THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

DEPARTMENT OF RESEARCH AND DEVELOPMENT

SEDIMENT OXYGEN DEMAND OF BOTTOM DEPOSITS IN DEEP DRAFT WATERWAYS IN COOK COUNTY

This report was prepared as part of the NIPC-MSDGC 208 Contract and represents Work Item III-5-F, Sediment Oxygen Demand of Bottom Deposits

Irwin Polls and Charles Spielman **December 1977**

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Research and Development Department
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I. INTRODUCTION

Much of the suspended solids discharged from domestic and industrial waste sources and from non-point runoff settles to the bottom of rivers, streams or lakes to form bottom deposits. These deposits vary in depth, composition, and location depending upon (1) the character and nature of the sediment or waste entering a water body, (2) the changing hydraulic conditions, and (3) the rate and nature of chemical decomposition occurring during different seasons of the year.

The self-purification process in streams and rivers involves a complex balance between many oxygen assets and liabilities. It is essential in the evaluation of this process to include all possible sources that significantly contribute or utilize dissolved oxygen. Without this, in many instances a river will undoubtedly behave quite differently than would be predicted by a mathematical water quality model.

The oxidation of organics in a receiving water places a demand on the oxygen resources of this water. This is known as the Biochemical Oxygen Demand (BOD), and is expressed in mg/l of oxygen consumed over a given period of time and under specified conditions.

Bottom deposits undergo continuous decomposition by the biochemical oxidation of organics through the action of aquatic bacteria, periphyton (attached algae), fungi, protozoans, oligochaete worms, insect larvae and molluscs. This also places a demand on the oxygen resources in a river. If the overlying water contains dissolved oxygen, aerobic conditions will exist only at the surface layer of the sediment, because the diffusion of oxygen is normally so slow that the lower layers remain anaerobic. Decomposition of the lower layers will, therefore, be anaerobic, while the upper layers will be stabilized aerobically. The terms "Benthal Decomposition" and "Sediment Oxygen Demand" (SOD) have been applied to this combination of biochemical anaerobiosis and aerobic stabilization. Since the oxygen exertion is at the water-sediment interface, it is an areal rather than volumetric demand and is expressed in units of grams of oxygen consumed/m^2/day.

The importance of sediment oxygen demand in the oxygen regime of lakes and rivers has been described by a number of investigators (Baity, 1938; Fair, *et al*, 1941; Velz, 1958; and Owens and Edwards, 1963). The methods so far devised for measuring sediment oxygen demand fall into two major categories: (A) laboratory methods which utilize a respirometer (Edwards and Rolley, 1965; Haines and Irvine, 1966; Rolley and Owens, 1967; McDonnell and Hall, 1967; Oldaker, *et al*, 1968; and Reynolds, *et al*, 1973), and (B) *in situ* methods which use various types of closed chamber respirometers which are placed over the benthic deposits (Lucus and Thomas, 1972; James, 1974; and Butts, 1974).

The purpose of this study was to determine the extent of the sediment oxygen demand exerted by the benthal deposits on the dissolved oxygen of the overlying water in the study area, and to collect biological, chemical and physical data which will be useful in describing the relative effects of such parameters on that demand. The specific objectives of this study were to determine the following at selected sampling stations in the deep draft waterways in Cook County:

1. The oxygen consumption rate of bottom deposits (SOD) twice a year.
2. The macroinvertebrate communities present in the bottom deposits.
3. The composition and volume of the bottom deposits.
4. The Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Solids and Total Volatile Solids of the bottom deposits.

II. STUDY AREA

Sampling Locations

Twenty-one sampling stations were selected for the study (Figure 1). All sampling stations were located on the deep draft waterways in Cook County, Illinois. Three stations were located on the North Shore Channel, four on the North Branch of the Chicago River below its confluence with the Channel, one on the South Branch of the Chicago River, one on the South Fork of the South Branch of the Chicago River, five on the Chicago Sanitary and Ship Canal, two on the Calumet River, two on the Little Calumet River, and three on the Cal-Sag Channel. Table 1 lists the locations of the 21 sampling stations. The sampling sites were selected to reveal changes in the sediment oxygen demand above and below primary tributaries and major sources of waste (sewage treatment plant final effluents).

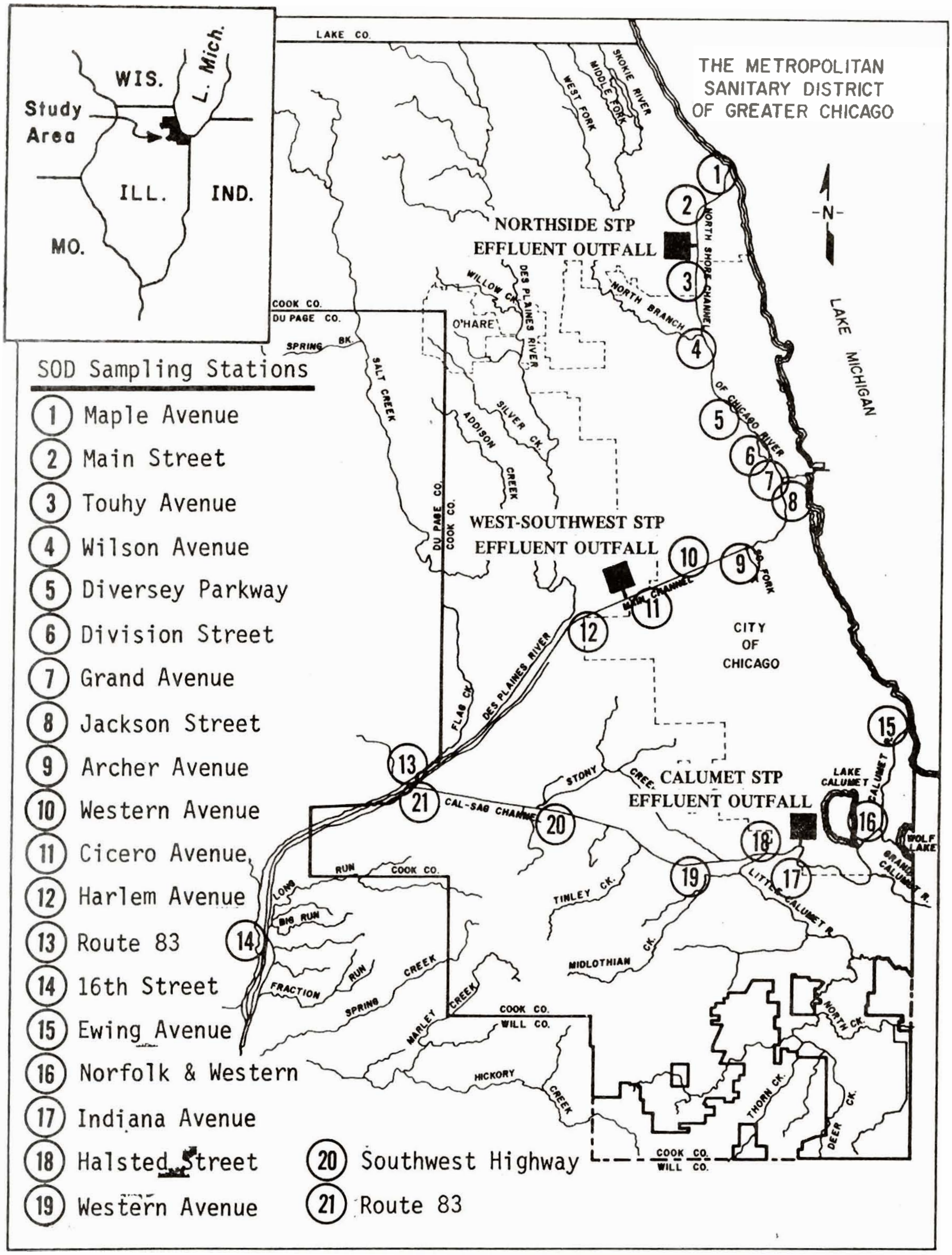

Figure 1 - Map of the Sediment Oxygen Demand Sampling Stations (Numbered Circles)

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TABLE 1

SAMPLING LOCATIONS AND STATION NUMBERS FOR 208 SEDIMENT OXYGEN DEMAND STUDY

<u>NORTH SHORE CHANNEL</u> (NSC)

1. Maple Avenue Bridge
2. Main Street Bridge
3. Touhy Avenue Bridge

<u>NORTH BRANCH OF CHICAGO RIVER</u> (NBCR)

4. Wilson Avenue Bridge
5. Diversey Parkway Bridge
6. Division Street Bridge
7. Grand Avenue Bridge

<u>SOUTH BRANCH OF CHICAGO RIVER</u> (SBCR)

8. Jackson Street Bridge

<u>SOUTH FORK OF SOUTH BRANCH OF CHICAGO RIVER</u> (SFSBCR)

9. Archer Avenue Bridge

<u>CHICAGO SANITARY AND SHIP CANAL</u> (CSSC)

10. Western Avenue Bridge
11. Cicero Avenue Bridge
12. Harlem Avenue Bridge
13. Route 83 Bridge
14. 16th Street Bridge

<u>CALUMET RIVER</u> (CR)

15. Ewing Avenue Bridge
16. Norfolk and Western Railroad Bridge

<u>LITTLE CALUMET RIVER</u> (LCR)

17. Indiana Avenue Bridge
18. Halsted Street Bridge

<u>CAL-SAG CHANNEL</u> (CSC)

19. Western Avenue Bridge
20. Southwest Highway Bridge
21. Route 83 Bridge

III. MATERIALS AND METHODS

Field Sediment Oxygen Demand Measurement

A bottom sampler, similar to a sampler designed by Butts (1974) for use in the Illinois River, was used in this study to measure the sediment oxygen demand *in situ* at 21 sampling stations during July-October, 1977 and again during November-December, 1977. The SOD sampler is a semi-cylindrical steel chamber, 24" long, 14" wide, and 10" deep (Figure 2). Three inch wide plates (flanges) were welded around the bottom three inches above the base, to prevent the chamber from sinking into the sediments. The top of the sampler was designed to hold a dissolved-oxygen and temperature probe, an intake hose and a discharge hose. The chamber holds 30.27 liters of water and covers a bottom area of 0.22 square meters. The total volume of water contained within the system (chamber and hoses) was 41.4 liters.

Water was circulated within the chamber by a small portable utility pump through 100 feet of heavy-duty 3/4" rubber garden hose and five feet of clear flexible plastic tubing which was attached to the discharge end of the pump. The clear tubing served as an observation window to control air-bleed off and bottom scouring. The unit was driven by a portable generator. A dissolved oxygen probe, with 50 feet of lead, attached to a portable recorder at the surface, continuously monitored the dissolved oxygen of the water within the chamber for approximately two hours. The sampling system is shown in Figure 3.

Procedures used to measure the rate of oxygen consumption

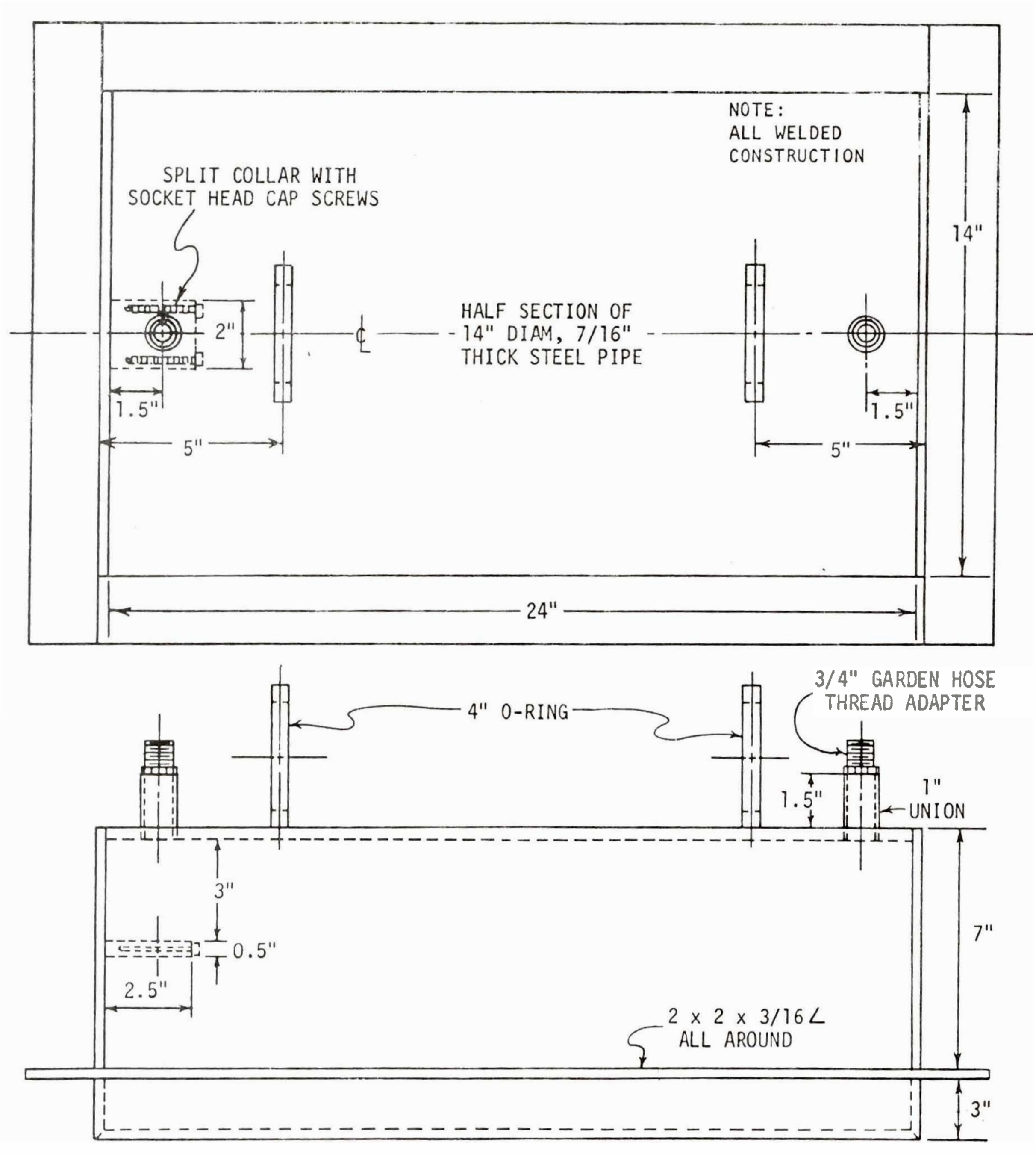

Figure 2 - Sediment oxygen demand bottom sampler (From Butts, 1974)

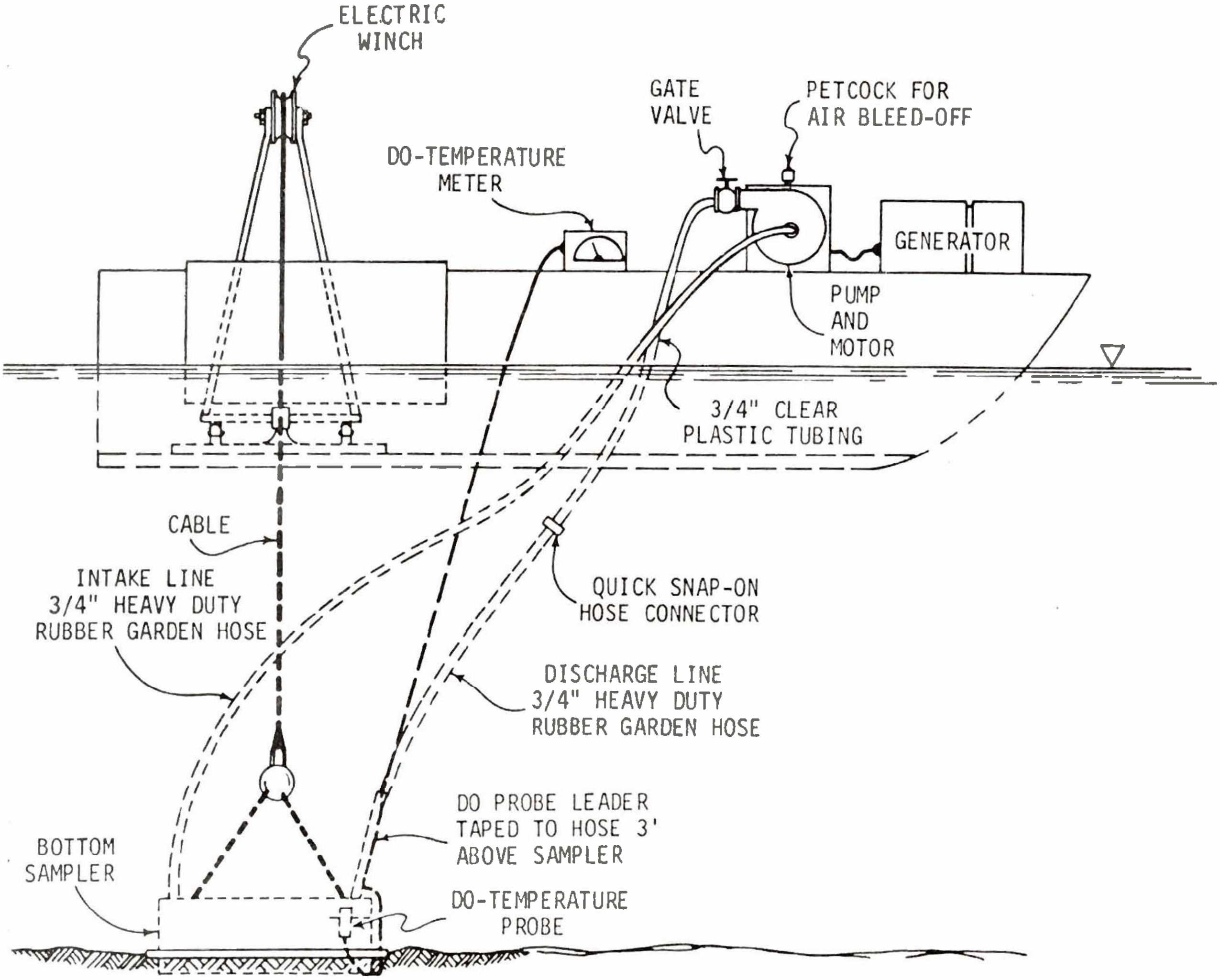

Figure 3 - Sediment oxygen demand sampling system (From Butts, 1974)

were those described by Butts (1974). In all cases, due to presence of barges or unsuitable conditions for securing the boat along the sides of the waterways, the SOD was measured near or under a bridge. The oxygen consumed was then calculated from the difference between the initial and final dissolved oxygen concentrations. From this information and a knowledge of the slope of the total or linear portion of the usage curve, the contact area, the chamber volume, and time, the sediment oxygen demand was determined using an equation derived from Butts (1974) shown in Table 2. The SOD measurements taken at various ambient water temperatures were corrected to 20° C using a formula also shown in Table 2.

Laboratory Sediment Oxygen Demand Measurement

If the initial dissolved oxygen measured in the field was less than 2 mg/l, a bottom sediment and water sample were collected from the sampling site in order to determine the oxygen demand of the sediment in the laboratory. Bottom samples were collected with a Ponar Grab Sampler. The sampler is designed to penetrate the sediment by virtue of its own weight and leverage and has a gravity activated closing mechanism. No attempt was made to obtain relatively undisturbed sediment samples or to refrigerate the sample. A water sample was collected approximately one foot from the bottom at the same location as the sediment sample.

The sediment oxygen demand of the sediment was determined in the laboratory using an electrolytic respirometer (E/BOD Respirometer System, Oceanographic International Corporation) shown in Figure 4.

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TABLE 2

FORMULA FOR CALCULATING SOD RATE

FIELD MEASUREMENT:

$$SOD_F = \frac{(1440)\ VS}{10^3 A} = \frac{(1440)\quad(41.3)\quad(S)}{(10^3)\quad(0.2167)} = 274.96S$$

SOD_F = Sediment Oxygen Demand in the Field, g/m^2/Day

1440 = Minutes/Day

V = Volume of Sampler (41.3), Liters

S = Slope of Total Portion of Usage Curve, mg/L/Min

10^3 = mg/gram

A = Area of Bottom Sampler (0.2167), m^2

LABORATORY MEASUREMENT:

$$SOD_{lab} = \frac{(24)\ VS}{10^3 A} = \frac{(24)\quad(0.8)\quad(S)}{(10^3)\quad(.0077)} = 2.523S$$

SOD_{lab} = Sediment Oxygen Demand in the Lab, g/m^2/Day

24 = Hours/Day

V = Volume of Container (0.8), Liters

S = Slope of Total Portion of Usage Curve, mg/L/Hr

10^3 = mg/gram

A = Area of Bottom of Container (0.0077), m^2

TABLE 2 cont'd

FORMULA FOR CALCULATING SOD RATE

CORRECTING SOD MEASUREMENT TO 20°C:

SOD_T = $SOD_{\text{rate at any temperature, T}}$ (field or laboratory measurement).

$$SOD_{20} = SOD_{\text{rate at }20°C} = SOD_T\,(1.047^{20-T})$$

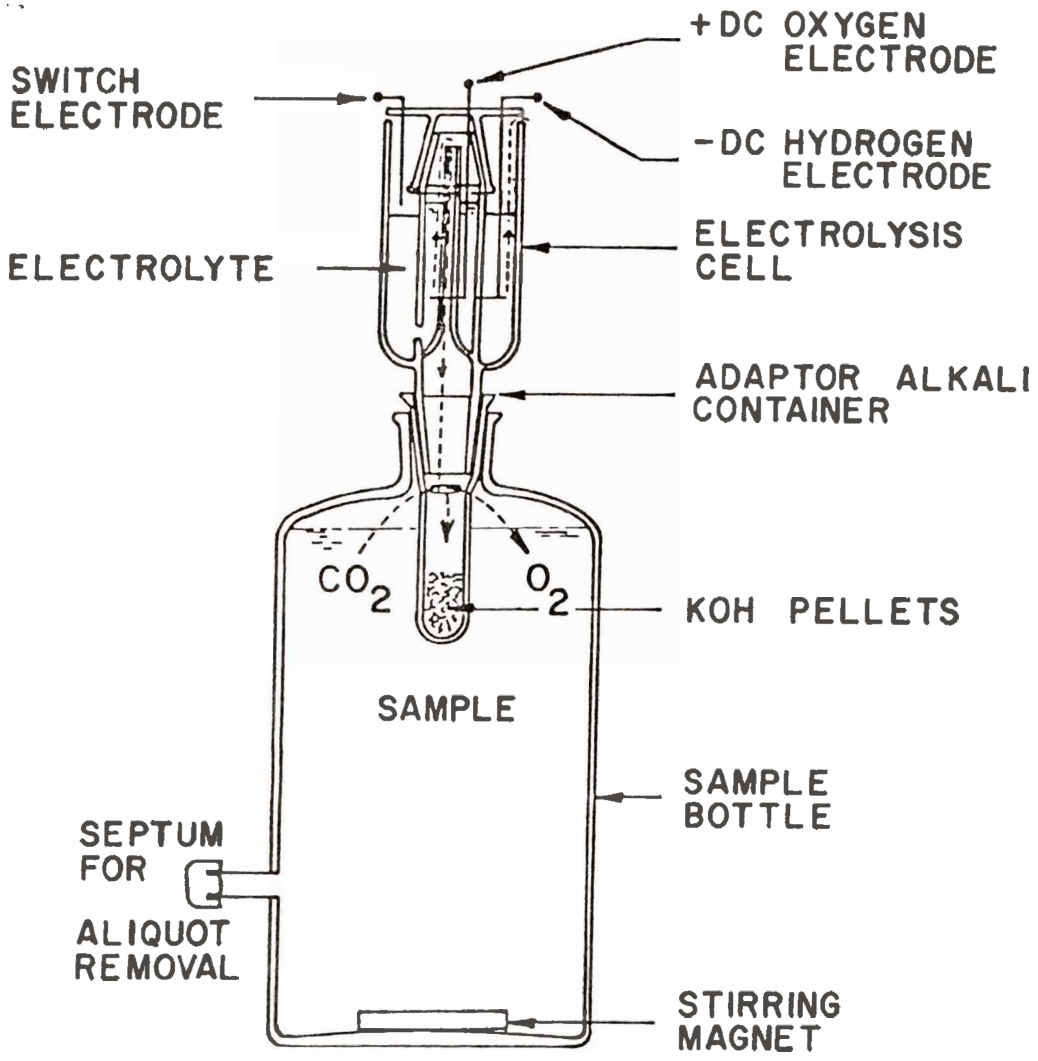

Figure 4

SCHEMATIC DIAGRAM SHOWING THE BASIC OPERATION OF THE ELECTROLYSIS SYSTEM

Basically, the system continuously replaces oxygen used in the sample by a manometrically triggered electrolysis reaction. The time during which the electrolysis cell is generating oxygen to the sample is converted electronically and displayed as milligrams of oxygen. A pump with an adjustable flow rate was used to recirculate the air, and to provide a fluid flow over the sediment without scouring (Figure 5).

Two-hundred milliliters of the sediment were poured through a funnel into the one liter reaction vessel. The water sample was siphoned slowly into the vessel, being careful not to disturb the sediment. Thirty minutes were allowed for the sediment to resettle. The sediment samples were monitored hourly for a total of 24 hours. The tests were initiated within six hours of the sampling time. The daily oxygen demand was computed using an equation derived from Butts (1974) shown in Table 2. No attempt was made to determine whether the field and laboratory samples had similar oxidation reduction potential (ORP).

Macroinvertebrate Sampling

Single grabs of $0.05m^2$ were taken with a Ponar Grab during July-October, 1977 and again during November-December, 1977 from the center and from both sides of the waterway at each of 21 sampling stations.

The bottom samples were washed and screened in the field through a number 30, U. S. Standard Sieve. These samples were placed in one gallon plastic bottles and transported to the labora-

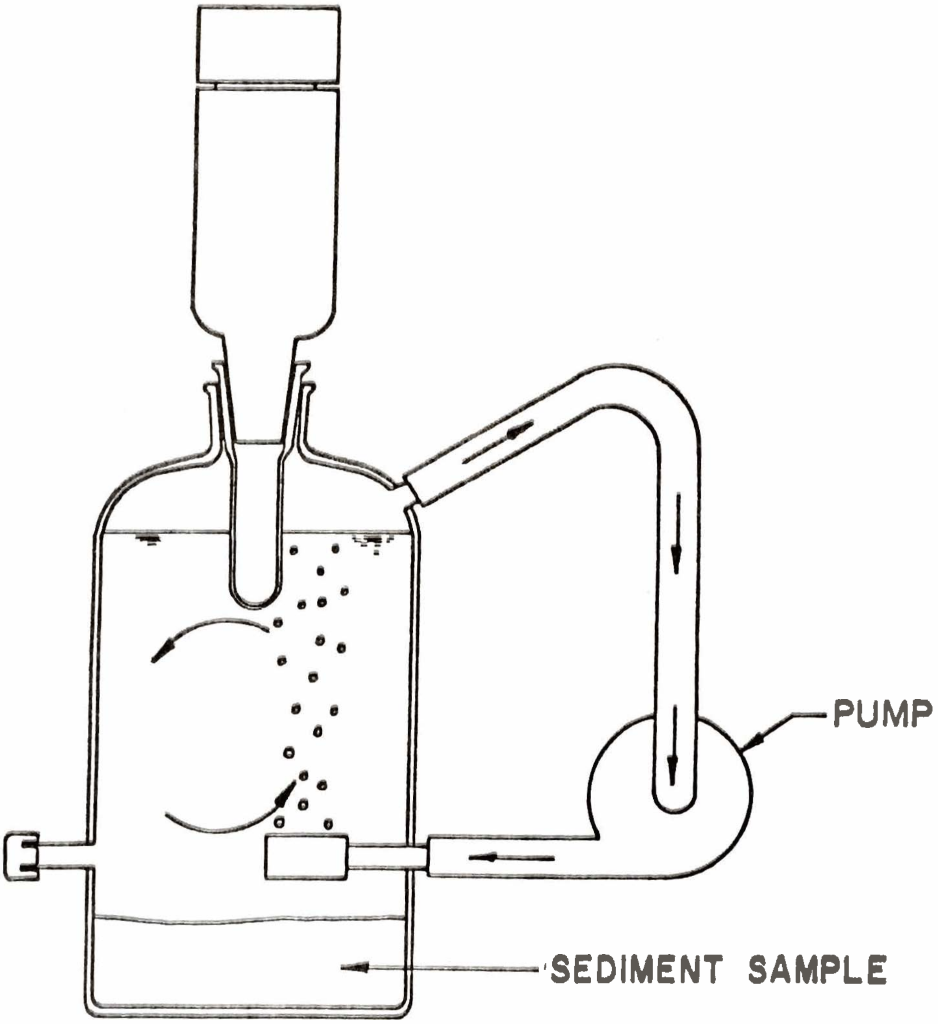

Figure 5

ELECTROLYSIS SYSTEM WITH RECIRCULATING PUMP tory. The organisms were then separated from the substratum and debris, sorted into major taxonomic groups, and counted. In situations where large numbers of organisms were collected, estimates of their abundance were made by examining portions of the sample.

The density of the benthic organisms for each station was expressed in numbers per square meter of channel or river bottom. The total number of individuals of each major taxon was obtained.

Sediment Sampling and Analysis Procedures

The field corer used in this study is designed to collect sediment samples approximately 500mm long and 47mm in diameter from a variety of substrata. The corer was attached by a cable (plastic coated to prevent kinking) to a boom with an electric winch. Cores were collected at the 21 locations by allowing the corer to drop freely to the bottom of the waterway. At each sampling station, a total of three cores were collected, at the right, left, and center of the waterway.

The depth of penetration was a function of the sediment composition, and was measured in the laboratory using a ruler. Any noticeable layers in the core were then measured and described as to sediment type. If the layers were of sufficient depth (75mm or more), they were separately analyzed using a series of sieves. If the layers were small and/or difficult to differentiate, the core was equally divided into artificial layers of approximately 150mm each, and these sieved separately. Sieving was done by allowing a layer of sediment to ease out onto a series of sieves beginning with a number 12 on top, then a number 25 below, 40, 60, and 100 on the bottom, respectively. The sediment was washed with a fairly strong stream of water so that the finer particles were forced down to the sieves with the finer mesh size. The bottom sieves tended to become clogged quickly and had to be emptied frequently to prevent overflow. The sediments collected on each sieve were finally rinsed into beakers with a similar inside diameter as the core container, allowed to settle, and measured with a ruler. The accumulated depth from each sieve was reported in millimeters, and the percentage of the total core for each particle size was calculated.

Sediment Chemical Sampling and Analyses

Samples to determine the physical and chemical characteristics of the bottom deposits were taken at approximately the same locations as the SOD measurement. Bottom samples were collected with a Ponar Grab. The samples were transported to the laboratory and analyzed for BOD, COD, Total Solids, and Total Volatile Solids. A water suspension was prepared from the sample, and the BOD was determined on the suspension. The Chemical Oxygen Demand was expressed as a percentage based on dry weight. A portion of the sample was also weighed, and the Total Solids and Total Volatile Solids determined, and expressed as a percentage. One percent is equivalent to 10,000 mg/kg.

IV. RESULTS

The sediment oxygen demand determined at each of the 21 sampling stations is presented in Table 3. Cumulative oxygen consumption rates for each sampling station are shown in Figures 6-27. The SOD values range from 1.23 - 27.39 grams/m^2/day. The highest rates generally occurred in the North Shore Channel and North Branch of the Chicago River, as well as in areas below sewage treatment plants and sewage pumping station outfalls. In some cases, higher oxygen consumption rates occurred during the winter rather than in the summer. No explanation for this is available.

The results of the macroinvertebrate sampling are summarized in Table 4. Except for Touhy and Indiana, pollution-tolerant oligochaetes (sludgeworms) were the dominant benthic macroinvertebrates in the sediments, comprising more than 90% of the community. The above two sampling stations were less dominated in terms of community structure by oligochaetes, and also supported other macroinvertebrate taxa such as leeches, midges and/or clams.

Table 5 indicates the sediment type and volume of sediment sampled at the 21 sampling stations. Bottom deposits were composed primarily of sludge, with varying amounts of sand and gravel in the upper portion of the North Shore Channel, lower portion of the North Branch of the Chicago River, South Fork of the South Branch of the Chicago River, Chicago Sanitary and Ship Canal and Cal-Sag Channel. The substratum in the lower portions of the North Shore

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TABLE 3

SEDIMENT OXYGEN DEMAND VALUES IN DEEP DRAFT WATERWAYS IN COOK COUNTY FOR 1976

	Sampling Station # and Nearest Street	Date of Sampling	Water Temperature (°C)	SOD$_T$ g/m^2/Day	SOD$_{20}$ g/m^2/Day
1	Maple (NSC)	7-6-76	22.0	10.15	9.26
2.	Main (NSC)	9-20-76	20.0	16.32*	16.32*
3.	Touhy (NSC)	7-9-76	23.0	10.37	9.04
4	Wilson (NBCR)	7-28-76	24.0	16.14	13.43
5.	Diversey (NBCR)	9-7-76	23.5	27.39	23.32
		11-10-76	9.6	11.39	6.76
6.	Division (NBCR)	9-20-76	20.0	1.23*	1.23*
7.	Grand (NBCR)	10-18-76	20.0	2.38*	2.38*
		12-2-76	10.0	3.72*	5.89*
8.	Jackson (SBCR)	7-20-76	24.0	7.55	6.28
		11-9-76	10.5	5.98	9.25

TABLE 3 (cont'd)

SEDIMENT OXYGEN DEMAND VALUES IN DEEP DRAFT WATERWAYS IN COOK COUNTY FOR 1976

Sampling Station # and Nearest Street		Date of Sampling	Water Temperature (°C)	SOD$_T$ g/m^2/Day	S D$_{20}$ g/m /Day
9.	Archer (SFSBCR)	9-27-76	20.0	3.42*	3.42*
		12-6-76	10.0	2.79*	4.42*
10.	Western (CSSC)	9-27-76	20.0	5.62*	5.62*
		12-7-76	4.0	1.45	3.02
11.	Cicero (CSSC)	10-22-76	20.0	3.43*	3.43*
12.	Harlem (CSSC)	8-30-76	28.0	20.42	14.14
13.	Rt. 83 (CSSC)	10-4-76	27.5	5.22*	3.70*
14.	16th Street (CSSC)	10-4-76	20.0	3.46*	3.46*
15.	Ewing (CR)	8-11-76	22.5	2.69	2.40
		11-23-76	11.5	2.85	4.21

TABLE 3 (cont'd)

SEDIMENT OXYGEN DEMAND VALUES IN DEEP DRAFT WATERWAYS IN COOK COUNTY FOR 1976

Sampling Station # and Nearest Street	Date of Sampling	Water Temperature (°C)	SOD_T g/m^2/Day	SOD_{20} g/m^2/Day
16. Norfolk & Western (CR)	8-10-76	24.5	9.36	7.61
	11-19-76	8.5	3.21	5.44
17. Indiana (LCR)	8-12-76	25.0	8.81	7.00
	11-17-76	8.5	2.20	3.73
18. Halsted (LCR)	8-16-76	24.0	9.23	7.68
	11-18-76	12.5	8.51	12.01
19. Western (CSC)	10-12-76	22.0	3.77*	3.44*
	11-16-76	9.0	5.49	9.10
20. Southwest Hwy (CSC)	8-31-76	25.0	No Data Available	
21. Rt. 83 (CSC)	10-12-76	22.0	2.48*	2.26*

* Laboratory Studies; All Others In-Situ

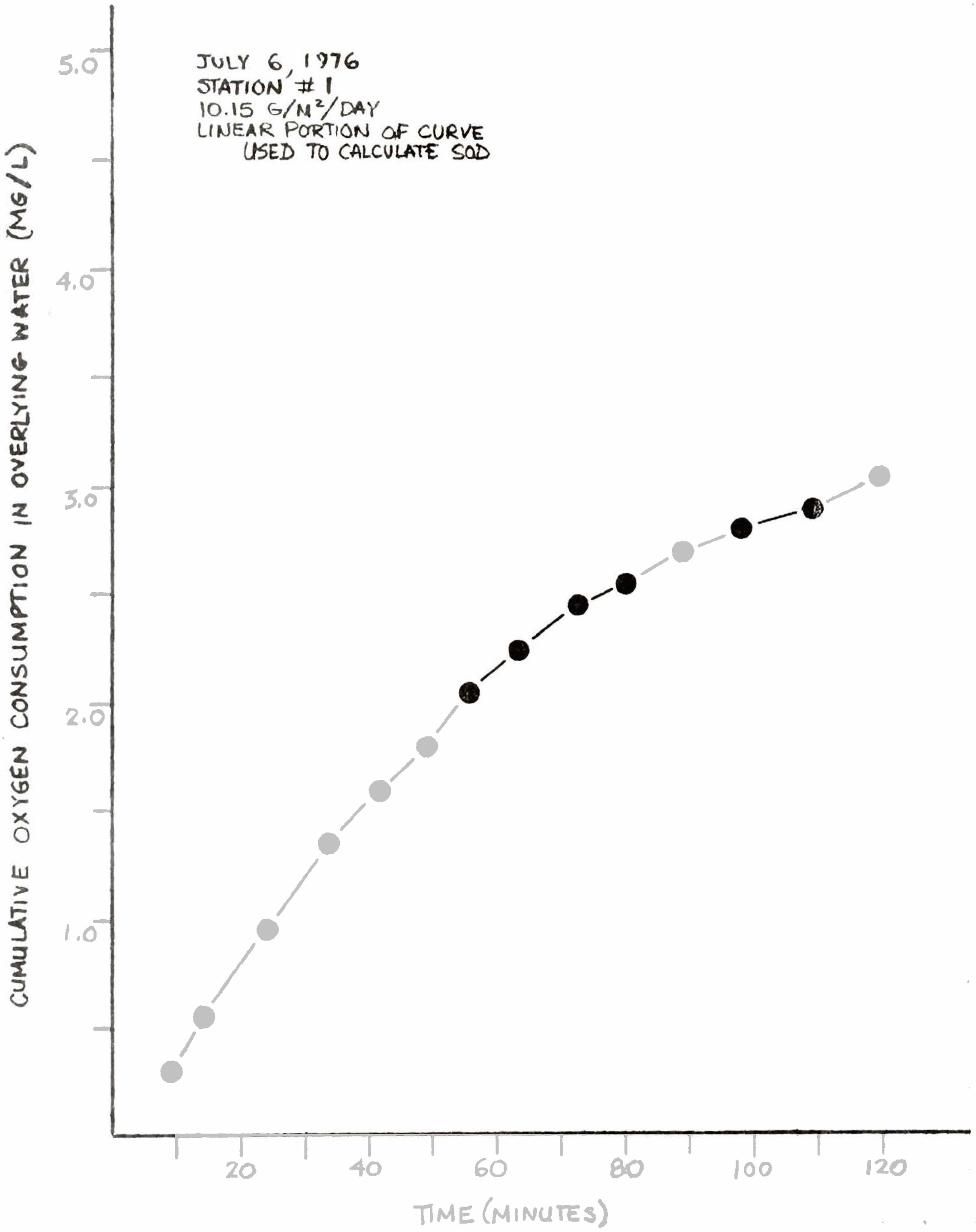


FIGURE 6 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT MAPLE IN THE NORTH SHORE CHANNEL (FIELD MEASUREMENT)

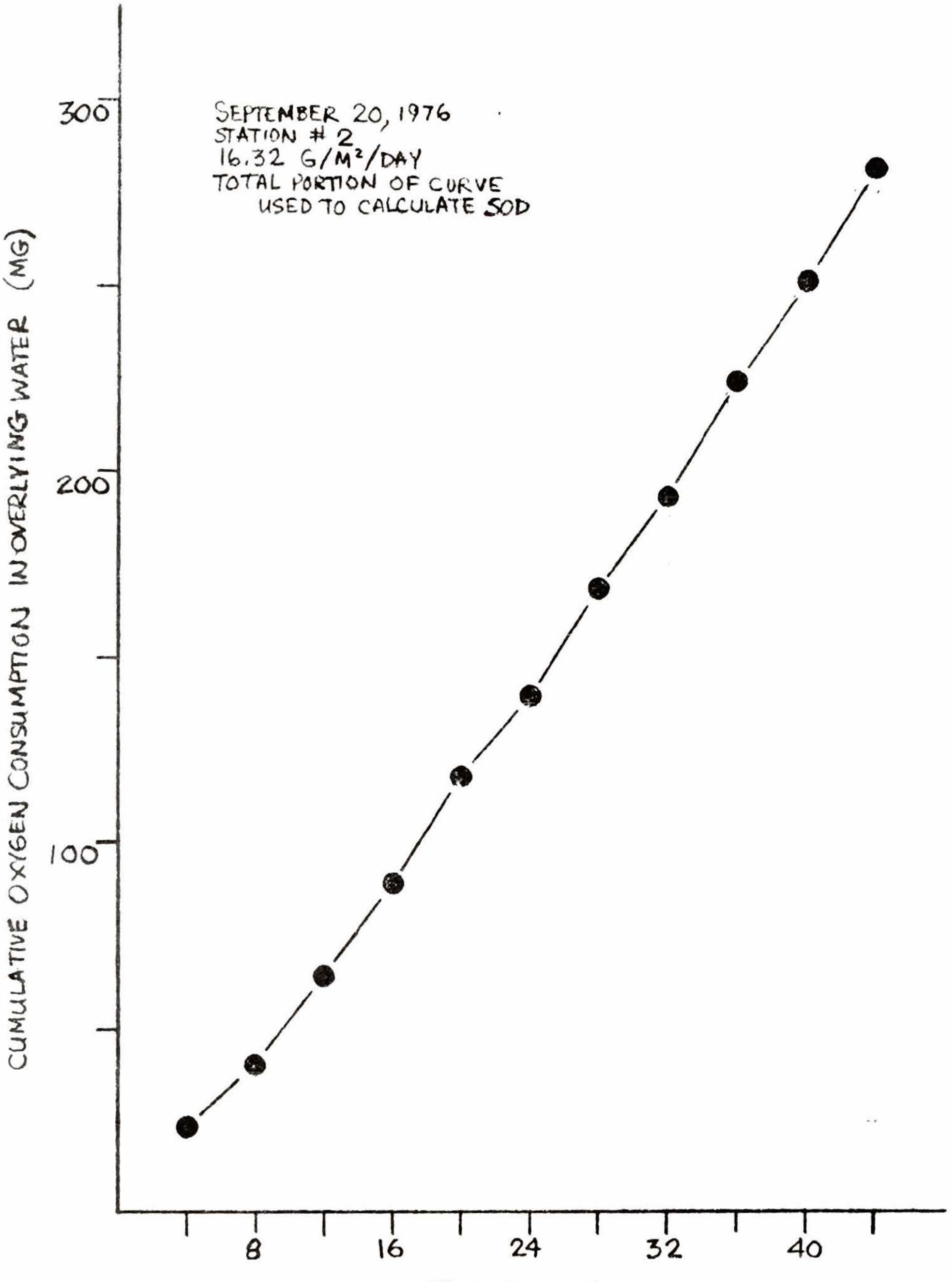


FIGURE 7. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT MAIN IN THE NORTH SHORE CHANNEL (LABORATORY MEASUREMENT)

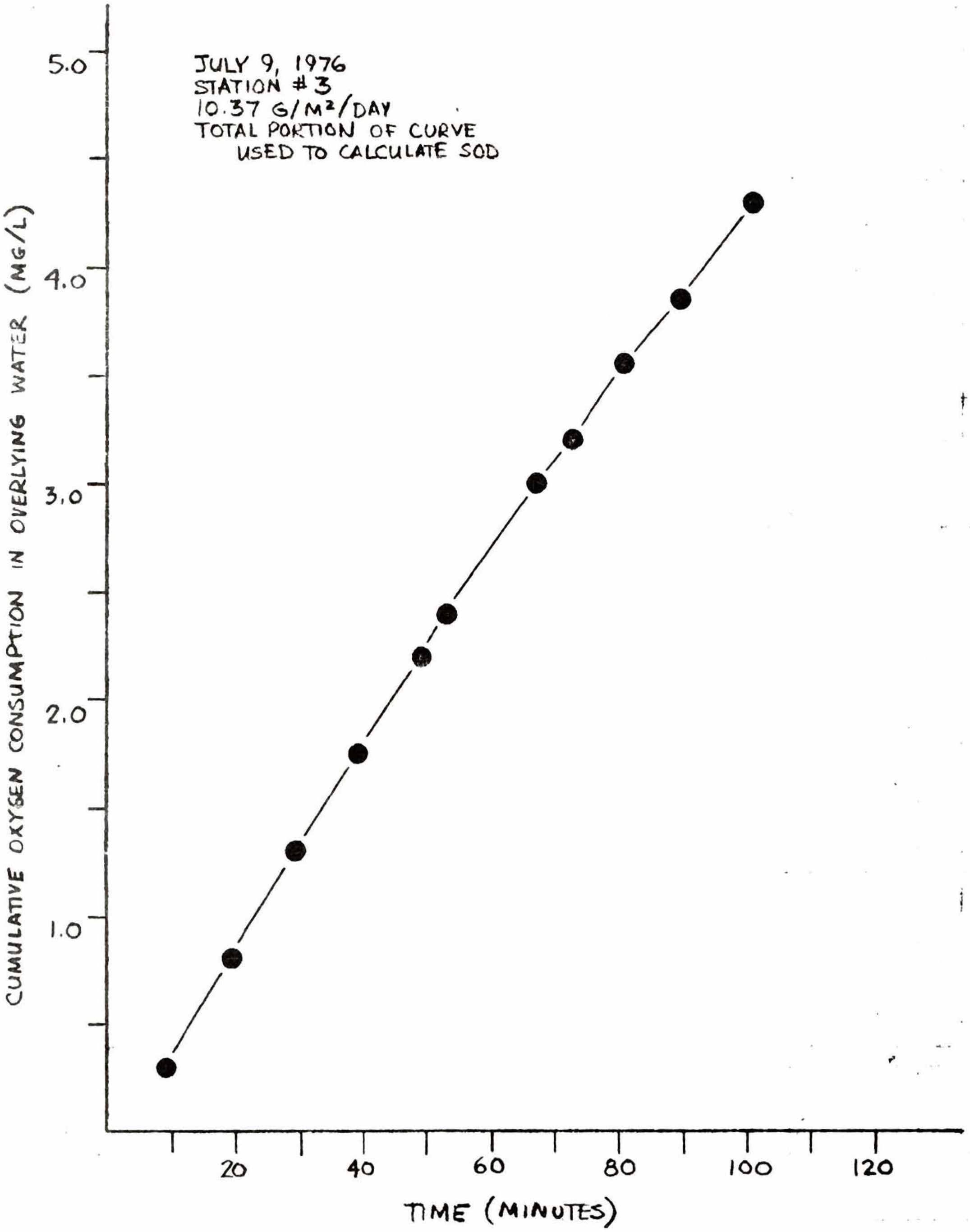


FIGURE 8 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT TOUHY IN THE NORTH SHORE CHANNEL (FIELD MEASUREMENT)

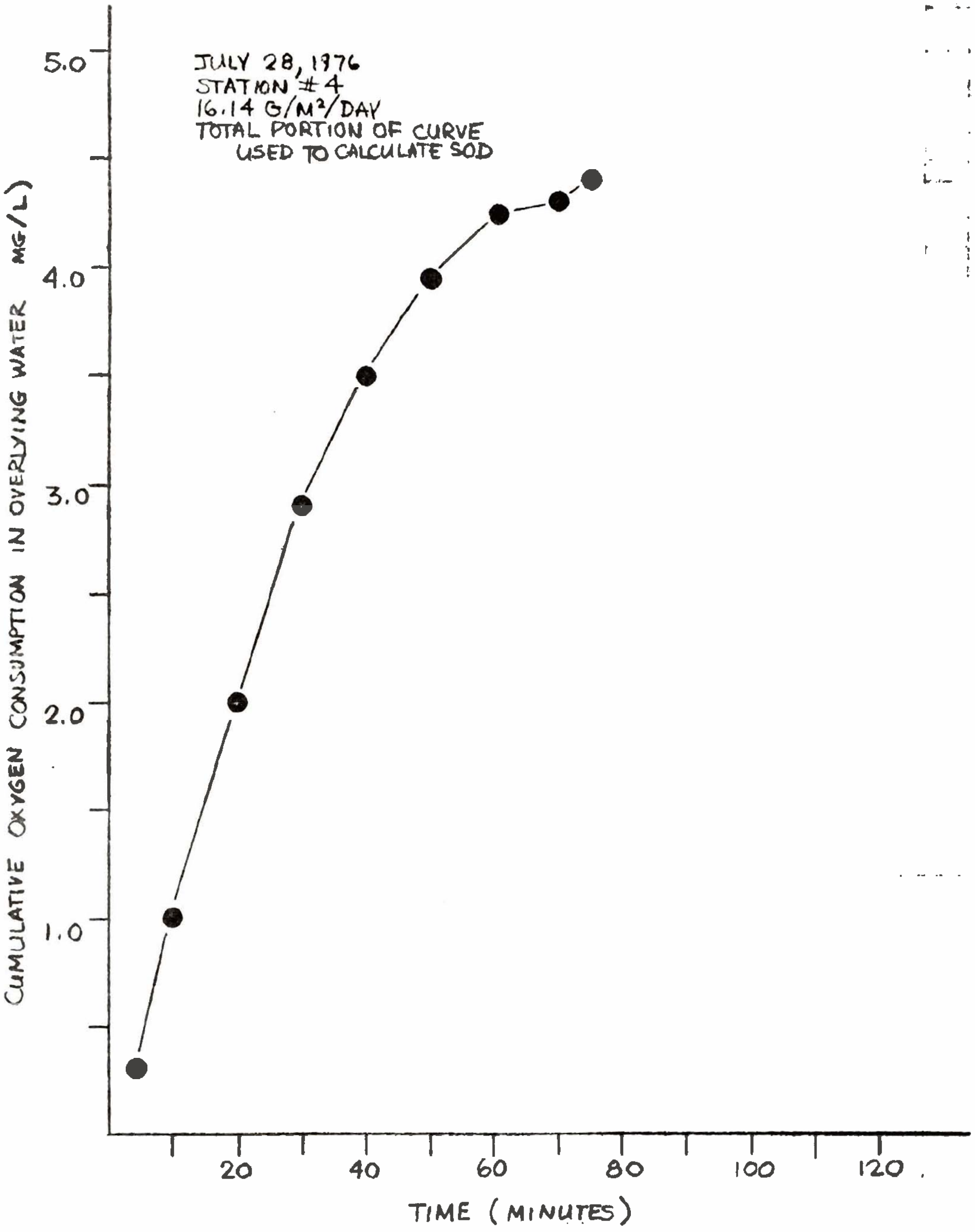


FIGURE 9 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT WILSON IN THE NORTH BRANCH OF THE CHICAGO RIVER (FIELD MEASUREMENT)

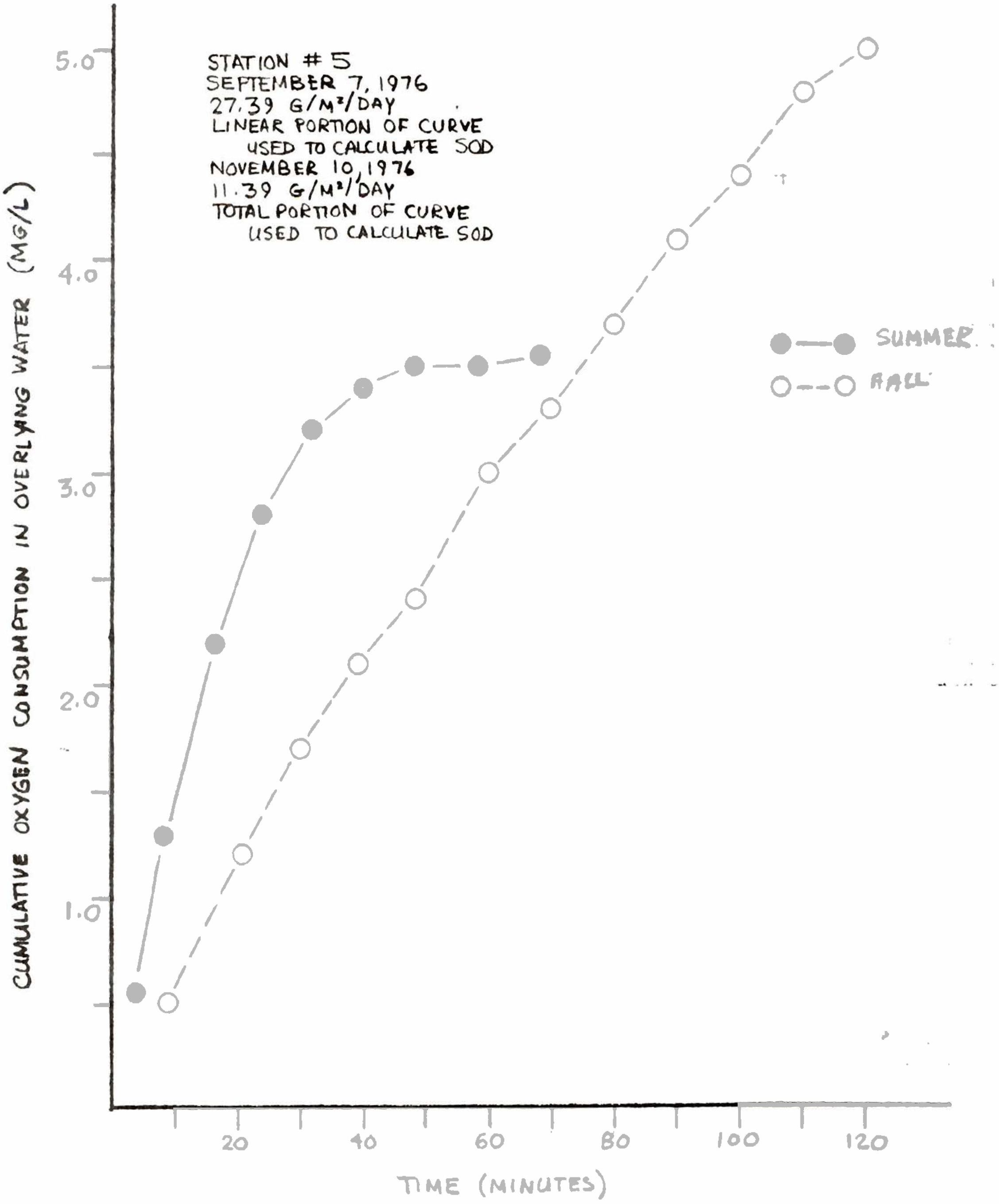
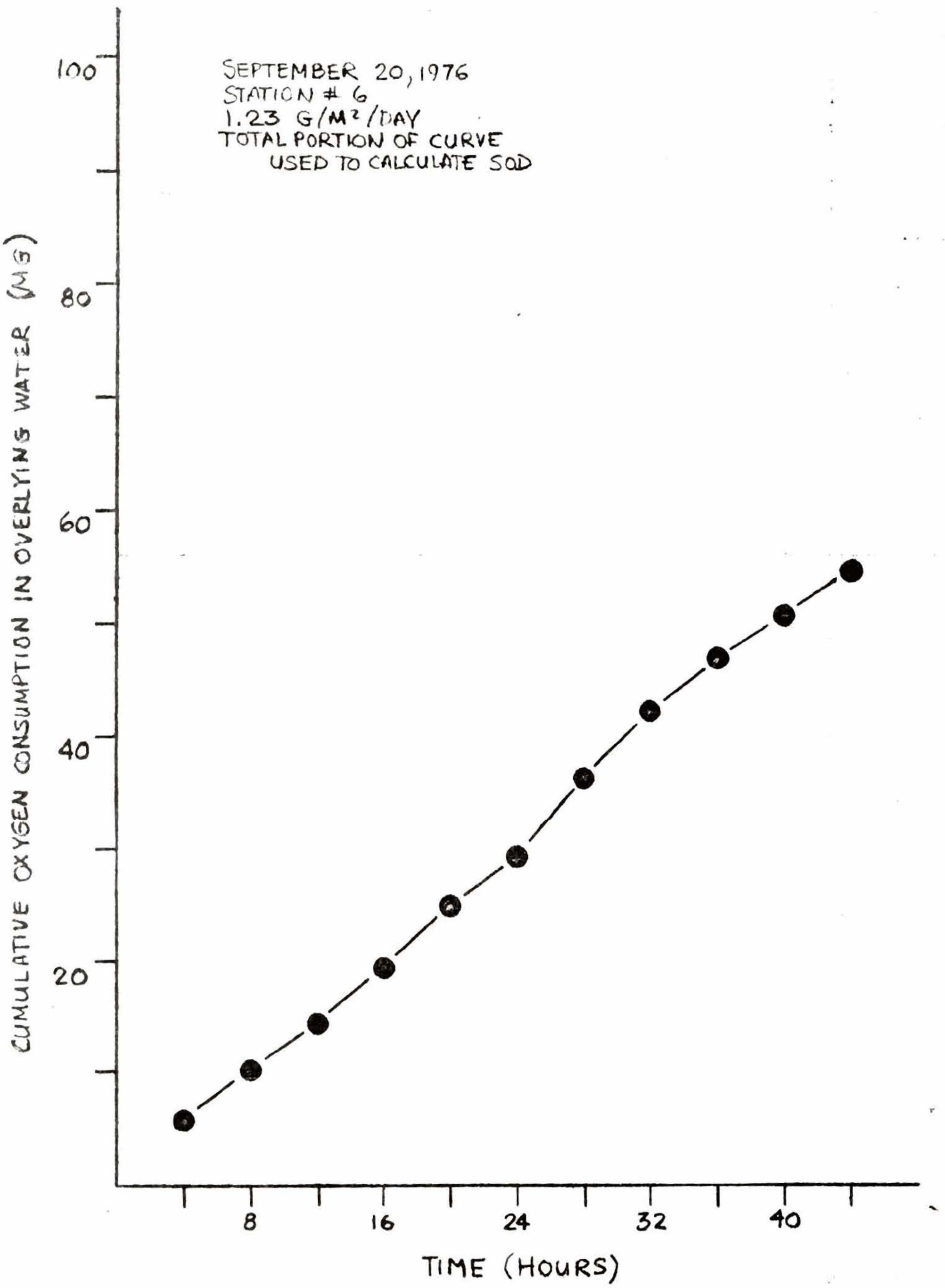


FIGURE 10 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT DIVERSEY IN THE NORTH BRANCH OF THE CHICAGO RIVER (FIELD MEASUREMENT)



SEPTEMBER 20, 1976
STATION # 6
1.23 G/M²/DAY
TOTAL PORTION OF CURVE
USED TO CALCULATE SOD

FIGURE 11 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT DIVISION IN THE NORTH BRANCH OF THE CHICAGO RIVER (LABORATORY MEASUREMENT)

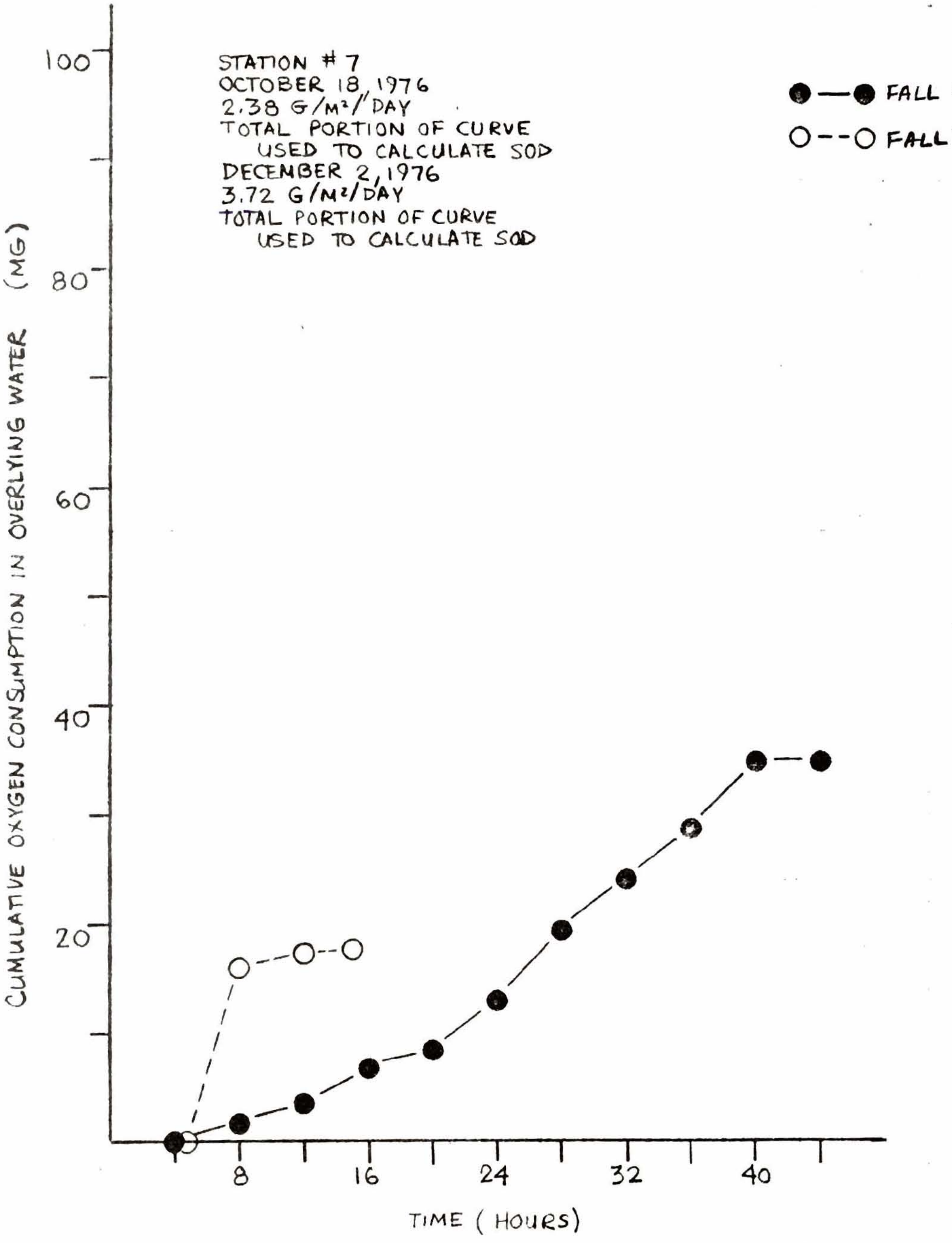
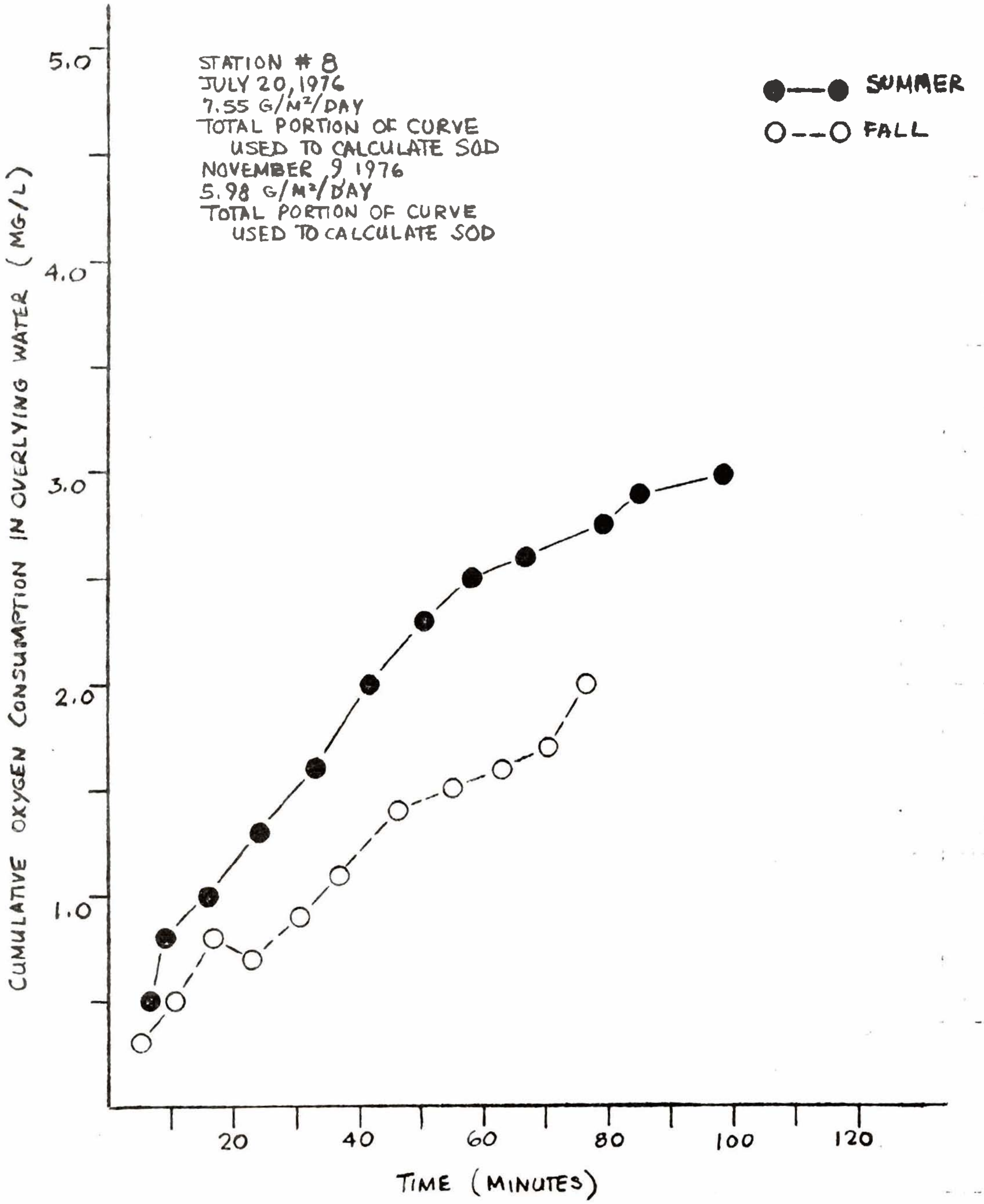


FIGURE 12. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT GRAND IN THE NORTH BRANCH OF THE CHICAGO RIVER (LABORATORY MEASUREMENT)



STATION # 8
JULY 20, 1976
7.55 G/M²/DAY
TOTAL PORTION OF CURVE
USED TO CALCULATE SOD
NOVEMBER 9 1976
5.98 G/M²/DAY
TOTAL PORTION OF CURVE
USED TO CALCULATE SOD

FIGURE 13. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT JACKSON IN THE SOUTH BRANCH OF THE CHICAGO RIVER (FIELD MEASUREMENT)

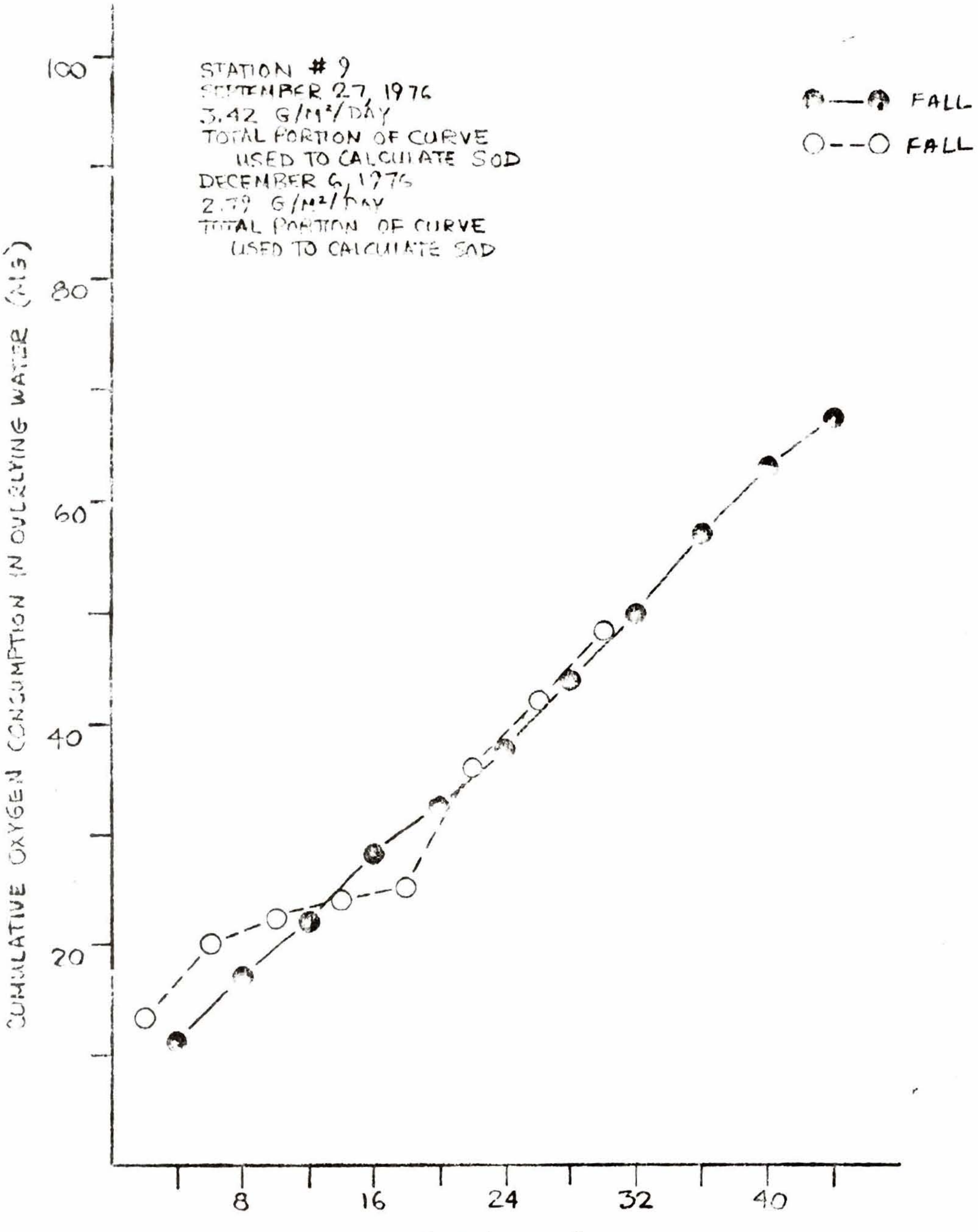


FIGURE 14. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT ARCHER IN THE SOUTH FORK OF THE SOUTH BRANCH OF THE CHICAGO RIVER (LABORATORY MEASUREMENT)

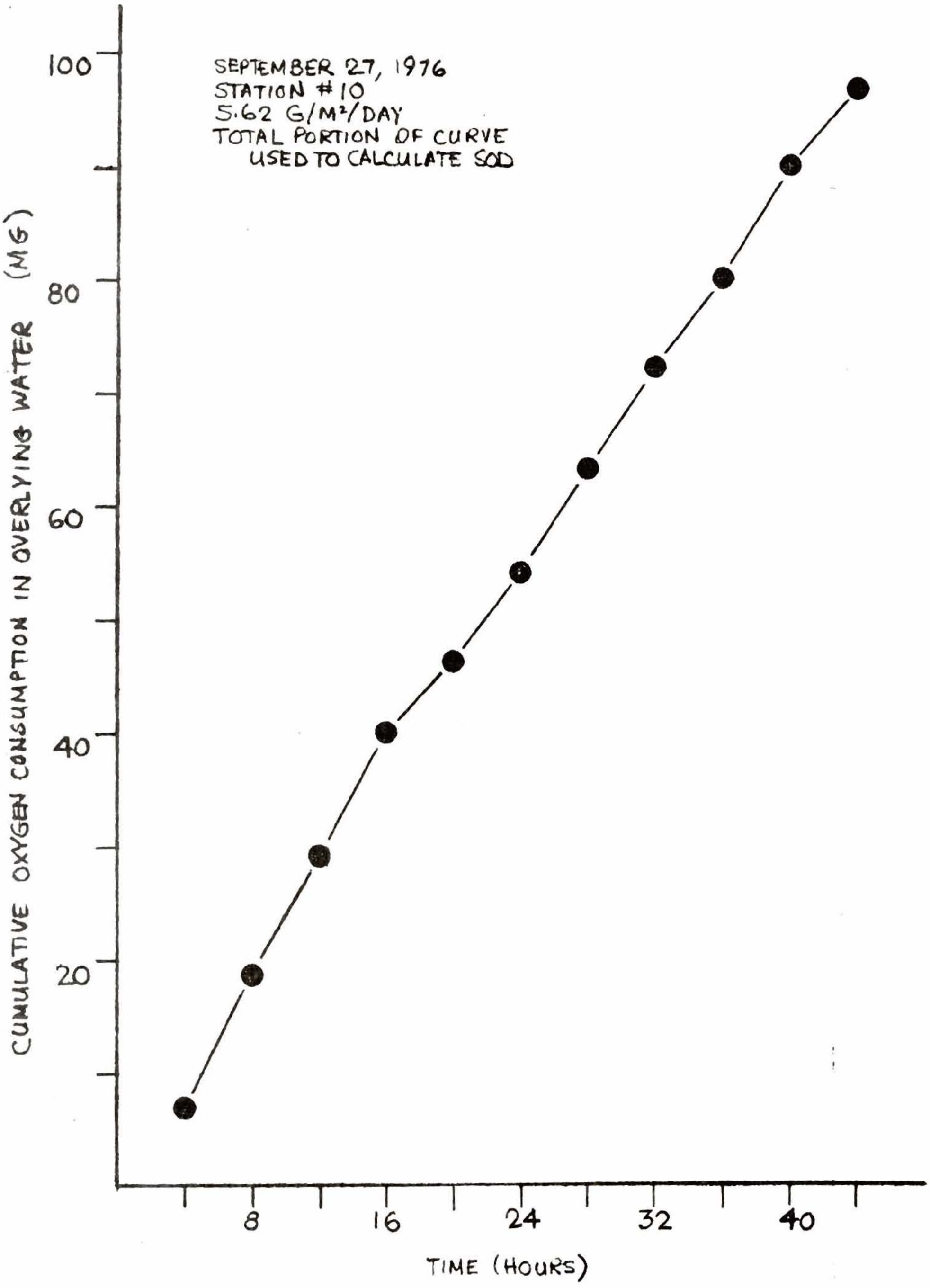


FIGURE 15 , CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT WESTERN IN THE CHICAGO SANITARY AND SHIP CANAL (LABORATORY MEASUREMENT)

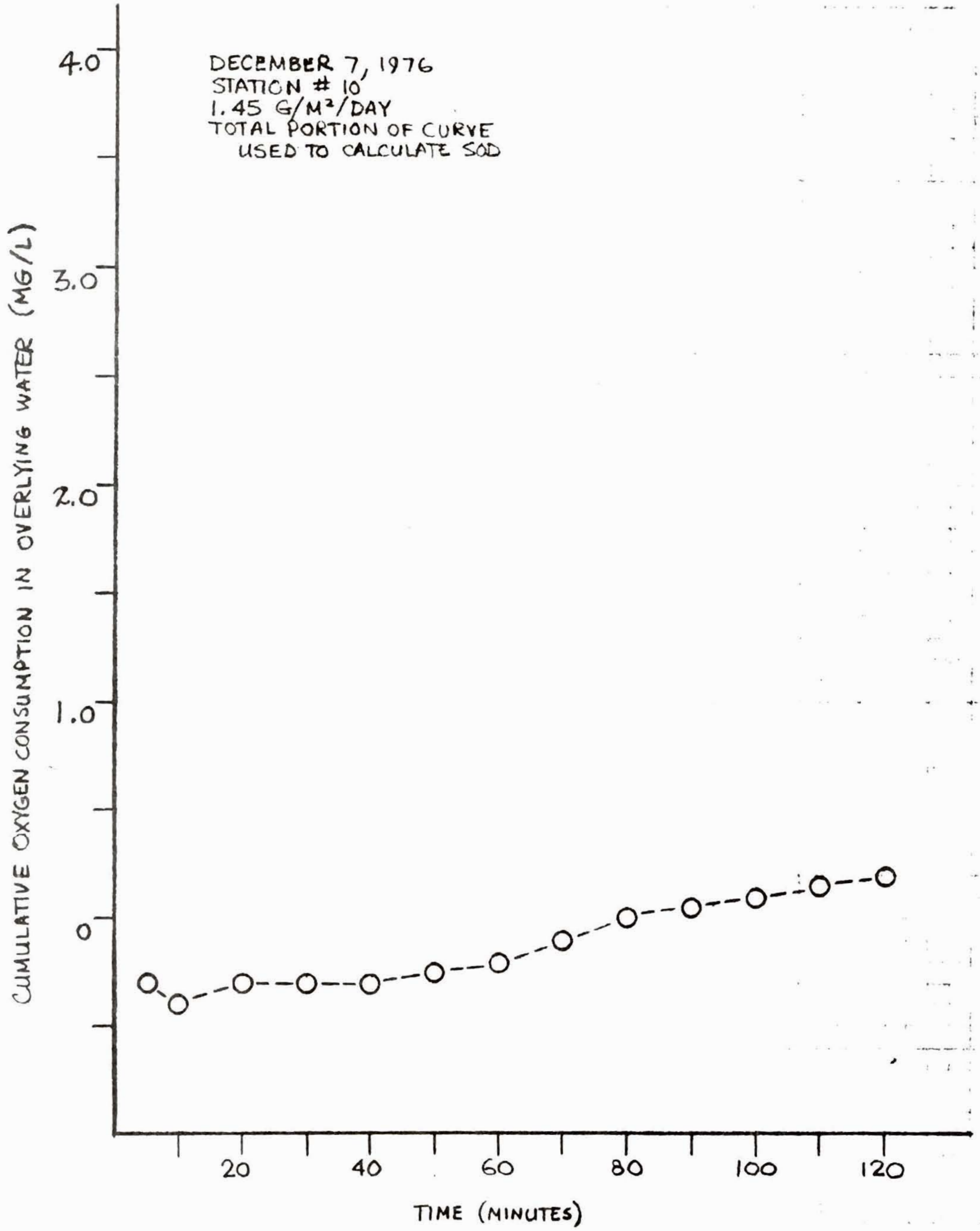


FIGURE 16. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT WESTERN IN THE CHICAGO SANITARY AND SHIP CANAL (FIELD MEASUREMENT)

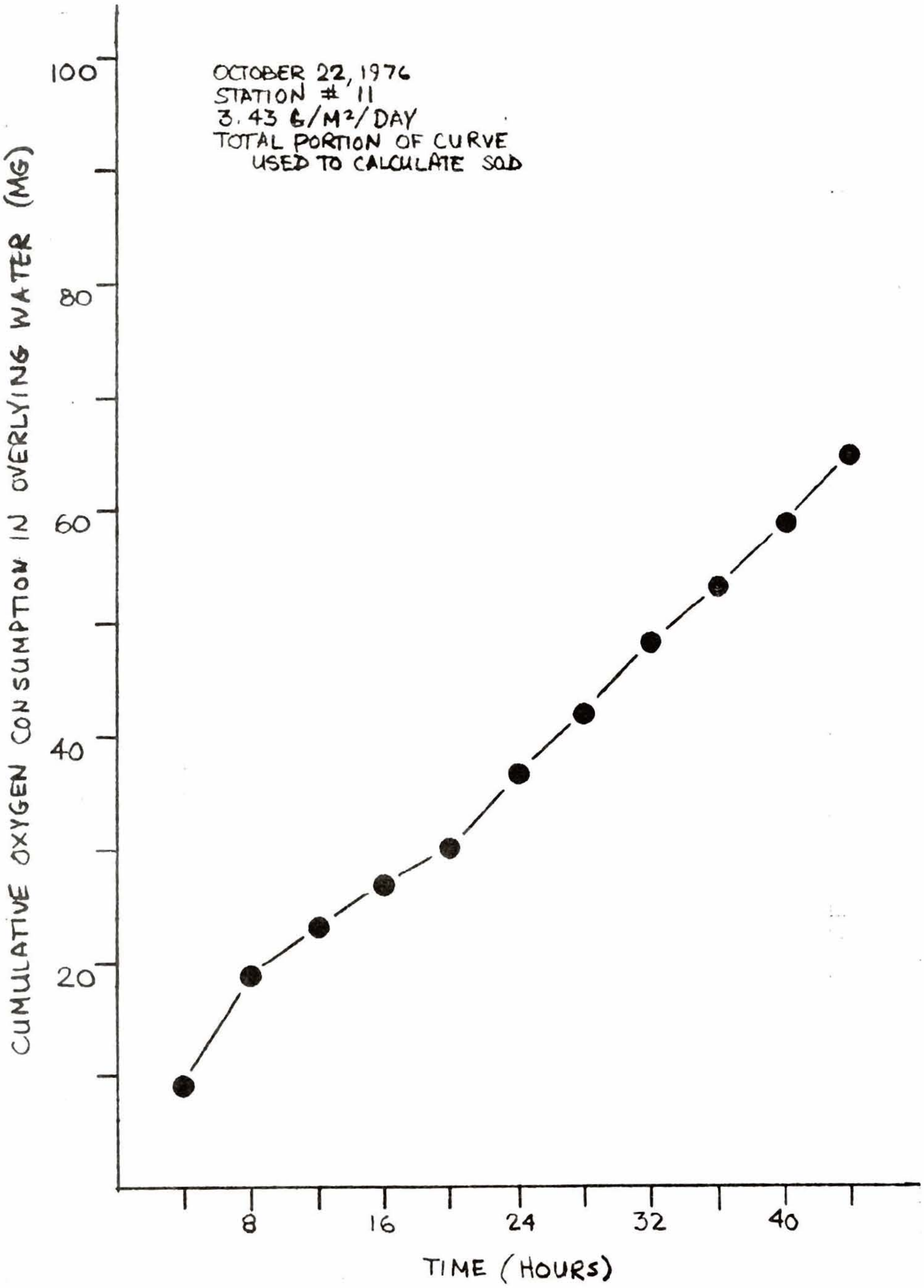
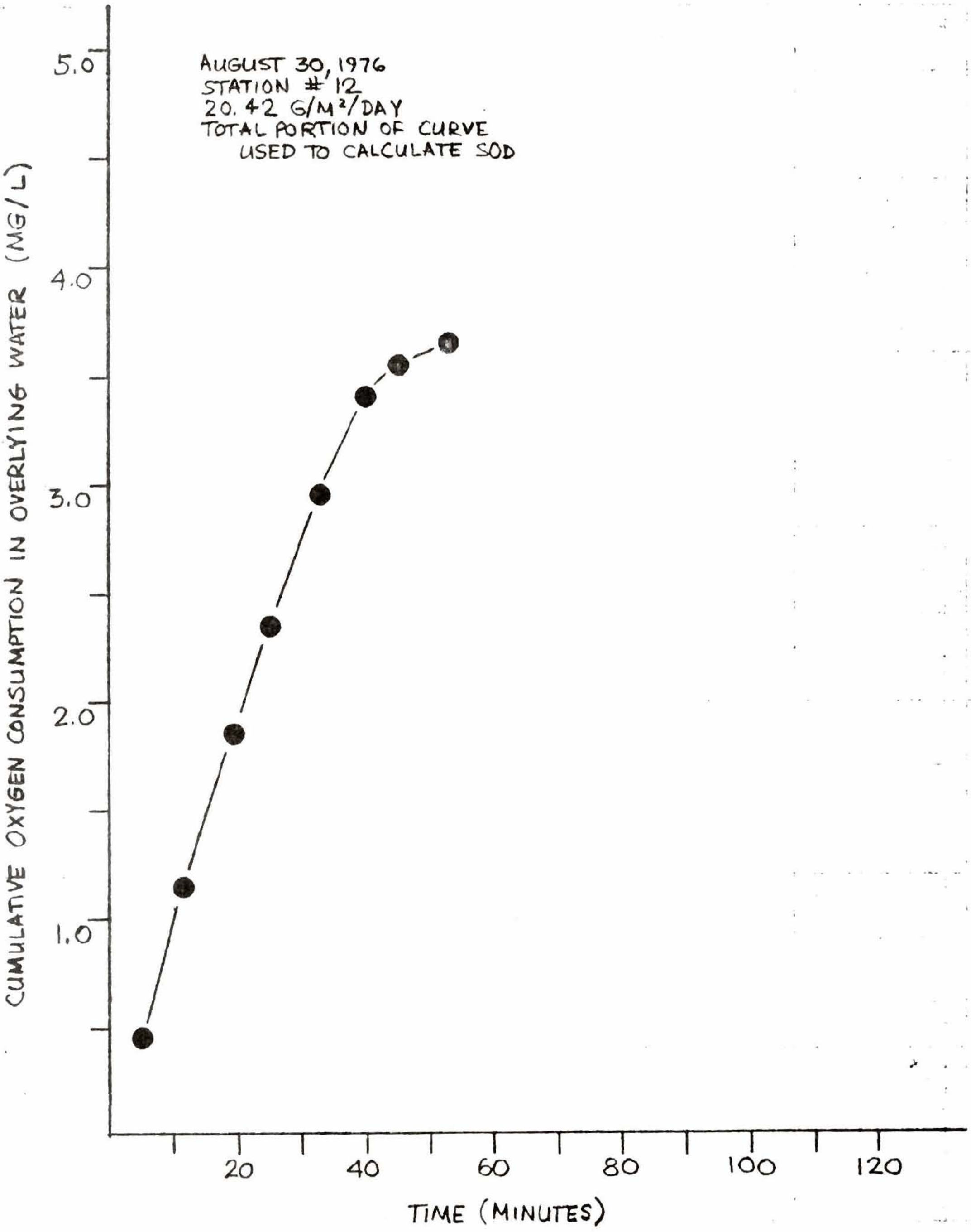


FIGURE 17. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT CICERO IN THE CHICAGO SANITARY AND SHIP CANAL (LABORATORY MEASUREMENT)



AUGUST 30, 1976
STATION # 12
20.42 G/M²/DAY
TOTAL PORTION OF CURVE
USED TO CALCULATE SOD

FIGURE 18. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT HARLEM IN THE CHICAGO SANITARY AND SHIP CANAL (FIELD MEASUREMENT)

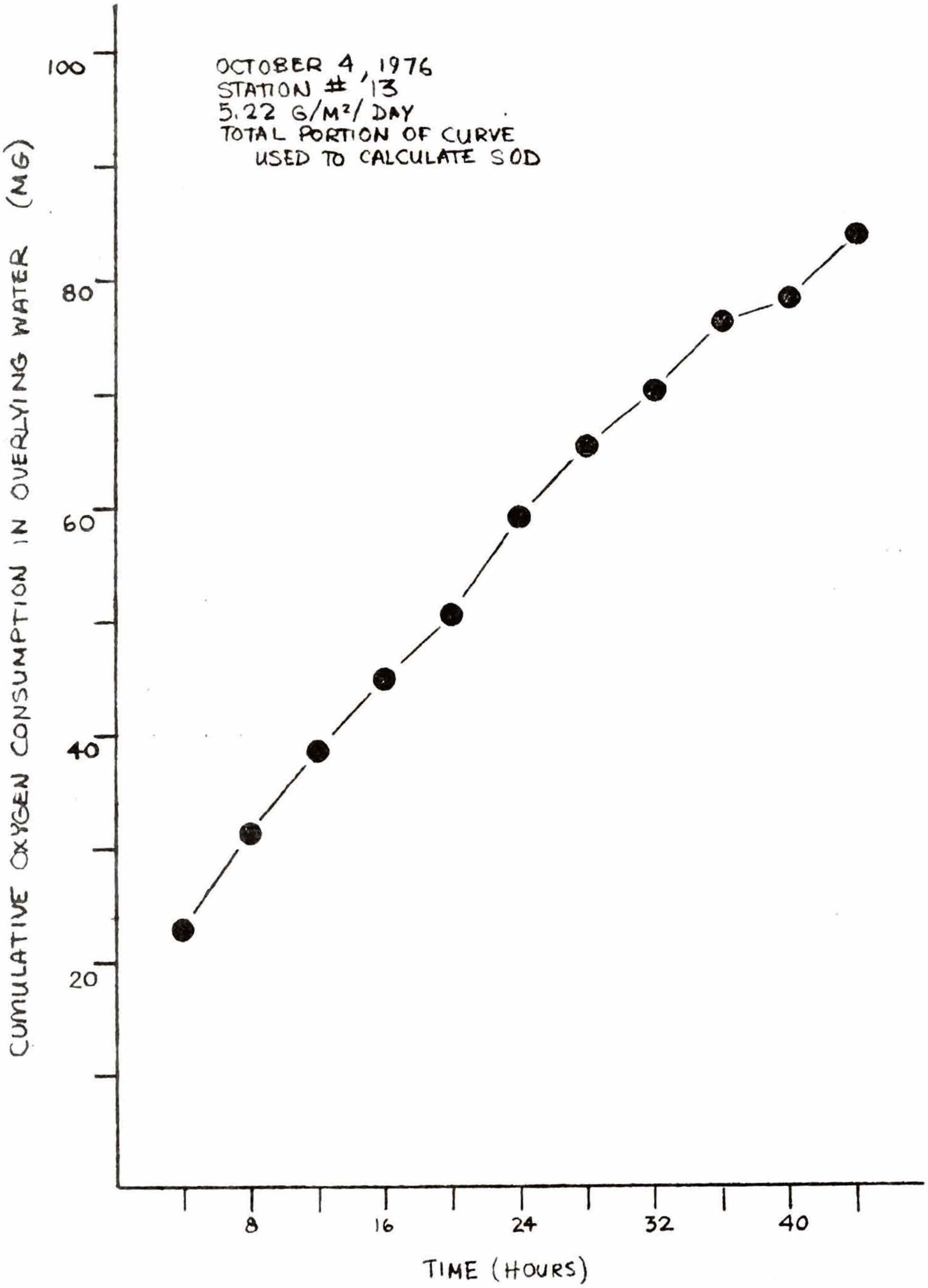


FIGURE 19. CUMULATIVE OXYGEN CONSUMPTION IN OVERLYING WATER AS A FUNCTION OF TIME AT ROUTE 83 IN THE CHICAGO SANITARY AND SHIP CANAL (LABORATORY MEASUREMENT)

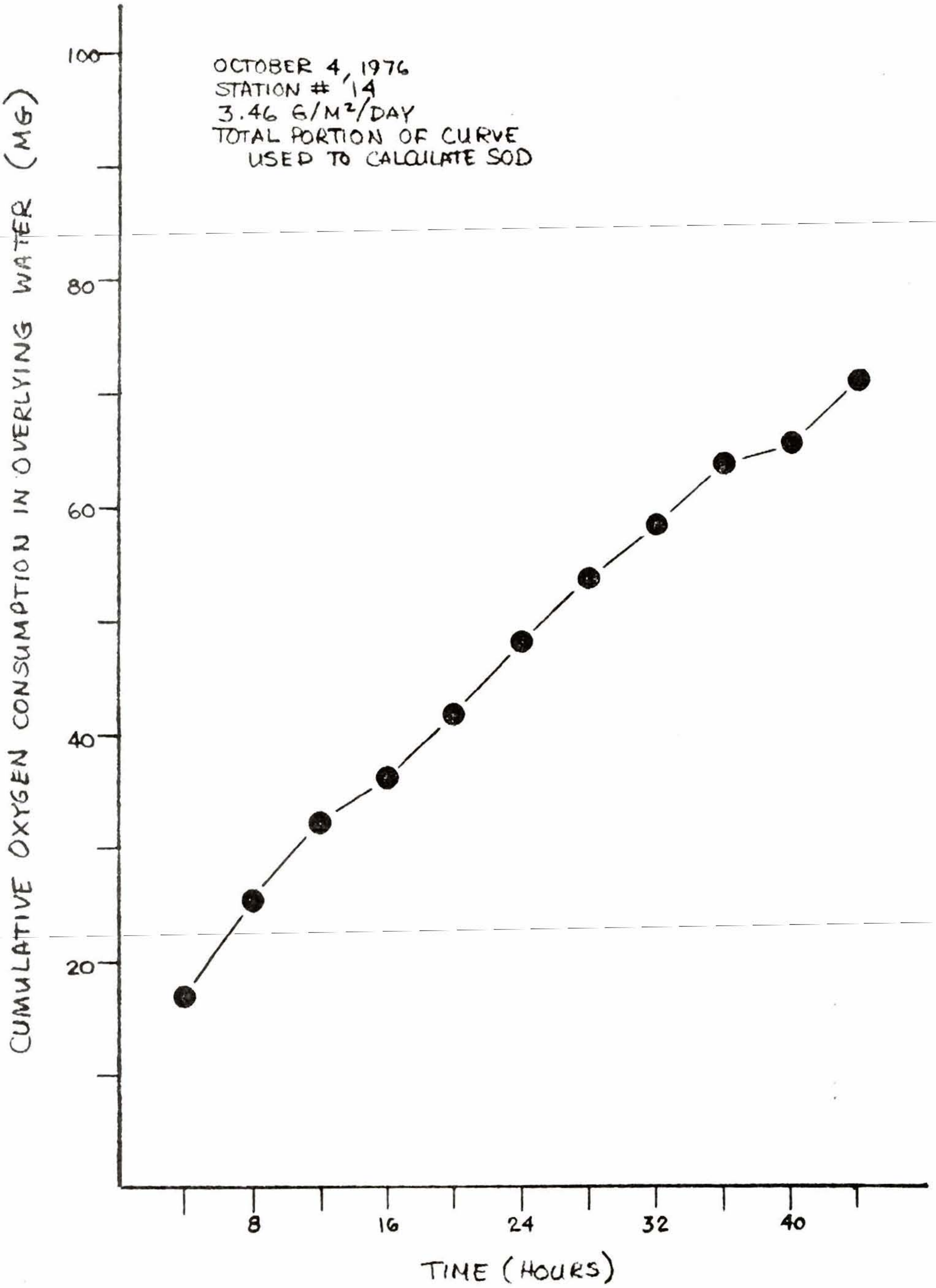


FIGURE 20, CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT 16th STREET IN THE CHICAGO SANITARY AND SHIP CANAL (LABORATORY MEASUREMENT)

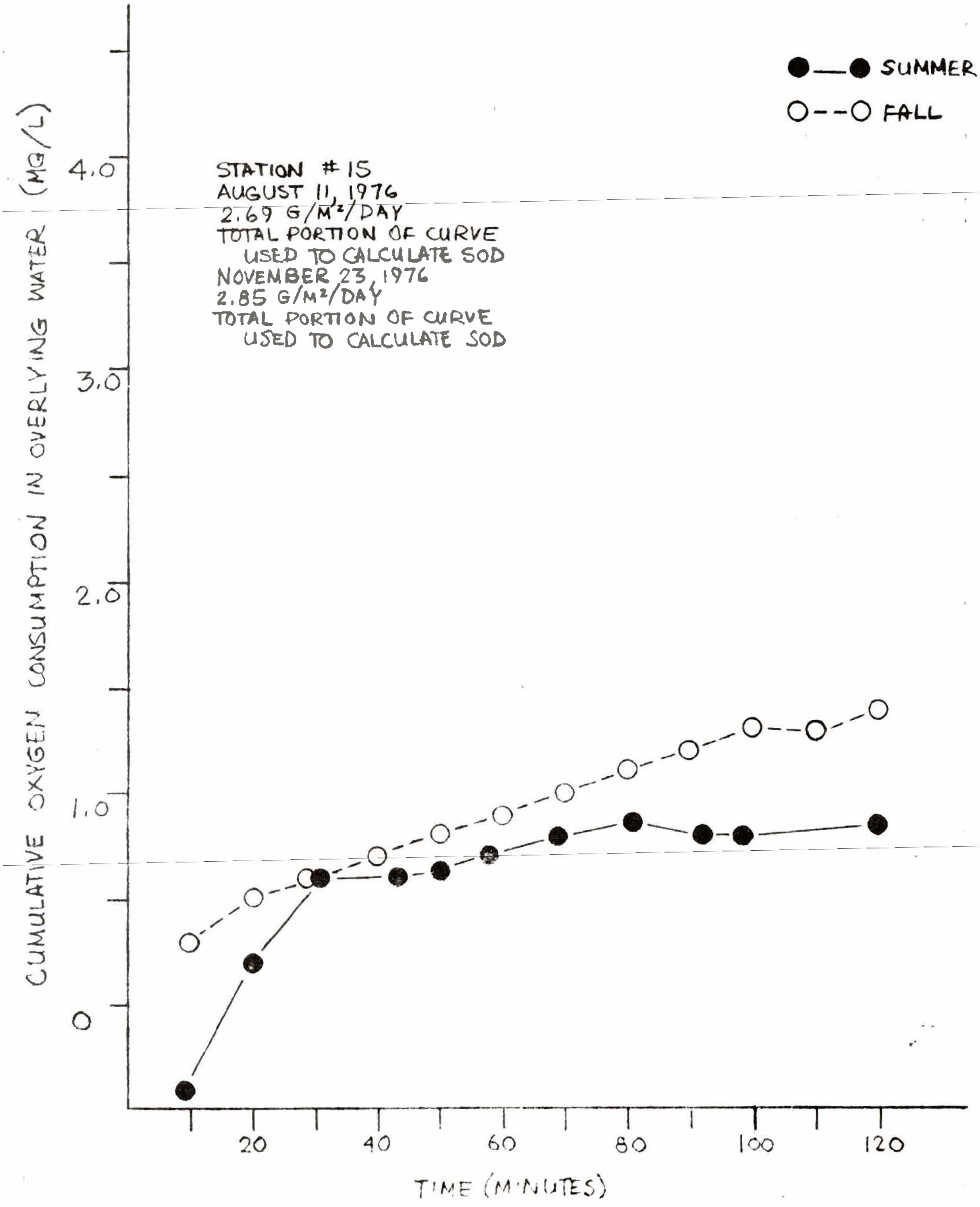


FIGURE 21. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT EWING IN THE CALUMET RIVER (FIELD MEASUREMENT)

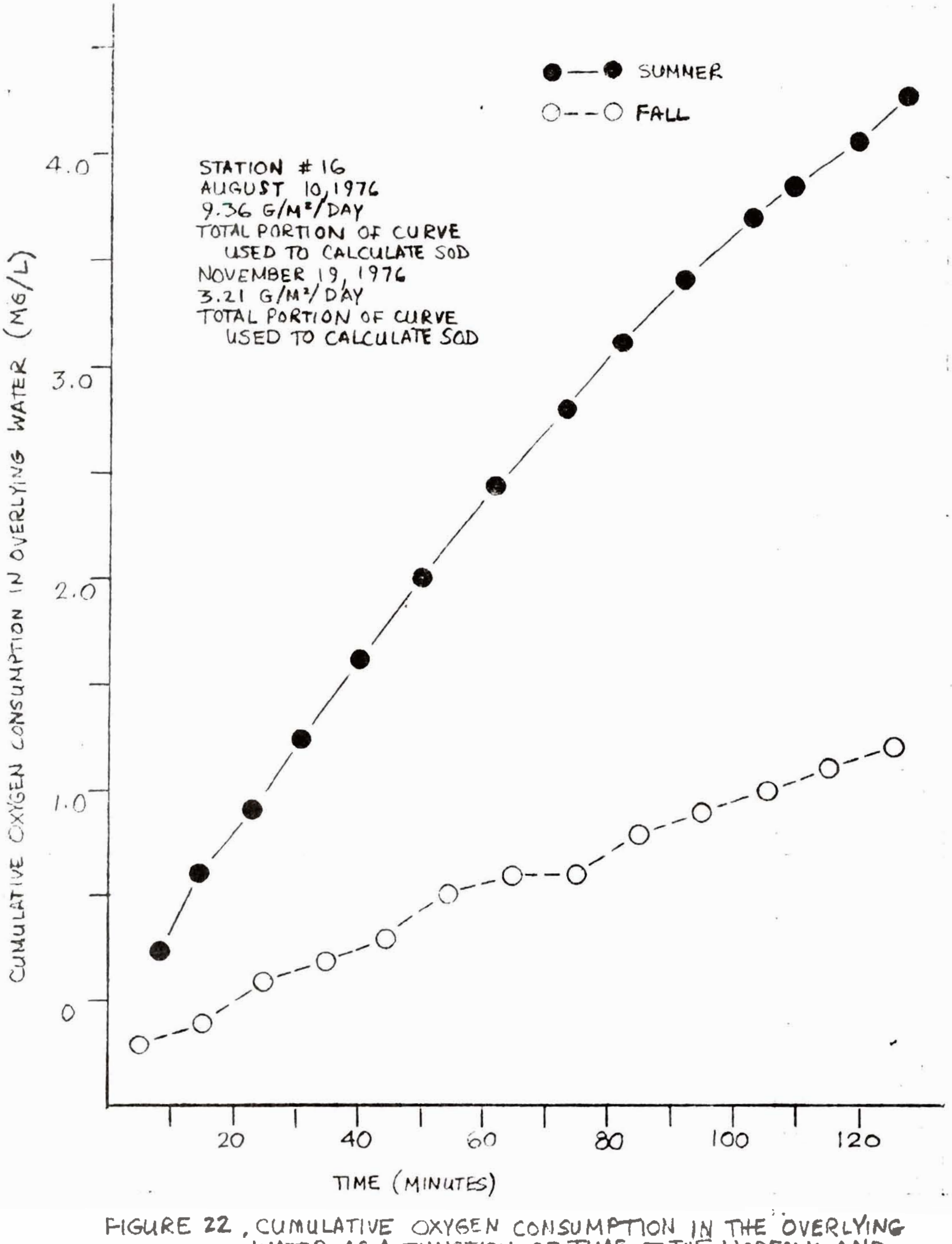


FIGURE 22, CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT THE NORFOLK AND WESTERN IN THE CALUMET RIVER (FIELD MEASUREMENT)

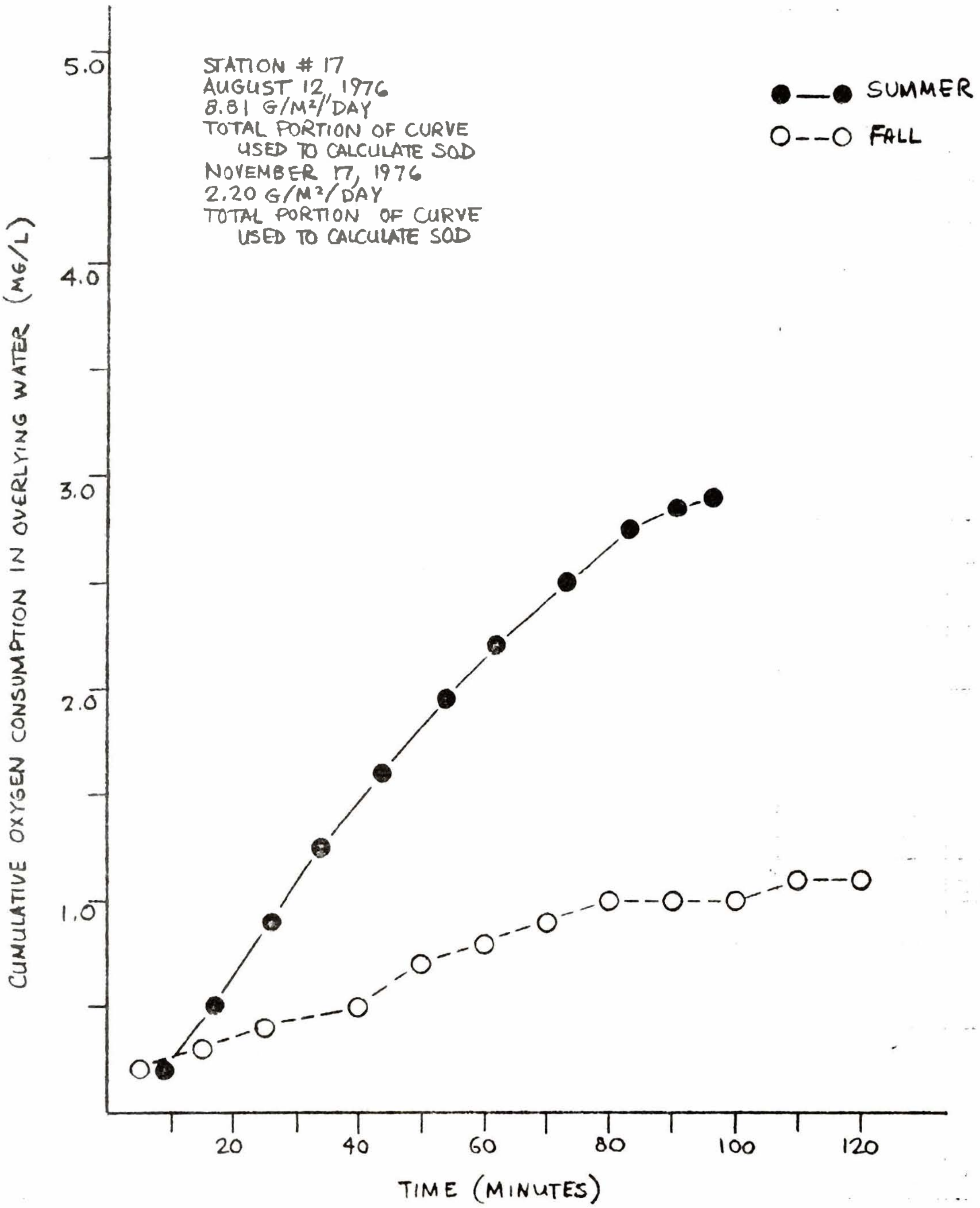


FIGURE 23. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT INDIANA IN THE LITTLE CALUMET RIVER (FIELD MEASUREMENT)

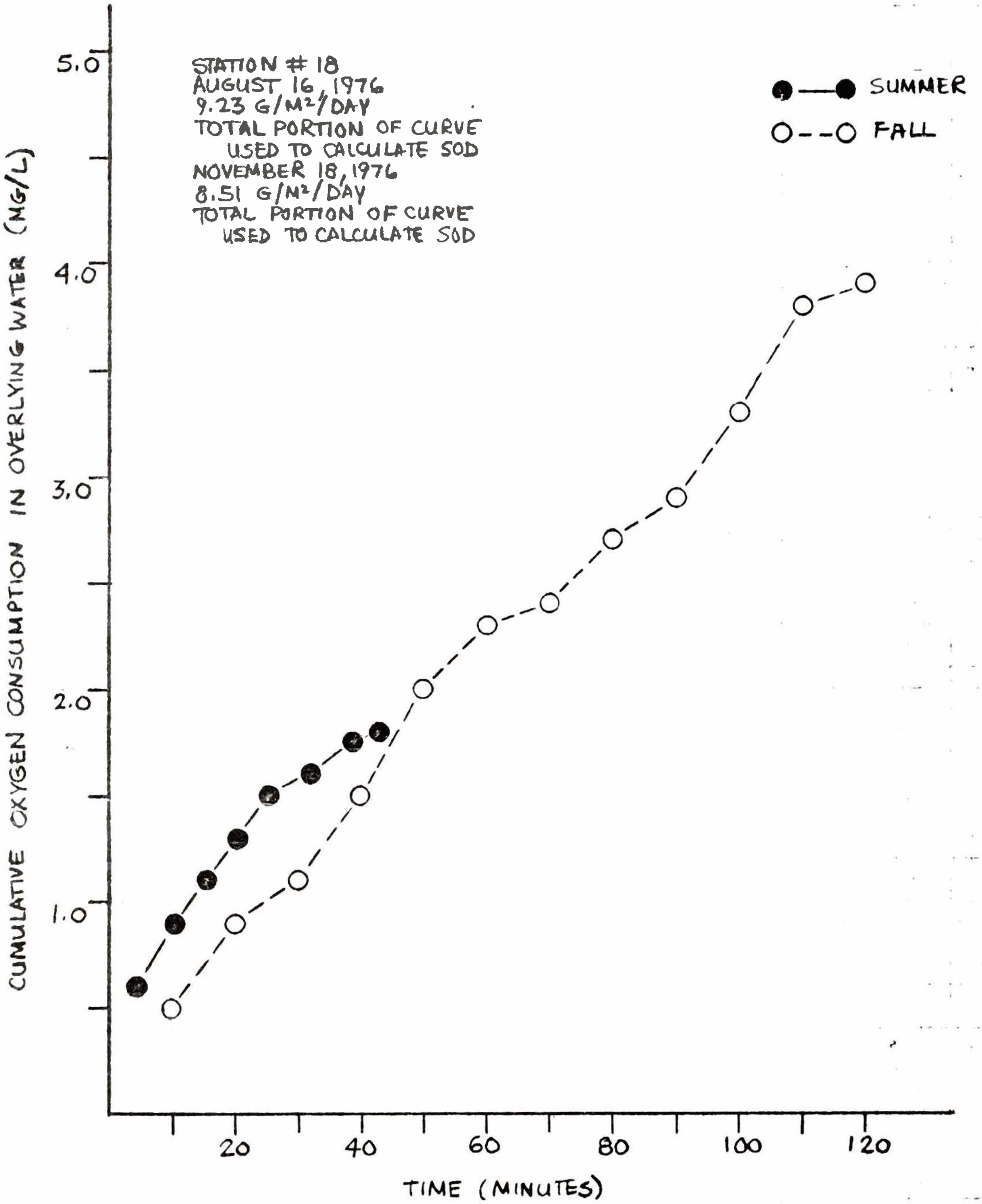
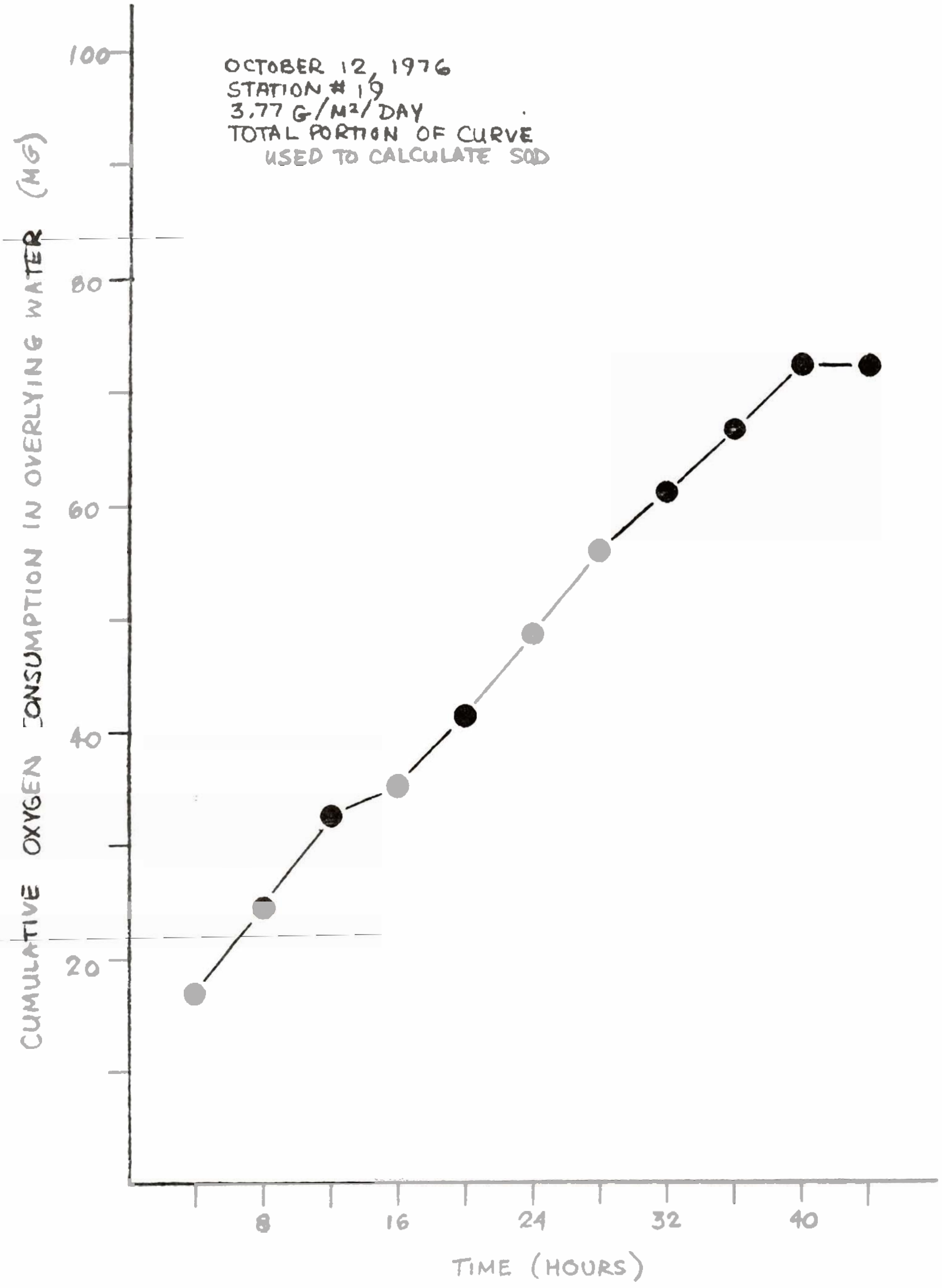


FIGURE 24 . CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT HALSTED IN THE LITTLE CALUMET RIVER (FIELD MEASUREMENT)



OCTOBER 12, 1976
STATION # 19
3.77 G/M²/DAY
TOTAL PORTION OF CURVE
USED TO CALCULATE SOD

FIGURE 25. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT WESTERN IN THE CAL-SAG CANAL (LABORATORY MEASUREMENT)

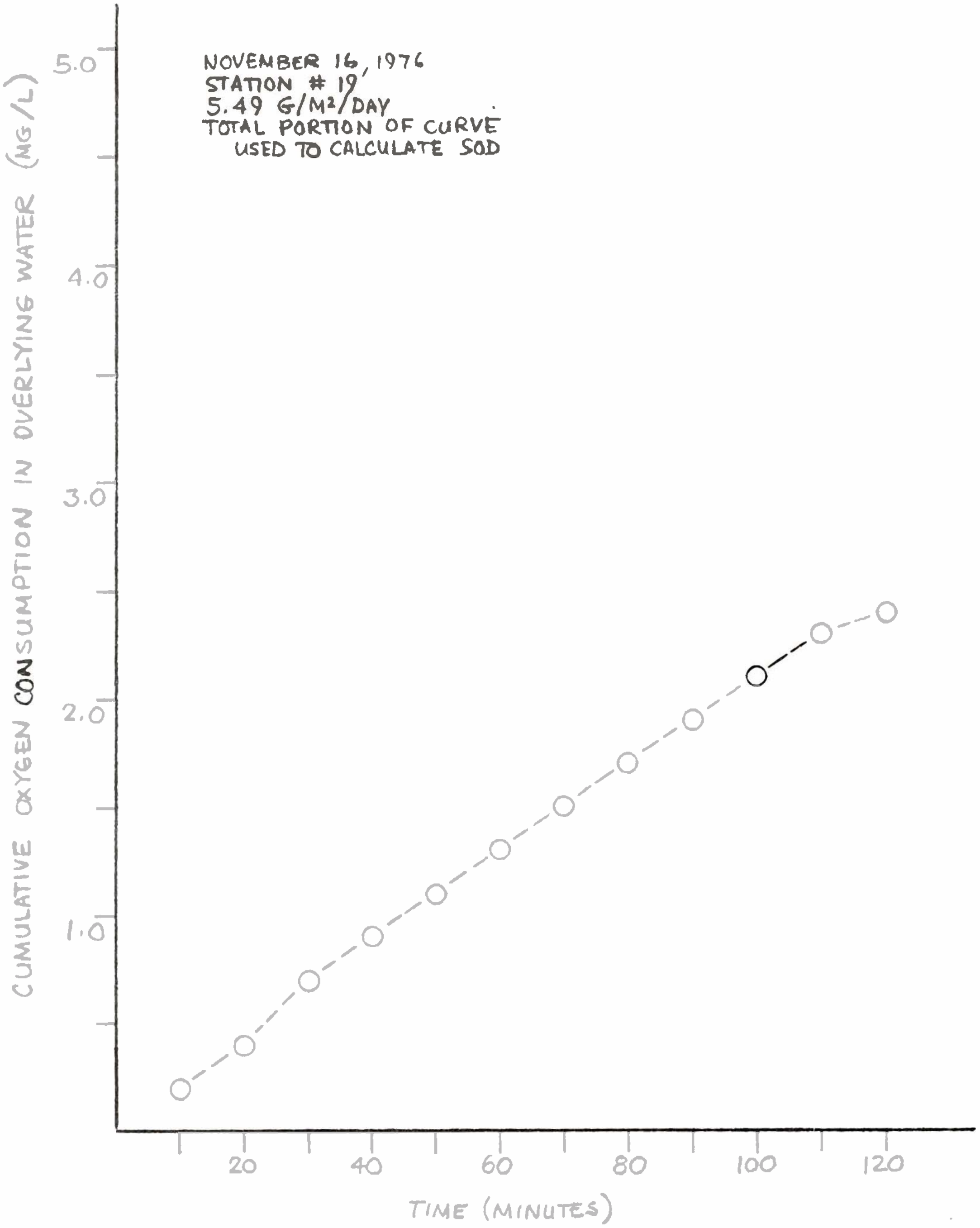


FIGURE 26. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT WESTERN IN THE CAL-SAG CHANNEL (FIELD MEASUREMENT)

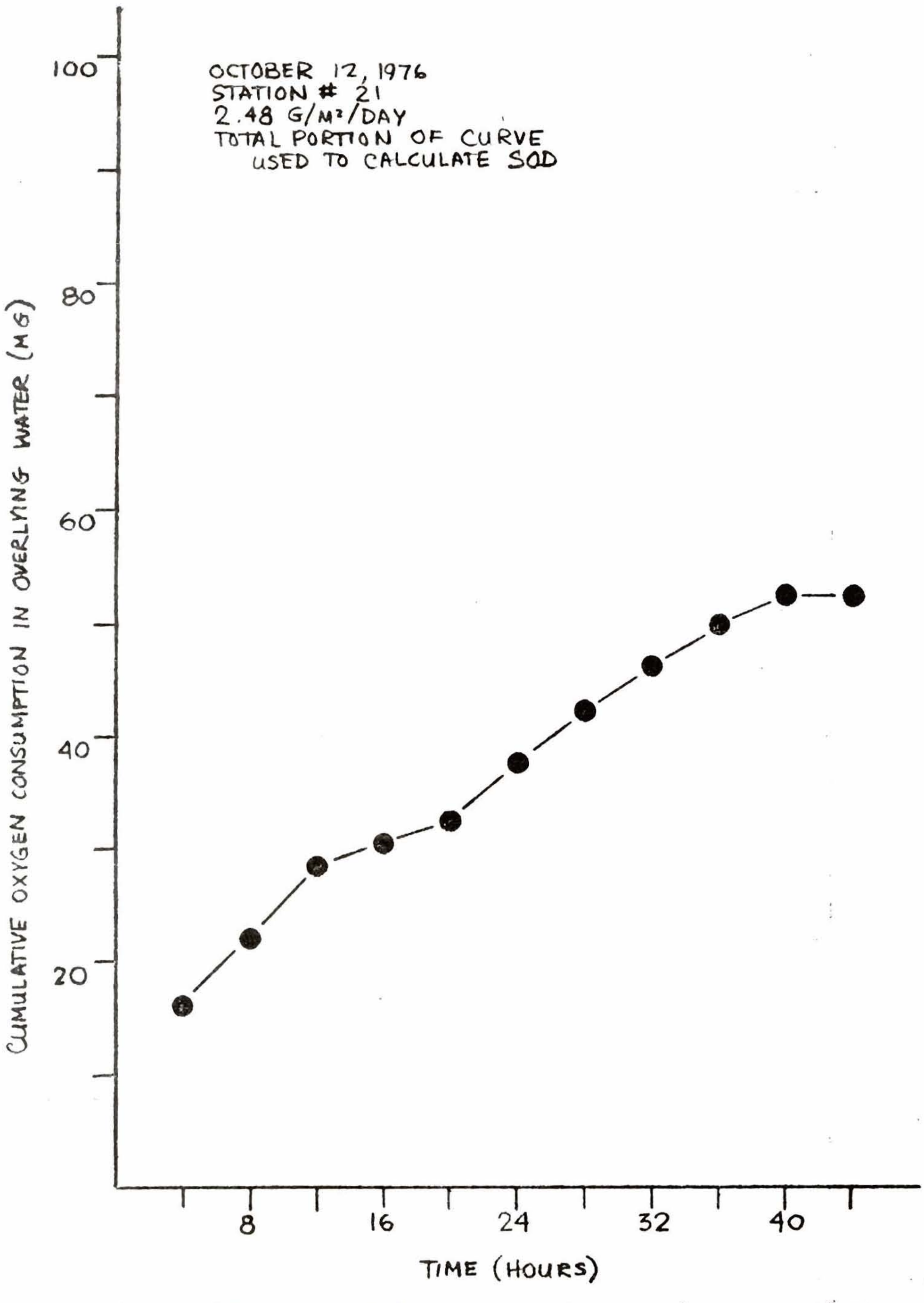


FIGURE 27. CUMULATIVE OXYGEN CONSUMPTION IN THE OVERLYING WATER AS A FUNCTION OF TIME AT ROUTE 83 IN THE CAL-SAG CANAL (LABORATORY MEASUREMENT)

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
May, 1977

TABLE 4

MEAN DENSITY OF BENTHIC MACROINVERTEBRATES PER SQUARE METER FROM DEEP DRAFT WATERWAYS IN COOK COUNTY

			Benthic Macroinvertebrates (per square meter)*				
Sampling Station	Waterway	Date	Oligochaeta (sludgeworms)	Hirudinea (leeches)	Chironomidae (midges)	Pelecypoda (clams)	Isopoda (sow bugs)
Maple	NSC	7-6-76	46867	6	589	0	0
Main	NSC	9-20-76**	276	0	0	0	0
Touhy	NSC	7-9-76	106400	0	17049	0	0
Wilson	NBCR	7-28-76	426560	13	3895	0	0
Diversey	NBCR	9-7-76	15833	0	1488	0	0
		11-10-76	1824	13	1083	6	0
Division	NBCR	9-20-76	10773	0	0	0	0
Grand	NBCR	10-18-76	76190	0	0	0	0
		12-2-76	62795	0	19	0	0
Jackson	SBCR	7-20-76	360473	0	0	3483	0
		11-9-76	14047	0	95	950	0
Archer	SFSBCR	9-27-76**	57	0	0	0	0
		12-6-76	0	0	0	0	0
Western	CSSC	9-27-76	120523	0	13	0	0
		12-7-76	10165	6	0	0	0
Cicero	CSSC	10-21-76	28722	0	0	0	0
Harlem	CSSC	8-30-76	170588	0	0	0	0
Rt 83	CSSC	10-4-76	128408	0	0	0	0
16th Street	CSSC	10-4-76	28354	0	0	0	0

TABLE 4 (cont'd)

MEAN DENSITY OF BENTHIC MACROINVERTEBRATES PER SQUARE METER FROM DEEP DRAFT WATERWAYS IN COOK COUNTY

			Benthic Macroinvertebrates (per square meter)*				
Sampling Station	Waterway	Date	Oligochaeta (sludgeworms)	Hirudinea (leeches)	Chironomidae (midges)	Pelecypoda (clams)	Isopoda (sow bugs)
Ewing	CR	8-9-76	4053	228	0	0	0
		11-23-76	849	57	0	0	13
Norfolk & Western	CR	8-10-76	570	0	25	0	0
		11-19-76	437	0	38	38	0
Indiana	LCR	8-12-76	3154	152	1944	2730	0
		11-17-76**	2413	0	1482	38	0
Halsted	LCR	8-16-76	330885	13	19	0	0
		11-18-76	77938	0	13	0	0
Western	CSC	10-12-76	72232	0	0	0	0
		11-16-76	81795	0	0	0	0
Southwest Hwy	CSC	8-31-76	25956	0	0	0	0
Rt 83	CSC	10-12-76	54055	0	6	0	0

* Average of three samples per sampling station

** Average of two samples per sampling station

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
May, 1977

TABLE 5

PARTICLE-SIZE ANALYSIS OF THE SEDIMENT SAMPLES FROM THE DEEP DRAFT WATERWAYS IN COOK COUNTY

Sampling Station		Waterway	Date	Depth of Core (mm)	General Description of Sediment Type	% Of Total Sediment Type Retained On Sieve					
						#12	#25	#40	#60	#100	Passed Through #100 Sieve
						(Rubble/Gravel)	(Coarse & Fine Sand)				(Clay/Silt/Sludge)
Maple	R*	NSC	7-6-76		Hard Clay	(Unable to Process)					
	C			No Sample**							
	L				Hard Clay	(Unable to Process)					
Main	R	NSC	9-20-76		Hard Clay	(Unable to Process)					
	C			315	Sludge-Gravel	20	14	15	21	18	12
	L				Hard Clay	(Unable to Process)					
Touhy	R	NSC	7-9-76		Hard Clay	(Unable to Process)					
	C			No Sample**							
	L				Hard Clay	(Unable to Process)					
Wilson	R	NBCR	7-28-76	250	Clay-Gravel-Sludge	3	6	10	6	10	65
	C			No Sample**							
	L			230	Sand-Clay-Sludge	10	9	8	11	14	48
Diversey	R	NBCR	9-7-76	335	Debris-Sand-Sludge	15	16	12	10	12	35
	C			475	Sand-Mud-Sludge	7	8	9	8	11	57
	L			55	Debris-Sand-Sludge	18	13	11	16	20	22
Division	R	NBCR	9-20-76	377	Sludge	10	12	10	7	7	54
	C			310	Sludge	11	10	9	7	7	56
	L			455	Sludge	8	14	9	8	8	53
Grand	R	NBCR	9-20-76	100	Gravel-Sludge	45	8	11	6	6	24
	C			No Sample**							
	L			383	Sludge	3	6	6	7	8	70

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
May, 1977

TABLE 5 (cont'd)

PARTICLE-SIZE ANALYSIS OF THE SEDIMENT SAMPLES
FROM THE DEEP DRAFT WATERWAYS IN COOK COUNTY

Sampling Station		Waterway	Date	Depth of Core (mm)	General Description of Sediment Type	% Of Total Sediment Type Retained On Sieve					
						#12 (Rubble/Gravel)	#25 (Coarse & Fine Sand)	#40	#60	#100	Passed Through #100 Sieve (Clay/Silt/Sludge)
Jackson	R	SBCR	7-20-76	115	Gravel-Sand-Sludge	29	17	15	10	8	21
	C			370	Sand-Sludge	5	5	5	4	4	77
	L			330	Gravel-Sand-Sludge	22	21	14	9	8	26
Archer	R	SFSBCR	9-27-76	270	Sludge	11	7	4	6	5	67
	C			160	Sludge-Sand	16	12	10	10	9	43
	L			365	Sludge	7	6	7	7	7	65
Western	R	CSSC	9-27-76	No Sample**							
	C			95	Sludge-Sand	25	13	11	26	11	14
	L			No Sample**							
Cicero	R	CSSC	9-27-76	55	Sludge	2	7	7	9	11	64
	C			No Sample**							
	L			No Sample**							
Harlem	R	CSSC	8-30-76	115	Gravel-Sand	18	23	19	29	9	2
	C			65	Gravel-Sand	18	15	17	18	12	20
	L			110	Clay	1	2	5	7	6	79
Rt 83	R	CSSC	10-4-76	No Sample**							
	C			150	Sand	1	2	6	7	84	0
	L			180	Sludge	16	7	2	4	9	62
16th Street	R	CSSC	10-4-76	95	Clay-Sludge	1	3	8	8	5	75
	C			200	Clay-Sludge	4	8	9	11	8	61
	L			460	Clay-Sludge	1	3	3	4	5	84

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
May, 1977

TABLE 5 (cont'd)

PARTICLE-SIZE ANALYSIS OF THE SEDIMENT SAMPLES FROM THE DEEP DRAFT WATERWAYS IN COOK COUNTY

Sampling Station		Waterway	Date	Depth of Core (mm)	General Description of Sediment Type	% Of Total Sediment Type Retained On Sieve					
						#12	#25	#40	#60	#100	Passed Through #100 Sieve
						(Rubble/Gravel)	(Coarse & Fine Sand)				(Clay/Silt/Sludge)
Ewing	R	CR	8-9-76	No Sample**							
	C			No Sample**							
	L			85	Sand-Sludge	4	6	6	6	12	66
Norfolk & Western	R	CR	8-10-76	167	Sand -Clay	5	6	6	9	28	46
	C			160	Mud-Clay	3	3	3	5	17	69
	L			110	Gravel-Clay	23	9	5	4	8	51
Indiana	R	LCR	8-12-76	370	Sand-Mud-Sludge	5	5	5	6	8	71
	C			70	Sand-Clay	4	4	4	6	11	71
	L			50	Sand-Clay	6	4	2	2	2	84
Halsted	R	LCR	8-16-76	350	Sand-Mud-Sludge	6	7	7	17	15	48
	C			70	Clay	11	9	4	7	6	63
	L			440	Mud-Clay-Sludge	1	4	3	4	7	81
Western	R	CSC	10-12-76	415	Mud-Clay-Sludge	3	3	5	5	6	78
	C			245	Mud-Clay-Sludge	1	2	2	2	4	89
	L			385	Clay-Sludge	0	3	4	5	13	75
Southwest Hwy	R	CSC	8-31-76	485	Mud-Clay	0	1	2	4	5	88
	C			No Sample**							
	L			No Sample**							
Rt 83	R	CSC	10-12-76	490	Mud-Clay	0	0	1	2	2	95
	C			105	Mud	0	1	2	3	5	89
	L			275	Rubble-Mud	7	3	3	4	3	80

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* R, L, and C represent right and left sides, and center of waterways respectively, facing upstream
** No sample taken due to absence of bottom deposits (hard bottom)

Channel and in the Calumet River were comprised largely of sand, gravel and clay.

The results of the physical and chemical analyses of the sediments are presented in Table 6. The BOD and COD in the bottom sediments ranged from 400-4080 mg/l, and 8,000 - 539,000 mg/kg, respectively, indicating great variability in the organic content of the sediments.

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
May, 1977

TABLE 6

PHYSICAL AND CHEMICAL CHARACTERISTICS OF BOTTOM SEDIMENTS FROM DEEP DRAFT WATERWAYS IN COOK COUNTY

Sampling Station	Waterway	Date	TS* (%)	TVS* (%)	COD* (%)	BOD$_5$ (mg/l)
Maple	NSC	7-6-76	0.4	0.2	35.4	1000
Main	NSC	9-20-76	14.6	29.3	51.3	1773
Touhy	NSC	7-9-76	0.7	0.2	40.0	1120
Wilson	NBCR	7-28-76	34.8	32.4	48.6	2900
Diversey	NBCR	9-7-76	24.8	18.0	29.9	1580
		11-10-76	14.0	1.6	30.2	1720
Division	NBCR	9-20-76	25.0	17.9	30.1	1670
Grand	NBCR	9-20-76	25.3	17.3	28.5	2100
		12-2-76	28.2	15.1	29.5	1680
Jackson	SBCR	7-20-76	0.6	0.2	43.1	800
		11-9-76	33.1	19.8	28.2	1347
Archer	SFSBCR	9-27-76	27.8	19.0	30.7	2760
		12-6-76	10.0	4.7	53.9	2340
Western	CSSC	9-27-76	11.9	18.9	31.6	400
		12-7-76	44.0	11.6	22.4	4080
Cicero	CSSC	9-27-76	14.2	16.5	26.2	400
Harlem	CSSC	8-30-76	26.1	20.9	29.1	2600
Rt 83	CSSC	10-4-76	30.3	18.5	30.3	1140
16th Street	CSSC	10-4-76	44.6	11.5	17.0	615
Ewing	CR	8-9-76	45.7	2.0	37.9	3040
		11-23-76	37.9	1.2	38.3	1560
Norfolk & Western	CR	8-10-76	10.1	1.1	35.1	875
		11-19-76	70.6	2.1	4.7	495
Indiana	LCR	8-12-76	36.5	7.5	36.8	2380
		11-17-76	60.2	3.6	0.8	983
Halsted	LCR	8-16-76	5.3	18.5	26.8	3220
		11-18-76	19.4	17.7	32.6	420
Western	CSC	10-12-76	40.3	65.1	7.5	2167
		11-16-76	67.9	2.9	5.4	2220
Southwest Hwy	CSC	8-31-76	39.9	6.9	13.6	1450
Rt 83	CSC	10-12-76	33.2	89.0	11.8	1240

*Expressed as a percentage based on dry weight of sample

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