Upstream)	18 (West Downstream)	Significant (P < 0.05)
1972: mg C/m³/hr										
8-11 August C	3	13.18	1.90	[illegible]	17.65	16.76	No	19.18	12.52	Yes
	7	14.12	2.48	Yes	19.81	18.76	No	18.67	31.78	No
	24	20.78	3.76	Yes	29.74	27.26	No	21.11	23.52	Yes
	48	25.55	4.09	Yes	26.89	30.82	No	31.36	32.38	No
	72	27.32	4.17	Yes	37.91	41.85	Yes	29.93	38.19	Yes
22-25 August NC	3	21.16	23.15	No	23.61	28.23	No	26.17	56.61	Yes
	7	27.52	25.61	No	25.86	26.88	No	22.57	88.55	Yes
	24	39.53	44.56	No	62.77	46.92	No	45.79	175.18	Yes
	48	68.26	98.85	Yes	77.23	81.16	No	90.16	294.82	Yes
	72	90.29	138.90	Yes	81.22	152.42	Yes	146.14	267.89	Yes
5-8 September C	3	26.53	2.48	[illegible]	29.21	31.67	No	21.17	26.89	Yes
	7	25.67	1.81	Yes	30.23	34.38	No	33.18	22.45	Yes
	24	30.49	1.98	Yes	35.42	39.63	Yes	36.72	34.52	Yes
	48	44.32	3.71	Yes	39.17	[illegible]	No	41.05	[illegible]	Yes
	72	59.93	6.06	Yes	48.63	67.35	Yes	44.82	[illegible]	Yes
19-22 September NC	3	7.89	8.44	No	8.66	11.08	No	7.88	12.46	Yes
	7	10.67	11.11	No	11.31	15.61	Yes	11.38	15.65	Yes
	24	11.75	16.96	Yes	15.22	18.16	Yes	15.69	21.78	Yes
	48	19.87	28.47	Yes	26.35	29.62	Yes	25.76	34.58	Yes
	72	24.65	31.93	Yes	31.62	36.57	Yes	30.17	43.21	Yes
3-6 October C	3	15.09	7.68	Yes	20.68	24.36	Yes	14.21	16.66	No
	7	19.85	4.81	Yes	22.42	27.72	Yes	15.54	19.25	Yes
	24	21.39	3.93	Yes	28.35	35.09	Yes	16.95	19.91	No
	48	29.30	3.53	Yes	30.27	45.35	Yes	17.83	30.21	Yes
	72	35.02	3.49	Yes	32.73	49.30	Yes	21.70	36.4[illegible]	Yes
17-20 October NC	7	46.12	43.94	No	43.73	49.24	Yes	48.15	49.21	No
	24	30.61	25.86	No	29.62	38.65	Yes	31.78	29.57	No
	48	33.66	29.94	Yes	32.61	39.75	Yes	36.46	33.08	Yes
	72	48.27	45.31	No	51.09	71.61	Yes	62.78	41.05	No
7-10 November NC	7	15.76	16.27	No	16.26	16.67	No	11.56	19.60	Yes
	24	7.37	6.65	No	7.34	7.35	No	5.75	6.22	No
	48	6.95	6.90	No	7.63	6.86	No	6.25	5.73	No
	72	8.09	8.62	Yes	8.40	8.56	No	6.37	6.65	No
28 November-1 December C	7	17.49	8.27	Yes	35.81	35.40	Yes	17.87	35.97	Yes
	24	13.66	8.13	Yes	15.59	16.91	No	6.60	13.89	Yes
	48	13.83	4.09	Yes	16.17	19.78	Yes	4.63	17.14	Yes
	72	22.87	8.11	Yes	24.41	23.36	Yes	16.96	22.31	Yes
6-9 December C	7	17.18	8.16	Yes	b	b		b	b	
	24	57.57	7.95	Yes	b	b		b	b	
	48	18.50	8.18	Yes	b	b		b	b	
	72	27.80	8.12	Yes	b	b		b	b	
1973: 18-21 December NC	7	33.83	43.77	Yes	31.24	42.29	Yes	22.28	24.13	No
	24	9.61	10.18	No	11.19	13.44	No	7.76	10.23	Yes
	48	14.66	12.28	No	12.67	15.25	No	16.37	9.11	No
	72	21.95	26.58	Yes	31.48	35.17	No	22.95	25.82	No
9-12 January C	7	4.43	0.07	Yes	4.45	5.09	Yes	1.43	2.82	No
	24	3.27	0.03	Yes	3.80	3.45	No	1.25	1.49	No
	48	4.19	0.05	Yes	3.81	6.06	Yes	1.76	1.98	No
	72	6.73	0.06	Yes	7.15	9.35	Yes	2.09	3.34	Yes
23-26 January NC	7	.63	1.67	No	1.40	1.41	No	1.00	1.85	No
	24	1.72	1.37	Yes	1.52	1.24	Yes	0.80	1.18	Yes
	48	2.27	1.12	Yes	2.06	2.39	Yes	1.15	1.71	Yes
	72	4.15	1.41	Yes	1.84	3.38	Yes	2.58	2.13	Yes
1972: mg [illegible]/m³										
8-11 August C	3	8.87	6.73	No	7.27	6.93	No	7.13	7.80	No
	7	6.87	8.00	No	7.47	7.84	No	7.27	9.00	No
	24	11.33	5.48	Yes	7.73	8.80	No	9.80	8.73	No
	48	8.07	6.73	Yes	11.33	11.87	No	6.73	13.52	Yes
	72	10.67	3.33	Yes	9.93	12.20	No	13.53	16.40	No
22-25 August NC	3	5.40	6.33	No	6.40	10.60	No	6.20	52.67	Yes
	7	9.80	16.87	No	6.93	17.87	No	11.47	76.00	Yes
	24	[illegible]	17.33	No	15.00	16.67	No	17.33	47.33	Yes
	48	20.00	46.00	No	20.00	35.13	No	48.00	140.00	Yes
	72	20.67	50.67	No	29.33	63.33	No	62.67	81.33	Yes
5-8 September C	3	9.47	5.73	Yes	11.47	10.67	No	[illegible]	7.73	No
	7	8.67	7.40	No	12.53	12.40	No	10.67	10.13	No
	24	15.53	5.93	Yes	15.73	15.87	No	11.73	12.20	No
	48	27.33	5.20	Yes	21.33	21.37	No	17.13	21.73	Yes
	72	42.67	4.00	Yes	20.67	26.67	No	24.67	31.33	Yes
19-22 September NC	3	5.87	6.00	No	6.40	6.73	No	5.93	6.20	No
	7	9.33	8.13	No	8.47	8.13	No	7.80	8.47	No
	24	10.47	11.53	No	11.20	11.13	No	10.13	[illegible]	No
	48	9.67	15.93	Yes	16.33	16.07	No	13.13	16.87	Yes
	72	22.00	24.00	No	15.40	12.80	Yes	14.87	25.13	Yes
3-6 October C	3	11.20	8.33	Yes	9.67	9.33	No	8.53	8.33	No
	7	8.47	9.80	No	11.00	10.00	No	9.80	10.00	No
	24	11.67	6.40	Yes	11.73	11.13	Yes	9.47	8.67	No
	48	14.47	8.33	Yes	15.87	17.60	Yes	9.00	13.67	Yes
	72	22.80	5.73	Yes	22.00	22.80	No	13.13	16.27	Yes
17-20 October NC	7	14.80	14.00	d	12.53	10.33	d	12.47	12.47	d
	24	13.73	13.80	d	14.53	17.33	d	14.87	15.20	d
	48	22.67	22.00	d	22.00	22.67	d	23.80	22.67	d
	72	31.33	38.67	d	29.13	30.00	d	31.13	20.67	d
7-10 November NC	7	7.87	7.00	No	7.87	7.67	No	5.40	5.53	No
	24	[illegible]	6.80	No	7.40	6.93	No	5.47	6.40	No
	48	7.60	7.00	No	7.00	6.93	Yes	5.67	5.60	No
	72	7.40	6.20	No	6.27	6.67	Yes	5.40	5.73	No
28 November-1 December C	7	23.13	23.13	No	22.00	20.67	No	10.67	17.27	Yes
	24	24.00	14.20	Yes	23.33	22.67	No	11.53	19.87	Yes
	48	24.00	[illegible].87	[illegible]	22.67	22.67	No	11.47	22.67	Yes
	72	[illegible].67	3.13	Yes	22.27	42.67	No	11.00	21.33	Yes
6-9 December C	7	35.33	36.67	No	b	b		b	b	
	24	44.00	31.33	Yes	b	b		b	b	
	48	79.00	[illegible].67	Yes	b	b		b	b	
	72	[illegible].67	5.73	Yes	b	b		b	b	
18-21 December NC	7	[illegible]	15.33	No	18.13	18.60	No	[illegible]	15.33	No
	24	21.13	19.60	No	19.60	17.27	Yes	[illegible].93	13.83	No
	48	22.33	22.13	No	19.93	19.23	No	[illegible].00	17.27	Yes
	72	26.00	22.87	Yes	21.50	22.29	No	16.89	18.60	No
1973: 9-12 January C	7	[illegible].27	4.60	No	4.33	5.47	Yes	1.92	2.00	No
	24	6.00	1.93	Yes	3.87	4.29	No	1.12	1.87	Yes
	48	5.73	2.60	Yes	5.00	5.47	No	1.00	2.33	No
	72	7.87	1.00	Yes	6.60	7.40	Yes	2.45	2.93	No
23-26 January NC	7	4.13	2.93	No	2.00	2.87	No	2.20	3.27	No
	24	2.87	2.67	No	2.53	2.47	No	1.93	2.33	Yes
	48	[illegible]	2.53	Yes	2.00	2.60	No	2.00	2.00	No
	72	[illegible].87	3.07	[illegible]	3.13	3.33	No	2.33	2.53	No

a Mean of four subsamples.
b Sample not obtained.
c Mean of three subsamples.
d Mean [illegible] from which [illegible] demonstrated no significant difference between locations for all hours.
C = Samples obtained during chlorination.
NC = Samples obtained during non-chlorination.

Table 6. Comparison of mean carbon fixation rates between sampling locations during chlorination (C) and non-chlorination (NC), Quad-Cities Station, February-July 1973.

	Hours	6 (Intake)	7 (Discharge)	Significant ($P < 0.05$)	15 (East Upstream)	20 (East Downstream)	Significant ($P < 0.05$)	17 (West Upstream)	18 (West Downstream)	Significant ($P < 0.05$)
mg C/m³ per hr[a]										
13-16 February (C)	7	5.20	0.07	Yes	4.21	4.65	Yes	1.74	3.79	Yes
	24	5.10	0.07	Yes	4.85	3.95	Yes	1.51	3.45	Yes
	48	5.61	0.05	Yes	4.87	4.75	No	1.42	3.25	Yes
	72	6.43	0.06	Yes	6.11	4.54	Yes	1.66	3.24	Yes
20-23 February (NC)	7	4.78	4.84	No	4.54	6.39	Yes	2.56	4.05	Yes
	24	4.69	4.09	No	4.46	5.78	Yes	2.28	3.26	Yes
	48	4.59	3.41	Yes	4.34	4.13	No	1.68	2.99	Yes
	72	5.81	6.28	No	6.29	9.34	Yes	2.49	4.75	Yes
6-9 March (NC)	7	10.09	10.52	No	10.35	11.40	No	2.06	6.43	Yes
	24	11.84	12.81	No	11.55	13.82	No	2.71	8.16	Yes
	48	14.47	14.63	No	14.91	15.16	No	3.40	7.85	Yes
	72	22.35	23.24	No	22.83	25.15	Yes	4.56	15.13	Yes
20-23 March (C)	7	6.79	0.22	Yes	6.23	6.67	No	4.13	4.31	No
	24	6.02	0.13	Yes	6.02	5.26	Yes	3.22	4.39	Yes
	48	6.89	0.09	Yes	6.19	7.27	Yes	3.94	4.19	No
	72	10.06	0.13	Yes	9.78	10.07	No	5.10	5.82	Yes
3-6 April (C)	7	51.85	0.40	Yes	42.85	51.04	No	42.38	50.19	No
	24	72.07	0.03	Yes	70.21	79.15	No	64.81	79.14	No
	48	106.51	0.06	Yes	100.32	135.11	Yes	81.72	113.20	Yes
	72	127.40	0.63	Yes	129.87	155.51	Yes	120.24	139.82	Yes
10-13 April (NC)	7	65.59	62.02	No	57.40	63.63	No	54.87	65.31	Yes
	24	51.09	51.69	No	50.29	47.55	No	44.55	44.12	No
	48	65.61	61.94	No	62.83	56.82	No	52.08	50.87	No
	72	100.75	99.27	No	99.21	108.16	No	89.29	86.50	No
8-11 May (C)	7	270.32	39.55	Yes	215.64	298.02	Yes	299.65	236.50	Yes
	24	177.38	33.70	Yes	179.27	267.68	Yes	191.47	209.29	No
	48	198.06	19.77	Yes	221.29	257.33	Yes	214.39	261.23	Yes
	72	271.04	22.51	Yes	296.99	395.55	Yes	324.88	351.38	No
22-25 May (NC)	7	153.91	156.50	No	160.31	193.89	Yes	170.69	180.35	No
	24	171.22	193.99	Yes	155.43	201.31	Yes	164.03	197.24	Yes
	48	196.40	201.20	No	192.36	255.07	Yes	205.52	220.27	No
	72	178.75	201.61	Yes	192.29	237.05	Yes	203.68	245.06	Yes
5-8 June (C)	7	159.60	113.27	Yes	174.79	238.32	Yes	202.41	221.46	No
	24	156.16	141.41	No	169.52	222.33	Yes	177.30	243.32	Yes
	48	174.30	214.80	Yes	176.96	243.58	Yes	191.50	233.70	Yes
	72	192.48	254.02	Yes	191.98	241.96	Yes	209.36	252.08	Yes
26-29 June (NC)	7	156.45	99.63	Yes	117.09	162.90	Yes	122.69	141.26	No
	24	158.20	128.38	Yes	125.34	168.55	Yes	120.66	124.67	No
	48	283.64	253.58	Yes	221.38	287.93	Yes	227.79	267.42	Yes
	72	361.37	386.71	No	308.66	404.25	Yes	293.34	334.82	Yes
10-13 July (C)	7	157.79	3.70	Yes	165.11	145.19	No	159.70	114.16	Yes
	24	205.78	6.50	Yes	216.50	54.25	Yes	213.01	59.33	Yes
	48	269.45	15.50	Yes	307.75	459.95	Yes	332.70	390.39	Yes
	72	240.40	23.66	Yes	236.55	542.80	Yes	392.09	398.32	No
24-27 July (NC)	7	66.67	60.91	No	62.58	68.83	No	[illegible]	60.02	No
	24	114.44	114.71	No	112.64	122.66	No	98.67	99.69	No
	48	253.93	262.53	No	220.25	295.32	Yes	246.74	229.83	Yes
	72	585.75	624.01	Yes	463.96	647.04	Yes	562.83	604.63	Yes

[a] Mean of four subsamples.

Table 7. Comparison of mean chlorophyll a concentrations between sampling locations during chlorination (C) and non-chlorination (NC), Quad-Cities Station, February-July 1973.

	Hours	6 (Intake)	7 (Discharge)	Significant ($P < 0.05$)	15 (East Upstream)	20 (East Downstream)	Significant ($P < 0.05$)	17 (West Upstream)	18 (West Downstream)	Significant ($P < 0.05$)
mg chl a/m³[a]										
13-16 February (C)	7	3.07	4.00	Yes	2.93	2.13	Yes	1.24	2.33	Yes
	24	3.67	2.60	Yes	3.20	2.53	Yes	1.22	2.47	Yes
	48	4.40	1.00	Yes	3.80	3.13	Yes	1.30	2.93	Yes
	72	4.93	0.92	Yes	4.67	3.60	Yes	1.58	3.40	Yes
20-23 February (NC)	7	4.40	3.60	Yes	3.33	2.73	Yes	2.00	2.47	Yes
	24	3.80	3.80	No	3.53	3.67	No	2.13	2.47	No
	48	4.13	4.13	No	4.13	4.13	No	2.33	2.73	No
	72	5.00	4.47	Yes	4.73	4.53	No	2.47	3.33	Yes
6-9 March (NC)	7	9.67	11.13	No	9.80	8.53	No	2.87	5.40	Yes
	24	10.47	11.80	No	9.80	8.60	No	3.20	5.53	Yes
	48	11.87	11.00	No	3.47	9.67	No	3.87	5.73	Yes
	72	14.33	15.53	No	14.53	13.53	No	4.33	5.93	Yes
20-23 March (C)	7	4.87	4.47	No	5.40	4.20	Yes	4.13	3.73	No
	24	4.60	4.13	No	4.47	4.20	No	3.27	4.33	Yes
	48	5.53	3.67	Yes	5.07	4.53	No	4.20	3.53	Yes
	72	6.53	2.33	Yes	7.40	2.00	Yes	4.20	5.00	Yes
3-6 April (C)	7	28.00	33.33	No	30.00	26.67	No	24.00	25.33	No
	24	37.33	16.00	Yes	35.33	31.33	No	29.33	29.33	No
	48	44.67	6.33	Yes	47.33	39.33	Yes	40.67	38.67	No
	72	60.67	3.20	Yes	60.00	58.67	No	57.33	52.00	No
10-13 April (NC)	7	36.00	32.00	No	29.33	25.33	No	30.00	28.67	No
	24	37.33	44.00	No	37.33	34.67	No	33.33	33.33	No
	48	41.33	41.33	No	39.33	52.00	Yes	36.00	41.33	No
	72	64.00	67.33	Yes	65.33	55.33	Yes	60.67	64.67	No
8-11 May (C)	7	60.00	55.33	No	50.00	54.00	No	52.67	49.33	No
	24	62.00	46.00	Yes	53.33	43.67	No	56.00	57.33	No
	48	65.33	45.33	Yes	72.00	62.67	No	60.00	48.67	No
	72	135.33	42.00	Yes	45.33	105.33	No	81.33	100.00	Yes
22-25 May (NC)	7	44.67	41.33	No	42.00	36.00	No	38.67	34.00	No
	24	48.00	53.33	No	42.00	48.00	No	46.67	35.33	No
	48	90.00	78.67	Yes	72.00	64.67	No	64.67	62.67	No
	72	142.67	126.00	Yes	112.00	114.67	No	114.00	100.00	Yes
5-8 June (C)	7	72.00	44.67	Yes	64.67	58.00	No	46.00	46.00	No
	24	85.33	62.67	Yes	83.33	86.00	No	79.33	76.67	No
	48	124.00	99.33	Yes	123.33	112.67	No	107.33	102.00	No
	72	182.67	168.00	No	152.00	140.00	No	137.33	144.67	No
26-29 June (NC)	7	10.00	7.87	No	5.07	6.00	No	5.07	5.73	No
	24	10.40	8.53	No	7.07	7.73	No	6.53	7.20	No
	48	17.60	14.27	Yes	12.53	1.60	No	10.66	11.47	No
	72	29.73	30.93	No	18.13	23.87	Yes	22.67	22.40	No
10-13 July (C)	7	28.00	7.60	Yes	26.00	20.67	No	21.33	20.00	No
	24	47.33	2.67	Yes	47.33	38.00	Yes	36.00	36.00	No
	48	67.33	2.20	Yes	67.33	70.00	No	69.33	57.33	Yes
	72	102.67	2.00	Yes	104.67	102.67	No	86.00	62.67	Yes
24-27 July (NC)	7	13.33	11.33	No	12.00	10.67	No	10.00	10.00	No
	24	20.67	23.33	No	22.00	21.33	No	15.67	18.00	No
	48	53.33	48.67	No	50.67	42.00	Yes	38.00	36.00	No
	72	118.67	120.00	No	88.67	92.67	No	79.33	90.00	Yes

[a]Mean of three subsamples.

2. Upstream (Locations 15 and 17) - Downstream (Locations 18 and 20) Comparisons

During full open-cycle cooling, an overall stimulatory effect on phytoplankton was measured in the river downstream of the diffuser pipe that was not interpreted as a negative influence. Mean values for carbon fixation rates, chlorophyll a concentrations and phytoplankton abundances during chlorination and non-chlorination were compared for Locations 7 (discharge), 6 (intake), 20 (east downstream), 15 (east upstream), 18 (west downstream), and 17 (west upstream). Ratios less than 1.0 indicate reduction of carbon fixation rate, chlorophyll a concentration, or phytoplankton abundance at these locations. These data are summarized for the period August 1972 through January 1973 in Figures 3, 4 and 5 and for February through July 1973 in Figures 6, 7 and 8. No trends of significant differences ($P \leq 0.05$) in phytoplankton productivity and chlorophyll a concentrations were observed during the period August 1972 to January 1973, between river locations immediately upstream (Locations 15 and 17) and downstream (Locations 18 and 20) of the diffuser pipes (see Figures 4 and 5 as examples). Many of the significant differences that were identified during this period between upstream and downstream locations may be attributed to non-homogeneity of phytoplankton populations between locations.

Significant stimulation of phytoplankton productivity ($P \leq 0.05$) was observed after 72 hours of storage for Location 20 (east downstream) as compared with Location 15 (east upstream) during August, September and October of 1972 (Table 3). No trends of significant differences were

observed between Locations 17 (west upstream and 18 (west downstream) for phytoplankton productivity during the period August 1972 through January 1973. The occasional significant differences that were observed between these locations during this period may be attributed to non-homogeneity of phytoplankton and influence of the Wapsipinicon River.

Comparison of productivity data collected during periods of non-chlorination at locations upstream from the Station with similar data from downstream locations showed a mean phytoplankton productivity stimulation of 25.4% actually occurred downstream of the diffuser pipe system. The stimulation was pronounced during February and early March when ambient river temperatures ranged from 0-3 C (32-37.4 F). Similar studies by Morgan and Stross (1969) indicated stimulation of productivity when ambient water temperatures were 16 C (60.8 F) or lower. Similarities in the number of species, abundance of phytoplankton and chlorophyll a concentrations among upstream and downstream locations indicate that the downstream stimulation response was not a result of sampling non-homogeneous phytoplankton populations, but may be attributed to Station operation. This result is not interpreted as a negative influence on the river.

A summary of the predicted inhibition and/or stimulation of river phytoplankton resulting from entrainment by the Station operation is presented in Table 8. The percentage of the river used for condenser cooling at the Quad-Cities Station varied seasonally. The lowest river flow encountered during the study occurred on December 6, 1972. At this time the flow through the plant, expressed as a percent of total river flow, was 9%. In contrast, during highest river flow

Table 8

TOTAL EFFECTS OF QUAD-CITIES STATION ON THE VIABILITY OF PHYTOPLANKTON IN THE MISSISSIPPI RIVER, FEBRUARY-JULY 1973

Date	Average River Flow at Lock & Dam #14 (cfs)	% River Flow through Quad-Cities Station	% Inhibition(-) or % Stimulation(+) of Phytoplankton Productivity[a] Predicted by % Volume of River Passing through the Station[b]	% Inhibition(-) or % Stimulation(+) of Phytoplankton Productivity[a] at Downstream Locations when Compared with Upstream Locations[c]
1972				
5 Sep.	81,300	2.5	-2.3	-11.0
19 Sep.	57,800	3.6	+0.2	+35.0
[illegible] Oct.	88,000	2.4	-1.8	+24.0
17 Oct.	59,500	3.5	-0.2	+77.0
7 Nov.	75,900	2.8	+0.1	+12.0
28 Nov.	59,400	3.5	-3.5	+43.0
6 Dec.	23,300	9.0	-4.8	d
18 Dec.	34,100	6.2	+2.0	+24.0
1973				
9 Jan.	47,000	4.5	-4.5	+17.0
23 Jan.	67,500	3.1	-0.3	+3.0
13 Feb.	41,700	5.0	-5.[illegible]	+54.0
20 Feb.	34,100	6.2	-0.5	+48.0
6 Mar.	61,600	3.4	-0.0	+100.0
20 Mar.	181,400	1.2	-1.2	+9.0
3 Apr.	135,800	1.5	-1.5	+23.0
10 Apr.	124,000	1.7	-0.1	+2.0
8 May	125,400	1.7	-1.5	+19.0
22 May	124,200	1.7	-0.0	+20.0

Table 8 (Cont.)

Date	Average River Flow at Lock & Dam #14 (cfs)	% River Flow through Quad-Cities Station	% Inhibition(-) or % Stimulation(+) of Phytoplankton Productivity[a] Predicted by % Volume of River Passing through the Station[b]	% Inhibition(-) or % Stimulation(+) of Phytoplankton Productivity[a] at Downstream Locations when Compared with Upstream Locations[c]
5 June	134,600	1.6	-0.0	+20.0
26 June	65,200	3.2	-0.5	+23.0
10 July	47,300	4.4	-4.2	-2.0
24 July	36,500	5.8	-0.0	+17.0
7 Aug.	33,200	6.3	+1.3	+4.0
21 Aug.	42,600	4.9	-4.7	+18.0
Mean	74,246	3.7	-1.6	+25.4

[a] Based on carbon fixation rate

[b] Based on condenser effect at Location 7

[c] Based on data from Locations 18 and 20 vs. Locations 15 and 17

[d] Not measured

(March 20, 1973) only 1.2% of the river flow passed through the plant. The mean percentage flow through the plant during the study was computed as 3.7%. The effect of the Quad-Cities Station on Mississippi River plankton was predicted by multiplying the condenser effects in the discharge bay by the fraction of river passing through the Station (Table 8).

Using this procedure, mean productivity of phytoplankton in the river might be inhibited 1.6% during a twelve month sampling period (Table 8). Maximum inhibition of productivity would be expected to occur when total chlorine levels are highest while inhibition of productivity would be negligible during periods of non-chlorination. However, the actual downstream experience showed enhanced productivity, as discussed in Section B.2 above.

3. Calculated Impact on Total River Population Comparison of Effects: Side-Jet Discharge vs. Diffuser Pipe Discharge

Studies conducted during operation of the side-jet discharge indicated decreases in phytoplankton productivity and chlorophyll a concentration at Locations 7 and 20 (east downstream), and in phytoplankton abundance at Location 7, during chlorination. However, the studies indicated stimulation of phytoplankton productivity at Location 7 during non-chlorination.

Although no significant changes served at Location 7 after start-up of the diffuser pipe, no decrease in phytoplankton productivity was observed at Location 20 (east downstream) during chlorination, indicating good dilution capabilities of the diffuser pipe discharge system. Moreover, stimulation however of phytoplankton productivity, was observed at Location 20 during some periods of both chlorination and non-chlorination.

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316b Demonstration

April, 1975

(31 pages)

AN EVALUATION OF THE

QUAD-CITIES STATION

OF COMMONWEALTH EDISON CO.

FOR A 316 (b) DEMONSTRATION

Prepared by:

Commonwealth Edison Co.
Chicago, Illinois

April 1975

TABLE OF CONTENTS

I. INTRODUCTION

This report presents a review of the effects of impingement on the aquatic biota of Pool 14 of the Mississippi River resulting from the once-through condenser cooling water operation of Commonwealth Edison's Quad-Cities Generating Station for the purpose of providing as much information and documentation as possible within a limited time framework to permit U. S. EPA, Region V, to make its determination pursuant to § 316 (b) of the Federal Water Pollution Control Act of 1972. The Quad-Cities Station is a nuclear fueled steam electric generating facility that began operation in April 1972. It consists of two units, each with a thermal output of 2,511 megawatts thermal (MWt) or 809 megawatts net electrical (MWe).

The Station is located in Rock Island County on the east bank of the Mississippi River in Pool 14 about 3 miles north of Cordova, Illinois and about 20 miles northeast of the Rock Island, Moline, Davenport, Bettendorf area and about 7 miles southwest of Clinton, Iowa. Pool 14 is about 29 miles in length and encompasses the area of the Mississippi River between lock and dam 14 at river mile 493.3, about 5 miles north of Bettendorf, Iowa and lock and dam 13 at river mile 522.5, about 2 miles north of Clinton, Iowa. The total acreage of the pool is approximately [illegible],200 acres.

Cooling-water intake for the condensers of both units is provided by an intake canal extending into the river. The canal is approximately 235 ft. long, 180 ft. wide, and 12 ft. deep at the point of juncture with the river. At the Station's maximum cooling water flow rate of 2,270 cfs, the entrance velocity to the intake canal is less than one foot per second. A floating

boom which extends 33 inches beneath the surface operates at the mouth of the canal to deflect material. Between the floating boom and the condensers there is a trash rack composed of vertical metal bars spaced approximately 3 inches apart which extend from about 20 feet above the water line to the bottom of the intake canal. Immediately behind the trash rack are the traveling screens with a mesh size of 3/8". These screens change positions at preset time intervals or when activated by a buildup of pressure due to the collection of debris. The screens collect the smaller bits of debris that pass through the trash racks and also prevent organisms larger than the mesh from passing through the pumps and condensers.

At low river flow with all six intake pumps operational, maximum intake velocity at the traveling screens would be approximately 1.85 feet per second. At higher river flows or with operation of fewer intake pumps intake velocities are correspondingly lower. Calculated mean intake velocity with all intake pumps operating is 1.55 feet per second.

Commonwealth Edison Company believes that the biological data which has been collected during intensive studies conducted over the past two years clearly demonstrates that impingement at the Quad-Cities Station has not caused appreciable harm to aquatic communities in the Mississippi River in the vicinity of the Station, and will not cause any such harm in the future.

1

IMAGE EVALUATION TEST TARGET (MT-3)

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

A. Methods and Background

The impingement study was undertaken to determine the weight, size, number and species of fish species impinged on the traveling screens at the Quad-Cities Station and subsequently to evaluate the effects of this impingement on Pool 14 of the Mississippi River.

Fish or other materials impinged by the intake current onto the 3/8" square mesh traveling screens are washed off into trash baskets. On collection dates the trash baskets contained fishes and debris accumulated over a 24 hour period. Collections were made twice per week. Fish species were identified and counted, and size ranges, mean size ranges and total weights were recorded.

In order to determine the magnitude of fish impinged at the Station, intensive studies of trash basket contents were instituted in January 1973.

There are a number of conditions that must be considered when interpreting the results of trash basket samples. Initially, small (5/8" square) mesh baskets were used to collect fishes. Most of the fishes impinged on traveling screens were too large to pass through the small mesh baskets and would have been retained in collections except that accumulation of leaves and debris often caused the baskets to overflow. Since heavy equipment was necessary for the removal of the trash baskets and a limited number of qualified Station personnel were available, it was not possible to remove trash baskets any more frequently than at 24 hour intervals. The loss of fish which resulted from the overflow would have made it impossible to determine the actual number of fish impinged during the 24 hour period of the study. Thus it

became necessary to utilize large (3 3/4" x 1") mesh baskets which were not easily clogged over the 24 hour sampling period. However, the evaluation of large mesh basket collections must take into consideration the fact that smaller fishes were not as well represented in the "large mesh" trash basket counts.

Other factors that must be taken into account are hydrological conditions, seasonal variation and spray canal operation which affect the behavior of the various fish species and influence the fish impingement collections. These factors will be discussed in more detail below.

B. Attempts to Reduce Fish Impingement

During 1974 efforts were made to develop methods to decrease the number of fish impinged on the traveling screens. Two systems were tested: (a) an underwater sound system and (b) a bubble screen. Both of these systems were located at the mouth of the intake bay. The primary function of both systems was to discourage fishes from entering the intake bay.

The underwater sound system consisted of four speakers situated on the pilings at mid-depth in the mouth of the intake bay. The depth of the speakers was adjustable so that mid-depth position could be maintained during fluctuating water levels. A continuous playing tape track was installed in the laboratory adjacent to the intake bay. The sound played through the speakers was that of a "pile driver." The underwater system was operational from March 1, 1974 through August 31, 1974 when it became evident that its operation was having no effect on the number of fish impinged (Table 11).

The "bubble screen" system became operational on June 1, 1974 and was continued through December 31, 1974. It had been hypothesized that

the disturbance caused by a swift rising curtain of bubbles produced by forcing compressed air through tiny apertures in a 2" diameter PVC plastic pipe positioned across the entire mouth of the intake bay would deter fish from entering the bay. Data collected during the "bubble screen" operation was variable (Table 11). It is doubtful that "bubble screen" operation resulted in decreased impingement numbers. Consequently, the use of the "bubble screen" was discontinued in December 1974.

C. Results of 1973 Impingement Collections

Results of counts, weights and percent occurrence of fishes collected in the intake trash baskets during 1973 are presented in Table 9. A total of 128,159 fishes were collected from the traveling screens. Total numbers of fishes and numbers of species varied considerably from day to day. During the period April through September 1973 large and small mesh basket samples were collected. The total number and weight of fish collected varied considerably between the two mesh sizes (Tables 12 and 13). On the average, small mesh collections contained twice as many fishes by weight and four times as many fishes by number as comparable large mesh collections. These results indicate that many small fishes pass through the large mesh screens, resulting in a variable that must be taken into consideration when evaluating large mesh basket collections.

Gizzard shad represented 74.9% of the total numerical catch; freshwater drum 8.2%; crappies 3.9%; carp 3.7%; buffaloes 2.9%; white bass 2.5%; mooneye 1.0%; channel catfish and bluegill 0.9% each with 44 additional species making up the remaining 1.1%. Weights of impinged fish were recorded from March through December 1973. The bulk of the catch by weight was composed of gizzard shad which represented

Table 1

NUMBERS, TOTAL WEIGHT AND PERCENT OCCURRENCE OF FISHES REMOVED FROM THE TRAVELING INTAKE SCREENS AND DEPOSITED IN THE TRASH BASKET DURING 1973

Species	Jan. large[a] (9)	Jan. small (0)	Feb. large (8)	Feb. small (0)	Mar. large (11)	Mar. small (0)	Apr. large (2)	Apr. small (4)	May large (4)	May small (5)	June large (5)	June small (2)	July large (6)	July small (2)
Silver lamprey	3	--[c]	1	--	4	--	0	3	0	1	2	1	0	0
American eel	0	--	0	--	0	--	0	0	0	0	0	0	0	0
Shovelnose sturgeon	0	--	0	--	0	--	0	0	0	0	0	0	3	0
Paddlefish	2	--	10	--	5	--	0	2	0	1	1	0	0	0
Longnose gar	3	--	4	--	9	--	4	3	3	1	2	1	7	6
Shortnose gar	3	--	8	--	17	--	4	0	0	1	1	0	5	2
Bowfin	0	--	0	--	1	--	1	2	0	3	0	63	8	2
Gizzard shad	1,017	--	265	--	131	--	22	700	8	27	180	1,933	1,186	2,053
Mooneye	33	--	121	--	404	--	15	176	77	114	84	6	18	26
Central mudminnow	0	--	0	--	2	--	0	1	0	2	1	1	1	1
Grass pickerel	0	--	1	--	0	--	0	3	0	1	1	0	3	0
Northern pike	1	--	1	--	2	--	2	0	0	2	8	23	20	9
Stoneroller	0	--	0	--	3	--	0	0	0	0	0	0	0	0
Carp	2	--	1	--	3	--	0	6	0	7	11	261	1,832	1,078
Silver chub	0	--	0	--	4	--	0	1	0	1	1	1	1	3
Golden shiner	0	--	0	--	0	--	0	2	0	0	1	2	3	2
Emerald shiner	0	--	0	--	0	--	0	0	0	4	1	10	4	7
River shiner	0	--	0	--	1	--	0	1	0	0	0	0	0	1
Spottail shiner	0	--	0	--	0	--	0	0	0	0	0	0	0	0
Sand shiner	0	--	0	--	0	--	0	0	0	1	0	0	0	0
Flathead minnow	0	--	0	--	0	--	0	0	0	0	0	0	0	0
River carpsucker	6	--	5	--	10	--	0	1	1	4	1	3	31	3
Quillback carpsucker	0	--	0	--	0	--	0	0	0	1	2	9	5	1
Highfin carpsucker	0	--	0	--	0	--	0	0	0	1	0	0	0	0
Blue sucker	0	--	0	--	0	--	0	0	0	0	0	1	0	0
Smallmouth buffalo	2	--	36	--	49	--	3	13	30	46	17	3	6	4
Bigmouth buffalo	1	--	3	--	1	--	1	2	1	1	78	323	0	3
Ictiobus sp. YOY	0	--	0	--	0	--	0	0	0	0	0	0	1,118	1,636

Table 1 (Cont.)

Species	Jan. large[a] (9)	Jan. small (0)	Feb. large (8)	Feb. small (0)	Mar. large (11)	Mar. small (0)	Apr. large (2)	Apr. small (4)	May large (4)	May small (5)	June large (6)	June small (2)	July large (6)	July small (2)
Spotted sucker	0	--	0	--	0	--	0	0	1	1	0	0	0	0
Moxostoma sp.	0	--	1	--	1	--	0	2	0	14	28	146	1	1
Black bullhead	0	--	0	--	77	--	2	24	1	19	5	9	24	40
Yellow bullhead	0	--	0	--	0	--	0	0	0	1	0	0	0	0
Channel catfish	48	--	87	--	62	--	3	6	9	23	7	8	27	49
Stonecat	0	--	0	--	0	--	0	2	0	3	1	1	0	3
Tadpole madtom	0	--	0	--	1	--	0	5	0	2	1	0	0	0
Flathead catfish	0	--	0	--	3	--	1	1	0	1	0	0	2	1
Brook silverside	0	--	0	--	1	--	0	0	0	0	0	0	0	0
Yellow bass	0	--	0	--	0	--	0	7	2	15	1	0	1	0
White bass	15	--	12	--	33	--	8	66	13	44	12	2	0	1,479
Green sunfish	0	--	0	--	0	--	0	0	1	4	1	1	0	0
Pumpkinseed	0	--	0	--	0	--	0	0	0	2	2	0	0	0
Warmouth	0	--	0	--	0	--	0	0	1	4	1	0	0	0
Orangespotted sunfish	0	--	0	--	0	--	0	0	1	4	3	8	0	5
Bluegill	0	--	0	--	17	--	7	42	36	377	70	330	45	38
Largemouth bass	0	--	0	--	0	--	1	1	1	6	7	30	2	9
Smallmouth bass	0	--	0	--	0	--	0	0	0	0	27	1	0	0
White crappie	4	--	4	--	7	--	3	2	9	21	59	19	252	15
Black crappie	1	--	11	--	41	--	6	63	5	22	0	55	302	225
Pomoxis sp. YOY	0	--	0	--	0	--	0	0	0	0	0	0	0	915
Yellow perch	0	--	0	--	2	--	0	0	1	2	0	0	0	0
Logperch	0	--	0	--	2	--	0	1	0	1	1	0	1	0
River darter	0	--	0	--	0	--	0	2	0	2	0	0	1	0
Sauger	1	--	2	--	21	--	0	0	0	0	7	9	4	1
Walleye	0	--	0	--	2	--	0	0	0	0	1	1	1	0
Freshwater drum	212	--	400	--	750	--	192	2,081	166	237	127	22	204	673
Total No.	1,354	--	973	--	1,666	--	275	3,221	367	1,024	753	3,275	5,118	8,291
Ang. No./day	150	--	122	--	151	--	138	805	92	205	126	1,638	853	4,146
Total Wt.(kg)	--	--	44.8[d]	--	170.4	--	43.5	158.8	55.4	66.2	69.2	23.6	60.7	40.0
Avg. Wt./day(kg)	--	--	9.0[e]	--	15.5	--	21.8	79.4	13.9	13.2	11.5	11.8	10.1	20.0
Avg. Wt./fish(g)	--	--	122	--	102	--	158	49	151	64.7	92	7	12	10

[a] Large mesh basket
[b] Small mesh basket
[c] Not sampled
[d] Weight not recorded before Feb. 14
[e] 5 days of sampling - 366 fish
[f] Less than 0.1%

Table 1 (Cont.)

Species	Aug. large (7)	Aug. small (2)	Sept. large (5)	Sept. small (1)	Oct. large (6)	Oct. small (0)	Nov. large (2)	Nov. small (0)	Dec. large (6)	Dec. small (0)	Totals large (72)	Totals small (16)	Total (88)	Percent Occurrence
Silver lamprey	0	0	0	0	0	--	1	--	0	--	11	5	16	--[f]
American eel	0	0	1	0	0	--	0	--	0	--	1	0	1	--
Shovelnose sturgeon	0	0	0	0	0	--	0	--	0	--	3	0	3	--
Paddlefish	1	0	0	0	0	--	0	--	0	--	19	3	22	--
Longnose gar	4	3	0	4	37	--	3	--	0	--	76	19	95	0.1
Shortnose gar	4	3	3	0	52	--	0	--	0	--	97	6	103	0.1
Bowfin	1	1	0	0	0	--	0	--	0	--	11	71	82	--
Gizzard shad	2,077	4,684	9,611	14,509	11,658	--	2,374	--	43,501	--	72,030	23,906	95,936	74.9
Mooneye	28	59	28	50	29	--	6	--	6	--	849	431	1,280	1.0
Central mudminnow	0	0	0	0	0	--	0	--	0	--	4	5	9	--
Grass pickerel	0	0	0	0	0	--	0	--	0	--	5	4	9	--
Northern pike	1	1	0	0	2	00	0	--	2	--	39	35	74	--
Stoneroller	0	0	1	0	0	--	0	--	0	--	4	0	4	--
Carp	112	1,081	6	12	254	--	15	--	4	--	2,240	2,445	4,685	3.7
Silver chub	3	5	5	9	7	--	2	--	0	--	23	20	43	--
Golden shiner	0	2	0	2	2	--	0	--	0	--	6	10	16	--
Emerald shiner	3	4	2	5	14	--	2	--	0	--	26	30	56	--
River shiner	1	1	3	1	1	--	0	--	0	--	6	4	10	--
Spottail shiner	0	0	0	0	1	--	0	--	0	--	1	0	1	--
Sand shiner	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Flathead minnow	0	0	0	0	0	--	1	--	0	--	1	0	1	--
River carpsucker	2	11	1	6	26	--	2	--	7	--	92	28	120	0.1
Quillback carpsucker	0	0	0	0	0	--	0	--	0	--	7	2	9	--
Highfin carpsucker	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Blue sucker	0	0	0	0	0	--	0	--	0	--	0	1	1	--
Smallmouth buffalo	11	105	20	45	50	--	4	--	9	--	237	216	453	0.4
Bigmouth buffalo	19	23	7	5	19	--	0	--	1	--	131	357	488	0.4
Ictiobus sp. YOY	0	0	0	0	0	--	0	--	0	--	1,118	1,636	2,754	2.1

Table 1 (Cont.)

Species	Aug. large (7)	Aug. small (2)	Sept. large (5)	Sept. small (1)	Oct. large (6)	Oct. small (0)	Nov. large (2)	Nov. small (0)	Dec. large (6)	Dec. small (0)	Totals large (72)	Totals small (16)	Total (88)	Percent Occurrence
											1	1	2	--
Spotted sucker	0	0	0	0	0	--	0	--	0	--	38	163	201	0.2
Moxostema sp.	3	0	0	0	4	--	0	--	0	--	205	158	363	0.3
Black bullhead	39	58	11	8	30	--	7	--	9	--	1	1	2	--
Yellow bullhead	0	0	0	0	1	--	0	--	0	--	722	422	1,144	0.9
Channel catfish	231	187	179	149	58	--	1	--	10	--	4	13	17	--
Stonecat	1	3	1	1	1	--	0	--	0	--	5	7	12	--
Tadpole madtom	0	0	0	0	2	--	1	--	0	--	9	3	12	--
Flathead catfish	1	0	0	0	2	--	0	--	0	--	1	0	1	--
Brook silverside	0	0	0	0	0	--	0	--	0	--	7	23	30	--
Yellow bass	1	1	1	0	0	--	0	--	1	--	488	2,768	3,256	2.5
White bass	140	1,089	30	88	182	--	27	--	16	--	2	5	7	--
Green sunfish	0	0	0	0	0	--	0	--	0	--	3	2	5	--
Pumpkinseed	1	0	0	0	0	--	0	--	0	--	2	4	[illegible]	--
Warmouth	0	0	0	0	0	--	0	--	0	--	8	19	27	--
Orangespotted sunfish	0	1	0	1	2	--	2	--	0	--	292	825	1,117	0.9
Bluegill	9	24	8	14	99	--	1	--	0	--	35	49	84	--
Largemouth bass	2	3	3	0	6	--	8	--	5	--	37	1	38	--
Smallmouth bass	0	0	0	0	0	--	0	--	10	--	450	95	545	0.4
White crappie	20	19	8	19	55	--	7	--	22	--	551	421	972	0.8
Black crappie	32	30	30	26	119	--	4	--	0	--	0	3,434	3,434	2.7
Pomoxis sp. YOY	0	2,519	0	0	0	--	0	--	0	--	3	2	5	--
Yellow perch	0	0	0	0	0	--	0	--	0	--	6	2	8	--
Logperch	0	0	0	0	2	--	0	--	0	--	1	4	5	--
River darter	0	0	0	0	0	--	0	--	0	--	44	10	54	--
Sauger	0	0	1	0	5	--	1	--	2	--	5	1	6	--
Walleye	1	0	0	0	0	--	0	--	0	--	5,587	4,946	10,533	8.2
Freshwater drum	305	1,793	89	139	2,858	--	80	--	204	--				
Total No.	3,053	11,710	10,049	15,094	[illegible],578	--	2,549	--	43,809	--				
Avg. No./day	436	5,855	2,010	15,094	2,596	--	1,275	--	7,302	--				
Total Wt.(kg)	53.9	45.2	83.0	75.0	205.4	--	57.3	--	945.0	--				
Avg. Wt./day(kg)	7.7	22.6	17.6	75.0	34.2	--	28.7	--	157.5					
Avg. Wt./fish(g)	18	4	9	5	13	--	23	--	22					

[a]Large mesh basket
[b]Small mesh basket
[c]Not sampled
[d]Weight not recorded before Feb. 14
[e]5 days of sampling - 366 fish
[f]Less than 0.1%

58.5% of the 4,718 pounds of fish impinged. Gizzard shad, carp, buffaloes, channel catfish, white bass, bluegill, crappies and freshwater drum were almost entirely young-of-the-year and juvenile fishes. In most other species, juveniles and young-of-the-year also accounted for the largest percentage of impinged fish. Young-of-the-year individuals were deposited in the trash baskets in large numbers following spawning periods when they are most abundant and least able to escape from the turbulent currents existing in the area of the traveling intake screens (Table 9 and 13). Throughout 1973 young drum and gizzard shad were most susceptable to impingement, possibly because of their slow growth rate, great abundance or attraction for the intake area. For example, freshwater drum gain little body weight during their first two years of growth (Priegel 1967).

Gizzard shad were abundant at all sampling locations during 1973. The extent of their abundance was exemplified by large impingement numbers. The primary reasons for the large impingement numbers appear to be the following: (1) extreme abundance (excellent spawn and survival of young-of-the-year); (2) difficulty in negotiating the turbulence and currents near the screens; and (3) presence in large groups due to schooling behavior of young-of-the-year. Young-of-the-year gizzard shad tend to school, but schooling behavior decreases after the first year (Dendy 1946).

Large numbers of gizzard shad were impinged during December 1973 and January and February 1974 (Table 10). Construction of a bulkhead in the intake bay during October in conjunction with cooling canal construction narrowed the opening to the traveling intake screens causing an increase in turbulence and current velocities close to the screens which together

with the cooler water temperatures, decreased fish swimming capabilities and made it more difficult for the fish to avoid becoming impinged.

Annual operation of the ice melt recirculation system was commenced on November 7, 1973 to provide heated water in the intake bay during winter months to combat ice formation and provide ice-free water for condenser cooling. This warmer water may have attracted fishes in the local area of the intake bay and may also have contributed to increased winter impingement. Most young-of-the-year gizzard shad had also reached sufficient size (Carlander 1969) to assure that they would be retained by large mesh baskets.

D. Results of 1974 Impingement Collection

Results of counts, 'ghts and percent occurrence of fish collected in the intake trash basket during 1974 are presented in Table 10. A total of 55,041 fish were collected from the traveling screens. The total number of fishes and numbers of species again varied considerably from day to day. The most abundant fish were again gizzard shad, representing 63.9% of the total numerical catch; freshwater drum 27.9%; channel catfish 1.7% and white bass 1.5%. The remaining 5% were made up of 47 additional species. A total weight of 4,383 pounds of fish were collected during 1974. The bulk of the catch weight was composed of gizzard shad (2,691 pounds) and freshwater drum (962 pounds).

For most species (particularly gizzard shad, freshwater drum, channel catfish and white bass) juveniles and young-of-the-year individuals accounted for the largest percentage of impinged fish. Young-of-the-year individuals of many species were impinged following spawning periods. During these periods the young fish were most abundant and

Table 2

NUMBERS, TOTAL WEIGHT AND PERCENT OCCURRENCE OF FISHES REMOVED FROM THE TRAVELING INTAKE SCREENS AND DEPOSITED IN THE TRASH BASKET DURING 1974

	Jan. (5)	Feb. (7)	Mar. (5)	Apr. (6)	May (8)	June (8)	July (7)	Aug. (8)	Sep. (8)	Oct. (10)	Nov. (7)	Dec. (6)	Total	Percent Occurrence
Silver lamprey	0	1	1	0	0	0	0	0	0	0	0	0	2	--
Shovelnose sturgeon	0	0	0	6	1	0	0	0	0	0	0	0	1	--
Paddlefish	0	4	1	5	0	0	0	0	0	0	0	C	10	--
Longnose gar	2	3	12	31	15	4	13	3	0	11	6	1	101	0.2
Shortnose gar	5	5	6	13	4	3	6	5	1	5	1	1	55	0.1
Bowfin	0	0	0	0	3	0	6	1	0	0	0	0	10	--
Gizzard shad	9,095	4,527	644	296	203	43	80	221	289	3,590	13,820	2,372	35,180	63.9
Mooneye	14	63	94	105	32	31	14	11	6	22	3	6	401	0.7
Goldeye	1	1	0	0	0	1	0	0	0	0	0	0	3	--
Central mudminnow	0	2	0	1	0	0	0	0	0	0	0	0	3	--
Grass pickerel	0	0	7	0	0	2	1	0	0	0	0	0	10	--
Northern pike	0	0	0	2	9	7	17	0	2	0	0	0	37	
Creek chub	0	0	2	1	0	0	0	0	0	0	0	0	3	--
Stoneroller	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Carp	2	8	24	106	62	26	26	28	7	4	2	2	297	0.5
Silver chub	0	7	5	13	4	2	2	5	13	1	0	0	52	0.1
Golden shiner	0	0	1	4	3	0	1	0	0	0	0	0	9	--
Emerald shiner	2	2	2	1	9	0	7	2	8	4	5	0	42	--
River shiner	1	2	0	1	1	1	2	0	0	3	3	0	14	--
Spotfin shiner	0	0	1	0	0	0	0	0	0	0	0	0	1	--
Sand shiner	0	0	0	0	0	0	0	0	0	0	0	C	0	--
Bluntnose minnow	0	0	1	0	0	0	0	0	0	0	0	0	1	--
Fathead minnow	0	1	0	0	0	0	0	0	0	0	0	0	1	--
River carpsucker	3	22	16	17	12	1	6	12	1	2	1	1	94	0.2
Quillback carpsucker	1	0	1	0	1	1	1	0	0	0	0	0	5	--
White sucker	0	1	0	0	0	0	0	0	0	0	0	0	1	--
Blue sucker	0	0	0	0	0	0	0	0	0	0	1	0	1	--
Smallmouth buffalo	6	17	18	12	11	5	3	1	2	3	6	5	89	0.2
Bigmouth buffalo	0	8	6	4	6	0	4	0	0	0	0	1	29	--

Table 2 (Cont.)

	Jan. (5)	Feb. (7)	Mar. (5)	Apr. (6)	May (8)	June (8)	July (7)	Aug. (8)	Sep. (8)	Oct. (10)	Nov. (7)	Dec. (6)	Total	Percent Occurrence
Spotted sucker	0	0	0	1	0	0	0	0	0	0	0	0	1	--
<u>Moxostoma</u> sp.	0	1	3	4	17	6	32	1	0	1	0	0	65	0.1
Black bullhead	5	14	26	233	66	9	11	14	1	0	3	0	382	0.7
Yellow bullhead	0	1	0	0	0	0	1	0	0	0	0	0	2	--
Channel catfish	79	101	80	46	39	8	146	206	192	18	16	15	946	1.7
Stonecat	0	0	0	4	0	0	9	0	4	0	0	1	18	--
Tadpole madtom	0	0	1	1	0	1	3	0	0	0	0	0	6	--
Flathead catfish	0	2	1	1	1	1	2	4	1	0	1	0	14	--
Yellow bass	0	3	1	19	3	1	0	0	0	1	1	0	29	--
White bass	25	47	51	165	55	17	119	155	23	80	51	25	813	1.5
Green sunfish	0	0	0	2	6	0	2	3	1	0	0	0	14	--
Pumpkinseed	0	0	0	4	3	0	1	0	0	0	0	0	8	--
Orangespotted sunfish	0	0	1	2	2	0	1	0	0	1	2	0	5	--
Bluegill	1	3	[illegible]	40	170	51	82	11	12	25	7	0	416	0.8
Largemouth bass	0	0	4	7	43	19	30	1	2	1	5	1	113	0.2
Smallmouth bass	0	0	0	0	0	0	1	10	0	0	1	0	12	--
White crappie	0	10	12	28	10	8	40	16	7	1	6	9	147	0.3
Black crappie	11	10	17	33	14	11	54	0	6	11	10	9	186	0.3
Yellow perch	0	0	2	2	0	0	1	0	0	[illegible]	0	0	5	--
Logperch	0	0	0	1	0	0	0	1	0	1	0	0	3	--
River darter	0	0	0	1	0	0	0	1	0	0	0	0	2	--
Sauger	0	0	1	6	10	4	7	0	0	1	1	0	30	--
Walleye	0	0	2	1	4	2	5	2	0	0	0	0	16	--
Freshwater drum	171	994	2,170	4,310	1,902	164	872	1,393	505	1,409	1,286	176	15,352	27.9
Total No.	9,424	5,860	3,228	5,523	2,721	429	1,608	2,107	1,083	5,195	15,238	2,625		
Avg. no./day	1,885	837	646	921	340	54	230	263	135	520	2,177	438		
Total wt.(kg)	502.0	348.6	188.6	211.6	118.1	38.0	59.5	39.5	28.8	84.1	253.8	118.1		
Avg.wt/day(kg)	100.6	49.8	37.7	35.3	14.8	4.8	8.5	4.9	3.6	8.4	36.3	19.7		
Avg.wt/fish(g)	53.4	59.5	58.4	38.3	43.4	88.7	37.0	18.7	26.6	16.2	16.7	45.0		

least capable of counteracting the turbulent currents existing in the area of the traveling screens (Tables 10 and 13).

The attempts made during 1974 to reduce the number of fish becoming impinged by a submerged speaker system and a bubble screen have been previously discussed. Impingement collections were quite variable during 1974 (Tables 10 and 11). Since a reduction in the number of fish impinged was independent of operation of either system,their use was discontinued.

E. Comparison of 1973, 1974 Impingement Collection

Comparisons of 1973 and 1974 impingement collections are shown in Tables 12, 13 and 14. During 1973 a total of 128,159 fish were collected in trash baskets compared to 55,041 during 1974. From March through December 1973 (weights were not recorded during January or February) a total weight of 4,752 pounds of fish were removed from trash baskets compared to 2,508 pounds for the same period during 1974 (Table 12).

The larger 1973 collection could be attributed to several factors. Several species had very successful spawn and good survival of young-of-the-year during 1973. Young-of-the-year of gizzard shad, crappie, carp, buffaloes, mooneye, channel catfish, white bass and largemouth bass dominated river collections following their spawning periods and the small mesh basket collections taken during 1973 contained many small fish Although small fish may have passed through the large mesh baskets

Table 3

PHYSICAL VARIABLES OCCURRING DURING TRASH BASKET COLLECTION DATES
AT QUAD-CITIES STATION DURING 1974

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers off Spray Canal off	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	Bubble Screen & spray canal not operating
March 1974								
No. sampling days	3	2	--	--	--	--	--	--
Total No. fish	1,844	1,388	--	--	--	--	--	--
Avg. no./day	615	694	--	--	--	--	--	--
Total wt. (g)	94,357	94,286	--	--	--	--	--	--
Avg.wt.(g)/day	31,452	47,143	--	--	--	--	--	--
Avg.wt./fish	51.2	67.9	--	--	--	--	--	--
April 1974								
No. sampling days	4	2	--	--	--	--	--	--
Total No. fish	2,876	2,647	--	--	--	--	--	--
Avg. no./day	719	1,324	--	--	--	--	--	--
Total wt. (g)	122,500	89,143	--	--	--	--	--	--
Avg.wt.(g)/day	30,625	44,572	--	--	--	--	--	
Avg.wt./fish	42.6	33.7	--	--	--	--	--	
May 1974								
No. sampling days	--	--	2	6	--	--	--	--
Total No. fish	--	--	156	2,566	--	--	--	--
Avg. no./day	--	--	78	428	--	--	--	--
Total wt. (g)	--	--	11,843	106,223	--	--	--	--
Avg.wt.(g)/day	--	--	5,922	17,704	--	--	--	--
Avg.wt./fish	--	--	75.9	41.4	--	--	--	--

Table 3 (Cont.)

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers off Spray Canal off	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	Bubble Screen & spray canal not operating
June 1974								
No. sampling days	--	--	--	--	6	2	--	--
Total No. fish	--	--	--	--	403	29	--	--
Avg. no./day	--	--	--	--	67	15	--	--
Total wt. (g)	--	--	--	--	35,159	2,885	--	--
Avg.wt.(g)/day	--	--	--	--	5,860	1,443	--	--
Avg.wt./fish	--	--	--	--	87.2	99.5	--	--
July 1974								
No. sampling days	--	--	--	--	5	2	--	--
Total No. fish	--	--	--	--	1,578	30	--	--
Avg. no./day	--	--	--	--	316	15	--	--
Total wt. (g)	--	--	--	--	54,895	4,615	--	--
Avg.wt.(g)/day	--	--	--	--	10,979	2,308	--	--
Avg.wt./fish	--	--	--	--	34.9	153.8	--	--
August 1974								
No. sampling days	--	--	--	--	6	--	2	--
Total No. fish	--	--	--	--	1,728	--	379	--
Avg. no./day	--	--	--	--	288	--	190	--
Total wt. (g)	--	--	--	--	27,976	--	11,493	--
Avg.wt.(g)/day	--	--	--	--	4,663	--	5,747	--
Avg.wt./fish	--	--	--	--	16.2	--	30.3	--
September 1974								
No. sampling days	--	--	--	--	4	--	3	1
Total No. fish	--	--	--	--	112	--	714	257
Avg. no./day	--	--	--	--	28	--	238	257
Total wt. (g)	--	--	--	--	10,695	--	14,725	3,380
Avg.wt.(g)/day	--	--	--	--	2,674	--	4,908	3,380
Avg.wt./fish	--	--	--	--	95.5	--	20.6	13.2

Table 3 (Cont.)

Date	Speakers on	Speakers off	Speakers on Spray Canal off	Speakers off Spray Canal off	Bubble Screen and spray canal operating	Bubble Screen operating, spray canal not operating	Bubble Screen not operating spray canal operating	bble Screen & spray canal not operating
October 1974								
No.sampling days	--	--	--	--	7	3	--	--
Total No. fish	--	--	--	--	345	4,850	--	--
Avg. no./day	--	--	--	--	49.3	1,617	--	--
Total wt. (g)	--	--	--	--	19,345	64,774	--	--
Avg.wt.(g)/day	--	--	--	--	2,764	21,591	--	--
Avg.wt./fish	--	--	--	--	56.1	13.4	--	--
November 1974								
No.sampling days	--	--	--	--	4	2	1	--
Total No. fish	--	--	--	--	1,705	13,365	168	--
Avg. no./day	--	--	--	--	426	6,683	168	--
Total wt. (g)	--	--	--	--	49,448	198,198	6,165	--
Avg.wt.(g)/day	--	--	--	--	12,362	99,099	6,165	--
Avg.wt./fish	--	--	--	--	29.0	7.4	36.7	--
December 1974								
No.sampling days	--	--	--	--	4	2	--	--
Total No. fish	--	--	--	--	1,524	1,102	--	--
Avg. no./day	--	--	--	--	381	551	--	--
Total wt. (g)	--	--	--	--	86,235	31,815	--	--
Avg. wt.(g)/day	--	--	--	--	21,559	15,908	--	--
Avg.wt./fish	--	--	--	--	56.6	28.9	--	--

Table 4

COMPARISON OF NUMBERS AND WEIGHTS OF FISHES COLLECTED BY LARGE AND SMALL MESH TRASH BASKETS DURING 1973 AND 1974

Year	Mesh	No. days	Total No. Jan-Dec	Avg.no. day Jan-Dec	Total wt.(lbs) Jan-Dec	Avg.wt. day Jan-Dec	No. days	Total No. Mar-Dec	Avg.no. day Mar-Dec	Total wt.(lbs) Mar-Dec	Avg.wt. day Mar-Dec	No. days	Total No. Apr-Sep	Avg.no. day Apr-Sep	Total wt.(lbs) Apr-Sep	Avg.wt. day Apr-Sep
1973	large	72	85,554	1,188	--	--	55	83,217	1,513	3,852.0	70.0	30	19,615	653.8	816.5	27.2
	small	16	42,615	2,663	--	--	16	42,615	2,663	900.4	56.3	16	42,615	2,663.4	900.4	56.3
	Total	88	128,159	1,456	--	--	71	125,832	1,772	4,753.4	66.9	46	62,230	1,352.8	1,716.9	37.3
1974	large	85	55,041	648	4,383	51.6	73	39,757	544	2,507.6	34.4	45	13,471	299.4	1,091.4	24.3

Table 5

NUMBER, WEIGHT AND PERCENT OCCURRENCE OF THE MOST COMMON FISH COLLECTED IN TRASH BASKETS

Species	1973 Month	Number	(g) Weight	Percent Occurrence	1974 Month	Number	(g) Weight	Percent Occurrence
Gizzard shad	Jan.	1,017	--	78	Jan.	9,095	479,825	97
	Feb.	265	--	27	Feb.	4,527	278,040	77
	Mar.	131	9,180	8	Mar.	644	50,580	20
	Apr.	722	19,395	21	Apr.	296	7,205	5
	May	35	1,535	3	May	203	7,215	8
	June	2,113	6,715	53	June	43	2,325	10
	July	3,239	6,650	24	July	80	5,280	5
	Aug.	6,761	22,180	44	Aug.	221	1,795	11
	Sep.	24,120	115,270	96	Sep.	289	3,500	27
	Oct.	11,658	108,055	75	Oct.	3,590	54,770	69
	Nov.	2,374	48,690	93	Nov.	13,820	228,655	91
	Dec.	43,501	908,525	99	Dec.	2,372	102,595	90
Total		95,936				35,180	1,221,785	
Mar.-Dec. Total		94,654	1,246,195			21,558	463,920	
Freshwater drum	Jan.	212	--	14	Jan.	171	9,985	2
	Feb.	400	--	41	Feb.	994	42,205	17
	Mar.	750	81,710	45	Mar.	2,170	105,530	67
	Apr.	2,273	138,550	65	Apr.	4,310	153,300	78
	May	403	40,521	29	May	1,902	53,290	70
	June	150	18,075	4	June	164	6,245	38
	July	877	5,760	7	July	872	7,050	54
	Aug.	2,098	9,445	14	Aug.	1,393	11,730	66
	Sep.	228	7,365	1	Sep.	505	7,245	47
	Oct.	2,858	50,307	18	Oct.	1,409	16,795	27
	Nov.	80	3,120	3	Nov.	1,286	17,370	8
	Dec.	204	14,210	--	Dec.	176	5,835	7
Total		10,533				15,352	436,580	
Mar.-Dec. Total		9,921	369,063			14,187	384,390	
Channel catfish	Jan.	48	--	2	Jan.	79	2,628	1
	Feb.	87	--	9	Feb.	101	1,615	2
	Mar.	62	3,815	4	Mar.	80	3,475	2
	Apr.	9	2,363	-	Apr.	46	1,000	1
	May	32	2,432	2	May	39	958	1
	June	15	1,090	--	June	8	143	2
	July	76	4,614	--	July	146	7,570	9
	Aug.	418	33,954	3	Aug.	206	9,445	10
	Sep.	328	20,205	1	Sep.	192	8,260	18
	Oct.	58	4,909	--	Oct.	18	907	0.3
	Nov.	1	6	--	Nov.	16	585	0.1
	Dec.	10	823	--	Dec.	15	1,025	0.6
Total		1,144				946	37,611	
Mar.-Dec. Total		999	74,211			766	33,368	

Table 5 (Cont.)

Species	1973 Month	Number	(g) Weight	Percent Occurrence	1974 Month	Number	(g) Weight	Percent Occurrence
White bass	Jan.	15	--	1	Jan.	25	396	--
	Feb.	12	--	1	Feb.	47	3,140	1
	Mar.	33	2,293	2	Mar.	51	1,310	2
	Apr.	74	4,363	2	Apr.	165	3,525	3
	May	57	2,505	4	May	55	1,217	2
	June	14	3,165	--	June	17	500	4
	July	1,479	4,255	13	July	119	2,980	7
	Aug.	1,229	5,820	8	Aug.	155	1,295	7
	Sep.	118	2,060	--	Sep.	23	1,995	2
	Oct.	182	2,207	1	Oct.	80	2,020	2
	Nov.	27	380	1	Nov.	51	1,245	0.3
	Dec.	16	220	--	Dec.	25	725	1
Total		3,256				813	20,348	
Mar.-Dec. Total		3,229	27,268			741	16,812	
Additional Fishes	Jan.	62	--	5	Jan.	54	10,146	<1
	Feb.	209	--	22	Feb.	191	23,620	3
	Mar.	690	73,440	41	Mar.	283	27,748	9
	Apr.	418	37,634	12	Apr.	706	44,813	13
	May	865	74,610	62	May	522	55,395	10
	June	1,736	63,729	43	June	197	28,831	46
	July	7,738	79,421	56	July	391	36,635	25
	Aug.	4,257	27,756	31	Aug.	132	15,204	6
	Sep.	349	18,044	2	Sep.	74	7,800	7
	Oct.	822	39,957	6	Oct.	98	9,627	2
	Nov.	66	5,144	3	Nov.	65	5,956	0.2
	Dec.	78	21,252	<1	Dec.	37	7,970	1.5
Total		17,290				2,750	273,745	
Mar.-Dec. Total		17,019	440,987			2,505	239,979	

Table 6

COMPARISON OF NUMBERS OF THE MOST COMMON SPECIES COLLECTED
IN TRASH BASKETS DURING 1973-1974

Species	Year	Large Mesh	Small Mesh	Total	Difference[a]
Gizzard Shad	1973	72,030	23,906	95,936	+60,756
	1974	35,180	--	35,180	
Crappies	1973	1,001	3,950	4,951	+ 4,618
	1974	333	--	333	
Carp	1973	2,240	2,445	4,685	+ 4,388
	1974	297	--	297	
Buffaloes	1973	1,486	2,209	3,695	+ 3,577
	1974	118	--	118	
White Bass	1973	488	2,768	3,256	+ 2,443
	1974	813	--	813	
Mooneye	1973	849	431	1,280	+ 879
	1974	401	--	401	
Bluegill	1973	292	825	1,117	+ 701
	1974	416	--	416	
Freshwater Drum	1973	5,587	4,946	10,533	- 4,819
	1974	15,352	--	15,352	

a Difference between numbers in 1973 and 1974

utilized in 1974, comparison of the large mesh collections taken during similar periods in 1973 and 1974 (Table 14) shows decreases in 1974 of the numbers of gizzard shad, crappies, carp, buffaloes and mooneye impinged. Moreover, gizzard shad were present in great abundance in the river during winter months in both years when most had reached a large enough size to prevent passage through large mesh baskets. This was also true for freshwater drum which appeared at their greatest abundance during early spring 1974 (Table 13).

The apparent highly successful spawn for many species during 1973, accompanied by unusually good survival rates for young-of-the-year, possibly accounted for their large numbers in trash basket collections and minnow seine collections in 1973 in contrast to the collections in 1974 (Industrial Bio-Test Laboratories, Inc. 1974 a Appendices).

F. Impact of Impingement on the Fishes of Pool 14

In order to assess the effects of impingement of fish at Quad-Cities Station on the fishery of the Mississippi River an estimate of the standing crop of various species of fish in Pool 14 of the river was undertaken. The large amount of fishery data collected from the Pool during the Quad-Cities fishery studies (1971-1974) greatly increases the accuracy of these estimates.

The mean weight (pound/acre) was calculated through obtaining the total weight of each species for each month, by summing the combined weight of that species collected by seining, electroshocking and trawling. The total estimated acreage sampled by each method was calculated and multiplied by the number of sampling periods. The sum of the combined weights from all collection methods of a given species was divided by the sum of the total acreage sampled to give pounds per

acre of that species for each month. The mean weight (pounds per acre) was then derived from the sum of all months sampled. The estimated pounds per acre for Pool 14 as calculated from the fisheries surveys conducted by Industrial Bio-Test Laboratories are compared to standing crop estimates for reservoirs (Carlander 1955) in Table 15. Carlander (1955) listed means and ranges of standing crops for fishes in reservoirs and "reservoir-type" habitats. Because of the pool created by the locks and dams present in the Mississippi River, Pool 14 is considered a "reservoir-type" habitat for means of comparison in this report. The standing crop for Pool 14 was calculated by multiplying the estimated standing crop by 12,200 surface acres for Pool 14 (Table 16).

Table 16 also presents an estimate of the poundage of fish impinged which was calculated by taking the 8 samples that were collected each month and the total weight for a given species during that month divided by 8 which resulted in obtaining an average weight/day impinged. The average weight/day was then multiplied by the number of days in that particular month, for a total monthly weight. This was continued for each species for every month and the totals for each species for every month were summed, resulting in an extrapolated total yearly weight for each species. This total weight of a given species removed from the traveling screens was then divided by the estimated total poundage of that species for the pool to obtain the percent of total weight removed by the traveling screens in relation to the standing crop of that species within the pool.

A comparison was made to relate the weight of fish removed by impingement to the weight harvested by commercial fishermen. This was

Table 7

STANDING CROP OF FISH (lbs/acre) FOR RESERVOIRS, FROM CARLANDER[a]
COMPARED WITH ESTIMATES FOR POOL 14, MISSISSIPPI RIVER

Species	Mean	Range	Pool 14[b] Mean	Est. Standing Crop[c] (Total lbs.)
Gizzard shad	204	26-468	90	1,098,000
Carp	73	4.6-233	70	854,000
Suckers (incl. carpsuckers)	38	0.6-212.5	70	854,000
Buffalo (all spp.)	161	0.5-1,016	60	732,000
Bullhead (all spp.)	60	0.1-292	5	61,000
Channel catfish	14	4-57	15	183,000
White bass	3	0.1-23	1	12,200
Largemouth bass	19	0.1-59	10	122,000
Crappies (all spp.)	31	1-85	15	183,000
Sauger & Walleye	2	0.4-5.6	1	12,200
Freshwater drum	20	-80	60	732,000

[a]Carlander, K. D., 1955. The standing crop of fish in lakes. J. Fish. Reg. Bd. Canada, 12(4):543-570

[b]Estimates based upon four years of fishery surveys, Industrial Bio-Test Laboratories, Inc., 1971-1974

[c]Based on 12,200 surface acres for Pool 14

Table 8

POUNDS OF PREDOMINANT FISH SPECIES IMPINGED ON THE TRAVELING SCREENS AT QUAD-CITIES STATION COMPARED TO ESTIMATED STANDING CROP OF POOL 14, MISSISSIPPI RIVER, 1973-73

Species	Pool 14 Standing Crop (Total lbs.)	1973 Traveling Screen loss[a]		1974 Traveling Screen loss[c]	
		Est. Total lbs.[b]	% of Standing Crop	Est. Total lbs.	% of Standing Crop
Gizzard shad	1,098,000	15,010	(1.367)	13,650	(1.243)
Carp	854,000	291	(0.034)	217	(0.025)
Carpsuckers (all spp.)	854,000	109	(0.012)	95	(0.011)
Buffalo (all spp.)	732,000	833	(0.113)	338	(0.046)
Bullhead (all spp.)	61,000	74	(0.121)	70	(0.114)
Channel catfish	183,000	662	(0.361)	364	(0.198)
White bass	12,200	251	(2.057)	195	(1.598)
Largemouth bass	122,000	108	(0.088)	143	(0.117)
Crappies (all spp.)	183,000	583	(0.318)	358	(0.195)
Sauger and Walleye	12,200	69	(0.565)	70	(0.573)
Freshwater drum	732,000	3,529	(0.482)	4,718	(0.644)
TOTALS	4,843,400	21,519	(0.44)	20,218	(0.42)

[a] March-December 1973 (Program was not conducted during January and February by Industrial Bio-Test)
[b] The mean poundage was calculated for each species for each month from the raw data and multiplied by the number of days in each month to obtain a total poundage for the month. The estimated total pounds reflects the sum of the calculated total poundage for all months.
[c] January-December 1974.

done by dividing the total commercial catch for a given species by the estimated standing crop for that species, resulting in the percent (by weight) that the commercial catch exploits each year. Using these data it was possible to compare the effects of impingement and commercial fishing on the fishery of Pool 14 and to calculate the value of fish lost by impingement. These results are presented in Table 17.

The estimated standing crop (pounds/acre) for Pool 14 (Mississippi River) in Table 15 is an estimate based upon four years of fishery surveys (1971-1974) conducted in Pool 14 (Industrial Bio-Test Laboratories, Inc. 1972 a, 1972 b, 1973 a, 1973 b, 1974 a, 1974 b, 1975). The values ranged from 1 lb./acre for white bass, sturgeon and walleye to 90 lbs./acre for gizzard shad. The species listed in Table 14 comprised over 90% of the total biomass impingement data collected during 1973 and 1974.

Using the estimated standing crop for each species under consideration in Pool 14 (Table 16), the percentage of the standing crop impinged on the traveling screens during 1973 and 1974 was calculated. In 1973 the values ranged from 69 pounds of sauger-walleye to 15,010 pounds of gizzard shad. In terms of percentage impinged, 1973 values ranged from 0.012% of the estimated standing crop of carpsuckers to 2.05% of the estimated standing crop of white bass. In 1974 values ranged from 70 pounds of bullheads and sauger-walleye to 13,650 pounds of gizzard shad. Percent of the standing crop impinged during 1974 ranged from 0.011% for carpsuckers, to 1.598% for white bass. The sum of the percent of estimated standing crop loss for all major species due to impingement is less than 0.5% in each year.

This small percentage constitutes a minimal proportion of the standing

Table 9

TOTAL COMMERCIAL CATCH (ALL GEAR COMBINED, POOL 14) OF MAJOR FISH SPECIES AND PERCENT OF THE STANDING CROP EXPLOITED BY COMMERCIAL FISHING, WITH AVERAGE COMMERCIAL VALUE

Species	Commercial Catch 1970: Average value[a] (cents/lb.)	Commercial Catch 1970: lbs.	Commercial Catch 1970: % of Standing Crop	Commercial Catch 1971: Average value[a] (cents/lb)	Commercial Catch 1971: lbs.	Commercial Catch 1971: % of Standing Crop	Commercial Catch 1972: Average value[a] (cents/lb)	Commercial Catch 1972: lbs.	Commercial Catch 1972: % of Standing Crop
Carp	0.05	90,600	(10.6)	0.04	95,700	(11.2)	0.05	89,600	(10.5)
Carpsuckers (all spp.)	0.05	0	(0)	0.09	2,100	(0.2)	0.05	750	(0.9)
Buffalo (all spp.)	0.16	118,300	(16.2)	0.15	139,500	(19.1)	0.18	162,300	(22.2)
Bullhead (all spp.)	0.15	250	(0.4)	0.14	250	(0.4)	0.16	450	(0.7)
Channel catfish	0.32	65,400	(35.7)	0.31	63,200	(34.5)	0.36	87,200	(47.7)
Freshwater drum	0.08	23,700	(3.2)	0.08	26,500	(3.6)	0.09	46,600	(6.4)

Species	Impingement 1973: Total lbs. loss on traveling screens	Impingement 1973: Commercial value[b]	Impingement 1973: % of value of the commercial catch for 1972	Impingement 1974: Total lbs. loss on traveling screens	Impingement 1974: Commercial value[b]	Impingement 1974: % of value of the commercial catch for 1972
Carp	291	$ 14.55	(0.32)	217	$ 10.85	(0.24)
Carpsuckers (all spp.)	109	5.45	--	95	4.75	(12.66)
Buffalo (all spp.)	833	149.94	(0.51)	339	60.84	(0.21)
Bullhead (all spp.)	74	11.84	(16.44)	70	11.20	(15.55)
Channel catfish	662	238.32	(0.75)	364	131.04	(0.41)
Freshwater drum	3,529	317.61	(7.57)	4,718	424.62	(10.12)

[a]Taken from the UMRCC report 1972, 73, 74
[b]Based on commercial value of 1972; 1973 and 1974 commercial value data not published

crop of Pool 14. Since most of the fishes impinged during both 1973 and 1974 were juveniles or young-of-the-year individuals of low value species which have high natural mortality rates, the impact on the fisheries resource due to impingement of these fishes does not appear to be significant. Most species of fish appear to have constant age-specific mortality rates in the juvenile life (Warren and Doudorhoff 1971). By the time most fish reach a size sufficient to be important for recreational or commercial purposes, most of their contemporaries have died (Ricker 1971). Since nearly all of the fishes impinged were juveniles or young-of-the-year (primarily gizzard shad and freshwater drum) the impact on the fishery due to impingement of these fishes appears inconsequential when considering the high natural mortality rates expected of these fish. Because gizzard shad and freshwater drum exhibit primarily a pelagic habitat preference in early life stages and are most likely to be present in great numbers in the drift, it is also likely that they experience the highest natural mortalities.

Table 17 shows the value of the major commercial species impinged. In no instance was the percent of standing crop of any commercial fish species impinged anywhere near the percent exploited by commercial fishermen. For example, commercial fishermen exploit up to 47.7% of the standing crop of channel catfish, while only 0.361% were impinged during 1973 and 0.198% in 1974. The 1973-74 commercial catch data has not been published to date, therefore the 1973-74 impingment data is compared to the most recent (1970-72)) published commercial catch data.

The 1972 value per pound of commercial species was also used in calculating the commercial value, for want of more recent data. In Table 17 the commercial market price of channel catfish impinged (using

1972 prices) was $238.32, which represents 0.75% of the commercial value of $31,392 for the harvest by commercial fishermen. This monetary figure "lost due to impingement" is minimal relation to commercial fish value.

A major reason that only relatively low numbers and biomass of "harvestable size" fish are impinged is the physical location of the Quad-Cities Station in relation to habitat type within the Mississippi River. The Station is situated along the main channel of the river as opposed to side channel or slough-like habitat where fish reproduction occurs and sustained nursery sites for most species are located. Therefore, one would anticipate that the Station would impinge primarily the migrant or wandering (schooling) fishes which utilize the main channel habitat (i.e., gizzard shad and freshwater drum). The fish impingement data collected over the past two years (1973 through 1974) supports this expectation.

From the impingement data presented in this report it is not expected that future impingement will adversely affect the standing crop in Pool 14, in view of the extremely low percentages of standing crop removed due to impingement. Where commercial harvest is exploiting up to 47% of the channel catfish standing crop alone, it is clear that the impingement of less than one percent of the standing crop of this species would not adversely affect the total production of channel catfish. This is also true for other species for which impingement was studied.

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