University of Minnesota
St. Anthony Falls Hydraulic Laboratory

Project Report No. 163

FIELD INVESTIGATIONS OF WATER TEMPERATURE STRATIFICATION AND WIND EFFECTS ON DISSOLVED OXYGEN IN POOL NO. 2 OF THE MISSISSIPPI RIVER

by

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ABSTRACT

Dissolved oxygen, water temperatures, Secchi depth, and surface drift currents were measured in pool No. 2 of the Mississippi River during very low flow conditions from August 24 through September 25, 1976 on eleven different days and under significantly varied weather conditions. Water quality parameters were found to vary, both in time and space and in direct relationship to prevailing weather, particularly wind and sunshine. With total river flows from approximately 1000 to 2000 cfs, the measured D.O. distributions, water temperatures, and transparencies were predominantly typical of a series of interconnected lakes and to a lesser degree typical of a river. Natural convection, density currents, and wind drift were found to be of great importance. Recovery from low dissolved oxygen levels due to the effluent from the Metropolitan Waste Treatment Plant occurred in the pool upstream from Dam No. 2 mainly as the result of photosynthesis, surface aeration, and the hydrodynamic exchange processes between different regions of the pool.

A. INTRODUCTION

In the summer of 1976, flow rates in portions of the Upper Mississippi River fell to record low levels. Recordings at Anoka, St. Paul (Minnesota) and Prescott (Wisconsin) were near or below the river flows during the drought periods of the early and late 1930's. With low flow waste load allocation studies for the Minneapolis/St. Paul Metropolitan area underway, the summer of 1976 seemed a most appropriate time to study Mississippi River water quality under extreme low flow conditions. Recognizing this opportunity, the Metropolitan Wastes Control Commission and the Minnesota Pollution Control Agency cooperated in an intensive investigative program during which water samples were collected at stations between Dam No. 1 (Ford Dam at Minneapolis), river mile 847.7, and Dam No. 2 at Hastings, river mile 815.4. This river reach includes the outlet of the metropolitan sewage treatment plant at river mile 835.2, about 3.5 miles below downtown St. Paul. Data were collected mostly in the navigation channel and at 1m depth below the surface.

From experience in previous investigations it appeared to us that the Mississippi River below St. Paul and particularly below St. Paul Park, a roaring river during snowmelt runoff, would become essentially a lake, with such typical hydrologic features as stratification, wind drift currents, density currents, etc., during very low summer flow. Flow rates in the summer of 1976 fell below 1000 cfs at St. Paul on several days, as shown in Table A-1. A supplemental discharge on the order of 300 cfs was received from the Metro Waste Treatment Plant. Waste allocation studies are based on a 10 year, 7 day low flow which was estimated to be 2184 cfs at St. Paul. For mean river widths of 1100 ft and average depths of 7 to 10 ft for the river main stem, mean flow velocities were on the order of 0.1 fps in the summer of 1976 and will be on the order of 0.2 fps for the design flow. In those reaches where the river channel is submerged in the impoundment created by Dam No. 2, mean flow velocities will be less than the above.

Table A-1 - Mississippi River Discharge During Period of Measurements.

	U.S.G.S. ST. PAUL STATION (cfs)	MWCC METRO PLANT DISCHARGE OUTLET 001 (cfs)	TOTAL FLOW (cfs)
August 24, 1976	1390	330	1720
	1090	329	1419
	1050	347	1397
	1200	318	1518
	1190	271	1461
	1450	245	1695
	630	336	966
31	1360	332	1692
September 1, 1976	790	302	1092
	995	312	1307
	1620	304	1924
	1280	228	1508
5	886	217	1103
	1080	251	1331
	877	336	1213
	829	330	1159
	1040	318	1358
10	965	287	1252
	1040	273	1313
	819	260	1079
	1050	361	1411
	844	318	1162
15	1140	313	1453
	1280	316	1596
	984	313	1297
	1140	301	1441
	1340	288	1628
20	1410	316	1726
	1380	308	1688
	1300	308	1608
	1160	304	1464
	1170	301	1471
25	1160	264	1424

The backwater created by Dam No. 2 covers vast areas. Using the navigation charts published by the U.S. Army Corps of Engineers, 11 separate backwater areas have been identified and their approximate surface areas determined with the results shown in Table A-2. Not all of these are well enough connected to the river main stem to have a significant exchange flow. Undoubtedly, however, the stumpfields of the lower pool, Spring Lake and Baldwin Lake, share wide open areas through which large amounts of water can frequently flow. The total surface area of these selected fields is approximately 8 square miles. By comparison, the river main channel between the sewage treatment plant outlet and Dam No. 2, measuring an average width of 1100 ft, would have a surface area of only approximately 4 square miles.

With this background information in mind, a preproposal was submitted to the Metropolitan Wastes Control Commission for field and analytical investigations of the interaction between the Mississippi River main stem and the backwaters, including stratification characteristics. The following are excerpts from the proposal.

> "Questions have been raised regarding the applicability of a one-dimensional water quality model to the Mississippi River between St. Paul Park and Hastings, Minnesota. This river reach is also known as Pool No. 2 and is formed by Lock and Dam No. 2 at river mile 815.4 upstream from the Ohio River. Figure A-1 identifies the water surface contours. A major portion of the pool area is on the order of a mile wide. The main river or navigation channel winds through the pool. It is on the order of 300 to 500 ft wide and 15 to 20 ft deep under low and normal conditions. Elongated islands separate the channel mainstream from wide open lake areas identified as Baldwin Lake, Spring Lake, Moore Lake, or simply as Stump Fields.
>
> The proposed main study reach extends from mile 815.4 (Lock and Dam No. 2) at Hastings to mile 828 (St. Paul Park). It appears that the river main stem and the adjacent water bodies are fairly differentiated in terms of flow velocities, depths, residence times, and probably also biology and water chemistry. The flow and exchange of water between the main stem and different subregions of the pool should be important for the water quality in the pool and its effluent at the dam. It is proposed to make studies that will relate a longitudinal and transverse exchange of water in the pool to pool morphology, river flow, and weather, particularly wind. The latter is important because of the very weak water surface gradients in the pool under low flow conditions. Flow through the pool must be expected to display a dual character: (a) Under high flow the water exchange throughout the pool will be a gravity controlled open channel flow through a system of parallel channels in the upper pool region (miles 820 to 828) and through a composite channel in the lower pool region (miles 815.4 to 820). The two regions and the channels are identified in Fig. A-2; (b) Under low flow the pool is basically a lake. If wind is present,

Table A-2 - Approximate Surface Areas of Backwater Adjacent to the Mississippi River Main Stem Between Mile 815.4 (Dam No. 2) and Mile 828.

		Sq. Miles
Upper Grey Cloud Slough		0.208
River Lake		0.215
Baldwin Lake		0.932
Moore Lake		0.212
Spring Lake		2.912
Backwater Behind Unnamed Islands		0.463
Lower Grey Cloud Slough Basin		0.686
Stumpfield South of River Mile 819		0.604
Stumpfield North of River Mile 818		1.216
Stumpfield Southwest of Buck Island		0.754
	Total Area	8.102

Average channel width between river miles 836 and 822: 0.211 mile ≃ 1110 ft.
Equivalent river length of the total area ≃ 38 miles.

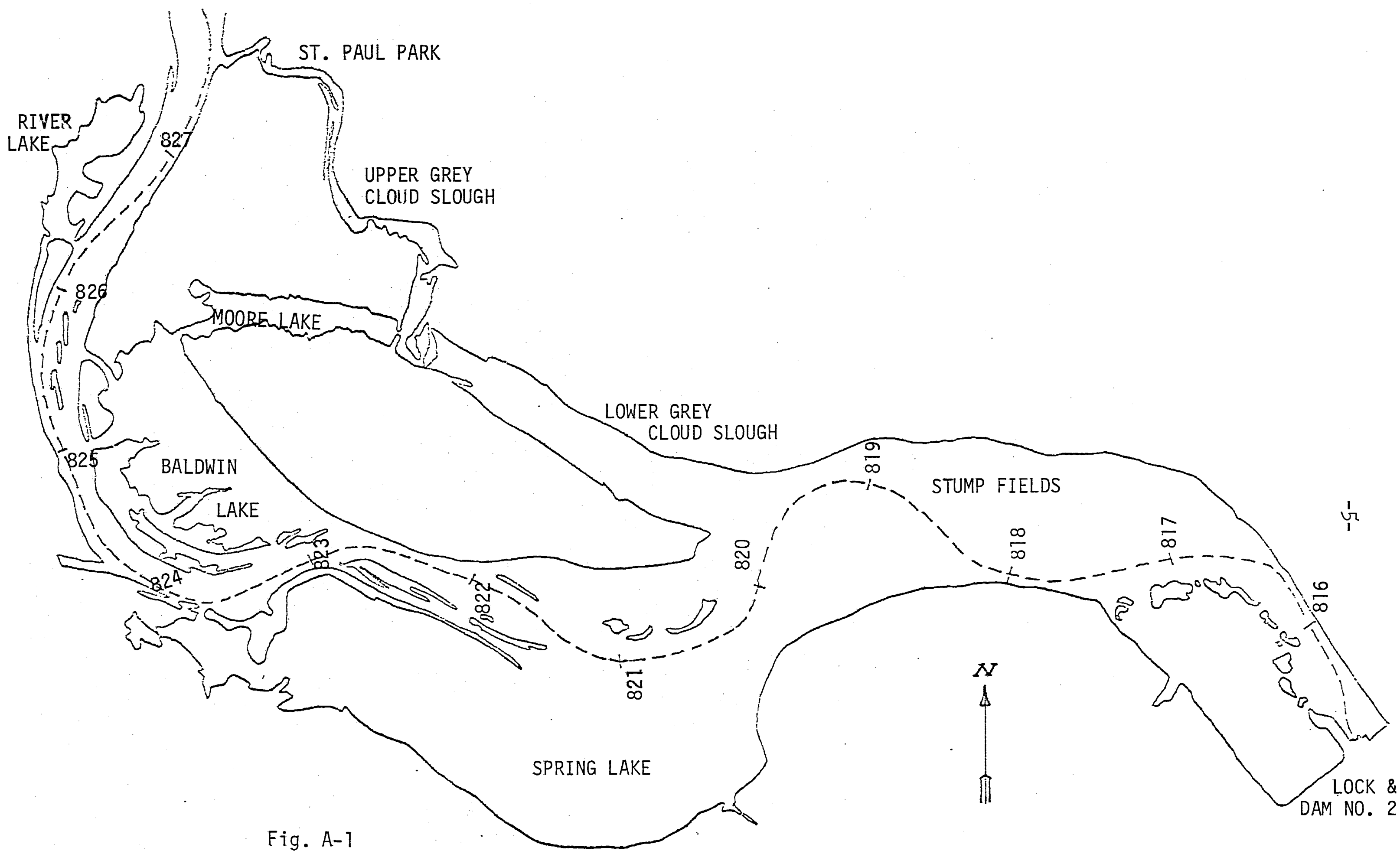

Fig. A-1

MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
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1 mile

MAP OF MISSISSIPPI RIVER
POOL NO. 2

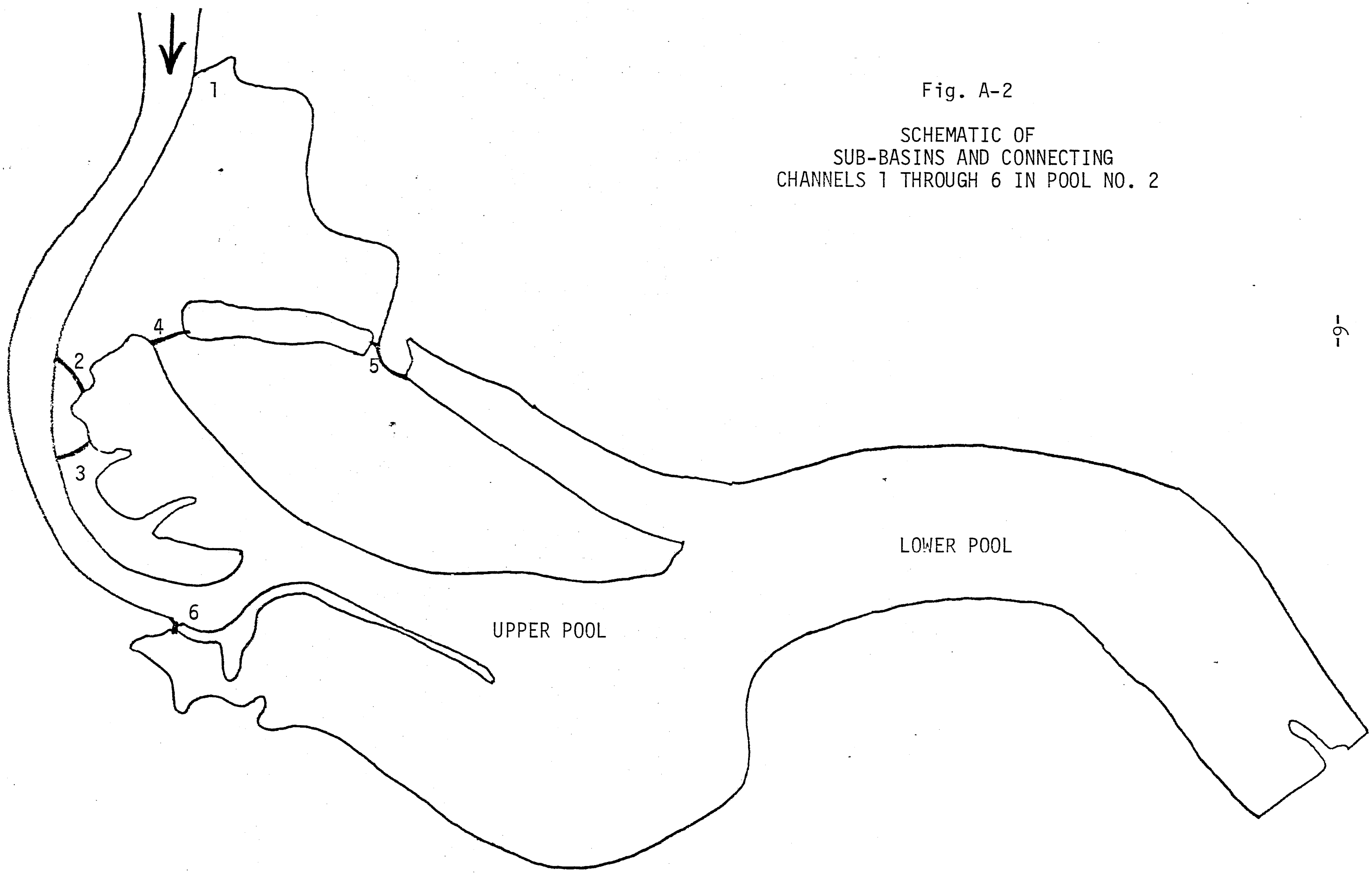

Fig. A-2

SCHEMATIC OF
SUB-BASINS AND CONNECTING
CHANNELS 1 THROUGH 6 IN POOL NO. 2

major wind drift currents will develop. Southeasterly winds often prevail in summer, coincident with low flow and high water temperatures. That wind direction coincides with the main orientation of the pool. A southeasterly wind will oppose the flow towards the dam and presumably affect a redistribution of the flow. Surface aeration by wind mixing has been ignored in D.O. modeling but may be expected to have significant effect on the oxygen budget. It will increase D.O. levels of the pool water and has to be added to oxygen production by algal photosynthesis. In that sense the pool has similarity to a very large aeration pond.

Intermittent stratification of the main stem is very likely to occur during calm weather because of the inflow of warmer water from the lake-type regions, where surface heating would be much more dominant. Water temperature stratification will be intermittent because stronger winds are likely to cause complete vertical mixing. An analysis of the frequency and strength of stratification can be made. Water temperature stratification will cause the river to flow through the pool as a density current either on the surface or along the bottom in the main channel. Formation of bottom currents would significantly shorten residence times in the pool and eliminate surface aeration. This could represent the most adverse conditions for river D.O. Such currents have been observed at other sites before and have been studied in the field and in the Laboratory.

A one-dimensional water quality model containing a longitudinal dispersion term can accomodate differences in transport velocity in different parts of a river section and longitudinal mixing by wind, by selection of a reasonable longitudinal dispersion coefficient. Obviously this coefficient must depend on river morphology and wind. A term for surface aeration may also be included in a one-dimensional model.

However, if the deep portions and the shallow portions of a pool operate at totally different travel times, they must be considered as basically separate or parallel reactors and a one-dimensional approach may not be adequate.

The main objective of the proposed study is to determine if a one-dimensional D.O. model is justified for Pool No. 2, and if so, how the currently available one could be improved by more adequate representation of the flow and wind action in Pool No. 2. Field measurements and a flow analysis will be used. If a one-dimensional simulation is not found representative of the pool, an alternative approach will be proposed.

The objective will be pursued by theoretical analysis of the flow through the pool under different river flow and weather conditions, supplemented by field measurements of water temperatures, current velocities, and dissolved oxygen. A conservative substance and oxygen will be routed through the system."

The results reported herein refer only to the field investigations which were conducted between August 24 and September 25, 1976.

B. OBJECTIVE OF STUDY

The objective of the field measurements as quoted in the proposal was as follows:

> "D.O. is the water quality parameter which is of prime interest. A one-dimensional model is based on the assumption of identical D.O. levels in a river cross-section. However, the exchange of oxygen between main stem and lakelike sub-regions could be a very important factor in the oxygen balance. Field measurements of D.O. will be made in several cross-sections between river main stem and sub basins. Such measurements will be made under low flow conditions on calm days, on windy days, and on bright and grey days. Wind velocity and solar radiation data will be acquired. Solar radiation may be important to have if photosynthesis is important. Simultaneously, water temperatures will also be measured. A 3-4 week field investigation period is envisioned. The main purpose of these measurements is to determine uniformity of D.O. in horizontal and vertical direction of several pool sections. Secondarily, D.O. measurements will also provide some information on water motion through the system. Measurements in a given section will be repeated on several days to identify changes in response to weather and flow."

An additional objective had been stated as follows, but was not included in the research grant:

> "Current velocities will be measured in channels connecting the main channel and various sub-regions. The purpose of these measurements is to indicate the possible percentage of the total flow going through different parts of the system. Measurements will be conducted for calm weather and when wind is blowing from the southeast at more than 10 mph."

Directions of surface drift currents between Spring Lake, Baldwin Lake, and the river main stem were determined on several occasions.

C. PREVIOUS STUDIES

Preceeding the construction of the Pigs Eye Sewage Treatment Plant, now called Metropolitan Sewage Treatment Plant, studies of water quality and in particular dissolved oxygen have been conducted in the Mississippi River reach below Minneapolis-St. Paul. The extensive work done by G. Schroepfer in the 1930's and 1940's provided the background for the design of the first sewage treatment plant in St. Paul. Much of this data was never published. Subsequent river studies were conducted in the late 1950's by Schroepfer, Robins, and Susag [1962], Susag, Robins, and Schroepfer [1967] and others. The Minnesota Pollution Control Agency has sampled the river at selected stations periodically and the data have been placed on the Sturette system. A field study was made in the summer of 1974 to provide data for the adaptation of QUAL 2 for river water quality simulation. Spring Lake was the target of studies by Hokanson [1968] and E. Miller.

From time to time conferences, symposia, and workshops have assessed the river water quality situation. One of these was held by the Federal Water Pollution Control Administration, Department of the Interior in Minneapolis (1967). More recently (1975), the Minnesota Pollution Control Agency has held extensive hearings on Waste Load Allocation on the Mississippi River.

The senior author of this report has made studies of dissolved oxygen and ice conditions on the river during the winter of 1973/74. Related to the field measurements reported herein are also his studies on water temperature stratification in Minnesota lakes (1975) and on wind effects on algae growth (1976) (see list of references).

D. METHODS OF INVESTIGATION

All measurements reported herein were made from a 16 ft aluminum fishing boat equipped with two 10 hp outboard motors. A back-up motor proved to be useful for operation in the stumpfield and water regions outside the navigation channel where submerged logs and other obstacles are encountered frequently. Measurements were taken during daytime hours only.

Stations where measurements were taken were identified by river mileage using posted navigation markers along the navigation channels or by compass and range finder in the backwaters and lakes. A numbering system for the stations outside the navigation channel is given in Fig. D-1. Measurements of dissolved oxygen and of water temperature were usually taken at 1 m depth intervals beginning at the surface. Measurements labelled "surface" were usually taken 3 to 10 cm below the surface, with higher values used under rougher surface conditions. When strong gradients over the first meter of depth were encountered, an additional measurement at 0.5 m was sometimes taken. Depths were identified by markers attached to the cables on which the sensors were lowered overboard.

Dissolved oxygen was measured with a YSI 54 oxygen meter. A pressure and temperature compensated sensor No. 5419 attached to a YSI 5492 battery operated stirrer was used. Prior to each field survey the meter was set (calibrated) in the laboratory using a saturated or nearly saturated water bath and barometric pressure readings from the National Weather Service. Two water samples for D.O. determination by the Winkler method were withdrawn from the bath and subsequently analyzed in the laboratory. Two gallons of water from the bath were taken along on the field trip in a thermos jug and used two to three times during the survey to check the meter setting for possible drift. In most surveys drift was found to be negligible, except for the first two surveys where the water bath had not achieved saturation. Six to eight water samples were usually taken in the field for laboratory analysis of dissolved oxygen by the Winkler method as a check. Field readings of D.O. for any survey were adjusted by the constant ratio of values obtained from chemical analysis of the samples and the direct readings. That coefficient had typically a value near 0.90.

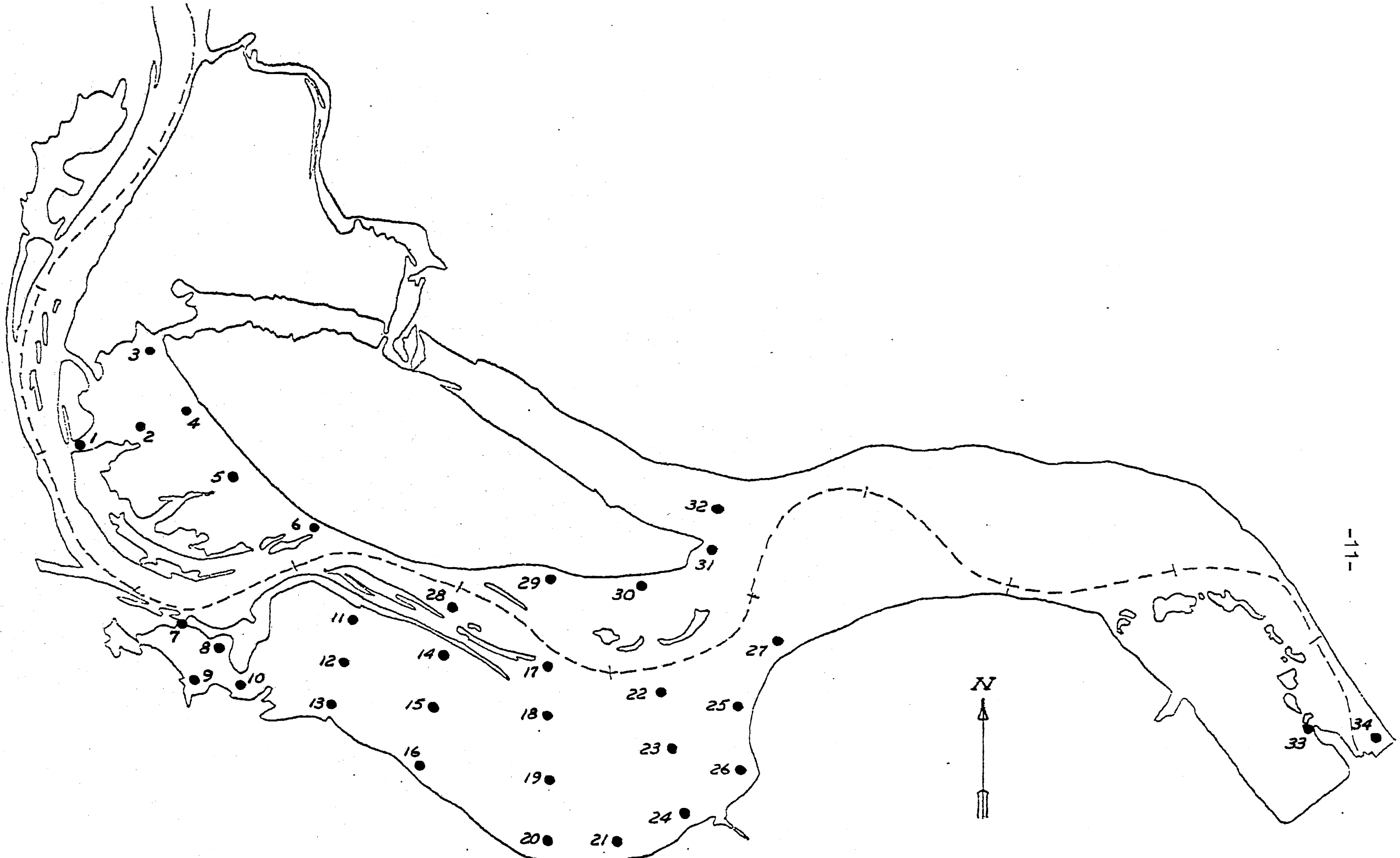

Fig. D-1

MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
UNIVERSITY OF MINNESOTA

UNSTATIONED SURVEY DATA POINTS	
MASTER MAP	8/24/76 — 9/25/76

The YSI dissolved oxygen probe also provided temperature readings in degrees Celsius but with no better than 0.2°C resolution. A separate YSI thermister probe connected to a YSI telethermometer, which could be read to the nearest one tenth of a degree Fahrenheit, was therefore used in parallel. The two independent temperature readings will be reported.

An 8 inch diameter Secchi Disk was used to read Secchi depth as a measure of light extinction in the water.

On two occasions water samples were taken for laboratory analysis of chlorine, total inorganic carbon, and total organic carbon.

Time was recorded with each set of measurements for possible correlation with weather, effluent conditions, etc.

A complete set of weather data for the one month period, during which surveys were conducted, was obtained from the National Weather Service, except for solar radiation values which were obtained from the University of Minnesota St. Paul Campus (Dr. Donald Baker). Weather data are given in Tables D-1, D-2, and D-3. Field measurements of dissolved oxygen water temperature and Secchi depth were taken on August 24, 26, 27, 30, September 3, 7, 8, 15, and 25. Surface dirft currents were observed on September 11, 1976. Water quality data are given in the Appendix.

Table D-1

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

MISCELLANEOUS WEATHER DATA

1976 Date	Max. Temp. (°F)	Min. Temp. (°F)	Ave. Temp. (°F)	Temp. Depart. From Normal (°F)	Ave. Wind Speed (Knots)	Solar[1] Radiation (Langleys Day)	Percent Possible Sunshine	Sky Cover Sunrise - Sunset (Tenths)	Precip. (Inches)
● 8/24	91	69	80	+12	6.7	507	81	4	0
8/25	89	64	77	+ 9	7.4	463	74	5	0
● 8/26	93	68	81	+13	10.3	-	80	3	0.03
● 8/27	81	62	72	+ 5	10.6	365 (partial)	82	5	T
8/28	73	56	65	- 2	10.2	560	99	1	0
8/29	76	48	62	- 5	6.3	520	93	3	0
● 8/30	87	57	72	+ 6	6.2	533	90	2	0
8/31	81	62	72	+ 4	4.9	192	28	10	0.22
9/01	67	56	62	- 3	7.7	342	34	9	T
9/02	82	53	68	+ 3	13.9	478	93	2	0.02
● 9/03	83	62	73	+ 9	12.8	536	94	1	0
9/04	79	50	65	+ 1	5.9	542	99	0	0
9/05	87	54	71	+ 7	10.2	518	95	2	0
9/06	92	59	76	+13	10.2	507	100	0	0
● 9/07	98	73	86	+23	13.6	473	96	2	0
● 9/08	78	58	68	+ 6	7.8	136	28	10	0.22
9/09	69	51	60	- 2	9.5	494	97	1	0
9/10	81	43	62	0	5.4	514	100	0	0
● 9/11	88	50	69	+ 8	6.8	504	97	0	0
9/12	92	62	77	+16	12.3	430	91	9	0
9/13	74	62	68	+ 7	8.7	81	3	10	.51
9/14	62	50	56	- 4	6.4	109	39	10	T
● 9/15	65	51	58	- 2	8.1	290	73	7	0
9/16	73	43	58	- 2	2.1	478	92	4	0
9/17	75	49	62	+ 3	3.8	465	99	4	0
9/18	82	49	66	+ 7	5.5	448	91	3	0
9/19	73	53	63	+ 4	9.2	158	41	10	0.52
9/20	67	46	57	- 1	8.7	423	86	4	0
9/21	61	40	51	- 7	7.5	460	98	1	0
9/22	74	41	58	0	8.2	416	99	2	0
9/23	59	35	47	-10	6.2	464	100	0	0

[1] From University of Minnesota, Climatological Station, St. Paul (Dr. D. Baker).

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

MISCELLANEOUS WEATHER DATA
(Cont'd.)

	1976 Date	Max. Temp. (°F)	Min. Temp. (°F)	Ave. Temp. (°F)	Temp. Depart. From Normal (°F)	Ave. Wind Speed (Knots)	Solar[1)] Radiation (Langleys Day)	Percent Possible Sunshine	Sky Cover Sunrise - Sunset (Tenths)	Precip. (Inches)
	9/24	68	37	53	- 4	4.8	386	100	4	0
●	9/25	67	41	54	- 3	5.6	424	96	8	0

Legend:

A dot marks days on which field measurements were taken.

1) From University of Minnesota, Climatological Station, St. Paul (Dr. D. Baker).

Table D-2

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

3-HOUR WIND DATA

ORDER OF DISPLAY: DIRECTION (00-36) - SPEED (KNOTS)

Hour / Date	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
8/22/76	19-9	20-10	35-6	0-0	7-9	9-9	1-11	1-10
8/23/76	7-9	4-6	6-6	10-9	10-11	13-12	13-9	11-7
8/24/76	14-9	13-4	14-6	15-7	14-6	21-10	14-10	13-6
8/25/76	17-7	16-5	11-6	13-4	22-6	21-12	19-11	15-7
8/26/76	17-7	12-5	14-5	17-8	18-18	19-17	19-14	15-8
8/27/76	16-9	14-6	22-13	31-13	28-15	28-11	28-16	0-0
8/28/76	24-5	25-7	24-6	30-12	30-13	30-14	30-14	31-7
8/29/76	1-8	6-6	7-3	13-5	18-6	14-9	15-8	12-8
8/30/76	12-10	8-7	11-8	14-5	12-6	10-5	13-8	14-7
8/31/76	6-4	0-0	35-2	27-3	18-6	1-11	1-8	31-3
9/01/76	35-4	4-7	5-5	7-10	15-8	11-7	9-8	9-10
9/02/76	13-8	12-7	12-8	17-13	18-18	18-18	19-15	17-11
9/03/76	19-18	20-16	21-14	25-12	29-17	30-15	29-16	27-6
9/04/76	29-6	24-3	26-3	30-6	31-13	32-13	34-8	0-0
9/05/76	0-0	12-9	12-6	14-10	13-14	18-15	17-14	13-6
9/06/76	16-9	15-6	12-7	13-10	17-15	18-15	18-11	15-8
9/07/76	15-8	21-11	21-12	18-14	22-13	21-16	20-17	18-12
9/08/76	18-14	19-8	30-6	35-15	33-14	32-6	31-7	23-5
9/09/76	30-3	31-8	31-8	32-11	31-14	32-13	31-14	25-5
9/10/76	0-0	0-0	20-3	23-7	24-10	23-11	24-8	7-3
9/11/76	10-4	10-3	14-2	23-5	18-8	21-13	21-8	15-8
9/12/76	17-12	17-10	14-7	17-8	17-15	18-18	18-14	17-10
9/13/76	16-11	18-10	16-8	18-13	22-8	19-10	--	--
9/14/76	34-06	34-07	01-05	28-08	34-08	33-04	36-05	02-05
9/15/76	01-05	04-08	07-09	07-07	09-09	06-11	11-04	00-00
9/16/76	29-03	00-00	00-00	21-03	11-05	35-04	08-04	00-00
9/17/76	29-03	00-00	10-04	14-04	17-05	16-05	18-06	12-06
9/18/76	14-03	00-00	12-05	12-06	12-10	17-07	16-05	12-07
9/19/76	14-03	23-04	19-06	26-03	28-05	35-10	36-14	35-12
9/20/76	36-09	34-06	31-06	31-06	32-12	30-14	27-08	22-02

(Cont'd.)

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

3-HOUR WIND DATA

ORDER OF DISPLAY: DIRECTION (00-36) - SPEED (KNOTS)

(Cont'd.)

Hour / Date	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
9/21/76	36-14	35-06	35-05	36-09	34-09	30-08	32-11	35-02
9/22/76	00-00	00-00	15-04	19-06	16-06	27-13	31-12	35-10
9/23/76	36-14	35-10	32-04	31-06	31-08	28-11	31-06	21-03
9/24/76	00-00	00-00	00-00	18-06	23-15	25-07	00-00	00-00
9/25/76	02-07	36-07	36-03	08-08	07-06	09-07	13-06	13-06

Legend:

Underlined numbers mark hours during which field measurements were taken.

Table D-3

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

3-HOUR - AIR TEMPERATURES (°F)

Date	Day	Midnight 0:00	3:00	6:00	9:00	Noon 12:00	15:00	18:00	21:00	Min.	Max.
8/22/76	S	80	75	72	78	88	95	94	84	70	96
8/23/76	M	77	73	68	74	82	89	87	79	68	89
8/24/76	T	77	73	70	72	84	90	89	79	69	91
8/25/76	W	76	71	64	72	83	88	87	77	64	89
8/26/76	Th	74	68	68	71	85	92	92	82	68	93
8/27/76	F	78	76	80	77	80	73	80	71	62	81
8/28/76	S	62	61	57	64	71	73	71	60	56	73
8/29/76	S	58	54	52	56	66	74	75	69	48	76
8/30/76	M	63	61	58	67	77	85	87	77	57	87
8/31/76	T	72	66	67	70	79	65	67	64	62	81
9/01/76	W	62	62	57	59	63	66	65	62	56	67
9/02/76	Th	60	58	54	60	70	80	82	75	53	82
9/03/76	F	76	75	73	75	77	83	79	68	62	83
9/04/76	S	62	56	55	65	74	78	79	69	50	79
9/05/76	S	61	58	54	62	74	84	85	72	54	87
9/06/76	M	68	62	59	70	81	90	91	83	59	92
9/07/76	T	78	76	76	81	92	97	95	84	73	98
9/08/76	W	80	70	67	68	61	60	60	58	58	78
9/09/76	Th	60	58	53	55	64	69	66	59	51	69
9/10/76	F	52	49	44	45	73	79	80	68	43	81
9/11/76	S	62	55	55	63	79	87	86	70	50	88
9/12/76	S	71	68	64	71	85	92	87	80	92	62
9/13/76	M	73	72	69	72	68	67	68	64	62	74
9/14/76	T	63	61	58	60	60	59	62	56	50	62
9/15/76	W	50	54	53	54	58	64	64	55	51	65
9/16/76	Th	51	48	44	54	66	71	72	60	43	73
9/17/76	F	55	50	49	55	69	74	74	61	49	75
9/18/76	S	59	54	49	58	75	80	79	69	49	82
9/19/76	S	68	63	63	65	71	73	61	58	53	73
9/20/76	M	54	49	48	52	62	66	66	61	46	67
9/21/76	T	56	47	44	48	56	60	61	52	40	61
9/22/76	W	43	42	44	47	64	73	71	59	41	74
9/23/76	Th	52	46	38	45	54	58	57	50	35	59

(Cont'd.)

MINNEAPOLIS - ST. PAUL INTERNATIONAL AIRPORT

3-HOUR - AIR TEMPERATURES (°F)
(Cont'd.)

Date	Day	Midnight 0:00	3:00	6:00	9:00	Noon 12:00	15:00	18:00	21:00	Min.	Max.
9/24/76	F	42	40	38	47	63	67	68	53	37	68
9/25/76	S	54	45	43	47	59	67	63	55	41	67

Legend:

Underlined numbers mark hours during which field measurements were taken.

E. RESULTS

All measurements of dissolved oxygen and temperature obtained are listed in chronological order by station and by depth in the Appendix. Secchi depths, where measured, are also given. Measurements of chlorine, total inorganic carbon and total organic carbon, and surface drift current measurements will be reported in the main text.

1. Minimum Dissolved Oxygen Levels

In all surveys conducted, the minimum D.O. levels in the uppermost 2 m of water in the river mainstem (navigation channel) were found upstream from mile 826, that is 11 or more miles upstream from Dam No. 2. The furthest upstream location of the sag point was near river mile 833, less than three miles downstream from the Metro Sewage Treatment Plant outlet.

2. Longitudinal Gradients and Stratification in Main Channel

Fast flowing rivers are usually well mixed vertically. The Mississippi during the period of investigation was a very sluggishly moving river. Vertical mixing by gravity flow was therefore found to be insufficient. Other mechanisms, such as natural convection (due to heat loss) or strong winds, had to be present to produce complete or nearly complete uniformity of dissolved oxygen and water temperature with depth.

Northerly winds and cool weather were found to be favorable for vertical mixing. Examples of measured D.O. and water temperature distributions under well mixed conditions are given in Figs. E-1 through E-6.

Measurements in Figs. E-1 and E-2 were taken after a cool night producing vertical convection as part of a diurnal heating and cooling cycle. In addition, a wind from the northwest was blowing.

Measurements in Figs. E-3 and E-4 were taken after a two-day period of cloud coverage resulting in strong cooling and associated mixing along the axis of the river (as shown by the temperature measurements) and aided by an ENE wind. The measurements in Figs. E-5 and E-6 were taken during the fall cooling period also resulting in strong convective water motion.

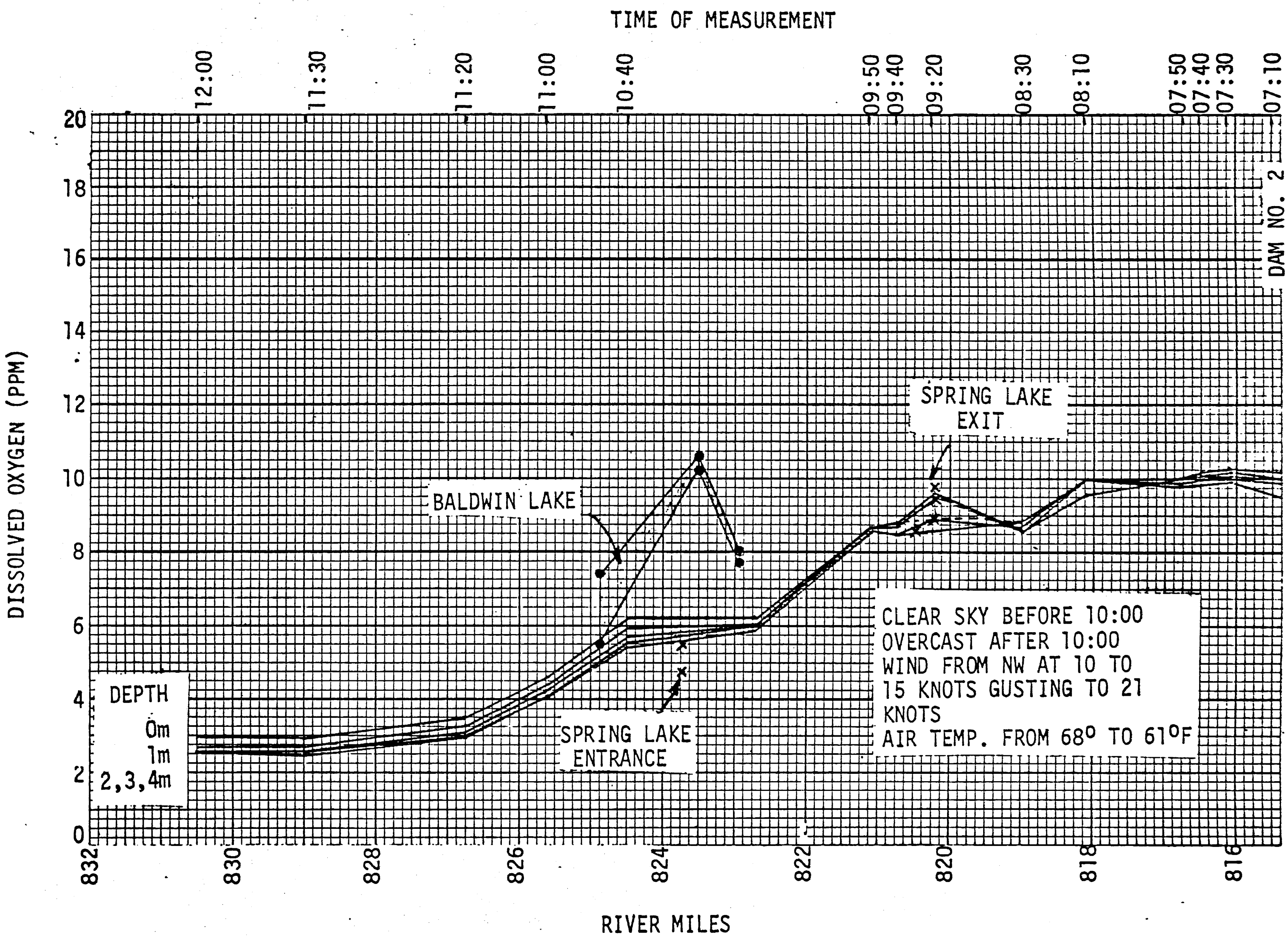

Fig. E-1 - MISSISSIPPI RIVER, SEPTEMBER 8, 1976

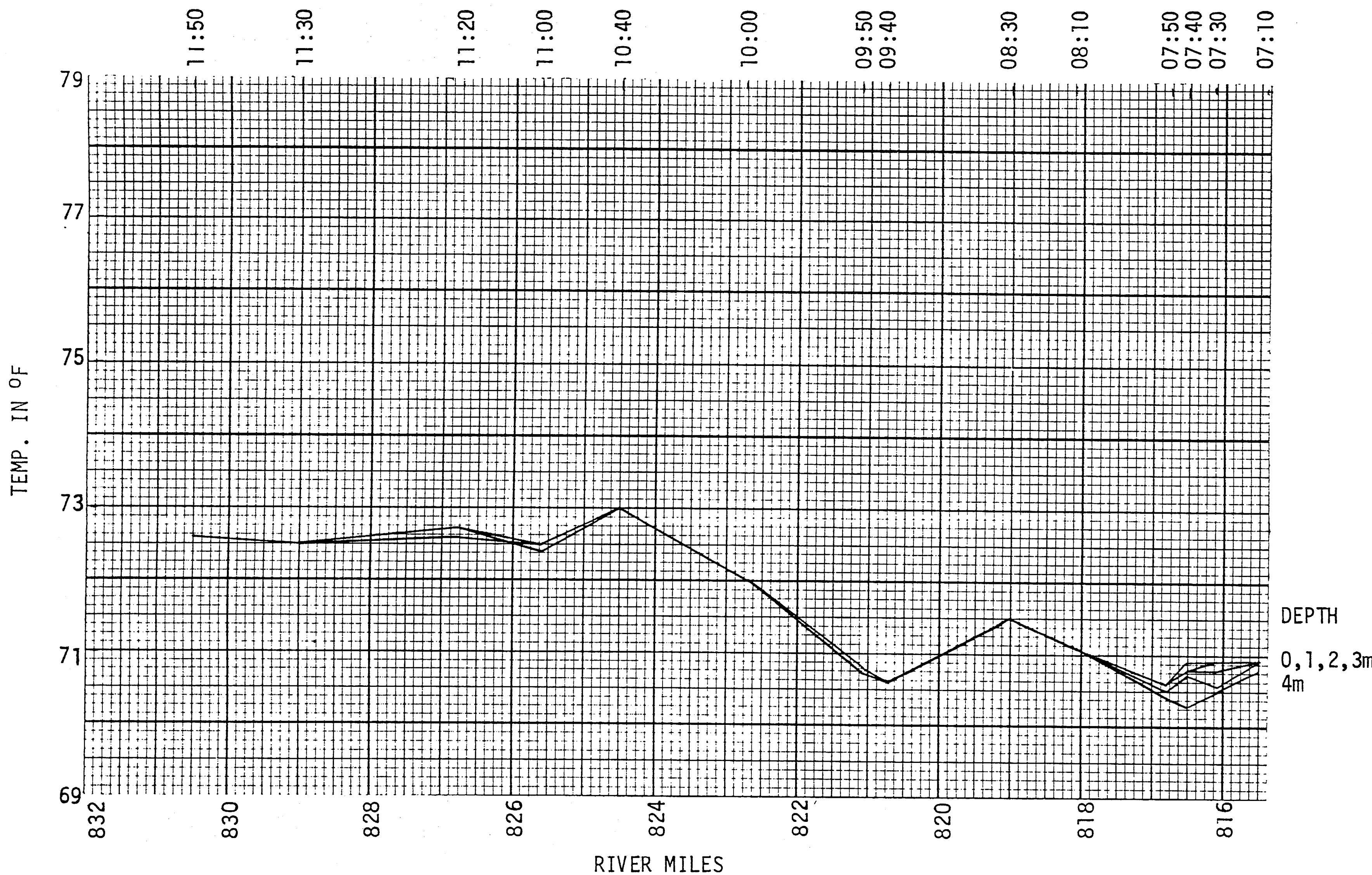

Fig. E-2 - MISSISSIPPI RIVER, SEPTEMBER 8, 1976.

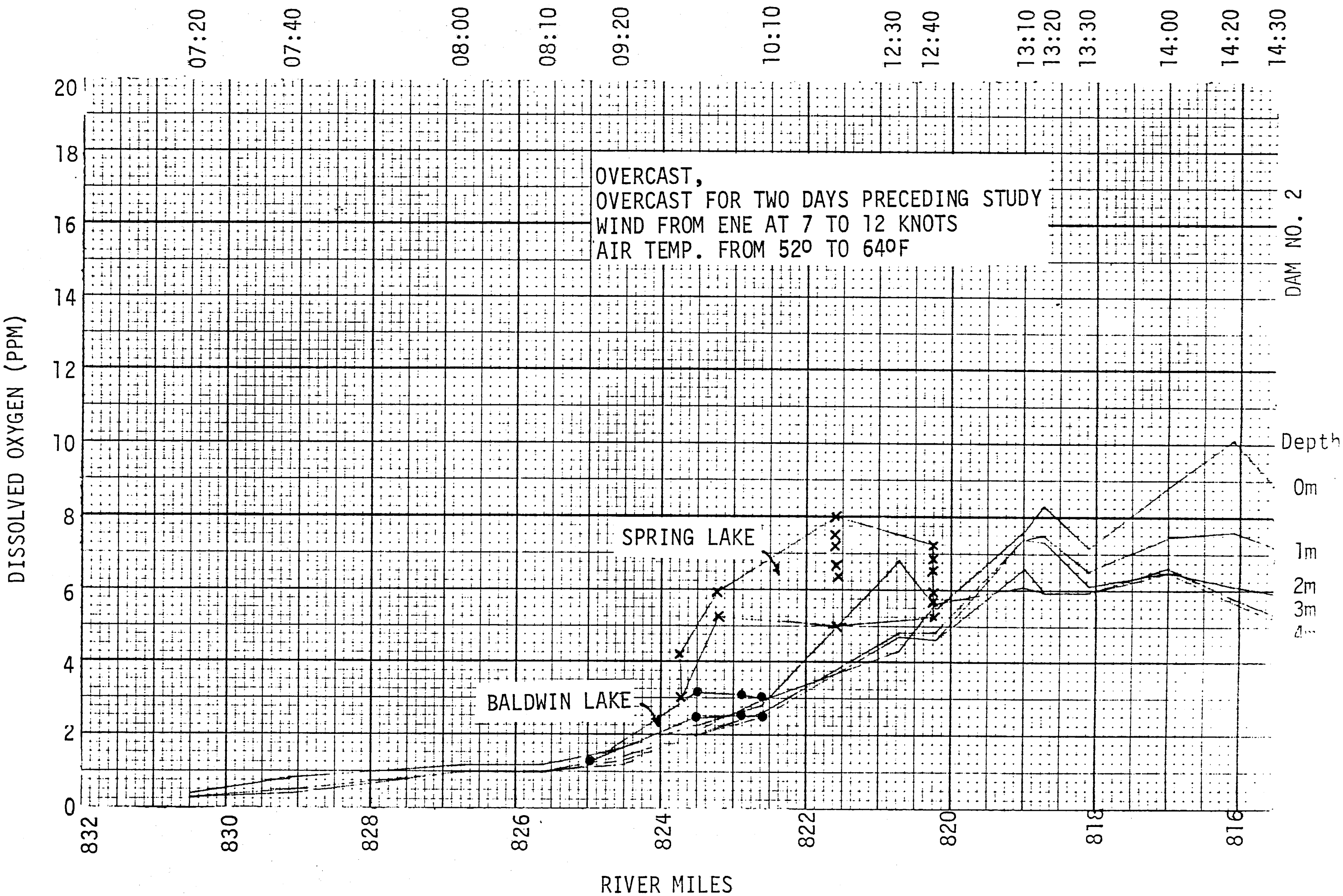

Fig. E-3 - MISSISSIPPI RIVER, SEPTEMBER 15, 1976

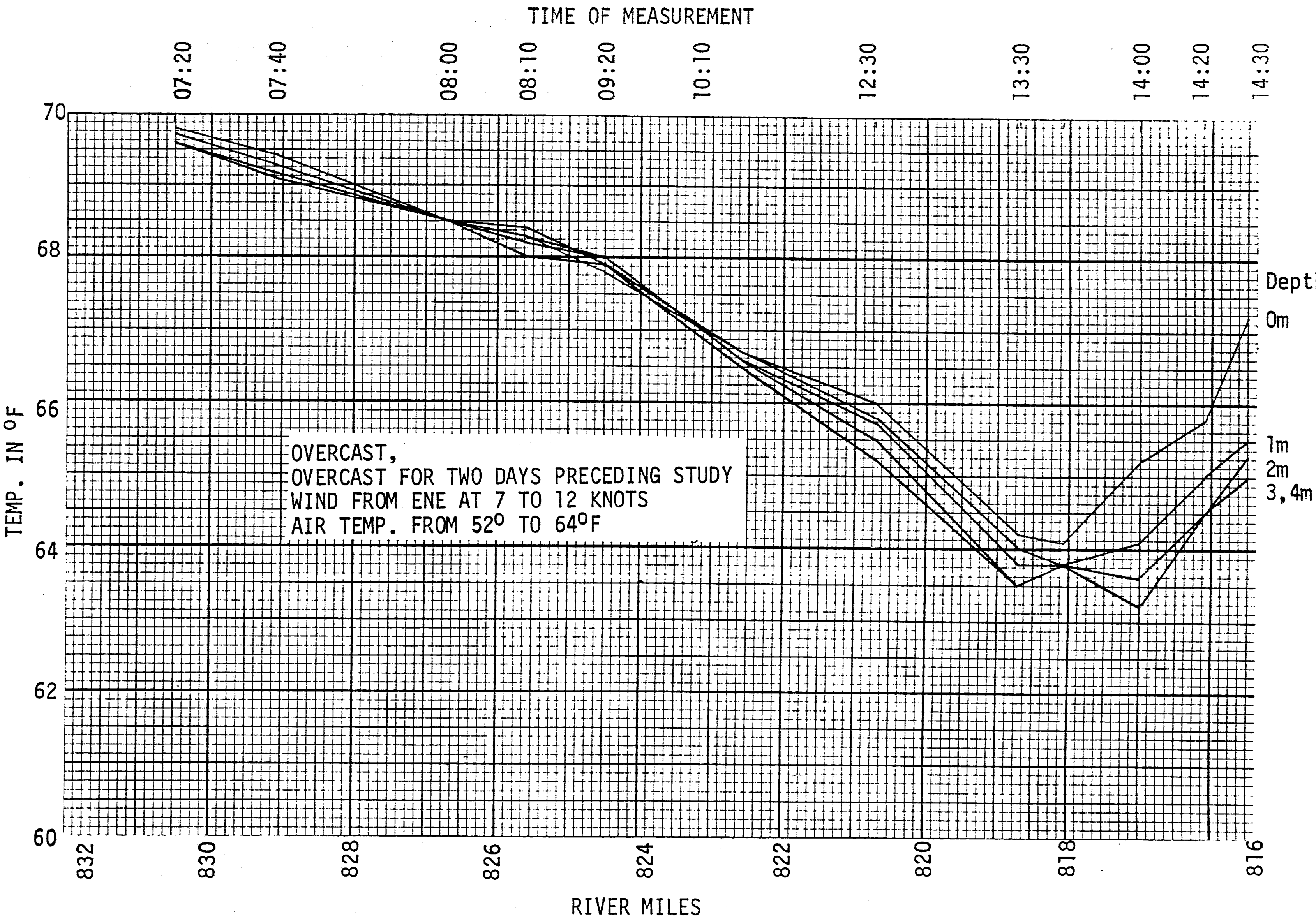

Fig. E-4 - MISSISSIPPI RIVER, SEPTEMBER 15, 1976.

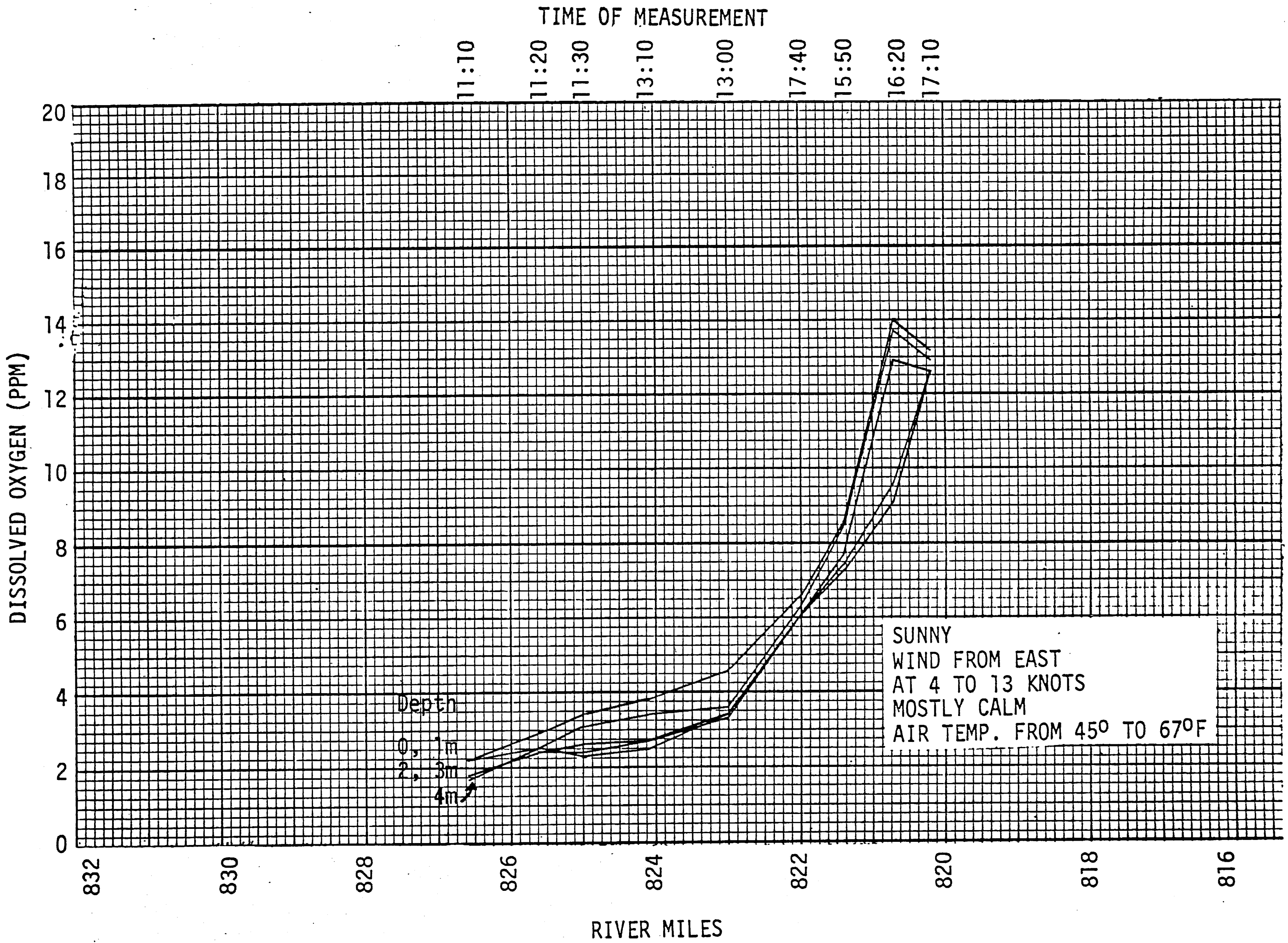

Fig. E-5 - MISSISSIPPI RIVER, SEPTEMBER 25, 1976.

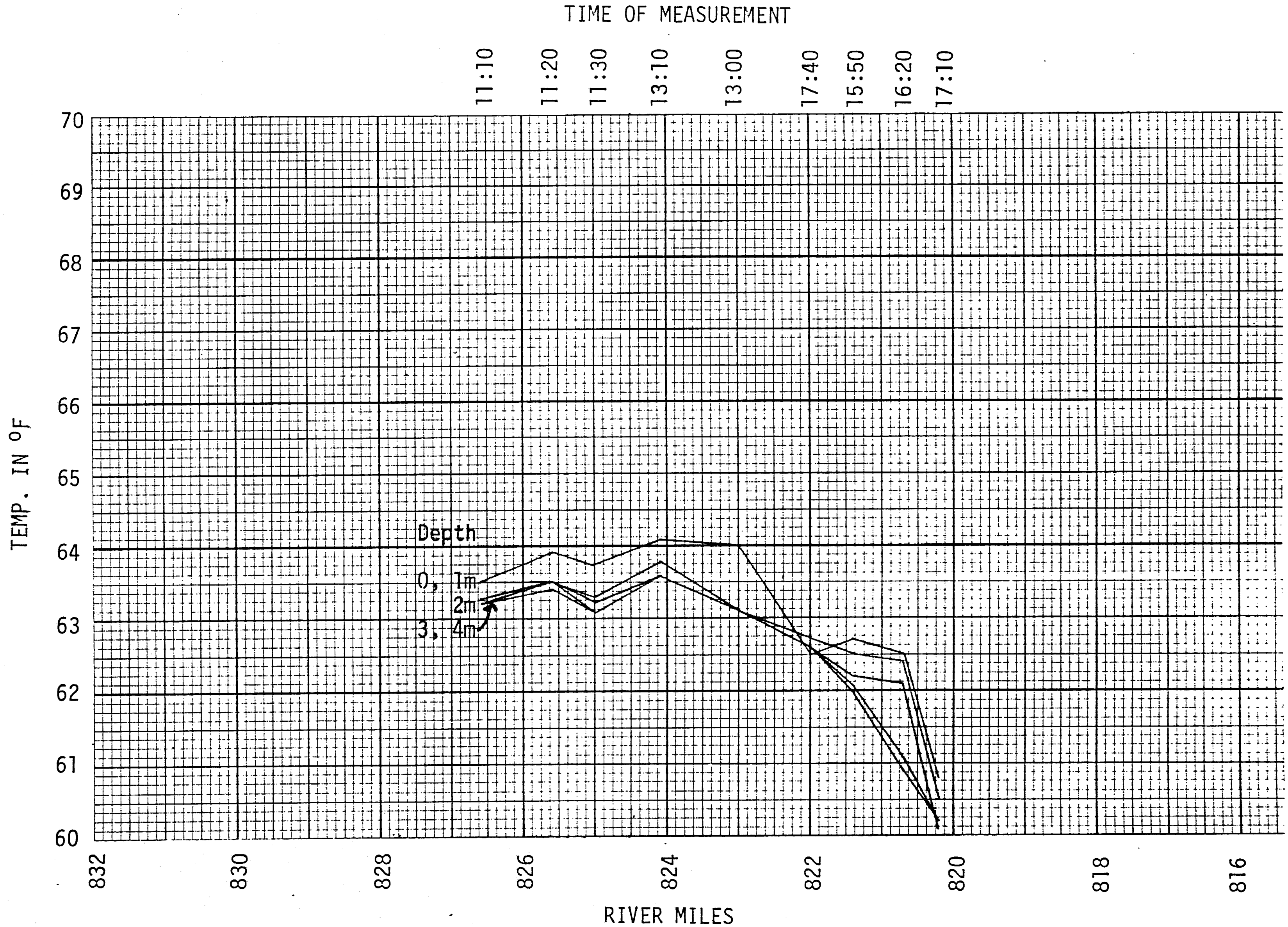

Fig. E-6 - MISSISSIPPI RIVER, SEPTEMBER 25, 1976

Stratification, that is vertical gradients of dissolved oxygen and of water temperature, were found more often than anticipated. They were found not only in Baldwin and Spring Lake but also in the navigation channel itself when the weather conditions were favorable. Examples of dissolved oxygen stratification are given in Figs. E-7, E-9, and E-11. The associated water temperature stratifications are given in Figs. E-8, E-10, and E-12.

Sunny weather and southerly wind enhanced the probability of stratification in the main channel. A southerly wind blows opposite to the river flow direction, at least upstream from river mile 824. The surface wind shear stress retards the flow velocities near the surface forcing the flow velocities at greater depth to increase. Under a strong wind a counterflow may even be produced. It is known that vertical velocity gradients in a weakly density stratified fluid can lead to stronger density gradients and stratified flows. The process is associated with the formation of mixed layers of nearly uniform temperature and dissolved oxygen. The existence of a surface mixed layer limited by a strong thermocline was found on several occasions. Its thickness was found to vary depending on wind velocities. Some mixed layer depths measured in the main river channel are given in Table E-1.

On September 3, a very strong northwesterly wind was unable to mix the narrow and north-south oriented portion of the river between river miles 830 and 823, due to the orientation of the river valley, but produced very high waves and virtually well-mixed conditions downstream from Spring Lake exit (river mile 823). The measurements are shown in Figs. E-13 and E-14.

Another mechanism contributing to the stratification of the river main stem is found at the Metro Sewage Treatment Plant Outlet itself. It is the formation of a sinking plume due to the slightly higher density of the effluent relative to the river. The density differential is caused by slightly lower temperatures of the sewage effluent (near 75^{o}F on August 24 and August 26, 1976) compared to river temperatures (near 80^{o}F on August 24 and August 26, 1976). Suspended solids in the effluent may also be a contributing factor. The plunge point of the effluent is very well marked by the accumulation of floating debris on the water surface at the end of the outlet channel. The sinking plume of effluent sewage flows along the bottom of the navigation channel both downstream and upstream. Near bottom values of D.O. decrease in both directions from the outlet as shown in Fig. E-15 indicating that the flow must be in both directions. No attempt was made to trace the sinking plume.

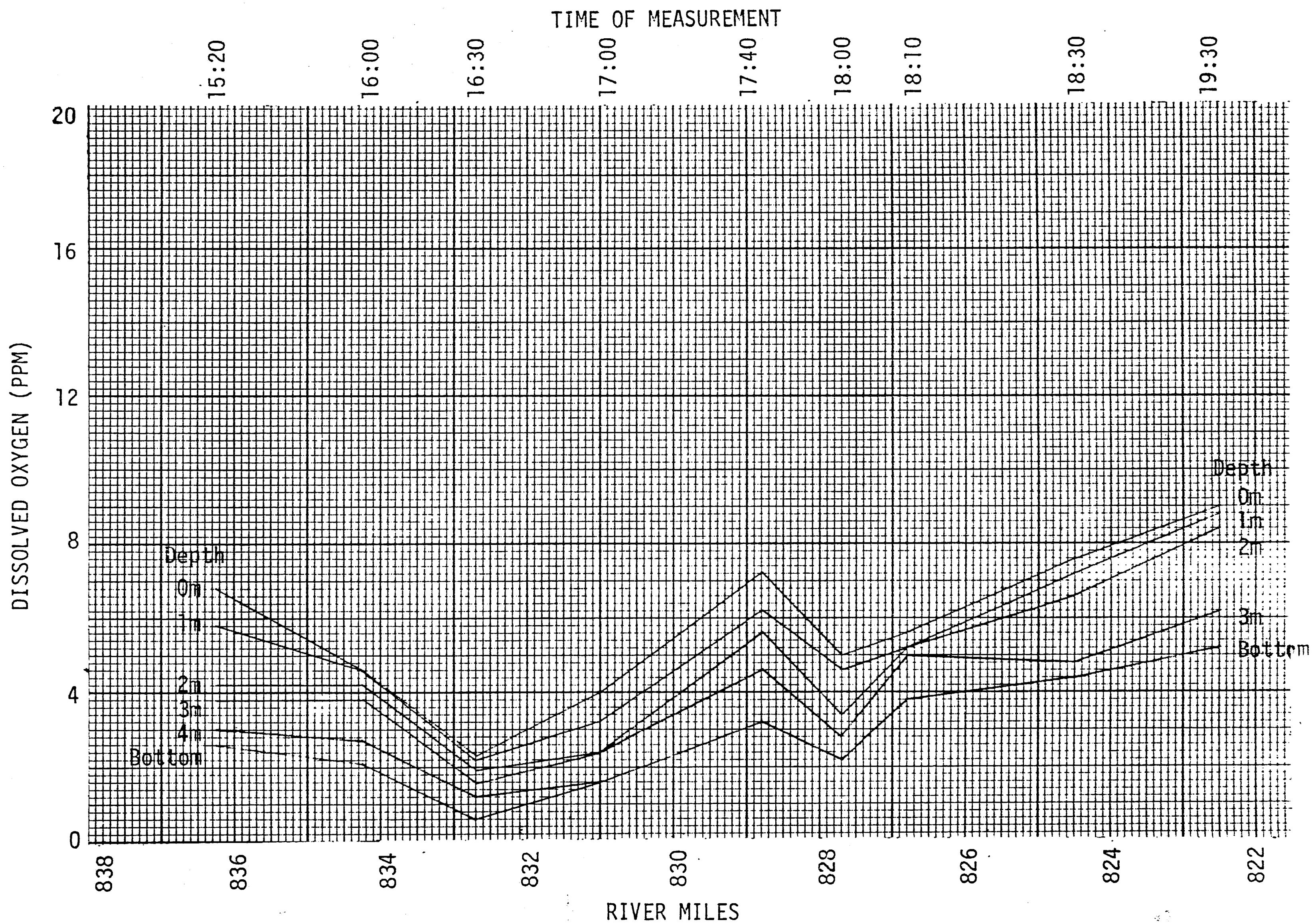

Fig. E-7 - MISSISSIPPI RIVER, AUGUST 26, 1976.

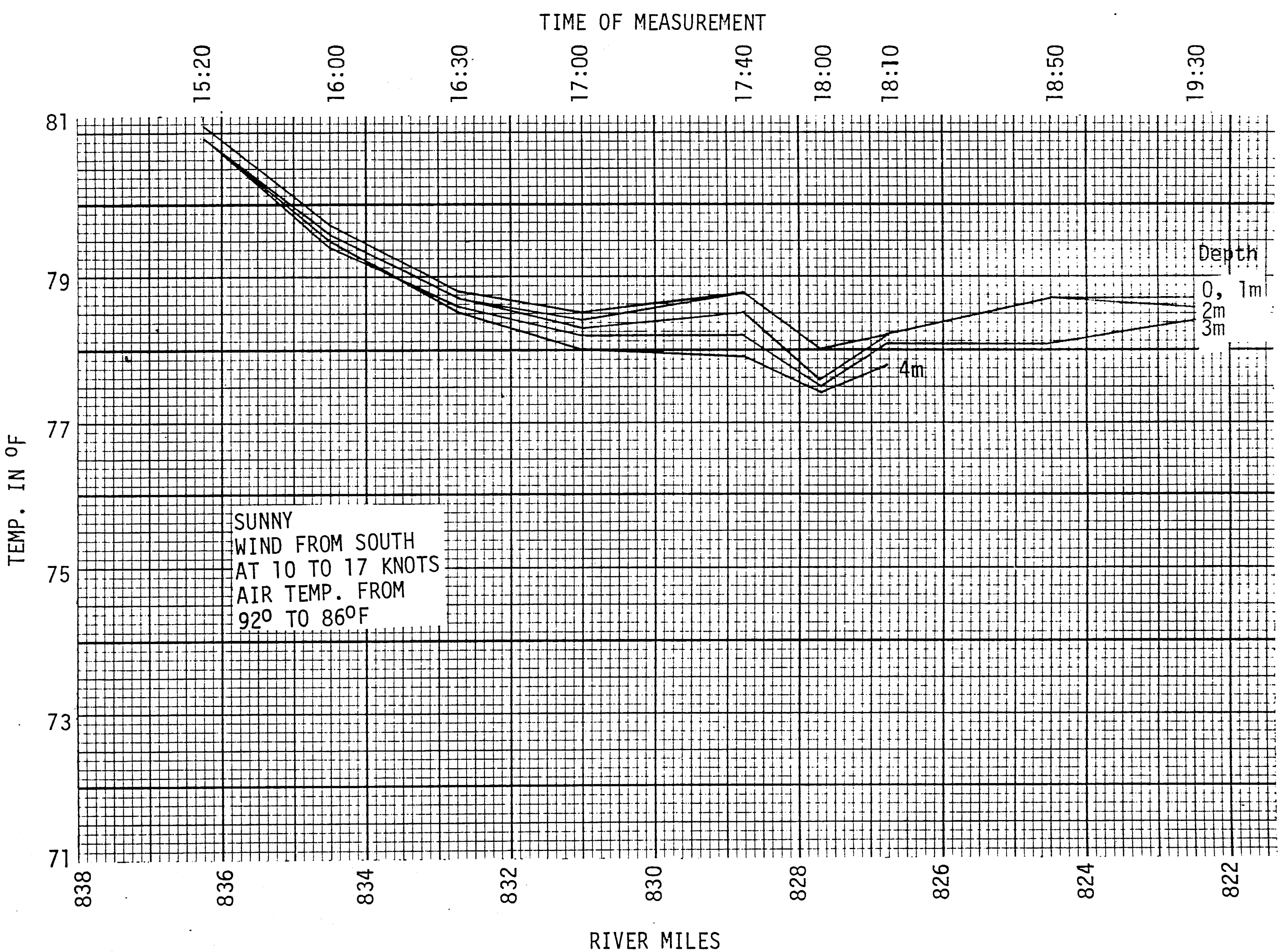

Fig. E-8 - MISSISSIPPI RIVER, AUGUST 26, 1976.

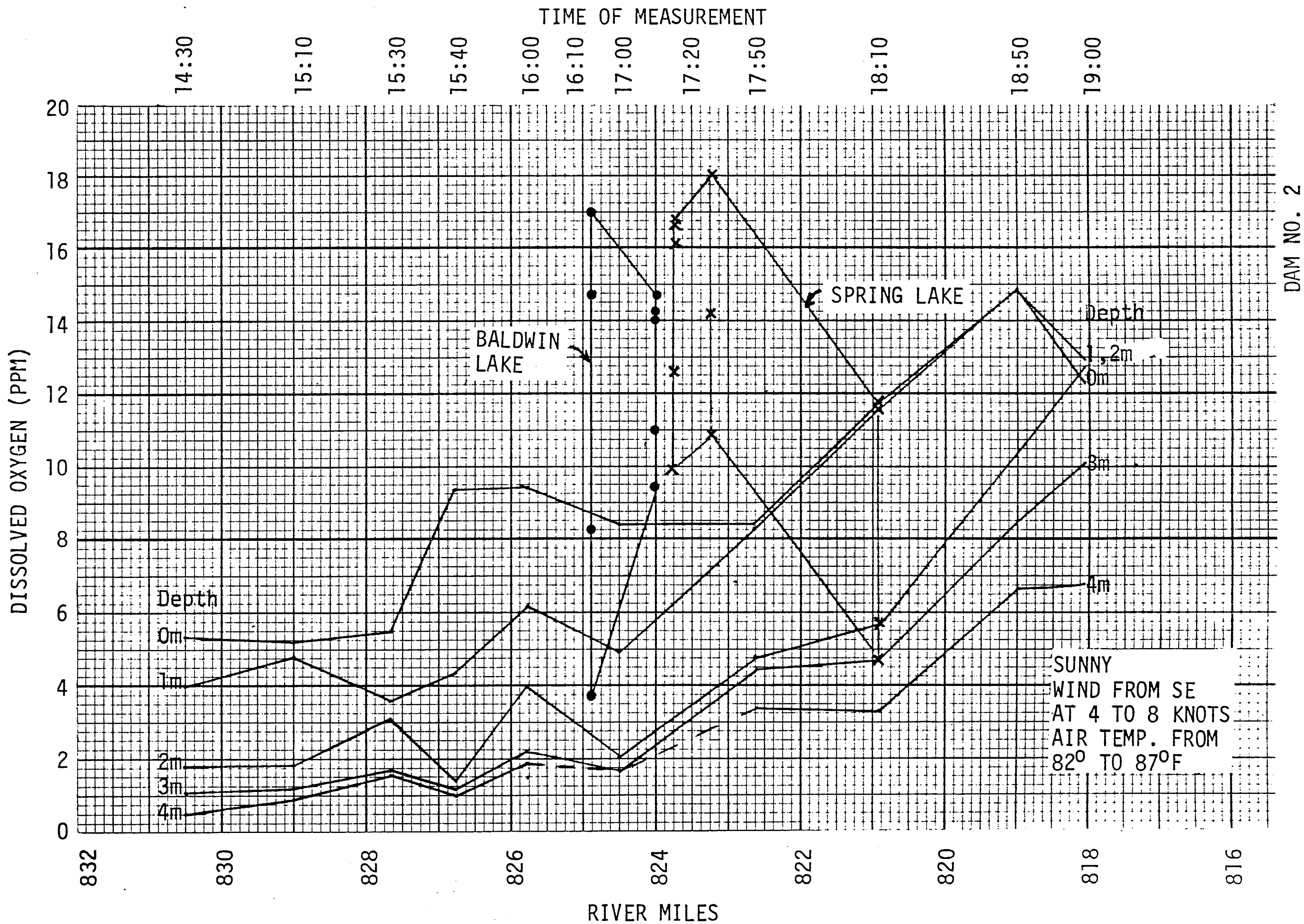

Fig. E-9 - MISSISSIPPI RIVER, AUGUST 30, 1976.

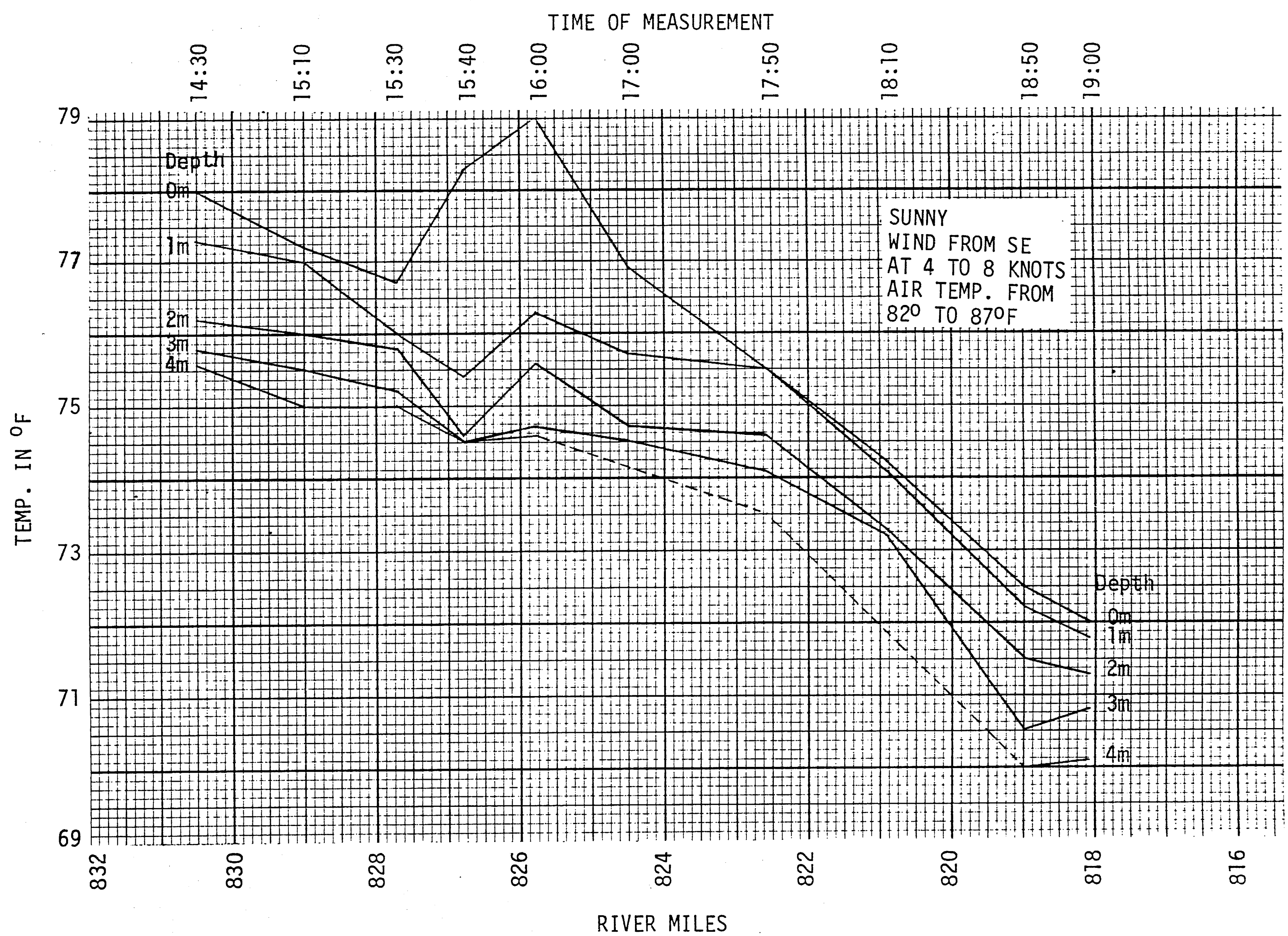

Fig. E-10 - MISSISSIPPI RIVER, AUGUST 30, 1976.

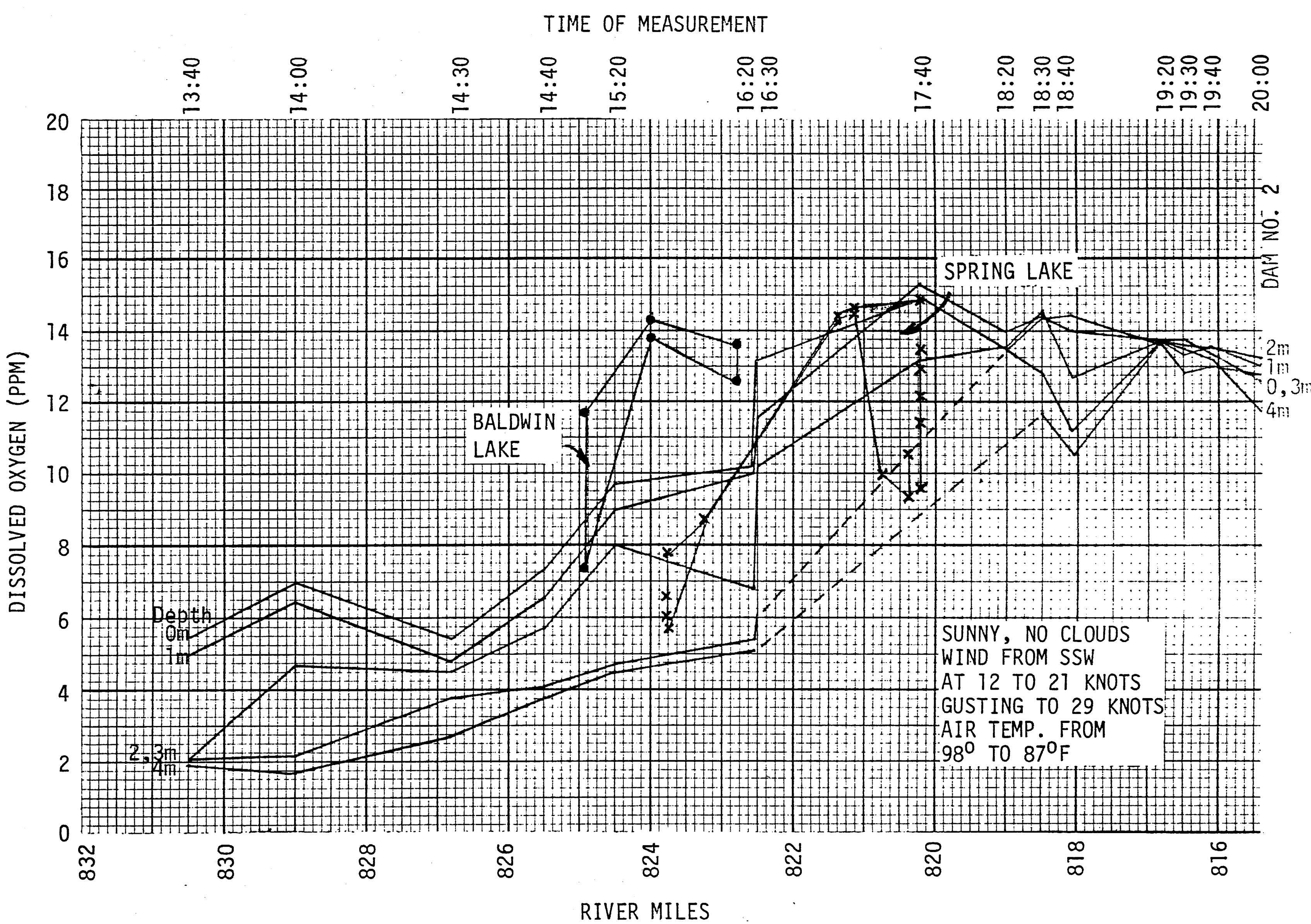

Fig. E-11 - MISSISSIPPI RIVER, SEPTEMBER 7, 1976.

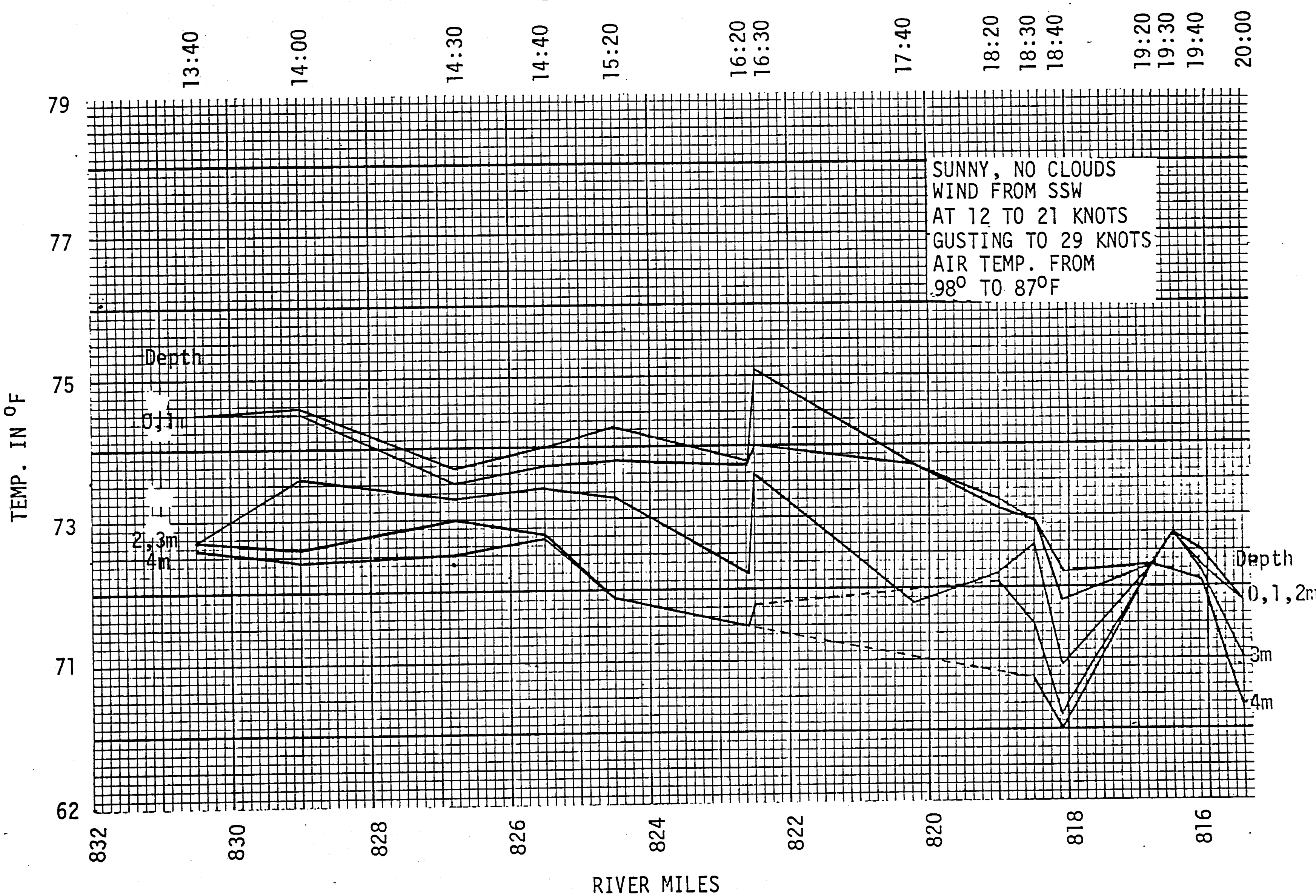

Fig. E-12 - MISSISSIPPI RIVER, SEPTEMBER 7, 1976.

Table E-1 - Examples of Approximate Surface Mixed Layer Thicknesses.

Date	River Mile	Time	Depth of Mixed Layer (m)	Wind Direction (00-36)-Speed (knots) previous 3 hrs.	Wind Direction (00-36)-Speed (knots) previous 24 hrs.
Aug. 24, 76	829.0	1920	1.3	14 - 10	21 - 10
Aug. 26, 76	822.5	1925	1.75	19 - 14	19 - 17
Aug. 30, 76	820.9	1813	1.4	13 - 8	12 - 10
Aug. 30, 76	818.1	1910	1.8	13 - 8	12 - 10
Sept. 3, 76	829.0	1346	2.5	29 - 17	19 - 18
Sept. 7, 76	829.0	1402	1.0	22 - 13	18 - 15

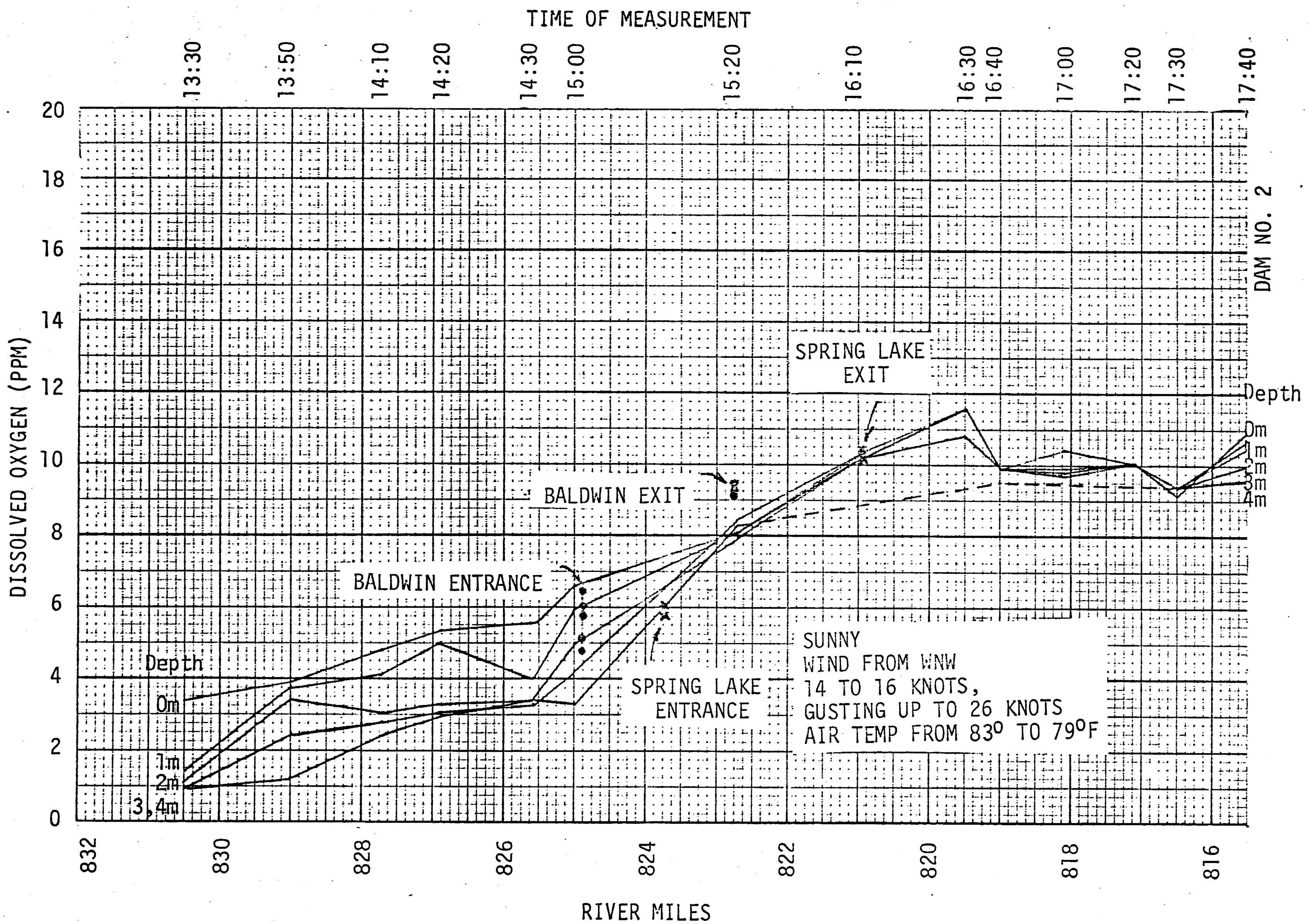

Fig. E-13 - MISSISSIPPI RIVER, SEPTEMBER 3, 1976.

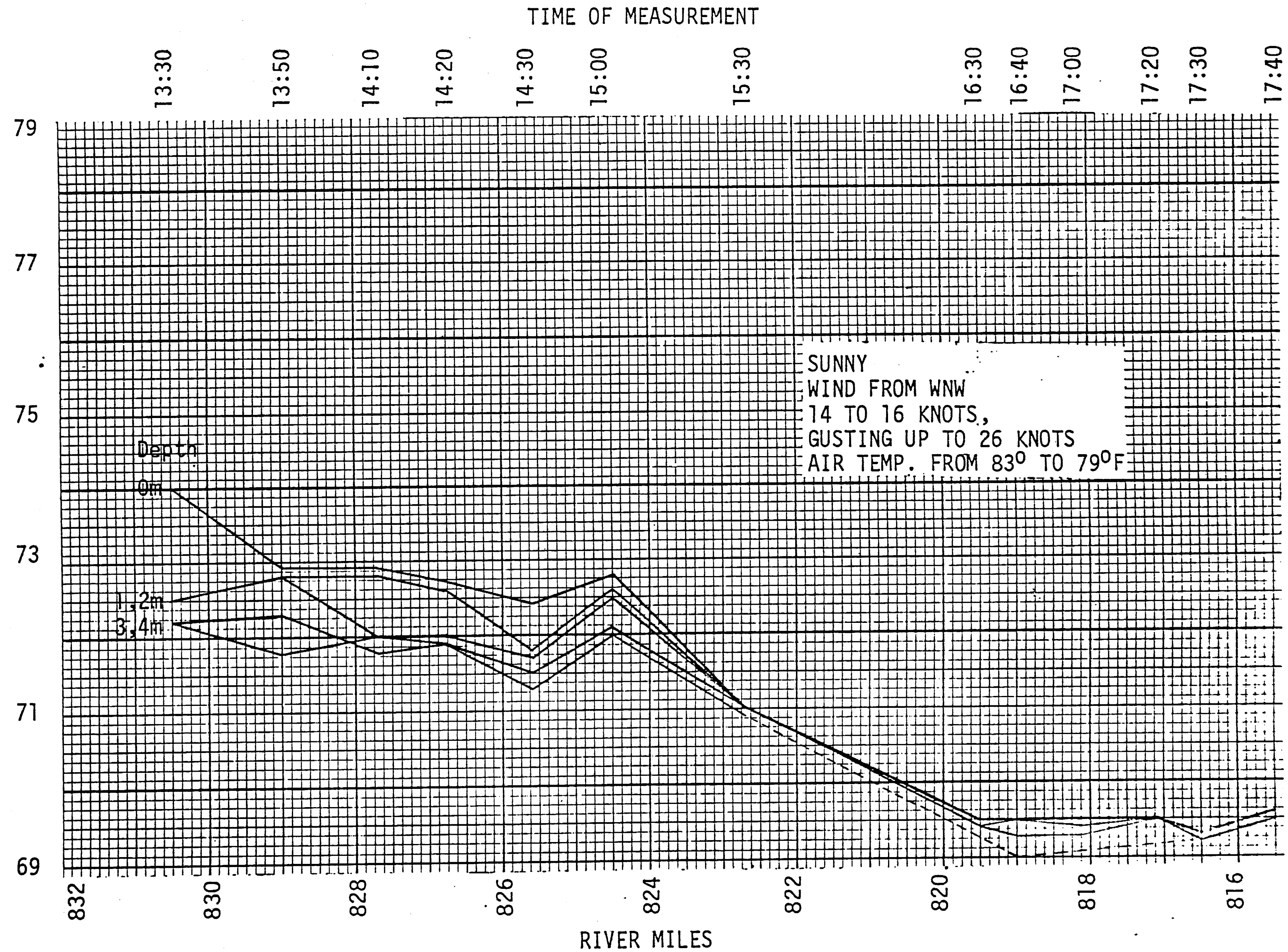

Fig. E-14 - MISSISSIPPI RIVER, SEPTEMBER 3, 1976.

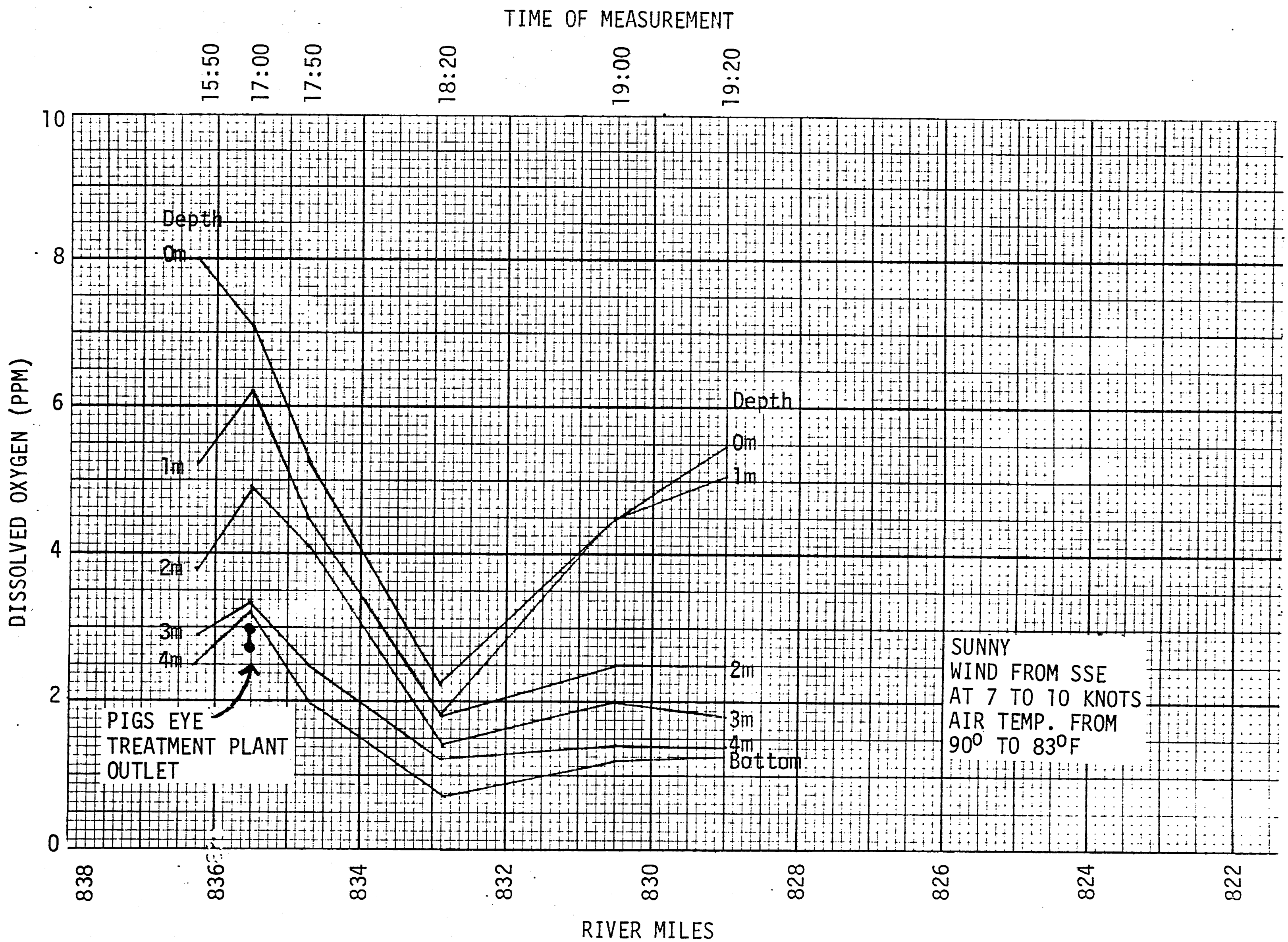

Fig. E-15 - MISSISSIPPI RIVER, AUGUST 24, 1976.

Treated sewage water effluent temperatures are lower than ambient river water temperatures throughout most of the summer as shown by data for 1975. The sinking plume is therefore not an unusual phenomenom but rather the typical summer flow condition.

Barge traffic stirs up and mixes the water in the navigation channel. Measurements taken 5 and 10 minutes after the passage of multi-unit barge convoys on different days and at different locations showed very nearly well-mixed condition. Stratification appears to reform, however, after more time has elapsed.

3. Baldwin Lake and Spring Lake

Baldwin Lake and Spring Lake are shallow bodies of water with a combined surface area of approximately 3.8 square miles connected to the river main stem by multiple inlets and outlets, some of which are very wide. Major portions of the lakes are 3 to 5 ft deep, but there are also some major navigation channels of 10 and more feet depth through Baldwin Lake and near the upper end of Spring Lake. Actually, depths up to 30 ft were measured in what appears to be a scour hole in the Baldwin Lake entrance. Measurements in the lakes and backwater areas were usually taken at several of the stations shown in Fig. D-1. The data are given in the Appendix.

A number of observations important to the mathematical modeling of water quality in the Mississippi River can be reported:

On sunny and not very windy days the lakes were found to be stratified and D.O. levels in the upper one half to two meters were above saturation. Figs. E-16 and E-17 show such conditions. A significant temperature stratification also existed in addition to the D.O. stratification. The main thermocline was between depths 0.5m and 1.0m. Water temperature data are shown in Figs. E-18 and E-19. The measurements in Figs. E-16 through E-19 are not synoptic because of the travel times from one measuring station to another, but they give an idea of the spatial distributions of D.O. and water temperature on a clear day.

Most noteworthy and important is the strong increase in D.O. levels in the river main stem as it winds past Baldwin Lake and noteably Spring Lake.

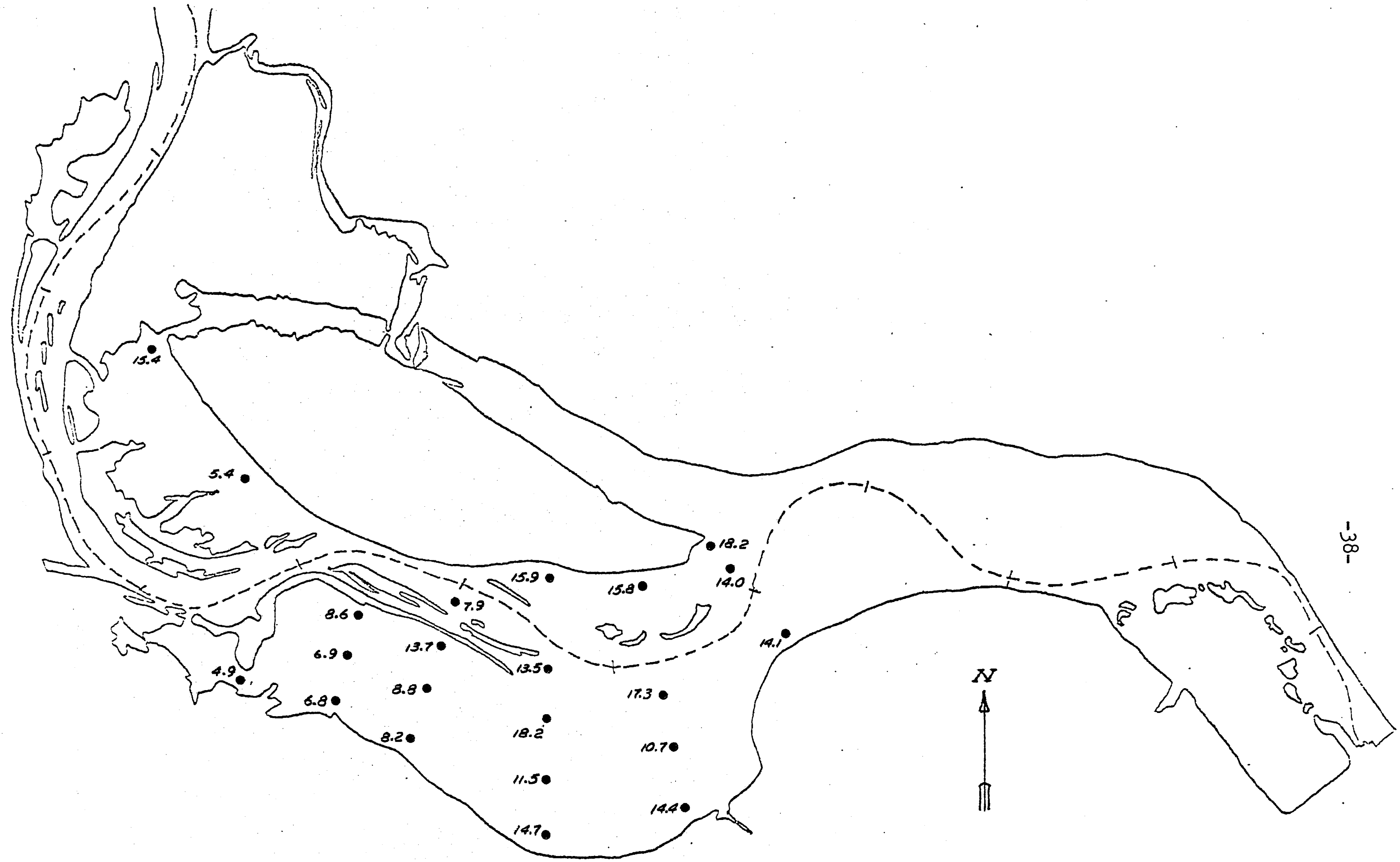

Fig. E-16

MWCC: MISSISSIPPI RIVER STUDY 76
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D.O. AT 0.5m (mg/l)	
9/25/76	1100–1830

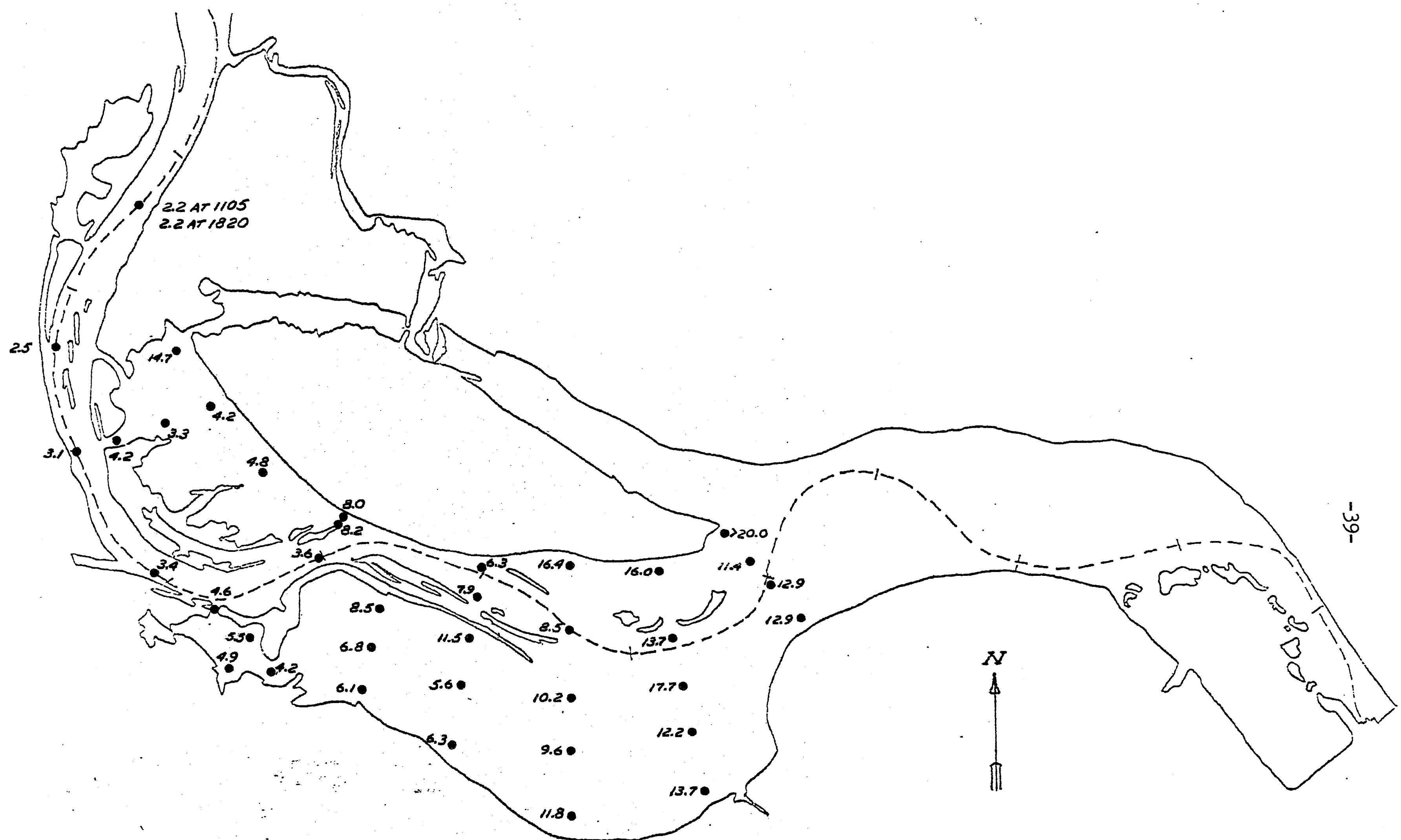

Fig. E-17

MWCC: MISSISSIPPI RIVER STUDY 76
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UNIVERSITY OF MINNESOTA

D.O. AT 1.0M (mg/ℓ)	
9/25/76	1100–1830

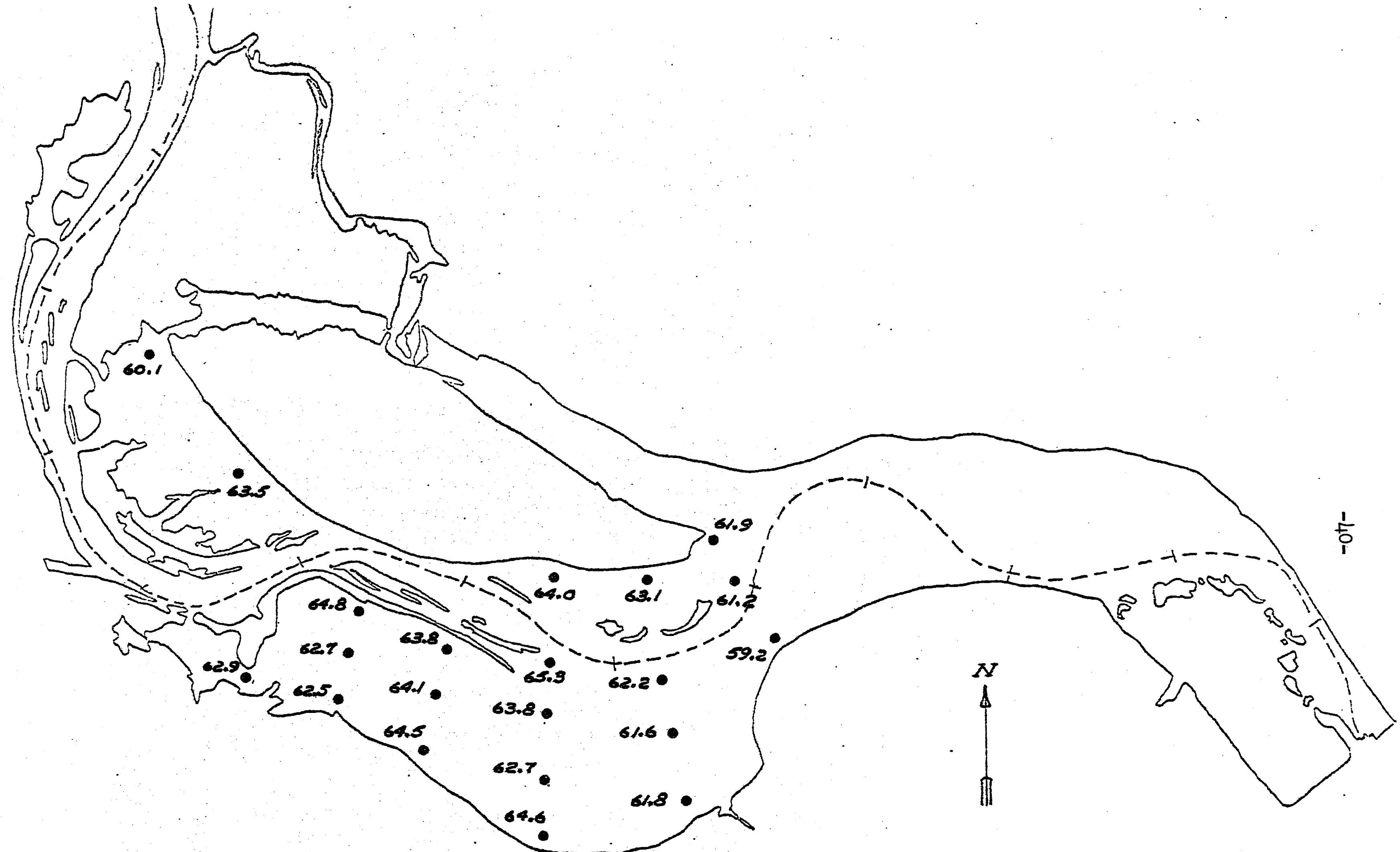

Fig. E-18

MWCC: MISSISSIPPI RIVER STUDY 76
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WATER TEMP. (°F) AT 0.5M	
9/25/76	1100-1830

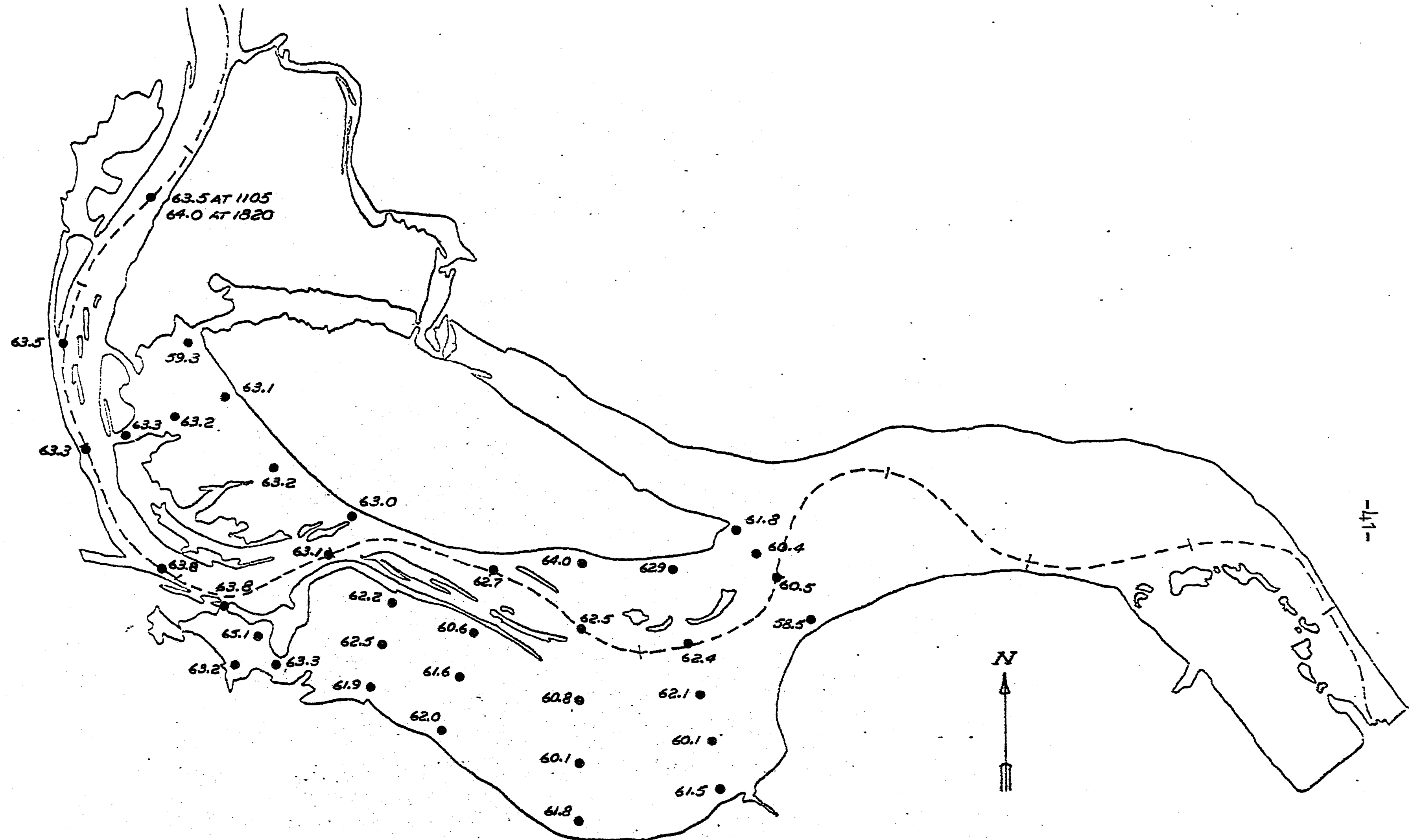

Fig. E-19

MWCC: MISSISSIPPI RIVER STUDY 76
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WATER TEMP.(°F) AT 1.0m	
9/25/76	1100→1830

At the same time, water temperatures drop significantly. The observed gradients in longitudinal direction cannot be explained by processes in the main stem alone. They must therefore be the result of flow processes resulting in strong water exchange between Baldwin Lake and the river main stem and Spring Lake and the river main stem. This is of great importance for dissolved oxygen modeling in that region.

The high D.O. levels, particularly in Spring Lake, could be the result of surface aeration by wind or photosynthesis by phytoplankton. Both processes contribute. On sunny and calm days, when supersaturation occurs, photosynthesis must be the dominant mechanism. Indeed, the water was found to be very rich in phytoplankton, resulting in very low transparencies. A typical example of Secchi depths on a sunny day is shown in Fig. E-20. Secchi depths in the lakes were usually from 0.3m to 0.5m, those in the river main stem upstream from the lakes from 0.5m to 1.0m.

If photosynthetic production of oxygen is a major factor in the D.O. budget of Pool No. 2, weather conditions, and in particular sunshine must be a factor. In particular, D.O. levels should be expected to decrease during the night and also during periods of extensive cloud coverage.

To examine diurnal effects, measurements along the river main stem and at some points in Baldwin Lake and at the edge of Spring Lake were made on the sunny afternoon of September 7 between approximately 2 and 8 p.m. and on the following partially cloud covered morning of September 8 between 7 a.m. and noon.

Graphical presentations of the measured D.O.'s have been given in Figs. E-1 and E-11. A comparison shows that 'overnight' the river went from a very strongly stratified condition to a vertically, nearly uniform condition. The change was accompanied by very significant reductions in D.O. levels and water temperatures in the upper two meters. The losses in D.O. were on the order of 4 mg/1 and the temperature drop was on the order of 2^{o}F. With little doubt one can say that surface heat loss to the atmosphere and oxygen consumption by biochemical decomposition of suspended materials and respiration of the phytoplankton mass are responsible for the observation. The vertical mixing is mainly the result of natural convective currents produced by surface cooling.

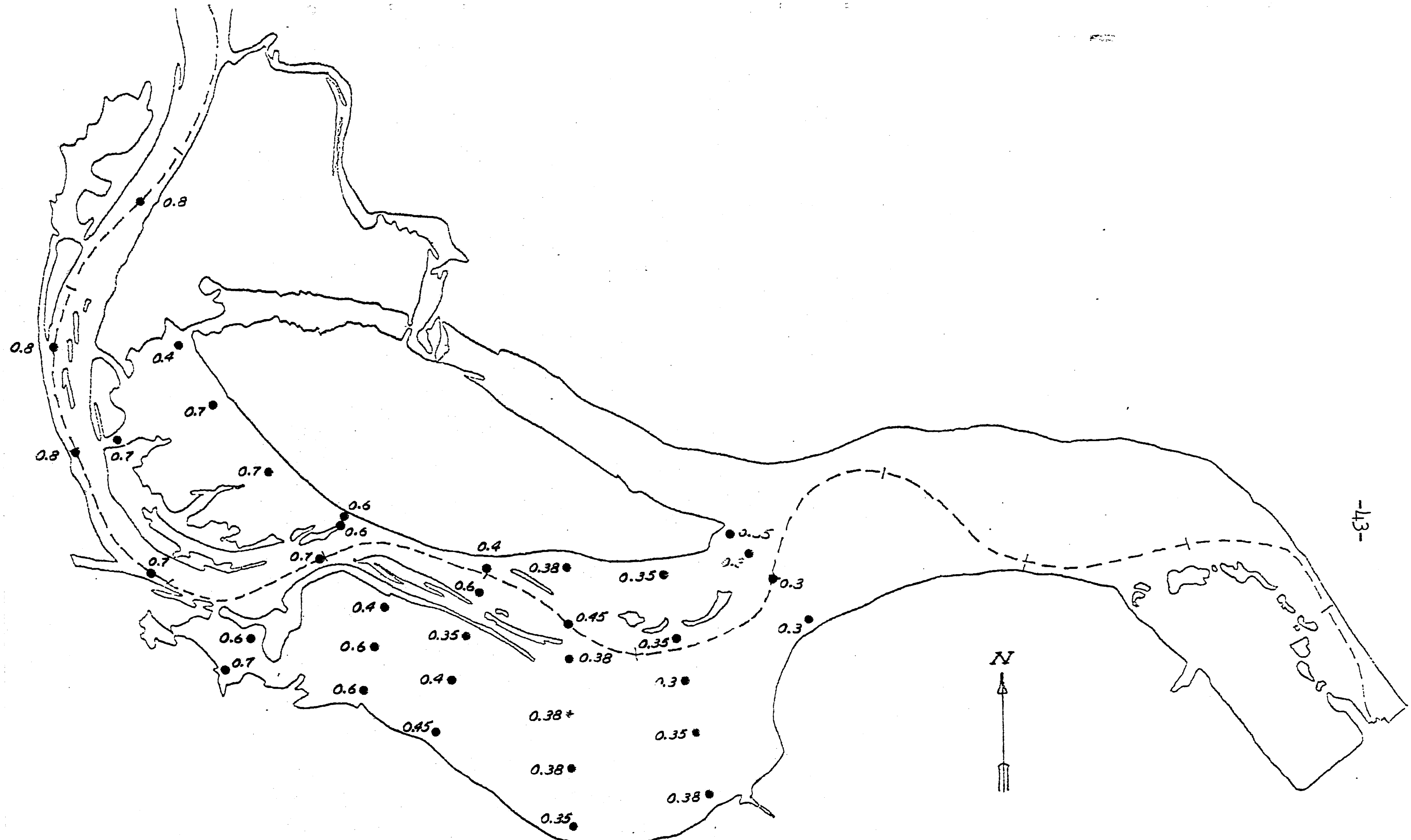

Fig. E-20

MWCC: MISSISSIPPI RIVER STUDY 76
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SECCHI DISK MEASURMENTS (M)	
9/25/76	1100~1830

To examine the effect of cloud coverage, measurements were also made on September 15 after two days of overcast skies. The resulting D.O.'s and water temperatures have been shown in Figs. E-3 and E-4. Vertical gradients in water quality, except near the dam, were small due to convective cooling and mixing. D.O. levels were down 1-3 mg/1 in Baldwin Lake and 3-8 mg/1 in Spring Lake, compared to 3-17 mg/1 and 5-18 mg/1, respectively, under sunny weather conditions on August 30 or 7-14 mg/1 and 5-15 mg/1, respectively, on September 7.

D.O. levels in the main stem were less than 1 mg/1. Obviously, high oxygen consumption and low production caused depressed D.O. level.

Spatial distributions of D.O. and water temperature in plan view are given in Figs. E-21 and E-22. They reveal the still markedly higher D.O. levels in Spring Lake compared to the river main stem upstream from it. Secchi depths reported in Fig. E-23 are much the same as found under sunny conditions. It is concluded that Spring Lake is still a major oxygen source for the recovery of the river main stem. Surface aeration by wind and photosynthetic production (at a reduced rate) are the major contributing mechanisms and oxygen sources.

4. Lower Pool

We shall call "Lower Pool" the water volume downstream from river mile 820. The navigation channel winds through this pool and thereby crosses the pool three times at about 45° to the valley orientation. Measurements taken along the edge of the navigation channel are therefore representative of both the deep portions of the pool and the adjacent shallow stumpfields over which the water is moved by winddrift. The role of the navigation channel in the lower pool was not fully investigated. It was found, however, to be a place where cooler water of different D.O. content than the surface waters could accumulate, possibly even flow as a density current. D.O. levels in the lower pool were generally above levels which cause concern, i.e., above 5 mg/ℓ. On sunny afternoons supersaturated water was found in portions of the lower pool.

The effect of the shallow water regions and stumpfields on the oxygen balance is believed to be much the same as that of Spring Lake and Baldwin Lake further upstream except that the D.O. levels were already high when the water entered the lower pool region.

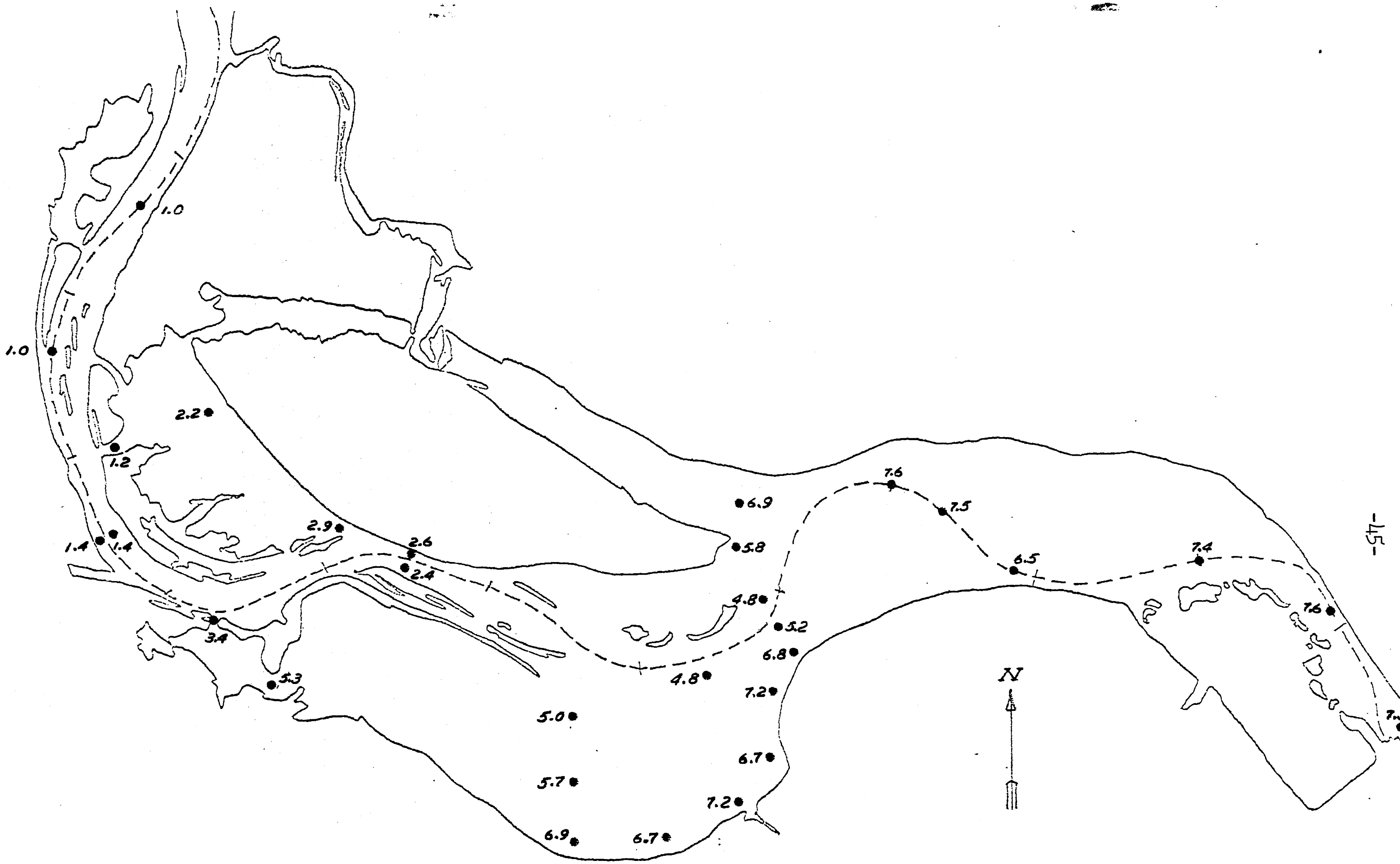

Fig. E-21

MWCC: MISSISSIPPI RIVER STUDY 76

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D.O. AT 1.0m (mg/l)	
9/15/76	0700—1600

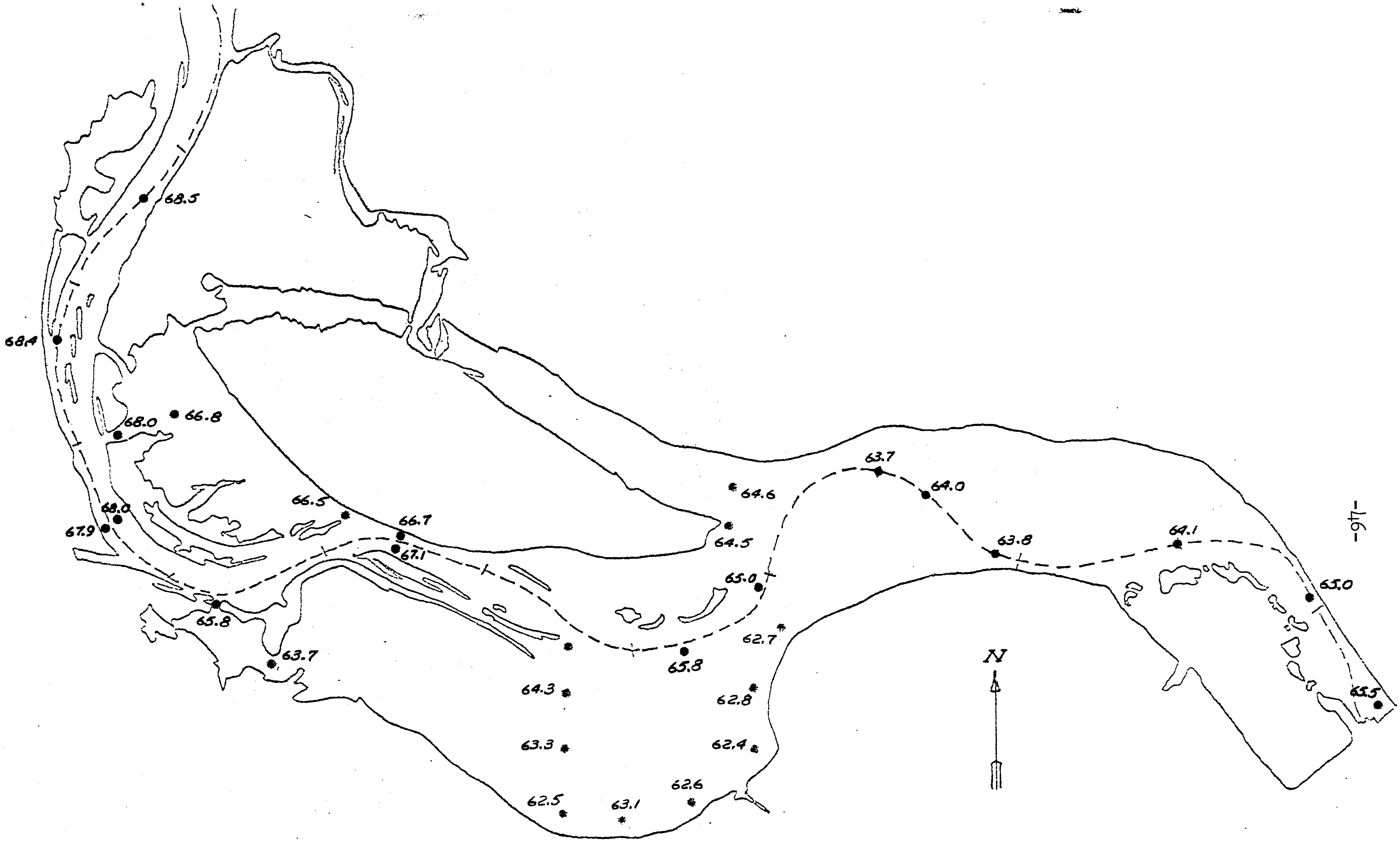

Fig. E-22

MWCC: MISSISSIPPI RIVER STUDY 76
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WATER TEMP. (°F) AT 1.0M	
9/15/76	0700~1600

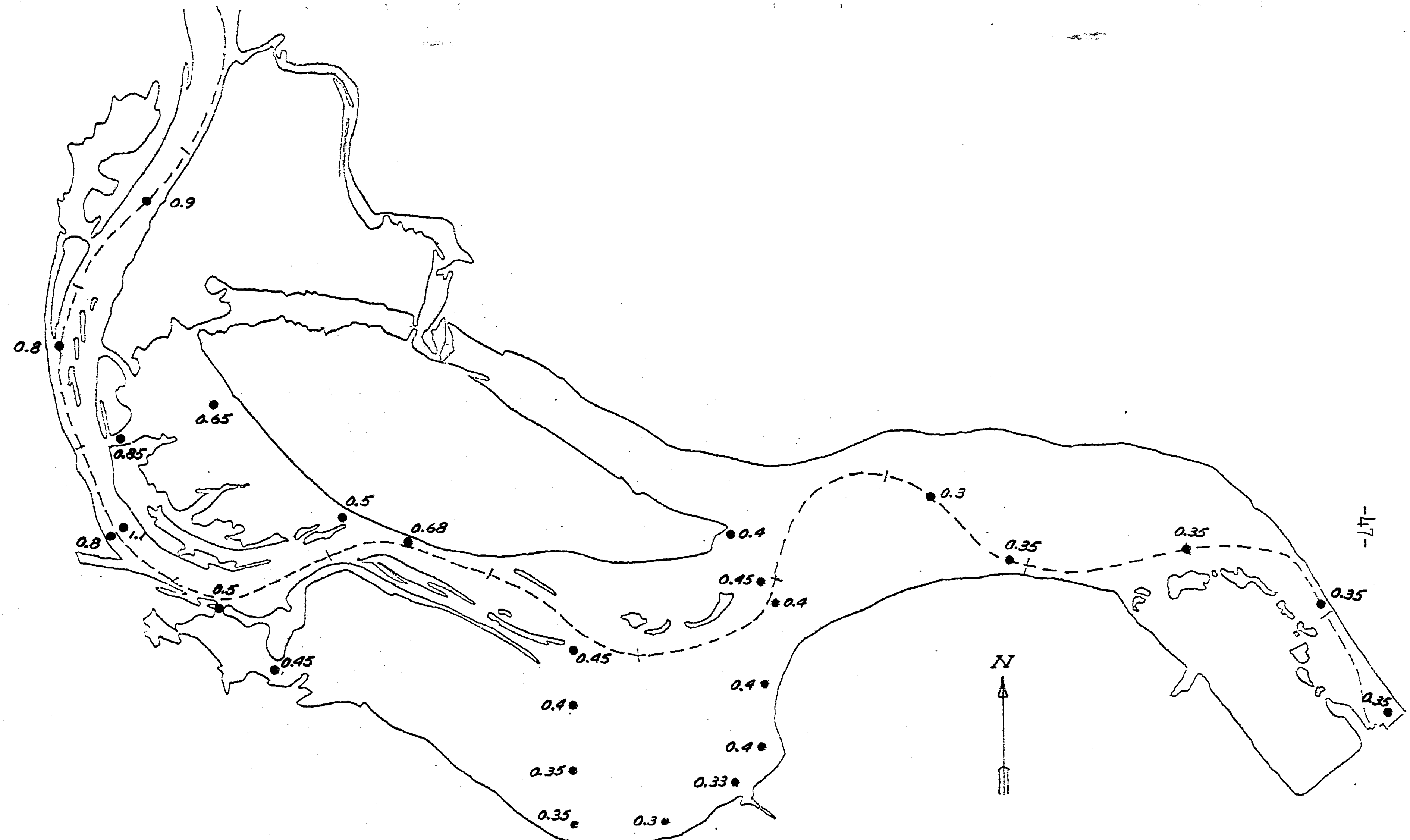

Fig. E-23

MWCC: MISSISSIPPI RIVER STUDY 76
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SECCHI DISK MEASUREMENTS (M)	
9/15/76	0700~1600

5. Wind Drift Currents

Wind drift was observed to play an important role in the surface flow of water through the pool. Because no funds had been allocated for current measurements over depth, only occasional estimates of currents on the water surface could be made. Drift bodies that were almost neutrally buoyant and did therefore not protrude through the water surface, were used. They were bright yellow, about 1 inch high and 9.4 inches in diameter with an inward bent rim. Because of their low mass but high drag when laying flat in the water, they are good markers of the water motion near the surface. The displacement of the markers with reference to fixed points on shore or marker buoys in the water was measured using a range finder. Surface current directions and a few approximate surface current velocities were determined.

In the wide open water body, surface current directions were usually found to coincide with wind direction as expected. Near the shore the correlation was less clear.

Currents through the entrances and exits of Baldwin Lake and Spring Lake were of particular interest because of their previously noted strong effect on D.O. recovery of the river main stem. It was observed that surface current directions in the entrances to the two lakes, identified as station 1 and station 7 in Fig. D-1, could reverse themselves depending on wind direction.

Table E-2 summarizes the observations, while Fig. E-24 shows the rough correlation of the data. Directions start with 00 from north. Typically, for a strong wind from the west, water will be drawn into the lakes through the entrance sections and blown out of the lake through the downstream exit sections. Fig. E-25 shows surface measurements made under such conditions. To prevent misinterpretations, it must be pointed out that sometimes the direction of the surface drift current is opposite to the current direction at greater depth below the surface. For example, upstream from river mile 825 a strong southerly wind can generate a surface current going upstream while the flow 2 or 3 m below the surface must be downstream.

It must also be mentioned that on at least one occasion flow velocities through the entrance of Spring Lake were oscillatory as if dependent on a seiche motion in the lake. Since winds do not normally blow at exactly constant speed, a periodically reversible flow direction through the entrances and exits of Spring Lake and Sturgeon Lake are also quite plausible.

Table E-2 - Wind and Observed Surface Currents.

Day	Location	Wind Vel. (knots)	Wind Dir. 00-36	Surface Current Vel. (fps)	Surface Current Dir. 00-36	Time
8/30	Baldwin L. Entr.	5-8	14	0.2	Out(8)	16:10
	Spring L. Entr.	8	14	0.2	Out(11)	17:30
9/3	Blwnlen	14-26	27-30	0.5	In(26)	14:46
	Shiely Dock	14-26	27-29	0.3		13:46
	Sprglen	15-26	29-30	0.5	In(0)	15:12
	Blwnlex	15-26	29-30		Out(29)	15:32
	Sprglex	14-21	28-29	> 0.5	Out(22)	16:08
9/7	Blwnlen	16-24	21		In(26)	15:00
	Sprglen	16-24	21		Out(18)	15:32
	Blwnlex	18-29	21-22		Out(29)	16:06
	Sprglex	18-29	21-22		Out(20)	16:46
9/8	Sprglen	15-21	32-34		In(0)	10:27
	Blwnlex	15-21	32-34		Out(32)	10:15
	Sprglex	15-20	34-35		In(0)	9:43
9/11	Shiely Dock	11-73	20-21	0.06	Upstream(18)	14:47
	Blwnlen, Alt.	10-13	21	0.06	Out(12)	15:00
	Blwnlen	10	21	0.6	In(25)	16:00
	Sprglen	8-10	18-21	0.08	In(0)	16:48
	Blwnlex	8	18-21	0.15	Out(28)	17:32

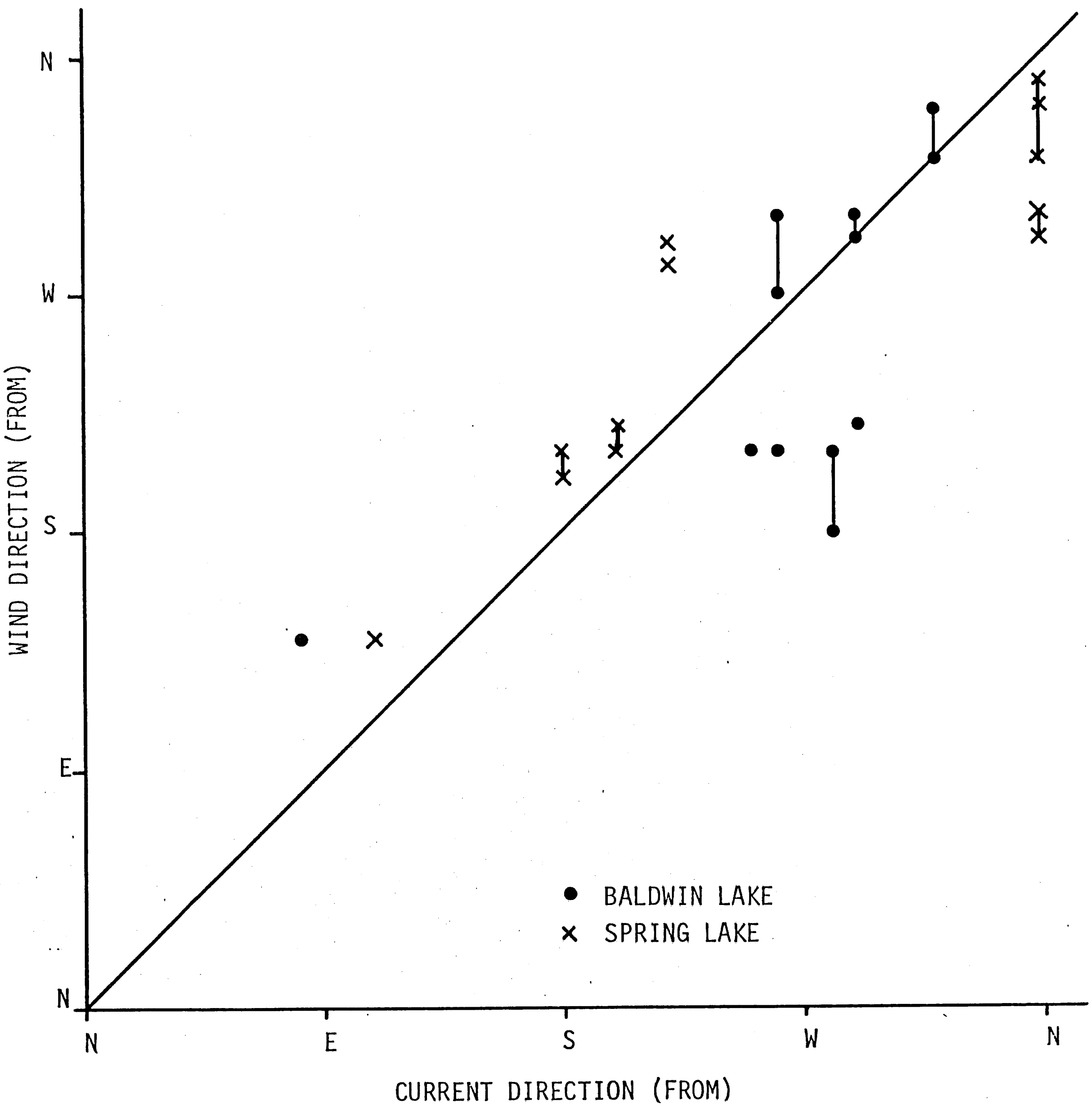

Fig. E-24 - Correlation Between Surface Current Directions and Wind Directions in the Entrances and Exits of Baldwin Lake and Spring Lake.

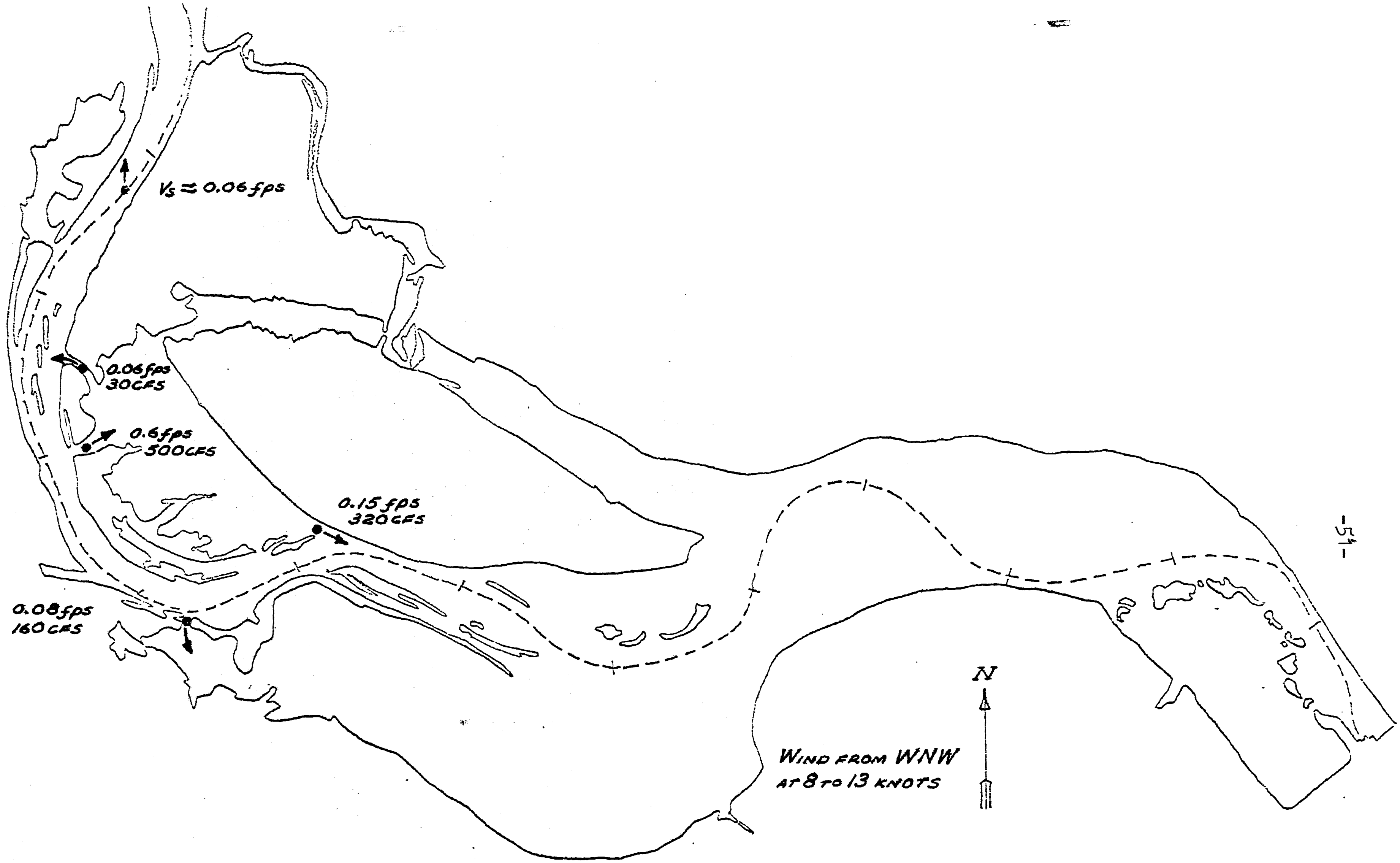

Fig. E-25

MWCC: MISSISSIPPI RIVER STUDY 76
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SURFACE CURRENT VELOCITIES	
9/11/76	1300–1600

Although local instantaneous velocities into and out of the lakes may be quite small, they produce significant flow rates when integrated over the available areas. Some estimates are given in Fig. E-25, with the assumption that only the surface mixed layer is subjected to wind drift.

The largest and probably the most important exchange area is the downstream end of Spring Lake, which is about 1.4 miles wide and up to 10 ft deep, with an average on the order of probably 4 ft. At a velocity of only 0.5 fps, a surface layer of only 2 ft thickness will move 740 cfs of water through that area.

Finally, wind drift out of the lakes into the river main stem can contribute to heterogeneous water quality in the river causing e.g. significant differences in D.O. from one shore to another. An example is given in Fig. E-26. One single D.O. measurement in such a cross-section would not be very representative.

Only in the absence of wind will the river and lake flows in Pool No. 2 be fully gravity controlled. In that case, density currents will have an important role. There is indication that such currents exist.

6. Wind Mixing

Wind blowing over a water surface not only generates drift currents, but also causes wave motion and vertical turbulent mixing. As a result one finds a so-called "mixed layer" in which water temperature, D.O., and other water quality parameters are vertically uniform with depth. The depth of the mixed layer varies from a few centimeters under calm conditions to several meters under strong winds. Actually the mixed layer depth is not only a function of wind velocity and fetch but also of the density stratification of the water prior to wind action. Approximate mixed layer depths can be determined by interpolation from most measured D.O. and water temperature profiles reported in the Appendix. In some cases a particular effort was made to measure the mixed layer depth directly. Some such measurements are reported in Table E-1, but a more complete analysis of mixed layer depths has not been made.

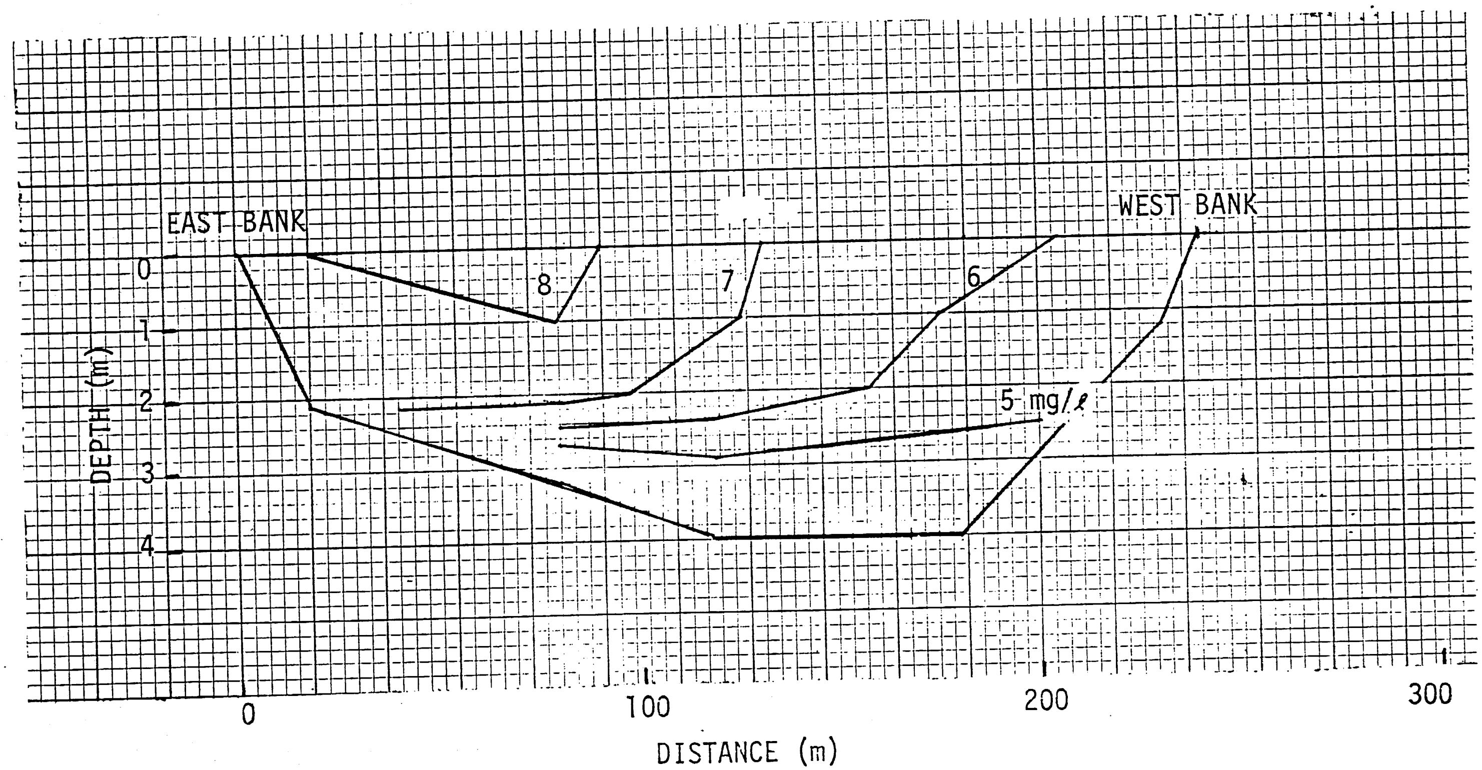

Fig. E-26 - Dissolved Oxygen in Mississippi River Cross-Section, Mile 824.5, August 26, 1976.

7. Measurements of Chlorine, Total Organic Carbon, and Total Inorganic Carbon

Water quality parameters other than D.O. and temperature are indicative of stratified or non-stratified conditions. For this and other reasons, water samples were taken on September 11 and September 15 at several locations and depths of 1, 3, and 4m. A laboratory analysis for Cl^-, TOC, and TIC was made by Dr. S. Eisenreich with the results shown in Fig. E-27. The measurements show nonstratified conditions corroborating the temperature and D.O. measurements made on September 15, 1976.

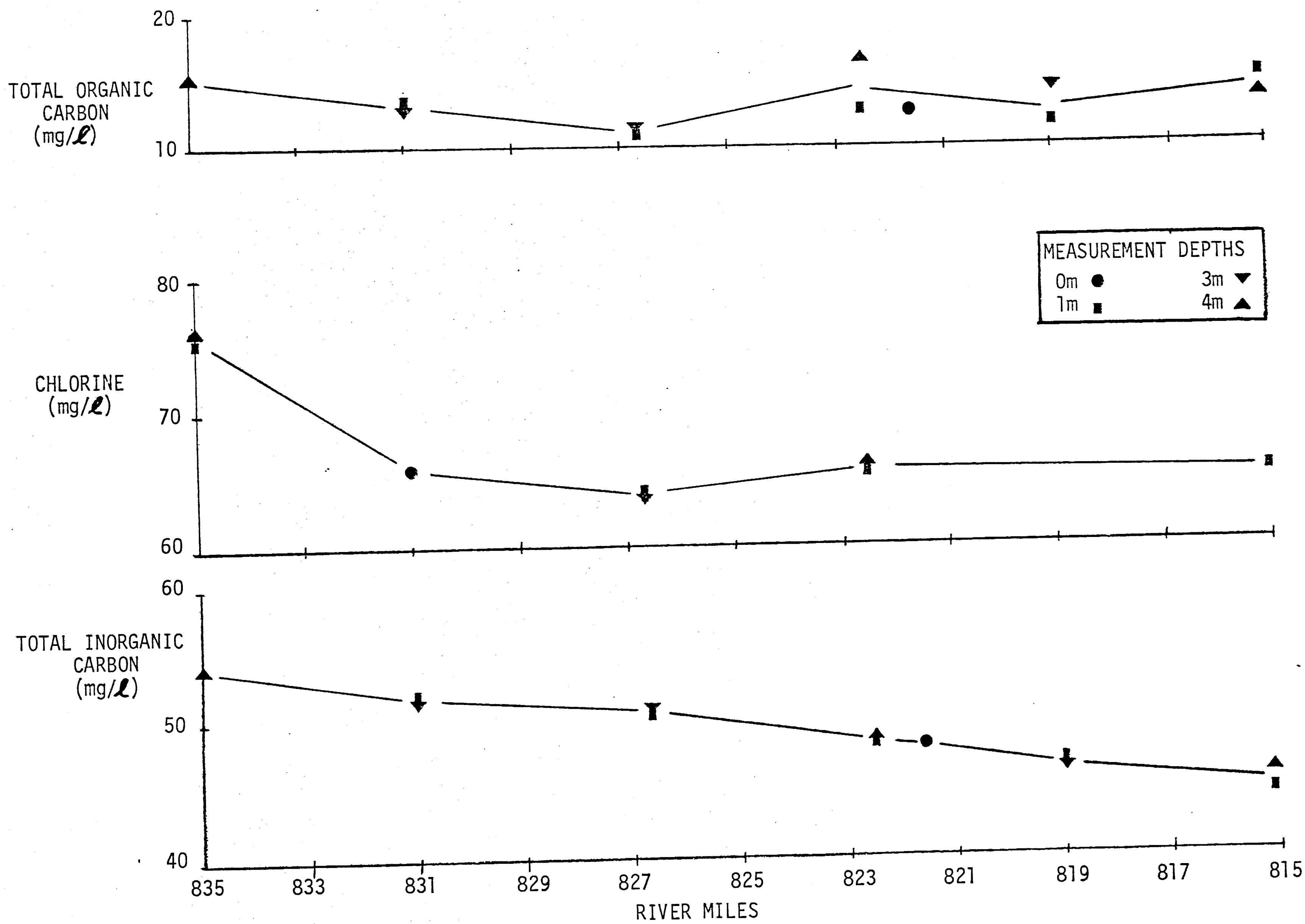

Fig. E-27 - TOTAL ORGANIC CARBON, CHLORINE AND TOTAL INORGANIC CARBON ON SEPTEMBER 11 AND 15, 1976

F. CONCLUSIONS

Field measurements of water temperatures, dissolved oxygen, and Secchi depths supplemented by a few surface drift current measurements in Pool No. 2 of the Mississippi River under very low flow conditions, obtained from August 24 through September 25, 1976 and reported herein lead to the following observations and conclusions regarding exchange and flow phenomena with important effects on water quality. (A location map may be found in Fig. A-1, page 5.)

1. With total river flows from approximately 1000 to 2000 cfs, the measured D.O. distributions, water temperatures, and transparencies were predominantly typical of a lake or reservoir and to a lesser degree typical of a river.

2. From survey to survey, D.O. and, on a smaller scale, water temperatures were found to vary greatly in all three dimensions:
    a. as a function of distance along the thalweg: An oxygen sag curve existed.
    b. as a function of depth: Over a period of time stratified conditions alternated with well-mixed conditions.
    c. as a function of lateral distance from the thalweg: D.O. levels and water temperatures outside the navigation channel and in particular in the adjacent lake regions differed markedly from those in the main channel.

3. The minimum oxygen levels were found to occur between river miles 832 and 818, i.e., significantly upstream from Dam No. 2 and between 3 and 17 miles downstream of the Pig's Eye sewage treatment plant.

4. Water supersaturated in dissolved oxygen was found in the lower pool (downstream of river mile 820) and in the adjacent lake areas on several sunny days, indicating that internal oxygen production by photosynthesis must be very high under favorable weather conditions and in shallow water. This is not totally surprising since nutrients are only partially removed by the primary and secondary sewage treatment process. Measured Secchi depths were very small indicating very high concentrations of suspended particulate matter, mostly phytoplankton. Cloudy weather was observed to reduce D.O. levels in the

entire system significantly, presumably by reducing photosynthetic oxygen production.

5. Surface wind drift currents were observed to be quite significant. At a given location they were found to change in direction and magnitude from survey to survey. Orders of magnitude of these surface current velocities were often from 0.03 to 0.3 fps. These currents contribute significantly to the exchange of water between the river main stem and the adjacent lake areas and stump-fields. Although the surface velocities are low, cross-sectional areas through which water can be exchanged are large resulting in exchange flow rates on the order of hundreds of cfs, e.g. between Spring Lake and the main stem. Depending on wind direction, the currents referred to may be into or out of a lake at a given cross-section. Under time-variable wind conditions these currents can be reversible either in an apparently random or in an oscillatory fashion. The latter would be associated with a seiche motion in a lake.

6. Under low wind conditions yet another mechanism becomes effective in the horizontal exchange of water: Density currents, which are caused by either differential cooling or heating of adjacent water bodies, e.g. due to different depths or by groundwater seepage, e.g. into Spring Lake.

7. The gravity induced turbulence and secondary currents in the river main stem were found to be insufficient to produce complete or even significant vertical mixing. Strong stratification was observed on several occasions. When complete or partial vertical mixing was observed, it was accomplished by:

   (1) natural convection, particularly during night cooling periods
   (2) wind drift and waves
   (3) boat traffic

   Resulting mixed layer depths were found to vary greatly with time and location.

8. The effluent from the Metro Sewage Treatment plant was observed to form a sinking plume at the end of the outlet channel from the plant, thus contributing to the stratification in the river main stem. The sinking was caused by a temperature differential between the effluent and the river water.

The main purpose of this and other Mississippi River field studies conducted during the summer of 1976 was to provide insight and data needed in the development of a mathematical model for the prediction of dissolved oxygen under various waste load allocation strategies. Several additional comments can be made with regard to this objective:

1. The above observations and those made by others recently can be used to formulate a mathematical model of water quality in Pool No. 2. The highly dynamic nature and the complex spatial distribution of the described phenomena and water quality parameters can probably not be modelled in detail. However, a dynamic mathematical model of a coupled lake system incorporating the essential observed processes can be developed and will be considerably more representative than a one-dimensional river model.

2. The measurements obtained and reported herein show that under low flow conditions numerous measurements must be made in places other than the river main stem in order to comprehend the recovery of the river from the waste load or to verify a mathematical water quality model for low flow conditions.

3. The strong relationship between water temperatures, dissolved oxygen, and weather conditions, including solar radiation intensity and wind, must be emphasized.

G. ACKNOWLEDGEMENTS

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APPENDIX

Field Data for Dissolved Oxygen, Water Temperature and Secchi Depth

METEOROLOGICAL DATA FOR AUGUST 24, 1976

Type \ Time	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	14-09	13-04	14-06	15-07	14-06	21-10	14-10	13-6
TEMPERATURE: DEGREES FAHRENHEIT	77	73	70	72	84	90	89	79

WIND: AVERAGE (KNOTS) = 6.7

TEMPERATURE:

MAXIMUM = 69
MINIMUM = 91
AVERAGE = 80

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = +12

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 507

PERCENT POSSIBLE SUNSHINE = 81

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 4

MISSISSIPPI RIVER, AUGUST 24, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Sewage Treatment Plant By pass Outlet 836.3	0	8.0	80.8	27.0		1550	
	1.0	5.2	80.5	27.0			
	2.0	3.8	80.0	26.7			
	3.0	2.9	79.7	26.2			
	4.0	2.5	79.6	26.2			
	5.0	2.4	79.5	26.2			
	6.0 (bottom)	2.1	79.5	26.2			
Sewage Treatment Plant Main Outflow	0	2.7	75.3	24.0			
	1.0	3.0	75.3	23.5			
Mid-River by Main Outflow 835.2	0	7.1	80.0	26.5			
	1.0	6.2	79.3	26.2			
	2.0	4.9	78.8	26.0			
	3.0	3.3	78.2	25.5			
	4.0	3.2	77.8	25.2			
	5.0	3.0	77.7	25.1			
	6.0	2.7	77.0	24.7			
	7.2 (bottom)	2.3	76.2	24.5			
834.6	0	5.0	78.9	26.0	0.6	1735	
	1.0	3.5	78.9	26.0			
	2.0	3.4	78.5	26.0			
	3.0	2.6	78.2	25.5			
	4.0	2.1	78.2	25.5			
	4.7 (bottom)	1.7	77.7	25.1			
834.7	0	5.2	79.0	26.4		1745	
	1.0	4.5	79.0	26.2			
	2.0	4.1	78.4	26.0			
	3.0	2.5	78.3	25.8			
	4.0	2.0	78.2	25.7			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 24, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
832.9	0	2.2	78.5	26.0	0.7	1815	
	1.0	1.8	78.5	26.0			
	2.0	1.8	78.5	25.7			
	3.0	1.4	78.2	25.5			
	4.0	1.2	78.1	25.5			
	5.0	1.2	78.1	25.5			
	6.0	1.1	78.1	25.5			
	7.0	1.0	78.1	25.5			
	8.0	0.8	77.9	25.5			
	9.0	0.7	77.8	25.4			
830.5	0	4.5	79.2	26.1		1855	
	1.0	4.7	79.2	26.1			
	2.0	2.5	78.8	26.1			
	3.0	2.0	78.6	26.0			
	4.0	1.4	78.5	25.9			
	4.6	1.2	78.5	25.9			
829.0	0	5.5	79.2	26.2	0.7	1920	
	1.0	5.1	79.2	26.2			Mixed layer depth = 1.3 m
	2.0	2.5	78.8	26.1			
	3.0	1.8	78.5	26.0			
	4.0	1.4	78.4	25.8			
	4.3	1.3	78.4	25.8			

[1] Separate instruments, one sensor incorporated in D.O. probe.

METEOROLOGICAL DATA FOR AUGUST 26, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	17-07	12-05	14-05	17-08	18-18	19-17	19-14	15-08
TEMPERATURE: DEGREES FAHRENHEIT	74	68	68	71	85	92	92	82

WIND AVERAGE (KNOTS) = 10.3

TEMPERATURE:
MAXIMUM = 93
MINIMUM = 68
AVERAGE = 81

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (°F) = +13

PRECIPITATION (INCHES) = 0.03

SOLAR RADIATION (LANGLEYS/DAY) = NO RECORD

PERCENT POSSIBLE SUNSHINE = 80

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 3

MISSISSIPPI RIVER, AUGUST 26, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
836.25	0	6.8	81.1	27.2		1519	
	1.0	5.8	80.9	27.0			
	2.0	4.2	80.9	27.0			
	3.0	3.8	80.9	27.0			
	4.0	3.0	80.9	27.0			
	4.5 (bottom)	2.6	80.8	27.0			
Sewage Treatment Plant Main outflow channel	0	4.5	74.8	23.9			
	1.0	4.5	74.8	23.5			
834.5	0	4.6	79.7	26.5		1600	
	1.0	4.6	79.6	26.5			
	2.0	4.2	79.6	26.5			
	3.0	3.8	79.4	26.0			
	4.0	2.7	78.5	25.9			
	5.0	2.3	78.5	25.9			
	6.0	2.1	78.2	25.7			
832.7	0	2.3	78.8	26.2		1631	
	1.0	2.2	78.7	26.0			
	2.0	1.9	78.7	26.0			
	3.0	1.6	78.6	26.0			
	4.0	1.2	78.5	25.9			
	5.0	0.8	78.3	25.7			
	6.0	0.6	78.2	25.7			
	6.5 (bottom)	0.6	78.1	25.7			
831.0	0	4.0	78.5	26.0		1655	
	1.0	3.2	78.4	25.8			
	2.0	2.4	78.3	25.7			
	3.0	2.4	78.2	25.7			
	4.0 (bottom)	1.6	78.0	25.5			
828.8	0	7.2	78.8	26.4		1740	
	1.0	6.2	78.8	26.2			
	2.0	5.6	78.5	26.0			

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 26, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
828.8 (Cont'd.)	3.0	4.6	78.2	25.9			
	4.0	3.2	77.9	25.5			
827.7	0	5.0	78.0	25.5		1757	
	1.0	4.6	78.0	25.5			
	2.0	3.4	77.6	25.5			
	3.0	2.8	77.5	25.2			
	4.0 (bottom)	2.2	77.4	25.2			
826.8	0	5.6	78.2	25.7	0.5	1811	
	1.0	5.2	78.2	25.7			
	2.0	5.2	78.2	25.7			
	3.0	5.0	78.1	25.5			
	4.0	3.8	77.8	25.4			
	4.5 (bottom)						
824.5	0	8.2	78.7	26.0		1832	
buoy 88 yds	1.0	8.0	78.7	26.0			
from east shore	2.0	7.4	78.7	26.0			
	3.0	4.4	78.1	25.5			
	3.2 (bottom)						
824.5	0	6.3	78.4	25.7		1845	
110 yds west of buoy	1.0	6.0	78.2	25.5			
	2.0	5.7	78.2	25.5			
	3.0	4.8	78.0	25.5			265 yds - total river width
	4.0 (bottom)	4.2	77.8	25.5			
824.5	0	5.8	78.0	25.7		1855	
10 yds from west shore	1.0	5.4	78.0	25.7			
	1.2 (bottom)						

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 26, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
824.5	0	7.6	78.6	25.9		1901	
43 yds west of buoy	1.0	7.2	78.6	25.9			
	2.0	6.6	78.6	25.8			
	3.0	4.8	78.0	25.5			
	4.0 (bottom)	4.4	78.0	25.5			
824.5	0	8.0	78.7	26.0			
20 yds from east shore	1.0	7.5	78.5	25.9			
	2.0	7.4	78.5	25.9			
	2.1 (bottom)						
822.5	0	9.0	78.6	26.0		1925	
	1.0	8.8	78.6	26.0			
	2.0	8.4	78.7	26.0			
	2.5	8.0	78.7	26.0			
	2.75	7.0	78.6	25.9			Mixed layer depth = 1.75 m
	3.0	6.2	78.4	25.9			
	3.8 (bottom)	5.2	78.2	25.6			
822.5	0	8.9	78.7	25.9	0.5		
90 yds west of buoy	1.0	8.6	78.7	25.9			
	2.0	7.8	78.7	25.9			
	2.5 (bottom)	6.8	78.2	25.8			

[1] Separate instruments, one sensor incorporated in D.O. probe.

METEOROLOGICAL DATA FOR AUGUST 27, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	16-09	14-06	22-13	31-13	28-15	28-11	28-16	00-00
TEMPERATURE: DEGREES FAHRENHEIT	78	76	80	77	80	73	80	71

WIND: AVERAGE (KNOTS) = 10.6

TEMPERATURE:

MAXIMUM = 81
MINIMUM = 62
AVERAGE = 72

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = +5

PRECIPITATION (INCHES) = TRACE

SOLAR RADIATION (LANGLEYS/DAY) = 365 (PARTIAL RECORD ONLY)

PERCENT POSSIBLE SUNSHINE = 82

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 5

MISSISSIPPI RIVER, AUGUST 27, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
830.5	0	2.6	78.5	25.5	1.0	1810	
	1.0	2.4	78.5	25.5			
	2.0	1.9	78.5	25.5			
	3.0	1.5	78.5	25.5			
	4.0	1.3	78.5	25.5			
829.0	0	2.8	78.0	25.1	1.0	1854	Wind from west
	1.0	2.8	78.0	25.1			
	2.0	2.8	78.0	25.1			
	3.0	2.4	78.0	25.1			
	4.0	2.1	78.0	25.1			
	4.2 (bottom)						
827.7	0	4.6	77.7	25.0	1.0	1912	
	1.0	4.7	77.7	25.0			
	2.0	4.8	77.7	25.0			
	3.0	4.1	77.8	25.1			
	4.0	3.8	77.8	25.1			
	4.1 (bottom)						
826.8	0	3.1	77.5	24.9		1930	
	1.0	3.0	77.6	25.0			
	2.0	3.0	77.7	25.			
	3.0	2.8	77.7	25.			
	4.0	2.7	77.7	25.			
	5.0 (bottom)	2.4	77.7	25.			
825.8	0	2.8	77.5		1.0	1945	
	1.0	2.7	77.7				
	2.0	2.9	77.7				
	3.0	2.8	77.7				
	4.0	2.6	77.7				
	5.0	2.4	77.7				
	5.7 (bottom)						

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 27, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 4	0	5.1	77.0	24.7		2000	
Baldwin Lake	1.0	5.0	77.2	24.8			
buoy	2.0	5.0	77.2	24.8			
	3.0	5.5	77.2	24.8			
	3.5 (bottom)						

1) Separate instruments, one sensor incorporated in D.O. probe.

METEOROLOGICAL DATA FOR AUGUST 30, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)								
	12-10	08-07	11-08	14-05	12-06	10-05	13-08	14-07

AVERAGE (KNOTS) = 6.2

TEMPERATURE: DEGREES FAHRENHEIT

--

MAXIMUM = -- 87
MINIMUM = -- 58
AVERAGE = -- 72

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = +6

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 533

PERCENT POSSIBLE SUNSHINE = 90

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 2

MISSISSIPPI RIVER, AUGUST 30, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
830.5	0	5.3	78.0	25.2	0.65	1427	
	0.5	5.1	77.5	25.0			
	1.0	4.0	77.3	24.7			
	1.5	1.9	76.2	24.2			
	3.0	1.1	75.8	24.0			
	4.0	0.5	75.6	23.9			
	4.3 (bottom)						
829.0	0	5.2	77.2	24.8	0.65	1505	
	0.5	4.8	77.0	24.7			
	1.0	4.7	77.0	24.6			
	1.5	3.0	76.2	24.2			
	2.0	1.9	76.0	24.2			
	3.0	1.7	75.5	23.8			
	4.0	0.9	75.0	23.5			
	4.2 (bottom)						
827.7	0	5.5	76.7	24.5		1525	
	1.0	3.6	76.0	24.1			
	2.0	3.1	75.8	24.0			
	3.0	1.7	75.2	23.7			
	4.0	1.6	75.0	23.7			
	4.2 (bottom)						
826.8	0	9.3	78.3	25.4	0.6	1538	
	0.5	6.9	75.4	24.4			
	1.0	4.3	76.8	24.7			
	2.0	1.4	74.6	23.5			
	3.0	1.2	74.5	23.2			
	4.0	1.0	74.5	23.2			
	4.5 (bottom)						
825.8	0	9.4	79.0	25.5		1555	
	0.5	9.3	78.5	25.4			
	1.0	6.2	76.3	24.2			
	2.0	4.0	75.6	24.0			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 30, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
825.8 (Cont'd.)	3.0	2.1	74.7	23.5			
	4.0	1.9	74.6	23.2			
	5.0	1.5	74.2	23.2			
	6.0	2.4	73.8	22.7			
	6.4 (bottom)						
Point 1 Entrance to Baldwin Lake	0	17.0	78.8	25.5	0.3	1610	Surface current going out ≈ 0.2 fps
	0.5	14.7	77.5	25.0			
	1.0	8.2	76.3	24.5			
	2.0	3.7	73.9	23.0			
	3.0	3.8	72.5	22.2			
	4.0	4.2	71.9	22.0			
	5.0	4.2	71.5	21.5			
	5.3 (bottom)						
Point 4 Baldwin Lake	0	14.2	75.2	24.0	0.3		Waves ≈ 3 inches
	0.5	14.7	75.1	23.9			
	1.0	14.0	74.8	23.7			
	2.0	11.0	72.3	22.5			
	3.0	9.4	71.5	22.0			
	4.2 (bottom)						
824.5 buoy	0	6.1	76.4	24.5	0.45	1653	
	1.0	5.3	76.0	24.5			
	2.0	3.7	75.5	24.2			
	3.0 (bottom)	1.3	74.3	23.5			
824.5 Mid-Channel 100 yds west of buoy	0	8.4	76.9	24.9		1702	
	1.0	4.9	75.7	24.5			
	2.0	2.1	74.7	23.7			
	3.0	1.7	74.5	23.5			
	3.7 (bottom)						

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 30, 1976

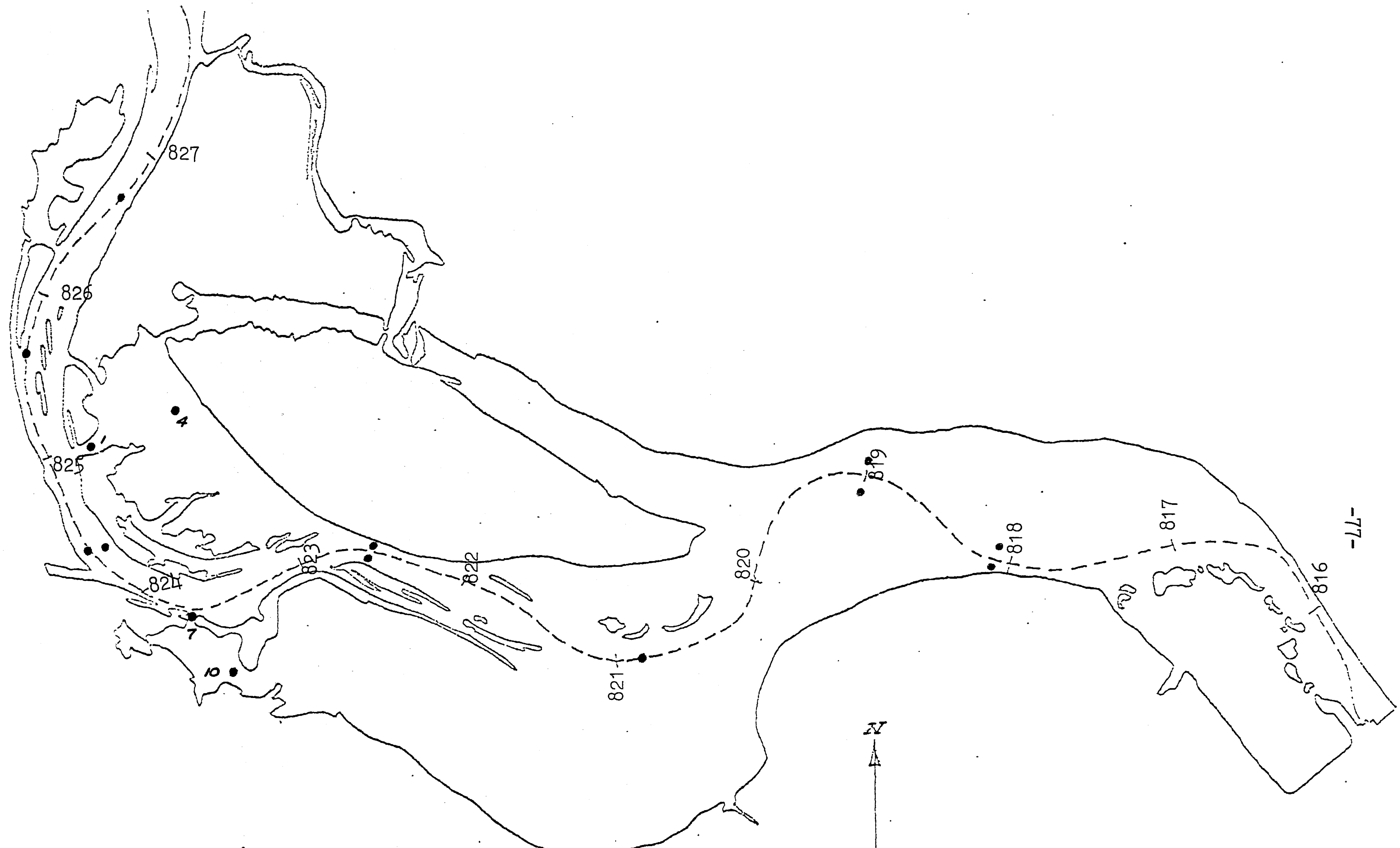
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 7 - Entrance Spring Lake	0	16.6	77.7	25.0	0.25	1715	
	0.5	16.8	76.5	24.7			
	1.0	16.1	76.2	24.5			
	2.0	12.7	74.8	23.9			
	3.0	9.9	73.7	23.2			
	3.1 (bottom)						
Point 10 Spring Lake Point	0	>18	75.6	24.0		1730	Surface drift ≈ 0.2 fps
	0.5	>18	75.4	24.0			
	1.0	>18	75.0	23.9			
	1.5	14.2	72.0	22.2			
	2.0	10.9	70.6	21.2			
	2.1 (bottom)						
822.6 50 yds from west bank	0	8.7	75.6	24.2	0.4	1750	
	1.0	7.1	75.1	24.0			
	2.0	3.0	73.5	23.1			
	3.0	2.4	73.2	22.7			
	3.5 (bottom)						
822.6 50 yds from east bank	0	8.4	75.5	24.0			Current apparent
	1.0	8.3	75.5	24.0			
	2.0	4.8	74.6	23.5			
	3.0	4.4	74.1	23.2			
	4.0	3.3	73.5	23.0			
	5.0	5.0	72.0	22.0			
	6.0	4.4	71.5	22.0			
	6.5 (bottom)						
820.9	0	11.8	74.2	23.5	0.3	1813	
	1.0	11.7	74.1	23.2			Mixed layer depth = 1.4 m
	2.0	5.7	73.3	22.9			
	3.0	4.7	73.2	22.7			
	3.8 (bottom)						

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, AUGUST 30, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
819.0	0	13.8	72.0	22.1		1831	Wind east-southeast
South buoy	1.0	13.4	71.9	22.1			
	2.0	10.4	71.2	21.7			
	2.6 (bottom)						
819.0	0	15.7	72.5	22.2		1841	
North buoy	1.0	15.7	72.3	22.2			
	1.7 (bottom)						
819.0	0	14.9	72.5	22.2	0.3	1845	
Mid-Channel	1.0	14.9	72.2	22.2			
	2.0	10.4	71.5	21.8			
	3.0	8.5	70.5	21.2			
	4.0	6.7	70.0	21.0			
	5.0	6.0	69.7	20.7			
	6.0	5.9	69.6	20.7			
	6.7 (bottom)						
818.1	0	12.3	72.0	22.0		1859	
South side	1.0	12.9	71.8	22.0			
40 yds north	2.0	12.7	71.3	21.7			
	3.0	10.1	70.8	21.4			
	4.0	6.8	70.1	21.2			
	5.0	7.6	70.0	20.9			
	6.0	7.1	69.5	20.7			
	6.5 (bottom)						
818.1	0	14.6	71.5			1910	
North side	1.0	14.8	71.5	21.9			Mixed layer depth = 1.8 m
180 yds north	2.0	12.5	71.5	21.9			
	2.5 (bottom)						

[1] Separate instruments, one sensor incorporated in D.O. probe.



MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
UNIVERSITY OF MINNESOTA

8/30/76	1400 – 1915
SURVEY DATA POINTS	

METEOROLOGICAL DATA FOR SEPTEMBER 3, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	19-18	20-16	21-14	25-12	29-17	30-15	29-16	27-06
TEMPERATURE: DEGREES FAHRENHEIT	76	75	73	75	77	83	79	68

WIND AVERAGE (KNOTS) = 12.8

TEMPERATURE:

MAXIMUM = 83
MINIMUM = 62
AVERAGE = 73

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL ($^{\circ}F$) = +9

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 536

PERCENT POSSIBLE SUNSHINE = 94

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 1

MISSISSIPPI RIVER, SEPTEMBER 3, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
830.5	0	3.3	74.0	23.2	1.0	1332	
	1.0	1.4	72.5	22.5			
	2.0	1.1	72.5	22.2			
	3.0	0.9	72.2	22.2			
	4.0	0.9	72.2	22.2			
	4.4 (bottom)						
829.0	0	3.9	72.9	22.5	0.7	1346	Drift Bodies Start 1346
	1.0	3.8	72.8	22.5			Stop 1356
	2.0	3.4	72.8	22.5			Distance 62 yds
	3.0	2.4	72.3	22.2			
	4.0	1.2	71.8	22.0			Mixed layer depth = 2.5 m
	4.3 (bottom)						
827.7	0	4.8	72.9	22.5		1409	
	1.0	4.2	72.8	22.2			
	2.0	3.1	72.0	22.0			
	3.0	2.8	71.8	22.0			
	4.0	2.4	72.0	22.0			
	4.2 (bottom)						
826.8	0	5.3	72.7	22.2	0.6	1420	Waves ≈ 8 inches
	1.0	5.0	72.6	22.2			
	2.0	3.3	72.0	22.0			
	3.0	3.1	71.9	21.9			
	4.0	2.9	71.8	21.8			
	4.1 (bottom)						
825.6	0	5.6	72.4	22.0		1433	
	1.0	4.0	71.8	22.0			
	2.0	3.4	71.7	21.7			
	3.0	3.3	71.5	21.5			
	4.0	3.4	71.3	21.4			
	5.0	3.6	71.2	21.4			
	6.0	3.6	71.3	21.4			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 3, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
825.6 (Cont'd.)	6.6 (bottom)	3.6	71.1	21.2			
Point 1	0	6.4	72.3	21.9	0.5	1446	Strong current into lake ≈ 0.5 fps
Entrance -	1.0	6.0	72.3	22.0			
Baldwin Lake	2.0	5.8	72.3	22.0			
	3.0	5.1	72.0	22.0			
	4.0	4.8	71.2	21.2			
	4.8 (bottom)						
824.5	0	6.2	72.6	22.1	0.5	1458	
at buoy	1.0	6.0	72.6	22.1			
	2.0	5.4	72.3	22.0			
	3.0	4.9	72.3	21.9			
	3.2 (bottom)						
824.5	0	6.6	72.8	22.2		1503	
Mid-way from body	1.0	5.9	72.6	22.0			
to west shore	2.0	5.0	72.5	21.9			
	3.0	4.2	72.1	21.7			
	4.0	3.3	72.0	21.5			
	4.2 (bottom)						
Point 7 - Entrance	0	6.1	72.3	21.7		1512	Drift Bodies Start 1512
Spring Lake	1.0	5.9	72.2	21.7			Stop 1522
	2.0	5.8	72.3	21.7			Distance 100 yds
	3.0	5.8	72.1	21.5			Direction west
	3.2 (bottom)						Drift Bodies Start 1513
							Stop 1519
							Distance 70 yds
822.7	0	8.1	71.0	21.0	0.4	1532	Baldwin Lake Downstream
	1.0	8.1	71.0	21.0			Exit: Wind directly out of
	2.0	8.0	71.0	21.0			Lake. White caps.
	3.0	8.4	71.0	21.0			
	4.0	8.3	70.9				

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 3, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
822.7 (Cont'd.)	5.0	8.0	70.5				
	5.2 (bottom)						
822.6	0	7.0	70.4	20.9	0.4	1552	Wind out of lake and down river channel.
	1.0	6.9	70.3	20.9			
	2.0	6.8	70.3	20.9			
	3.0	6.8		20.7			
	3.5 (bottom)						
820.9	0	10.2		21.5		1608	Waves ≈ 2 ft.
	1.0	10.3		20.2			
	2.0	10.3		20.2			
	3.0 (bottom)	10.3		20.2			
819.5	0	10.8	69.5	20.5	0.25	1625	
	1.0	11.6	69.4	20.2			
	2.0	11.6	69.4	20.2			
	3.0	11.6	69.4	20.2			
	3.1 (bottom)						
819.0	0	10.3	69.3	20.5		1641	
North buoy	1.0	9.9	69.2	20.5			
	2.0	9.7	69.2	20.5			
	2.7 (bottom)			20.2			
819.0	0	9.9	69.5	20.5			
Mid-Channel	1.0	9.9	69.5	20.5			
	2.0	9.9	69.5	20.5			
	3.0	9.9	69.3	20.5			
	4.0	9.5	69.0	20.2			
	5.0	9.4	69.0	20.2			
	6.0 (bottom)	9.0	68.9	20.2			
818.1	0	9.8	69.5	20.2	.25	1658	
North buoy	1.0	9.9	69.5	20.2			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 3, 1976

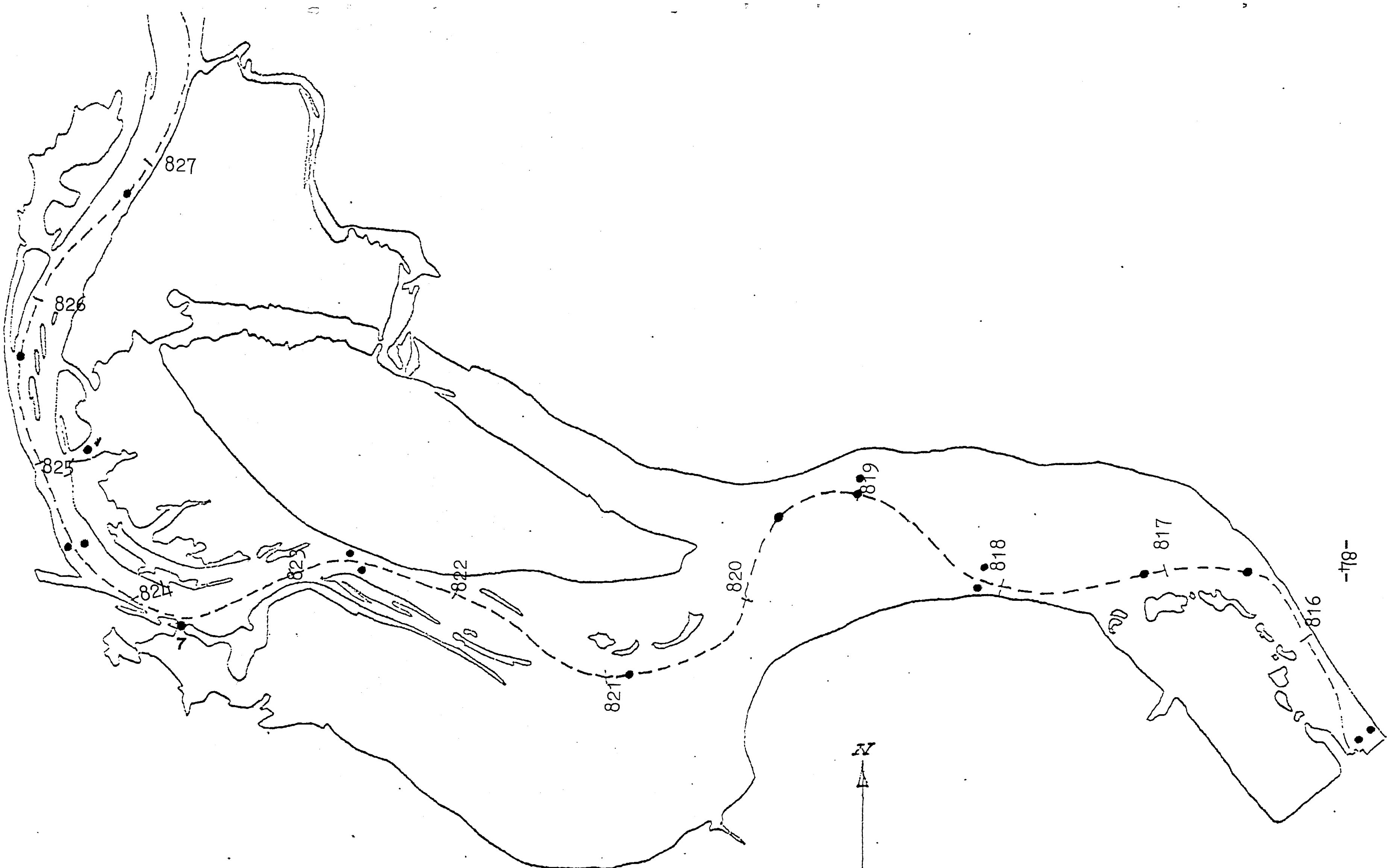
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
818.1 North buoy (Cont'd.)	2.0	9.7	69.4	20.2			
	3.0	10.4	69.3	20.2			
	3.4 (bottom)						
818.1	0	9.4	69.5	20.5			
South buoy	1.0	9.5	69.5	20.5			
	2.0	9.5	69.5	20.5			
	3.0	9.5	69.5	20.5			
	4.0	9.5	69.5	20.5			
	5.0	9.4	69.4	20.2			
	5.7 (bottom)						
817.1	0	10.1	69.5	20.5	0.2	1715	
	1.0	10.1	69.5	20.5			
	2.0	10.1	69.5	20.5			
	3.0 (bottom)	10.1	69.5	20.5			
816.5	0	9.2	69.3	20.5		1726	
	1.0	9.4	69.3	20.2			
	2.0	9.4	69.2	20.2			
	3.0	9.4	69.2	20.2			
	4.0	9.4	69.2	20.2			
	5.0 (bottom)	9.2	69.2	20.2			
Point 34 - Dam	0	10.9	69.6	20.5		1738	
South side	1.0	10.7	69.6	20.5			
	2.0	10.5	69.5	20.5			
	3.0	10.0	69.5	20.5			
	4.0	9.6	69.3	20.5			
	5.0	9.2	69.0	20.2			
	5.8 (bottom)						
Point 34 - Dam	0	8.8	69.0	20.2			
North side	1.0	9.0	69.1	20.2			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 3, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 34 - Dam, So. side (Cont'd.)	2.0	9.1	69.0	20.2			
	3.0	9.1	69.0	20.2			
	4.0	9.1	69.0	20.2			
	5.0	9.1	69.0	20.2			
	6.0	9.1	69.0	20.2			
	7.0	9.1	69.0	20.2			
	7.5 (bottom)						

1) Separate instruments, one sensor incorporated in D.O. probe.



MWCC: MISSISSIPPI RIVER STUDY 76

SAINT ANTHONY FALLS HYDRAULIC LABORATORY

UNIVERSITY OF MINNESOTA

9/3/76	1330—1800
SURVEY DATA POINTS	

METEOROLOGICAL DATA FOR **SEPTEMBER 7, 1976**

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	15-08	21-11	21-12	18-14	22-13	21-16	20-17	18-12

AVERAGE (KNOTS) = 13.6

TEMPERATURE: DEGREES FAHRENHEIT	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
	78	76	76	81	92	97	95	84

MAXIMUM = 98
MINIMUM = 73
AVERACE = 86

AVERACE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = +23

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 473

PERCENT POSSIBLE SUNSHINE = 96

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 2

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
830.5	0	5.5	74.5	23.2	0.8	1344	Wind drift upstream
	1.0	5.0	74.5	23.2			
	1.1	3.6	73.8	23.2			
	1.25	3.5	73.6	22.7			
	1.50	2.9	73.0	22.5			
	2.0	2.1	72.7	22.5			
	3.0	2.1	72.7	22.2			
	4.0	1.9	72.6	22.2			
	4.3 (bottom)						
829.0	0	7.0	74.6	23.2	0.6	1402	Mixed layer depth = 1 m
	1.0	6.4	74.5	23.2			
	2.0	4.7	73.6	23.0			
	3.0	2.2	72.6	22.5			
	4.0	1.7	72.4	22.2			
	4.3 (bottom)						
826.8	0	5.4	73.7	23.0	0.7	1425	
	1.0	4.8	73.5	23.0			
	2.0	4.5	73.3	22.7			
	3.0	3.8	73.0	22.5			
	4.0 (bottom)	2.7	72.5	22.2			
825.6	0	7.3	74.0	23.2		1436	
	1.0	6.5	73.7	23.2			
	2.0	5.7	73.4	22.7			
	3.0	4.1	72.8	22.5			
	4.0	3.8	72.7	22.5			
	5.0	3.5	72.6	22.2			
	6.0	3.5	72.6	22.2			
	6.7 (bottom)						
Point 1	0	11.7	73.2	22.7	0.4	1500	Surface flow into lake
Entrance -	1.0	11.0	72.5	22.2			
Baldwin Lake	2.0	10.6	72.1	22.0			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 1 - Baldwin Lake (Cont'd.)	3.0	8.6	71.5	21.8			
	4.0	8.1	71.3	21.7			
	5.0 (bottom)	7.3	71.0	22.5			
Point 4 -	0	13.8	74.2	23.2	0.3	1510	
Baldwin Lake	1.0	14.1	74.2	23.2			
	2.0	14.3	74.2	23.2			
	3.0	14.1	74.2	23.2			
824.5	0	9.7	74.3	23.2		1522	
Mid-Channel	1.0	9.0	73.8	23.1			
	2.0	8.0	73.3	22.9			
	3.0	4.7	71.9	22.0			
	4.0	4.5	71.9	22.0			
Point 7 -	0	7.9	72.5	22.2		1532	Surface out of lake
Entrance	1.0	6.6	72.1	22.1			
Spring Lake	2.0	6.0	72.0	22.0			
	3.0	5.7	71.9	22.0			
	3.3 (bottom)						
Point 10 -	0	8.7	73.5	23.1	0.45	1550	
Spring Lake	1.0	8.8	73.3	23.0			
Point 6	0	13.6	74.8	23.7	0.3	1606	
Baldwin Lake	1.0	13.6	74.8	23.7			
Exit Channel	2.0	12.2	74.5	23.5			
	3.0	12.6	74.0	23.0			
	3.7 (bottom)						
822.6	0	10.2	73.8	23.1	0.5	1615	
	1.0	10.0	73.7	23.0			
	2.0	6.8	72.7	22.2			
	3.0	5.4	71.5	21.7			
	4.0	5.1	71.5	21.7			
	4.6 (bottom)						

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
822.5	0	13.2	75.1	24.1	0.4	1630	
	1.0	11.6	74.0	23.5			
	2.0	10.2	73.6	23.0			
	3.0	6.1	71.8	22.2			
	3.3 (bottom)						
Point 17	0	14.4	75.3	24.0	0.2	1646	D.O.B. #10 untreated
	1.0	14.3	74.5	24.0			Flow out of Spring Lake
821.1	0	15.4	73.7	23.0		1700	
	0.5	15.6	73.7	23.0			
820.7	0	10.0	70.7	21.5			
	1.0	10.0	70.7	21.5			
	2.0	10.0	70.7	21.5			
	2.3 (bottom)						
820.4	0	9.3	71.2	21.7		1718	
	1.0	10.4	71.2	21.7			
	2.0	10.6	71.2	21.7			
	2.7 (bottom)						
820.2	0	11.4	72.4	22.2	0.25	1725	
	1.0	12.1	72.5	22.2			
	1.5 (bottom)						
Point 27 - Boulanger Pt.	0	12.9	72.5	22.2		1730	
	1.0	13.4	72.3	22.2			
	2.0	13.1	72.0	22.0			
	3.0	12.1	71.0	21.5			
	4.0	9.5	69.5	20.7			
	4.5 (bottom)						
820.2	0	14.9	73.7	23.0	0.3	1740	
Red buoy - North	1.0	15.3	73.7	23.0			
	2.0	13.2	71.8	22.0			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
820.2 Red buoy - No. (Cont'd.)	2.1 (bottom)						
Point 31	0	12.5	74.3	23.2	0.3	1752	
	1.0	12.6	74.3	23.2			
	2.0	12.6	74.2	23.2			
	2.4 (bottom)						
Point 32	0	17.7	75.1	23.7	0.3	1800	D.O.B. #26 untreated
	1.0	16.6	74.6	23.4			
	1.4 (bottom)						
819.0 - North	0	14.0	72.6	22.2		1820	
	1.0	14.1	72.5	22.2			
	1.6 (bottom)						
819.0 - South	0	13.5	73.2	22.7	0.25	1823	
	1.0	14.0	73.1	22.6			
	2.0	13.6	72.2	22.0			
	3.0	13.5	72.1	22.0			
	3.3 (bottom)						
818.5	0	14.3	72.9	22.5	0.3	1830	
	1.0	14.4	72.9	22.5			
	2.0	14.6	72.6	22.2			
	3.0	12.8	71.5	21.7			
	4.0	11.7	70.7	21.2			
	4.1 (bottom)						
818.1	0	14.4	72.2	22.0		1837	
	1.0	14.0	71.8	21.9			
	2.0	12.7	70.9	21.2			
	3.0	11.2	70.2	21.0			
	4.0	10.5	70.0	20.9			
	5.0	9.7	69.8	20.7			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

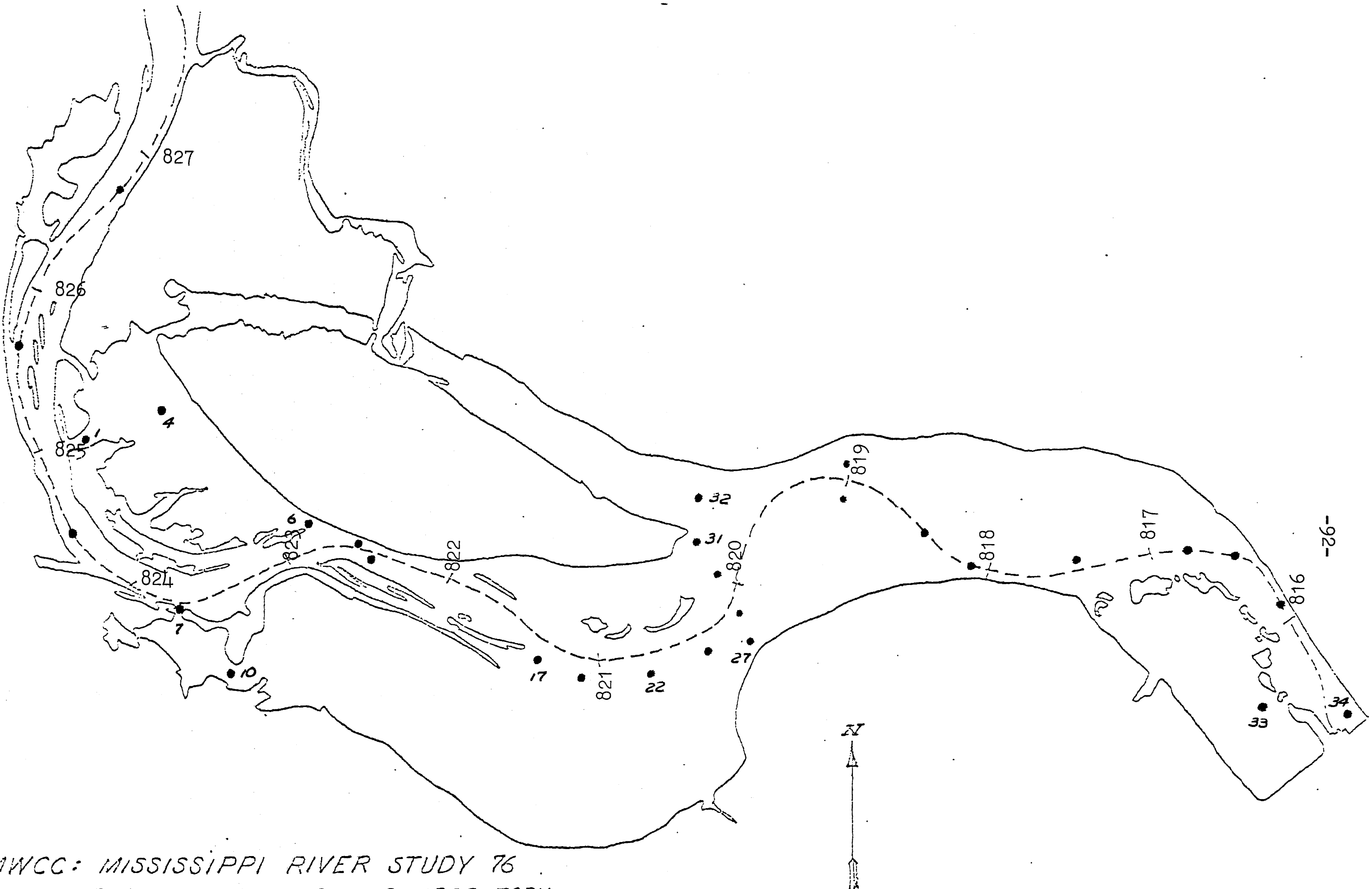
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
818.1 (Cont'd.)	6.0	9.2	69.7	20.5			
	7.0	8.4	69.4	20.5			
	7.2 (bottom)						
817.5 Red buoy	0	13.8	72.3	22.0		1915	Sun setting - wind slacked
	1.0	13.9	72.2	22.0			Wind from south ≈ 10 mph
	2.0	14.0	72.3	22.0			Front moving in from west
	2.2 (bottom)						
816.8	0	13.6	72.3	22.0		1923	
Mid-Channel	1.0	13.7	72.3	22.0			
	2.0	13.7	72.3	22.0			
	3.0	13.7	72.3	22.0			
	4.0	13.7	72.3	22.0			
816.5	0	12.8	72.7	22.2	0.3	1930	
Mid-Channel	1.0	13.3	72.7	22.2			
	2.0	13.6	72.7	22.2			
	3.0	13.7	72.7	22.2			
	4.0	13.5	72.2	22.0			
	4.7 (bottom)						
816.1	0	13.0	72.5	22.1		1941	
Mid-Channel	1.0	13.5	72.5	22.1			
	2.0	13.5	72.3	22.1			
	3.0	13.3	72.2	22.0			
	4.0	13.2	72.1	22.0			
	5.0	13.2	72.1	22.0			
	6.0	13.2	72.0	22.0			
	7.0	13.1	71.9	21.9			
Point 33	0	11.2	71.7	21.7		1953	
Dam Lake Outlet	1.0	12.0	71.5	21.7			
	2.0	12.3	71.5	21.5			
Point 34	0	12.7	71.8	21.9		2000	
Dam	1.0	13.0	71.8	21.9			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 7, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 34 - Dam (Cont'd.)	2.0	13.2	71.8	21.9			
	3.0	12.5	71.0	21.2			
	4.0	11.7	70.3	21.0			
	5.0	10.9	70.0	20.7			
	6.0	9.1	69.0	20.2			
	7.0	8.1	68.7	20.0			

1) Separate instruments, one sensor incorporated in D.O. probe.



MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
UNIVERSITY OF MINNESOTA

9/7/76	1345 – 2000
SURVEY DATA POINTS	

METEOROLOGICAL DATA FOR SEPTEMBER 8, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	18-14	19-08	30-06	35-15	33-14	32-06	31-07	23-05
TEMPERATURE: DEGREES FAHRENHEIT	80	70	67	68	61	60	60	58

WIND AVERAGE (KNOTS) = 7.8

TEMPERATURE:
MAXIMUM = 78
MINIMUM = 58
AVERAGE = 68

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = +6

PRECIPITATION (INCHES) = 0.22

SOLAR RADIATION (LANGLEYS/DAY) = 136

PERCENT POSSIBLE SUNSHINE = 28

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 10

MISSISSIPPI RIVER, SEPTEMBER 8, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 34 - Dam	0	10.2	70.9	21.2		0712	
	1.0	10.0	70.9	21.2			
	2.0	10.0	70.9	21.2			
	3.0	9.9	70.9	21.2			
	4.0	9.5	70.8	21.2			
	5.0	9.1	70.6	21.2			
	6.0	8.5	70.1	21.0			
	7.0	8.2	69.8	20.8			
Point 33 - Dam	0	9.8	70.5	21.0	0.25	0725	
Lake Outlet	1.0	9.9	70.6	21.0			
	2.0	9.7	70.5	21.0			
816.1	0	10.3	70.9	21.2	0.3	0732	Wind out of north ≈ 5 mph
Mid-Channel	1.0	10.2	70.9	21.2			
	2.0	10.1	70.8	21.2			
	3.0	10.0	70.6	21.2			
	4.0	9.9	70.5	21.1			
	5.0	9.9	70.4	21.1			
	6.0	9.7	70.3	21.0			
	7.0	9.6	70.2	21.0			
	8.0	7.3	69.3	20.5			
816.5	0	10.2	70.8	21.2	0.3	0741	
Mid-Channel	1.0	10.2	70.9	21.2			
	2.0	10.2	70.8	21.2			
	3.0	10.0	70.7	21.2			
	4.0	9.8	70.3	21.0			
	5.0	9.5	70.1	21.0			
	6.0	9.3	70.1	21.0			
816.8							
Mid-Channel	0	10.0	70.6	21.1		0748	
	1.0	10.0	70.6	21.1			
	2.0	10.0	70.6	21.1			
	3.0	9.9	70.5	21.1			

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 8, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
816.8 (Cont'd.)	4.0	9.8	70.4	21.0			
	5.0	9.7	70.3	21.0			
817.5	0	10.4	70.9	21.2	0.35	0800	
Red buoy	1.0	10.3	71.0	21.2			
	2.0	10.3	70.9	21.2			
818.1	0	9.6	71.1	21.2	0.3	0807	Wind from north ≈ 10 mph
Mid-Channel	1.0	10.0	71.1	21.2			
	2.0	10.0	71.1	21.2			
	3.0	10.0	71.1	21.5			
	4.0	10.0	71.1	21.5			
	5.0	10.0	71.1	21.5			
	6.0	9.8	71.0	21.5			
818.5	0	9.8	70.6	21.2		0816	
Black buoy	1.0	9.8	70.6	21.1			
	2.0	9.8	70.6	21.2			
	3.0	9.7	70.6	21.2			
	4.0	9.7	70.6	21.2			
819.0	0	8.6	71.5	21.5			
Mid-Channel	1.0	8.6	71.5	21.5			
	2.0	8.7	71.5	21.7			
	3.0	8.7	71.5	21.7			
	4.0	8.8	71.5	21.7			
	5.0	8.8	71.5	21.7			
Point 32	0	9.4	70.6	21.2		0858	
	1.0	9.3	70.6	21.2			
	0	8.8	70.9	21.2		0906	
	1.0	8.6	70.8	21.2			
	2.0	8.1	70.8	21.2			
Point 31	0	9.0	70.6	21.1	0.3	0915	
	1.0	9.1	70.6	21.1			
	2.0	8.9	70.6	21.1			
	3.0	8.6	70.5	21.1			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 8, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
820.2	0	8.8	70.8	21.1		0922	
	1.0	8.9	70.8	21.2			
Point 27	0	9.7	70.1	21.0	0.4	0926	
Boulanger Point	1.0	9.7	70.2	21.0			
	2.0	9.4	70.0	21.0			
820.5	0	8.6	70.5	21.2		0935	
Mid-Channel	1.0	8.6	70.6	21.2			
	2.0	8.7	70.5	21.1			
	3.0	8.8	70.2	21.0			
	4.0	8.4	70.3	21.0			
	5.0	8.6	70.3	21.0			
	6.0	8.7	70.2	21.0			
820.7	0	8.8	70.6	21.0	0.3	0943	
	1.0	8.7	70.6	21.2			
	2.0	8.5	70.6	21.2			
	3.0	8.5	70.6	21.2			
	4.0	8.8	70.6	21.2			
	5.0	8.4	70.6	21.2			
821.1	0	8.6	70.7	21.2	0.4	0950	
	1.0	8.6	70.8	21.2			
	2.0	8.6	70.7	21.2			
	3.0	8.6	70.7	21.2			
	4.0	8.6	70.7	21.2			
822.6	0	6.3	72.0	22.0	0.4	1002	Overcast
	1.0	6.2	72.0	22.0			
	2.0	6.2	72.0	22.0			
822.7	0	6.2	72.0	22.0	0.5		
	1.0	6.1	72.0	22.0			
	2.0	6.0	72.0	22.0			
	3.0	6.0	72.0	22.0			
	4.0	5.9	72.0	22.0			
	5.0	5.8	72.0	22.0			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 8, 1976

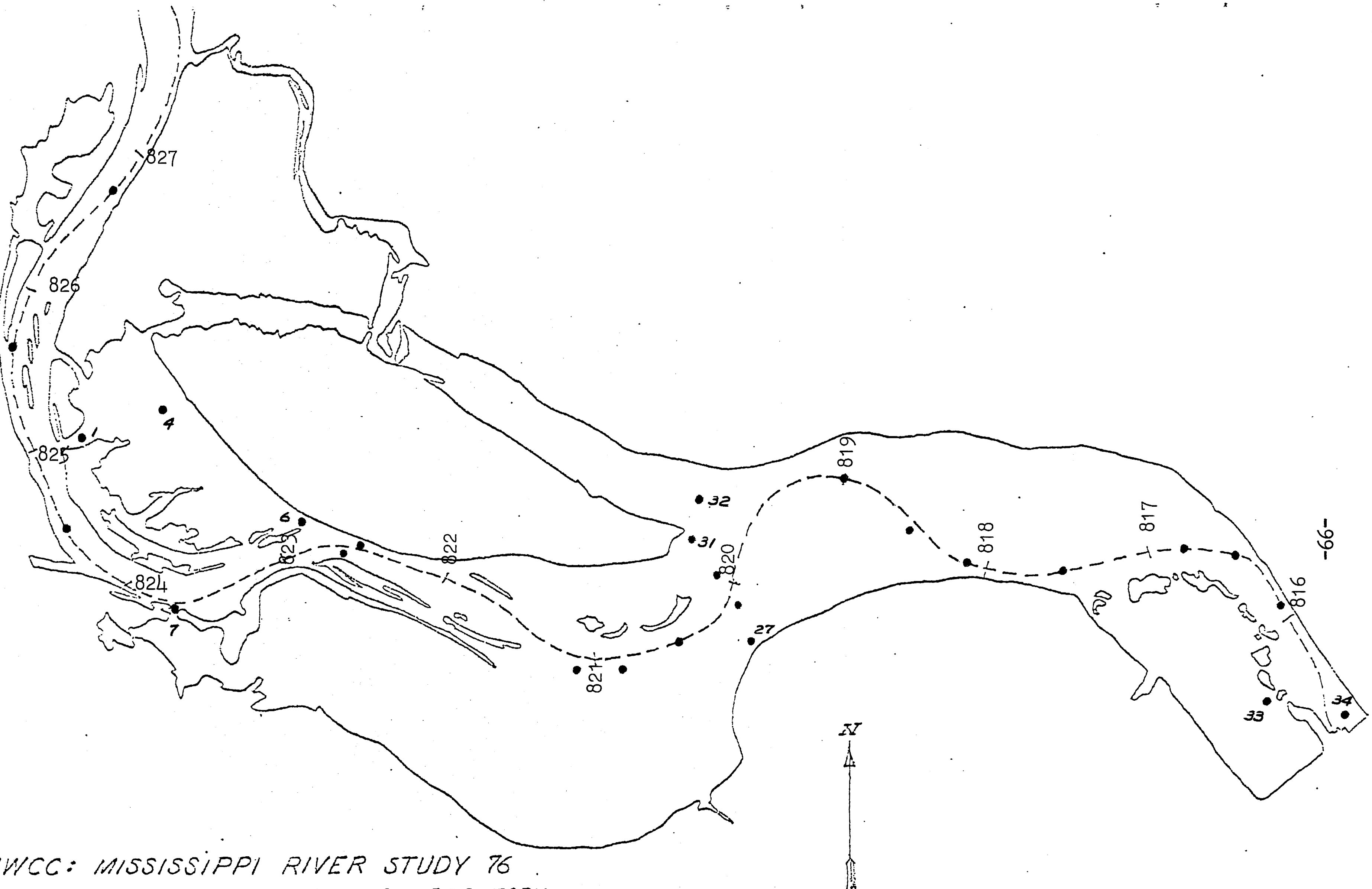
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 6 - Exit	0	8.0	72.1	22.0		1015	
Baldwin Lake	1.0	7.9	72.1	22.0			
	2.0	7.8	72.1	22.0			
	3.0	7.7	72.0	22.0			
	4.0	7.7	72.0	22.0			
Point 7	0	5.5	72.7	22.2		1027	Surface current into lake
Entrance	1.0	5.3	72.7	22.2			
Spring Lake	2.0	4.8	72.7	22.2			
	3.0	4.7	72.6	22.2			
824.5	0	6.2	73.0	22.5	0.5	1036	
	1.0	5.9	73.0	22.5			
	2.0	5.7	73.0	22.5			
	3.0	5.5	73.0	22.5			
	4.0	5.4	73.0	22.5			
Point 1	0	7.3	72.8	22.5		1043	
Entrance	1.0	6.0	72.7	22.5			
Baldwin Lake	2.0	5.9	72.7	22.5			
	3.0	5.7	72.7	22.5			
	4.0	5.5	72.7	22.5			
	5.0	4.5	72.4	22.2			
	6.0	4.3	72.0	22.0			
	7.0	3.0	70.8	21.2			
Point 4	0	10.2	71.7	21.7	0.3	1053	
Baldwin Lake	1.0	10.4	71.5	21.7			
	2.0	10.4	71.5	21.7			
	3.0	10.6	71.5	21.7			
825.6	0	4.6	72.4	22.2		1104	
	1.0	4.4	72.5	22.2			
	2.0	4.3	72.5	22.2			
	3.0	4.1	72.5	22.2			
	4.0	4.1	72.5	22.2			
	5.0	4.0	72.5	22.2			
	6.0	3.9	72.5	22.2			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 8, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
826.8	0	3.4	72.7	22.2	0.55	1115	
	1.0	3.3	72.7	22.2			
	2.0	3.1	72.7	22.2			
	3.0	3.0	72.6	22.2			
	4.0	2.9	72.6	22.2			
	5.0	2.8	72.6	22.2			
829.0	0	2.9	72.5	22.2		1134	
	1.0	2.7	72.5	22.2			
	2.0	2.6	72.5	22.2			
	3.0	2.6	72.5	22.2			
	4.0	2.5	72.5	22.2			
830.5	0	2.9	72.6	22.2	0.55	1153	
	1.0	2.7	72.6	22.2			
	2.0	2.6	72.6	22.2			
	3.0	2.6	72.6	22.2			
	4.0	2.6	72.6	22.2			

[1] Separate instruments, one sensor incorporated in D.O. probe.



MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
UNIVERSITY OF MINNESOTA

9/8/76	0700 ~ 1200
SURVEY DATA POINTS	

METEOROLOGICAL DATA FOR SEPTEMBER 15, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	01-05	04-08	07-09	07-07	09-09	06-11	11-04	00-00
TEMPERATURE: DEGREES FAHRENHEIT	50	54	53	54	58	64	64	55

WIND: AVERAGE (KNOTS) = 8.1

TEMPERATURE:

MAXIMUM = 65
MINIMUM = 51
AVERAGE = 58

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{O}F) = -2

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 290

PERCENT POSSIBLE SUNSHINE = 73

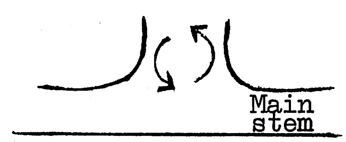
SKY COVER - SUNRISE TO SUNSET (TENTHS) = 7

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
830.5	0	0.4	69.7	20.5	0.9	0722	Wind--light from N.E.
Jolly Roger	1.0	0.3	69.8	20.5			
Black buoy	2.0	0.3	69.8	20.5			
	3.0	0.3	69.6	20.5			
	4.0	0.3	69.6	20.5			
	5.0	0.3	69.6	20.5			
829.1	0	0.8	69.3	20.2	1.0	0740	
Red buoy	1.0	0.5	69.4	20.2			
	2.0	0.4	69.4	20.2			
	3.0	0.4	69.3	20.2			
	4.0	0.4	69.1	20.2			
	4.2 (bottom)	0.4					
826.7	0	1.2	68.5	19.7			
Black buoy	1.0	1.0	68.5	19.7			
	2.0	1.0	68.5	19.7			
	3.0	1.0	68.5	19.7			
	4.0	1.0	68.5	19.7			
	4.7 (bottom)						
825.6	0	1.2	68.3	19.5	0.8	0809	5 minutes after barge passage
Mid-Channel	1.0	1.0	68.4	19.7			
	2.0	1.0	68.3	19.7			
	3.0	1.0	68.2	19.7			
	4.0	1.0	68.0	19.5			
	5.0	1.0	67.4	19.2			Suspicion spring water
	6.0	1.1	67.5	19.2			
	6.4 (bottom)	2.0	65.2	18.0			
825.0 - Point 1	0	1.3	68.0	19.7	0.85	0821	Wind and waves moving out of lake
Baldwin Lake	1.0	1.2	68.0	19.7			
Entrance	2.0	1.1	68.0	19.7			
	3.0	1.1	68.0	19.7			
	4.0	1.1	68.0	19.7			

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Entrance (Cont'd.)	5.0 (bottom)	1.2	67.5	19.5			
Point 2	0	2.4	66.8	18.7	0.65	0849	
Baldwin Lake	1.0	2.1	66.8	19.0			
	2.0	3.1	65.6	18.2			
	3.0	2.3	66.5	18.7			
824.5	0	1.7	67.9	19.5	1.1	0910	
Red buoy	1.0	1.4	68.0	19.7			
	2.0	1.3	68.0	19.7			
	3.0	1.3	68.0	19.7			
	3.3 (bottom)						
824.5	0	1.6	67.8	19.5	0.8	0915	Waves ≈ 1 inch
80 yards from shore	1.0	1.4	67.9	19.5			
	2.0	1.4	68.0	19.7			
	3.0	1.3	68.0	19.7			
	4.0 (bottom)	1.2	67.9	19.7			
823.7 - Point 7	0	2.7	67.0	18.7	0.5	0924	Big Eddy Current
	1.0	3.4	65.8	18.2			
	2.0	3.8	64.9	17.7			
	3.0	4.2	64.2	17.5			
	3.1 (bottom)						
Point 10	0	5.6	63.7	17.0	0.45	0937	Surface drift ≈ .3 fps out of lake
Spring Lake Point	1.0	5.3	63.7	17.0			
	2.0	5.9	62.8	16.7			
	2.2 (bottom)						
Point 6	0	3.1	66.5	18.7	0.5	1000	Drift in 0955
Baldwin Lake	1.0	2.9	66.5	18.8			No apparent drift
Exit Channel	2.0	2.6	66.5	18.8			Suspect flow out
	3.0 (bottom)	2.6	66.5	18.8			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
822.6	0	2.8	66.7	18.7	0.7	1012	Waves moving up river
Red buoy	1.0	2.6	66.7	18.7			
	2.0	2.5	66.6	18.7			
	3.0	2.6	66.6	18.7			
	4.0	2.9	66.5	18.7			
	4.6 (bottom)						
822.6	0	2.7	67.0	19.0		1020	
Black buoy	1.0	2.4	67.1	19.0			
	2.0	2.4	66.9	19.0			
	3.0	2.9	66.0	18.5			
	3.7 (bottom)						
SPRING LAKE SURVEY							
Point 17 - Stump field	0	6.9	65.7	18.2	0.45	1037	Drift east at ≈ 0.5 fps
	0.5 (bottom)						
Point 18 - 1/3 width	0	5.2	64.4	17.2	0.4	1048	
	1.0	5.0	64.3	17.2			
Point 19 - 2/3 width	0	5.8	63.3	16.7	0.35	1056	
	1.0	5.7	63.3	17.0			
	1.5 (bottom)						
Point 20 - Far shore	0	7.3	62.6	16.2	0.35	1102	
	1.0	6.9	62.5	16.5			
	1.3 (bottom)						
Point 21	0	6.7	63.2	16.7	0.3	1135	
	1.0	6.7	63.1	16.7			
	1.4 (bottom)						
Point 24 - Spring	0	7.5	62.6	16.5	0.33	1143	Untreated surface samples

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 24 (Cont'd.)	1.0	7.2	62.6	16.5			
	1.8	5.9	61.8	16.1			
Point 26 - Bend	0	8.0	62.8	16.5	0.4	1156	
	1.0	6.7	62.4	16.5			
	1.8 (bottom)	5.6	62.3	16.2			
Point 25 - Point	0	7.6	62.8	16.5	0.45	1205	
	1.0	7.2	62.8	16.7			
	2.0	7.0	62.8	16.5			
	3.0	6.3	62.5	16.5			
	3.5 (bottom)						
Point 27 - Boulanger's Point	0	7.2	62.8	16.5		1212	
	1.0	6.8	62.7	16.7			
	2.0	6.9	62.6	16.5			
	3.0	7.3	62.6	16.5			
	4.0	5.9	62.5	16.5			
820.2	0	5.7	64.5	17.5	0.45	1223	
Light	1.0	5.2	64.4	17.5			
820.7	0	6.8	66.0	18.2		1230	
	1.0	4.8	65.8	18.2			
	2.0	4.7	65.7	18.2			
	3.0	4.7	65.5	18.2			
	4.0	4.3	65.2	18.0			
	5.0	4.1	65.2	18.0			
820.2	0	5.5	65.0	18.0	0.4	1242	
Mid-Channel	1.0	4.8	65.0	18.0			
	2.0	4.6	64.3	17.5			
	3.0	4.6	64.3	17.5			
	4.0 (bottom)	5.6	64.2	17.5			
Point 31	0	6.3	64.6	17.7	0.4	1250	
	1.0	5.8	64.5	17.5			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

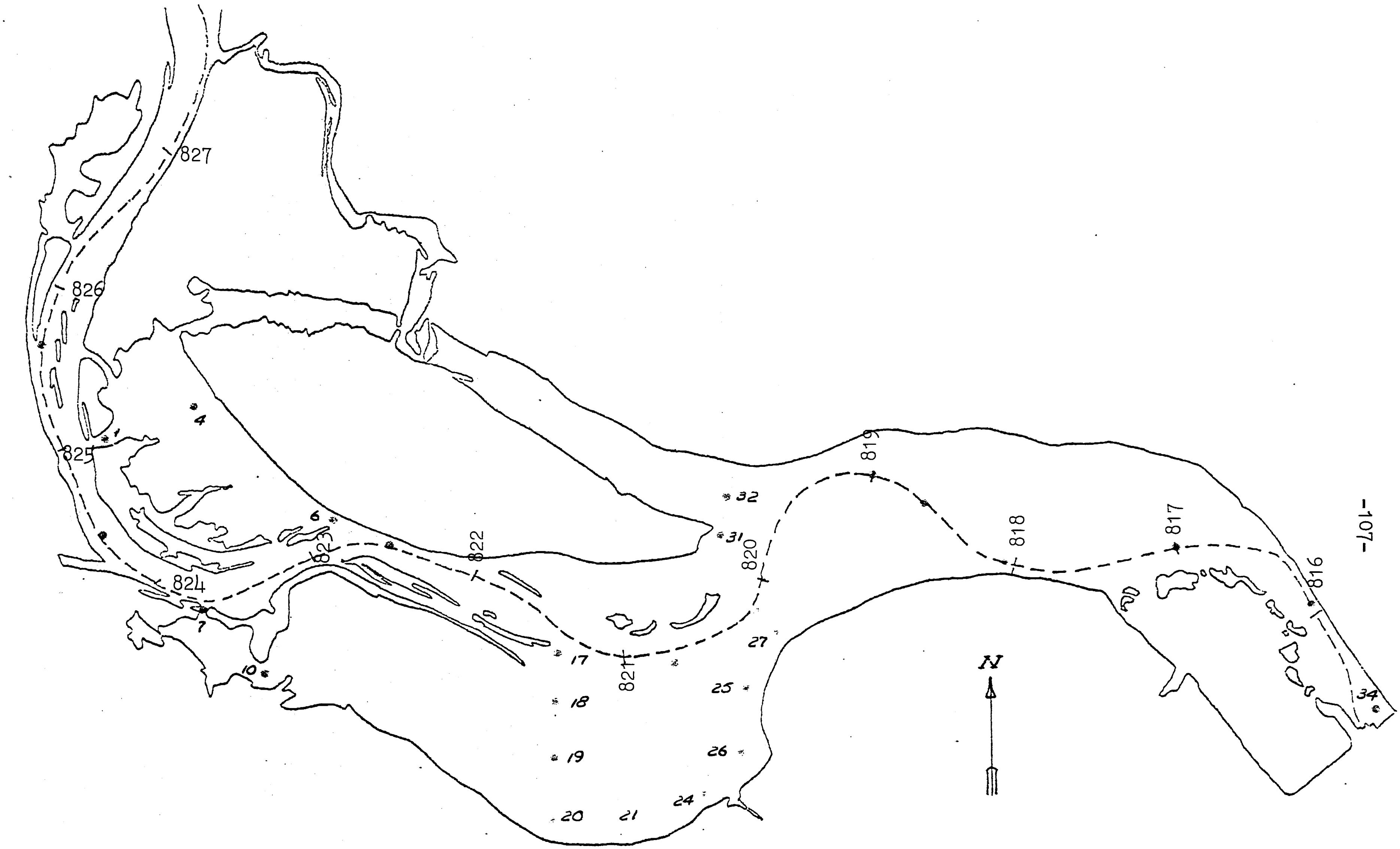
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 31 (Cont'd.)	0	6.3	64.6	17.7	0.4	1250	
	1.0	5.8	64.5	17.5			
	2.0 (bottom)	5.7	63.9	17.2			
Point 32	0	7.3	64.6	17.5		1255	
Mid-Channel	1.0 (bottom)	6.9	64.6	17.7			
819.0	0	7.6	63.8	17.2		1305	Untreated samples
Mid-Channel	1.0	7.6	63.7	17.2			
	1.5	6.6	63.7	17.2			
	2.0	7.4	63.8	17.2			
	3.0	6.6	63.6	17.0			
	4.0	6.1	63.4	17.0			
	5.0	6.0	63.3	17.0			
	5.8 (bottom)						
818.7	0	8.3	64.2	17.5	0.3	1325	
Mid-Channel	1.0	7.5	64.0	17.5			
	2.0	7.3	63.8	17.2			
	3.0	5.9	63.5	17.1			
	4.0	5.9	63.5	17.1			
	4.1 (bottom)						
818.1	0	7.2	64.1	17.2	0.35	1331	
Mid-Channel	1.0	6.5	63.8	17.2			
	2.0	6.1	63.8	17.2			
	3.0	5.9	63.8	17.2			
	4.0	5.9	63.8	17.2			
	5.0	6.0	63.8	17.2			
	6.0	6.5	63.8	17.2			
	7.0	5.9	63.5	17.0			
817.0	0	8.8	65.2	18.0	0.35	1400	
	1.0	7.4	64.1	17.2			
	2.0	6.6	63.6	17.1			
	3.0	6.6	63.6	17.1			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 15, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
817.0 (Cont'd.)	4.0	6.5	63.2	17.0			
816.1	0	10.1	65.8	18.5	0.35	1418	
	1.0	7.6	65.0	18.0			
	2.0	6.1	64.5	17.7			
	3.0	5.8	64.5	17.5			
	4.0	5.7	64.5	17.5			
	5.0	5.2	64.2	17.5			
	6.0	5.2	64.0	17.5			
	7.0	5.1	64.0	17.5			
	7.4 (bottom)						
Point 34 -							
Dam	0	8.8	67.2	19.1	0.35	1428	
	1.0	7.2	65.5	18.2			Untreated samples
	2.0	5.9	65.3	18.2			
	3.0	5.3	65.0	18.0			
	4.0	5.2	65.0	18.0			
	5.0	5.1	64.9	18.0			
	6.0	5.1	64.8	18.0			
	7.0	4.9	64.7	17.9			
	8.0	4.8	64.7	17.9			
	9.0	4.7	64.6	17.9			
822.6	0	5.2	68.0	20.0	0.6	1535	Very gentle wind and minimal waves going upstream
	1.0	4.5	67.2	19.5			
	2.0	3.6	66.8	19.0			
	3.0	3.1	66.0	18.5			
	4.0	3.6	65.2	18.0			
	5.0	3.4	65.0	18.0			
Point 6 -	0	7.4	69.2	20.2	0.45	1546	
Baldwin Lake	0.5	7.0	66.9	20.0			
Exit Channel	1.0	4.5	66.5	19.2			
	2.0	3.3	68.4	19.0			
	2.6 (bottom)						

[1]Separate instruments, one sensor incorporated in D.O. probe.



MWCC: MISSISSIPPI RIVER STUDY 76
SAINT ANTHONY FALLS HYDRAULIC LABORATORY
UNIVERSITY OF MINNESOTA

9/15/76	0730 — 1600
SURVEY DATA POINTS	

METEOROLOGICAL DATA FOR SEPTEMBER 25, 1976

Time / Type	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
WIND: DIRECTION (00-36) - SPEED (KNOTS)	02-07	36-07	36-03	08-08	07-06	09-07	13-06	13-06
TEMPERATURE: DEGREES FAHRENHEIT	54	45	43	47	59	67	63	55

WIND AVERAGE (KNOTS) = 5.6

TEMPERATURE:

MAXIMUM = 67
MINIMUM = 41
AVERAGE = 54

AVERAGE TEMPERATURE DEPARTURE FROM NORMAL (^{o}F) = -3

PRECIPITATION (INCHES) = 0.0

SOLAR RADIATION (LANGLEYS/DAY) = 424

PERCENT POSSIBLE SUNSHINE = 96

SKY COVER - SUNRISE TO SUNSET (TENTHS) = 8

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
826.6	0	2.2	63.5	17.1	0.8	1105	Wind E.N.E., Surface Drift
Mid-Channel	1.0	2.2	63.5	17.1			Downstream; Sunny 10% Clouds
	2.0	1.8	63.3	17.0			
	3.0	1.8	63.2	17.0			
	4.0	1.7	63.2	16.9			
	4.5 (bottom)						
825.6	0	2.9	63.9	17.2	0.8	1118	Wind calm
Mid-Channel	1.0	2.5	63.5	17.1			
	2.0	2.4	63.5	17.1			
	3.0	2.4	63.5	17.1			
	4.0	2.5	63.4	17.0			
	5.0	2.6	63.3	17.0			
	6.0	4.1	62.5	16.5			Possible sinking plume out of side channel
	7.0 (bottom)	5.6	61.4	16.0			
825.0	0	3.4	63.7	17.1	0.8	1132	calm
Mid-Channel	1.0	3.1	63.3	17.0			
	2.0	2.6	63.2	17.0			
	3.0	2.4	63.1	17.0			
	4.0	2.3	63.1	16.9			
	5.0	2.3	63.1	16.9			
	5.2 (bottom)						
Point 1 - Entrance	0	4.3	63.6	17.1	0.7	1140	Slow surface current into Baldwin Lake
Baldwin Lake	1.0	4.2	63.4	17.0			
	2.0	3.8	63.2	17.0			
	3.0	3.5	63.1	16.9			
	4.0	3.5	63.0	16.8			
	4.8 (bottom)						
Point 2	0	4.1	64.1	17.5		1155	
	1.0	3.3	63.2	17.0			
	2.0	2.9	63.0	16.8			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, **SEPTEMBER** 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 2 (Cont'd.)	2.5 (bottom)						
Point 3	0	15.4	60.3	15.2	0.4	1205	
	0.5	15.4	60.1	15.2			
	1.0	14.7	59.3	14.7			
Point 4	0	4.8	64.2	17.5	0.7	1218	
	1.0	4.2	63.1	16.9			
	2.0	3.5	62.5	16.5			
	3.0	5.4	61.6	16.0			
	3.5 (bottom)						
Point 5	0	5.6	63.5	17.1	0.7	1228	
	0.5	5.4	63.5	17.1			
	1.0	4.8	63.2	17.0			
	1.5	3.3	62.3	16.5			
	2.0	3.6	61.9	16.2			
	2.5	3.7	61.9	16.2			
	3.0	3.8	61.8	16.1			
	3.2 (bottom)						
Point 6	0	8.1	62.7	16.7	0.6	1241	
South side	1.0	8.2	62.3	16.5			
	2.0	10.9	60.1	15.2			
	3.0	11.4	59.5	15.0			
Point 6	0	7.6	63.1	16.9	0.6	1246	Surface flow weak into lake, bottom current out
North side	1.0	8.0	63.0	16.9			
	2.0	7.5	62.2	16.2			
	3.0	5.7	61.2	16.0			
	4.0	6.5	60.7	15.5			
	4.3 (bottom)						
823.0	0	4.6	64.0	17.2	0.7	1257	
Mid-Channel	1.0	3.6	63.1	17.0			
	2.0	3.4	63.1	16.9			
	3.0	3.3	63.1	16.9			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
823.0 (Cont'd.)	4.0	3.4	63.1	16.9			
	5.0 (bottom)	3.4	63.1	16.9			
824.1	0	3.8	64.1	17.4	0.7	1309	
Mid-Channel	1.0	3.4	63.8	17.2			
	2.0	2.7	63.6	17.1			
	3.0	2.7	63.6	17.1			
	4.0	2.5	63.6	17.1			
	4.5 (bottom)						
Point 7	0	5.4	64.5	17.7		1317	Suspect bottom density current into lake - surface flow out of lake at ≈ 0.2 fps
	1.0	4.6	63.8	17.2			
	2.0	3.2	63.1	17.0			
	3.0	3.1	62.7	16.7			
	3.2 (bottom)						
Point 9	0	5.5	64.4	17.6	0.7	1330	
	1.0	4.9	63.2	16.9			
	2.0	3.4	62.0	16.2			
	3.0	3.0	61.5	16.0			
	3.7 (bottom)						
Point 8	0	5.7	65.1	17.5	0.6	1344	
	1.0	5.5	65.1	17.2			
	1.1						
Point 10	0	5.8	64.5	17.7		1350	Surface current out at 0.13 fps
	0.5	4.2	62.9	16.9			
	1.0	4.9	63.3	17.0			
	1.5	3.6	62.4	16.5			
	2.0	3.7	62.1	16.2			
	2.2 (bottom)						
Point 13	0	6.6	65.0	18.0	0.6	1415	
	0.5	6.8	62.5	17.2			
	1.0	6.1	61.9	16.2			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 13 (Cont'd.)	1.5	5.6	61.3	16.0			
	1.7 (bottom)						
Point 12	0	7.0	65.6	18.2	0.6	1425	Very calm
	0.5	6.9	62.7	17.0			
	0.7 (bottom)	6.8	62.5	16.5			
Point 11	9	8.8	65.2	18.0	0.4	1435	
	0.5	8.6	64.8	18.0			
	1.0 (bottom)	8.5	62.2	16.5			
Point 14	0	10.8	65.6	18.2	0.35	1441	
	0.5	13.7	63.8	17.1			
	1.0	11.5	60.6	15.5			
Point 15	0	8.8	64.8	17.9	0.4	1451	
	0.5	8.8	64.1	17.5			
	1.0	5.6	61.6	16.1			
	1.3 (bottom)						
Point 16	0	8.6	66.4	18.7	0.45	1458	
	0.5	8.2	64.5	17.5			
	1.0 (bottom)	6.3	62.0	16.2			
Point 20	0	14.9	64.6	17.9	0.35	1512	
	0.5	14.7	64.6	17.7			
	1.0	11.8	61.8	16.2			
	1.2 (bottom)	11.3	59.1	14.9			
Point 19	0	12.2	63.5	17.1	0.4	1519	
	0.5	11.5	62.7	16.8			
	1.0	9.6	60.1	15.2			
	1.3 (bottom)	7.5	59.5	15.0			
Point 18	0	>18.2	64.0	17.5	0.4	1526	
	0.5	>18.2	63.8	17.2			
	1.0	10.2	60.8	15.7			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	$T^{1)}$ (°F)	$T^{1)}$ (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 18 (Cont'd.)	1.5 (bottom)	8.6	59.9	15.2			
Point 17	0	13.2	65.5	18.2	0.38		Wind from east ≈ 5 mph
	0.5	13.5	65.3	18.2			
	0.7 (bottom)						
821.4	0	8.6	62.7	16.7	0.45	1545	
Mid-Channel	1.0	8.5	62.5	16.7			
	2.0	7.7	62.2	16.2			
	3.0	7.4	62.1	16.2			
	4.0	7.2	62.0	16.2			
	4.3 (bottom)						
Point 29	0	15.1	64.0	17.2	0.38	1555	
	0.5	15.9	64.0	17.2			
	1.0	16.4	64.0	17.2			
	1.15 (bottom)	16.7	63.8	17.0			
Point 30	0	14.7	63.1	16.8	0.35	1605	
	0.5	15.8	63.1	16.7			
	1.0	16.0	62.9	16.7			
	1.5	12.7	60.7	15.5			
	1.7 (bottom)						
820.7	0	14.0	62.5	16.5	0.35	1615	
Red buoy	1.0	13.7	62.4	16.5			
	2.0	12.9	62.1	16.2			
	3.0	9.6	61.1	15.7			
	4.0 (bottom)	9.1	60.9	15.5			
Point 22	0	16.6	62.3	16.2	0.30	1625	
	0.5	17.3	62.2	16.2			
	1.0	17.7	62.1	16.2			
	1.5 (bottom)	13.7	60.1	15.2			

1) Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

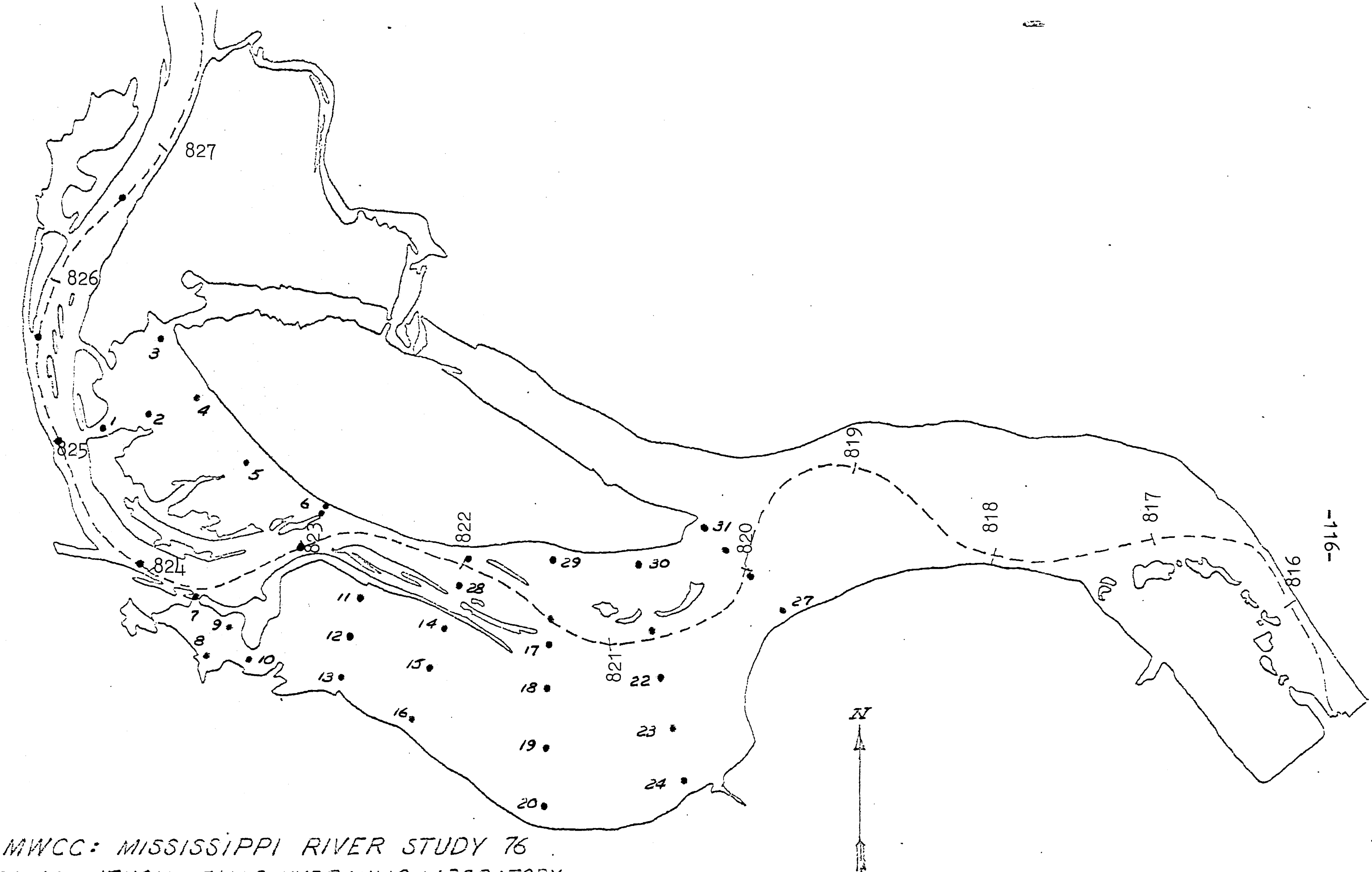
STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 23	0	10.4	61.8	16.1	0.35	1639	
	0.5	10.7	61.6	16.0			
	1.0	12.2	60.1	15.1			
	1.5	11.8	58.6	14.5			
	1.7 (bottom)						
Point 24	0	14.0	61.9	16.1	0.38	1645	Calm
	0.5	14.4	61.8	16.0			
	1.0	13.7	61.5	16.0			
	1.5	12.6	58.2	14.2			
	1.7 (bottom)						
Point 27	0	18.0	61.9	16.1	0.30	1701	Strong bottom current going out
	0.5	14.1	59.2	14.7			
	1.0	12.9	58.5	14.2			
	2.0	12.3	58.3	14.2			
	3.0	11.7	58.2	14.0			
	4.0	11.4	58.2	14.0			
	4.7 (bottom)						
820.2	0	13.2	60.8	15.5	0.30	1709	
Mid-Channel	1.0	12.9	60.5	15.2			
	2.0	12.6	60.1	15.2			
	3.0	12.6	60.2	15.2			
	4.0	12.6	60.2	15.2			
	5.0 (bottom)	12.2	60.0	15.1			
820.0	0	14.0	61.4	15.8	0.30	1715	
West of center line	0.5	14.0	61.2	15.8			
	1.0 (bottom)	11.4	60.4	15.2			
Point 31	0	17.7	61.8	16.1	0.35	1720	
	0.5	18.2	61.9	16.1			
	1.0	>18.2	61.8	16.1			
	1.5	15.9	59.0	14.7			

[1] Separate instruments, one sensor incorporated in D.O. probe.

MISSISSIPPI RIVER, SEPTEMBER 25, 1976

STATION (RIVER MILE)	DEPTH (m)	D.O. (mg/l)	T[1] (°F)	T[1] (°C)	SECCHI DEPTH (m)	TIME	NOTES
Point 31 (Cont'd.)	1.9 (bottom)	15.9	58.5	14.2			
822.0	0	6.6	62.5	16.5	0.40	1738	Barge passed 10 minutes previously
Mid-Channel	1.0	6.3	62.7	16.5			
	2.0	6.1	62.6	16.5			
	3.0	6.1	62.6	16.5			
	4.0	6.1	62.6	16.5			
	5.0	6.1	62.6	16.5			
	6.0	6.1	62.7	16.5			
	6.5 (bottom)	6.1					
822.0	0	8.1	63.1	16.7	0.60	1745	
South side	0.5	7.9	63.1	16.7			
	1.0	7.9	63.1	16.7			
	1.5	7.8	63.1	16.7			
823.0	0	3.6	64.0	17.2	0.55	1758	Calm
Mid-Channel	1.0	3.6	64.0	17.2			
	2.0	3.6	64.0	17.2			
	3.0	3.6	64.0	17.2			
	4.0	3.6	64.0	17.2			
	4.4 (bottom)						
826.6	0	2.3	64.0	17.2		1820	
Mid-Channel	1.0	2.2	64.0	17.2			
	2.0	2.2	64.1	17.2			
	3.0	2.2	64.1	17.2			
	4.0	2.2	64.1	17.2			
	4.3						

[1] Separate instruments, one sensor incorporated in D.O. probe.



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9/25/76	1100–1830
SURVEY DATA POINTS	