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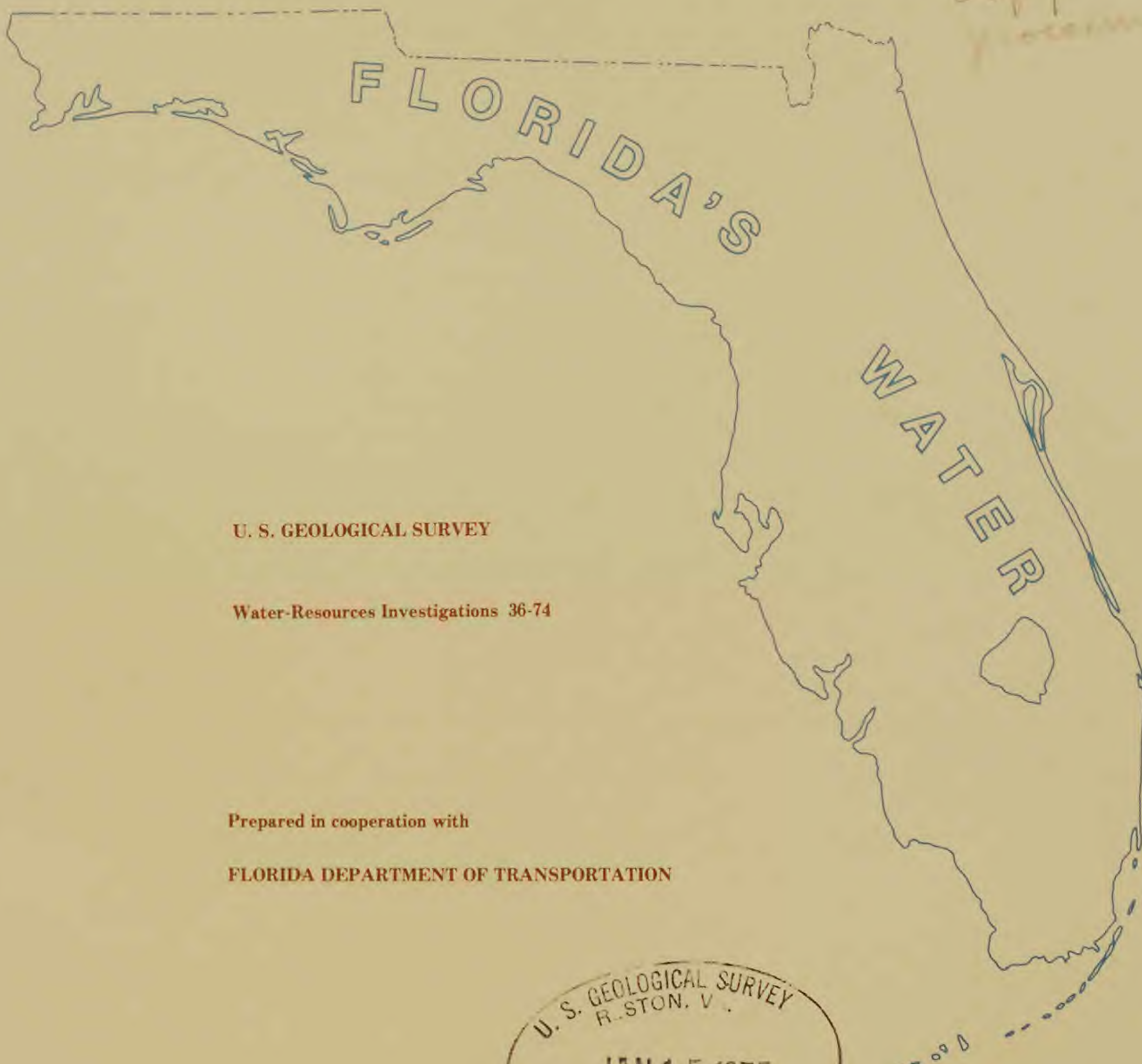

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After a storm drain was constructed to carry runoff from part of the city of Eustis into Lake Dicie, algal blooms occurred in the lake. Street runoff was found to contain high concentrations of nitrogen, phosphorus, and lead as well as other trace metals. The quantity of inorganic nitrogen and orthophosphate carried into the lake during the course of the investigation (March, 1971-June, 1973) was equivalent to about 3,500 pounds of commercial 6-6-6 fertilizer and was more than sufficient to support large populations of phytoplankton. Algal blooms occurred in the winter when the lake slowly "turned over," mixing the nutrient-rich bottom water with water from the upper part of the lake. An experiment in which lake samples were fertilized with nitrogen and phosphorus indicated that the explosive growth of phytoplankton was related to the abundance of inorganic nitrogen which was available to the phytoplankton during the winter when the lake was not stratified.

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CHEMICAL AND BIOLOGICAL QUALITY OF LAKE DICIE AT EUSTIS, FLORIDA WITH EMPHASIS ON THE EFFECTS OF STORM RUNOFF

By A. G. Lamonds

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 36-74

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December 1974

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CHEMICAL AND BIOLOGICAL QUALITY OF LAKE DICIE AT EUSTIS, FLORIDA WITH EMPHASIS ON THE EFFECTS OF STORM RUNOFF

By A. G. Lamonds

ABSTRACT

After the construction of a storm drain designed to carry runoff from the southeastern part of the city of Eustis into Lake Dicie, algal blooms occurred in the lake. In order to determine the nature and extent of these blooms, the quality of both the lake and storm runoff into the lake was monitored from March 1971 through June 1973.

Surface runoff makes up about 65 percent of the total input to the lake and the storm drain probably contributes about half of the total input. Average concentrations of the major ions in samples of storm runoff collected from the storm drain were not appreciably different from concentrations found in Lake Dicie. However, the storm runoff contained high concentrations of suspended sediment, nitrogen, phosphorus, lead and other trace elements.

Most of the sediment and trace elements and much of the phosphorus carried into the lake by storm runoff were trapped in the bottom sediments. The only appreciable change in the quality of the lake since it was first sampled in 1969 is a reduction in the concentration of phosphorus.

The amount of inorganic nitrogen and soluble orthophosphate carried into the lake during this investigation was equivalent to about 3,500 pounds (1,600 kilograms) of 6-6-6 commercial fertilizer. Most of these nutrients were taken up by the large phytoplankton population and eventually incorporated into the bottom sediments in Lake Dicie.

During much of the year Lake Dicie is thermally stratified and the water near the bottom becomes enriched with nutrients, particularly nitrogen, from the decomposition of algal cells and other organic matter. In the winter months, the water cools and the lake slowly "turns over." The mixing of the nitrogen-rich bottom water with the water in the upper part of the lake where the dissolved oxygen and light penetration are sufficient to support algae often results in explosive algal growth, commonly called a bloom. The two highest concentrations of phytoplankton observed in Lake Dicie during the investigation occurred in December when the lake was not stratified.

In Big Bass Lake, a control lake which receives no street runoff, the phytoplankton population is much smaller than in Lake Dicie. Variations in the concentration of phytoplankton appear to be more closely related to rainfall (the major source of nitrogen and phosphorus for Big Bass Lake) than to the seasonal turnover in the lake.

As an experiment, samples of water from both lakes were fertilized with inorganic nitrogen and orthophosphate. A comparison of the growth rates of phytoplankton in these samples over an 11-week period indicated that inorganic nitrogen was the limiting nutrient in Lake Dicie and that phosphorus was probably the limiting nutrient in Big Bass Lake.

INTRODUCTION

As part of a program to improve State Highway 19, the Florida Department of Transportation, in the summer of 1967, constructed a drain to expedite the removal of storm runoff from this highway and other streets in the southeastern section of Eustis, in Lake County. The storm runoff was collected at street gutters and storm drains and discharged into Lake Dicie thereby increasing the inflow of both water and chemical constituents into the lake. In March 1969, local residents reported an intense algal bloom in Lake Dicie. The appearance of this algal bloom prompted the Department of Transportation to request the U.S. Geological Survey to make a brief reconnaissance of the water quality in Lake Dicie. This was done in May 1969, when water samples for chemical analyses were collected from Lake Dicie and an adjacent lake, West Crooked Lake. The report (Knochenmus, 1969) containing the results of this brief investigation described Lake Dicie as having the appearance of "green pea soup" and indicated that Lake Dicie had much higher concentrations of the major nutrients, nitrogen and phosphorus than did nearby West Crooked Lake. Knochenmus concluded that the higher concentrations of nitrogen and phosphorus in Lake Dicie were related to the increase in drainage area and the increase in inflow through the storm drain. However, because the program was limited in scope the data collected were insufficient to indicate the source of these nutrients and the effects of the additional street drainage on the quality of the lake water.

Late in 1970, the Department of Transportation requested the U.S. Geological Survey to develop a water-quality monitoring program which would provide data for a better understanding of the water-quality problems in Lake Dicie. This monitoring program, which provided for the periodic measurement of physical, chemical, and biological parameters in the lake and in the street runoff entering the lake, began in March 1971, and continued through June 1973. This report presents the results of that monitoring program.

Throughout this report the results of chemical analyses have been expressed in the metric units of milligrams per litre or micrograms per litre, and temperature has been expressed in degrees Celsius. Measurements of length, depth, distance, area, and volume have been expressed in English units. For convenience, the English units appearing in the text are followed by the equivalent metric value in parentheses. The metric equivalents for values expressed in English units in the tables may be computed using the following conversions:

English unit	Multiplied by		Metric unit
inches	25.4	=	millimetres
	2.54	=	centimetres
feet	.3048	=	metres
miles	1.609	=	kilometres
acres	.4047	=	hectares
	4,047	=	square metres
acre-feet	1,233	=	cubic metres
tons	.9072	=	tonnes
pounds per cubic foot	16.02	=	kilograms per cubic metre
pounds	.4536	=	kilograms

Temperature in degrees Celsius can be converted to degrees Fahrenheit as follows:

$$^{o}F = 1.8 \times (^{o}C + 17.78)$$

PURPOSE AND SCOPE

The purposes of the water-quality monitoring program were to: (1) describe the quality of Lake Dicie; (2) describe the quality of the storm runoff which flows into the lake; (3) determine whether degradation of the quality of the lake is continuing; and (4) determine, to the extent possible, the effect that the diversion of storm runoff into the lake had on lake quality.

To meet these objectives, the monitoring program provided for the measurement of rainfall and lake stage and for the collection and analysis of water samples from the lake and the storm drain three times a year. The lake water was sampled and analyzed before and after rainstorms in April, August, and December. Storm runoff to the lake was sampled twice during each of these storms. A control lake, Big Bass Lake in Ocala National Forest, north of Eustis, was also sampled three times a year, in April, August, and December for chemical analyses. Both Lake Dicie and Big Bass Lake were sampled three times a year for phytoplankton analyses. Bottom sediments from each of the lakes were collected annually and analyzed for major nutrients.

METHODS

All water samples for chemical analyses were collected, preserved and analyzed by the U.S. Geological Survey in accordance with methods prescribed by Brown, Skougstad, and Fishman (1970). Except the oil and grease determinations, all chemical analyses performed in the laboratory were on depth-integrated samples. Water samples for bacteriological analyses were collected about 1 foot (0.3 metre) below the water's surface and analyzed by the U.S. Geological Survey using the membrane filter method.

Phytoplankton in the lakes were identified by Dr. Jackson L. Fox of the University of Florida at Gainesville. The identification was made on composite water samples consisting of equal amounts of water collected from three sites in each lake. These samples were collected just beneath the water surface near the center of the lake, near the windward shore, and near the lee shore. Phytoplankton were identified as to species when possible and counts were expressed as numbers of cells per millilitre.

DESCRIPTION OF LAKE DICIE AND DRAINAGE BASIN

Lake Dicie is a small closed basin lake just outside the city limits of Eustis. The lake is elliptical in shape and has a surface area of about 8 acres (3.2 hectares). Before the storm drain was placed in operation in 1967, Lake Dicie had a drainage area of about 70 acres (28 hectares) which consisted primarily of citrus groves on the north side of the lake and residential areas south and west of the lake. Installing the storm drain in 1967 more than doubled the drainage area of Lake Dicie increasing it to about 150 acres (61 hectares). The added drainage area is primarily residential and light commercial development where much of the runoff occurs from streets, roofs and other impervious surfaces. Thus, the proportionate increase in surface-water inflow to the lake probably is substantially greater than the increase in drainage area. The drainage area added by the installation of this storm drain is shown in figure 1.

West of Lake Dicie the land surface rises steeply but on the other three sides of the lake it rises gently. On the east side of the lake, only a narrow strip of land 5 or 6 feet (1.5 or 1.8 metres) higher than the normal lake stage separates Lake Dicie from West Crooked lake. Neither Lake Dicie nor West Crooked Lake has a surface outflow at normal stages.

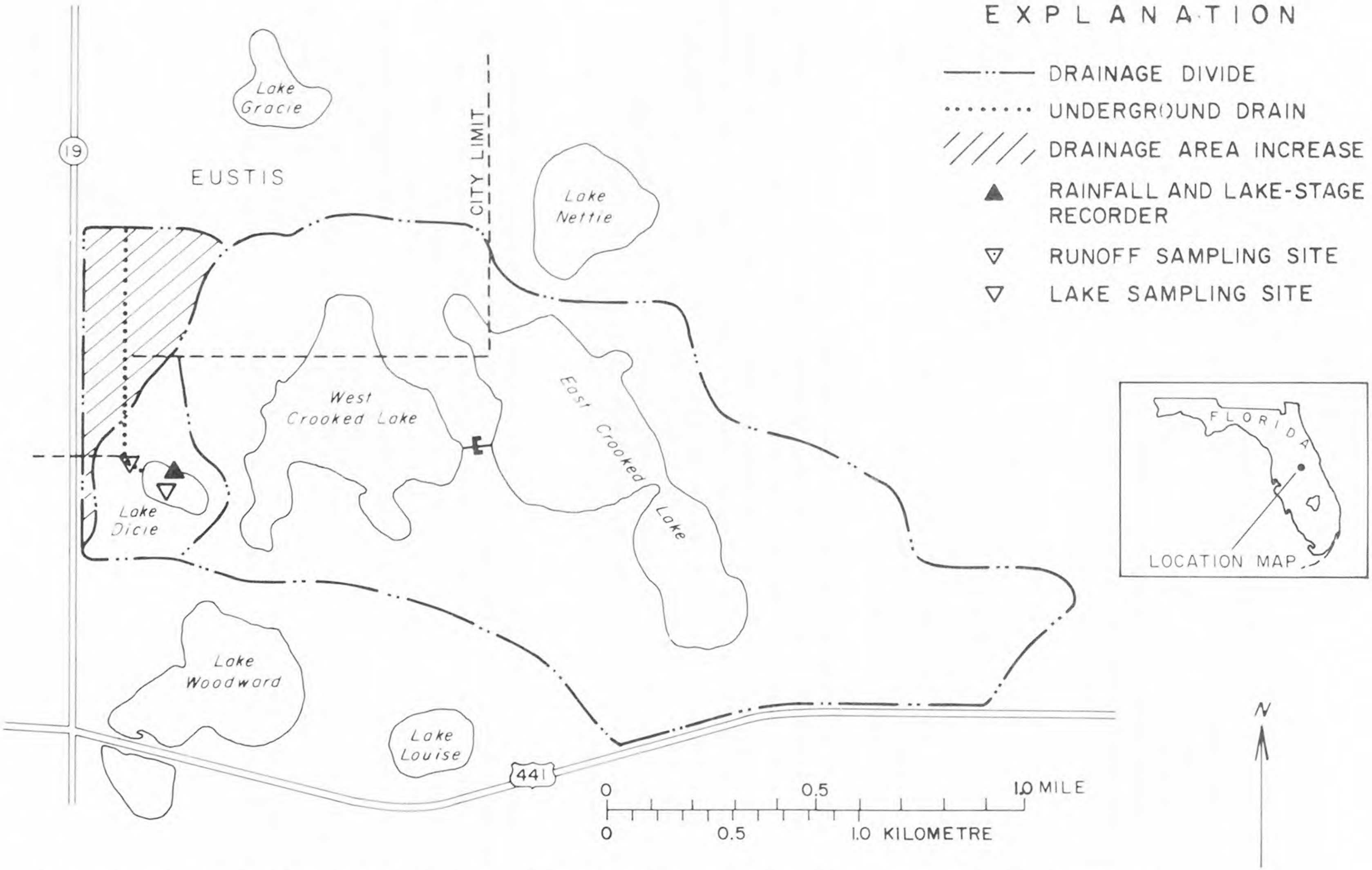

Figure 1.--Map of Lake Dicie and West Crooked Lake drainage basins showing locations of recorder and sampling sites. (Adapted from Knochenmus, 1969).

HYDROLOGY OF THE BASIN

As in any hydrologic system, rainfall is the ultimate source of water in Lake Dicie. Inflow to the lake consists of rainfall on the surface of the lake; overland and sewered runoff of rainfall on the drainage basin; and possibly seepage into the lake from a shallow aquifer that is in turn recharged by the percolation of rainfall through the soil. Some water is pumped from the lake for irrigation uses, but most of the water leaves the lake by evaporation and by seepage into the shallow aquifer or the Floridan aquifer, a deeper limestone aquifer which underlies most of central Florida.

Rainfall on Lake Dicie averages 48.50 inches (1,230 millimetres) per year, based on the average annual rainfall during 75 years of record at the National Oceanic and Atmospheric Administration (formerly U.S. Weather Bureau) station at Eustis. Generally, more than 50 percent of the annual rainfall occurs during June-September. Average monthly rainfall at Eustis (table 1) ranges from 1.80 inches (46 millimetres) in November to 7.22 inches (183 millimetres) in July.

The amount of runoff reaching a lake varies with the amount and intensity of the rainfall, topography of the basin, permeability of the soil or other surface materials, type of vegetative cover, soil moisture, and other factors. Because Lake Dicie is located on the west edge of a high sandy ridge where the soil is well drained, most of rain falling on the drainage basin percolates into the soil where it supplies moisture for plants and recharges the shallow aquifer. Only a small part of the rainfall in the basin reaches the lake as overland runoff (storm runoff). Average annual runoff from drainage basins in the vicinity of Eustis has been estimated to be in the range of 4 to 8 inches (100 to 200 millimetres) (Knochenmus, written commun., 1973).

The amount of ground water entering a lake as seepage is dependent upon the permeability of the lake bed and upon direction of the ground-water gradient. Where the water table slopes toward a lake ground water generally seeps into the lake. The water-table gradient and permeability of the lake bed have not been measured at Lake Dicie but analysis of the chemical quality of Lake Dicie, West Crooked Lake, storm runoff, and water from a shallow well on the east shore at East Crooked Lake, shown in figure 2, indicates that ground-water inflow to Lake Dicie probably is small in relation to surface-water inflow. The shallow ground water and the water in West Crooked Lake are magnesium sulfate waters whereas the water in Lake Dicie and the storm runoff entering Lake Dicie are calcium bicarbonate waters.

Table 1.--Average monthly rainfall at Eustis.

(Averages based on the periods 1891-1949, 1952-1957 and 1963-1972)

Month	Rainfall (Inches)	Rainfall (Millimetres)
January	2.52	64.0
February	2.79	70.9
March	3.05	77.5
April	2.55	64.8
May	3.75	95.2
June	6.16	156
July	7.22	183
August	6.75	171
September	6.23	158
October	3.39	86.1
November	1.80	45.7
December	2.29	58.2
Average Annual	48.50	1230

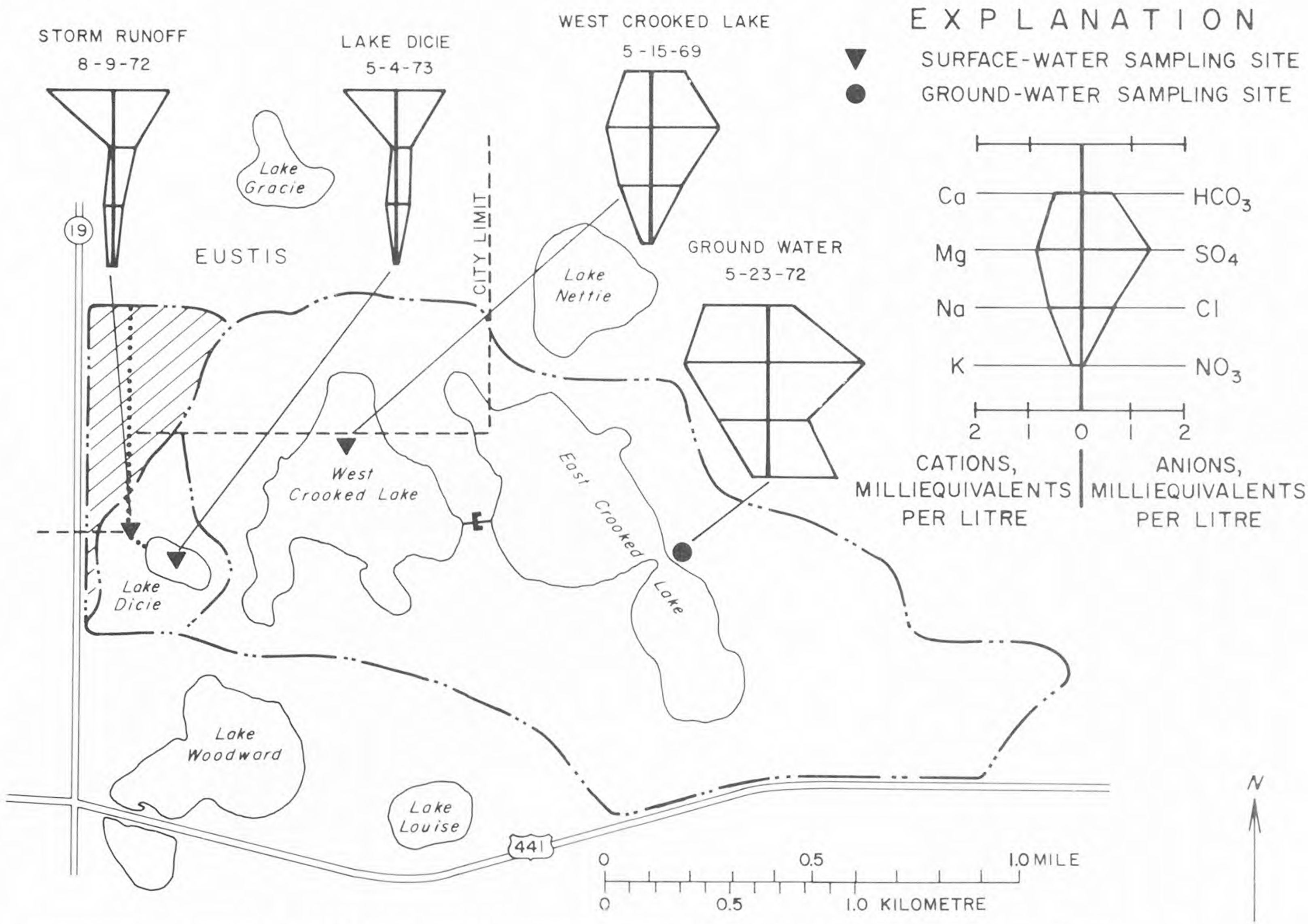

Figure 2.--Chemical quality of surface and ground water in the vicinity of Lake Dicie.

The water table beneath the high ridge just east of East Crooked Lake (fig. 2) stood more than 60 feet (18 metres) above the level of the lake in May 1973. Because of the steep water-table gradient, East Crooked Lake and West Crooked Lake probably receive large amounts of ground water, giving these lakes chemical characteristics similar to those of shallow ground water. If the chemical quality of water from the shallow well east of Lake Dicie truly represents the quality of ground water entering Lake Dicie, the volume of ground-water inflow from the shallow aquifer is small enough that its effect on the chemical quality of the lake is obscured by a greater volume of surface-water inflow.

Evaporation accounts for much of the water leaving Lake Dicie. Maps published by Kohler and others (1959) indicate that lake evaporation in the vicinity of Lake Dicie is equal to about 77 percent of Class A pan evaporation. On the basis of this pan coefficient and the average Class A pan evaporation at Lisbon, about 7 miles (11 kilometres) northwest of the lake, evaporation from Lake Dicie averages about 45 inches (1140 millimetres) a year and is nearly equal to the average annual rainfall. In years when rainfall is deficient, evaporation from Lake Dicie is sometimes greater than the rainfall on the surface of the lake.

Water leaving Lake Dicie also includes seepage out of the lake and the withdrawal of lake water for irrigation. The amount of water pumped from the lake for irrigation has not been accurately measured but it can be estimated. In much of Florida, citrus groves, particularly young groves, are irrigated. However, the mature citrus grove on the north side of Lake Dicie was not irrigated during this investigation. Lake water was used to prepare chemical sprays for the citrus trees but the amount of water used for this purpose was very small. Lake water was also used for lawn and garden irrigation at one home on the south side of the lake. Based on reported application rates and the size of the area irrigated, the amount of water used for lawn and garden irrigation in recent years has probably averaged less than 2 acre-feet (2,500 cubic metres) per year. Pumping from Lake Dicie probably resulted in lake-level declines of about 3 inches (7.6 centimetres) per year.

Because Lake Dicie gains more water from rainfall and storm runoff than it loses by evaporation and pumpage, Lake Dicie must lose water by underground seepage into the shallow aquifer or the Floridan aquifer. During the study the level of Lake Dicie was 1 to 3 feet (0.3 to 1 metre) higher than the level of West Crooked Lake. During dry periods the water table of the shallow aquifer may slope continuously from Lake Dicie to West Crooked Lake. Thus, at times some water could move eastward through the shallow aquifer from Lake Dicie to West Crooked Lake. Water may also be moving downward through the lake bottom to the Floridan aquifer, an extensive confined aquifer that underlies the lake basin at a depth of about 150 feet (46 metres). Maps of the potentiometric surface of the Floridan aquifer indicate that in the vicinity of Lake Dicie the static head of water in the Floridan aquifer is below the levels of Lake Dicie and neighboring lakes. Thus, there is a potential for downward seepage from Lake Dicie to the Floridan aquifer.

The amount of water leaving Lake Dicie in the form of seepage into the shallow aquifer or the Floridan aquifer is difficult to measure. Seepage can be calculated if the hydraulic gradient and the permeability of the lake bed and aquifer are accurately defined. The net of seepage into and out of a lake, hereafter called net seepage, is more easily determined by measuring the other components of the water budget and solving the following equation for the value of net seepage.

Net Seepage = Rainfall + Surface Inflow (Runoff) -Surface Outflow -Evaporation ± Change in Storage.

If over the long term the change in storage is zero and there is no surface outflow except irrigation withdrawals, net seepage must be equal to the sum of rainfall and surface inflow minus the evaporation losses and irrigation withdrawals. Inasmuch as the average annual rainfall at Lake Dicie is about equal to the sum of the average annual evaporation and the estimated withdrawals for irrigation, the net seepage must be out of the lake and about equal to the average annual runoff (surface inflow). This means that the average annual net-seepage loss is equivalent to a depth of more than 6 feet (1.8 metres) of water over the surface of the lake (assuming that the runoff from the drainage area averages 4 inches -- 100 millimetres -- per year).

Other than the water-quality data, the only hydrologic data collected during this investigation were lake-stage and rainfall data. These data indicated that between April 1, 1971, and June 30, 1973, rainfall at Lake Dicie was more than 10 inches (250 millimetres) below normal (average rainfall at Eustis). As a result of the rainfall deficiency, the stage of Lake Dicie declined 3.0 feet (0.91 metre) during this period. The month-end stage hydrograph and the graph of departure from normal rainfall are shown in figure 3. A comparison of the rainfall and lake stage data collected during this investigation indicates that the lake stage rises rapidly in response to rainfall and stops rising shortly after the rainfall ceases. Because the opportunity for evaporation and outseepage from Lake Dicie during the short periods of rising stage is very small, runoff can be estimated from the difference in the rise in stage and rainfall on the lake. Monthly totals of rainfall at Lake Dicie, rises in stage of the lake and runoff to the lake are given in table 2, for April 1971 through June 1973.

The total rainfall and runoff from April 1971 through June 1973 were equivalent to depths on the lake surface of 8.21 and 15.14 feet (2.50 and 4.61 metres), respectively. These values were used with the change in storage and estimates of evaporation and irrigation withdrawals in the water budget equation to determine the net-seepage loss during this period. The generalized water budget for Lake Dicie is given in table 3. The data in this table indicate that during the 27-month period the net-seepage loss was equivalent to a depth of 16.94 feet (5.16 metres) over the surface of the lake. This was almost twice the amount of water lost by evaporation and represents a large loss with respect to the lake and an appreciable amount of recharge to the aquifers. The table also indicates that the amount of water contributed to the lake by runoff was equivalent to a depth

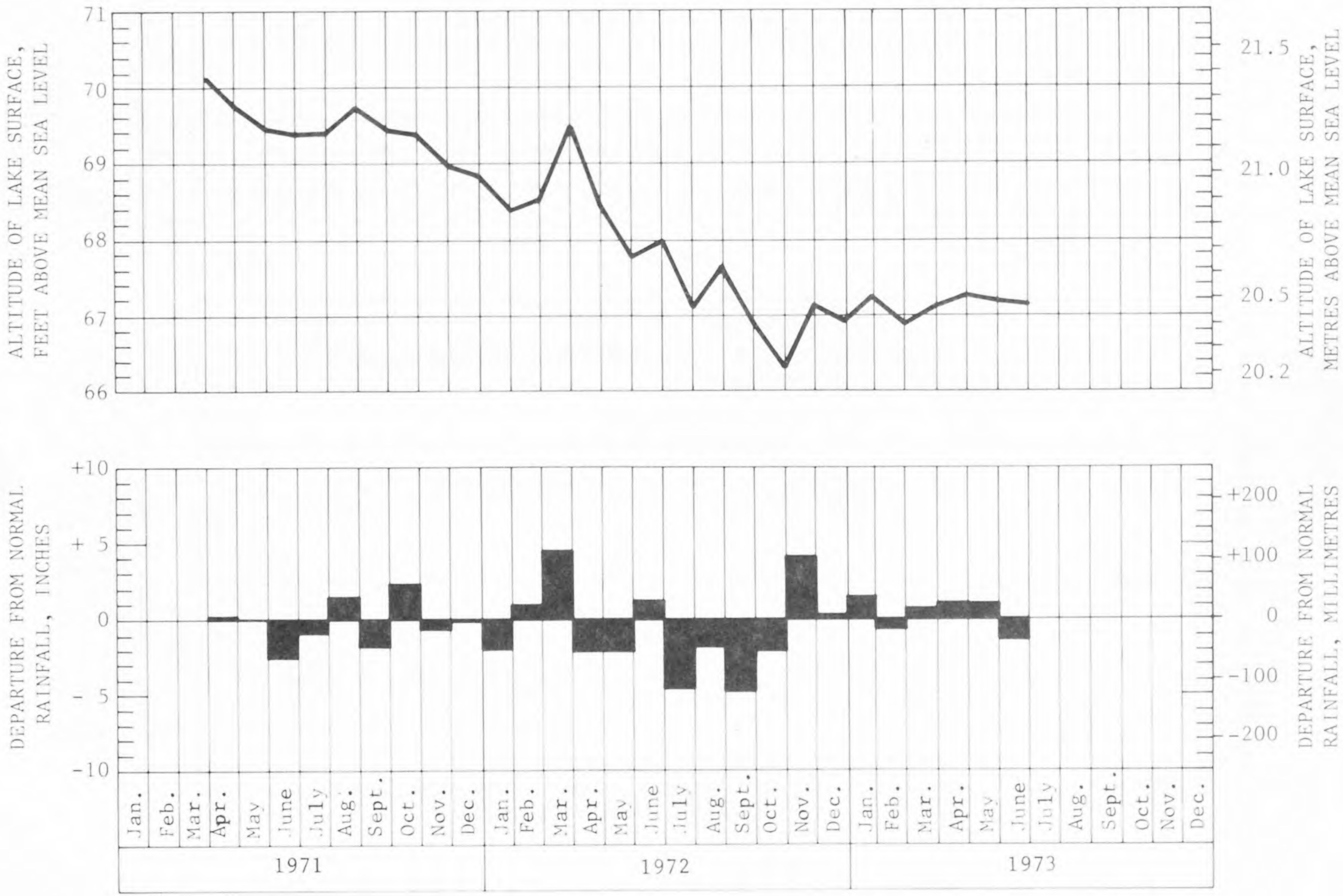

Figure 3.--Month-end lake stage and departure from normal rainfall at Lake Dicie.

Table 2.--Monthly total of rises in stage, rainfall and runoff for Lake Dicie.

Month	Sum of increases in lake stage (feet)	Rainfall		Runoff	
		(feet)	(inches)	(feet on lake surface)	(acre-feet)
April, 1971	0.57	0.23	2.76	0.34	2.7
May	1.00	.31	3.72	.69	5.5
June	.89	.28	3.36	.61	4.9
July	1.16	.52	6.24	.64	5.1
August	1.56	.67	8.04	.89	7.1
September	.73	.37	4.44	.36	2.9
October	1.11	.47	5.64	.64	5.1
November	.44	.08	.96	.36	2.9
December	.68	.18	2.16	.50	4.0
January, 1972	.24	.05	.60	.19	1.5
February	.89	.30	3.60	.59	4.7
March	1.84	.62	7.44	1.22	9.8
April	.11	.03	.36	.08	.6
May 1/	.25	.13	1.56	.12	1.0
June 1/	1.75	.60	7.20	1.15	9.2
July 1/	.57	.21	2.52	.36	2.9
August 1/	1.01	.40	4.80	.61	4.9
September	.40	.11	1.32	.29	2.3
October	.28	.10	1.20	.18	1.4
November	1.42	.49	5.88	.93	7.4
December	.64	.21	2.52	.43	3.4
January, 1973	.99	.32	3.84	.67	5.4
February	.45	.17	2.04	.28	2.2
March	1.02	.30	3.60	.72	5.8
April	1.21	.29	3.48	.92	7.4
May	1.07	.38	4.56	.69	5.5
June	1.07	.39	4.68	.68	5.4

1/ Rainfall and runoff records synthesized for one or more days from rainfall at Eustis and rainfall-runoff relation.

Table 3.--Generalized water budget for Lake Dicie, April 1, 1971 through June 30, 1973.

Inflow			Outflow			Change in storage		
Source	Feet	Acre-feet[1]	Source	Feet	Acre-feet[1]	Source	Feet	Acre-feet[1]
Rainfall on the lake	8.21	65.7	Evaporation[2]	8.85	70.8			
Runoff	15.14	121.1	Net seepage	16.94	135.5			
			Irrigation withdrawals[3]	.56	4.5			
Total	23.35	186.8	Total	26.35	210.8	Net decline	3.00	24.0

1. Acre-feet computations are based on a surface area of 8.0 acres.
2. Estimated from Class A pan evaporation at Lisbon, Fla., and a pan coefficient of 0.77.
3. Estimated from reported application rates on lawns.

of 15.14 feet (4.61 metres) over the surface of the lake and was almost twice the amount of rainfall on the lake. Runoff averaged 53.8 acre-feet (66,300 cubic metres) per year which represents an annual runoff of 4.3 inches (110 millimetres) from the drainage basin. An annual runoff of 4.3 inches (110 millimetres) is equivalent to the natural runoff from sandy terrain and suggests that the natural runoff to Lake Dicie is considerably lower than the 4 to 8 inches (100 to 200 millimetres) estimated earlier.

CHEMICAL QUALITY OF LAKE DICIE

In order to determine the quality of Lake Dicie and describe any changes that might be occurring in that quality, the lake was sampled before and after rainfall three times a year (in April, August, and December). For comparison, Big Bass Lake near Starkes Ferry, Florida, about 11 miles (18 kilometres) north of Eustis, was sampled three times a year in April, August, and December. Big Bass Lake is in the Ocala National Forest and receives virtually no runoff from paved streets or highways. It was selected as a control lake so that concentrations of nutrients, trace metals, and other substances in Lake Dicie might be compared with the concentrations of those elements in a lake that is affected very little by man. During April 1971-June 1973, field determinations were made and water samples were collected for chemical analyses 14 times at Lake Dicie and 7 times at Big Bass Lake. Results of these analyses are given in tables A1 through A7 in the basic data.

Lake Dicie contains a hard, alkaline, calcium bicarbonate water whereas Big Bass Lake contains a soft, acidic, sodium chloride water. The mineral content of Big Bass Lake is much less than that of Lake Dicie as can be seen from the graph of dissolved solids in figure 4.

The difference in dissolved-solids concentrations of the two lakes is due primarily to the higher concentrations of calcium and bicarbonate ions in Lake Dicie. Data in tables 4 and 5, which summarize the chemical and physical characteristics of the two lakes, indicate that Lake Dicie also contained higher concentrations of potassium, sulfate and several other ions but these made up only a small part of the dissolved solids. Average concentrations of dissolved trace elements, including lead and other metals, normally associated with automobile emission products, were low in both lakes. The average concentration of mercury and dissolved aluminum, manganese, nickel, strontium and vanadium was slightly higher in Lake Dicie than in Big Bass Lake.

The average concentration of a major nutrient, nitrogen, (total N), in Lake Dicie was almost identical to the average concentration in Big Bass Lake. In Lake Dicie, however, a much higher percentage of the total nitrogen was in the inorganic form which is more readily used by plants. Data in tables 4 and 5 indicate that the highest concentration of ammonia in Lake Dicie was seven times the highest concentration in Big Bass Lake.

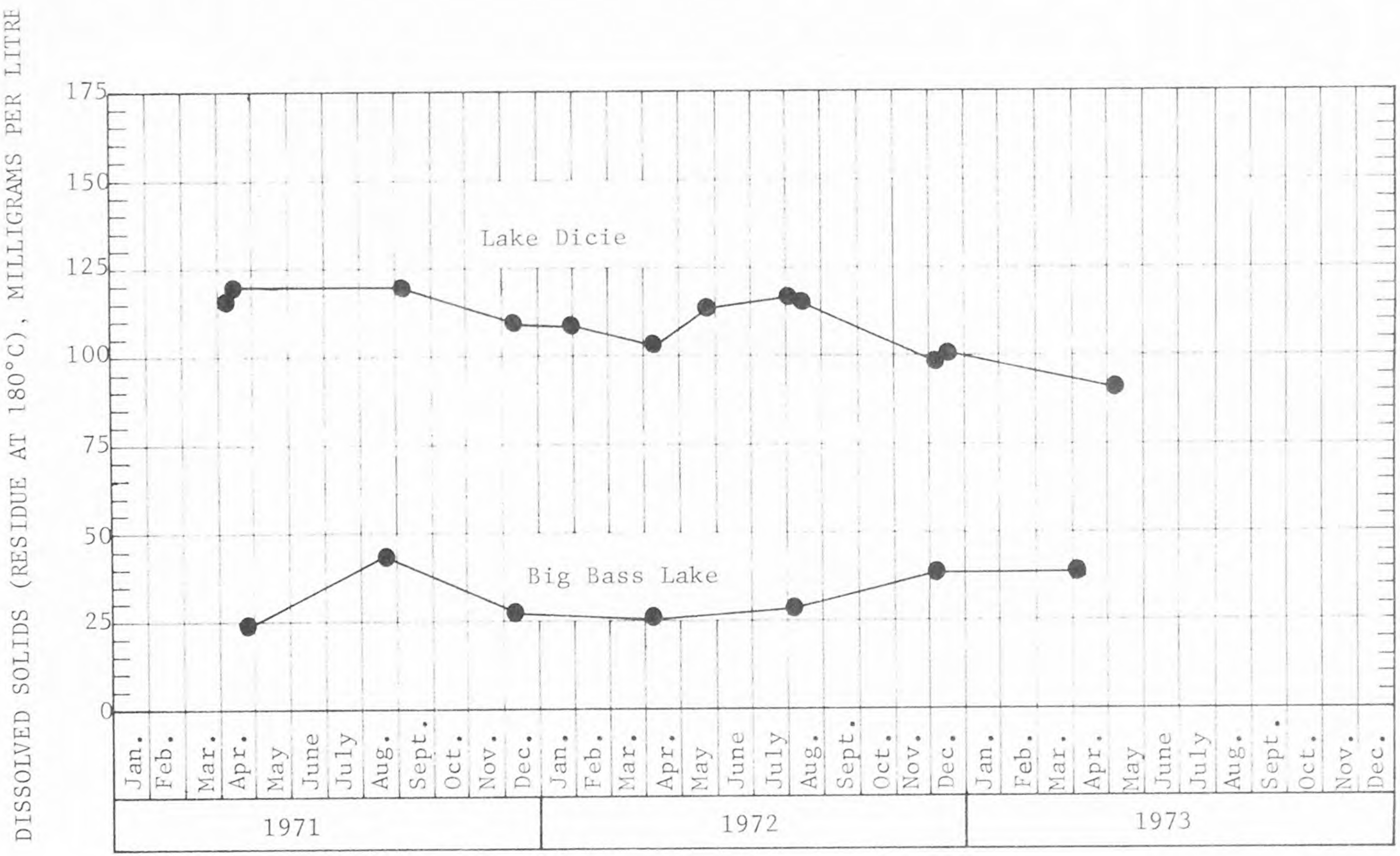

Figure 4.--Dissolved-solids concentrations in Lake Dicie and in Big Bass Lake.

Table 4.--Chemical and physical characteristics of Lake Dicie, April 1971 through June 1973.

Laboratory determinations	Before Rain (Seven samples)			After Rain (Seven samples)			Average of all Samples
	Max.	Min.	Avg.	Max.	Min.	Avg.	
Major cations, mg/l							
Calcium	26	20	24	25	21	23	24
Magnesium	3.2	2.1	2.6	3.3	2.2	2.6	2.6
Potassium	4.5	2.6	3.4*	4.7	2.6	3.4	3.4
Sodium	6.5	5.4	5.8	6.5	5.6	6.1	6.0
Major anions, mg/l							
Bicarbonate	90	54	70	76	52	68	69
Chloride	10	8.5	9	10	8	9.4*	9.2
Fluoride	.2	.1	.2*	.2	.1	.1	.1
Sulfate	19	14	16*	20	13	16	16
Trace elements, μg/l							
Aluminum, dissolved	100	0	40*	100	0	40	40
Arsenic	10	0	4**	20	0	6	5
Cadmium, dissolved	1	0	0*	0	0	0*	0
Chromium, dissolved	6	0	1*	0	0	0*	0
Copper, dissolved	20	0	10*	30	0	10	10
Iron, dissolved	20	0	10*	20	0	10	10
Lead, dissolved	2	0	1*	6	0	1	1
Manganese, dissolved	10	0	0*	30	0	10	10
Mercury	1.9	0	.4*	2.3	0	.4	.4
Molybdenum, dissolved	1	0	0**	1	0	0**	0
Nickel, dissolved	4	0	1*	4	0	1	1
Strontium, dissolved	120	50	90**	80	10	60	70
Vanadium, dissolved	3	1	1**	2	0	1	1
Zinc, dissolved	100	10	40*	60	10	20	30
Nutrients, mg/l							
Organic nitrogen as N	1.3	.23	.88	1.6	.85	1.2*	1.0
Nitrite as NO_2	.05	.01	.02	.03	.01	.02	.02
Nitrate as NO_3	.3	.0	.1	.2	.0	.0	.0
Ammonia nitrogen as NH_4	2.3	.06	.46	2.5	.04	.59	.52
Total nitrogen as N	2.02	.85	1.26	3.55	.89	1.71*	1.47
Orthophosphate as PO_4	.10	.03	.06	.08	.02	.04	.05
Total phosphate as PO_4	.11	.08	.09	.12	.05	.09	.09
Total phosphorus as P	.037	.025	.030	.040	.017	.030	.030
Total organic carbon, mg/l	15	5	10	14	2	10*	10
Oil and grease, mg/l	16	1.5	9.8	19	5.3	11	10
Biochemical oxygen demand, mg/l	5.4	2.2	3.6	4.9	2.3	3.6	3.6
Total coliform, colonies/100 ml.	4,400	56	1,454*	1,400	100	622**	1,076
Dissolved solids, mg/l	118	98	110**	117	91	110	110
Specific conductance, micromhos	210	145	176	210	155	184	180
Turbidity (JTU)	20	4	8	25	5	11	10
Color	20	0	10	25	0	15	10
pH	7.8	7.3	7.6	8.0	6.5	7.3	7.4
Total hardness, mg/l	77	59	70*	76	62	69	70
Noncarbonate hardness, mg/l	15	3	12*	20	12	14	13
Silica, mg/l as SiO_2	2.0	.5	1.1	2.3	.5	1.0	1.0

* Average of Six Values.
** Average of Five Values.

Table 5.--Chemical and physical characteristics of Big Bass Lake near Starkes Ferry, Fla., April 1971 through June 1973.

Laboratory determinations	Maximum	Minimum	Average (7 samples)
Major cations, mg/l			
Calcium	2.4	0.5	1.3
Magnesium	1.1	.6	.9
Potassium	.5	.2	.3
Sodium	5.2	4.0	4.6
Major anions, mg/l			
Bicarbonate	5	0	2
Chloride	10.0	6.5	8.1
Fluoride	.4	.0	.1
Sulfate	6.4	0	3.2
Trace elements, µg/l			
Aluminum, dissolved	100	0	30
Arsenic	10	0	5
Cadmium, dissolved	0	0	0 **
Chromium, dissolved	0	0	0 *
Copper, dissolved	10	0	10
Iron, dissolved	30	0	10
Lead, dissolved	4	0	1
Manganese, dissolved	30	10	20
Mercury	1.8	0	.3
Molybdenum, dissolved	0	0	0 *
Nickel, dissolved	1	0	0 *
Strontium, dissolved	100	10	50 *
Vanadium, dissolved	0	0	0 *
Zinc, dissolved	70	20	40
Nutrients, mg/l			
Organic nitrogen as N	3.2	.10	1.3
Nitrite as NO_2	.03	.01	.02
Nitrate as NO_3	.5	.0	.2
Ammonia nitrogen as NH_4	.35	.06	.20
Total nitrogen as N	3.51	.79	1.46
Orthophosphate as PO_4	.09	.04	.06
Total phosphate as PO_4	.09	.04	.06
Total phosphorus as P	.029	.013	.020
Total organic carbon, mg/l	25	3	10
Oil and grease, mg/l	0	23	12
Biochemical oxygen demand, mg/l	2.3	.3	1.0
Total coliform, colonies/100 ml.	3,200	0	550
Dissolved solids, mg/l	43	24	33
Specific conductance, micromhos	54	40	46
Turbidity (JTU)	15	3	7
Color	20	5	15
pH	5.9	4.5	5.0
Total hardness, mg/l	10	4	7
Noncarbonate hardness, mg/l	9	0	6
Silica, mg/l as SiO_2	1.0	.1	.3

* Average of Six Values.
** Average of Five Values.

Although the average concentration of another major nutrient, total phosphorus, was relatively low in both lakes, it was higher in Lake Dicie than in Big Bass Lake. However, the average concentration of orthophosphate (as PO_4), the form of phosphorus most readily used by plants, was slightly higher in Big Bass Lake. The concentration of orthophosphate fluctuated over a wider range in Lake Dicie than in Big Bass Lake and the maximum concentration observed in Lake Dicie was greater than the maximum concentration in Big Bass Lake.

Variations in dissolved-solids concentrations in both Lake Dicie and Big Bass Lake during this investigation are shown in figure 4. Dissolved-solids concentration of the two lakes fluctuated in response to variations in rainfall, runoff, and evaporation but there was no apparent trend in the changes from April 1971 to June 1973. There seemed to be no overall increase or decrease in the concentrations of any constituent (tables A1-A7 in the basic data). The range in concentrations of some of the trace elements and nutrients fluctuated by an order of magnitude.

The earliest water-quality data for Lake Dicie were collected by Knochenmus in May 1969, during an intense algal bloom. These data are given in table A8 in the basic data. Comparison of these data with the analyses of samples collected from Lake Dicie during this study indicates that the concentrations of most of the constituents analyzed in 1969 were within the ranges of fluctuations observed during this investigation. However, the concentration of phosphorus in 1969, when the lake was experiencing an algal bloom, was more than twice the average concentration during the present study. The maximum concentration of total phosphorus (as P) observed during this investigation was 0.040 mg/l (milligram per litre) as compared to a concentration of 0.065 mg/l in May 1969.

Each time Lake Dicie was sampled, temperature and dissolved-oxygen concentration were measured in a vertical profile near the center of the lake. Temperature and dissolved-oxygen concentrations at 10, 30, 50, 70 and 90 percent of the total depth are shown in figure 5. This figure shows that during the warmer part of the year temperature and dissolved-oxygen concentration decreased with depth. Stratification of the lake particularly with respect to dissolved-oxygen concentration was apparent in all of the profiles made in April, May, August, and September. Dissolved-oxygen concentrations were high, 5 to 12 mg/l, in the upper 6 to 8 feet (1.8 to 2.4 metres) of the lake in most profiles. However, in the spring and summer months, the concentration decreased rapidly below this depth and was almost zero near the bottom of the lake.

When the lake is stratified the lower one-third of the lake is almost devoid of oxygen and will not support fish and many other forms of aquatic life. The dissolved-oxygen concentration near the bottom is severely depressed by the decomposition (oxidation) of dead algal cells and other organic matter which settle to the bottom of the lake. The decomposition

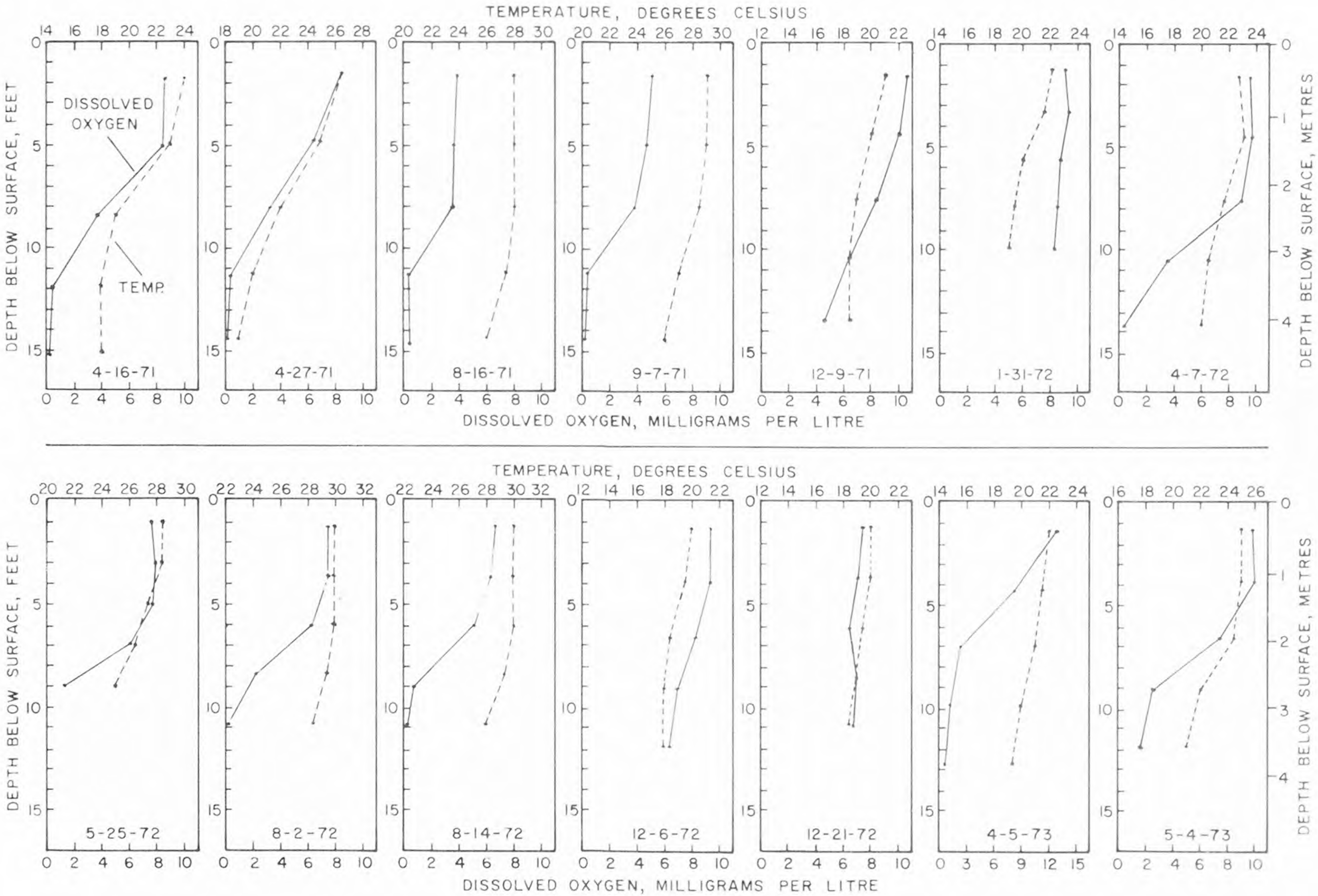

Figure 5.--Vertical profiles of temperature and dissolved oxygen in Lake Dicie.

of this organic material also releases large quantities of nutrients into the lower part of the lake. Mixing of the lower part of the lake with the upper part is severely limited by the thermal stratification or the lack of vertical density currents and these nutrients are not readily available to plants in the upper part of the lake.

The temperature and dissolved-oxygen profiles in figure 5 show that in April and May the lake is generally stratified with respect to dissolved oxygen and temperature. In August and September, the lake generally is stratified with respect to dissolved oxygen but thermal stratification is less apparent on figure 5. By December and January, the lake is no longer stratified. The water near the surface is cooled by the winter temperatures and the downward movement of the cool water, which has a greater density than the warmer water near the bottom, mixes the water in the lake. Temperature profiles indicate that this "turnover" probably is not a sudden occurrence but a more gradual mixing of the oxygen-rich water near the surface and the nutrient-rich water near the bottom during periods when ambient temperatures are low. The result is a high and uniform dissolved-oxygen concentration and a uniform temperature in the lake. The concentration of dissolved oxygen was never less than 4 mg/l anywhere in the profiles during December and January 1971 and December 1972 (fig. 5).

As temperatures begin to rise in early spring, water near the surface is warmed first. The warmer water, having a lower density than the cool water near the bottom tends to remain near the surface so that the lake begins to stratify thermally. With cessation of downward movement mixing no longer occurs. Continued decomposition of algal cells and organic material soon depletes the oxygen in the lower part of the lake causing it once again to become stratified with respect to dissolved oxygen. Figure 5 indicates that this sequence of stratification in the warmer months and mixing in the cooler months occurs each year in Lake Dicie.

Temperature and dissolved-oxygen profiles for Big Bass Lake are shown in figure 6. It is apparent from these profiles that although the pattern of stratification during warm weather and the seasonal turnover in the winter occurs in Big Bass Lake as well as in Lake Dicie, stratification is less noticeable and not as pronounced in Big Bass Lake. A comparison of dissolved-oxygen profiles for the two lakes shows the concentration of dissolved oxygen in the lower part of Big Bass Lake generally was higher than that in the lower part of Lake Dicie. The less noticeable stratification and higher dissolved oxygen is due in part to Big Bass Lake being shallower than Lake Dicie. High dissolved-oxygen concentrations occur in both lakes to depths of 6 to 8 feet (1.8 to 2.4 metres).

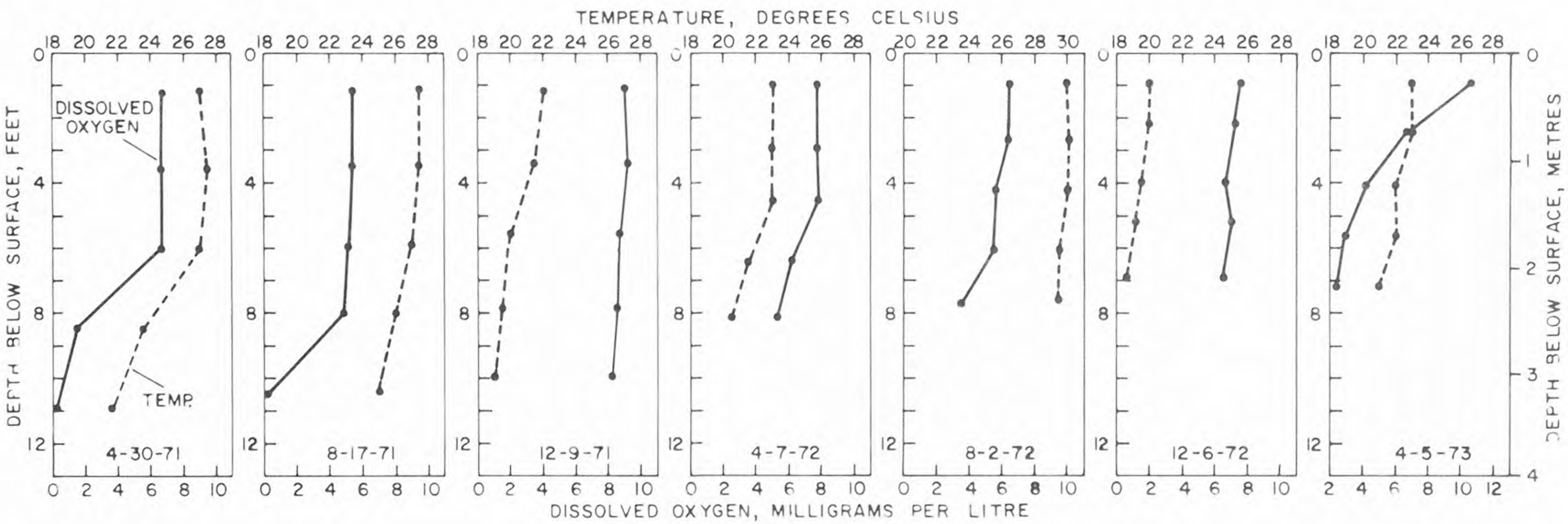

Figure 6.--Vertical profiles of temperature and dissolved oxygen in Big Bass Lake near Starkes Ferry, Florida.

CHEMICAL QUALITY OF STORM RUNOFF

In order to determine the quality of storm runoff entering Lake Dicie, water samples were collected from the storm drain at the west end of the lake (fig. 1) three times a year and analyzed. This storm drain carries runoff from the southeastern section of the city of Eustis and contributes well over half the total runoff to the lake. The area served by this drain constitutes a little over half of the total drainage basin and runoff from the area is primarily from streets, roofs, and other impervious surfaces. Runoff from the remainder of the basin which consists of citrus groves, undeveloped land, and low density residential areas is smaller than from the impervious areas because of the high permeability of the sandy soil.

Runoff samples were collected from the storm drain during storms in April and September 1971; January, May, August, and December 1972; and April 1973. The sampling schedule provided for the collection of two runoff samples from the storm drain during each of these storms because it was felt that one sample would not be representative. One sample, the early runoff sample, was to be collected when the runoff first started flowing through the storm drain, the other, the late runoff sample, at about the time of peak runoff. The early runoff was expected to contain the bulk of the material washed from the streets and buildings. The late runoff was expected to contain much smaller concentrations of most constituents because it represents runoff from washed streets and buildings. On April 24, 1971, runoff was insufficient to provide the second sample and on January 26, 1972, field personnel did not arrive at the sampling site in time to collect the early runoff samples. Except on these two occasions, runoff to Lake Dicie was sampled at the storm drain twice during each of the seven storms. The samples, 12 in all, were analyzed for major chemical constituents, dissolved trace elements, nutrients and other parameters. The results of these analyses are listed in tables A1-A7 in the basic data.

Chemical analyses in these tables indicate that runoff collected from the storm drain is a calcium bicarbonate water similar to the water in Lake Dicie, although the quality of this runoff is much more variable than that of the lake water. The concentration of dissolved solids in runoff from this drain ranged from 56 to 219 mg/l whereas, in the lake, the range was relatively small, 91 to 118 mg/l. The chemical quality of runoff varies because the concentration of chemical constituents in runoff depends on the amount and intensity of rainfall, the time elapsed since the previous storm, the amount of traffic in the area drained, and many other factors. The quality of the lake water generally does not change appreciably as the result of any one storm because the runoff from most storms makes up only a small part of the total volume of the lake.

Results of the analyses of both early and late runoff collected from the storm drain are summarized in table 6. The data in this table indicate that the expected differences in the quality of early and late runoff to Lake Dicie did not always occur. Although the variations in the concentrations of most constituents were large, concentrations were not always highest in the samples of early runoff. Average concentrations of dissolved

Table 6.--Chemical and physical characteristics of street runoff to Lake Dicie, April 1971 through April 1973.

Laboratory determinations	Early Runoff (Six samples)			Late Runoff (Six samples)			Average of all Samples
	Max.	Min.	Avg.	Max.	Min.	Avg.	
Major cations, mg/l							
Calcium	28	9.2	19	33	10	22	20
Magnesium	2.2	.6	1.0	2.0	.6	1.2	1.1
Potassium	24	1.1	5.7	3.6	1.1	2.0	3.8
Sodium	5.9	1.7	3.7	10	1.7	4.3	4.0
Major anions, mg/l							
Bicarbonate	64	37	48	66	32	53	50
Chloride	24	3.1	8.2	35	4.1	13	11
Fluoride	.4	.1	.3	.3	.2	.3*	.3
Sulfate	22	4.0	12	30	5.6	13	12
Trace elements, µg/l							
Aluminum, dissolved	100	0	70	200	50	90	80
Arsenic	10	5	9*	10	8	6*	8
Cadmium, dissolved	1	0	1*	0	0	0*	0
Chromium, dissolved	0	0	0*	0	0	0*	0
Copper, dissolved	40	10	20	40	10	20	20
Iron, dissolved	120	30	50	50	10	40	40
Lead, dissolved	115	12	61	100	18	52	56
Manganese, dissolved	30	0	10	20	0	10	10
Mercury	1.6	.0	.3	1.8	0	.3	.3
Molybdenum, dissolved	1	0	0	1	0	1	0
Nickel, dissolved	14	1	5	4	2	3	4
Strontium, dissolved	150	40	80	200	60	110	100
Vanadium, dissolved	4	1	2**	10	0	3*	3
Zinc, dissolved	120	10	50	50	10	30	40
Nutrients, mg/l							
Organic nitrogen as N	2.6	.47	1.5	1.9	.41	1.3*	1.4
Nitrite as NO_2	.27	.01	.11	.43	.04	.22	.16
Nitrate as NO_3	6.6	.0	2.6	5.3	.0	2.4	2.5
Ammonia nitrogen as NH_4	1.8	.05	.51	.42	.09	.24	.38
Total nitrogen as N	4.15	.52	2.54	3.34	.51	2.06*	2.32
Orthophosphate as PO_4	1.6	.04	.67	.92	.34	.62	.64
Total phosphate as PO_4	1.8	.06	.84	1.3	.37	.78	.81
Total phosphorus as P	.59	.02	.27	.44	.12	.26	.26
Total organic carbon, mg/l	73	2	33	65	9	31*	32
Oil and grease, mg/l	16	3.4	12	50	5.6	19	16
Biochemical oxygen demand, mg/l	>8.3	6.6	-	>8.9	6.1	-	-
Dissolved solids, mg/l	163	56	106	219	58	119	112
Suspended solids, mg/l	639	7	157	84	7	40	99
Specific conductance, micromhos	246	88	146	240	89	148	147
Turbidity (JTU)	45	2	18	45	15	29	24
Color	90	0	50	180	10	80	65
pH	7.7	6.5	7.0*	7.8	6.5	7.1	7.1
Total hardness, mg/l	74	25	52	91	28	59	56
Noncarbonate hardness, mg/l	26	0	13	43	2	16	14
Silica, mg/l as SiO_2	3.9	.6	1.8	4.9	.9	2.6	2.2

* Average of five values.
** Average of four values.

iron, lead, zinc and most forms of nitrogen and phosphorus were slightly higher in early runoff but the average concentrations of most of the major ions were somewhat higher in the late runoff. With the exception of suspended solids, the differences between the average concentrations of most constituents in early and late runoff were small.

Because the quality of storm runoff varies, it can best be described by averaging the results of all runoff analyses. These averages are given in table 6. This table indicates that although the average concentration of dissolved solids in runoff was only 112 mg/l, runoff had high color and typically contained high concentrations of nitrogen, phosphorus, total organic carbon, oil and grease, suspended sediment and several trace elements, particularly lead.

The data in tables 4 and 6 indicate that the average concentrations of dissolved aluminum, copper, iron, lead, nickel and vanadium in street runoff were several times the average concentrations of those elements in Lake Dicie. The concentration of lead in runoff averaged 56 μg/l (micrograms per litre) whereas the concentration of lead in the lake averaged only 1 μg/l. The lowest concentration of lead found in samples of runoff was 12 μg/l, twice the highest concentration found in Lake Dicie.

The average concentration of total nitrogen in runoff was 2.32 mg/l whereas the average concentration in the lake was 1.47 mg/l. Although the difference between the total nitrogen concentration of the lake and that of runoff was not extremely large, the inorganic forms of nitrogen, the forms most readily used by algae and other plants, were found in much higher concentrations in the runoff. The average concentration of inorganic nitrogen in runoff was almost twice the average concentration in the lake. Nitrate (as NO_3) averaged 2.5 mg/l in runoff and less than 0.1 mg/l in the lake.

One of the most obvious differences between the quality of runoff and the quality of the lake was in the phosphorus concentration. The average concentration of total phosphorus in Lake Dicie was only 0.03 mg/l, whereas the average concentration of phosphorus in the runoff samples was 0.26 mg/l. Not only was the average concentration of phosphorus in runoff more than eight times the average concentration in the lake, but a much larger percentage of the total phosphorus in the runoff was in the soluble, inorganic form (orthophosphate) which is the form most readily used by algae and other plants. The concentration of phosphorus was much lower in the lake water probably because of uptake by these plants and the incorporation of large amounts of phosphorus in the bottom sediments.

EFFECTS OF STORM RUNOFF ON THE CHEMICAL QUALITY OF LAKE DICIE

The storm runoff to Lake Dicie contains high concentrations of dissolved and particulate materials. Because runoff from the drainage basin makes up about 65 percent of the total input, including rainfall on the surface of the lake, the amount of these materials carried into Lake Dicie is large. Although some dissolved and particulate materials are washed into the lake from all parts of the drainage basin, most of these materials are probably carried into the lake by the storm drain. The storm drain probably contributes at least 70 percent of the total runoff to the lake. The amount of dissolved and particulate material carried into the lake by this storm drain probably exceeds 70 percent of the total amount contributed by runoff.

During this investigation, April 1971 through June 1973, total storm runoff to Lake Dicie amounted to about 121 acre-feet (149,000 cubic metres). If 70 percent of this runoff was carried into the lake by the storm drain, based on average concentrations of dissolved and suspended solids given in table 6, the storm drain carried 13 tons (12 tonnes) of dissolved solids and 11 tons (10 tonnes) of suspended solids into the lake during this period.

Of the 11 tons (10 tonnes) of suspended solids carried into the lake by the storm drain, most consisted of inorganic soil particles (sand, silt and clay) washed from streets, sidewalks and driveways. The introduction of this particulate material often increased the turbidity of the lake for a few days but the solids soon settled to the bottom. The amount of sediment deposited in this manner was not determined but a permanently submerged mixture of clay, silt and sand would have a weight of 50 to 80 pounds per cubic foot (800 to 1,280 kilograms per cubic metre) (Guy, 1970, p. 33). Thus, if the 11 tons (10 tonnes) of suspended solids carried into Lake Dicie by the storm drain had consisted entirely of sand, silt, and clay, the volume of the lake would have been reduced by 275 to 440 cubic feet (7.8 to 12.5 cubic metres). Although, to some people this might be construed to represent a sizeable reduction in the volume of the lake, about 15,000 years would be required for the lake to be filled at this rate of deposition.

The 13 tons (12 tonnes) of dissolved solids carried into Lake Dicie by the storm drain consisted primarily of bicarbonate, calcium, sulfate, chloride, sodium and potassium ions. These dissolved solids did not accumulate in the lake as did the suspended solids. Seepage out of the lake carried with it approximately 20 tons (18 tonnes) of dissolved solids. Because of the large amount of dissolved solids removed from the lake by seepage and because the average concentration of dissolved solids in runoff was not much higher than the concentrations in the lake, the dissolved-solids concentration of Lake Dicie is unlikely to increase appreciably, provided the quantity and quality of runoff do not change.

The dissolved solids carried into Lake Dicie by the storm drain also included nitrogen, phosphorus, dissolved lead and several other dissolved metals. Based on the average concentrations given in table 6, the storm drain carried 535 pounds (243 kilograms) of nitrogen, 60 pounds (27 kilograms) of phosphorus, 13 pounds (5.9 kilograms) of lead, 8 pounds (3.6 kilograms) of iron and zinc, 4 pounds (1.8 kilograms) of copper, 3 pounds (1.4 kilograms) of manganese and 1.4 pounds (0.6 kilogram) of arsenic and nickel into the lake during the period April 1971 through June 1973. The average concentrations of these constituents were higher in runoff from the storm drain than in the lake. Their introduction into the lake probably had a greater effect upon the quality than did the introduction of the major ions which were found in similar concentrations in the lake and in runoff.

Storm runoff was contributing dissolved and particulate materials to Lake Dicie before 1967 but the construction of the storm drain in that year greatly increased the load of these materials flowing into the lake. The introduction of this additional load, particularly of the nutrients and trace elements which are found in high concentrations in runoff from the storm drain, has probably affected the chemical quality of the lake. Unfortunately, because there is no chemical quality data for Lake Dicie before 1967, the extent to which the quality has been affected cannot be assessed. Lake Dicie presently (1973) contains a calcium bicarbonate water similar in some respects to storm runoff but before 1967 it may have contained water more closely resembling the magnesium sulfate or sodium chloride waters in nearby lakes.

Although the present quality of the lake cannot be compared to preconstruction quality, the effects of runoff from individual storms on present quality can be seen from an examination of the chemical analyses in tables A1-A7 in the basic data. A comparison of the analyses of samples collected from Lake Dicie before and after storms indicates that although the concentration of major ions in the lake changed very little, the turbidity, color, and concentrations of oil and grease, and nitrogen, particularly ammonia and organic nitrogen often increased temporarily as a result of the storm runoff carried into the lake. The magnitude of these increases is indicated by the average physical and chemical characteristics of lake samples collected before and after the storms (table 4).

The concentrations of phosphorus, nitrate nitrogen, total organic carbon and numerous dissolved trace elements, including lead, aluminum, iron, copper, and zinc did not increase appreciably in Lake Dicie during this investigation although these constituents were found in characteristically high concentrations in the runoff carried into the lake by the storm drain. They were apparently removed from the lake by adsorption on the particulate material which settled to the bottom and by biological activity.

Bottom sediments were not analyzed for trace elements but during the last sampling period (April 1973) both filtered and unfiltered samples of storm runoff and water from Lake Dicie and Big Bass Lake were analyzed for these elements. The results of these analyses are given in table 7. The data in this table indicate that most of the trace elements in the lakes and in runoff are adsorbed on particulate material. Concentrations

Table 7.--Concentrations of trace elements in Lake Dicie, Big Bass Lake and in street runoff to Lake Dicie.

(Concentrations in micrograms per litre)

Condition Sampled		Early Runoff to Lake Dicie	Late Runoff to Lake Dicie	Lake Dicie	Big Bass Lake
Date		4-26-73	4-26-73	5-4-73	4-5-73
Aluminum	filtered	70	70	30	30
	unfiltered	780	580	100	100
Arsenic	filtered	5	-	2	4
	unfiltered	8	8	3	4
Copper	filtered	10	10	0	10
	unfiltered	30	20	10	-
Iron	filtered	40	50	0	0
	unfiltered	600	520	50	50
Lead	filtered	100	100	6	0
	unfiltered	220	230	8	8
Manganese	filtered	10	10	30	20
	unfiltered	20	20	40	20
Molybdenum	filtered	0	0	0	0
	unfiltered	0	0	1	0
Nickel	filtered	1	3	0	0
	unfiltered	4	4	1	1
Zinc	filtered	20	20	10	20
	unfiltered	100	70	10	-

of several metals and arsenic in the unfiltered samples of runoff were as much as 10 to 15 times the concentration of those elements in solution in the filtered sample. If the relation between dissolved trace elements and the total concentrations of these elements in table 7 is representative, the total loads of lead and other metals carried into the lake by the storm drain during the course of this project is much greater than the estimated loads of dissolved trace elements mentioned earlier in this section.

Phosphorus is a major plant nutrient and some of the phosphorus carried into Lake Dicie by runoff is undoubtedly incorporated into living algae and other aquatic plants. Soluble orthophosphates are readily assimilated by these plants forming particulate organic phosphorus. Upon the death and decay of these plants, part of the phosphorus is released and again becomes available for uptake by living organisms. Part of the algae and plant material is relatively resistant to decomposition, however, and this material along with the phosphorus it contains is incorporated into the organic sediments in the bottom of the lake.

Orthophosphates also combine with several cations (principally calcium, magnesium, aluminum and iron) to form relatively insoluble phosphates (Black, 1970). These insoluble phosphates settle to the bottom and are incorporated into the bottom sediments. Because of the abundance of calcium, magnesium, aluminum and iron in Lake Dicie, most of the phosphorus carried into the lake by the storm runoff is probably removed by the formation of these insoluble phosphates.

The low concentration of nitrate in Lake Dicie is due almost entirely to biological action. Unlike phosphates, nitrates are very soluble and are not adsorbed appreciably on particulate material. Nitrates are taken up and incorporated in plants, forming particulate organic nitrogen compounds. Upon death and decay of these plants part of the nitrogen is released (largely in the form of ammonia). Decomposition of these plants is seldom complete, however, and some of the organic material with its cellular nitrogen is incorporated into the bottom sediments.

Bottom sediments of Lake Dicie and Big Bass Lake contain high concentrations of nitrogen and phosphorus. Percentages of these nutrients in bottom sediments from the two lakes are given in table 8. Data in this table indicate that bottom sediments in Lake Dicie contain more phosphorus but less nitrogen than those in Big Bass Lake.

Most of the nitrogen and phosphorus in these bottom sediments is in organic cellular material. Although this material is somewhat resistant to decomposition it is gradually but continuously decaying. As it decays it releases soluble forms of nitrogen and phosphorus which can be taken up by living plants. Evidence of this decay can be seen in the presence of ammonia (the primary decomposition product of organic nitrogen) in some of the sediment analyses in table 8. The release of soluble nitrogen and phosphorus compounds in this manner would maintain concentrations of nitrogen and phosphorus sufficient for plant growth in the lakes even if all external nutrient inputs were eliminated.

Table 8.--Percentages of nutrients in bottom sediments of Lake Dicie and Big Bass Lake.

(Results in percent of dry weight)

Station Name	Date	Nutrients		
		Ammonia (NH_4)	Organic Nitrogen (N)	Phosphorus (PO_4)
Lake Dicie - center	12-9-71	0.00	0.11	0.14
	12-6-72	.18	1.70	.55
Lake Dicie - near north shore	12-9-71	.06	.39	.16
	12-6-72	.00	.13	.03
Lake Dicie - near south shore	12-9-71	.00	.05	.88
	12-6-72	.00	.09	.03
Big Bass Lake - center	12-9-71	.00	.32	.16
	12-6-72	.30	3.50	.23
Big Bass Lake - near east shore	12-9-71	.00	.15	.26
	12-6-72	.06	.59	.19
Big Bass Lake - near west shore	12-9-71	.00	.11	.12
	12-6-72	.01	.26	.01

As is the case with nitrogen and phosphorus, the amount of organic carbon in Lake Dicie is much lower than might be expected from the amount of organic carbon in storm runoff. During the investigation the concentration of total organic carbon averaged 32 mg/l in runoff and only 10 mg/l in the lake. The concentration of organic carbon in the lake is low primarily because much of the organic carbon carried into the lake by storm runoff is decomposed by bacteria which convert the organic carbon to carbon dioxide. The carbon dioxide produced in this manner is then used by algae and other aquatic plants as a source of carbon, another major plant nutrient. Carbon, like nitrogen and phosphorus, is released back into the lake (primarily as carbon dioxide) when these plants decay.

Part of the algae and other plant material which settles to the bottom decomposes very slowly. When the lake is stratified, decomposition or oxidation of carbonaceous material is further hampered by the relatively low concentration of dissolved oxygen near the bottom. The decomposition of organic carbonaceous material in the bottom sediments can be greatly enhanced when these sediments are stirred up or when the concentration of dissolved oxygen near the bottom is increased.

EFFECT OF STORM RUNOFF ON THE BIOLOGICAL QUALITY OF LAKE DICIE

The biological community in any lake is part of an ecosystem which responds to changes in the aquatic environment. Changes in the quantity and quality of water flowing into the lake affect the biological community as well as the physical and chemical character of the water. Physical and chemical changes occur more rapidly than changes in the biological community and, generally, precede major shifts in the number and type of organisms in the lake. However, physical and chemical changes in the quality of the lake often go unnoticed by the casual observer. It is the more apparent biological changes that usually signal the deterioration or improvement of the quality of the lake.

The sampling schedule for this program provided for the monitoring of two biological parameters as well as the physical and chemical characteristics of Lake Dicie and Big Bass Lake. The biological parameters measured were the phytoplankton, or algae, that produced the blooms in Lake Dicie, and coliform bacteria which have long been used as indicators of pollution.

Coliform bacteria are not in themselves harmful to man but they occur in large numbers in the intestinal tract of warm-blooded animals where harmful pathogenic bacteria are often found. The diversity of the pathogens makes their isolation and identification difficult but because coliform bacteria are almost always present when pathogens are found, coliform bacteria have been used as indicator organisms.

Although some members of the coliform group occur in soil and on vegetation, as well as in the feces of warm-blooded animals, high concentrations of coliform bacteria in water very often indicate sewage pollution and the possible presence of pathogens. For this reason, water-quality standards established by a number of States, including Florida, contain criteria as to the number of coliform bacteria allowable. Bacteriological criteria established by the Florida Department of Pollution Control for waters used for body contact recreational activities such as swimming recommend that coliform bacteria not exceed 1,000 colonies per 100 millilitres as a monthly average, and that this concentration not be exceeded in more than 20 percent of the samples analyzed in any month and that no sample contain more than 2,400 coliform bacteria colonies per 100 millilitres.

Concentration of coliform bacteria were generally higher in Lake Dicie than in Big Bass Lake. Storm runoff to Lake Dicie was probably responsible for this difference but this has not been verified as bacteriological analyses were not performed on samples of runoff. The concentration of coliform bacteria in the lake increased during only one of the sampling periods. However, the samples collected were too few to ascertain the degree and pattern of variations in the concentration of coliform bacteria during the sampling periods.

The maximum concentration of coliform bacteria in Lake Dicie was 4,400 colonies per 100 millilitres whereas the maximum concentration in Big Bass Lake was 3,200 colonies per 100 millilitres (tables 4 and 5). More importantly, the average concentration of coliform bacteria in Lake Dicie (1,076 colonies per 100 millilitres) was almost twice the average concentration in Big Bass Lake (550 colonies per 100 millilitres). The concentration of coliform bacteria in Lake Dicie often exceeds the limits recommended by the Florida Department of Pollution Control for waters used for swimming and other body contact recreation.

Phytoplankton, commonly called algae, convert inorganic chemicals into living organic matter using solar energy. They constitute the base of the food chain for almost all aquatic animals. Phytoplankton require sunlight and specific amounts of water, carbon dioxide, and certain mineral salts in solution, most notably nitrates and phosphates. In natural waters one or more of these mineral salts generally is present in relatively small quantities and phytoplankton growth is limited. However, in the presence of excessive amounts of the required nutrients, and under optimum conditions of sunlight, temperature and pH, the growth of phytoplankton is very rapid, sometimes resulting in a ten-fold increase in algal mass in only a few days (Mackenthun and others, 1968).

The explosive growth of phytoplankton, often called an algal bloom, has been known to occur in relatively unpolluted lakes as a result of seasonal changes in water quality, mixing of the lake during a turnover, mixing of bottom sediments in the lake and other natural occurrences. More often, however, algal blooms are related to artificial enrichment with waste waters, storm runoff or agricultural drainage which contain significant quantities of plant nutrients.

The algal bloom that occurred in Lake Dicie after the storm drain was constructed in all liklihood was caused by addition of nutrients to the lake by this drain. Assuming that the storm drain contributed 70 percent of the total runoff to Lake Dicie, the load of inorganic nitrogen (nitrate, nitrite and ammonia) and soluble phosphorus (orthophosphate) carried into the lake by the storm drain during this investigation was equivalent to more than 3,500 pounds (1,600 kilograms) of 6-6-6 commercial fertilizer.

During the investigation phytoplankton were much more prevalent in Lake Dicie than in Big Bass Lake (tables A9-A14). Blue-green algae were usually dominant in both of these lakes. Blue-green algae are generally considered the most troublesome, nuisance-producing type of phytoplankton: they are largely inedible, they often impart an objectionable odor and taste to water, and they contain gas vacuoles which enable them to rise to the water's surface where they sometimes aggregate in thick masses.

Blue-green algae generally make up a larger percentage of the total concentration of phytoplankton in Lake Dicie than in Big Bass Lake. Phytoplankton analyses summarized in table 9 indicate that concentrations of blue-green algae exceeded those of green algae in all seven samples from Lake Dicie and in five of the seven samples from Big Bass Lake.

Of the dominant genera of blue-green algae in Lake Dicie, Microcystis, Oscillatoria and Aphanizomenon are generally considered to be characteristic of eutrophic or over-enriched waters (Greeson, oral commun., 1973). Agmenellum was the dominant group of phytoplankton in most of the samples collected from Big Bass Lake. Although Agmenellum are also blue-green algae, they are found in clean waters as well as in polluted waters and are not necessarily characteristic of eutrophic waters (American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1971).

The concentrations of phytoplankton in samples collected during this investigation are presented graphically in figure 7. This figure shows that the concentration of phytoplankton varies seasonally in both lakes. The massive algal bloom in Lake Dicie (556,710 cells per millilitre) of December 1971 was by far the highest concentration of phytoplankton observed. The second highest concentration (57,600 cells per millilitre) also occurred in Lake Dicie in December 1972. The concentrations in Lake Dicie were least in the early summer and spring in both years (June 1971 and April 1972).

The fact that the phytoplankton concentrations in Lake Dicie were greatest during the driest part of the year when runoff was slight and the concentrations of nitrogen and phosphorus in the lake not particularly high, indicates that the algal blooms probably were not directly triggered by storm runoff. The nutrients carried into the lake by storm runoff, however, are probably responsible for the relatively high concentration of phytoplankton throughout the year. The algal blooms of December possibly were triggered by the mixing of the lake by vertical density currents which generally occur in mid-winter.

Table 9.--Summary of phytoplankton counts of samples collected from Lake Dicie and Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Date	Total Concentration (cells per millilitre)	Blue-Green Algae Phylum Cyanophyta (cells per millilitre)	Green Algae Phylum Chlorophyta (cells per millilitre)	Dominant Genera
		Lake Dicie		
06-18-71	13,720	11,928	1,680	*Aphanizomenon* (Blue-Green)
08-16-71	18,550	10,355	7,420	*Scenedesmus* (Green)
12-09-71	556,710	556,710	0	*Microcystis* (Blue-Green)
04-07-72	6,279	6,279	0	*Schizothrix* (Blue-Green)
08-02-72	20,481	19,512	969	*Schizothrix*[1] (Blue-Green)
12-06-72	57,600	53,760	2,560	*Oscillatoria*[2] (Blue-Green)
04-05-73	38,400	32,640	5,120	*Oscillatoria* (Blue-Green)
		Big Bass Lake		
06-18-71	3,640	2,800	784	*Agmenellum* (Blue-Green)
08-17-71	1,455	706	707	*Agmenellum* (Blue-Green)
12-09-71	693	312	311	*Microcystis* (Blue-Green)
04-07-72	1,572	477	537	*Spaerocystis* (Green)
08-02-72	2,000	1,303	516	*Agmenellum* (Blue-Green)
12-06-72	694	511	183	*Agmenellum* (Blue-Green)
04-05-73	3,180	2,739	74	*Agmenellum* (Blue-Green)

1 *Schizothrix* or *Porphyrosiphon*
2 Small filamentous blue-green algae tentatively identified as *Oscillatoria*

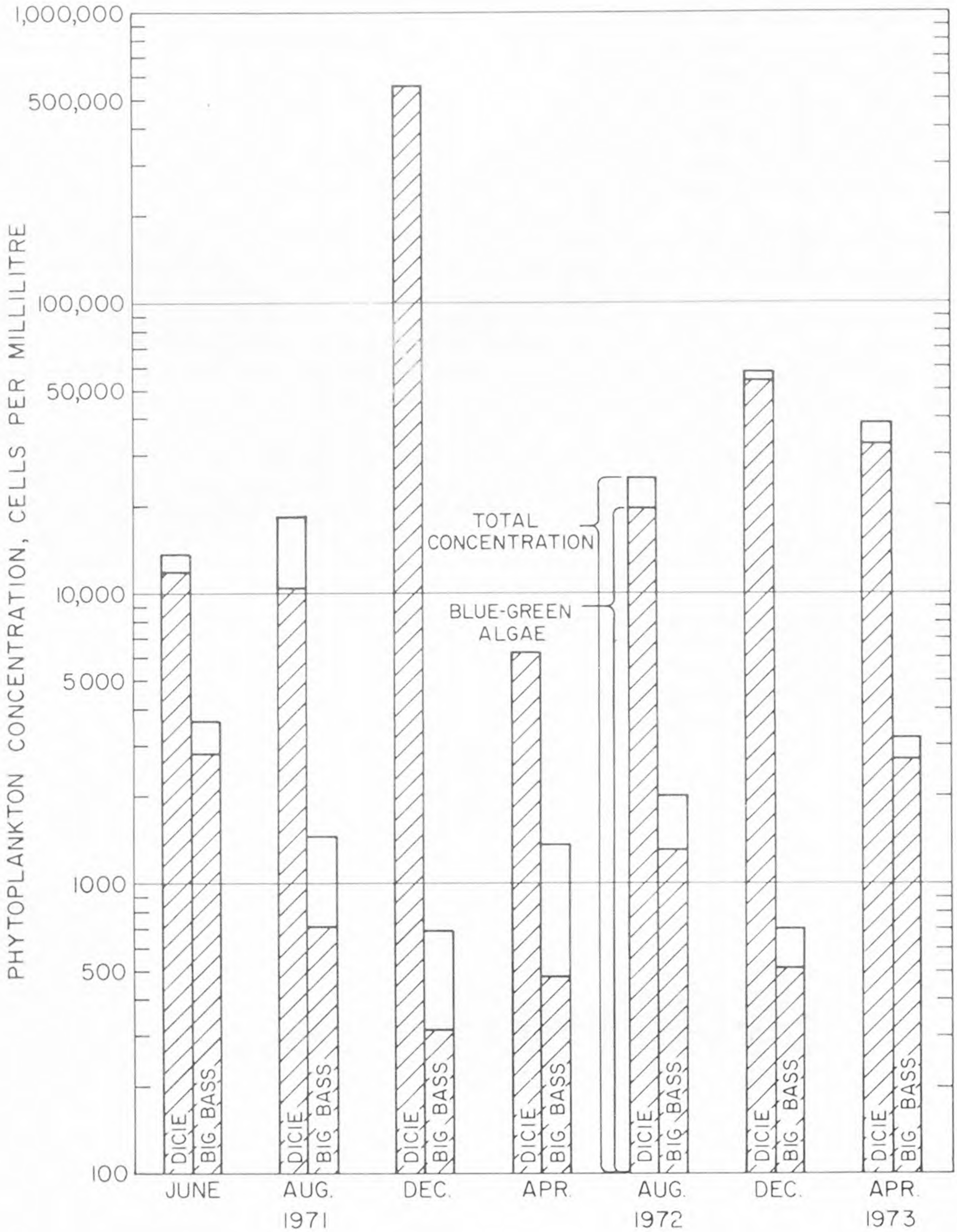

Figure 7.--Concentrations of phytoplankton in Lake Dicie and Big Bass Lake.

During the spring, summer and fall, Lake Dicie is thermally stratified with the nutrient-rich waters near the bottom isolated from the oxygen-rich waters near the surface by a thermocline. This thermocline prevents mixing of the lake and much of the nitrogen, phosphorus and other nutrients released from the decomposition of organic material remains below the thermocline. These nutrients are not available to the phytoplankton whose occurrence is primarily restricted to the area above the thermocline.

During the time that Lake Dicie was stratified, there was a buildup of nitrogen, particularly inorganic nitrogen. Most of the inorganic nitrogen was in the form of ammonia, indicating that the increase in nitrogen in the lake was probably occurring primarily in the lower part of the lake where dissolved-oxygen concentrations were low. Had oxygen been available, much of the ammonia would have been chemically and biologically oxidized to nitrate.

The disappearance of the stratification in the winter months allowed complete mixing of the lake and made the inorganic nitrogen available to the phytoplankton. Of all the samples collected from Lake Dicie, only those collected in December and January when the lake was no longer stratified contained nitrate nitrogen. The absence of oxidized forms of nitrogen during stratification indicates that the normal growth of phytoplankton may exhaust the inorganic nitrogen contributed to the upper part of the lake by rainfall and storm runoff. If so, inorganic nitrogen is probably the factor controlling growth of phytoplankton in the upper part of the lake when the lake is stratified.

Phosphorus is less likely than nitrogen to limit growth in the upper part of the lake because phytoplankton have the ability to store phosphorus in excess of their needs. Also, phosphorus is recycled much more rapidly, and hence, is more readily available for use. The release of considerable amounts of inorganic phosphorus from the breakdown of plant or animal tissue can occur in the upper part of the lake where it can be used by other plants (Russell-Hunter, 1970, p. 164).

The concentration of phytoplankton in Big Bass Lake also changes seasonally. However, the seasonal changes in Big Bass Lake are almost the complete reverse of those in Lake Dicie. That is, in December when concentrations of phytoplankton in Lake Dicie were highest, concentrations in Big Bass Lake were lowest (fig. 7). In Big Bass Lake concentrations of phytoplankton generally were highest in the summer when rainfall is relatively high.

As this lake is located in an undeveloped part of a national forest, and receives relatively little runoff, the close relation between the growth of phytoplankton and rainfall which probably contributes most of the nitrogen and phosphorus to the lake is not surprising. The effects of stratification and the seasonal turnover are less because the degree of stratification in Big Bass Lake is less than that of Lake Dicie. The amount of nutrients recycled by the decay of algal cells and other organic material is probably much smaller in Big Bass Lake than in Lake Dicie because the concentration of phytoplankton is much lower in Big Bass Lake.

Also, the rate at which these nutrients are recycled may be affected by the low pH or other physical or chemical characteristics of Big Bass Lake.

To determine whether nitrogen or phosphorus concentrations limit the growth of phytoplankton in Lake Dicie and Big Bass Lake, phytoplankton growth, in samples of lake water fertilized with nitrate and phosphate solutions and in unfertilized control samples, was observed for 11 weeks. Sodium nitrate solution was added to samples from each lake to increase the concentration of nitrogen by 10 mg/l. Dihydrogen sodium phosphate solution was added to other samples to increase the concentration of phosphorus by 0.20 mg/l. At the end of the 11 weeks some phytoplankton growth was apparent in all samples, including the control, but in the Lake Dicie sample fertilized with nitrate, growth of algae was very heavy. Of the Big Bass Lake samples, that fertilized with phosphate exhibited the greatest amount of algal growth. However, the effects of the addition of nutrients were less apparent in samples of water from Big Bass Lake than in the samples from Lake Dicie. This was probably due to the fact that Big Bass Lake contained much lower concentrations of phytoplankton initially than did Lake Dicie. Phytoplankton growth in Big Bass Lake samples may also have been affected by the lower pH. The results of this experiment indicate that nitrogen, particularly in organic nitrogen, is the factor controlling the growth of phytoplankton in Lake Dicie and that the concentration of phosphorus is probably the factor controlling the growth of phytoplankton in Big Bass Lake.

SUMMARY AND CONCLUSIONS

The drainage area of Lake Dicie, a small lake near Eustis, Florida, was doubled in 1967 when a storm drain was constructed to carry runoff from the southeastern part of the city into the lake. Early in 1969 and on several occasions since that time, the lake experienced massive algal blooms. In order to determine the nature and extent of the problems in Lake Dicie, the quality of both the lake and the runoff was monitored from March 1971 through June 1973. For purposes of comparison, a control lake (Big Bass Lake), which receives no runoff from developed areas, was also monitored. Some of the findings from the investigation are summarized as follows:

1. Storm runoff contributes about 65 percent of the total inflow to Lake Dicie. The storm drain probably contributes at least 70 percent of this runoff and about half of the total input which includes rainfall on the lake. Outflow from the lake consists primarily of seepage and evaporation. Seepage is almost twice the evaporation.

2. Lake Dicie contains a moderately hard, slightly alkaline, calcium bicarbonate water with an average dissolved-solids concentration of 110 mg/l, whereas Big Bass Lake contains a very soft, acidic, sodium chloride water with an average dissolved-solids concentration of 33 mg/l. In addition to the higher concentrations of the major ions, particularly calcium and bicarbonate, the concentration of inorganic nitrogen is higher in Lake Dicie than in Big Bass Lake. The average concentration of total phosphorus is

greater in Lake Dicie than in Big Bass Lake but the average concentration of orthophosphate is slightly higher in Big Bass Lake. Concentrations of lead and other trace elements are low in both lakes.

3. Although the chemical quality of Lake Dicie varies in response to rainfall, runoff and evaporation, no trend toward improvement or deterioration in the quality of Lake Dicie is indicated. Chemical analyses of samples collected during this investigation and in 1969 indicate that the only appreciable change in the quality of Lake Dicie during the last 4 years is a reduction in the concentration of phosphorus.

4. Both Lake Dicie and Big Bass Lake are often stratified in regard to temperature and dissolved oxygen during the spring and summer. Due to its greater depth and higher concentrations of phytoplankton, stratification is more pronounced in Lake Dicie where the water in the bottom of the lake is almost devoid of dissolved oxygen during warm weather periods. The lakes turn over as the water cools in early winter and are well mixed during much of December and January.

5. Average concentrations of the major ions in samples of runoff collected from the storm drain were not appreciably different from the average concentration of those ions in Lake Dicie. However, the concentrations of suspended sediment, nitrogen, and phosphorus, lead and several other dissolved trace elements were much greater in runoff than in the lake. The concentrations of lead averaged 56 μg/l in runoff and only 1 μg/l in the lake. Concentrations of inorganic nitrogen and phosphorus averaged 0.92 and 0.26 mg/l, respectively, in runoff and 0.47 and 0.03 mg/l, respectively, in Lake Dicie.

6. Although storm runoff contained high concentrations of suspended sediment, plant nutrients and several trace elments, the concentrations of these constituents in Lake Dicie were small. When the suspended sediment settled to the bottom of the lake, it apparently carried with it much of the phosphorus, lead and other trace elements carried into the lake by storm runoff. Most of the inorganic nitrogen and some of the orthophosphate was taken up by algae and other plants and incorporated in the cellular structure of these plants. Some of the cellular nitrogen and phosphorus was released upon the death and decomposition of the plants. However, the concentrations of these elements are higher in bottom sediments than in the water, indicating that a part of the organic nitrogen and phosphorus is trapped in the sediment by the incomplete decomposition of the algae and plants.

7. The most obvious effects of the introduction of storm runoff into Lake Dicie are upon the biological quality and not the chemical quality of the lake. Lake Dicie contains greater concentrations of coliform bacteria and phytoplankton than does Big Bass Lake which receives no runoff from developed areas. The highest concentrations of phytoplankton observed in the two lakes were 556,710 cells per millilitre in Lake Dicie and 3,640 cells per millilitre in Big Bass Lake. The higher concentrations of phytoplankton in Lake Dicie appear to be largely the result of the amount of inorganic nitrogen carried into the lake. In view of the amount of inorganic nitrogen carried into the lake by the storm drain, the introduction of storm runoff into Lake Dicie doubtlessly has increased the normal concentration of phytoplankton in the lake and has contributed to the algal blooms that have occurred periodically since the storm drain was installed. Storm runoff also carries large amounts of phosphorus into the lake. However, the amount of phosphorus in Lake Dicie appears to be much greater than the amount required to support the phytoplankton population. The limiting nutrient for phytoplankton in Lake Dicie is probably inorganic nitrogen. In Big Bass Lake the limiting nutrient may be orthophosphate.

8. Algal blooms in Lake Dicie appear to be related to the winter turnover. The two highest concentrations of phytoplankton in Lake Dicie occurred in December when the lake was not stratified. During the spring and summer, stratification in the lake isolates the nutrients, particularly nitrogen, released from the decomposition of organic material in the water near the bottom from the algae in the oxygen-rich water near the surface. In winter the lake becomes mixed by vertical density currents and these nutrients become available to the algae. Algal blooms of the magnitude observed in Lake Dicie do not occur in Big Bass Lake but a seasonal pattern in the concentration of phytoplankton in Big Bass Lake does exist. The concentration of phytoplankton in Big Bass Lake is highest in the spring and summer. The lowest concentration of phytoplankton occurs in the winter. This variation in the phytoplankton population appears to be more closely related to rainfall (the major source of nitrogen and phosphorus) than to the seasonal turnover in the lake.

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BASIC DATA

Table A1.--Physical, chemical and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April 1971.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-16-71	4-24-71		4-27-71	4-30-71
Time sampled	1050	1215		1200	
Lake altitude, feet above msl	70.13	-	-	69.84	-
Depth at sampling point, feet	17	-	-	15.7	12.0
Temperature, °C					
10% of depth	24.0	-	-	26.5	27.5
30% of depth	23.0	-	-	25.0	27.5
50% of depth	19.0	-	-	22.0	27.0
70% of depth	18.0	-	-	20.0	23.5
90% of depth	18.0	-	-	19.0	21.5
Dissolved oxygen, mg/l					
10% of depth	8.6	-	-	8.4	6.8
30% of depth	8.4	-	-	6.7	6.7
50% of depth	3.8	-	-	3.4	6.7
70% of depth	.5	-	-	.4	1.5
90% of depth	.2	-	-	.1	.1
Specific conductance, micromhos at 25°C					
10% of depth	181	-	-	175	37
30% of depth	179	-	-	178	37
50% of depth	178	-	-	175	37
70% of depth	181	-	-	179	36
90% of depth	180	-	-	197	36
Secchi disc, inches	30	-	-	17	82
pH (field)	-	-	-	-	-
Dissolved carbon dioxide, mg/l	2.7	-	-	1.3	0
Major cations, mg/l					
Calcium	25	19.0	-	25	*.8
Magnesium	3.2	1.2	-	3.3	*.6
Potassium	4.5	3.0	-	4.7	*.3
Sodium	6.5	4.2	-	6.5	*4.3
Major anions, mg/l					
Bicarbonate	74	37	-	74	*0
Carbonate	0	-	-	0	*0
Chloride	10	8	-	9	*8.5
Fluoride	.2	.4	-	.2	*.2
Sulfate	19	11	-	20	*0
Trace elements, μg/l					
Aluminum, dissolved	0	100	-	0	0
Arsenic	10	10	-	20	*10
Cadmium, dissolved	1	1	-	0	-

Table A1.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April 1971 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-16-71	4-24-71		4-27-71	4-30-71
Time sampled	1050	1215		1200	
Trace elements (continued)					
Chromium, dissolved	6	0	-	0	0
Copper, dissolved	20	40	-	30	10
Iron, dissolved	20	40	-	20	0
Lead, dissolved	2	115	-	1	0
Manganese, dissolved	0	10	-	0	10
Mercury	0	0	-	0	0
Molybdenum, dissolved	-	-	-	-	-
Nickel, dissolved	4	6	-	4	-
Strontium, dissolved	70	60	-	70	30
Vanadium, dissolved	-	-	-	-	-
Zinc, dissolved	100	70	-	60	70
Nutrients, mg/l					
Organic nitrogen as N	1.1	1.6	-	.85	.93
Nitrite as NO_2	.01	.13	-	.01	.01
Nitrate as NO_3	.0	3.2	-	.0	.1
Ammonia nitrogen as NH_4	.09	1.8	-	.35	.28
Orthophosphate as PO_4	.04	1.6	-	.06	.04
Total phosphate as PO_4	.09	1.8	-	.11	.04
Total organic carbon, mg/l	13	22	-	14	10
Oil and grease, mg/l	16	16	-	15	23
Total coliform, colonies per 100 ml	-	-	-	-	3200
Biochemical oxygen demand (5-day), mg/l	3.3	0.0	-	4.2	.9
Dissolved solids, mg/l					
Residue at 180°C	118	88	-	116	*24
Calculated	107	71	-	106	*15
Suspended solids, mg/l	-	88	-	-	-
Specific conductance, micromhos at 25°C (laboratory)	200	140	-	210	*45
Turbidity (JTU)	7	2.5	-	7	4
Color	0	0	-	0	10
pH (laboratory)	7.5	-	-	7.8	4.5
Hardness, mg/l					
Total	75	53	-	76	5
Noncarbonate	15	22	-	16	5
Silica as SiO_2, mg/l	.8	1.3	-	1.1	.4

*Sample collected May 4 at 1900 hours.

Table A2.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for August and September 1971.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	8-16-71	9-2-71	9-2-71	9-7-71	8-17-71
Time sampled	1115	1350	1410	1010	1015
Lake altitude, feet above msl	69.92	-	-	69.93	-
Depth at sampling point, feet	16.0	-	-	16.5	11.5
Temperature, °C					
10% of depth	28.0	-	-	29.0	27.5
30% of depth	28.0	-	-	29.0	27.5
50% of depth	28.0	-	-	28.5	27.0
70% of depth	27.5	-	-	27.0	26.0
90% of depth	26.0	-	-	24.0	25.0
Dissolved oxygen, mg/l					
10% of depth	3.9	-	-	5.1	5.3
30% of depth	3.8	-	-	4.8	5.2
50% of depth	3.8	-	-	3.9	5.1
70% of depth	.3	-	-	.4	4.9
90% of depth	.3	-	-	.2	.1
Specific conductance, micromhos at 25°C					
10% of depth	164	-	-	-	48
30% of depth	162	-	-	-	43
50% of depth	164	-	-	-	44
70% of depth	210	-	-	-	42
90% of depth	211	-	-	-	42
Secchi disc, inches	32	-	-	38	48
pH (field)	7.1	-	-	7.0	5.1
Dissolved carbon dioxide, mg/l	11	-	-	-	13
Major cations, mg/l					
Calcium	26	20	20	25	.5
Magnesium	2.8	.7	1.3	2.6	.7
Potassium	4.0	1.3	1.1	4.3	.5
Sodium	6.3	4.0	4.0	6.2	4.1
Major anions, mg/l					
Bicarbonate	90	60	60	72	5
Carbonate	0	0	0	0	0
Chloride	8.0	4.5	5.5	9.5	7.0
Fluoride	.2	.3	.2	.1	.1
Sulfate	15	7.6	7.6	16	2.4
Trace elements, μg/l					
Aluminum, dissolved	100	100	0	0	100
Arsenic	0	10	10	0	0
Cadmium, dissolved	0	1	0	0	0

Table A2.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for August and September 1971 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	8-16-71	9-2-71	9-2-71	9-7-71	8-17-71
Time sampled	1115	1350	1410	1010	1015
Trace elements (continued)					
Chromium, dissolved	0	0	0	0	0
Copper, dissolved	10	10	10	10	0
Iron, dissolved	0	120	20	0	30
Lead, dissolved	1	12	18	0	1
Manganese, dissolved	10	0	0	0	20
Mercury	.6	.0	.0	.0	.6
Molybdenum, dissolved	0	0	0	0	0
Nickel, dissolved	1	14	3	3	1
Strontium, dissolved	50	80	80	70	10
Vanadium, dissolved	1	2	3	1	0
Zinc, dissolved	50	40	20	10	60
Nutrients, mg/l					
Organic nitrogen as N	.23	.47	.41	1.6	.73
Nitrite as NO_2	.03	.04	.04	.03	.02
Nitrate as NO_3	.0	.0	.0	.0	.0
Ammonia nitrogen as NH_4	2.3	.05	.12	2.5	.06
Orthophosphate as PO_4	.09	.45	.48	.08	.09
Total phosphate as PO_4	.09	.60	.65	.10	.09
Total organic carbon, mg/l	5	-	-	-	25
Oil and grease, mg/l	9.2	3.4	7.2	6.0	9.2
Total coliform, colonies per 100 ml	1000	-	-	240	300
Biochemical oxygen demand (5-day), mg/l	5.4	7.1	6.1	4.3	.3
Dissolved solids, mg/l					
Residue at 180°C	-	105	105	117	43
Calculated	108	73	75	101	18
Suspended solids, mg/l	-	7	7	-	-
Specific conductance, micromhos at 25°C (laboratory)	210	130	130	200	40
Turbidity (JTU)	20	15	15	25	10
Color	5	10	10	10	10
pH (laboratory)	7.8	6.5	6.7	6.5	5.3
Hardness, mg/l					
Total	77	53	56	73	4
Noncarbonate	3	4	7	14	0
Silica as SiO_2, mg/l	2.0	3.9	4.9	2.3	.2

Table A3.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for Dec. 1971 and Jan. 1972.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	12-9-71		1-26-72	1-31-72	12-9-71
Time sampled	0905		1300	0915	1115
Lake altitude, feet above msl	69.22	-	-	68.43	-
Depth at sampling point, feet	15.3	-	-	14.5	11.0
Temperature, °C					
10% of depth	21.0	-	-	21.0	22.0
30% of depth	20.0	-	-	20.5	21.5
50% of depth	19.0	-	-	18.0	20.0
70% of depth	18.5	-	-	17.0	19.5
90% of depth	18.5	-	-	17.0	19.0
Dissolved oxygen, mg/l					
10% of depth	10.8	-	-	9.0	9.0
30% of depth	10.0	-	-	9.0	9.2
50% of depth	8.3	-	-	8.4	8.7
70% of depth	6.4	-	-	2.5	8.6
90% of depth	4.6	-	-	2.5	8.2
Specific conductance, micromhos at 25°C					
10% of depth	175	-	-	185	37
30% of depth	175	-	-	183	37
50% of depth	175	-	-	185	37
70% of depth	178	-	-	182	36
90% of depth	182	-	-	182	35
Secchi disc, inches	42	-	-	42	120
pH (field)	7.2	-	-	8.4	4.8
Dissolved carbon dioxide, mg/l	7.1	-	-	.6	25
Major cations, mg/l					
Calcium	24	-	22	24	.9
Magnesium	2.4	-	1.2	2.5	.9
Potassium	3.4	-	1.9	3.0	.2
Sodium	5.5	-	5.7	6.0	4
Major anions, mg/l					
Bicarbonate	73	-	53	76	0
Carbonate	0	-	0	0	0
Chloride	8.2	-	10	8.5	7.5
Fluoride	.1	-	.3	.1	.0
Sulfate	16	-	18	15	2.2
Trace elements, μg/l					
Aluminum, dissolved	100	-	100	100	0
Arsenic	0	-	0	0	0
Cadmium, dissolved	0	-	0	0	0

Table A3.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for Dec. 1971 and Jan. 1972 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	12-9-71		1-26-72	1-31-72	12-9-71
Time sampled	0905		1300	0915	1115
Trace elements (continued)					
Chromium, dissolved	0	-	0	0	0
Copper, dissolved	10	-	10	0	10
Iron, dissolved	10	-	50	0	10
Lead, dissolved	1	-	33	1	2
Manganese, dissolved	10	-	10	0	20
Mercury	.0	-	.0	.0	.0
Molybdenum, dissolved	.0	-	1.0	.0	.0
Nickel, dissolved	0	-	2	1	0
Strontium, dissolved	100	-	70	60	100
Vanadium, dissolved	2	-	1	2	0
Zinc, dissolved	30	-	20	20	20
Nutrients, mg/l					
Organic nitrogen as N	.85	-	-	-	.10
Nitrite as NO_2	.05	-	.21	.03	.02
Nitrate as NO_3	.3	-	3.2	.0	.1
Ammonia nitrogen as NH_4	.24	-	.10	.10	.13
Orthophosphate as PO_4	.05	-	.51	.04	.04
Total phosphate as PO_4	.11	-	.64	.10	.06
Total organic carbon, mg/l	12	-	15	12	7
Oil and grease, mg/l	11	-	5.6	5.6	22
Total coliform, colonies per 100 ml	4400	-	-	1150	38
Biochemical oxygen demand (5-day), mg/l	2.8	-	6.2	3.4	.8
Dissolved solids, mg/l					
Residue at 180°C	112	-	104	111	29
Calculated	97	-	92	97	16
Suspended solids, mg/l	-	-	15	-	-
Specific conductance, micromhos at 25°C (laboratory)	178	-	159	184	48
Turbidity (JTU)	4	-	30	15	3
Color	20	-	40	10	20
pH (laboratory)	7.6	-	7.1	7.6	4.6
Hardness, mg/l					
Total	70	-	60	71	5.5
Noncarbonate	10	-	17	8	5.5
Silica as SiO_2, mg/l	1.2	-	3	1.1	.1

Table A4.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April-May 1972.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-07-72	5-10-72	5-10-72	5-25-72	4-07-72
Time sampled	0815	0830	0925	1415	1000
Lake altitude, feet above msl	69.30	-	-	67.91	-
Depth at sampling point, feet	15	-	-	10.5	9.0
Temperature, °C					
10% of depth	22.5	-	-	28.5	23.0
30% of depth	23.0	-	-	28.3	23.0
50% of depth	21.5	-	-	27.5	23.0
70% of depth	20.5	-	-	26.5	21.5
90% of depth	20.0	-	-	25.0	20.5
Dissolved oxygen, mg/l					
10% of depth	9.3	-	-	7.8	7.7
30% of depth	9.5	-	-	8.0	7.7
50% of depth	8.9	-	-	7.8	7.8
70% of depth	3.5	-	-	6.3	6.1
90% of depth	.4	-	-	1.3	5.3
Specific conductance, micromhos at 25°C		-	-		
10% of depth	164	-	-	175	46
30% of depth	160	-	-	173	45
50% of depth	161	-	-	171	44
70% of depth	165	-	-	177	43
90% of depth	175	-	-	180	42
Secchi disc, inches	41	-	-	42	72
pH (field)	7.7	-	-	8.1	4.8
Dissolved carbon dioxide, mg/l	2.4	-	-	-	50
Major cations, mg/l					
Calcium	24	14	18	24	2.4
Magnesium	2.6	.7	.9	2.5	.9
Potassium	2.9	1.1	1.3	3.I	.4
Sodium	5.4	2.6	2.8	6.2	4.8
Major anions, mg/l					
Bicarbonate	69	38	48	68	5
Carbonate	0	0	0	0	0
Chloride	8	4	35	10	6.5
Fluoride	.1	.1	.3	.2	.1
Sulfate	14	4.0	5.6	18	1.6
Trace elements, µg/l					
Aluminum, dissolved	0	100	200	0	0
Arsenic	-	-	-	10	-
Cadmium, dissolved	0	0	0	0	0

Table A4.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April-May 1972 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-07-72	5-10-72	5-10-72	5-25-72	4-07-72
Time sampled	0815	0830	0925	1415	1000
Trace elements (continued)					
Chromium, dissolved	0	0	0	0	0
Copper, dissolved	0	10	10	10	0
Iron, dissolved	10	50	50	10	10
Lead, dissolved	0	36	43	0	0
Manganese, dissolved	0	10	10	0	10
Mercury	-	0	0	.8	0
Molybdenum, dissolved	1	1	1	1	0
Nickel, dissolved	0	4	3	0	0
Strontium, dissolved	-	150	160	10	-
Vanadium, dissolved	1	-	-	0	0
Zinc, dissolved	20	10	10	10	20
Nutrients, mg/l					
Organic nitrogen as N	.89	.75	1.3	.86	1.0
Nitrite as NO_2	.02	.10	.19	.01	.03
Nitrate as NO_3	.0	.6	.7	.0	.0
Ammonia nitrogen as NH_4	.06	.06	.09	.04	.23
Orthophosphate as PO_4	.10	.40	.61	.04	.07
Total phosphate as PO_4	.11	.49	.61	.12	.08
Total organic carbon, mg/l	7	13	22	4	4
Oil and grease, mg/l	1.5	16	7.8	15	0
Total coliform, colonies per 100 ml	1500	-	-	-	100
Biochemical oxygen demand (5-day), mg/l	2.2	6.6	7.7	2.3	1.1
Dissolved solids, mg/l					
Residue at 180°C	104	80	92	115	26
Calculated	93	48	60	110	20
Suspended solids, mg/l	-	14	21	-	-
Specific conductance, micromhos at 25°C (laboratory)	170	88	107	181	42
Turbidity (JTU)	6	15	30	5	4
Color	5	90	180	25	5
pH (laboratory)	7.3	7.7	7.8	8.0	5.9
Hardness, mg/l					
Total	70	38	49	71	10
Noncarbonate	14	7	9	15	6
Silica as SiO_2, mg/l	1.8	1.9	2.9	.7	1.0

Table A5.--Physical, chemical and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for August 1972.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	8-2-72	8-9-72	8-9-72	8-14-72	8-2-72
Time sampled	0735	1815	1835	0830	0855
Lake altitude, feet above msl	67.08	-	-	66.80	-
Depth at sampling point, feet	12.5	-	-	12.5	8.5
Temperature, ^{o}C					
10% of depth	30.0	-	-	30.0	30.0
30% of depth	30.0	-	-	30.0	30.0
50% of depth	30.0	-	-	30.0	30.0
70% of depth	29.5	-	-	29.5	29.5
90% of depth	28.5	-	-	28.0	29.5
Dissolved oxygen, mg/l					
10% of depth	7.6	-	-	6.8	6.5
30% of depth	7.6	-	-	6.4	6.4
50% of depth	6.3	-	-	5.1	5.6
70% of depth	2.2	-	-	.8	5.4
90% of depth	.2	-	-	.3	3.5
Specific conductance, micromhos at $25^{o}C$					
10% of depth	170	-	-	198	50
30% of depth	172	-	-	195	50
50% of depth	174	-	-	188	50
70% of depth	180	-	-	215	50
90% of depth	222	-	-	265	50
Secchi disc, inches	30	-	-	38	60
pH (field)	8.3	-	-	7.4	3.8
Dissolved carbon dioxide, mg/l	.5	-	-	3.6	0
Major cations, mg/l					
Calcium	24	28	26	24	1.8
Magnesium	2.7	.9	.9	2.7	1.1
Potassium	3.2	2.2	1.5	3.3	.4
Sodium	6.0	3.7	1.8	6.1	5.2
Major anions, mg/l					
Bicarbonate	70	64	66	72	0
Carbonate	0	0	0	0	0
Chloride	10	5.5	3.0	10	9.5
Fluoride	.2	.3	.3	.2	.1
Sulfate	15	18	14	15	4.8
Trace elements, μg/l					
Aluminum, dissolved	0	0	100	100	0
Arsenic	0	10	10	10	10
Cadmium, dissolved	0	1	0	0	0

Table A5.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for August 1972 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	8-2-72	8-9-72	8-9-72	8-14-72	8-2-72
Time sampled	0735	1815	1835	0830	0855
Trace elements (continued)					
Chromium, dissolved	0	0	0	0	0
Copper, dissolved	0	30	20	0	10
Iron, dissolved	0	30	10	10	0
Lead, dissolved	0	42	33	2	0
Manganese, dissolved	0	30	20	10	20
Mercury	0	1.6	1.8	2.3	1.8
Molybdenum, dissolved	0	1	1	0	0
Nickel, dissolved	0	4	2	0	0
Strontium, dissolved	120	70	70	70	60
Vanadium, dissolved	1	4	10	1	0
Zinc, dissolved	10	120	50	10	30
Nutrients, mg/l					
Organic nitrogen as N	1.3	2.2	1.9	1.3	1.8
Nitrite as NO_2	.02	.27	.31	.02	.01
Nitrate as NO_3	.0	6.6	3.7	.0	.0
Ammonia nitrogen as NH_4	.30	.48	.31	.88	.10
Orthophosphate as PO_4	.07	.31	.34	.04	.06
Total phosphate as PO_4	.09	.37	.37	.10	.06
Total organic carbon, mg/l	15	73	65	14	16
Oil and grease, mg/l	5.4	11	22	8.4	8.7
Total coliform, colonies per 100 ml	56	-	-	1400	0
Biochemical oxygen demand (5-day), mg/l	3.6	>7.9	>8.9	3.8	.6
Dissolved solids, mg/l					
Residue at 180°C	116	163	134	114	30
Calculated	96	99	83	99	23
Suspended solids, mg/l	-	118	36	-	-
Specific conductance, micromhos at 25°C (laboratory)	170	185	160	190	48
Turbidity (JTU)	8	45	30	9	6
Color	20	70	80	20	15
pH (laboratory)	7.8	6.8	7.3	7.3	4.9
Hardness, mg/l					
Total	71	74	69	71	9
Noncarbonate	14	21	15	12	9
Silica as SiO_2, mg/l	1.0	2.2	1.0	1.0	.2

Table A6.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for December 1972.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	12-6-72	12-15-72	12-15-72	12-21-72	12-6-72
Time sampled	0955	1015	1045	1015	0825
Lake altitude, feet above msl	67.09	-	-	66.67	-
Depth at sampling point, feet	13.0	-	-	12.0	7.5
Temperature, °C					
10% of depth	20.0	-	-	18.0	20.0
30% of depth	19.5	-	-	17.0	20.0
50% of depth	18.5	-	-	16.0	19.5
70% of depth	18.0	-	-	16.0	19.0
90% of depth	18.0	-	-	16.0	18.5
Dissolved oxygen, mg/l					
10% of depth	9.3	-	-	9.6	7.5
30% of depth	9.3	-	-	9.6	7.1
50% of depth	8.2	-	-	8.7	6.6
70% of depth	7.0	-	-	8.0	7.0
90% of depth	6.4	-	-	6.8	6.6
Specific conductance, micromhos at 25°C					
10% of depth	162	-	-	130	44
30% of depth	165	-	-	125	44
50% of depth	170	-	-	130	44
70% of depth	172	-	-	131	44
90% of depth	172	-	-	131	44
Secchi disc, inches	48	-	-	40	74
pH (field)	7.9	-	-	8.1	3.8
Dissolved carbon dioxide, mg/l	1.2	-	-	.8	-
Major cations, mg/l					
Calcium	20	23	33	21	1.4
Magnesium	2.1	2.2	2.0	2.4	1.1
Potassium	2.6	24	3.6	2.6	.3
Sodium	5.4	5.9	10	5.9	5.2
Major anions, mg/l					
Bicarbonate	54	50	59	52	0
Carbonate	0	0	0	0	0
Chloride	10	24	21	10	10
Fluoride	.2	.4	-	.1	.4
Sulfate	14	22	30	15	6.4
Trace elements, µg/l					
Aluminum, dissolved	60	60	50	30	60
Arsenic	10	10	0	0	10
Cadmium, dissolved	0	0	0	0	0

Table A6.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for December 1972 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	12-6-72	12-15-72	12-15-72	12-21-72	12-6-72
Time sampled	0955	1015	1045	1015	0825
Trace elements (continued)					
Chromium, dissolved	0	0	0	0	0
Copper, dissolved	0	30	40	10	0
Iron, dissolved	10	30	40	0	20
Lead, dissolved	1	62	83	0	4
Manganese, dissolved	0	20	20	0	30
Mercury	1.9	.0	.0	.0	.0
Molybdenum, dissolved	0	0	1	0	0
Nickel, dissolved	1	3	4	1	1
Strontium, dissolved	100	100	200	70	100
Vanadium, dissolved	3	1	0	2	0
Zinc, dissolved	10	60	50	10	30
Nutrients, mg/l					
Organic nitrogen as N	.72	2.6	1.7	.86	3.2
Nitrite as NO_2	.01	.13	.43	.02	.01
Nitrate as NO_3	.1	4.9	5.3	.2	.5
Ammonia nitrogen as NH_4	.14	.53	.40	.12	.26
Orthophosphate as PO_4	.03	1.2	.86	.02	.04
Total phosphate as PO_4	.08	1.7	1.3	.05	.04
Total organic carbon, mg/l	9	54	46	2	8
Oil and grease, mg/l	9.2	14	19	5.3	8.5
Total coliform, colonies per 100 ml	950	-	-	100	180
Biochemical oxygen demand (5-day), mg/l	3.0	7.5	8.1	4.9	2.3
Dissolved solids, mg/l					
Residue at 180°C	98	146	219	103	39
Calculated	82	130	140	84	26
Suspended solids, mg/l	-	639	84	-	-
Specific conductance, micromhos at 25°C (laboratory)	161	246	240	171	54
Turbidity (JTU)	4	20	45	8	15
Color	10	85	110	10	15
pH (laboratory)	7.5	7.0	7.0	7.2	5.0
Hardness, mg/l					
Total	59	67	91	62	8
Noncarbonate	15	26	43	20	8
Silica as SiO_2, mg/l	.6	.7	3.0	.5	.2

Table A7.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April-May 1973.

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-5-73	4-26-73	4-26-73	5-4-73	4-5-73
Time sampled	1200	1500	1515	1015	1305
Lake altitude, feet above msl	67.66	-	-	67.09	-
Depth at sampling point, feet	14.5	-	-	13.0	8.0
Temperature, °C					
10% of depth	22.0	-	-	25.0	23.0
30% of depth	21.5	-	-	25.0	23.0
50% of depth	21.0	-	-	24.5	22.0
70% of depth	20.0	-	-	22.0	22.0
90% of depth	19.5	-	-	21.0	21.0
Dissolved oxygen, mg/l					
10% of depth	12.8	-	-	9.8	10.6
30% of depth	8.4	-	-	10.0	6.7
50% of depth	2.4	-	-	7.5	4.1
70% of depth	1.3	-	-	2.6	2.9
90% of depth	1.0	-	-	1.9	2.3
Specific conductance, micromhos at 25°C					
10% of depth	150	-	-	150	50
30% of depth	150	-	-	150	49
50% of depth	150	-	-	153	50
70% of depth	158	-	-	165	49
90% of depth	160	-	-	185	49
Secchi disc, inches	30	-	-	24	24
pH (field)	9.4	-	-	9.3	5.1
Dissolved carbon dioxide, mg/l	0	-	-	0	25
Major cations, mg/l					
Calcium	-	9.2	10	21	1.5
Magnesium	-	.6	.6	2.2	1.1
Potassium	-	2.4	2.6	2.6	.3
Sodium	-	1.7	1.7	5.6	4.7
Major anions, mg/l					
Bicarbonate	62	38	32	59	1
Carbonate	-	0	0	0	0
Chloride	-	3.1	4.1	9.0	7.7
Fluoride	-	.2	.2	.1	.1
Sulfate	-	6.4	5.6	13	4.8
Trace elements, µg/l					
Aluminum, dissolved	-	70	70	30	30
Arsenic	-	5	8	2	4
Cadmium, dissolved	-	-	-	-	-

Table A7.--Physical, chemical, and biological characteristics of Lake Dicie, Big Bass Lake, and runoff into Lake Dicie for April-May 1973 (continued).

LAKE	DICIE				BIG BASS
Condition sampled	Before rain	Early runoff	Late runoff	After rain	Before rain
Date sampled	4-5-73	4-26-73	4-26-73	5-4-73	4-5-73
Time sampled	1200	1500	1515	1015	1305
Trace elements (continued)					
Chromium, dissolved	-	-	-	-	-
Copper, dissolved	-	10	10	0	10
Iron, dissolved	-	40	50	0	0
Lead, dissolved	-	100	100	6	0
Manganese, dissolved	-	10	10	30	20
Mercury	.0	.0	.0	.0	.0
Molybdenum, dissolved	-	0	0	0	0
Nickel, dissolved	-	1	3	0	0
Strontium, dissolved	-	40	60	80	20
Vanadium, dissolved	-	1	2	0	0
Zinc, dissolved	-	20	20	10	20
Nutrients, mg/l					
Organic nitrogen as N	1.1	1.6	1.1	1.6	1.1
Nitrite as NO_2	.01	.01	.11	.01	.01
Nitrate as NO_3	.0	.0	1.3	.0	.4
Ammonia nitrogen as NH_4	.12	.14	.42	.14	.35
Orthophosphate as PO_4	.05	.04	.92	.04	.05
Total phosphate as PO_4	.08	.06	1.1	.06	.06
Total organic carbon, mg/l	9	2	9	12	3
Oil and grease, mg/l	16	14	50	19	14
Total coliform, colonies per 100 ml	820	-	-	220	48
Biochemical oxygen demand (5-day), mg/l	4.7	>8.3	>8.6	2.4	1.1
Dissolved solids, mg/l					
Residue at 180°C	-	56	58	91	38
Calculated	-	43	41	83	21
Suspended solids, mg/l	-	75	80	-	-
Specific conductance, micromhos at 25°C (laboratory)	145	89	89	155	48
Turbidity (JTU)	8	10	25	10	10
Color	5	40	40	20	15
pH (laboratory)	7.7	6.8	6.5	6.8	5.1
Hardness, mg/l					
Total	-	25	28	62	8
Noncarbonate	-	0	2	14	7
Silica as SiO_2, mg/l	.5	.6	.9	.6	.2

Table A8.--Chemical and physical characteristics of Lake Dicie, May 15, 1969.

Major cations, mg/l	
Calcium	25
Magnesium	2.8
Potassium	3.6
Sodium	7.4
Major anions, mg/l	
Bicarbonate	79
Chloride	11
Sulfate	12
Nutrients, mg/l	
Organic nitrogen as N	1.2
Nitrite as NO_2	.01
Nitrate as NO_3	.0
Ammonia nitrogen as NH_4	.33
Total nitrogen as N	1.46
Orthophosphate as PO_4	.11
Total phosphate as PO_4	.20
Total phosphorus as P	.065
Dissolved solids, mg/l	136
Specific conductance, micromhos	198
Turbidity (JTU)	33
Color	0
pH	6.7
Total hardness, mg/l	74
Noncarbonate hardness, mg/l	9
Silica, mg/l as SiO_2	.6

Table A9.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Organisms	Lake Dicie		Big Bass Lake	
	6-18-71	8-16-71	6-18-71	8-17-71
Phylum Cyanophyta (blue-green algae)	11,928	10,355	2,800	706
Agmenellum glauca	56	2,650		
Agmenellum punctata			2,464	457
Aphanizomenon flos-aquae	7,056	2,385	56	
Coelosphaerium sp.				83
Gloeothece sp.			56	
Lyngbya contorta		3,975		
Microcystis aeruginosa	4,816	1,325	224	166
Phylum Chlorophyta (green algae)	1,680	7,420	784	707
Ankistrodesmus falcatus	56	530		
Chlorella sp.	1,064	1,060	336	83
Cosmarium sp.	56			
Micrasterias sp.				83
Oocystis sp.			224	208
Scenedesmus sp.	168	4,240	224	208
Selenastrum sp.	280	1,590		125
Tetraedron sp.	56			
Phylum Pyrrophyta (dinoflagellates)	112	265	0	42
Peridinium sp.	112	265		42
Phylum Chrysophyta (yellow-green algae including diatoms)	0	530	56	0
Dinobryon sp.			56	
Unidentified		530		
TOTALS	13,720	18,550	3,640	1,455

Table A10.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

	Lake Dicie	Big Bass Lake
	12-9-71	12-9-71
Phylum Cyanophyta (blue-green algae)	556,710	312
Microcystis aeruginosa	552,090	208
Oscillatoria sp.	4,620	
Unidentified		104
Phylum Chlorophyta (green algae)	0	311
Chlorella sp.		104
Oocystis sp.		138
Scenedesmus sp.		69
Phylum Pyrrophyta (dinoflagellates)	0	35
Peridinium sp.		35
Phylum Chrysophyta (yellow-green algae including diatoms)	0	35
Navicula sp.		35
TOTALS	556,710	693

Table A11.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and in Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Organisms	Lake Dicie	Big Bass Lake
	4-7-72	4-7-72
Phylum Cyanophyta (blue-green algae)	6279	477
Agmenellum punctata		298
Gloeocystis sp.		179
Microcystis aeruginosa	2751	
Schizothrix sp.	3528	
Phylum Chlorophyta (green algae)	0	537
Chlorella sp.		60
Selenastrum sp.		89
Sphaerocystis sp.		358
Staurastrum sp.		30
Phylum Euglenophyta (euglenoids)	0	358
Unidentified		358
TOTALS	6279	1372

Table A12.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and in Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Organisms	Lake Dicie	Big Bass Lake
	8-2-72	8-2-72
Phylum Cyanophyta (blue-green algae)	19,512	1,303
Agmenellum glauca	363	
Agmenellum punctata		879
Chroococcus sp.	606	273
Microcystis aeruginosa	2,666	
Microcystis rupestris		121
Raphidiopsis sp.	485	
Schizothrix sp. / Porphyrosiphon sp.	15,392 1/	
Unidentified		30
Phylum Chlorophyta (green algae)	969	516
Chlorella sp.		121
Dictyosphaerium pulchellum		61
Oocystis sp.	121	
Scenedesmus sp.	485	
Selenastrum sp.		212
Sphaerocystis sp.		61
Staurastrum sp.	121	61
Unidentified	242	
Phylum Pyrrophyta (dinoflagellates)	0	30
Peridinium sp.		30
Phylum Chrysophyta (yellow-green algae including diatoms)	0	151
Asterionella formosa		30
Dinobryon sp.		121
TOTALS	20,481	2,000

1/ Tentatively identified as Schizothrix or Porphyrosiphon

Table A13.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and in Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Organisms	Lake Dicie	Big Bass Lake
	12-6-72	12-6-72
Phylum Cyanophyta (blue-green algae)	53,760	511
Agmenellum glauca	640	
Agmenellum punctata		365
Microcystis aeruginosa	1,280	
Microcystis rupestris		110
Raphidiopsis sp.	640	
Oscillatoria sp.1/	51,200	
Unidentified		36
Phylum Chlorophyta (green algae)	2,560	183
Scenedesmus sp.	640	
Selenastrum sp.	1,280	
Sphaerocystis sp.		110
Tetraedron sp.	640	
Unidentified		73
Phylum Euglenophyta (euglenoids)	640	0
Unidentified	640	
Phylum Chrysophyta (yellow-green algae including diatoms)	640	0
Unidentified	640	
TOTALS	57,600	694

1/ Tentatively identified.

Table A14.--Phytoplankton concentrations in cells per millilitre in Lake Dicie and in Big Bass Lake. Counts made by Dr. Jackson L. Fox, University of Florida, Gainesville, Florida.

Organisms	Lake Dicie	Big Bass Lake
	4-5-73	4-5-73
Phylum Cyanophyta (blue-green algae)	32,640	2,739
Agmenellum punctata		2,665
Aphanizomenon flos-aquae	12,800	
Lyngbya contorta	1,280	
Lyngbya sp.		37
Microcystis aeruginosa	640	
Oscillatoria sp.	16,640	
Raphidiopsis sp.	1,280	
Unidentified		37
Phylum Chlorophyta (green algae)	5,120	74
Actinastrum sp.	640	
Ankistrodesmus falcatus	640	
Coelastrum sp.	640	
Cosmarium sp.		37
Scenedesmus bijuga	1,280	
Staurastrum sp.	640	
Tetraedron sp.	1,280	37
Phylum Chrysophyta (yellow-green algae including diatoms)	640	367
Asterionella formosa		37
Cocconeis sp.		146
Cyclotella sp.		37
Melosira sp.		37
Navicula sp.	640	110
TOTALS	38,400	3,180

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