FIRST QUARTERLY PROGRESS REPORT

APRIL 1979

COMPARATIVE EVALUATION OF EFFECTS OF OZONATED AND CHLORINATED THERMAL DISCHARGES ON ESTUARINE AND FRESH WATER ORGANISMS

U.S. DOE CONTRACT NO. EE-77-C-02-4384

CONTRIBUTORS

From Public Service Electric and Gas Co.: -533 6000

C. R. Guerra, Ph.D.
J. L. DelMonaco, P.E.
J. H. Singletary
R. J. Sugam, Ph.D.

From Ichthyological Associates, Inc.: 950 0462

J. W. Meldrim, Ph.D.
E. R. Holmstrom
G. F. Balog

DISCLAIMER

TABLE OF CONTENTS

1. Introduction

Biofouling accumulation can reduce the heat transfer across condenser tube walls and severely lower the power plant thermal efficiency and fuel utilization. The power industry prevents this accumulation by injecting biocides in the condenser inlet water. Presently, chlorine is the most popular biocide used, however, its impact on the aquatic environment has led to the search for other alternatives. We have proven that ozone can be used to prevent biofouling accumulation and are now studying its impact on the aquatic environment. This report covers the work at our Bergen Generating Station for the first quarter of 1979.

2. Laboratory Description

The Biological Evaluation Laboratory is a 12 x 46 ft mobile trailer located at the Bergen Generating Station adjacent to Overpeck Creek, a tributary of the Hackensack River(Fig. 1.a). It consists of three rooms (Fig.1.b). An office is located in the front room. The holding facility and physiological system are located in the back room. The middle room contains two toxicity systems and two modified Shelford-Allee avoidance systems. The Laboratory is located adjacent to the Water Quality Laboratory which houses the model condenser system. Discharge water from each of the three test condensers (untreated, chlorinated, and ozonated) is piped to the Laboratory for experimental studies. Separate pipes for each water condition enter the Laboratory in the back room and then run to the front of the middle room. Untreated condenser water can also be added to either the chlorinated or ozonated condenser water near the point of intake.

The holding facility is a flowing water closed-cycle system which consists of three 50-gallon (190 liter) oval holding tanks and a 88-gallon (333 liter) delivery tank. The delivery tank supplies dechlorinated city water to the holding tanks and is equipped with heaters and a refrigeration unit for temperature control. Water in the delivery tank is sterilized with a UV sterilizer, aerated, and filtered. Water is changed or replenished whenever necessary. The holding facility is maintained at ambient light levels under natural photoperiod. Test organisms to date have been collected from the watersheds of the Delaware River estuary, and upper Chesapeake Bay by seine and transported to the Bergen Laboratory in insulated holding vessels.

3. Objectives

The biological evaluation program incorporates three types of experimental tests: acute (96 hour) toxicity studies; behavioral (avoidance) response studies; and physiological ("cough") response studies. In addition, specimens used in testing are examined for physical damage resulting from exposure to chlorine or ozone.

The objective of the acute (96 hour) toxicity study is to determine the respective lethal levels (LC_{50}) of chlorinated and ozonated waters. The objective of the behavioral (avoidance) response study is to determine what (if any) concentrations of ozone and of chlorine will be avoided. The objective of the physiological ("cough") response study is to determine what concentrations of ozone and of chlorine are physiologically detected. Ozonated and chlorinated waters are to be evaluated in all studies for both the addition of increased temperature and without it.

4. Testing Procedures

4.1 Toxicity Studies

The toxicity testing system consists of two 4 x 8 ft tanks each containing twelve 10-gallon (38 liter) testing chambers and a water bath. Each tank is constructed of 3/4 inch exterior plywood and coated with inert epoxy resin. Nylon mesh baskets are suspended in each testing chamber to test invertebrates. Test concentrations are delivered to test chambers by mixing untreated water withtreated water via pipes tapped into the intake system.

In February, toxicity testing was conducted using flow-through exposure to chlorinated and ozonated water for two hours per day with a continuous flow of untreated water between exposure periods. Organisms were exposed for a duration of two hours once every 24 hours for 2 to 4 consecutive days at various concentrations of chlorinated and ozonated water. Aeration was not provided. Several concentrations of ozone and chlorine were used. Controls were maintained in untreated water. However, because of poor water quality and low levels of dissolved oxygen the results were unsatisfactory. Modifications in testing procedure were then implemented to improve survival.

The test condition between exposure periods was modified from the continuous flow-through to a static aerated condition. Test chambers were filled with untreated water and aerated to acceptable levels of dissolved oxygen. When this had been accomplished organisms were introduced and test concentrations were set. Test concentrations were produced by mixing untreated condenser water with chlorinated or ozonated water in the desired proportion. During the 2 hour exposure period the test was conducted in a continuous flow-through mode and aeration was supplied to the ozone control and chlorine chambers. (Aeration of the ozonated water was not necessary.) At the conclusion of the exposure period the flows were stopped and all test chambers were returned to the aerated static condition.

In the February test and in one test in March a flow rate of 1.89 liter per minute was used in each test chamber. However, clogging problems necessitated changing this to 3.79 liters per minute in the other March test.

Ozone and chlorine were measured using a Wallace and Tiernan

Series A-790 amperometric titrator and expressed as total oxidant. The test concentration was the average concentration of one to four measurements taken during the exposure period.

Observations were made periodically. Time of loss of equilibrium and death (defined as cessation of opercular activity and lack of response to prodding with a glass rod) were recorded for periods up to 96 hours. Dead organisms were measured, weighed, and preserved by freezing. Gill tissue was examined with a steroscopic microscope. At the end of a test the remaining (live) organisms were measured, weighed, examined, and preserved.

Water temperature, dissolved oxygen, pH, and salinity were measured before and during each exposure period.

4.2 Avoidance Studies

Behavioral responses of organisms to chlorinated and ozonated waters are evaluated in an avoidance system consisting of two modified Shelford-Allee avoidance apparatuses (Meldrim, et al. 1974). Each apparatus is made of 3/4 inch exterior plywood and coated with inert epoxy resin. Each apparatus is 2 x 6 ft and is subdivided into 1 x 6 ft sub-troughs. The system is enclosed in black plastic for light control and to permit movement outside the system. The Duro-Test "Vita-Lite"is used for lighting. Each apparatus has a dose box which is divided into two compartments. One side receives untreated water from the intake system. The other side receives untreated and treated water from the intake system to produce a desired concentration. Water from each side of the dose box flows to diagonally opposite ends of the sub-troughs and then drains in the center. Due to a sharp gradient at the center drains each apparatus is "divided" into quadrants. Concentrations are produced by adjusting flowmeters and the flow into each sub-trough is regulated by a flow meter. Organisms are exposed to successively increased concentrations of these oxidants in a "step-gradient" fashion and their responses observed. At the beginning of a test equal numbers of test organisms are placed into each sub-trough of the respective apparatus. After a five minute orientation period the amount of time spent in each quadrant (formed by the center drains) is determined for a duration of five minutes and a frequency distribution of organism-times is formed. The distribution is then subjected to statistical analysis to determine the significance of the response to the oxidant. A test continues until a significant avoidance response (P = 0.05 level), a 2:1 ratio of time in control: time in treated water, or death is exhibited. Water temperature, dissolved oxygen, pH, and salinity are measured before and at the end of each test. Organisms are measured, weighed, and examined.

4.3 Physiological ("Cough") Response Studies

The physiological study system consists of four testing chambers and a four channel physiograph. Two chambers receive a continuous flow of untreated water, one chamber receives chlorinated water and the other chamber receives ozonated water. All water is taken from the previously described avoidance system dose boxes. Stainless steel wire mesh electrodes are placed at each end of each chamber, the electrodes are then connected to the physiograph which records respiratory responses of test organisms. The chambers are placed in a three sided compartment with the fourth side covered with black plastic having small observation slits.

One fish is placed in each chamber and supplied with a continuous flow of untreated water for approximately 48 hours. During this time the fish are allowed to acclimate to the test chamber and establish a normal respiratory pattern. Periodic physiographic traces are made during this time and just prior to the exposure period for comparison with traces taken during the exposure period. Traces are taken at several concentrations. Exposure to a concentration is from 5 to 30 minutes before a trace is taken. Water temperature, dissolved oxygen, pH, and salinity are measured at the end of each test. Test organisms are measured, weighed, and examined.

5. Results and Discussion

5.1 Toxicity Studies

Acute (96-hr) toxicity tests of chlorine and ozone were conducted during February with mummichog, Fundulus heteroclitus, using the continuous flow-through condition. In the chlorine test (Table 1) the control group experienced 70% mortality, identical to that in the highest chlorine concentration (0.04 mg/l). The mortality in the control group in the ozone test (Table 2) was 40%. Mummichog were healthy and continued to feed well throughout the duration of the five day test period. Although the level of dissolved oxygen was low (3.8 mg/l average) the mortalities were likely due to an unexplained characteristic of water quality. Mummichog in both control and experimental groups had hemmorrhaging and aneurisms in the gills. When placed in the untreated (no biocide) test water, fish immediately went to the bottom of the test tank. After two hours they came to the surface "gulping air" and shortly thereafter lost equilibrium. Based on these tests the procedure was modified as described in the section on testing procedures.

Toxicity testing in subsequent weeks was directed at determining which species could be tested (using the modified procedure) under the conditions of adverse water quality found at Bergen. Species subsequently tested for suitability included: blueback herring, Alosa aestivalis; mummichog, Fundulus heteroclitus; silvery minnow, Hybognathus nuchalis; white perch, Morone americana; and grass shrimp, Palaemonetes pugio. All except blueback herring were deemed suitable for testing.

Acute toxicity studies of chlorine and ozone were conducted during March using the modified procedure with mummichog, Fundulus heteroclitus; tidewater silverside, Menidia beryllina; white perch, Morone americana; and grass shrimp, Palaemonetes pugio. Spottail shiner, Notropis hudsonius and silvery minnow, Hybognathus nuchalis were also tested but exposed only to ozonated water.

Results of tests on mummichog, tidewater silverside, white perch and grass shrimp with chlorine are given in Table 3. Concentrations of total chlorine below 0.40 mg/l did not result in mortalities with mummichog but 100% mortality resulted at

0.08 mg/l with tidewater silverside and at 0.37 mg/l with white perch. A concentration of 0.12 mg/l resulted in over 50% mortality with white perch. However, concentrations of 0.37 mg/l resulted in only 10% mortality with grass shrimp and 0.63 mg/l resulted in 40% mortality. Unexpectedly, 0.87 mg/l did not cause any mortality.

Results of tests on silvery minnow, spottail shiner, mummichog, tidewater silverside, white perch, and grass shrimp with ozonated water are given in Table 4. Although ozone concentrations (as total oxidant) of 0.93 mg/l resulted in 50% mortality with silvery minnow and 100% mortality with spottail shiner, levels of 1.0 mg/l did not cause any mortality with mummichog and only 10% mortality with grass shrimp and only 20% mortality with tidewater silverside. A concentration of 0.97 mg/l did not cause mortality with white perch. Concentrations below 0.71 mg/l did not cause mortality in 48 hours with silvery minnow and only 10% mortality with spottail shiner.

5.2 Behavioral (Avoidance) Studies

Several unsuccessful attempts were made with mummichog during February to determine behavioral avoidance responses to ozone. Conditions of water quality confounded these tests. No additional testing was conducted in March. It is anticipated that successful tests will be completed in April.

5.3 Physiological ("Cough") Response Studies

One series of tests was conducted with ozone during February.

"Cough" responses to 0.03 mg/l ozone (as total oxidant) were determined for mummichog and white perch. Physiographic traces of "coughs" of mummichog and white perch when exposed to 0.03 mg/l ozone are shown in Figure 2. The "cough" responses exhibited when exposed to untreated water immediately preceding the ozone exposure are shown in Figure 3.

During March physiographic traces of "coughs" were made of mummichog exposed to ozonated, chlorinated, and untreated water. Traces of mummichog exposed to untreated water immediately prior to exposure to chlorinated and ozonated waters are shown in Figure 4. Traces of mummichog simultaneously exposed to 0.15 mg/l total chlorine, 0.70 mg/l ozone (as total oxidant) and untreated (ambient) water are shown in Figure 5. Although one "cough" is shown for chlorine, ozone caused a rapid series of coughs. No coughs were seen in the untreated exposure. Traces of mummichog simultaneously exposed to 0.15 mg/l total chlorine, 1.0 mg/l ozone (as total oxidant) and ambient water are shown in Figures 6A-6D. Although an occassional "cough" was seen in the chlorine exposure (and one in the ambient exposure) the rapid series of "coughs" seen at 0.7 mg/l are again present. When concentrations of total chlorine were reduced to 0.05 mg/l and ozone to 0.40 mg/l (as total oxidant) the number and frequency of "coughs" subsided (Figs. 7A-7C). Apparently, then, mummichog can detect levels of chlorine of 0.05 mg/l and 0.40 mg/l ozone although neither concentration is lethal.

6. Recommendations and Concerns

It is apparent from the preceding that ozone is less toxic than chlorine under these test conditions. The lethal levels vary according to species but this is expected. It is also apparent that sublethal concentrations of chlorine and ozone are detected. Some questions which remain are: What are the minimum concentrations which are detected and what levels will be avoided? How does the oxygen which accompanies the introduction of ozone affect the biological responses to various concentrations of ozone? How does temperature and salinity affect the response? What is the lethal level of ozone for mummichog? These and other questions will be addressed in future testing.

A major concern is the poor water quality at Bergen. Levels of dissolved oxygen are now so low that aeration is required with a modified procedure. As levels of dissolved oxygen decrease further with rising water temperatures, the low dissolved oxygen "shock" which occurs in the modified procedure will become more severe. This problem must be overcome if testing is to continue at Bergen.

Literature Cited

Meldrim, J. W., J. J. Gift, and B. R. Petrosky 1974. The effect of temperature and chemical pollutants on the behavior of several estuarine organisms. Ichthyological Associates Bulletin 11, 129 p. (Final report to the Office of Water Research and Technology, U. S. Department of the Interior, available through N.T.I.S. as PB-239347).

TABLES

Table 1. - Results of acute toxicity tests with mummichog, <u>Fundulus heteroclitus</u>, exposed to various concentrations of chlorine for two hours per day for four consecutive days.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	TOTAL CHLOR. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
FUNDULUS HETEROCLITUS													
12 FEB 79	39.7	1	16	3.8	7.4	0.00	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	5	5	5	4	6	4
							48	4	6	4	3	7	3
							72	4	6	4	2	8	2
							90	3	7	3	2	8	2
12 FEB 79	43.8	1	16	3.8	7.4	0.00	0	10	-	-	9	-	-
							4	10	0	0	9	0	0
							24	5	5	5	6	3	6
							48	4	6	4	5	4	5
							72	4	6	4	4	5	4
							90	3	7	3	4	5	4
12 FEB 79	41.2	1	16	3.8	7.4	0.00	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	5	5	5	7	3	5
							48	4	6	4	6	4	6
							72	4	6	4	6	4	6
							90	3	7	3	3	7	3
12 FEB 79	41.4	1	16	3.8	7.4	0.01	0	10	-	-	9	-	-
							4	10	0	0	9	0	0
							24	5	5	5	5	4	5
							48	4	6	4	5	4	5
							72	4	6	4	4	5	4
							90	3	7	3	4	5	4
12 FEB 79	39.3	1	16	3.8	7.4	0.04	0	10	-	-	9	-	-
							4	10	0	0	9	0	0
							24	5	5	5	6	3	6
							48	4	6	4	3	6	3
							72	4	6	4	2	7	2
							90	3	7	3	2	7	2

Table 2. - Results of acute toxicity tests with mummichog, *Fundulus heteroclitus*, exposed to various concentrations of ozone for two hours per day for four consecutive days.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
FUNDULUS HETEROCLITUS													
12 FEB 79	47.7	1	16	3.8	7.4	0.04	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	10	0	0	6	4	6
							48	6	4	6	6	4	6
							72	6	4	6	5	5	5
							90	6	4	6	4	6	4
12 FEB 79	41	1	16	3.8	7.4	0.09	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	10	0	0	8	2	8
							48	6	4	6	7	3	7
							72	6	4	6	5	5	5
							90	6	4	6	4	6	4
12 FEB 79	38	1	16	3.8	7.4	0.03	0	10	-	-	8	-	-
							4	10	0	0	8	0	0
							24	10	0	0	8	0	0
							48	6	4	6	3	5	3
							72	6	4	6	3	5	3
							90	6	4	6	2	6	2
12 FEB 79	40.2	1	16	3.8	7.4	0.07	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	10	0	0	5	5	5
							48	6	4	6	5	5	5
							72	6	4	6	3	7	3
							90	6	4	6	2	8	2
12 FEB 79	40.6	1	16	3.8	7.4	0.03	0	10	-	-	10	-	-
							4	10	0	0	10	0	0
							24	10	0	0	10	0	0
							48	6	4	6	5	5	5
							72	6	4	6	5	5	5
							90	6	4	6	5	5	5

Table 3. - Results of toxicity tests with chlorine on mummichog, *Fundulus heteroclitus*; tidewater silverside, *Menidia beryllina*; white perch, *Morone americana*; and grass shrimp, *Palaemonetes pugio*, conducted during March 1979.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	CL2 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
FUNDULUS HETEROCLITUS													
20 MAR 79	68.2	0.5	19	5	7.4	1	0	10	-	-	10	-	-
							1	10	0	0	10	0	1
							1.3	10	0	0	5	5	2
							1.5	10	0	0	4	6	1
							2	10	0	0	2	8	0
							2.5	10	0	0	0	10	0
20 MAR 79	64.4	0.5	19	5	7.4	0.01	0	10	-	-	10	-	-
							96	10	0	0	10	0	0
20 MAR 79	62.5	0.5	19	5	7.4	0.7	0	10	-	-	10	-	-
							1.25	10	0	0	8	2	3
							1.5	10	0	0	6	4	4
							2	10	0	0	1	9	1
							3.5	10	0	0	0	10	0
20 MAR 79	69.6	0.5	19	5	7.4	0.04	0	10	-	-	10	-	-
							96	10	0	0	10	0	0
20 MAR 79	68.9	0.5	19	5	7.4	0.4	0	10	-	-	10	-	-
							96	10	0	0	10	0	0
20 MAR 79	67.8	0.5	19	5	7.4	0.09	0	10	-	-	10	-	-
							96	10	0	0	10	0	0

Table 3. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	CL2 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
MENIDIA BERYLLINA													
20 MAR 79	50.2	0.5	19	5.6	7.4	0.95	0	5	–	–	5	–	–
							0.6	5	0	0	0	5	0
20 MAR 79	45	0.5	19	5.6	7.4	0.08	0	5	–	–	5	–	–
							2.5	5	0	0	4	1	0
							20.5	5	0	0	3	2	0
							44.5	5	0	0	2	3	0
							50	5	0	0	1	4	0
							75	5	0	0	0	5	0
20 MAR 79	48.6	0.5	19	5.6	7.4	0.46	0	5	–	–	5	–	–
							0.6	5	0	0	4	1	3
							0.9	5	0	0	0	5	0
MORONE AMERICANA													
27 MAR 79	156	1	14.5	6.9	7.5	0.87	0	5	–	–	5	–	–
							1.5	5	0	0	0	5	0
27 MAR 79	153.6	1	14.5	6.9	7.5	0.02	0	5	–	–	5	–	–
							96	5	0	0	5	0	0
27 MAR 79	159	1	14.5	6.9	7.5	0.63	0	5	–	–	5	–	–
							1.5	5	0	0	0	5	0
27 MAR 79	154.4	1	14.5	6.9	7.5	0.12	0	5	–	–	5	–	–
							24	5	0	0	4	1	0
							45	5	0	0	3	2	0
							69	5	0	0	2	3	0
							96	5	0	0	2	3	0
27 MAR 79	156.2	1	14.5	6.9	7.5	0.37	0	5	–	–	5	–	–
							1.5	5	0	0	1	4	1
							24	5	0	0	0	5	0

Table 3. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	CL2 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
PALAEMONETES PUGIO													
27 MAR 79	25.6	1	14.5	6.9	7.5	0.37	0	10	-	-	10	-	-
							43	10	0	0	9	1	0
							96	10	0	0	9	1	0
27 MAR 79	26.2	1	14.5	6.9	7.5	0.63	0	10	-	-	10	-	-
							18	10	0	0	9	1	0
							67	10	0	0	8	2	0
							69	10	0	0	7	3	0
							96	10	0	0	6	4	0
27 MAR 79	27	1	14.5	6.9	7.5	0.12	0	10	-	-	10	-	-
							1.5	10	0	0	9	1	0
							96	10	0	0	9	1	0
27 MAR 79	25.7	1	14.5	6.9	7.5	0.87	0	10	-	-	10	-	-
							96	10	0	0	10	0	0
27 MAR 79	26.7	1	14.5	6.9	7.5	0.02	0	10	-	-	10	-	-
							43	10	0	0	9	1	0
							96	10	0	0	9	1	0

Table 4. - Results of toxicity tests with ozone (as total oxidant) on silvery minnow, Hybognathus nuchalis; spottail shiner, Notropis hudsonius; mummichog, Fundulus heteroclitus; tidewater silverside, Menidia beryllina; white perch, Morone americana, and grass shrimp, Palaemonetes pugio, conducted during March 1979. * = levels of dissolved oxygen beyond 20 mg/l.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
HYBOGNATHUS NUCHALIS													
30 MAR 79	89.4	1	15.5	*	7.5	0.93	0	8	-	-	8	-	-
							2	8	0	0	8	0	1
							2.5	8	0	0	7	1	2
							2.75	8	0	0	6	2	3
							3	8	0	0	4	4	4
							48	8	0	0	4	4	4
30 MAR 79	84.3	1	15.5	*	7.5	0.15	0	8	-	-	10	-	-
							48	8	0	0	10	0	0
30 MAR 79	88.2	1	15.5	*	7.5	0.71	0	8	-	-	5	-	-
							48	8	0	0	5	0	0
30 MAR 79	88.7	1	15.5	*	7.5	0.39	0	8	-	-	9	-	-
							48	8	0	0	9	0	0
NOTROPIS HUDSONIUS													
30 MAR 79	103	1	15.5	*	7.5	0.93	0	2	-	-	2	-	-
							2.5	2	0	0	1	1	1
							24	2	0	0	0	2	0
30 MAR 79	106	1	15.5	*	7.5	0.39	0	2	-	-	1	-	-
							48	2	0	0	1	0	0
30 MAR 79	96.8	1	15.5	*	7.5	0.71	0	2	-	-	5	-	-
							2.5	2	0	0	4	1	1
							48	2	0	0	4	1	0

Table 4. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
FUNDULUS HETEROCLITUS													
20 MAR 79	57.1	0.5	19	*	7.4	1	0	10	-	-	10	-	-
							19.5	9	1	0	10	0	0
							96	9	1	0	10	0	0
20 MAR 79	61.2	0.5	19	6.9	7.4	0.01	0	10	-	-	10	-	-
							19.5	9	1	0	10	0	0
							96	9	1	0	10	0	0
20 MAR 79	58.1	0.5	19	*	7.4	0.39	0	10	-	-	10	-	-
							19.5	9	1	0	10	0	0
							96	9	1	0	10	0	0
20 MAR 79	50.7	0.5	19	8.1	7.4	0.05	0	10	-	-	10	-	-
							19.5	9	1	0	10	0	0
							96	9	1	0	10	0	0
20 MAR 79	56.3	0.5	19	*	7.4	0.13	0	10	-	-	10	-	-
							19.5	9	1	0	10	0	0
							96	9	1	0	10	0	0

Table 4. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
MENIDIA BERYLLINA													
20 MAR 79	46.8	0.5	19	*	7.4	0.09	0	5	-	-	5	-	-
							72	5	0	0	5	0	0
20 MAR 79	41.8	0.5	19	*	7.4	1	0	5	-	-	5	-	-
							19.5	5	0	0	4	1	0
							72	5	0	0	4	1	0
20 MAR 79	47	0.5	19	*	7.4	0.18	0	5	-	-	5	-	-
							44	5	0	0	4	1	0
							72	5	0	0	4	1	0
20 MAR 79	47.6	0.5	19	*	7.4	0.49	0	5	-	-	5	-	-
							72	5	0	0	5	0	0
MORONE AMERICANA													
22 MAR 79	182.8	1	15.5	*	7.5	0.97	0	5	-	-	5	-	-
							96	5	0	0	5	0	0

Table 4. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
PALAEMONETES PUGIO													
20 MAR 79	24.1	0.5	19	8.8	7.4	0.09	0	10	-	-	10	-	-
							44	9	1	0	10	0	0
							72	9	1	0	10	0	0
20 MAR 79	25.4	0.5	19	6	7.4	0.02	0	10	-	-	10	-	-
							22	10	0	0	9	1	0
							44	9	1	0	9	1	0
							72	9	1	0	9	1	0
20 MAR 79	25	0.5	19	*	7.4	0.18	0	10	-	-	10	-	-
							44	9	1	0	8	2	0
							72	9	1	0	8	2	0
20 MAR 79	24.1	0.5	19	*	7.4	1	0	10	-	-	10	-	-
							19.5	10	0	0	9	1	0
							44	9	1	0	9	1	0
							72	9	1	0	9	1	0
20 MAR 79	27	0.5	19	*	7.4	0.49	0	10	-	-	10	-	-
							44	9	1	0	10	0	0
							72	9	1	0	10	0	0
28 MAR 79	27.1	1	15.5	*	7.5	0.39	0	10	-	-	10	-	-
							96	10	0	0	10	0	0
28 MAR 79	28.3	1	15.5	*	7.5	0.15	0	10	-	-	9	-	-
							65	10	0	0	7	2	0
							96	10	0	0	7	2	0
28 MAR 79	26.2	1	15.5	*	7.5	0.71	0	10	-	-	11	-	-
							96	10	0	0	11	0	0

Table 4. - Continued.

DATE	MEAN LENGTH (TL MM)	SALINITY (PPT)	TEST TEMP. (C)	DISS. O2 (MG/L)	PH	O3 CONC. (MG/L)	TIME(HRS.) FROM START OF TEST	CONTROL NO. ALIVE	CONTROL NO. DEAD	CONTROL NO. WITH L.O.E.	EXPERIMENTAL NO. ALIVE	EXPERIMENTAL NO. DEAD	EXPERIMENTAL NO. WITH L.O.E.
PALAEMONETES PUGIO													
28 MAR 79	21.6	1	15.5	*	7.5	0.97	0	10	-	-	10	-	-
							45	10	0	0	9	1	0
							48	10	0	0	8	2	1
							96	10	0	0	8	2	1

FIGURES

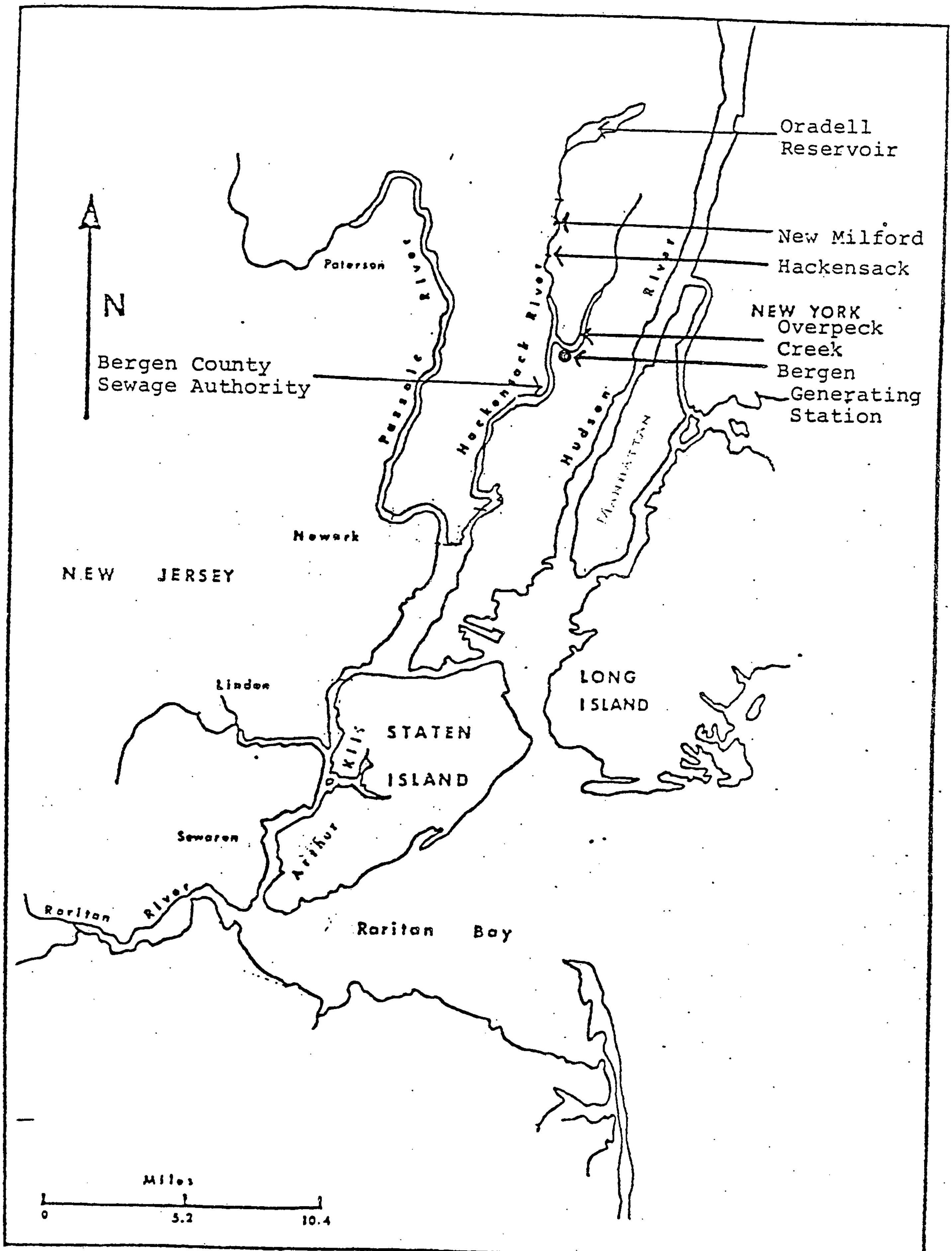
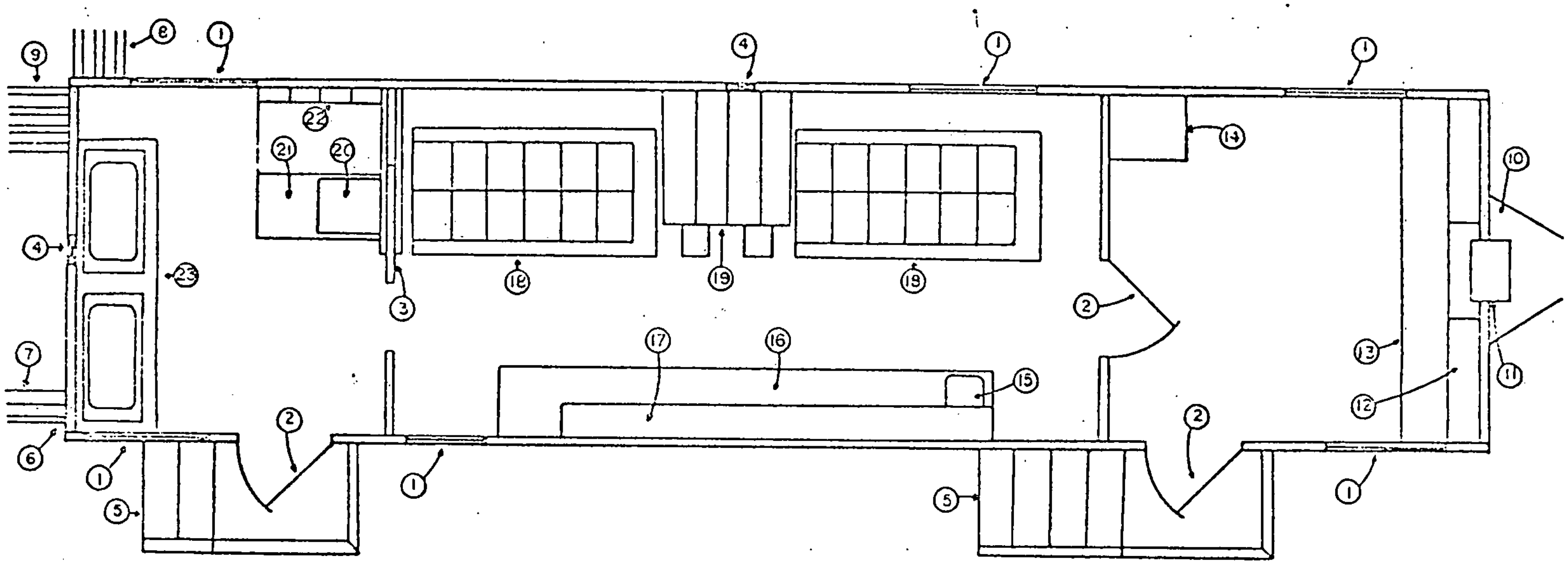


Fig. 1.a. - Location of Bergen Generation Station

BIOLOGICAL EVALUATION LABORATORY



1) Window
2) Door
3) Sliding Door
4) Fan
5) Stairs
6) City Water Inlet
7) Sink Drain
8) River Water Inlet
9) Tank Drains
10) Trailer Hitch
11) Air Conditioner
12) Shelves
13) Desk
14) Refrigerator
15) Sink
16) Lab Bench
17) Cabinets (above & below bench)
18) Toxicity Tanks
19) Avoidance Tanks
20) Physiograph
21) Table
22) Test Chambers
23) Holding Facility

Figure 1.b.- Diagram of the Biological Evaluation Laboratory and equipment.

Scale: none

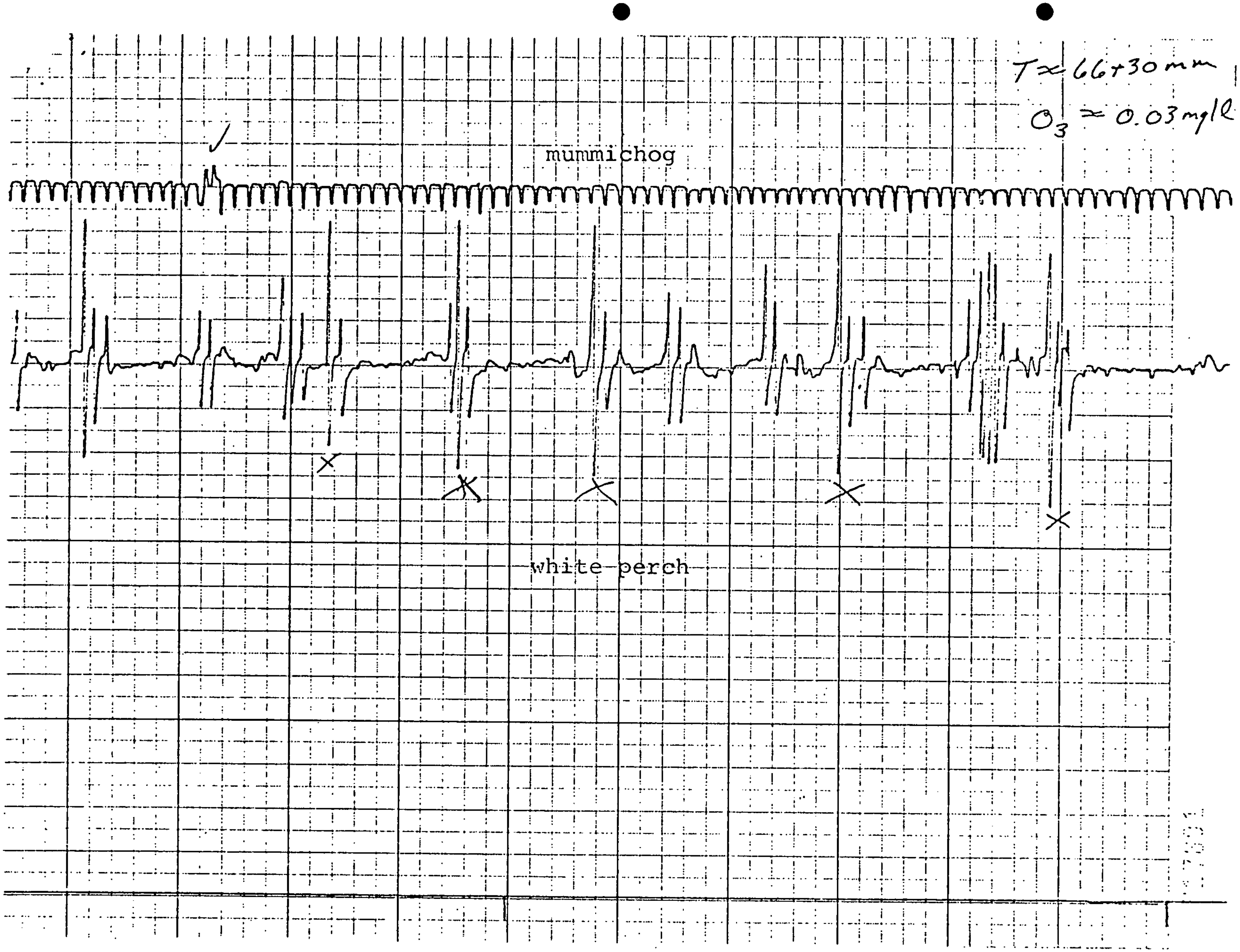


Figure 2. - Physiographic traces of "cough" responses of mummichog (top) and white perch (bottom) exposed to 0.03 mg/l ozone. "X's" mark traces for which "coughs" were observed. Time of testing was 66 hours 30 minutes after being placed in test apparatus.

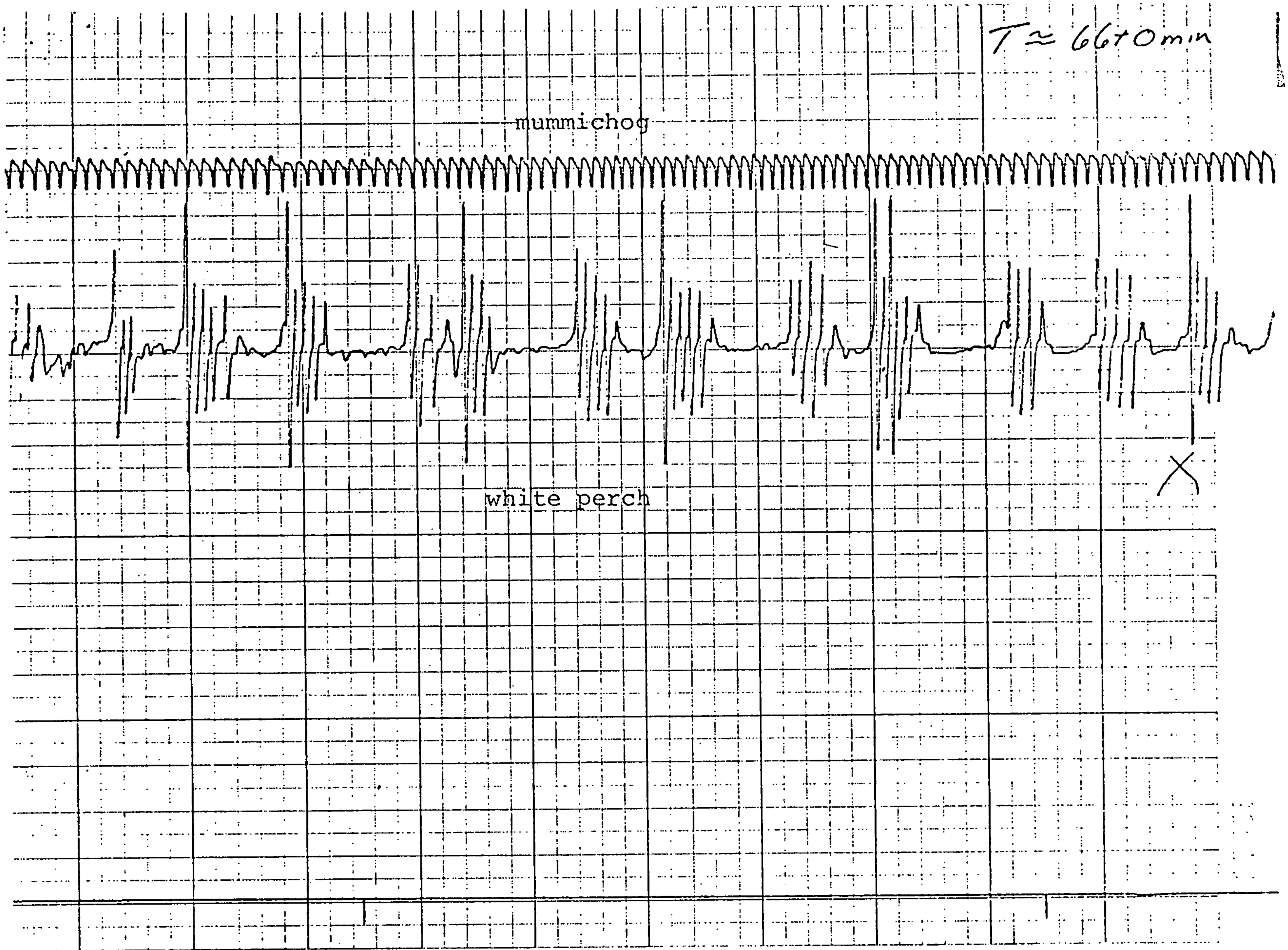


Figure 3. - Physiographic traces of "cough" responses of mummichog (top) and white perch (bottom) immediately prior to exposure to ozone. "X's" mark traces for which "coughs" were observed. Time of testing was 66 hours after being placed in test apparatus.

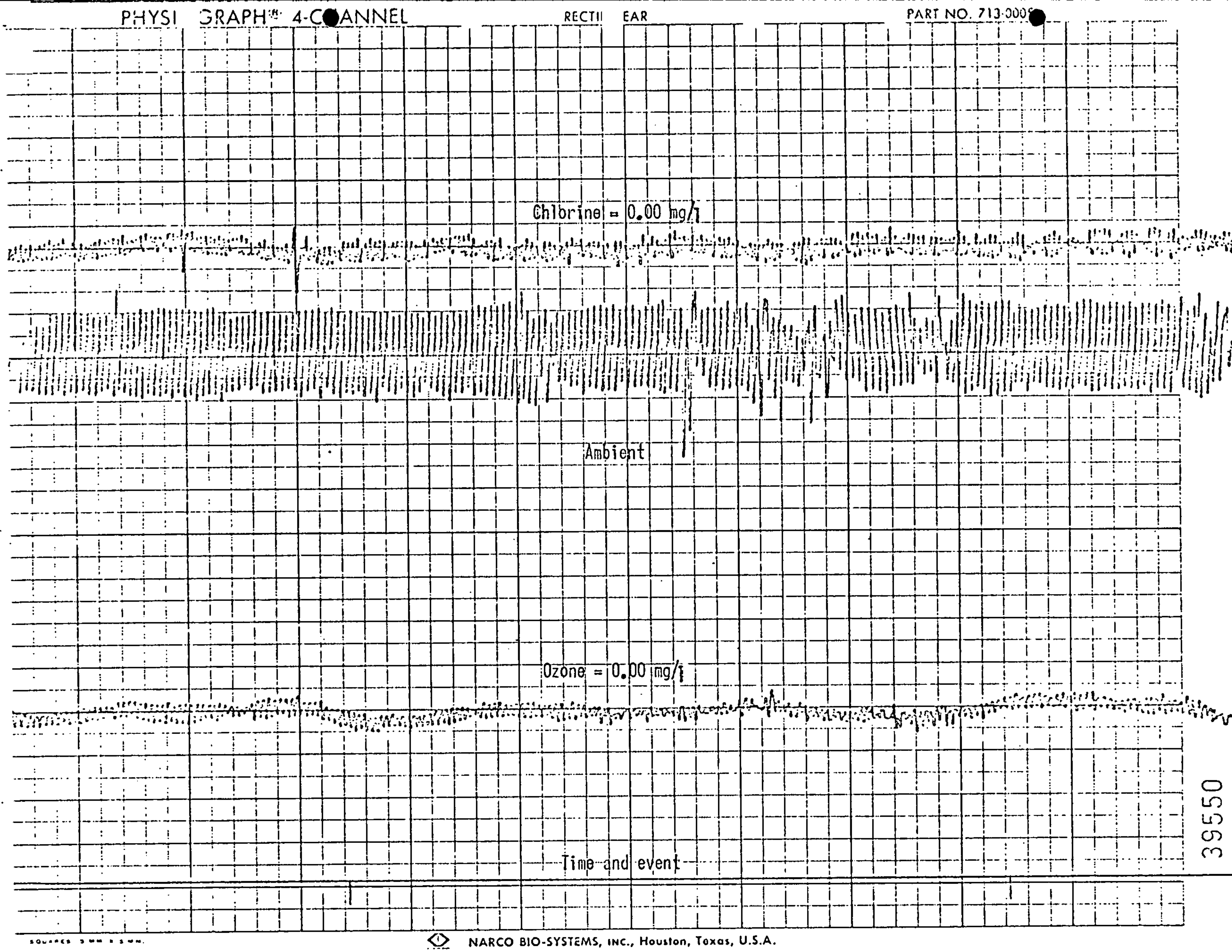


Fig. 4 - Physiographic traces of "cough" responses of mummichog on 23 March 1979 immediately prior to exposure to chlorine (top) and ozone (bottom). Ambient water chamber traces are in middle. Base line is from time and event marker (dashes are 1 minute apart).

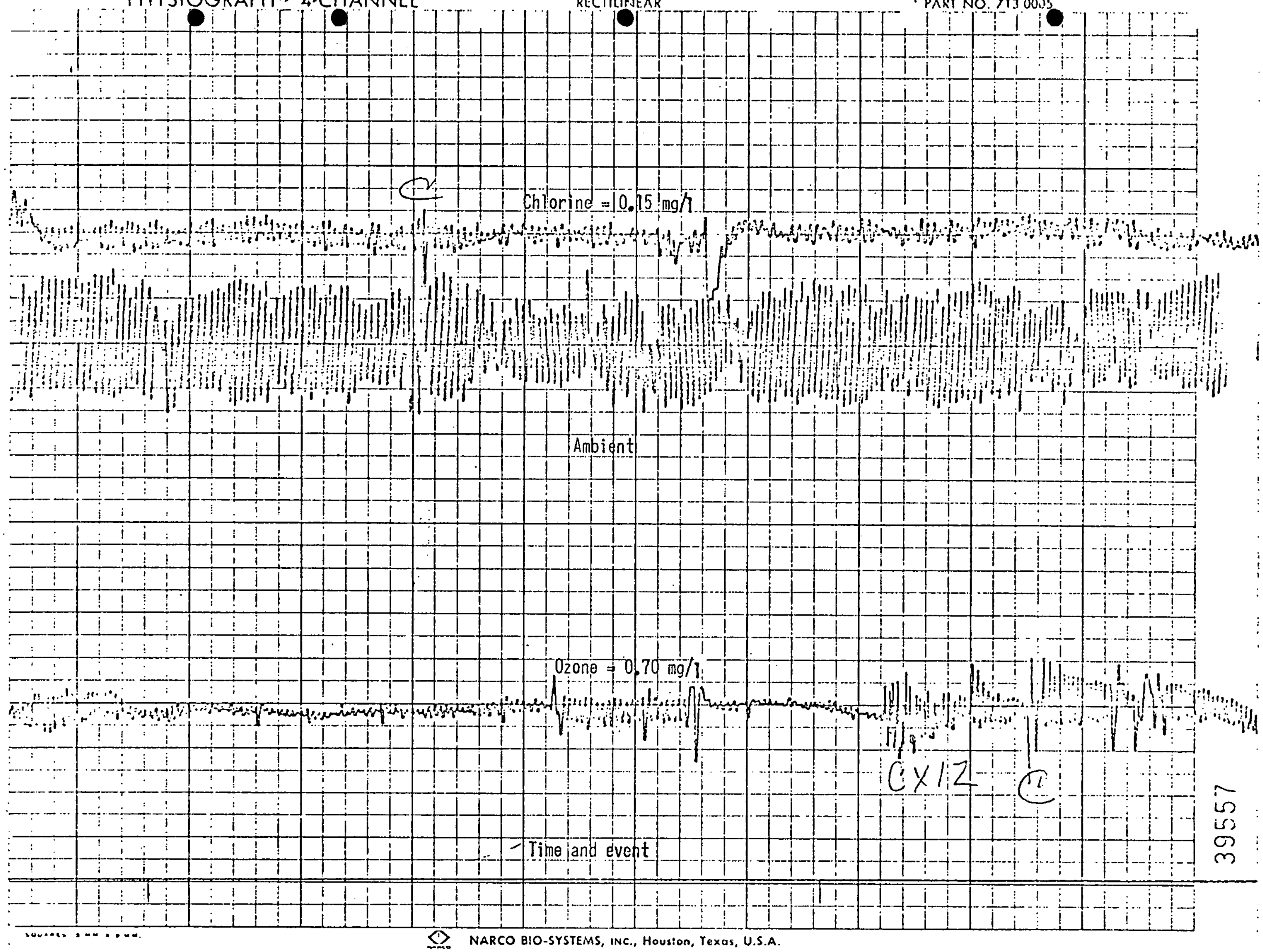


Fig.5 - Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.15 mg/l total chlorine and 0.70 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed. Dashes on time and event line are 1 minute apart.

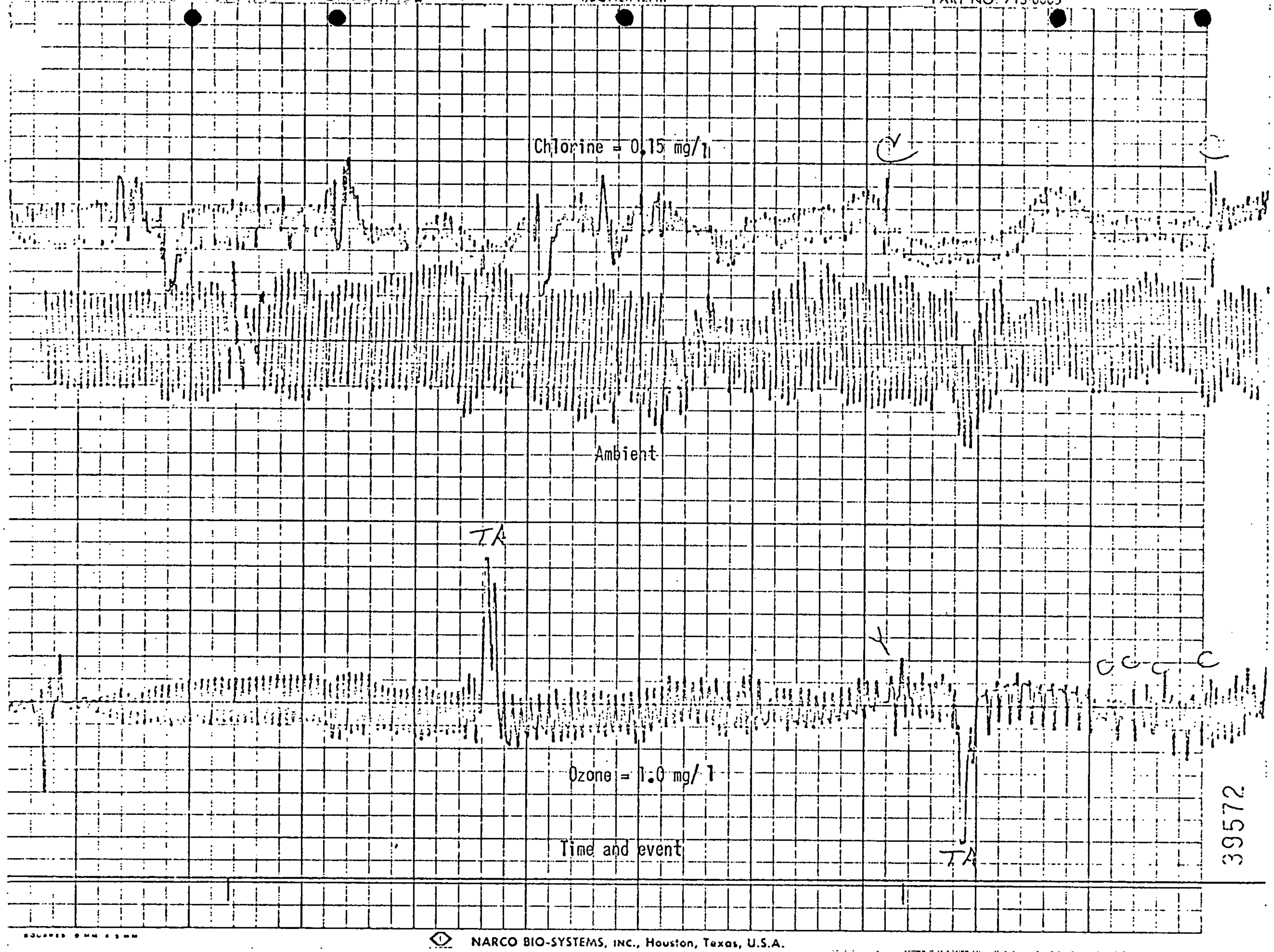


Fig. 6A – Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.15 mg/l total chlorine and 1.0 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns" and "TA" indicates fish turning around in test chamber. Dashes on time and event line are 1 minute apart.

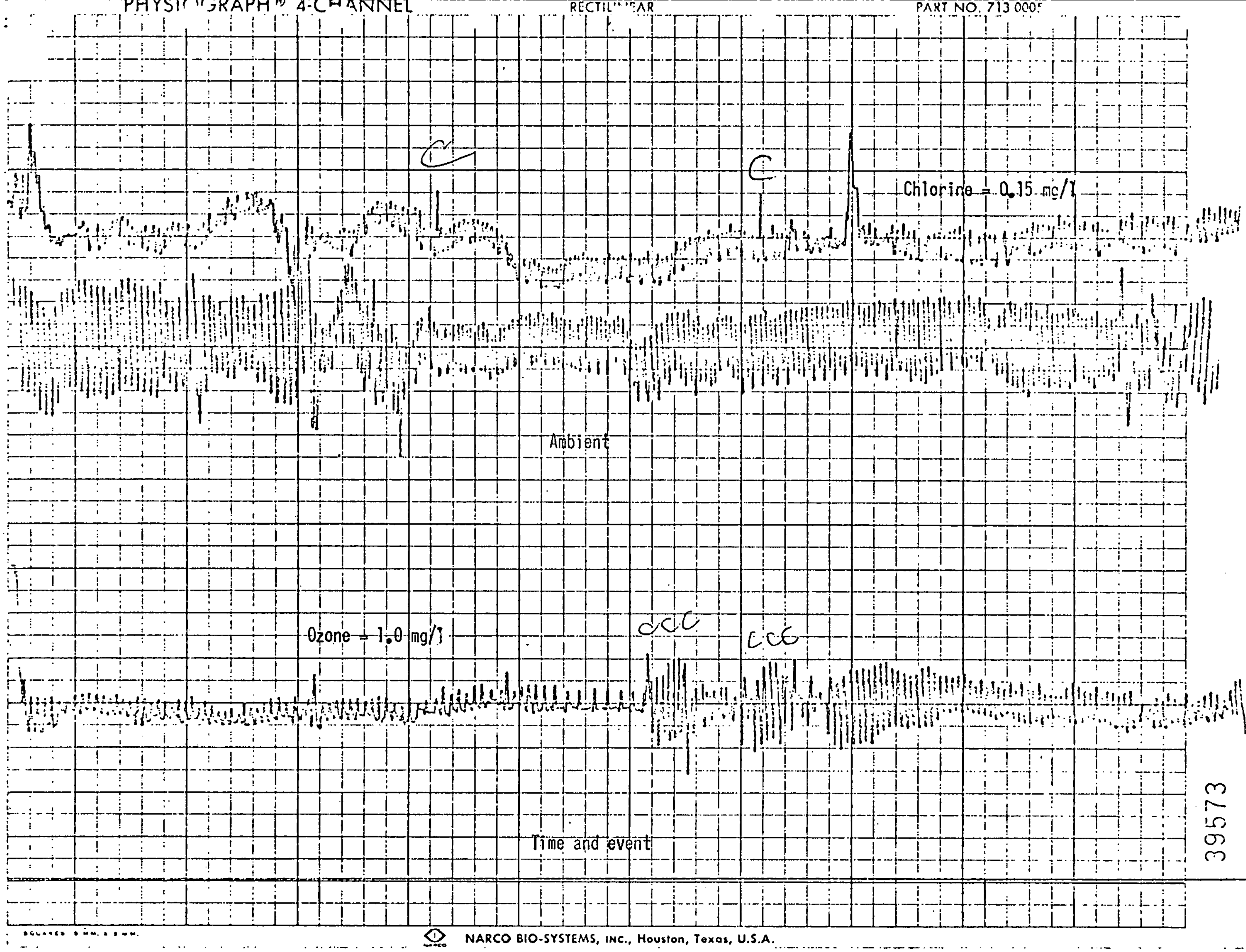


Fig. 6B – Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.15 mg/l total chlorine and 1.0 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns" and "TA" indicates fish turning around in test chamber. Dashes on time and event line are 1 minute apart.

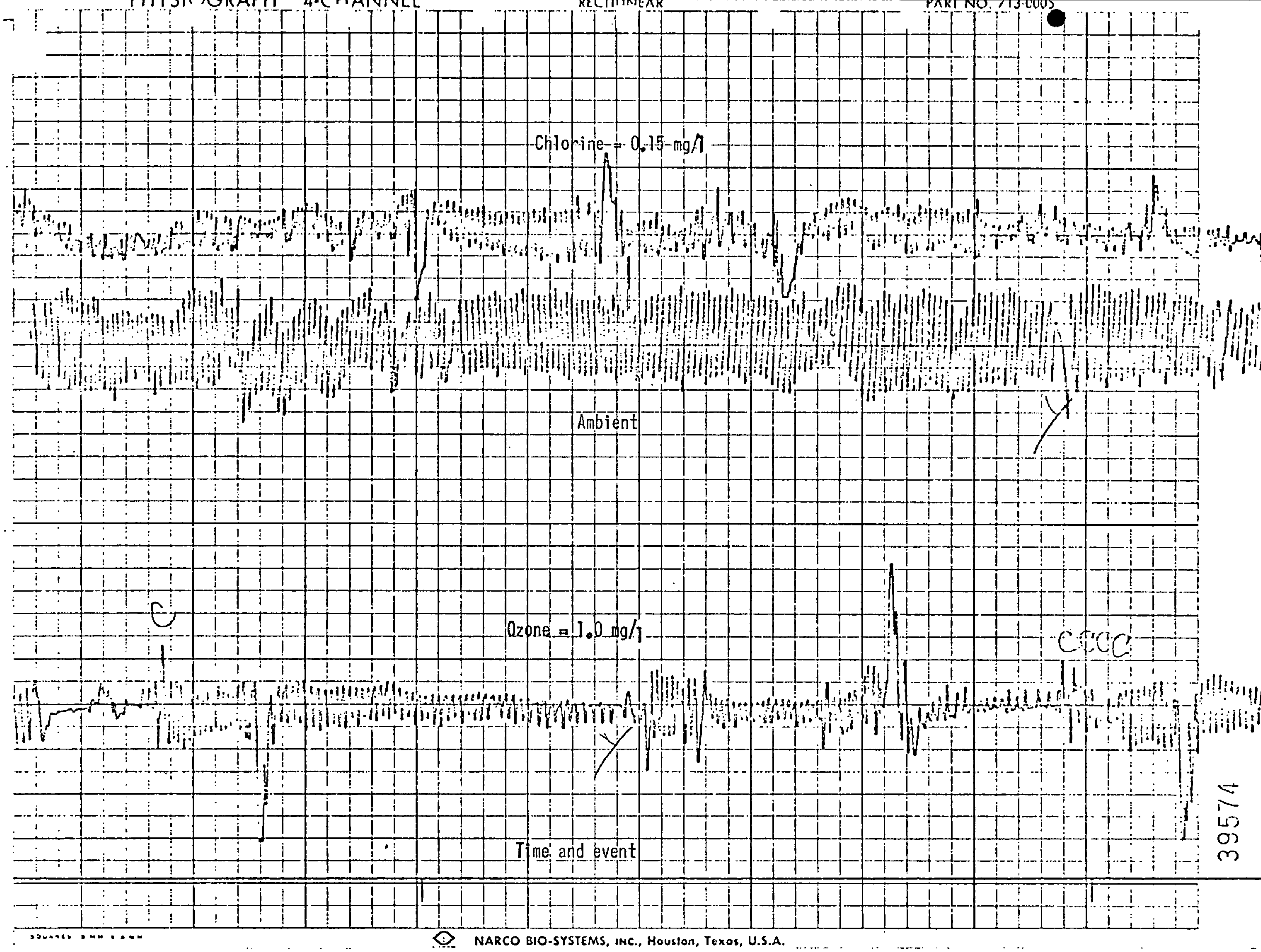


Fig. 6C - Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.15 mg/l total chlorine and 1.0 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns" and "TA" indicates fish turning around in test chamber. Dashes on time and event line are 1 minute apart.

Fig. 6D - Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.15 mg/l total chlorine and 1.0 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns" and "TA" indicates fish turning around in test chamber. Dashes on time and event line are 1 minute apart.

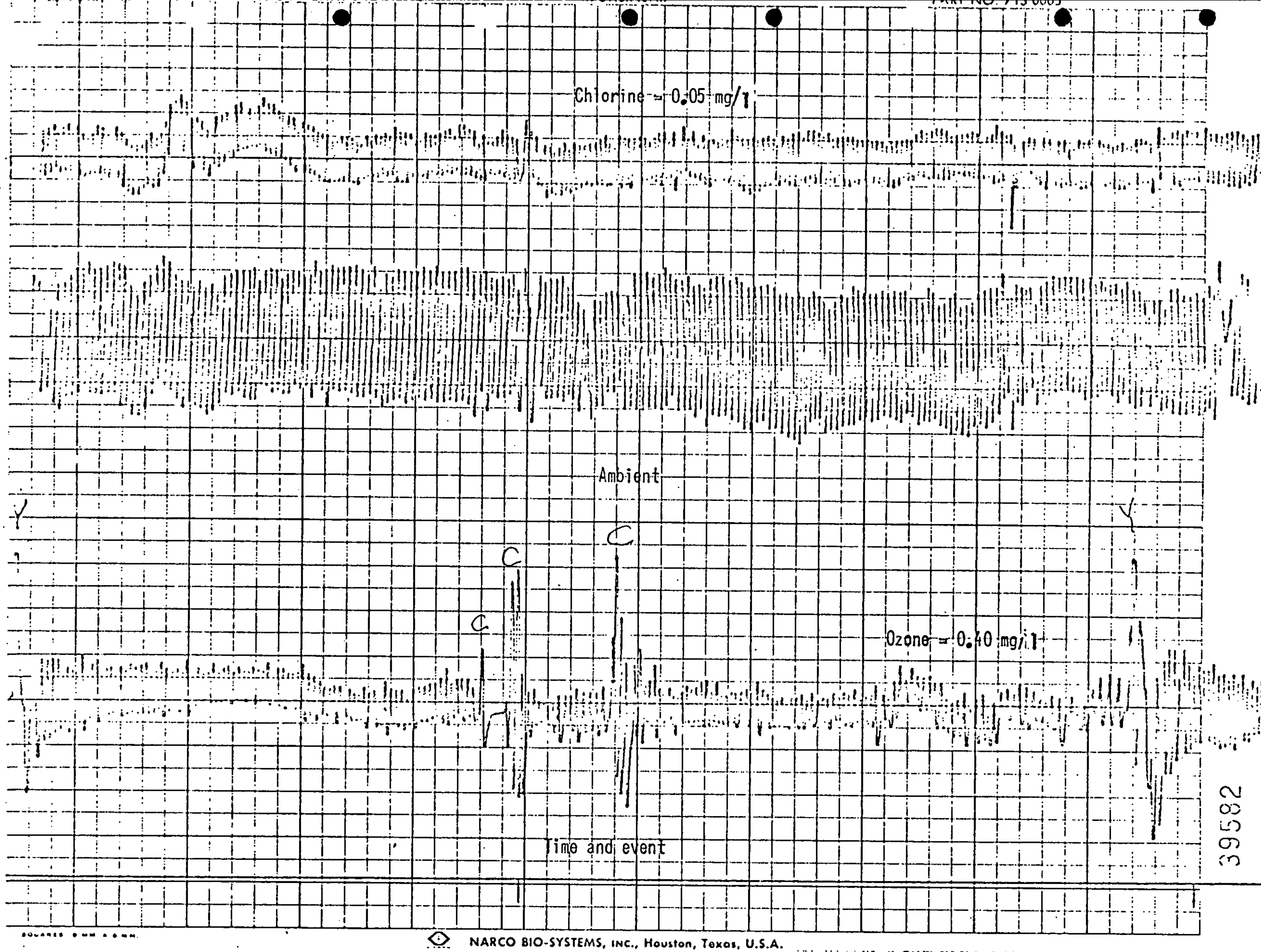


Fig. 7A – Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.05 mg/l total chlorine and 0.40 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns". Dashes on time and event line are 1 minute apart.

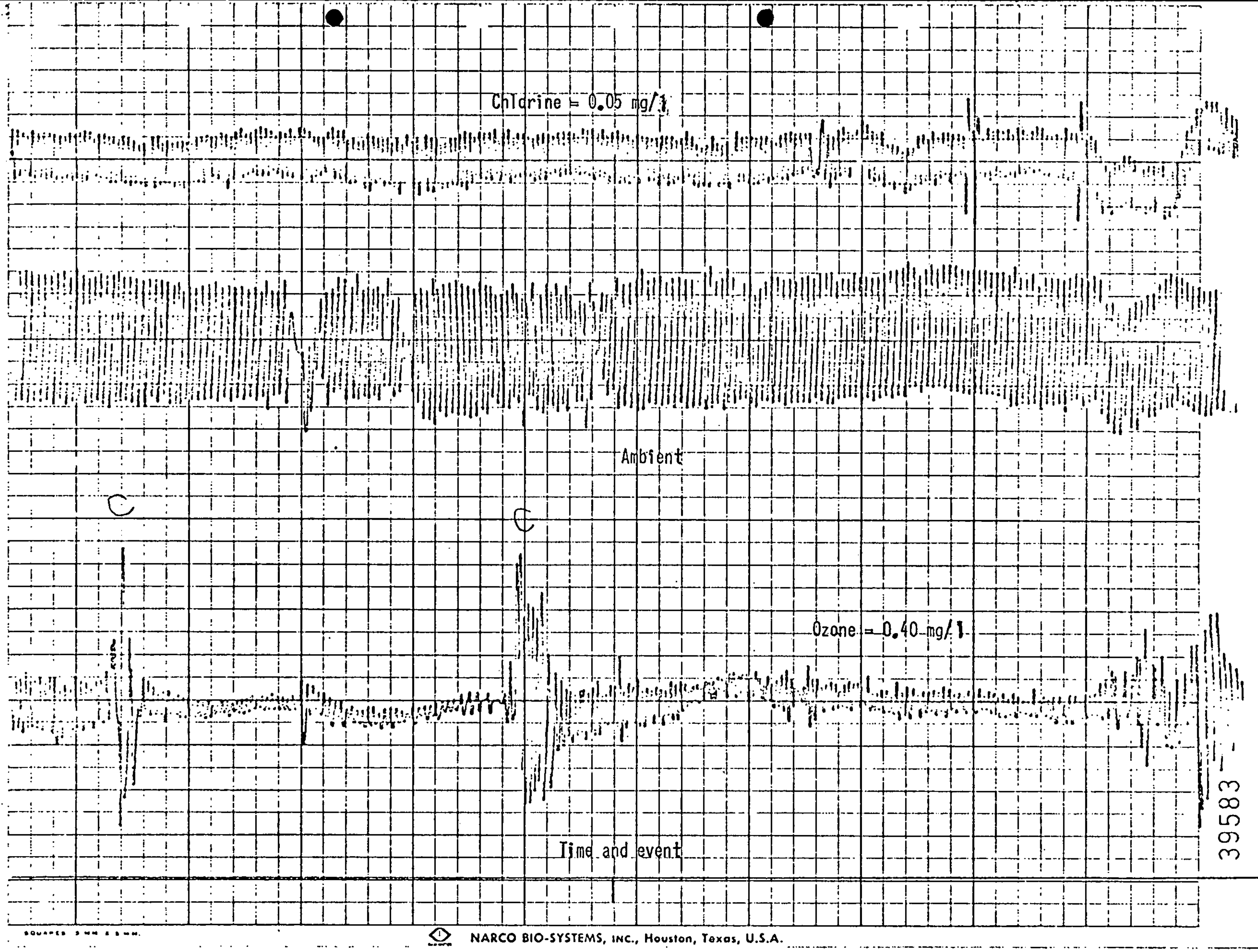


Fig. 78 – – Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.05 mg/l total chlorine and 0.40 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns". Dashes on time and event line are 1 minute apart.

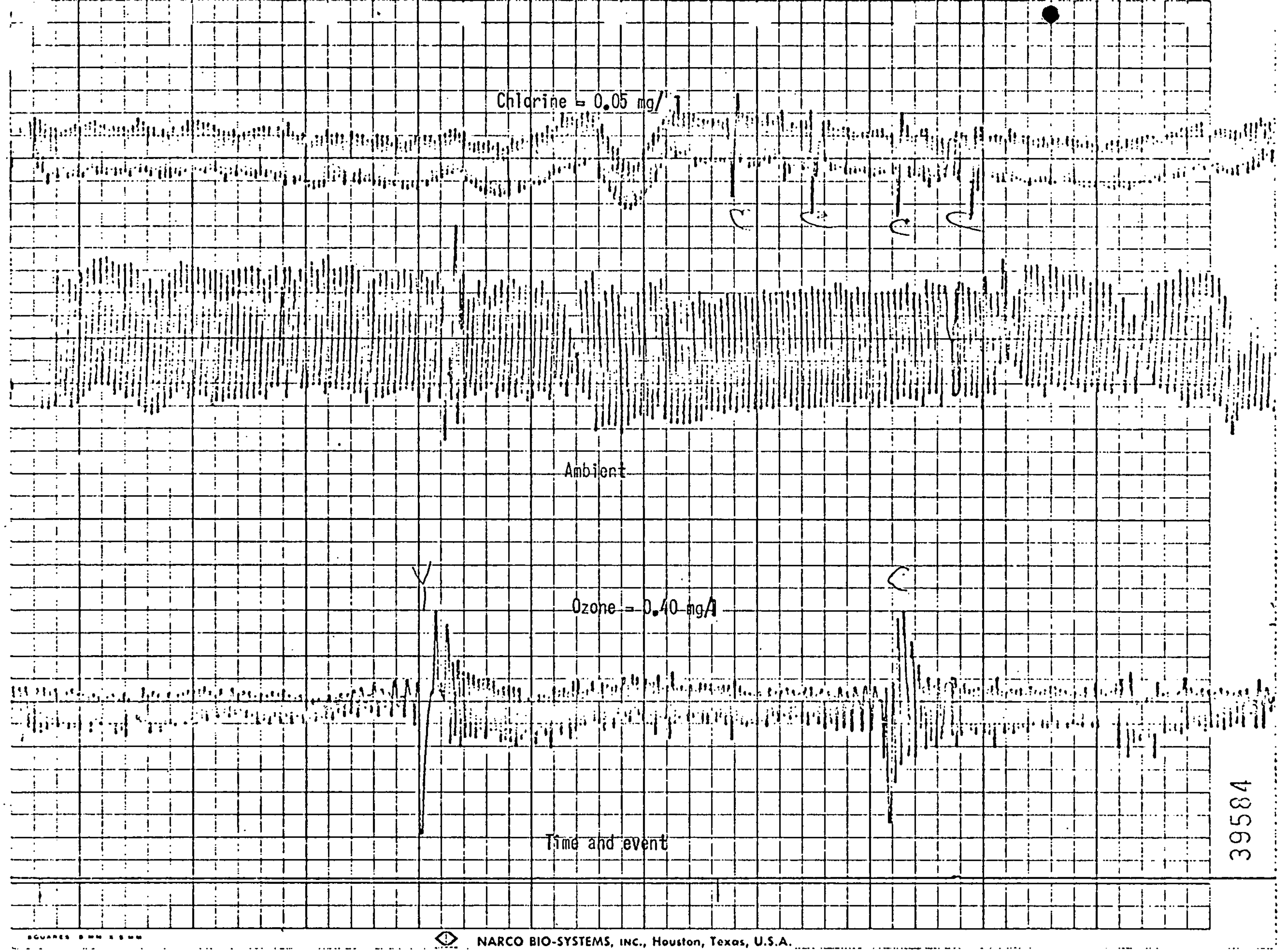


Fig. 7C – – Physiographic traces of "cough" responses of mummichog on 23 March 1979 exposed to 0.05 mg/l total chlorine and 0.40 mg/l ozone (as total oxidant). "C's" mark traces for which "coughs" were observed; "Y's" indicate "yawns". Dashes on time and event line are 1 minute apart.

APPENDICES

Appendix 1

List of Principal Equipment
in Biological Trailer

2	Toxicity Systems
2	Modified Shelford-Allee Systems
1	Narco 4-Channel Desk Model DMP-HB Physiograph
1	YSI Model 57 Dissolved Oxygen Meter and Probe
1	YSI Model 33 SCT Salinometer and Probe
1	Corning Model 610 A pH Meter and Probe
2	Wallace and Tiernan Series A-790 Amperometric Titrators
1	Aquafine Model PVCL-1 UV Water Sterilizer
1	Forma Scientific Refrigeration and Heating Unit
1	Conde Air Pump
2	Mod Four Filters
3	50-gal Oval Frigid Unit Tanks
1	88-gal Delivery Tank
1	Hewlett-Packard Programmable Calculator Model HP-67
1	Bausch and Lomb Stereoscopic Microscope Model BVB-73
1	Bausch and Lomb, Nicholas, Micro Lamp
1	Micro Dissecting Kit
1	Ohaus Cent-O-Gram Balance
9	Thermometers
6	Little Giant Submersible Pumps
3	Silent Giant Air Pumps
1	50-gal Transport Vessel
1	10-ft Common Seine
1	25-ft Bag Seine

Appendix 2

41-55

Water Quality at Bergen Generating Station

Water quality at Bergen Generating Station is variable. This variability can be attributed to the geographic location of the plant which is adjacent to the Hackensack River and Overpeck Creek. During operation, the plant takes inlet cooling water from Overpeck Creek and discharges it into the Hackensack River.

The factors which affect the variability of the water are as follows:

1. Changing tide levels of the Hackensack River;
2. Varying creek temperatures;
3. Location of Bergen County Sewage Authority near the generating station;
4. Large quantities of water being discharged from Oradell Reservoir.

The varying creek temperatures appear when locks, which divide Overpeck Creek, are opened, causing a tremendous amount of water, usually at a lower temperature, to mix at the cooling water inlet of the plant. Bergen County Sewage Authority is located near the station, and discharges large amounts of variable constituents into the river water daily. Finally, Oradell Reservoir annually discharges large quantities of water into the Hackensack. According to a report prepared by Woodward-Clyde Consultants in March 1976, over five billion gallons of water were released from the reservoir during a five day period in 1975.

Dissolved oxygen is one of the most essential constituents for aquatic organisms. It is a factor limiting the kind of marine life and the amount of life sustainable in a given body of water. When D.O. is less than a daily average of 5 mg/l, major fish populations cannot be sustained. Figures 1 and 2 give plots of dissolved oxygen data taken from annual water quality reports published by USGS for the Hackensack River at Hackensack and New Milford which are approximately two and three miles respectively upstream from Bergen Generating Station. Annually, the D.O. generally peaks around February-March and is lowest around June. Tables 1, 2, and 3 give readings of dissolved oxygen taken in October and November of 1978, and readings taken in January and February of 1979. The data show that the level of D.O. varies daily from 0.0 mg/l to some very low value.

During 1968-70 PSE&G made various river water surveys at Bergen Generating Station. The surveys were made once in 1968 and twice in each of the following two years, and excellent qualitative chemical information was obtained. The surveys reported data on: sodium, dissolved oxygen, ammonia, chlorides, calcium, magnesium, phosphates, sulfates, nitrates, iron, copper, silica, carbon dioxide, manganese, nickel, carbonates, bicarbonates, carbonic acid, hydroxides, sulfides and organic carbon. Results are given in Table 4.

Ammonia concentrations varied appreciably, a low for ammonia of 3.65 ppm and a high of 20.89 ppm were found at different periods in 1969. Ammonia reacts readily with chlorine forming toxic mono-, di-, and trichlroamines. Such toxic substances are harmful to fish and aquatic organisms if high levels are discharged to the aquatic environment. More recent ammonia data are given in Tables 5, 6 and 7.

Chlorine demands varied from a low of 1.1 ppm in 1969 to a high of 31.0 ppm in 1968. Other chlorine demands are based on a 30 seconds contact time. Results are given in Tables 5, 6 and 7.

Iron and manganese were found to be low and gave average concentrations of 1.1 ppm and 0.5 ppm, respectively. Other cation results taken in February of 1979 are given in Table 8.

Nitrates varied from a low of 0.8 ppm in 1969 to a high of 61.6 ppm in 1970, and were determined by the Cadmium method. Other nitrate values, taken during 1972, 1973, 1974 and 1975 from water quality reports published by USGS, are given in Table 9. A plot for 1975 values is shown in Figure 2. Annually, nitrates seem to peak between November and June.

Total organic carbon averaged 54.1 ppm in 1970. Organic carbon data are given in Table 9 and Report Excerpts 1 and 2. A plot of 1975 data is given in Figure 2. The data varies appreciably, however it is noted from Report Excerpt 2 that T.O.C. is reduced with filtration or by ozonation.

Chemical oxygen demand averaged 70 ppm, however, the readings were probably inflated by salinity values, because salinity interfers with Chemical Oxygen Demand (COD) analysis. Tables 5, 6 and 7 give recent salinity measurements at Bergen Station. COD indicates the quantity of oxidizable compounds in water.

A number of other constituents are reported as shown in Table 4.

41-57 Water temperatures, measured by USGS (1972-1975) are given in Table 10. The temperatures follow a uniform and expected pattern. and range from a low of 2°C in winter to a high of 29°C in summer. Both these high and low values were recorded at Hackensack. A plot of water temperatures for 1972 and 1978, at Bergen Generating Station, is given in Figure 3. Plots of daily water temperatures in 1978 and 1979 are given in Figures 4, 5 and 6. The latter plots give excellent views of the daily fluctuations in water temperatures.

pH values are given in Tables 2, 3, 4, 10, 11 and 12. The data shows that pH values vary slightly and range between 6.0 and 8.0 pH units. Fecal coliform measurements are given in Table 9 and total coliform measurements are given in Tables 5, 6 and 7. Fecal coliform seems to peak in April through June at Hackensack and New Milford. Total coliform bacteria are used as indicators of possible sewage pollution and are characterized as aerobic or facultative anaerobic, gram-negative, nonsporeforming, rod-shaped bacteria, which ferment lactose with gas formation within 48 hours at 35°C. Fecal coliform bacteria are present in the intestine or feces of warm blooded animals and are often used as indicators of the sanitary quality of the water.

The USGS report showed that Streptococci bacteria was found in the Hackensack, however, there was not enough data to study its existence for any given period. This bacteria is found in the intestine of warm blooded animals, and characterized as gram-positive, cocci bacteria, capable of growth in brain-heart infusion broth. It was also found from the USGS report that Phosphorus peaked in May through September, and Kjekdahl nitrogen and orthophosphorous ran at minimums in February through May. Phosphates, total plate count, B.O.D. and conductivity data, taken from the report are shown in Tables 5, 6 and 7.

Public Service 316a and b reports submitted to the Environmental Protection Agency in 1974 includes information about the aquatic life around Bergen Station. The major zooplanktons identified were: *Moina brachiata*, *Daphnia pulex*, *Diaptomus birgei* and *Diaptomus reighardi*. *Daphnia pulex* was abundant in June and July; *Moina branchita* was abundant in August and September; and *Diaptomus birgei* was abundant in October through December. Fishes reported were: the mummichog, goldfish, white perch, american eel, carp, yellow bullhead and the black crapple. The mummichog was abundant, accounting for more than 95% of the total fish population.

Values of salinity were given in that report, ranging from 0 to 7 PPT at different points in the river. Measurements of salinity along a transect indicated that there was no clear gradient existing across the river.

Appendix 2
Table 1

D.O. Values

DATE	D.O mg/l *
10/23/78	2.3
24	2.0
25	0.6
26	5.9
27	0.8
28	0.0
29	0.0
30	0.1
31	0.2
11/1/78	0.2
2	0.2
3	0.0
4	0.1
5	0.2
6	0.2
7	0.3
8	0.2
9	0.3
10	0.3
11	0.3
12	0.3
13	0.3
14	0.2
15	1.0
16	0.0
17	0.0
18	0.0
19	0.0
20	0.2

* D.O. sampled at model condenser inlet - Bergen Generating Station

Appendix 2 - Table 2
Water Quality Data February 1979

DATE	°F	pH	D.O. mg/l	Salinity mg/l	Conductivity mhos/cm
Feb. 1	36.86	-	-	-	-
2	38.67	-	-	-	-
3	37.39	-	-	-	-
4	37.05	-	-	-	-
5	35.17	-	-	-	-
6	34.70	-	-	-	-
7	35.23	-	-	-	-
8	34.35	-	-	-	-
9	36.63	-	-	-	-
10	38.63	-	-	-	-
11	37.59	-	-	-	-
12	39.41	-	-	500	1400
13	38.65	6.9	4.0	1000	2000
14	37.56	6.5	4.0	1000	2000
15	38.22	6.7	3.5	1500	2950
16	39.06	6.7	3.6	-	-
17	38.04	-	-	-	-
18	35.04	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	38.56	6.7	4.0	2500	4900
22	40.42	-	-	-	-
23	42.58	6.6	1.2	3000	5800
24	38.50	-	-	-	-
25	36.46	-	-	-	-
26	35.20	6.9	9.1	3000	5800
27	36.25	-	-	-	-
28	37.64	-	-	-	-

* Sampled at model condenser inlet - Bergen Generating Station

JHS:sar
3/36/79

Appendix 2

Table 3

Water Quality Data

Date	pH	D.O. mg/l	NaCl mg/l	Conductivity mhos/cm^2
Jan. 1	6.7	0.00	3700	7000
Jan. 2	6.8	0.30	4000	7200
Jan. 3	7.0	-	-	-
Jan. 5	6.9	1.04	-	-
Jan. 6	7.0	1.37	-	-
Jan. 7	6.9	0.12	-	-
Jan. 8	6.9	-	-	-
Jan. 9	7.0	-	-	-
Jan. 10	7.0	-	-	-
Jan. 11	6.9	1.84	1100	2000
Jan. 12	6.6	0.12	1600	3100
Jan. 13	6.6	-	-	-
Jan. 14	6.5	0.08	-	-
Jan. 15	6.6	-	-	-
Jan. 16	6.4	1.61	-	-

Appendix 2 - Table 4

PUBLIC SERVICE RIVER WATER SURVEY AT BERGEN
GENERATING STATION
1968 - 1970

Date	8-15-68		7-17-69		12-3-69		9-16-70		12-3-70	
Tide Condition	LOW	HIGH	HIGH	LOW	LOW	HIGH	HIGH	LOW	HIGH	L
Temp. °C	30	34	35	33	15	16	28.5	29.5	12	12
pH	6.6	7.1	6.8	6.7	7.3	6.9	6.5	6.8	6.9	7.
Conductivity M/MHOS	11400	12000	10220	9250	11550	11500	12000	12000	9900	93
Sodium as PPM Na	1950	2050	1680	1520	1700	1750	3000	3000	-	-
Alkinity as PPM $CaCO_3$	151.1	156.8	144.3	144.3	151	153	161	161	168	16
PPM Dissolved oxygen	1.6	3.7	5.0	5.7	0.4	0.5	0.7	3.7	3.4	4.
Reducing Subs as PPM H_2S	0.92	1.06	2.1	1.8	0.26	0.43	0.8	1.8	0.9	1.
PPM Ammonia	4.55	5.22	6.23	3.65	0.24	20.89	7.89	7.42	4.67	4.
Chlorides as PPM NaCl	5214	5306	4812	4204	4998	4967	9488	9281	-	-
PPM C.O.D.	76.48	95.6	58.7	43.9	-	-	63.2	55.2	95.2	75
Total hardness as PPM $CaCO_3$	1200	1280	1140	1000	1200	1140	1940	1920	-	-
Calcium as PPM $CaCO_3$	350	400	260	240	280	260	380	400	270	2C
Phosphate as PPM PO_4	4.1	4.0	4.7	4.1	5.6	5.3	6.2	6.4	6.0	7.
Sulfate as PPM SO_4	514	566	474	399	496	439	848	820	-	-
Nitrate as PPM NO_3	30.3	25.7	0.8	1.3	1.83	2.00	3.0	2.7	60.7	61
Iron as PPM Fe	0.75	0.55	1.8	0.9	1.19	2.02	0.98	0.84	-	-
Copper as PPM Cu	0.08	0.06	0.23	0.20	0.39	0.38	0.02	0.03	0.2	0.

Appendix 2 - TABLE 4 (Continued)

PUBLIC SERVICE RIVER WATER SURVEY AT BERGEN
GENERATING STATION
1968-1970 cont.

Date	8-15-68		7-17-69		12-3-69		9-16-70		12-3-70	
Tide Condition	LOW	HIGH	HIGH	LOW	LOW	HIGH	HIGH	LOW	HIGH	LOW
Souble Silica as PPM SiO_2	0.7	1.9	3.2	2.2	8.6	8.6	3.0	2.8	-	-
PPM dissolved solids	6127	7119	5794	5225	6099	6075	11679	11382	-	-
PPM Suspended Matter	2.02	2.78	104	123	120	111	65	48	-	-
Free Carbon dioxides as PPM CO_2	10.4	13.6	12.4	4.6	10.4	11.6	8.2	6.2	-	-
Manganese as PPM Mn	0.4	0.1	0.4	0.3	0.6	0.7	0.8	0.8	0.31	0.40
Nickel as PPM Ni	0.07	0.05	0.00	0.01	0.01	0.01	0.17	0.15	0.15	0.17
30 sec. Chloride demand (PPM)	27.2	31.0	14.2	10.8	1.10	2.00	2.9	3.0	-	-
PPM Total Organic Carbon	-	-	-	-	-	-	-	-	43.0	65.2
Carbonate as PPM CO_3	0.01	0.08	0.02	0.01	0.11	0.02	57.13	39.3	-	-
BiCarbonate as PPM HCO_3	86.7	111.8	83.6	80.6	99.07	81.83	79.2	101.4	-	-
Carbonic Acid as PPM H_2CO_3	53.8	22.35	33.4	40.2	13.27	27.27	0.01	0.03	-	-

Appendix 2

Table 5

Cooling Water Characterization Data *

DATE (1978)	12/15	12/21
Cl_2 demand 31 sec (mg/l)	1.03	1.00
NH_3-N mg/l)	13.5	16.5
PO_4=(mg/l)	10.0	6.0
Total Coliform (COl/100ml)	29000	30000
Total plate count (no./ml)	1040	5100
B.O.D. (mg/l)	11.1	———
D.O mg/l	0.06	0.00
Conductivity mhos/cm	6200	———
NaCl (mg/l)	3300	———

* Sampled at model condenser inlet - Bergen Generating Station

Appendix 2

Table 6

Water Characterization Data *

Date (1979)	Test	Quantity
Jan 6	Total Plate Count	740 counts/ml
Jan 6	Total coliform	43000 col/100 ml
Jan 6	Cl_2 demand (31 sec.)	1.03 mg/l
Jan 6	B.O.D.	11.1 mg/l
Jan 6	D.O.	1.37 mg/l
Jan 6	pH	6.8
Jan 6	NH_3-N	10.5 mg/l
Jan 6	$PO_4^{\equiv}$	19.5 mg/l
Jan 11	Ozone demand	1.5 mg/l
Jan 11	Conductivity	2000 mhos/cm
Jan 11	NaCl	1100 mg/l

* Sampled at model condenser inlet - Bergen Generating Station

WATER CHARACTERIZATION DATA *

(February 28, 1979)

Appendix 2 - Table 7

Test	Quantity
Water Temperature	38.4°F
Total Plate Count	240 counts/ml
Total Coliform	14,000 col/100 ml
Cl_2 Demand (31 sec)	0.82 mg/l
B.O.D.	8.1 mg/l
D.O.	9.2 mg/l
pH	7.1 pH units
NH_3 - N	3.5 mg/l
$PO_4^{\equiv}$	0.62 mg/l
NaCl	300 mg/l
Conductivity	650 mhos/cm

*Sampled at model condenser inlet - Bergen Generating Station

COOLING WATER ANALYSIS *
(Cations)

Appendix 2 - Table 8

Data:

Cations	2/15/79 After Condenser	10:00 am 2/23/79 Before Condenser	1:00 pm 2/23/79 After Condenser
Aluminium, as Al	< 0.04 mg/ l	< 0.04 mg/ l	< 0.04 mg/ l
Arsenic, as As	< 0.25 mg/ l	< 0.25 mg/ l	< 0.25 mg/ l
Calcium, as Ca	57 mg/ l	99 mg/ l	100 mg/ l
Cadmium, as Cd	< 0.0006 mg/ l	< 0.0006 mg/ l	< 0.0006 mg/ l
Cobalt, as Co	< 0.007 mg/ l	< 0.007 mg/ l	< 0.007 mg/ l
Chromium, as Cr	< 0.005 mg/ l	< 0.005 mg/ l	< 0.005 mg/ l
Copper, as Cu	< 0.003 mg/ l	< 0.003 mg/ l	< 0.003 mg/ l
Iron, as Fe	0.2 mg/ l	1.1 mg/ l	1.1 mg/ l
Potassium, as K	16 mg/ l	31 mg/ l	38 mg/ l
Magnesium, as Mg	19 mg/ l	60 mg/ l	90 mg/ l
Manganese, as Mn	2.1 mg/ l	2.3 mg/ l	2.5 mg/ l
Molybdenum, as Mo	< 0.04 mg/ l	< 0.04 mg/ l	< 0.04 mg/ l
Sodium, as Na	275 mg/ l	575 mg/ l	635 mg/ l
Nickel, as Ni	< 0.008 mg/ l	< 0.008 mg/ l	< 0.008 mg/ l
Lead, as Pb	< 0.02 mg/ l	< 0.02 mg/ l	< 0.02 mg/ l
Tin, as Sn	< 0.03 mg/ l	< 0.03 mg/ l	< 0.03 mg/ l
Vanadium, as V	< 0.11 mg/ l	< 0.11 mg/ l	< 0.11 mg/ l
Tungsten, as W	< 1.2 mg/ l	< 1.2 mg/ l	< 1.2 mg/ l
Zinc, as Zn	< 0.002 mg/ l	< 0.002 mg/ l	< 0.002 mg/ l

* Sampled at research trailer - Bergen Generating Station

Table II Continued
USGS River Water Survey
Hackensack River at New Milford

Appendix 2 - Table 9

	1972			1973			1974			1975		
	Nitrates Mg/L	Organic Carbon Mg/L	Fecal Coliform col/100ML	Nitrates Mg/L	Organic Carbon Mg/L	Fecal Coliform col/100ML	Nitrates Mg/L	Organic Carbon Mg/L	Fecal Coliform col/100ML	Nitrates Mg/L	Organic Carbon Mg/L	Fecal Coliform col/100ML
Jan	-	-	-	-	-	-	-	-	-	-	-	-
Feb	2.0	-	0	1.1	8.0	20	1.4	4.0	0	-	-	-
March	-	-	-	-	-	-	-	-	-	1.1	5.4	30
April	-	-	-	-	-	0	-	-	10	0.6	4.1	3
May	-	-	-	4.9	5.8	132	1.1	18.0	-	0.8	5.4	22
June	1.6	7.5	92	-	-	4	-	-	8	0.9	13.0	310
July	0.9	-	-	-	-	372	-	-	28	0.8	8.3	2
Aug	-	-	-	0.4	2.0	5000	-	9.3	2	0.2	6.9	0
Sept	1.0	6.5	-	-	-	-	-	-	20	0.3	7.2	64
Oct	-	-	52	-	-	-	-	-	112	-	-	-
Nov	-	-	-	1.0	-	260	0.6	18.0	176	-	-	-
Dec	1.3	5.0	274	-	-	-	-	-	-	-	-	-

USGS River Water Survey

Appendix 2 - Table 10

Hackensack River at Hackensack | Hackensack River at New Milford

	1972			1973			1974			1975		
	H_2O °C	D.O. Mg/L	pH	H_2O °C	D.O. Mg/L	pH	H_2O °C	D.O. Mg/L	pH	H_2O °C	D.O. Mg/L	pH
Jan	2.6	8.7	6.2	–	–	–	–	–	–	–	–	–
Feb	–	12.6	7.5	4.0	9.4	7.2	2.0	10.6	5.8	–	–	–
March	5.4	12.4	6.8	–	–	–	–	–	–	4.1	12.6	8.0
April	11.4	9.2	7.0	18.0	5.2	7.2	13.0	7.2	7.7	5.5	12.6	–
May	19.1	7.2	7.1	18.5	2.4	7.3	20.9	4.2	8.5	15.5	11.0	8.0
June	–	–	–	25.4	1.4	–	22.4	2.6	6.5	20.9	6.9	7.1
July	29.0	5.2	6.9	29.5	4.4	7.5	–	–	–	24.1	8.6	7.7
Aug	17.5	8.2	7.6	28.0	2.0	6.4	–	–	–	24.3	8.4	7.8
Sept	20.5	3.0	7.0	21.0	–	6.5	–	–	–	19.0	8.8	7.8
Oct	11.9	3.0	6.7	14.0	7.2	8.3	–	–	–	–	–	
Nov	5.7	12.6	7.7	11.9	1.0	–	–	–	–	–	–	
Dec	–	–	–	–	–	–	–	–	–	–	–	

Appendix 2
Table 11
pH Values

DATE	pH*
10/23/78	-
10/24/78	6.8
10/25/78	6.9
10/26/78	7.1
10/27/78	7.0
10/28/78	7.0
10/29/78	6.9
10/30/78	6.9
10/31/78	7.0
11/1/78	6.8
11/2/78	6.9
11/3/78	7.0
11/4/78	7.0
11/5/78	7.0
11/6/78	7.0
11/7/78	7.0
11/8/78	7.2
11/9/78	7.0
11/10/78	7.0
11/11/78	7.1
11/12/78	7.1
11/13/78	6.9
11/14/78	7.2
11/15/78	7.2
11/16/78	6.9
11/17/78	6.6
11/18/78	6.5
11/19/78	6.5
11/20/78	6.5

*Water sampled at model condenser inlet - Bergen Generating Station

Appendix 2

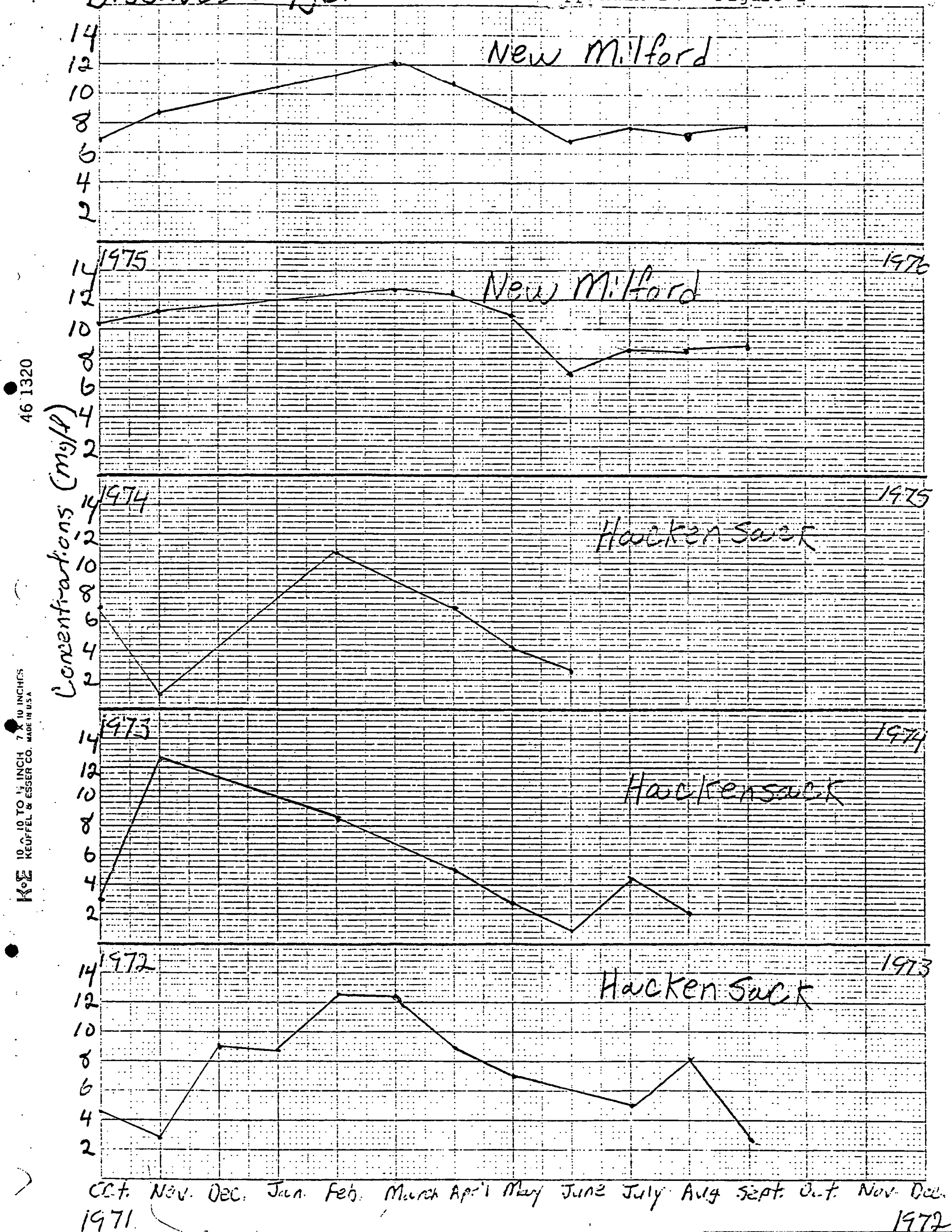
Table 12

pH of Cooling Water *

DATE (1978)	pH
12/7	7.0
12/8	6.4
12/9	6.7
12/10	6.7
12/11	6.4
12/12	6.3
12/13	6.4
12/14	6.3
12/15	6.3
12/16	6.1
12/17	7.0
12/18	7.1
12/19	6.6
12/20	6.5
12/21	6.5
12/22	6.4
12/23	6.4
12/24	6.5
12/25	7.0
12/26	6.6
12/27	7.0

* Sampled at model condenser inlet - Bergen Generating Station

Appendix 2 - Figure 1



Appendix 2

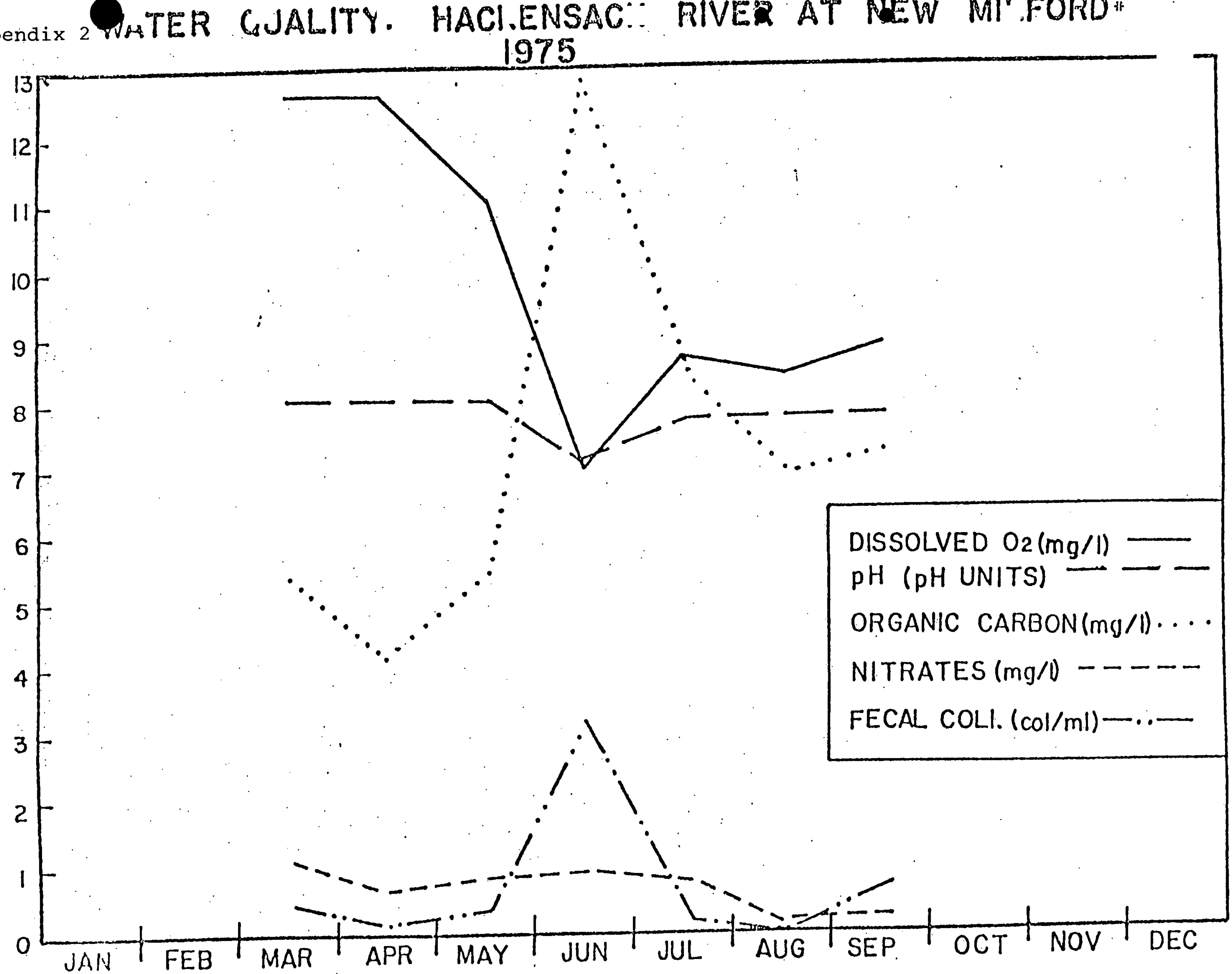
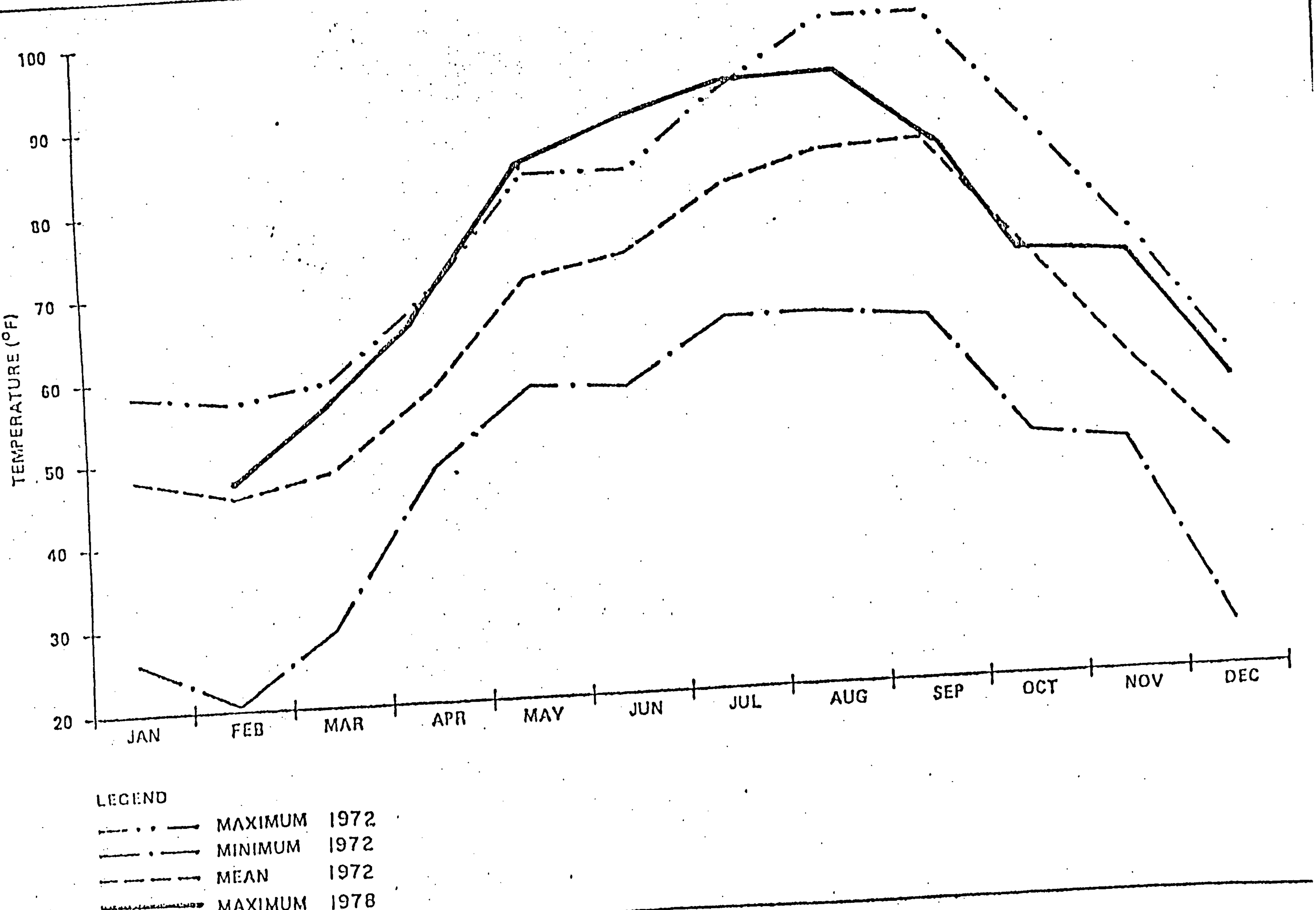


Figure 2

*FIVE MILES UPSTREAM OF BERGEN STATION INTAKE

Appendix 2

INTAKE WATER TEMPERATURES FOR THE BERGEN GENERATING STATION Figure 3



Appendix 2

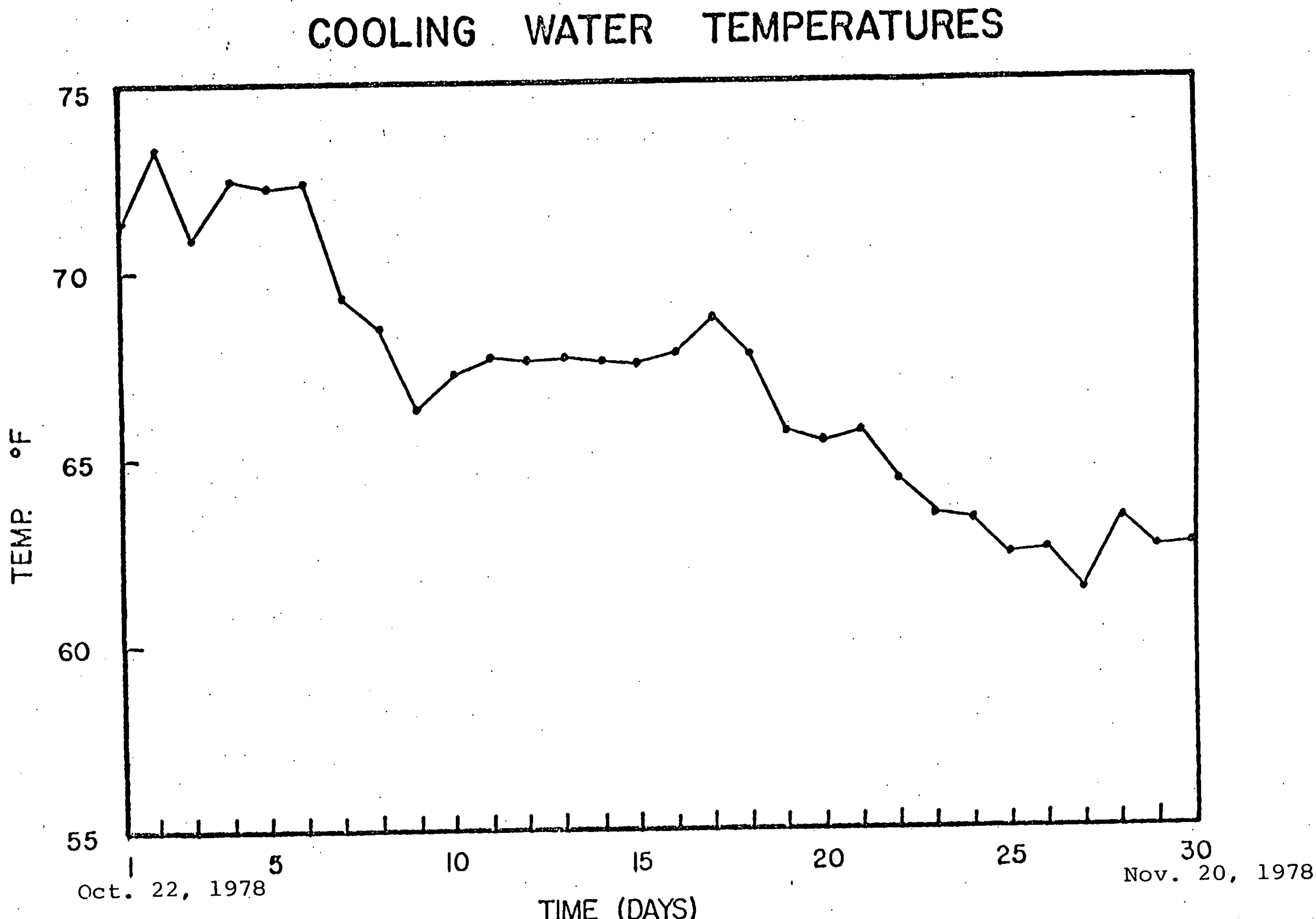


Fig. 4

Appendix 2

Figure 5 COOLING WATER TEMPERATURES

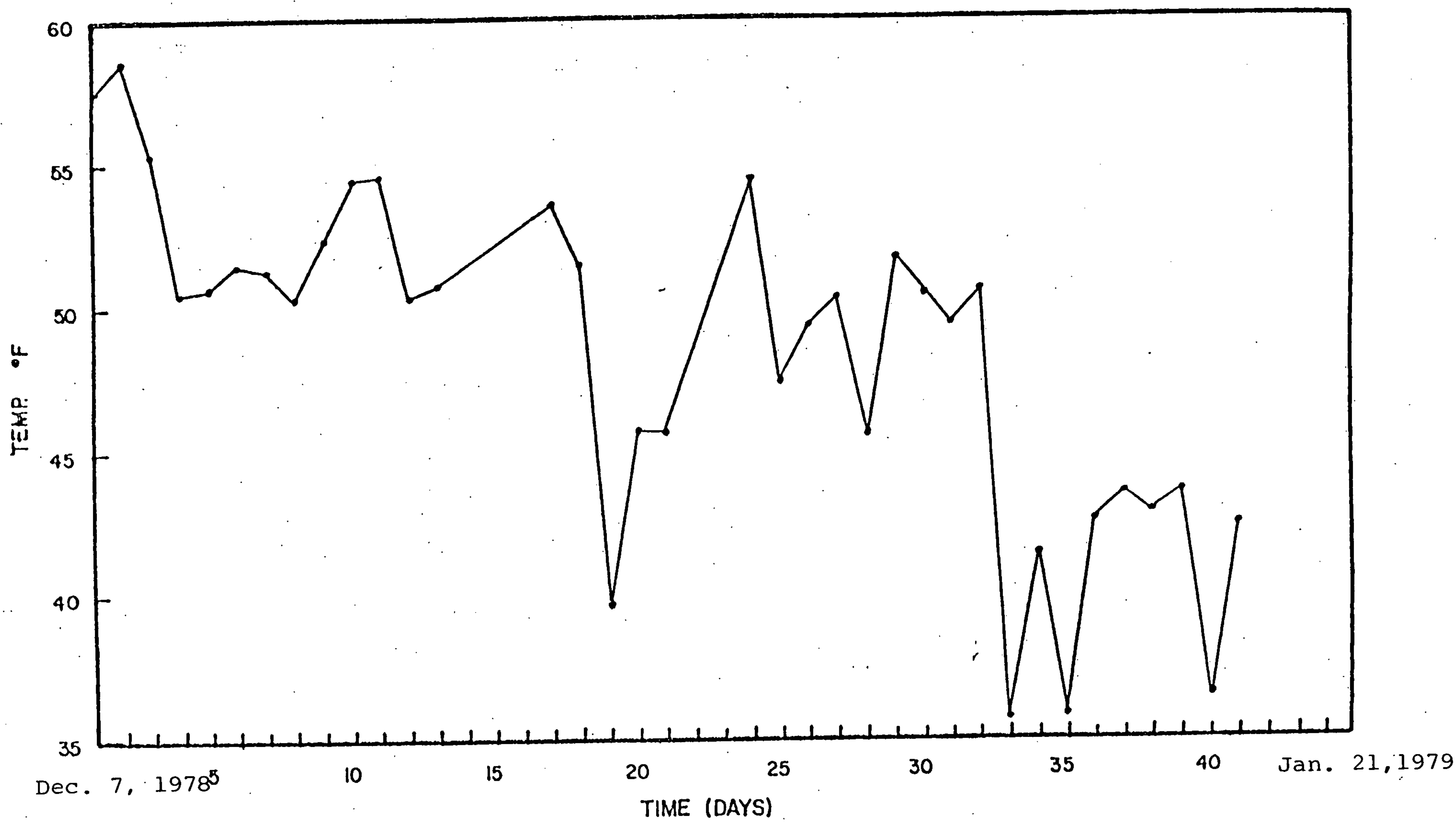
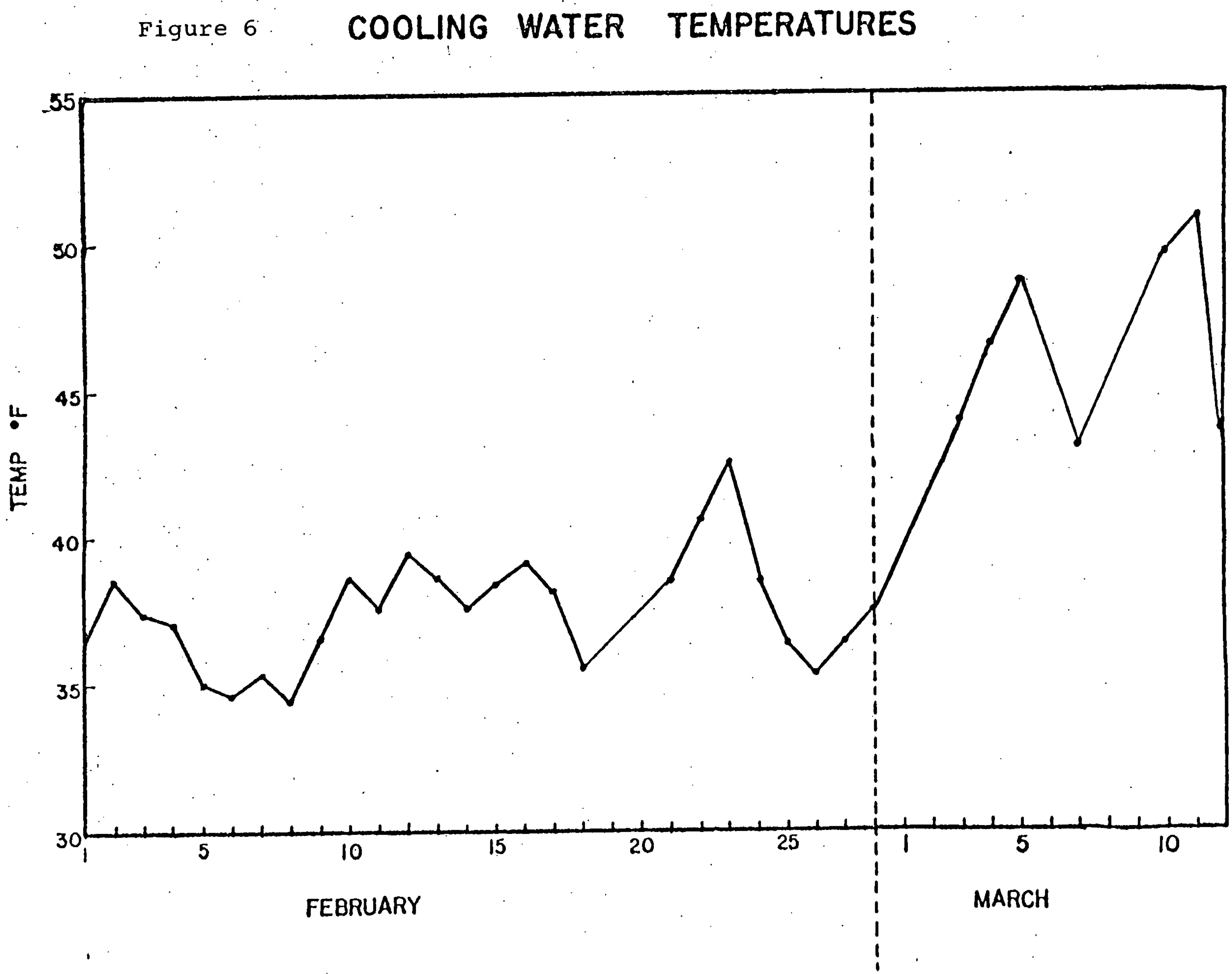


Figure 6


COOLING WATER TEMPERATURES
TEMP •F
55
50
45
40
35
30
1
5
10
15
20
25
1
5
10
FEBRUARY
MARCH

HARRISON GAS PLANT LABORATORY

Appendix 2 -Excerpt 1

REPORT NO. 24725

SAMPLE NO. 32136

SUBJECT: Three Water Samples from R & D (Ozone Project) collected & submitted By Mr. J. Singletary - Research Assistant - on 3-23-1979.

DATE RECEIVED: 3-23-79

TESTS COMPLETED: 3-28-79

DESCRIPTION OF SAMPLE: Three (125 mls) water samples identified as: 1.Untreated 2.Ozonated 3.Chlorinated

Test Results in PPm

Alkalinity
N= Phenolphthalein O= methyl orange

BEFORE FILTERING	pH	Alkalinity N	Alkalinity O	Cl^-	$SO_3^=$	$PO_4^{\equiv}$	Chromate	Phenols	CARBON Total	CARBON Inorganic	CARBON Organic
1. UNTREATED	6.7	0	90	188	2	Trace	0	0	51	29	22
2. OZONATED									44	31	13
3. CHLORINATED									51	30	21
AFTER FILTERING THROUGH #42 ASHLESS PAPER											
1. UNTREATED									36	29	7
2. OZONATED									39	29	10
3. CHLORINATED									33	27	6

Tested By: M. O.

F. Saada
Plant Chemist

[signature]
Manager- Gas Plant

CC: Chief Chemist
Mr. J.Singletary - R&D Dept. R.1116B

HG 213
Rev. 4/77

HARRISON GAS PLANT LABORATORY

RECEIVED
R & D DEPARTMENT
MAR 28 1979

Orig. To
Copies

Appendix 2 -
Excerpt 2

REPORT NO. 24663

SAMPLE NO. 32065

SUBJECT: Received one 4 oz. bottle of River Water from Overpeck Creek (Ozone Project)
Sample submitted by Mr. J. Singletary-Research Assistant R&D

DATE RECEIVED: 3-8-79

TESTS COMPLETED: 3-13-79

DATA: Using Beckman T.O.C. Analyzer - Model 915*

Test Results: Carbon in PPM

Date	Total	Inorganic	Organic
3-8-79	27	13	14

* Specifications: Requested by Mr. J. Singletary
Sensitivity: 0.5 per cent of full scale.
Repeatability: ± 2 per cent of full scale from 50 to 4,000 mg/liter

± 5 per cent of full scale at 10 mg/liter

Tested By M.Q.

F. SAADA
Plant Chemist

[signature]
Manager-Gas Plant

CC: Gen. Mgr. Gas Prod. Attn. Chief Chemist
Asst. Mgr. Adv. Sys. R&D

EXHIBITS

EXHIBIT 1 - Exterior of Biological Trailer

EXHIBIT 2 - Exterior of Biological Trailer

EXHIBIT 3 - Office of Biological Trailer

EXHIBIT 4 - Laboratory and Apparatus

EXHIBIT 5 - Testing Facility - Toxicity & Avoidance/Reference

EXHIBIT 6 - Testing Facility - Toxicity & Avoidance/Reference

EXHIBIT 7 - Holding Facility

EXHIBIT 8 - Holding Tank

EXHIBIT 9 - Holding Facility and Water Flow Regulators

EXHIBIT 10 - Physiograph Room

EXHIBITS

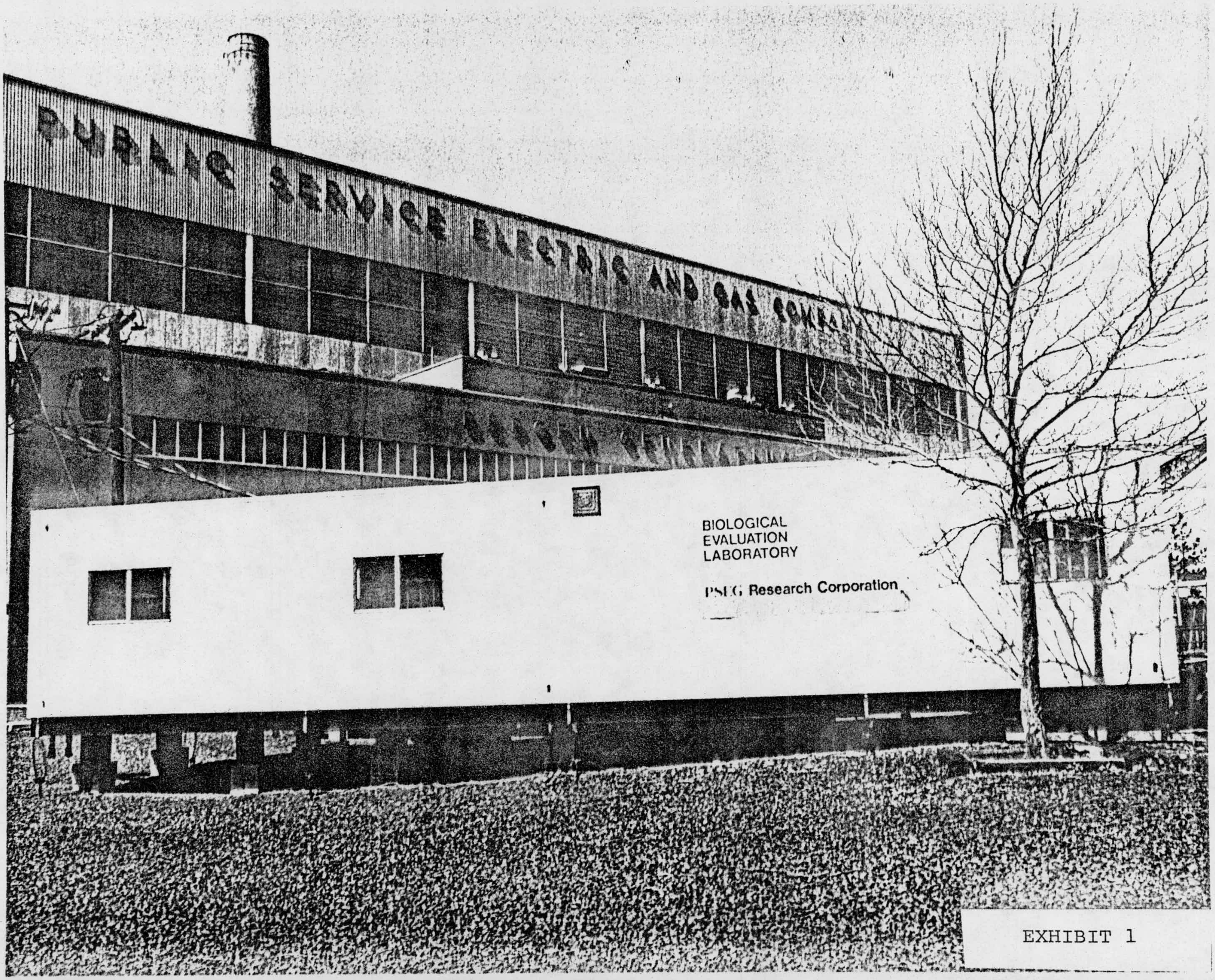

BIOLOGICAL
EVALUATION
LABORATORY
PSEG Research Corporation

EXHIBIT 1

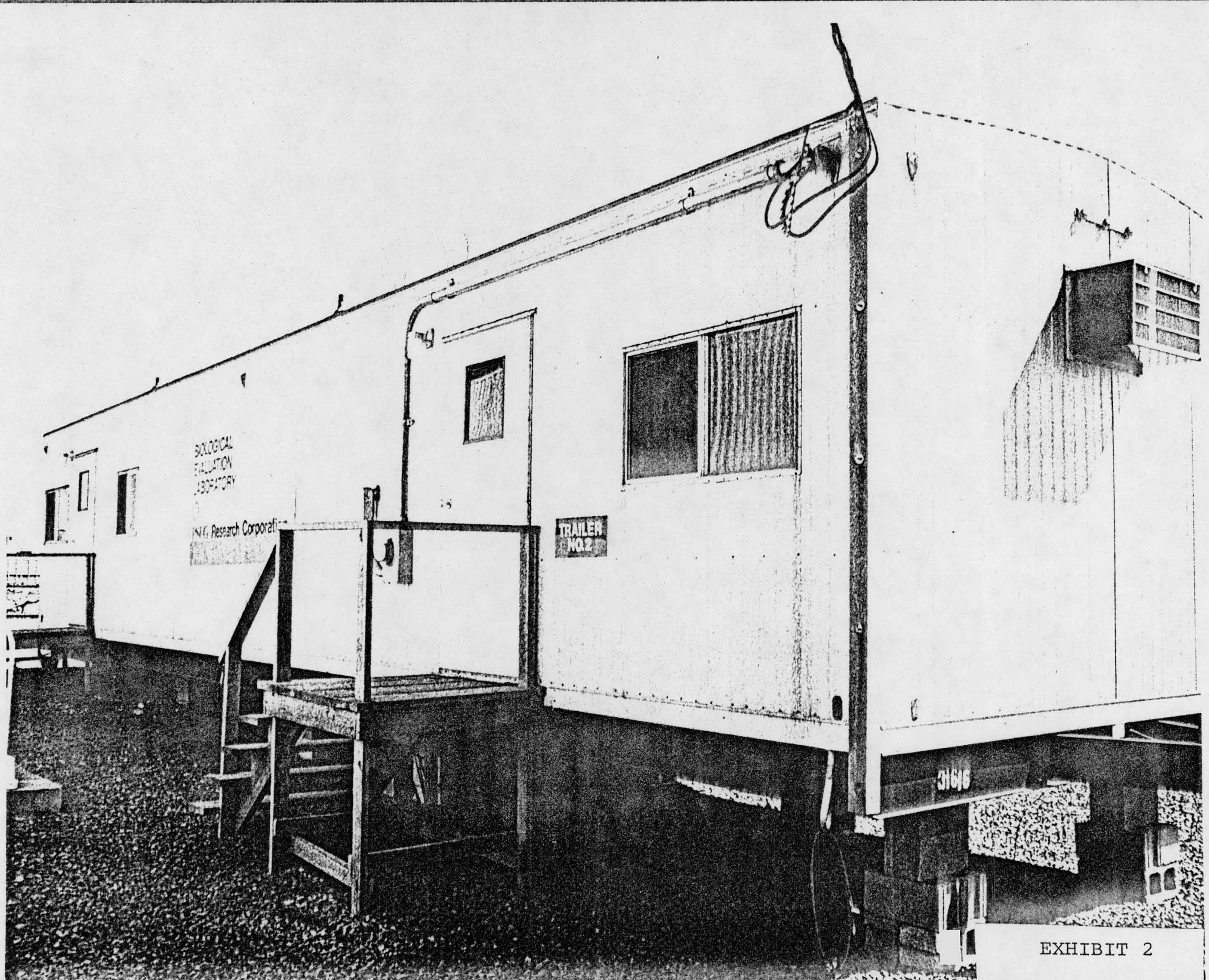

BIOLOGICAL
EVALUATION
LABORATORY
Research Corporation
TRAILER
NO.2
31646

EXHIBIT 2

EXHIBIT 3

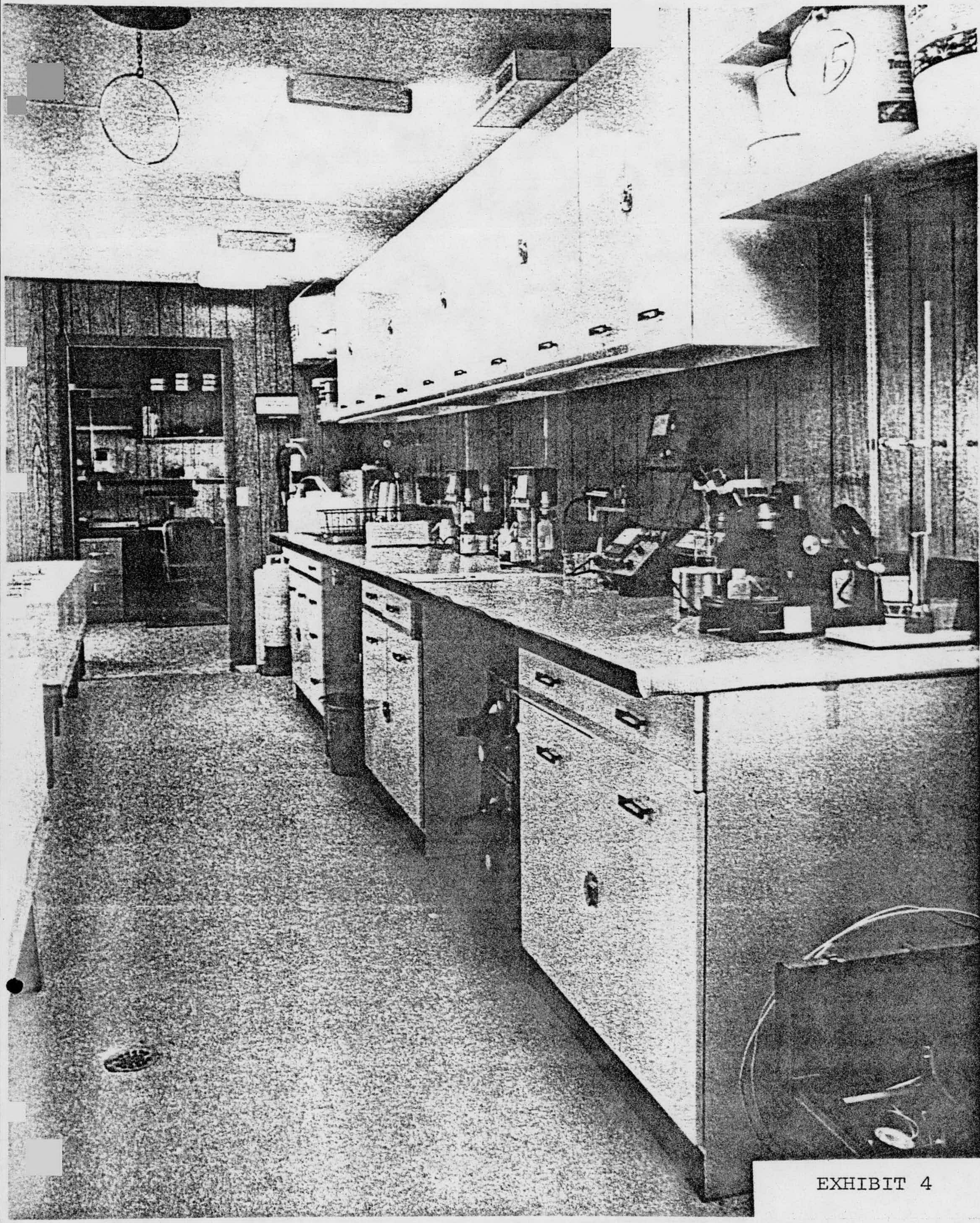


EXHIBIT 4

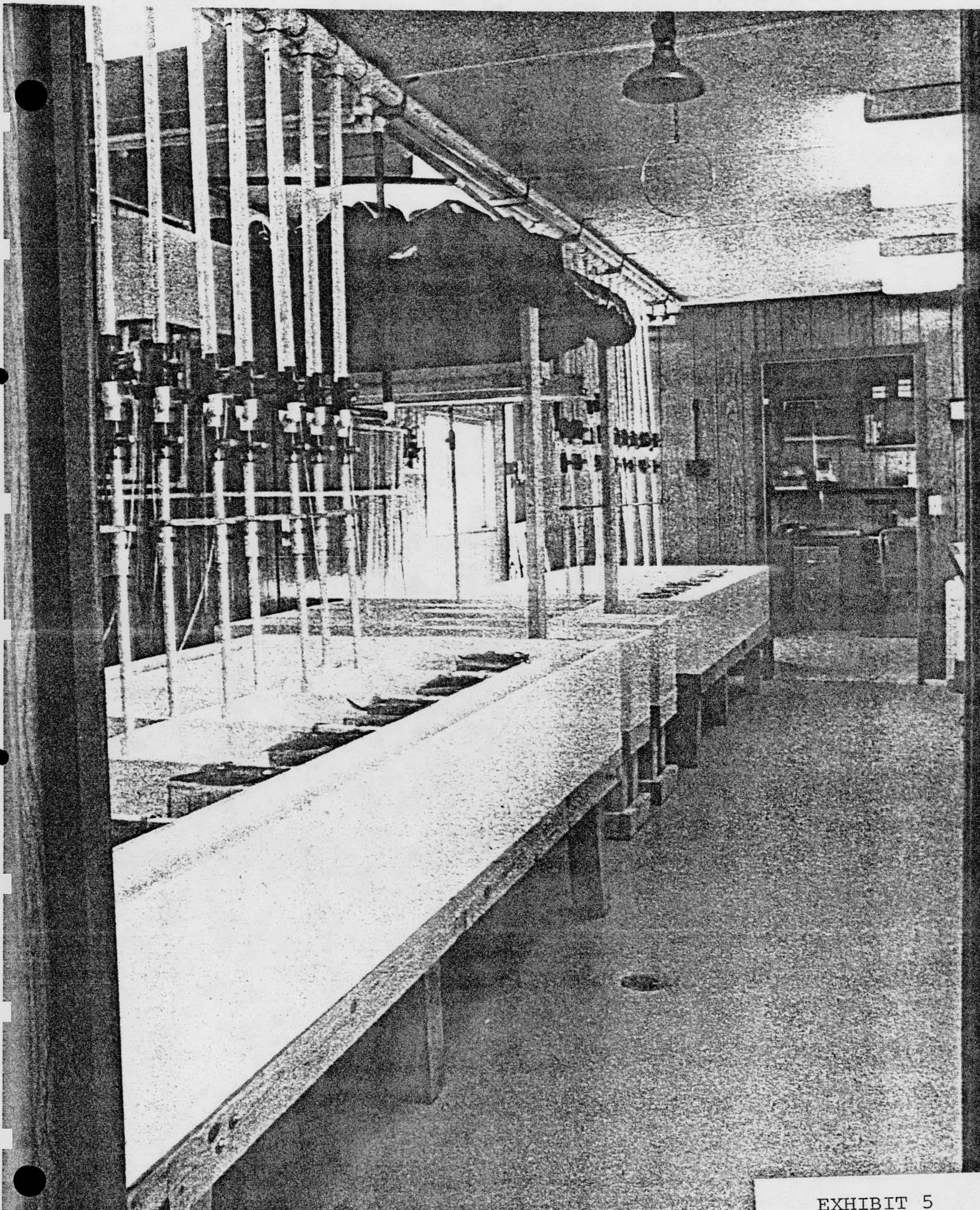


EXHIBIT 5

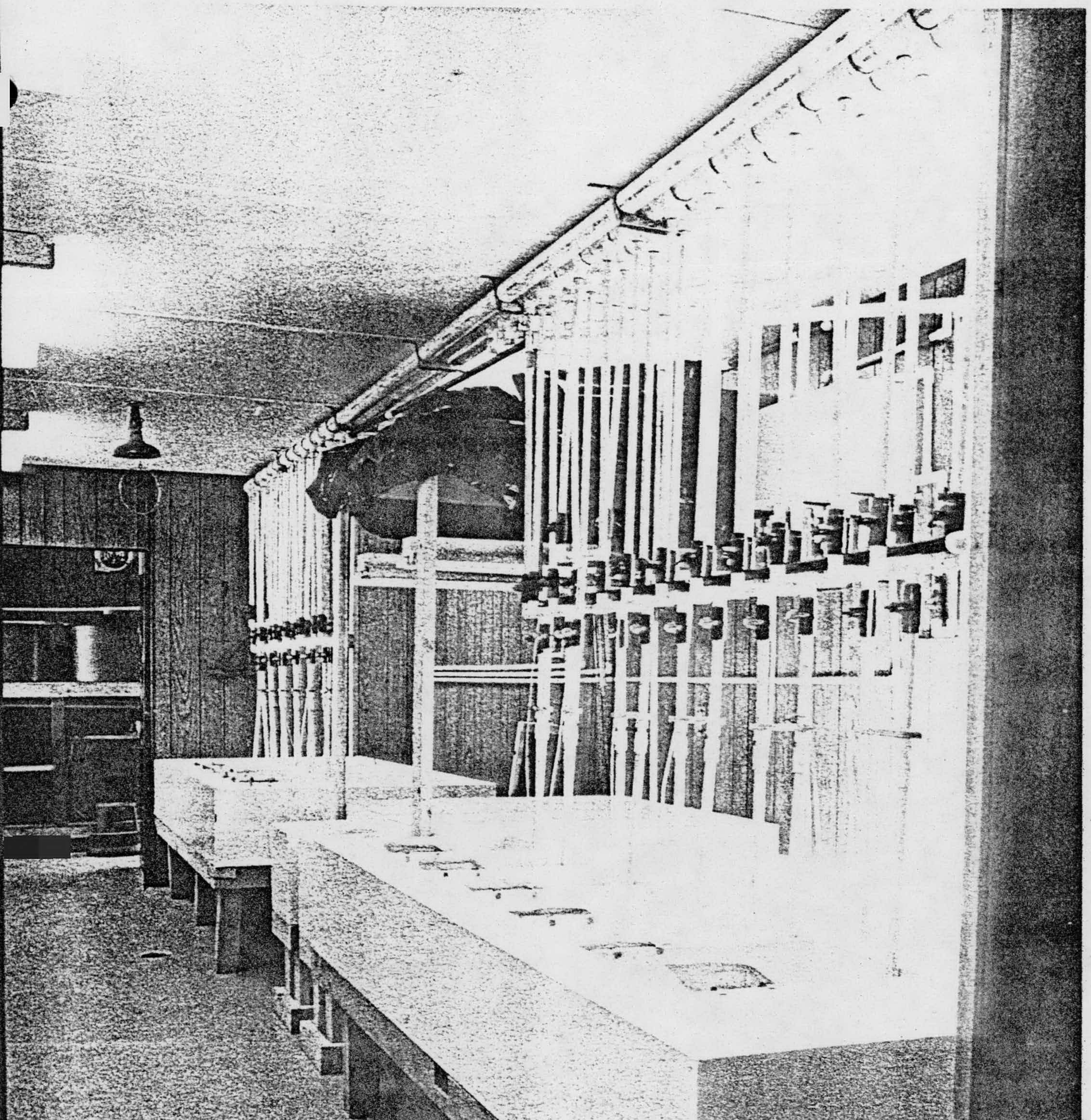


EXHIBIT 6

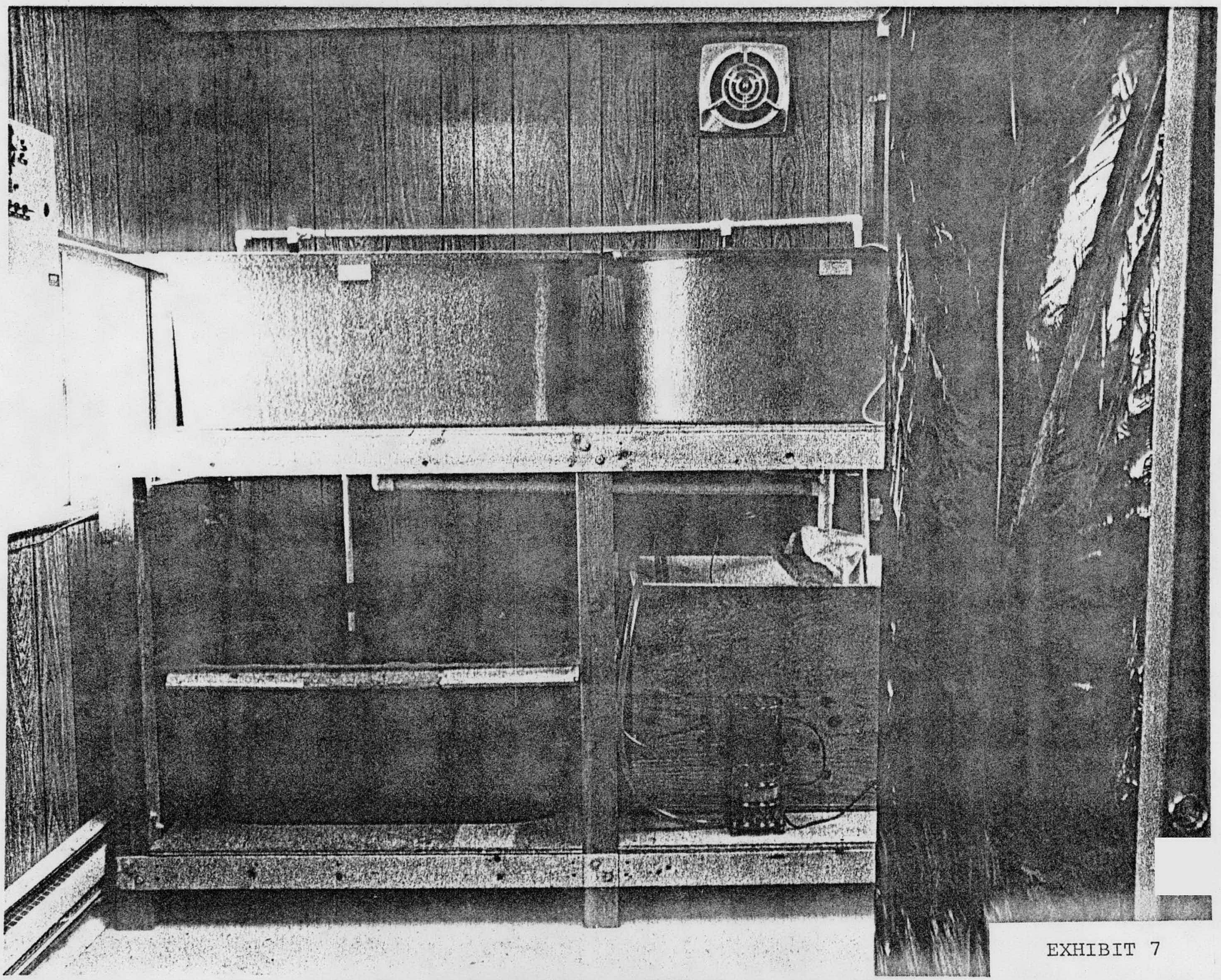


EXHIBIT 7

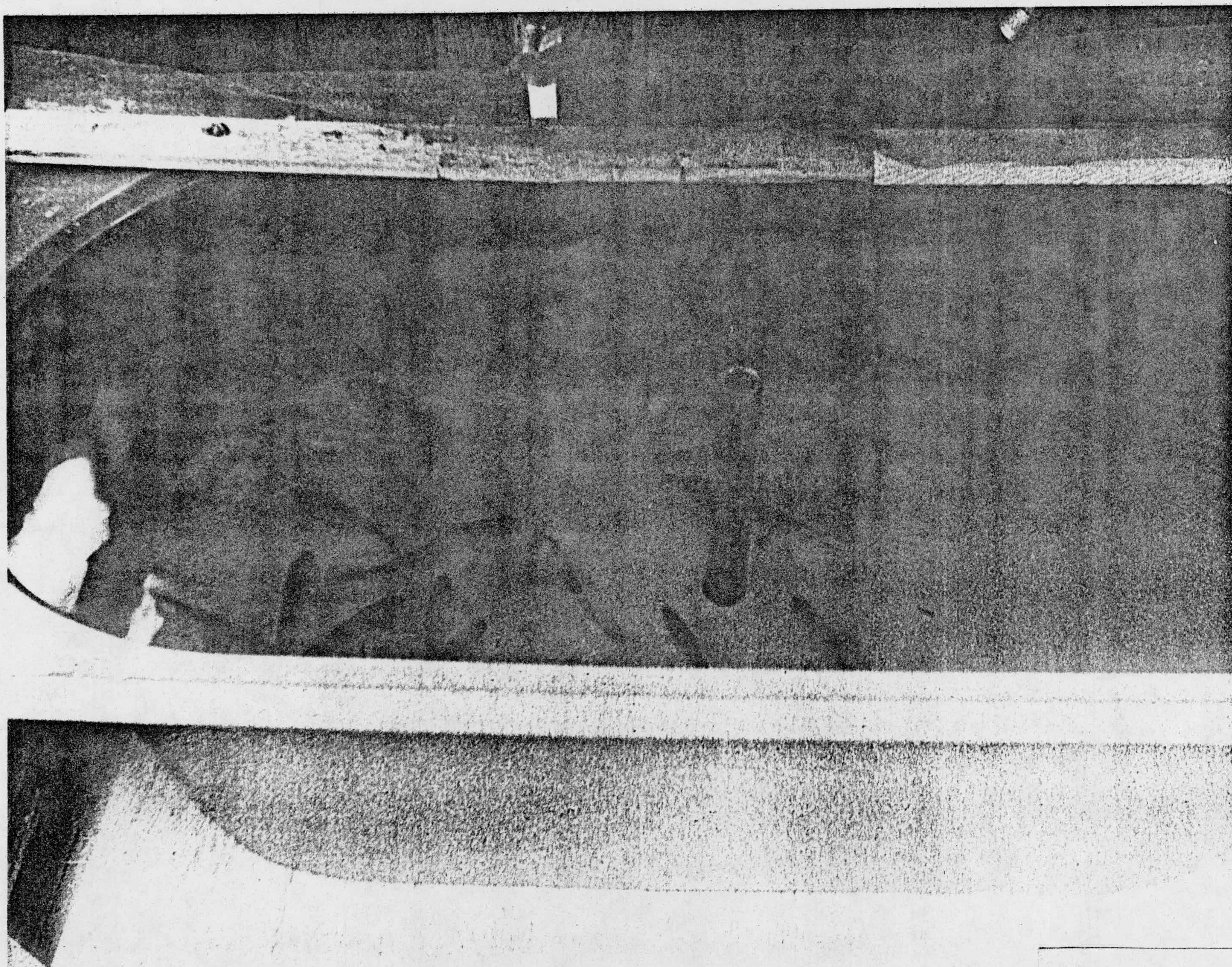


EXHIBIT 8

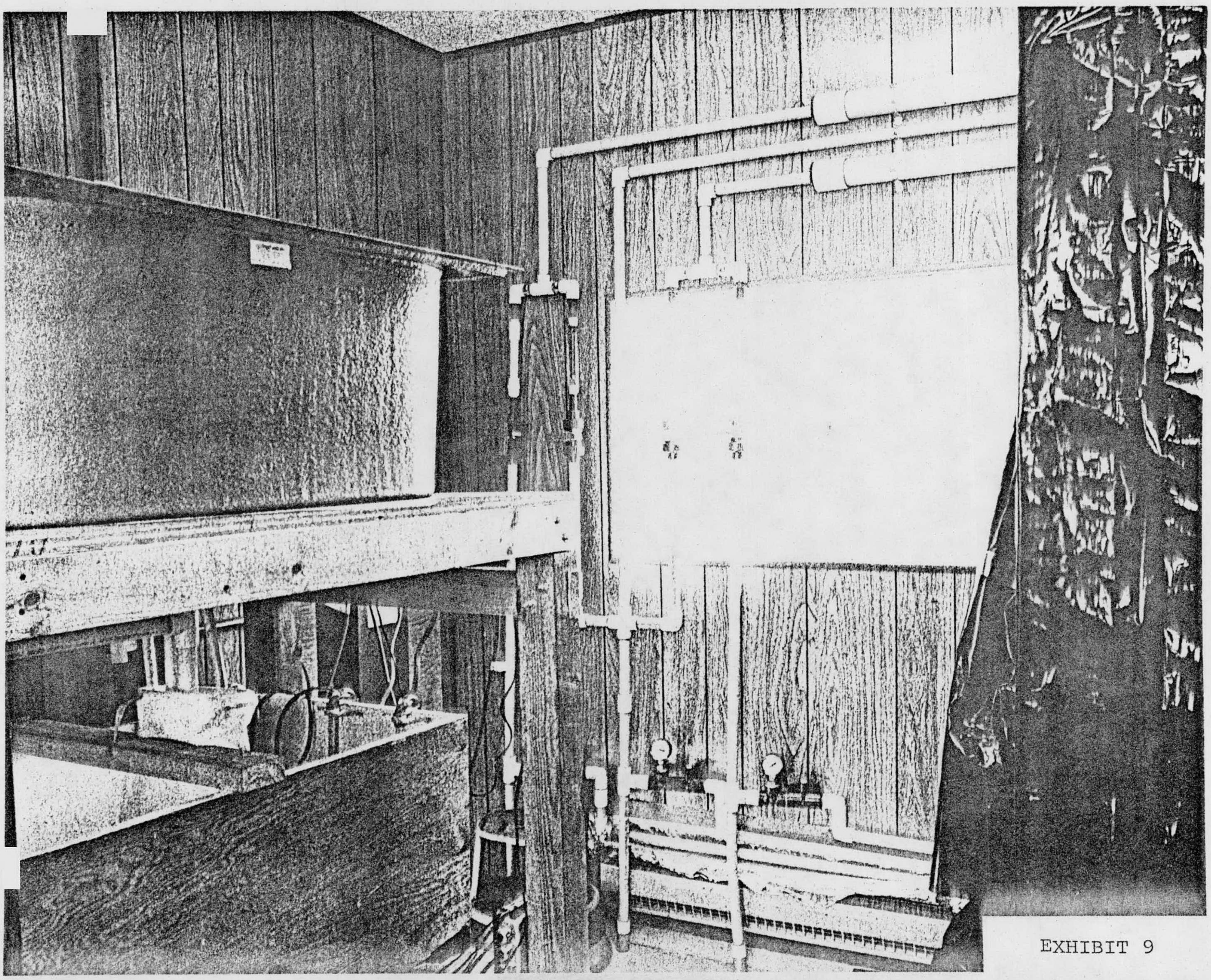


EXHIBIT 9

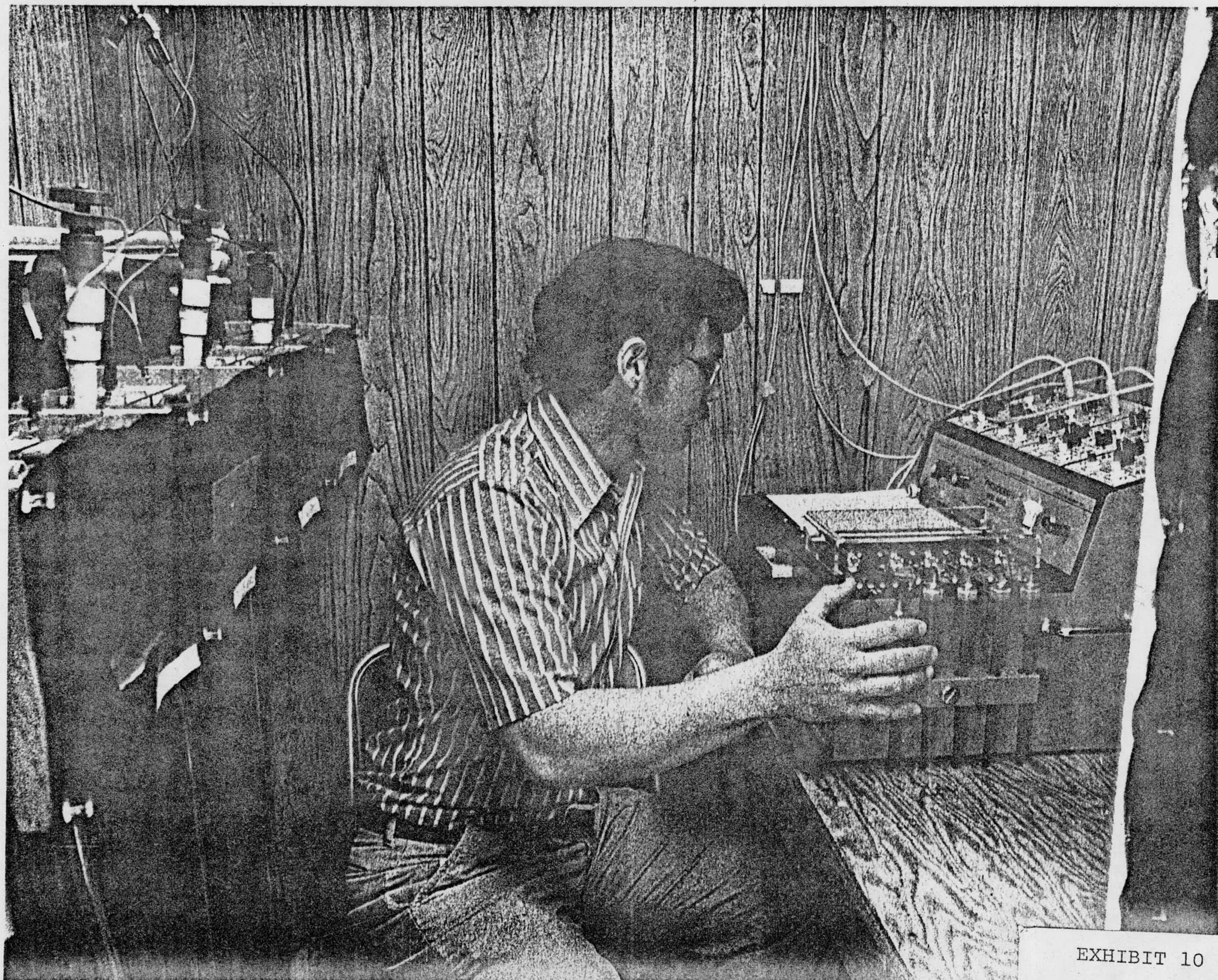


EXHIBIT 10