# AN INSTANCE OF THERMAL POLLUTION AND THE EFFECT ON TEMPERATURE AND OXYGEN LEVELS IN A MIDDLE GEORGIA RESERVOIR[1]

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## ABSTRACT

Limnological data collected during a four and one-half year period at Lake Sinclair is reviewed. Comparison of temperature and oxygen profiles are made in areas of the lake receiving hot water discharge and in unaffected areas. Hot water discharge was found to increase temperature and dissolved oxygen substantially during both summer and winter. In addition, hot effluent eliminated or altered the thermocline in the affected area. These effects were evident in varying degrees for 2.3 miles below the source. Observations concerning the sport fishery within the area receiving hot water discharge are noted. The possible effects of hot water discharge on the habitat and an aquatic ecosystem is also discussed.

## INTRODUCTION

Lake Sinclair is located in middle Georgia between Eatonton and Milledgeville in Putnam, Hancock and Baldwin counties. The main stem of the Oconee River was impounded in 1953 by the Georgia Power Company forming a 15,330 acre reservoir with 420 miles of shoreline. The Oconee and Little River are the major tributaries.

The Georgia Power Company operates a 45,000 kilowatt hydroelectric generating station at Sinclair Dam. In addition, this company operates Plant Harllee Branch, a steam-electric generating plant located on a peninsula between Little River and Beaverdam Creek. Water for cooling is pumped from Little River at a depth of approximately 20 feet, circulated through the steam plant and discharged into Beaverdam Creek. This discharge water is not circulated through a cooling tower. Four generating units are now operating 24 hours. A total of eight pumps (two for each generating unit) circulate cooling water through the steam plant at a rate of 791,100 gallons per minute. Plant Harllee Branch started operation in June, 1965 with one generating unit. Since then, three additional units were completed and put into operation in April 1967, June 1968, and June 1969, respectively. With these four generating units in operation, the plant has a rating of 1,539,000 kilowatts.

## PROCEDURES

To determine the effect of the hot water discharge in Lake Sinclair, five limnological sampling stations were selected in the Little River and Beaverdam Creek arms of the lake. During August, 1968, it was decided that Station No. 5 was superfluous and collection of data at this location was concluded. Temperature gradients and oxygen concentrations have been recorded monthly at four survey stations from January 1966 through July 1970. At each station, temperatures were recorded at five foot intervals and dissolved oxygen at ten foot intervals. Temperatures were collected using an electric thermometer and dissolved oxygen was measured by the Modified Winkler Method. During June, 1969, a

[1]This study was financed in part by Dingell-Johnson Project F-18-R, Work Plan II, Job 3, Special Limnological Investigations, Reservoir.

Weston and Stack dissolved oxygen analyzer (Model 300) was employed to collect temperature and oxygen data at all survey stations. Since that date oxygen concentrations have been recorded at five foot intervals. To determine the horizontal and vertical extent of thermal pollution in the Beaverdam Creek area, stations A and B (see Figure 1) were added during May, 1970. These stations were subject to more wind and wave action than other survey stations.

It should be noted that the maximum depth of all sampling stations varied from month to month due to water level fluctuations resulting from increased generation periods at Sinclair Dam and stream flow variations within the watershed.

## FINDINGS

Station No. 1 was located in the Little River arm of Lake Sinclair (see Figure 1) at U. S. Highway 441 Bridge. The maximum depth recorded at this location was fifty-five feet. This station is not affected by the steam plant discharge; therefore, temperature and oxygen data may be considered normal for the central portion of the lake. However, since the fourth generation unit began operation at Plant Harllee Branch, a slight upstream current has been detected at this station resulting from increased water intake. It should be noted that water pumped from a 20 foot depth to be used for cooling at the steam plant is taken from in or below the thermocline layer. Therefore, during the summer months this water may be very low in dissolved oxygen or actually devoid of oxygen. Summer stratification began during May and fall turnover occurred in October at this station. During July, a thermocline was present at a depth of 15 to 20 feet. Water temperatures began increasing during March, reaching a peak in July and exhibiting a sharp decrease during October (See Figure 2). Surface temperatures ranged from 45 F during winter to 95 F during the summer. Dissolved oxygen began dropping in late March, reached the lower level in June, and exhibited a sharp increase during September (see Figure 3). Oxygen concentrations at the surface ranged from a high of 11.4 ppm during the winter to a low of 5.6 ppm during the summer. During June and July water below 20 feet was completely devoid of oxygen.

Station No. 2 was located in the Beaverdam Creek arm of Lake Sinclair approximately one-half mile above the steam plant. Only a ten foot maximum depth was present at this station. Even though this station was located above the steam plant, higher than normal water temperatures were recorded due to great turbulence caused by large volumes of hot water discharged into Beaverdam Creek. No thermocline or summer stratification was evident at this station due to the shallow depth and turbulent eddy currents. Surface temperatures ranged from 57 F in the winter to 102 F during the summer. Surface oxygen concentrations ranged from 10.9 ppm during the winter to 5.1 ppm in the summer.

Station No. 3 was located in Beaverdam Creek at U. S. Highway 441 bridge crossing, approximately 150 yards below the steam plant. The maximum depth recorded here was 25 feet. This station was more directly affected by water discharged from Plant Harllee Branch than any other survey station. Thermal and chemical stratification was scarcely evident here due to the swift current and turbulence resulting from the large volume of water (791,100 gallons per minute) discharged by the steam plant. Temperatures on the surface ranged from 59 F in the winter to a high of 104 F during the summer. Dissolved oxygen at the surface ranged from 11.0 ppm during the winter months to 4.8 ppm in the summer.

Station No. 4 was located at the mouth of Beaverdam Creek approximately 1.2 miles below the steam plant. Forty feet was the maximum depth recorded at this station. A slight current, caused by steam plant discharge was still evident here. A distinct thermocline failed to develop at Station No. 4; however, a temperature gradient and chemical stratification did occur during the summer months. This phenomenon began in May and continued through August. Surface temperatures ranged from 48 F during the winter to a high of 99 F during the summer. Oxygen concentrations at the surface ranged from 11.1 ppm during the winter to 4.3 ppm in the summer. By the end of July, all water below 20 feet was devoid of oxygen.

Station A was located at the junction of Little River, Beaverdam Creek and the Oconee River approximately six-tenths of a mile east of Station No. 4. Dissolved oxygen and temperature profiles were recorded only during 1970 in May, June and July at this station. The maximum depth recorded at Station A was 44 feet. A thermocline was present at a depth of 25 feet. During July, water temperatures ranged from 91.4 F on the surface to 77 F on the bottom. Oxygen concentrations ranged from 4.8 ppm at the surface to 0.4 at a depth of 25 feet during this period. In July, a 19 foot column of oxygen devoid water was present below a depth of 25 feet at Station A.

Station B was located in the Oconee River arm approximately six-tenths of a mile due east of Station A. Dissolved oxygen and temperature data were only collected during 1970 in June and July at this location. The maximum depth recorded at this station was 50 feet. During June and July, a thermocline was present at a depth of 25 feet. In July, water temperatures ranged from 91.4 F at the surface to 75.2 F on the bottom. Dissolved oxygen concentrations ranged from 5.2 ppm on the surface to 2.0 ppm at a depth of 25 feet during the same period. A 25 foot column of oxygen devoid water was present below the 25 foot level in July.

Figures 2, 3, 4, 5, 6 and 7 further summarize oxygen and temperature data collected at Lake Sinclair during this study.

## DISCUSSION AND CONCLUSIONS

In comparing data collected in the Little River arm of Lake Sinclair with that recorded at the Beaverdam Creek stations, it is very evident that the aquatic environment has been drastically altered in Beaverdam Creek due to effluent from Plant Harllee Branch. Water of normal temperature and oxygen content is pumped from Little River, utilized as a coolant during steam plant operation, and discharged in large volumes into Beaverdam Creek in a hot, highly oxygenated state.[2] As a result the Beaverdam Creek arm of Lake Sinclair may now be considered a flowing stream. As estimated flow rate of 3 mph was observed at Station No. 3.

Average surface temperatures have exhibited a general increase since 1969 in Beaverdam Creek (See Figure 4). Water temperatures now average 15.8 degrees above normal in the vicinity of the steam plant. Temperatures as high as 25 degrees above normal have been recorded at Station No. 3. A high of 111.2 F was recorded during June, 1970 at Station No. 3. Surface temperatures during January in Beaverdam Creek now range from 59 F to 65 F (see Figure 5). In contrast, surface temperatures for Little River during the same period ranged from 45 F to 52 F. It should be noted that data collected during January, 1966 (see Figure 5) was during a period when the steam plant was not in operation for five days. Therefore, temperatures and dissolved oxygen were not influenced by steam plant effluent. Since the influence of hot water discharge was absent during this period, and temperatures and oxygen concentrations were comparable at all survey stations, it may be assumed that data recorded in Beaverdam Creek during January 1966 reflects normal conditions for this area. Surface temperatures during August in Beaverdam Creek now range 90 F to 100 F, while surface temperatures in Little River range from 82 to 86 during this period. (see Figure 6).

Dissolved oxygen remains high throughout the year in Beaverdam Creek (see Figure 3). This has resulted from the continual discharge of water super-

[2]Steam plant personnel can offer no explanation for this increase in dissolved oxygen.

saturated with oxygen from the steam plant. Thus, the normal inverse relationship of temperature and oxygen is minimized or absent in Beaverdam Creek. For example, dissolved oxygen as high as 13.2 ppm at a temperature of 104 F in June, 1969 at Station No.3 was recorded. The average dissolved oxygen was always higher at Beaverdam Creek stations than at Little River with the exception of January and February. During these months, temperatures were from 42 F to 45 F in Little River and a natural oxygen build-up occurred bringing oxygen levels above that in Beaverdam Creek for a short period.

Further analysis of data collected during this study reveals that approximately 3 percent of Lake Sinclair or approximately 470 surface acres are affected by hot, highly oxygenated water discharged by Plant Harllee Branch. The influence of this hot water discharge was found to extend 2.3 miles eastward from Station No. 3, beyond the mouth of Beaverdam Creek into the Oconee River arm of Lake Sinclair (see Figures 1 and 7). Both surface temperature and dissolved oxygen decreased sharply from Station No. 3 to Station No. 4, 1.1 miles due east. At this point, the surface temperature, during July, 1970 exhibited a decrease from 102.2 F to 95 degrees. Between these same stations during the above period, the oxygen concentration decreased from 5.6 ppm to a low of 4.4 at the surface. Surface temperatures continue to decrease for six tenths of a mile to Station A. Beyond this point, the temperature leveled off, at 91.4 degrees at Station B which is near the normal surface temperature (90.5 F) in Little River on this date. As water temperatures cooled between Station 4 and Station A, surface dissolved oxygen gradually increased to 5.2 ppm at Station B during the above period.

The increased water temperature and flow in Beaverdam Creek has resulted in a good winter fishery in this area. Creel census data and personal observations indicate a definite increase in catch of bass, crappie and white bass during winter months. Fish are attracted to this area during the winter by water temperatures ranging from 59 F to 71 F, while water temperatures in unaffected areas of Lake Sinclair seldom rise above 45 F during the winter months. In addition, the current resulting from the large volume of water discharged at the steam plant into Beaverdam Creek encourages the upstream migration of fish into this arm of Lake Sinclair. However, in June, July and August, it has become apparent that fish move out of the Beaverdam Creek vicinity due to high water temperatures. During the summer months, water temperatures now remain above 90 F in Beaverdam Creek (see Figure 6) which is above the temperature tolerance of most warm water species.

Since the Beaverdam Creek arm of Lake Sinclair has been changed from a warm water reservoir habitat to a not, highly oxygenated flowing stream it is obvious that these environmental conditions must affect aquatic organisms in this area. For example, increased spawning activity may be occurring and productivity of bottom organisms and plankton could also be altered. Certainly the increase in temperature and oxygen in this area has some effect on the bottom oxygen demand. There is also the possibility that the warm oxygenated water now present may serve as a reservoir for disease and parasite organisms which may over-winter in this area and increase in population, resulting in heavy infestation to the fish population at some later date. Since instances of thermal pollution will become more frequent due to the increase in demand for electric power and an increase in use of atomic power by industry, the author is of the opinion that further studies should be conducted to determine the effects of heated discharges on the aquatic ecosystem.

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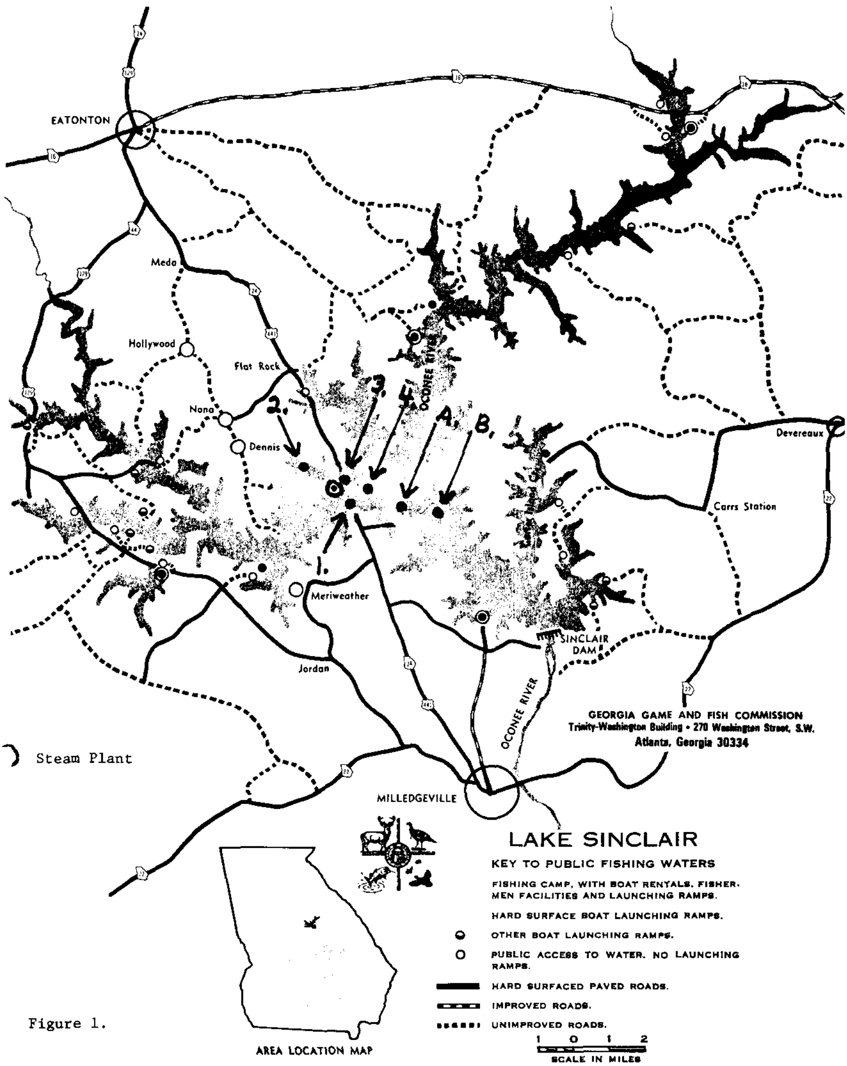


Figure 1.

1969 Monthly Average Temperatures For Lake Sinclair
At Beaverdam Creek (Station #3 Below Steam Plant)
And At Little River (Station #1)

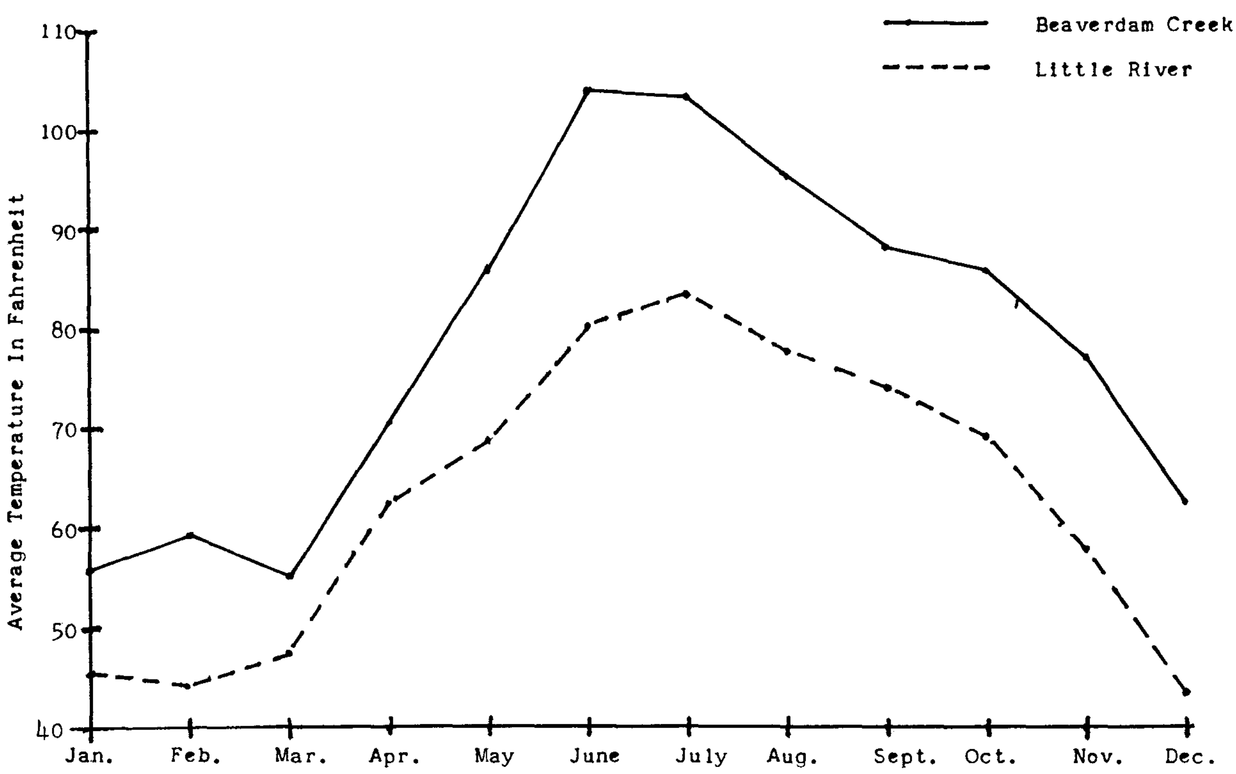


Figure 2.

1969 Monthly Average Oxygen Concentrations For Lake Sinclair
At Beaverdam Creek (Station #3 Below Steam Plant)
And At Little River (Station #1)

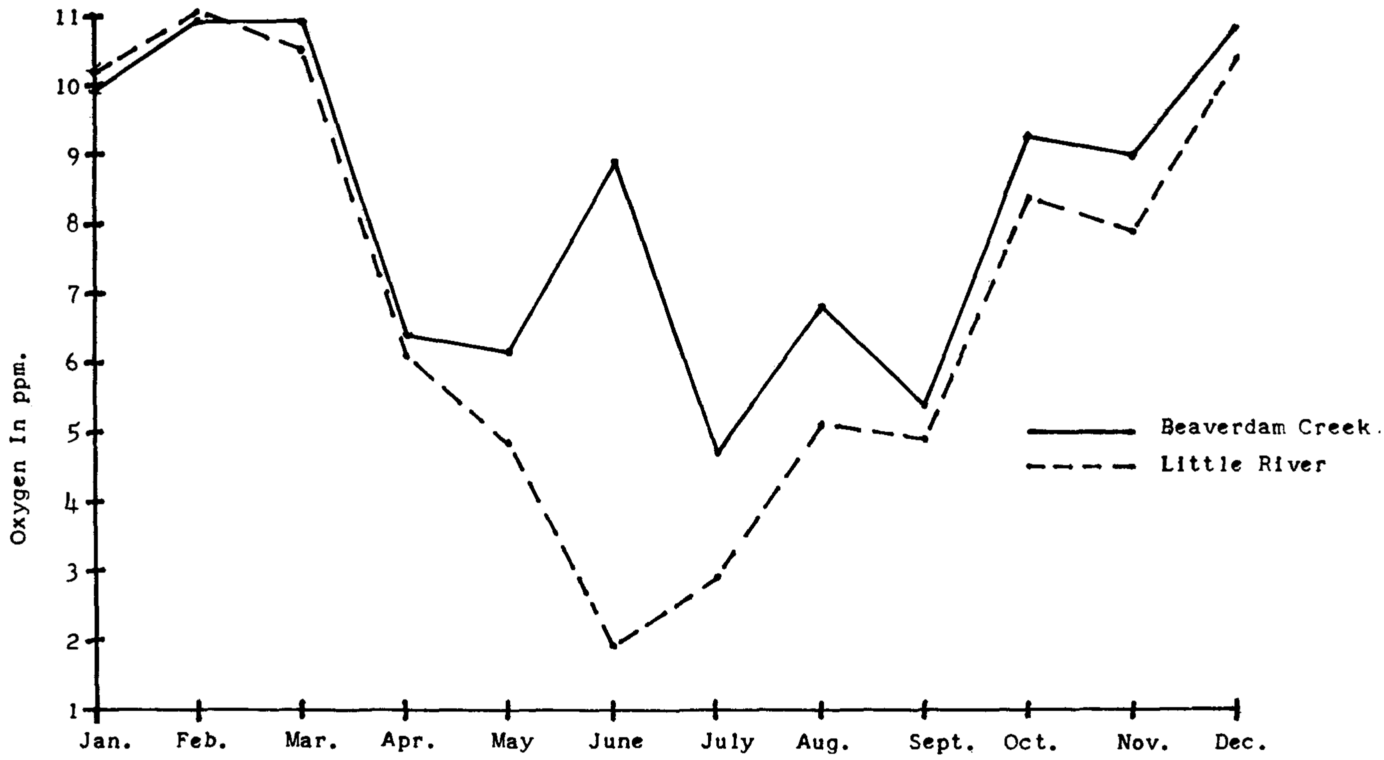


Figure 3.

Average Yearly Surface Temperature
For Little River And Beaverdam Creek
Arms Of Lake Sinclair 1966-1969

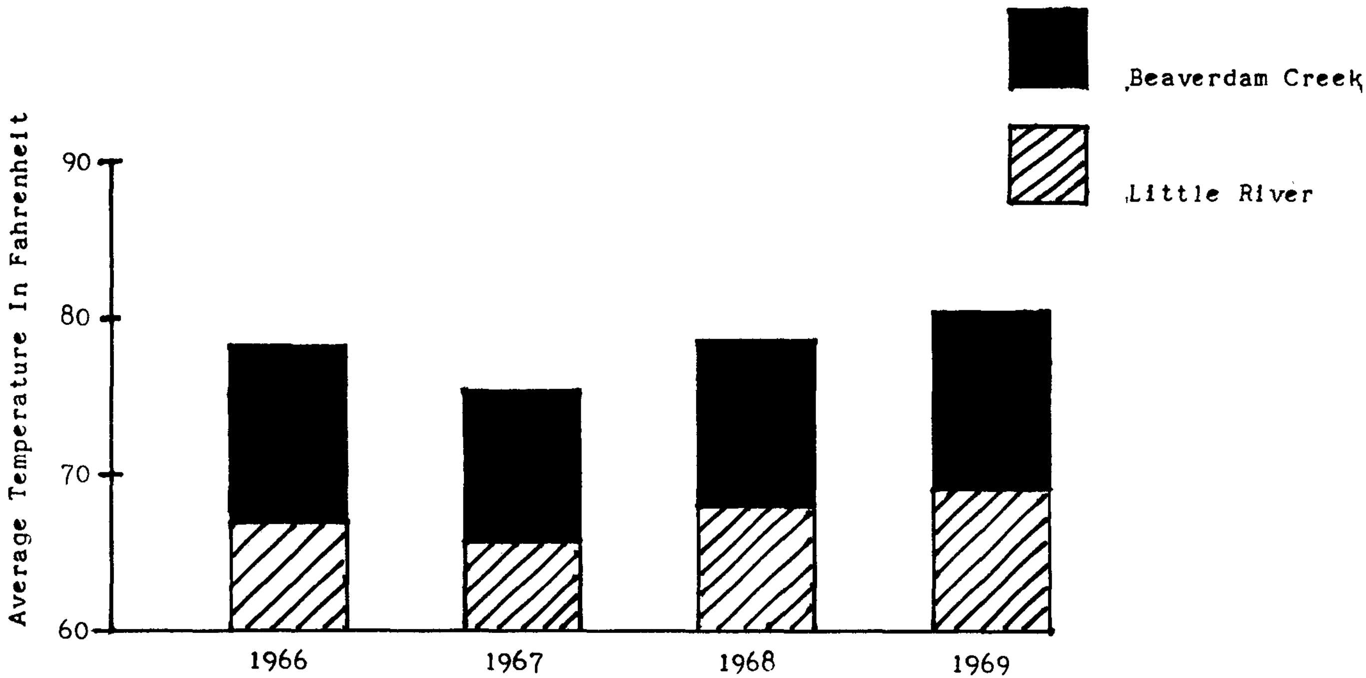


Figure 4.

SURFACE TEMPERATURE OF LITTLE RIVER AND BEAVERDAM CREEK DURING JANUARY 1966-JANUARY 1969

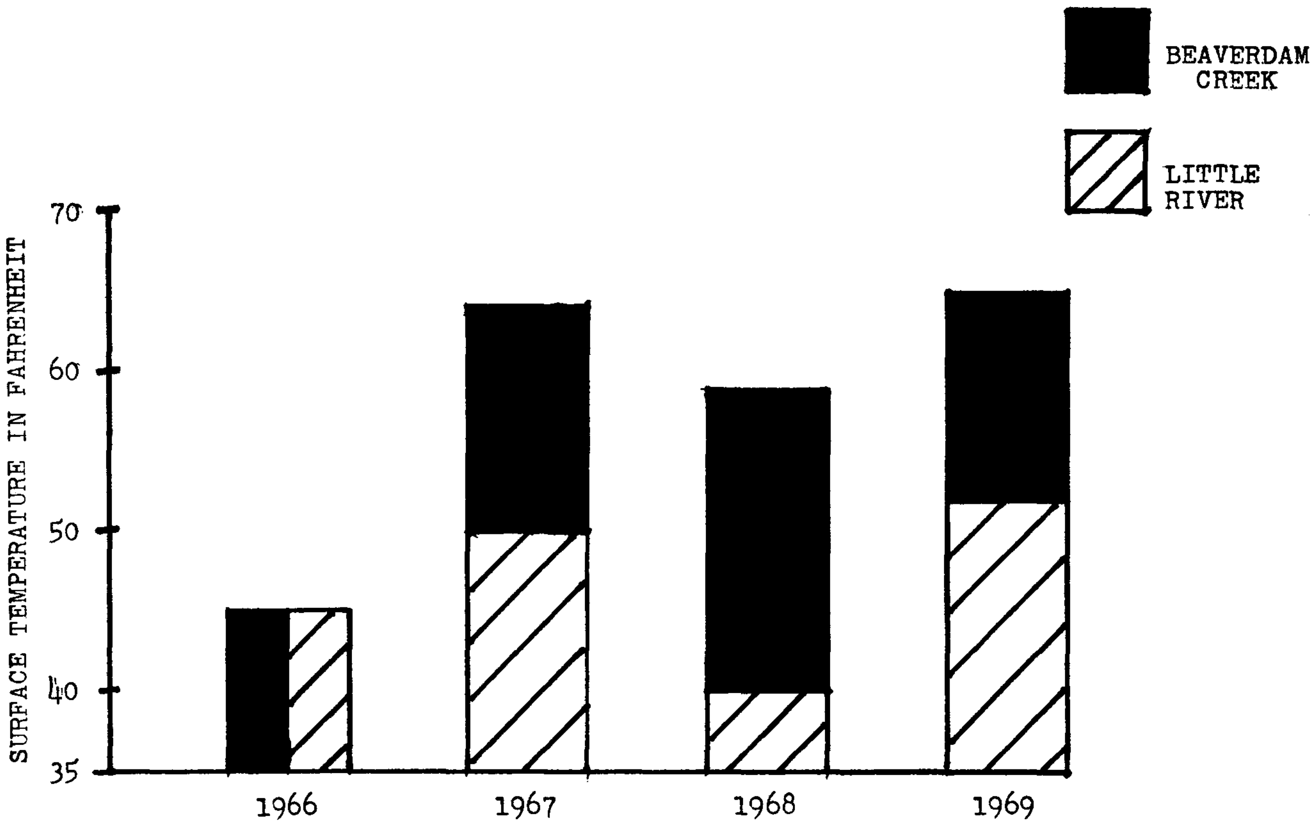


Figure 5.

SURFACE TEMPERATURE OF LITTLE RIVER AND BEAVERDAM CREEK DURING AUGUST 1966-AUGUST 1969

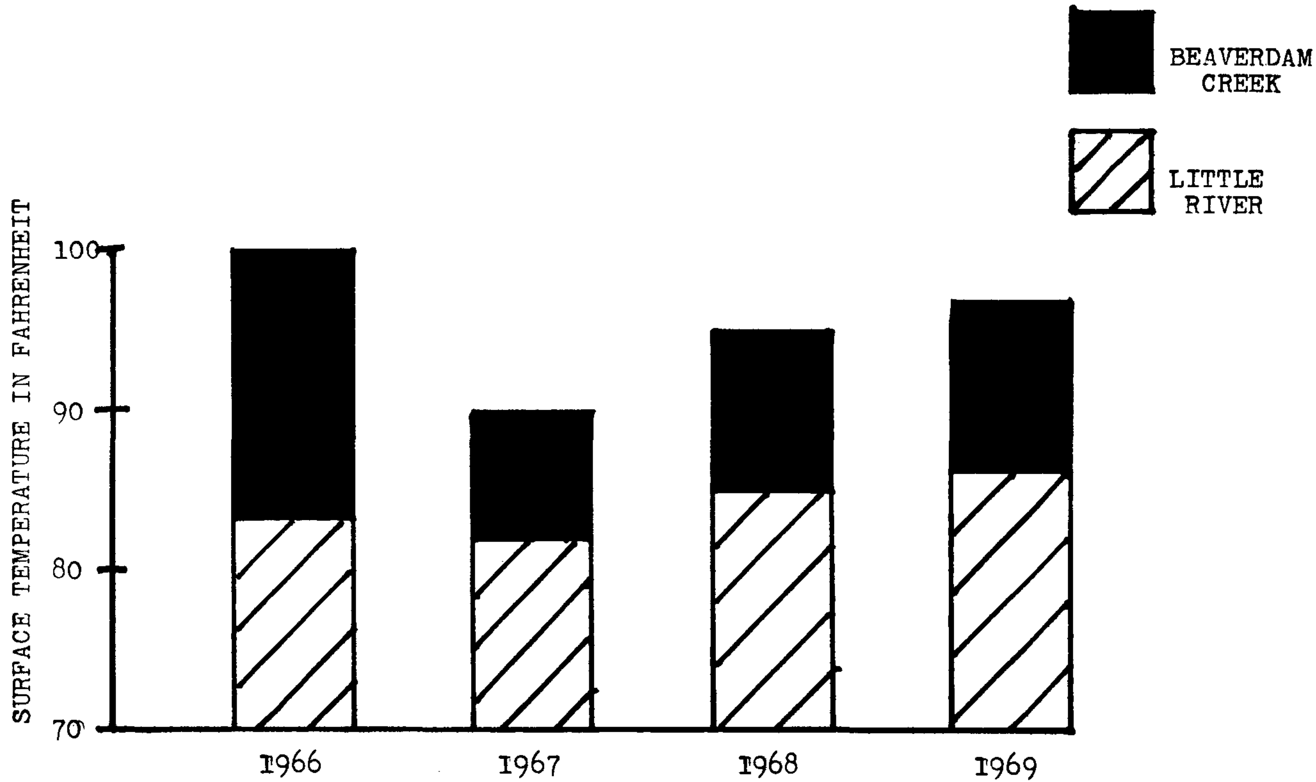


Figure 6.

EXTENT OF HOT OXYGENATED WATER IN LAKE SINCLAIR
DURING JULY 1970

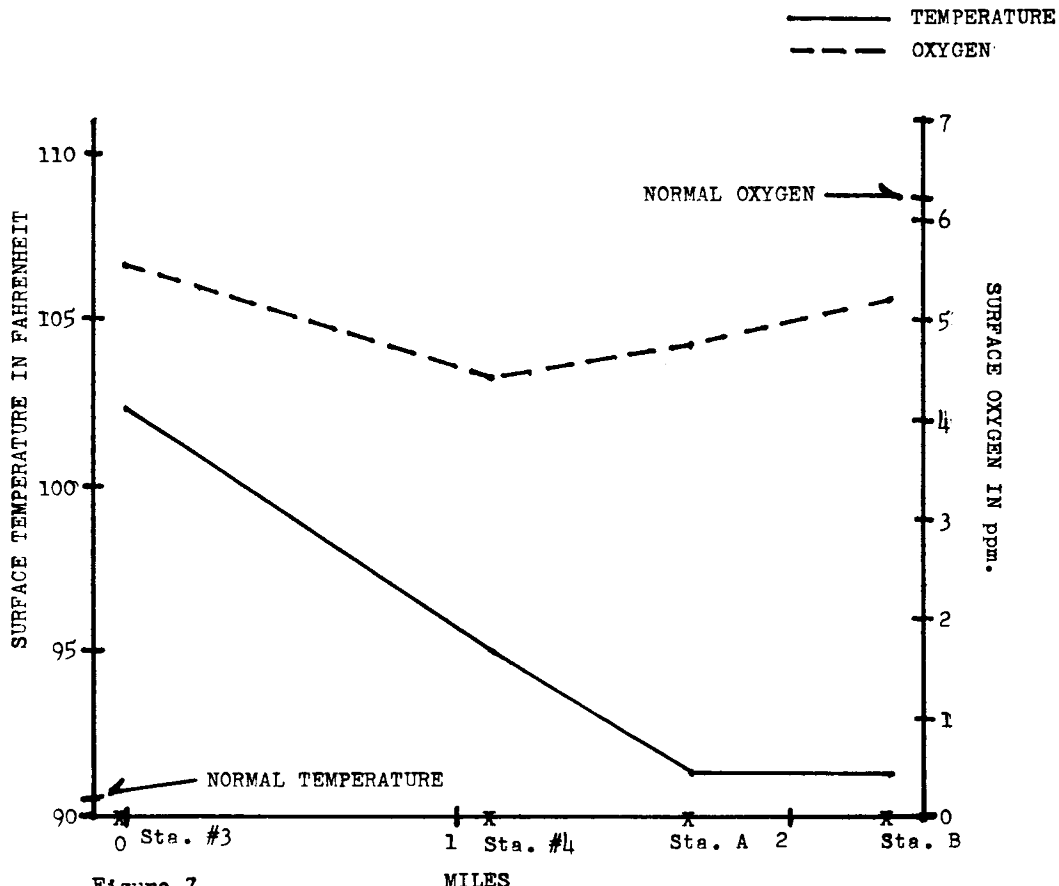


Figure 7.