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In-Lake Water Quality Management for Lake Eureka: Highlights of Third Year (1983) Operation

by Raman K. Raman and Davis B. Beuscher (Illinois State Water Survey)
and Benny R. Arbuckle (City of Peoria)

ILLINOIS STATE WATER SURVEY

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INTRODUCTION

City-owned Lake Eureka, situated in central Illinois (figure 1), was created in 1942 primarily to serve as a water supply source for the city of Eureka. The city owns and operates the water treatment and distribution systems. The lake has a surface area of 36 acres; mean and maximum depths of 6.3 and 18.0 feet, respectively; and a total volume of 227 acre-feet.

During the early 1970s, citizens began complaining about taste and odor problems in the finished waters. These complaints became numerous and in-

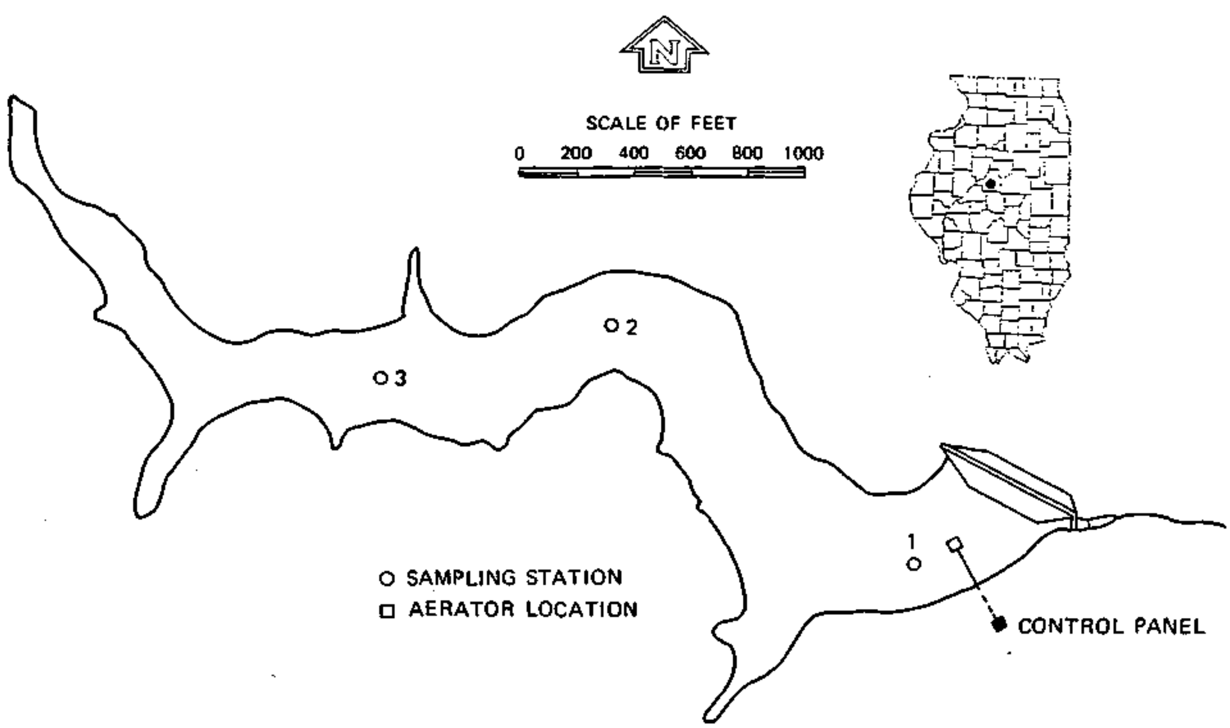

Figure 1. Location of aerator and sampling stations in Lake Eureka

cessant as the years progressed, despite efforts to control the taste and odor problems at the water treatment plant by such traditional methods as super chlorination, activated carbon adsorption, and potassium permanganate application. The severe taste and odor problems encountered during the winter of 1976-1977 marked the end of local tolerance. The city sought an alternate source of raw water supply and switched to groundwater in November 1979.

However, the use of groundwater as a source increased pumping, chemical, and treatment costs. Since the water treatment plant had not been designed to treat groundwater, the change created a different set of operating problems. The volume of softening sludge increased significantly. Floc carried over from the settling basins to the filter beds, and the softening sludge discharge pipes frequently clogged, adding to the plant's operational and maintenance loads.

A detailed investigation of Lake Eureka by Lin and Evans (1981), conducted during 1976-1978 to delineate the relationship between taste and odor and commonly measured water quality characteristics, revealed very high positive correlations between taste and odor and iron, manganese, and ammonia concentrations; chlorine demand values; and the dominance of blue-green algae in the lake waters during summer months.

The raw water intake in the lake is so constructed as to draw lake waters from the strata varying from 3'-6" to 6'-0" from the bottom. Roseboom et al. (1979) reported that the hypolimnetic zone of the lake became totally anoxic during the summer months from June through September, and the anoxic zone extended from the lake bottom to about 8 to 9 feet from the bottom. They observed that at all times during the thermal stagnation, the levels of phosphorus, ammonia-nitrogen, iron, manganese, and alkalinity were significantly greater in the lake's bottom waters than in the surface waters. Tables 1 and 2 show the mean and range of values of chemical parameters they reported for the surface and near bottom waters at the deep

Table 1. Summary of Water Quality Characteristics
at the Surface of Lake Eureka, Deep Station

	1983			1978		
Parameters	No. of observa-tions	Mean	Range	No. of observa-tions	Mean	Range
Secchi readings	19	19	6-35	48	28	12-68
Turbidity	16	27	4-60			
PH	18		7.7-9.4			8.0-9.2
Suspended solids	17	34	6-204			
Alkalinity	18	192	126-276	50	145	94-185
Conductivity	16	416	275-560			
Total ammonia-N	18	0.35	0.03-3.51	15	0.20	0.00-0.89
Dissolved nitrate-N	18	4.16	0.09-9.48			
Total dissolved iron	18	0.28	0.09-1.25	16	0.17	0.06-0.37
Total dissolved manganese	18	0.06	0.03-0.11	15	0.10	0.00-0.58
Chlorine demand	18	5.16	1.51-18.20	25	4.20	1.10-8.10

Units of measurement: Turbidity - NTU; secchi - inches, pH - dimensionless;
conductivity - μmho/cm; others-mg/l

Table 2. Summary of Water Quality Characteristics
of Near Bottom Waters of Lake Eureka, Deep Station

	1983			1978		
Parameters	No. of observa-tions	Mean	Range	No. of observa-tions	Mean	Range
Turbidity	16	41	10-152			
pH	18		7.5-8.5			7.2-8.3
Suspended solids	17	43	5-197			
Alkalinity	18	196	124-268	50	221	150-301
Conductivity	16	423	286-580			
Total ammonia-N	18	0.26	0.06-0.89	18	3.97	0.43-7.11
Dissolved nitrate-N	18	4.07	0.07-9.23			
Total dissolved iron	18	0.35	0.09-1.41	18	5.27	0.16-10.90
Total dissolved manganese	18	0.11	0.03-0.90	18	3.91	0.24-9.00
Chlorine demand	18	5.19	1.37-21.90	25	9.20	2.50-17.10

Units of measurement: Turbidity - NTU; pH - dimensionless;
Conductivity - μmho/cm; others - mg/l

station No. 1 (figure 1) in Lake Eureka. Because of the location of the intake, a significant portion of the raw water coming into the treatment plant was drawn from the hypolimnetic zone of the lake, which was anoxic during summer months and high in iron, manganese, and ammonia concentrations.

In 1981 the State Water Survey investigated the in-lake management technique of combining aeration-destratification of Lake Eureka with in-lake chemical control of blue-green algae to enhance the lake water quality, so that the lake could once again be used as a water supply source. A low energy mechanical destratifier with a 1-1/2-hp motor, developed by James E. Garton and his associates at Oklahoma State University, Stillwater, Oklahoma, was installed in the lake on May 1, 1981. The details regarding the destratifier used in the lake, the types and quantities of chemicals used, and the methods and frequency of applications are discussed in detail elsewhere (Kothandaraman and Evans, 1982).

On the [illegible] monitoring of the lake during 1981, it was concluded that the destratifier was capable of destratifying the lake and maintaining adequate levels of oxygen throughout the lake. The in-lake water quality management scheme improved the water quality characteristics significantly enough that the lake could once again be used as a water supply source.

The city reverted to the lake as a water supply source on April 13, 1982, on the recommendation of the State Water Survey. With the aerator in place and operating in the lake, the water supply system has functioned extremely satisfactorily since then, without any source-related' consumer complaints about taste and odor. A detailed discussion on the water quality characteristics of the lake and the cost savings in the water treatment system operation as a result of the switch to the lake as a water supply source for the year 1982 can be found in the report by Raman and Evans (1984). The results of the 1983 operation of the aerator in Lake Eureka are summarized below.

THIRD YEAR OPERATION

The aerator was operated during the winter of 1982-1983 and turned off in mid-March, the time when lakes generally have a tendency to be uniformly mixed after a spring turnover. The aerator was turned on again on May 23, 1983, for the summer season; was shut off for a brief period from October 14, 1983 to December 8, 1983; and was then put back in operation for the winter season.

The lake was monitored for physical, chemical, and biological characteristics on a once-a-month schedule from January to April and again from October to December. It was monitored on a bi-weekly basis from May to September. The procedures used for in-situ observations, sample collections, chemical analyses, and algal identification are all detailed in an earlier report (Kothandaraman and Evans, 1982).

The temperature and dissolved oxygen observations in the lake stations were normal until the end of July. The raw data for the dissolved oxygen, temperature, and chemical analyses can be found in the appendices. The July 20 sample for algal assay indicated the dominance of the green algae *Tetraedron quadratum* (table 3) in the lake. This was the first time this species of green algae had ever been found and identified by the Water Survey in surface waters of Illinois.

Table 3. Algal Types and Densities in Lake Eureka, Station 1
(Density in counts per milliliter)

	Surface samples					Near bottom samples				
Dates	B G	G	D	F	T	B G	G	D	F	T
1/12/83	0	10	0	0	10	0	30	10	0	40
2/15	0	7,420	90	0	7,510	0	14,990	0	0	14,990
3/15	0	3,270	80	0	3,350	0	4,570	30	0	4,600
4/15	0	3,200	70	0	3,270	0	3,250	140	100	3,490
5/4	0	560	60	0	620	0	580	50	20	650
5/17	0	60	60	9,120	9,240	0	50	110	0	160
6/8	0	90	0	0	90	0	20	100	0	120
6/22	0	390	900	0	1,290	0	150	210	0	360
7/5	100	590	1,130	0	1,820	0	200	790	0	980
7/20	30	3,160	80		3,270	30	1,320	80	0	1,430
8/2	0	32,760	160	370	33,290	0	150	690	0	840
8/17	0	1,970	330	70	2,370	0	280	0	0	280
8/30	0	70	80	210	360	0	30	40	30	100
9/14	0	220	60	0	280	0	100	10	0	110
9/29	0	950	10	0	960	0	70	0	0	70
10/14	0	17,220	0	0	17,220	0	2,450	3,030	0	5,480
11/11	10	90	0	0	100	0	40	140	0	180
12/13	0	40	20	0	60	0	30	90	0	120

Note: BG - blue-greens; G - greens; D - diatoms; *F* - flagellates;
T - total

The results of the August 2, 1983, monitoring survey were extraordinary. The entire lake appeared dark brown with a secchi disc reading of nine inches. The dissolved oxygen readings were in excess of 28 mg/1 in the top 4 feet of the lake surface, dropping to 5.1 mg/1 at 6 feet from the surface. The temperature varied from 31.0°C at the surface to 26.5°C near the bottom. There was a tremendous algal bloom comprised almost entirely of the green algae T. guadratum, which reached a density of 32,760 counts/ml of the total of 33,290 counts/ml.

The cells of these organisms are solitary and free-floating. They have from one to many chromatophores in their cell structure, which give them a greenish-brown hue. There is no recorded evidence to indicate that these organisms cause problems in water treatment systems.

Since one of the primary objectives of the water quality management in Lake Eureka was to control blue-green algae, which are known to cause problems in water supply systems, a decision was made not to treat the lake with chelated copper sulfate. As a matter of fact, there was no copper sulfate application to the lake during 1983.

However, it soon became apparent that this massive algal bloom observed on August 2, 1983, could create other water quality problems. The dissolved oxygen concentrations in the entire water column at station 1 decreased to less than 3.0 mg/1 on August 17, 1983 and to zero or near zero at depths below six feet on August 30, 1983 (appendix A-l). This is presumably due to the death and decay of the extremely high numbers of algae in the algal bloom observed on August 2, 1983. Algal counts observed during the subsequent field visits were in general much lower than those observed for this date (table 3). The oxygen demand exerted by the decaying algal cells was much higher than the oxygen transfer from the atmosphere. The destratifier kept the lake completely mixed during this period as evidenced by the depth-temperature relationship at station 1 (appendix A-l).

A massive fish kill (shad) occurred during the waning days of August 1983. Surprisingly, there was not much public commotion, and the fish kill episode was considered a blessing in disguise to rid the lake of unwanted fish population.

In retrospect, it is felt that the lake should have been treated with algicide during late July and early August 1983.

The dissolved oxygen concentrations in the deep waters of the lake began to improve by September 14, 1983. The lake was treated with 50 pounds of potassium permanganate on August 30, 1983 and again on September 16, 1983 to hasten the recovery of oxygen conditions in the lake. The dissolved oxygen conditions in the lake recovered and improved thereafter.

During the period of algal bloom and the subsequent fish kill, lasting for nearly six weeks, there were no uncontrollable taste and odor problems in the finished water supply. Increased amounts of activated carbon and chlorine were used for a very short period soon after the fish kill. The dead fish in the lake and those washed ashore were not removed but were allowed to decay in the lake itself.

Summaries of the water quality characteristics including mean, minimum, and maximum values observed in the lake during 1983 for the surface and near-bottom water samples at station 1 are given in tables 1 and 2.

The mean and maximum values for secchi disc readings in 1983 were much less than the values for 1978 (table 1). This is primarily because of heavy rainfall during the spring and early summer of 1983 and the prolonged period of algal bloom and its after-effects. The mean and maximum values for ammonia-nitrogen, total iron, and chlorine demand for the surface waters were higher in 1983 than in 1978. The high ammonia-nitrogen and chlorine demand values in the surface waters are attributable to the algal bloom and fish kill.

However, the mean, minimum, and maximum for ammonia-nitrogen, total dissolved iron, total dissolved manganese, and chlorine demand values (with the exception of the maximum value for chlorine demand) for the near-bottom waters were all less in 1983 than in 1978. The maximum value for chlorine demand — 21.9 mg/1 — occurred on August 30, 1983 shortly after the fish kill (table 2). Percentage reductions of 93, 93, 97, and 44 in the mean values for ammonia-nitrogen, iron, manganese, and chlorine demand, respectively, were achieved. These are primarily due to the oxic conditions that prevailed in the lake near-bottom waters during 1983. Percentage reductions of 91, 94, 98, and 55 in the mean values for ammonia-nitrogen, iron, manganese, and chlorine demand, respectively, were achieved in 1982 in the near-bottom water samples compared to the preaeration conditions (Raman and Evans, 1984).

Despite the massive algal bloom of green algae T_. quadrature and the fish kill in the lake, the water quality characteristics of the raw water remained satisfactory enough that the Eureka water supply system operated satisfactorily during 1983, without consumer complaints about source related taste and odor problems.

COST-BENEFIT ANALYSIS

As indicated earlier, the city reverted to the lake as its water supply source on April 13, 1982. The water treatment system continued to operate extremely well.

The use of lake water as a source resulted in total elimination of the power needs for pumping well water. It also resulted in reduced power consumption in plant operation, as there was no need to run the cascade aerator for iron, manganese, and hydrogen sulfide removal. Table 4 shows the actual power consumption and the chemicals used in the treatment plant for Fiscal Year 1981-82 (May 1, 1981 to April 30, 1982) and FY 1983-84. The treatment plant operated with groundwater as the source during FY 1981-82. Significant decreases in power consumption and in lime and carbon dioxide usages are evidenced in the table.

Table 4. Power Consumption and Chemicals Used in Eureka Water Treatment Plant

Items	FY 1981-82	FY 1983-84
Electricity for wells, 10^3 kwh	453.65	--
Electricity for plant, 10^3 kwh	256.48	234.56
Lime, tons	336.32	181.55
Chlorine, tons	4.95	3.83
Fluoride, tons	1.80	2.78
Carbon dioxide, tons	173.03	33.15
Alum, tons	--	37.50
Finished water, million gallons	166.5	188.7

Table 5. Cost Comparison of Water Treatment Plant Operations

(Thousands of dollars)

Items	FY 1981-82	FY 1983-84	FY 1983-84 at FY 1981-82 rates
Electricity for wells	24.75	--	--
Electricity for the plant	13.96	21.94	12.77
Lime	24.61	12.39	13.28
Chlorine	1.04	1.67	0.80
Fluoride	0.38	0.69	0.59
Carbon dioxide	26.99	6.39	5.17
Alum	--	9.45	9.45
Total	91.73	52.53	42.06
Cost/million gallons	0.55	0.28	0.23

Table 5 shows the cost savings realized by the city during FY 1983-84 because of the change in water supply source. The treatment plant operating cost (excluding manpower) was $91,730 for FY 1981-82. The operating cost for FY 1983-84 was $52,530, resulting in a savings of $39,200 or 42.7% of the FY 1981-82 operating cost. (The cost to operate the destratifier in 1983 was about $500, and chemical application costs were $100; thus the total cost for implementing the water quality management scheme in 1983 was about $600.) Table 5 also shows the cost of power and chemicals used during FY 1983-84 at the rates that prevailed during FY 1981-82. The operating cost of the plant in FY 1983-84 would have been only $42,060 at FY 1981-82 rates, representing an apparent savings of $49,670 or 54.1% of the operating cost in FY 1981-82. It should also be noted that the total amount of water treated by the system increased from 166.5 million gallons in FY 1981-82 to 188.7 million gallons in FY 1983-84.

Detailed analyses of energy use and costs for the pre- and post-project periods are given in table 6. It is noteworthy that the energy consumption decreased from 4300 kwh per million gallons treated in FY 1981-82 to 1300 kwh per million gallons in FY 1982-83 and 1200 kwh per million gallons in FY 1983-84.

The cost figures shown in table 6 are all expressed in 1981 dollars. The actual plant operating costs decreased from $551 per million gallons in 1981-82 to $226 per million gallons in 1983-84. Savings in operating costs due to the project implementation were 51 and 54% during the first and second years of the treatment plant operation after the city reverted to the lake as its potable water supply source.

Table 6. Comparison of the Pre- and Post-Project Operations of the Water Treatment System

Items	Pre-project operation FY 1981-82	Post-Project operations FY 1982-83	FY 1983-84
Energy used for pumping wells, 10^3 kwh	453,7	34.3	--
Energy used for plant operation, 10^3 kwh	256.5	192.7	234.6
Quantity of water treated, million gallons	166.5	168.8	188.7
Energy used per million gallons of water treated, 10^3 kwh	4.3	1.3	1.2
Cost of energy and chemicals used*	91730.0	43400.0	42060.0
Cost of project implementation*		1200.0	600.0
Cost per million gallons treated*	550.9	264.2	226.1
Savings due to project implementation*		47130.0	49070.0
Savings in operating costs as percent of 1981 operating cost		51.3	53.5
Benefit/cost ratio		39.3	81.8

*Cost in 1981 dollars

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Appendix A-l. Dissolved oxygen, temperature observations in Lake Eureka, Station 1

Depth feet	1-12-83 D.O.	1-12-83 Temp	2-15-83 D.O.	2-15-83 Temp	3-15-83 D.O.	3-15-83 Temp	4-15-83 D.O.	4-15-83 Temp	5-4-83 D.O.	5-4-83 Temp	5-17-83 D.O.	5-17-83 Temp	6-8-83 D.O.	6-8-83 Temp	6-22-83 D.O.	6-22-83 Temp	7-5-83 D.O.	7-5-83 Temp	7-20-83 D.O.	7-20-83 Temp
0	12.8	1.0	16.2	3.0	12.4	6.5	10.7	7.8	8.8	12.3	16.5	17.0	7.8	20.9	10.9	25.9	7.8	27.0	8.9	30.2
2	12.6	1.0	16.3	3.0	12.0	6.5	10.6	7.8	8.0	12.3	16.5	17.0	7.8	20.8	10.8	25.7	7.8	27.0	8.6	30.2
4	12.6	1.1	16.3	3.0	11.8	6.5	10.6	7.8	8.8	12.2	16.0	16.0	7.7	20.7	8.0	24.2	7.8	27.0	8.6	30.2
6	12.5	1.2	16.3	3.0	11.8	6.5	10.6	7.8	8.7	12.2	12.6	15.5	7.3	20.0	6.9	23.8	7.6	27.0	8.3	30.2
8	12.6	1.2	16.3	3.0	11.0	6.5	10.6	7.8	8.7	12.2	8.4	14.8	7.1	19.0	6.1	23.5	7.6	26.5	8.1	30.2
10	12.6	1.2	16.3	3.0	11.0	6.0	10.6	7.8	8.7	12.2	6.9	13.6	6.3	19.0	6.0	23.4	7.4	26.5	8.0	30.2
12	12.4	1.3	15.0	3.0	11.1	6.0	10.6	7.8	8.7	12.2	6.5	13.0	5.0	18.4	5.9	23.4	7.4	27.5	7.6	30.2
14	12.4	1.5	12.1	3.0	11.1	6.0	10.6	7.8	8.6	11.3	6.0	13.0	2.1	17.0	5.2	23.3	7.5	27.5	6.3	30.0
16	12.4	1.5			11.1	6.0	10.6	7.8	7.3	10.4	3.9	12.5	0.7	16.0	5.2	23.0	7.2	26.5	4.9	30.0
18					11.1	6.0	10.6	7.8	5.5	10.2	2.8	12.0	0.6	15.8	3.2	22.4	5.5	26.5	4.7	29.0

Depth feet	8-2-83 D.O.	8-2-83 Temp	8-17-83 D.O.	8-17-83 Temp	8-30-83 D.O.	8-30-83 Temp	9-14-83 D.O.	9-14-83 Temp	9-21-83 D.O.	9-21-83 Temp	9-29-83 D.O.	9-29-83 Temp	10-14-83 D.O.	10-14-83 Temp	11-11-83 D.O.	11-11-83 Temp	12-13-83 D.O.	12-13-83 Temp
0	27.3	31.0	2.8	26.2	5.1	27.0	3.8	23.0	5.7	19.2	11.5	19.0	8.5	13.5	9.5	9.5	9.7	2.5
2	>28.0	30.0	2.7	26.2	5.0	27.0	3.6	23.0	5.7	19.2	7.3	18.0	8.4	13.5	9.3	9.5	9.7	2.5
4	5.1	28.0	2.6	26.2	3.9	27.0	3.4	23.0	5.6	19.2	6.8	17.5	8.4	13.5	9.3	9.1	9.7	2.5
6	4.2	28.0	2.6	26.2	0.2	26.5	3.3	23.0	5.6	19.2	6.5	17.5	8.4	13.5	9.2	9.1	9.7	2.5
8	4.2	28.0	2.5	26.2	0.2	26.5	3.3	23.0	5.6	19.2	6.5	17.5	8.3	13.5	9.2	9.1	9.7	2.5
10	4.6	27.9	2.5	26.2	0.0	26.5	3.2	23.0	5.4	19.2	6.5	17.5	8.3	13.5	9.0	9.1	9.5	2.5
12	4.7	27.9	2.4	26.2	0.0	26.5	3.2	22.5	5.4	19.2	6.5	17.5	8.2	13.5	9.0	9.1	9.2	2.5
14	5.4	27.5	2.3	26.2	0.0	26.5	3.2	22.5	5.2	19.2	6.0	17.5	8.2	13.5	9.0	9.1	9.2	2.5
16	4.4	26.9	1.5	26.2	0.0	26.5	3.2	22.5	5.2	19.2	4.5	17.5	8.2	13.5	9.0	9.1	8.8	2.8
18	4.6	26.5			0.0	26.5											8.7	3.0

D.O. - mg/1
Temperature - degrees Celsius

Appendix A-2. Dissolved oxygen, temperature observations in Lake Eureka
Station 2

Depth	1-12-83		3-15-83		4-15-83		5-4-83		5-17-83		6-8-83		6-22-83		7-5-83		7-20-83	
feet	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
0	12.5	1.0	12.0	8.0	10.8	7.5	8.5	12.2	17.8	17.1	8.0	20.6	11.4	26.4	8.8	27.0	10.0	30.2
2	12.3	1.3	12.0	8.0	10.6	7.5	8.5	12.0	17.8	17.1	8.0	20.2	11.7	25.9	8.8	26.9	10.2	30.2
4	12.4	1.3	12.0	7.0	10.6	7.5	8.6	12.0	17.5	17.0	7.1	20.0	9.5	24.7	8.8	26.5	9.6	30.2
6	12.3	1.2	11.9	7.0	10.4	7.5	8.6	11.8	11.9	15.2	6.9	19.8	6.9	23.9	8.4	26.5	8.7	30.2
8	12.3	1.2	11.9	7.0	10.4	7.5	8.4	11.4	8.1	14.5	6.5	19.6	6.9	23.8	8.2	26.0	7.6	30.2
10	12.3	1.2	11.9	7.0	10.4	7.5	8.3	11.0	7.8	14.1	6.5	19.4	7.5	23.4	7.8	26.0	6.6	30.1

Depth	8-2-83		8-17-83		8-30-83		9-14-83		9-21-83		9-29-83		10-14-83		11-11-83		12-13-83	
feet	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
0	19.4	31.0	5.6	26.8	4.0	27.0	9.6	24.5	5.9	19.0	14.5	21.0	8.7	13.5	9.9	9.1	9.9	2.2
2	12.2	29.5	4.5	26.8	4.0	27.0	7.6	23.0	5.6	19.0	13.8	20.0	8.2	13.5	9.9	9.0	9.9	2.2
4	5.1	28.2	3.9	26.8	3.8	26.9	7.2	23.0	5.2	19.0	9.0	18.0	8.1	13.5	9.9	9.0	9.9	2.5
6	4.2	28.0	3.5	26.8	3.8	26.9	4.4	22.0	5.2	19.0	6.5	7.5	8.1	13.5	9.9	9.0	9.8	2.7
8	6.9	28.0	1.5	26.3	3.8	26.9	4.3	22.0	5.2	19.0	5.5	7.5	9.2	13.2	9.8	9.0	9.6	2.9
10	7.1	27.0	1.2	26.2	4.2	26.5	4.5	22.0	5.1	19.0	-	-	9.2	13.0	-	-	9.6	3.5

D.O. - mg/1
Temperature - degrees Celsius

Appendix B-l. Physical and chemical characteristics of surface waters at Station 1 in Lake Eureka

Parameters	1/12/83	2/15/83	3/15/83	4/15/83	5/4/83	5/17/83	6/8/83	6/22/83	7/5/83
Secchi readings	23	33	32	6	6	18	21	35	22
Turbidity	17	4	8	48	83	19	14	8	18
pH	8.0	8.7	8.3	8.0	7.8	8.9	8.3	8.4	8.4
Suspended solids	12	6	7	25	15	28	10	8	28
Alkalinity	194	201	203	147	126	167	176	176	180
Conductivity	275	410	375	312	317	370	440	560	480
Total ammonia-N	0.18	0.08	0.05	0.13	0.20	0.06	0.07	0.10	0.03
Dissolved nitrate-N	9.48	7.98	7.29	8.97	7.40	8.11	6.54	6.53	5.01
Total dissolved iron	0.27	0.11	0.09	1.00	1.25	0.24	0.43	0.20	0.20
Total dissolved manganese	0.03	0.04	0.03	0.04	0.05	0.03	0.04	0.04	0.04
Chlorine demand	2.30	1.51	1.55	2.17	3.60	3.28	5.32	1.60	2.17

Parameters	7/20/83	8/2/83	8/17/83	8/30/83	9/14/83	9/29/83	10/14/83	11/11/83	12/13/83
Secchi readings	18	9	21	23	20	13	9	18	24
Turbidity	20	60	—	13	20	—	49	32	17
pH	7.7	9.4	8.4	8.3	8.2	8.5	8.4	8.2	8.1
Suspended solids	39	204	25	16	23	—	58	36	7
Alkalinity	138	142	182	198	270	226	276	240	211
Conductivity	465	410	450	469	465	480	375		
Total ammonia-N	0.17	0.14	3.51	0.20	0.33	0.47	0.11	0.38	0.12
Dissolved nitrate-N	2.01	0.19	0.11	0.17	0.09	0.14	0.14	0.28	4.45
Total dissolved iron	0.10	0.10	0.09	0.10	0.13	0.11	0.18	0.18	0.30
Total dissolved manganese	0.10	0.08	0.11	0.06	0.05	0.06	0.06	0.08	0.06
Chlorine demand	3.68	8.73	18.20	14.80	6.20	5.32	3.86	5.63	2.90

Units of measurement: Secchi - inches; turbidity - NTU; pH - dimensionless; conductivity - µmho/cm; others - mg/l.

Appendix B-2. Physical and chemical characteristics of near bottom waters at Station 1 in Lake Eureka

Parameters	1/12/83	2/15/83	3/15/83	4/15/83	5/4/83	5/17/83	6/8/83	6/22/83	7/5/83
Turbidity	19	10	10	55	88	54	28	22	50
PH	8.0	8.4	8.1	8.0	7.9	7.5	7.9	8.0	8.3
Suspended solids	13	14	11	3 3	22	27	19	17	69
Alkalinity	193	208	202	148	132	187	184	191	180
Conductivity	286	430	382	310	322	380	435	580	470
Total ammonia-N	0.17	0.06	0.06	0.13	0.20	0.24	0.21	0.12	0.09
Dissolved nitrate-N	9.23	7.73	7.34	9.15	7.60	6.62	6.20	6.94	5.04
Total dissolved iron	0.27	0.11	0.10	1.07	1.41	0.48	0.37	0.40	0.24
Total dissolved manganese	0.03	0.04	0.03	0.04	0.05	0.06	0.04	0.04	0.04
Chlorine demand	2.83	1.59	1.37	2.17	3.90	3.90	4.34	2.50	2.66

Parameters	7/20/83	8/2/83	8/17/83	8/30/83	9/14/83	9/29/83	10/14/83	11/11/83	12/13/83
Turbidity	24	28	--	19	27	--	51	152	15
PH	7.8	8.1	8.3	7.7	8.1	7.9	8.5	8.1	8.1
Suspended solids	37	63	40	24	32	--	66	197	5
Alkalinity	124	168	188	236	268	226	244	248	215
Conductivity	472	470	450	499	460	455	375		
Total ammonia-N	0.15	0.28	0.33	0.89	0.28	0.75	0.11	0.41	0.16
Dissolved nitrate-N	1.95	0.21	0.07	0.15	0.09	0.19	0.14	0.25	4.32
Total dissolved iron	0.10	0.13	0.09	0.57	0.13	0.11	0.22	0.31	0.22
Total dissolved manganese	0.13	0.04	0.11	0.90	0.05	0.06	0.06	0.11	0.06
Chlorine demand	3.01	4.79	16.80	21.90	6.12	4.24	3.77	4.34	3.10

Units of measurement: Turbidity - NTU; pH - dimensionless; conductivity - μmho/cm; others - mg/l