Transactions of Illinois Academy of Sciences
(1984), Volume 77, 3 and 4, pp. 155-170

WATER QUALITY AND WATERSHED LAND USES OF JOHNSON SAUK TRAIL LAKE

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ABSTRACT

A study of Johnson Sauk Trail Lake, Henry County, was conducted in 1981 to delineate existing lake conditions, to examine causes of degradation, if any, and to identify and quantify the sources of nutrients and any pollutants flowing into the lake. The lake watershed, in general, is in excellent condidtion with excellent ground cover and very little land disturbance. The lake water quality characteristics were found to be typical of midwestern lakes, with high alkalinity, conductivity, and dissolved solids. There was an abundance of phosphorus in the lake system all the time. The main lake tributaries were not found to convey unusual amounts of suspended sediment loads. Fish flesh analyses revealed levels of pesticides, heavy metals, and organochemicals either below detectable limits or below regulatory limits. A number of water quality impairments were found to persist in the lake, including hypolimnetic oxygen depletion during summer months, algal blooms, and dense macrophyte growths in the littoral zone. Internal regeneration of nutrients was identified as the major source of nutrients to the lake. The lake is eutrophic by all the measures and indices suggested in the literature.

INTRODUCTION

Johnson Sauk Trail Lake is located in Henry County. It is a 57.4-acre lake with a maximum depth of 23 feet. The lake was formed in 1956 by the impoundment of King Creek. This publicly owned lake and the surrounding park area managed by the Illinois Department of Conservation for outdoor recreational activities. These include bank fishing, boat fishing, ice fishing in season, boating, canoeing, camping, picnicing, hiking, and winter sports. Hunting in season for cock pheasants, quails, rabbits, doves, and squirrels, as well as bow hunting for deer, are permitted in the state park. The location and watershed boundary for the lake are shown in Figure 1; other relevant general information is included in Table 1.

The park offers free interpretive programs during summer months from June through August. Nature study and cultural and historical aspects of the region are taught through tours, nature walks, craft workshops, and camp fire events. Approximately 8 miles of extensive foot trails exist in the park for visitors' use. There is no fee charged to the general public for the use of the state park facilities except for camping fees and annual state fishing and hunting license fees.

The lake is stocked and managed by the Fisheries Division of the Department of Conservation for warm water fish such as largemouth bass, bluegill, redear, sunfish, and catfish. Public access to the lake exists. A ramp and docks for private and rental boats are provided on the northwest shore. Boats other than those that are manually propelled are limited to electric-powered motors. Swimming is prohibited.

LAND USES

The watershed area for the lake is approximately 876 acres, and about 94 percent of it is now in state ownership. Detailed information on the land uses in the watershed and the changes which occurred between the years 1970 and 1979 is shown in Table 2. The land use information was extracted from aerial photographs taken in 1970 and 1979 by the Soil Conservation Service of the U.S. Department of Agriculture.

A significant shift in land use within the watershed occurred between 1970 and 1979. Cropland decreased form 36.9 to 6.2 percent. Pasture and grassland increased from 17.5 to 40.2 percent. There was a slight increase in woodland from 318 to 352 acres. Native oak and pine plantings surround the lake. The apparent increase in water surface area in 1979 over that in 1970 is probably due to the low lake water level in 1970 when the aerial photographs were taken.

The watershed, in general, is in excellent condition with excellent ground cover and very little land disturbance. All the five privately held land parcels lie on the outer fringes of the watershed. These land parcels are kept partly in permanent pastures and partly in cultivation. Two landowners raise a small number of dairy cattle and beef stock. Except for the wildlife food plots, there is no land disturbance activity within the state-owned portion of the watershed. The food plots, about 28 acres, are plowed and seeded with corn, sunflower, and millet by park officials, mainly to provide food and habitat for wild animals and birds. However, these food plots lie within a sodded boundary.

For estimating the soil loss rate from the watershed, the boundaries of land uses were first transposed on the watershed soil map. Fifteen categories of soil types, slopes, and erodibility potentials were identified. The soil types and their associated land uses within each subwatershed were then delineated with the aid of a digitizer. The soil loss rates were computed through use of the Universal Soil Loss Equation, or USLE (Wischmeier and Smith, 1965):

$$A = RKSLCP$$

In this equation A is the average annual soil loss rate in tons per acre per year, R is the rainfall factor, K is the soil erodibility factor, S is the steepness factor, L is the slope length factor, C is the cropping factor, and P is the support practice factor.

The slope, slope length, and cropping factors were determined for various land uses in consultation with the Henry County District Conservationist. The erodibility factor of each soil type was obtained from soil description files available from the Soil Conservation Service State Office at Champaign. The R × P factor value was assigned as 135 for agricultural cropland and 180 for all other land uses. Based on the soil information compiled in the watershed, the soil loss rates were computed. The total soil loss for each soil type was obtained by multiplying the rate and the soil acreage. The estimated soil losses are shown in Table 3.

The total amount of soil loss in the watershed was estimated as 599.8 tons/year. Excluding the lake area, the mean soil erosion rate for the watershed is estimated as 0.73 tons/acre/year.

LIMNOLOGICAL ASSESSMENT OF THE LAKE

In order to assess the current conditions of the lake, certain physical, chemical, and biological characteristics of the lake were monitored during the 1981 calendar year. The lake was monitored on a once-a-month basis during January through April and again from October through December, and it was visited on a biweekly schedule during the intervening summer months. A total of 17 visits were made during the year. During each of these visits water samples were collected from King Creek upstream and downstream of the lake for chemical and biological characterization. The locations of the lake and tributary monitoring stations are shown in Figure 1.

In-situ observations for temperature, dissolved oxygen, and secchi disc readings were made at the deep and shallow stations in the lake. Temperature and dissolved oxygen measurements were obtained in the water column, at 2-foot intervals for the deep station and at 1-foot intervals for the shallow station, commencing from the surface of the lake.

Water samples for chemical analyses were obtained from the lake with a Kemmerer sampler at points 1 foot below the surface, mid-depth, and 1 foot from the bottom. Integrated water samples within a depth twice the secchi disc readings were obtained for phytoplankton identification and enumeration, and chlorophyll-a determination. A Juday sampler was used for obtaining integrated samples. All the samples were stored on ice during transportation and kept in a refrigerator until processed, with the exception of the algae and chlorophyll-a samples. Chlorophyll-a samples were kept frozen.

Water subsamples in a volume of 380 ml were collected for algal identification and enumeration, preserved with 20 ml of formalin at the time of collection, and stored at room temperature until examined.

Determinations for pH, alkalinity, and conductivity were made at the lake site soon after sample collections. Laboratory analyses were performed to determine total suspended and dissolved solids, volatile suspended solids, turbidity, total and dissolved phosphorus, nitrate-nitrogen, total Kjeldahl-nitrogen, and chlorophyll-a. Streamwater samples were not examined for chlorophyll-a content. Composite fish flesh samples were analyzed for pesticides, organochemicals, and mercury. The methods and procedures involved in these determinations are given elsewhere (Kothandaraman and Evans, 1983).

A macrophyte survey of the lake was made in July from a boat with the sevices of a scuba diver. Samples of submerged vegetation were obtained with roots intact. The macrophyte beds were probed thoroughly by the scuba diver, and representative samples of the various types of vegetation found in the lake were obtained and placed in plastic bags with lake water, which were then sealed. These samples were then examined with stereo microscope, and identified. The areal extent of the submerged vegetation was noted on the lake map.

Benthic samples for macroinvertebrate examination were obtained at monthly intervals during June through September. The bottom muds were also examined for percent moisture and volatile fraction. Benthic samples were obtained at both the deep and shallow stations in the lake.

Water Quality Characteristics

Physical Characteristics

Temperature and Dissolved Oxygen. Lakes in the temperate zone generally undergo seasonal variations in temperature through the water column. These variations, with their accompanying phenomena, are perhaps the most influential controlling factors within the lake.

Isothermal plots for the deep station in Johnson Sauk Trail Lake are shown in Figure 2. The vertical temperature profiles for the deep station on selected dates are shown in Figure 3. From Figure 2 it is seen that the summer stratification begins to set in during the latter half of May and intensifies progressively during the summer months. The maximum water temperature of 28.0°C was observed on July 7, 1981. The lake experienced the maximum temperature differential of 12.0°C between the surface and bottom waters on the same date. Thereafter, the intensity of stratification began to decrease. The lake was found to be uniform in temperature after the fall turnover on October 6, 1981.

The isopleths of dissolved oxygen for Johnson Sauk Trail Lake are shown in Figure 2. Selected vertical DO profiles for the deep station are shown in Figure 4. Dissolved oxygen depletion began to occur during the early part of May. As the summer thermal stagnation intensified, the anoxic zone of hypolimnetic waters increased progressively, reaching a maximum during mid-July. The extent of this anaerobic zone started diminishing thereafter, and the DO concentration became uniform in the water column in late September. As is apparent from Figure 2, the progression of this anoxic zone coincided with the progression of the thermal stratification in the lake.

During the period of peak stratification, the lake was totally anoxic at depths 8 feet from the surface and below. About 177 acre-feet or approximately 38 percent of the water volume of the lake was anoxic, severely restricting its habitat for desirable fish food organisms and fish. During summer months, adequate oxygen levels did not generally exist at depths below 10 feet from the surface.

Secchi Disc Transparencies. Secchi disc visibility is a measure of the lake water transparency or its ability to allow light transmission. The mean and range of values observed for secchi disc readings at the deep station are given in Table 4 along with the summary of observations for other physical and chemical water quality parameters. The temporal variations in secchi disc observations are shown in Figure 5. The mean secchi disc reading was 50 inches. A maximum value of 103 inches was observed in February when the lake had ice cover. The minimum of 6 inches occurred in April immediately after a heavy rainfall. About 5.69 inches of rainfall was recorded over a period of 7 days, with 3.33 inches occuring in one 24-hour period. The decrease in secchi disc readings in April was due mainly to the influx of fine particulate matter into the lake after the prolonged and intense rainfall. Secchi disc readings during June, July, and August were in the range of 18 to 51 inches.

Turbidity. High turbidity affects aesthetic quality of the water. Temporal variations of turbidity in surface, mid-depth, and near bottom sampling points of the deep station are shown in Figures 5, 6, and 7, respectively. These values are summarized in Table 4. The turbidity of surface and mid-depth samples had relatively low mean values of 7.7 and 7.9 NTU, respectively, except for a single observation of 60.2 NTU on April 14, 1981. Lake turbidity at that time was nearly eight times as high as the normal values. This was caused by a significant influx of suspended sediments in to the lake after the heavy rainfall referred to earlier. Wet antecedent conditions prior to the heavy downpours created conditons conducive to soil erosion and sediment transport from the watershed. Turbidity of the near bottom water samples was relatively higher, due partly to the settling of particulate matter from the surface.

Chemical Characteristics

pH and Alkalinity. The pH and alkalinity values observed in Johnson Sauk Trail Lake are typical of Illinois lakes. The range of pH values was the highest for the surface waters (7.9-9.6) and the lowest for the near bottom waters (7.6-8.6). Also, alkalinity decreased in the surface water samples during summer months, presumably due to algal photosynthesis, and increased at the same time in the bottom water samples. Mean alkalinity values for the surface, mid-depth, and deep water samples were 157, 168, and 188 mg/1, respectively.

Conductivity. The mean conductivity values for the lake water samples were 281 μmho/cm for the surface, 291 μmho/cm for the mid-depth, and 312 μmho/cm for the near bottom. The increasing trend of conductivity toward the lake bottom follows the same pattern as for alkalinity. Conductivity of bottom waters was high during the summer months, indicating the increased mineralization of organic matter under anaerobic conditions. Lower conductivity values at the surface reflect biological uptake of dissolved minerals. The temporal variations of conductivity in the lake waters are shown in Figures 5, 6, and 7.

Phosphorus. A summary of the observations for total and dissolved phosphate-phosphorus in the lake is given in Table 4. Temporal variations in phosphorus content in the lake are depicted in Figures 5, 6, and 7. Even the lowest observed total phosphorus value was 3 or 4 times higher than the critical value of .01 mg/1 for inorganic phosphorus suggested by Sawyer (1952). The mean dissolve phosphorus levels in the lake varied from 0.07 mg/1 at the surface to 0.30 mg/1 near the bottom. Phosphorus level tended to increase in the lake after a heavy rainfall, and this phenomenon was most pronounced during the April 14, 1981, sampling which was preceded by a week-long heavy rainfall.

The total and dissolved phosphorus levels in the lake after the spring turnover were 0.09 and 0.02 mg/1, respectively. A significant and progressive increase in phosphorus content in the deep waters of the lake was noted during the summer months (Figure 7), until the onset of fall turnover. The highest total phosphorus level measured in the lake was 0.95 mg/1. This occurred in the near bottom waters on September 2, 1981.

The ratio of dissolved phosphorus to the total phosphorus in the surface water samples varied from 0.14 to 0.67 with a mean value of 0.35. The high values ranging from 0.14 to 0.67 occurred during the months January through May when primary productivity was very low. During summer months, when the primary productivity in the lake was relatively high, the ratio varied from 0.17 to 0.50 with a mean of 0.29.

The dissolved phosphorus to total phosphorus ratio at mid-depth varied from 0.16 to 0.67 with a mean of 0.36 for the duration of the lake monitoring. Corresponding values for the deep station were 0.05 to 0.83, and 0.50. The mean values at these locations during the summer months were respectively 0.31 and 0.65. There was no biological uptake of dissolved phosphorus taking place at these locations where anoxic conditions prevailed during summer months. The high concentrations of dissolved and total phosphorus levels at mid-depth and deep stations during summer months were the result of mineralization of organic-rich bottom sediments under anaerobic condition.

Nitrogen. The mean and range of values fo ammonia-, nitrate-, and Kjeldahl-nitrogen in the lake are included in Table 4, and the temporal variations in these parameters are shown in Figures 5, 6, and 7. Mean total inorganic nitrogen (total ammonia-nitrogen and nitrate-nitrogen) was always higher than the suggested critical concentration (0.3 mg/1) for inorganic nitrogen (Sawyer, 1952). The mean values for total ammonia-nitrogen increased from 0.19 mg/1 at the surface to 1.03 mg/1 at the bottom. Nitrate-nitrogen mean values were 0.10 mg/1 at the surface, 0.10 mg/1 at mid-depth, and 0.12 mg/1 at the bottom. Kjeldahl-nitrogen mean values showed an increasing trend toward the bottom of the lake.

Significant decreases in nitrate-nitrogen concentrations were detected throughout the lake during summer months. Ammonia and Kjeldahl-nitrogen concentrations increased severalfold at the mid-depth and the deep sampling points during the summer thermal stagnation period. This is a clear indication of the intense anaerobic decomposition of the organic debris occurring on the lake bottom.

Total Solids, Total Dissolved Solids, and Suspended Solids. Dissolved solids concentrations found in Johnson Sauk Trail Lake are typical of midwestern lakes. Abnormally high suspended solids concentrations were found in the lake only for the April 14, 1981, sampling trip. As indicated earlier, this was due to a week-long heavy rainfall preceding the sampling date. On this particular occasion only, the suspended sediments were predominantly inorganic in nature for the surface and mid-depth samples. Otherwise, the major portion of the suspended sediments was organic (volatile) matter, indicating that transparency was influenced primarily by algae. High suspended sediment values reported for the lake near-bottom samples may be due partly to the accidental lake bottom disturbance while sampling with a Kemmerer sampler, and partly to the settling of particulate matter from the water column. The results for solids determinations are shown in Table 4 and in Figures 5, 6, and 7.

Biological Characteristics

Algae. The total algal counts and the species distribution of algae found in the lake are shown in Table 5. Chlorophyll-a content and algal biomass are also listed in the table. Except for the observations during May, algal counts in the lake were found to be of bloom proportions (500 cts/ml), with blue-green dominating. Blue-green algae create unsightly conditions in the lake by forming algal scum under quiescent lake conditions. Chlorophyll-a was found to peak on July 7, 1981, with a concentration of 80 μg/1. Algal biomass was found to be the highest on

September 1, 1981, with a concentration of 151.4 mm^3/l. Relatively large numbers of flagellates were found in the water sample on that date. These organisms are much larger than the other types of algae found in the lake, accounting for the very large biomass. There apparently is no correlation between biomass, chlorophyll-a, and the counts of algae found in Johnson Sauk Trail Lake.

Benthic Organisms. The types and densities of benthic macroinvertebrate communities in the lake sediments are given in Table 6. *Chaoborus* was the dominant species found in both the shallow and deep stations. The overall population density was higher in the deep station than in the shallow station at all times. This is probably due to the lack of fish predation in the hypolimnetic zone of the deep station, which was anoxic. Even though the number of Chironomidae found in the lake was relatively small compared to *Chaoborus*, Chironomidae constituted a sizeable portion of the biomass. Relatively large numbers of large-sized Chironomidae were found in the samples. The overall averages of the macroinvertebrate densities were 3140 and 6350 counts/m^2 for the shallow and deep stations, respectively. However, the benthic populaton in the shallow station was more diverse than that in the deep station. The average number of taxa per sampling was 3.80 in the shallow station versus 2.00 for the deep station.

Macrophytes. Aquatic vegetation is found in most lakes and is beneficial to the natural ecosystem. It provides food and cover for aquatic organisms, provides oxygen, and stabilizes bottom sediments. However, excessive vegetation generally interferes with recreational activities, adversely affects aquatic life, and destroys asthetic values to the extent of decreasing the economic values of properties surrounding a lake. Under these circumstances, aquatic plants are often referred to as weeds.

The areal extent and types of vegetation found in Johnson Sauk Trail Lake are shown in Figure 8. All the macrophytes found in the lake were the submergent type except for a very small patch of bulrush. The dominant types of vegetation in the lake were horned pondweed and coontail. The shallow upper end of the lake was dense with coontail, which thrived in the lake at depths of 8 feet and less. About 15.4 acres of the lake, constituting 26.8 percent of the lake water surface, was covered by a dense growth of macrophytes. This portion of the lake was unsuitable for fishing or boating. During June and July 1981 the shallow portion of the lake was partially treated with aquathol-K for macrophyte control.

Fish Flesh Analyses

Rule 302.210 of the Water Pollution Regulations of Illinois (1982) states that "any substance toxic to aquatic life shall not exceed one-tenth of the 96 hour median tolerance limit (96 hr TL_m) for native fish or essential food organisms." The primary concern in fish flesh analysis is in regard to the possibility of the bioaccumulation of toxic sutstances like mercury, organocholorine, and other organochemicals in fish which may prove detrimental to higher forms of life in the food chain, including humans, the ultimate consumers.

Composite samples of fish flesh were taken from five largemouth bass fish of the following sizes: 1.08 lbs, 1.08 lbs, 0.93 lbs, 0.91 lbs, and 0,89 lbs. A composite sample from five redear fish of sizes 0.51 lbs, 0.50 lbs, 0.48 lbs, and 0.42 lbs was also analyzed. In addition, two separate analyses were performed on whole carp of sizes 6.10 lbs and 1.49 lbs.

Concentrations of all the toxicants examined showed levels below detection limits. Chlordane, dieldren, DDE, DDD, aldrin, lindane, heptachlor epoxide, DDT, endrin, benzene hexachloride, mirex, and hexachlorobenzene all showed concentrations $<$ 0.01 ppm. The concentration of methoxychlor was 0.05 ppm, and that of toxaphene was $<$ 0.5 ppm. PCBs were $<$ 0.1 ppm, and lipid content was 0.4 to 12.8 percent. Dieldrin concentrations in whole carp samples were 0.037 ppm for the 1.49-lb fish and 0.018 ppm for the 6.10-lb fish. Mercury levels in the carp samples were less than 0.03 ppm. They were 0.07 ppm in the redear fish samples and 0.33 ppm in the largemouth bass samples. The levels of pesticides and organochemicals found in the fish flesh samples are not cause for concern.

SUMMARY

Johnson Sauk Trail Lake, formed in 1956 by the damming of King Creek, is a 57.4-acre lake with a total watershed of about 876.1 acres. The lake and the surrounding park, which are publicly owned, are managed by the Department of Conservation for recreational purposes such as fishing, boating, camping, and hunting. The park system is open to the public throughout the year.

More than 90 percent of the watershed is in state ownership and the rest is in small private land holdings. Agriculture is a very minor land use in the watershed, constituting only 6.2 percent. Except for a few small tracts of land (28.2 acres; 3.2 percent of total) which are used as wildlife food plots, there is no activity within the state-owned portion of the watershed which involves land disturbance. There is no point source waste discharge within the watershed.

The lake has exhibited very high biological productivity since the early years of its formation, requiring algicide and herbicide applications to control algae and macrophytes. The lake experiences summer stratification. During the peak stratification period, the lake was found to be totally anoxic at depths below 8 feet from the surface. About 38 percent of the lake volume is devoid of oxygen at that time. Average summer secchi disc transparency was found to be about 3.2 feet.

The lake water quality characterisites were found to be typical of midwestern lakes with high alkalinity, conductivity, and dissolved solids. Mean phosphorus concentration in the lake during winter months was found to be 50 $\mu g/l$.

The three main tributarties to the lake were not found to convey unusual amounts of suspended sediment loads under normal rainfall conditions. Even tributary samples obtained immediately after storm events indicated values for turbidity and suspended sediments within the range of values observed for routine samples.

The lake exhibits a high biological productivity. Algal growths of bloom proportons were encountered during summer months, with blue-greens the dominant species. However, there was an abundance of phosphorus in the lake system all the time. About 15.4 acres of the lake was covered with dense growth of macrophytes. Coontail and pondweed were the dominant vegetation found in the lake.

The lake is eutrophic by all the measures and indices suggested in the literature. Even though the watershed has been returned to an undisturbed condition with permanent vegetative cover, such conditions as hypolimnetic oxygen depletion during summer months, algal blooms, dense macrophyte growths in the littoral zone, and other water quality impairments still persist. Internal regeneration of nutrients has been identified as the major source of nutrients to the lake.

The levels of pesticides, heavy metals, and organochemicals found in fish flesh samples were either below detectable limits or below regulatory limits.

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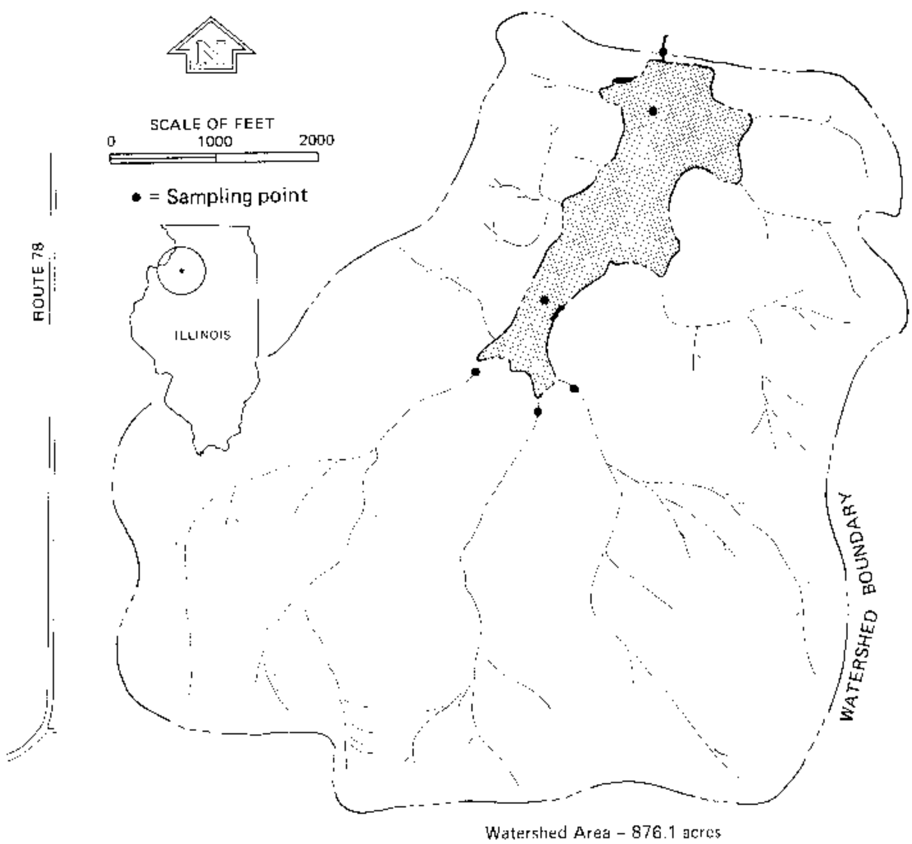


Figure 1. Location and watershed boundary, Johnson Sauk Trail Lake

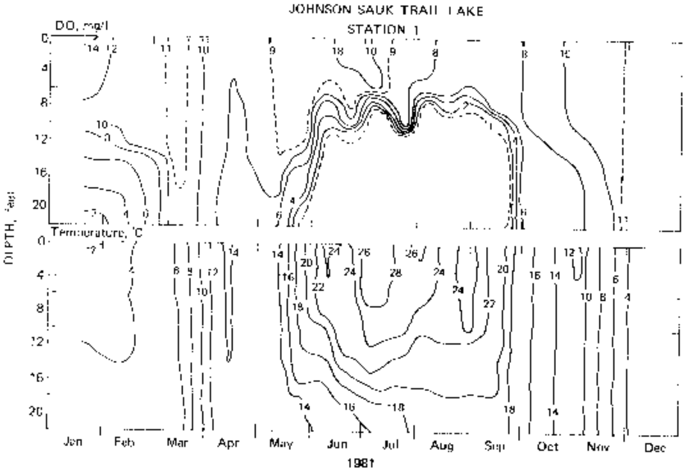
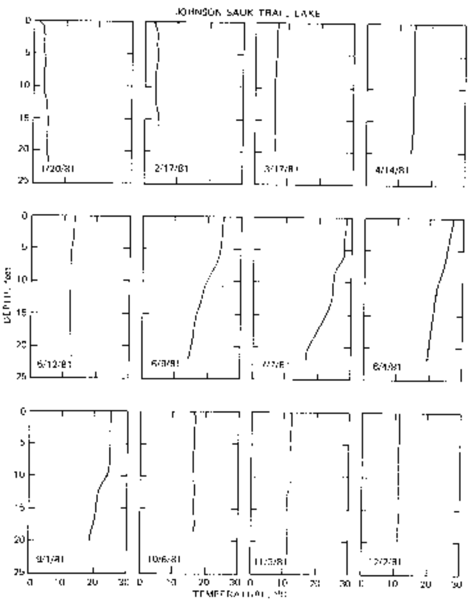


Figure 2. Isothermal and dissolved oxygen plots for the deep station



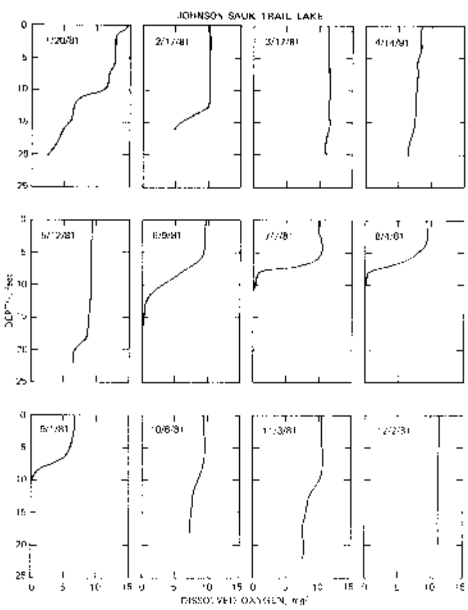


Figure 3. Temperature profiles at the deep station on selected dates

Figure 4. Dissolved oxygen profiles at the deep station on selected dates

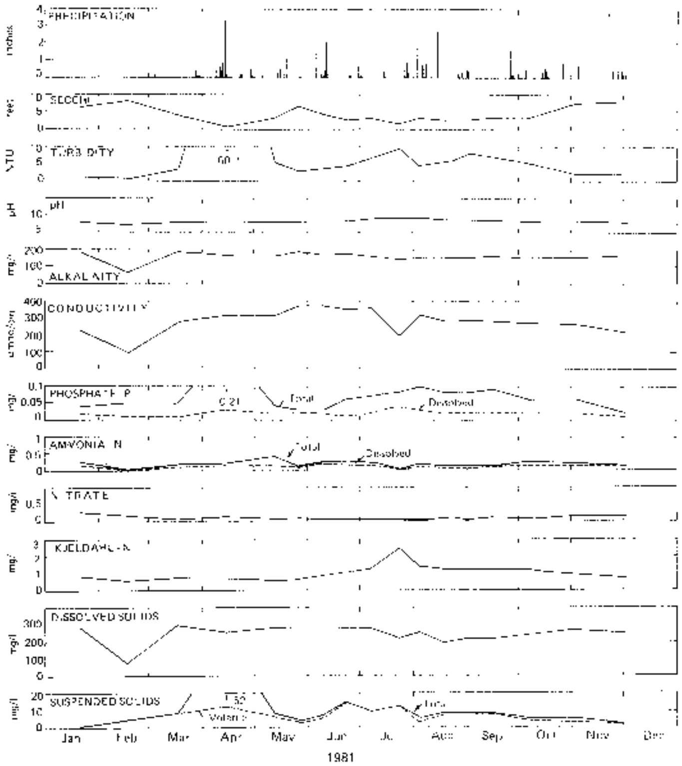


Figure 5. Temporal Variations in the near surface water quality characteristics at the deep station

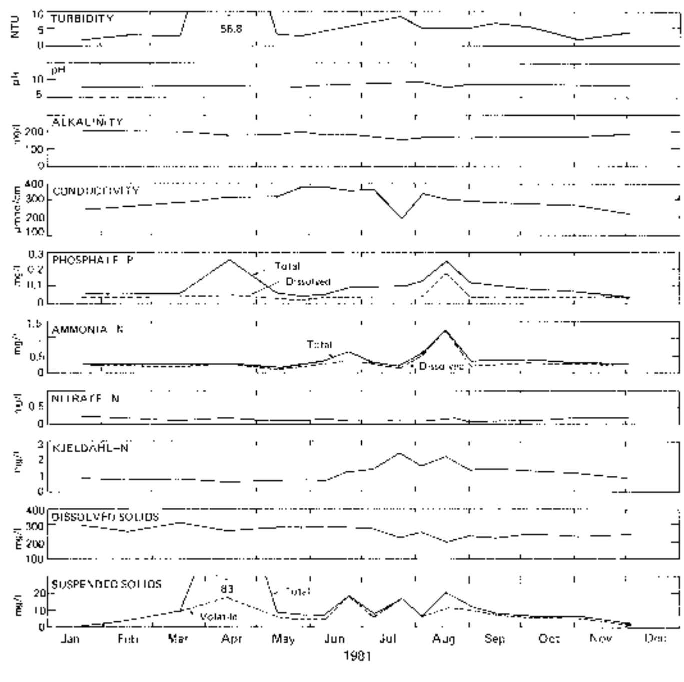


Figure 6. Temporal variations in mid-depth water quality characteristics at the deep station

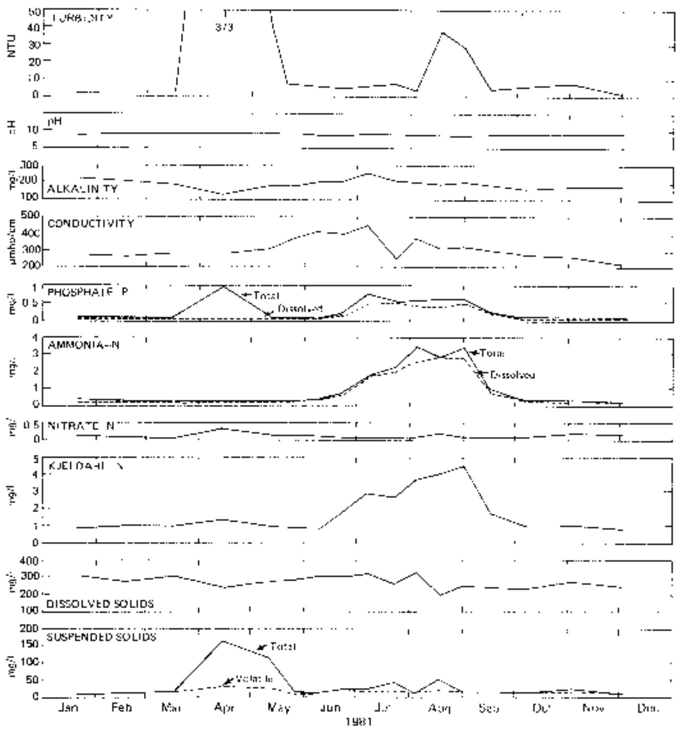


Figure 7. Temporal variations in near bottom water quality characteristics at the deep station

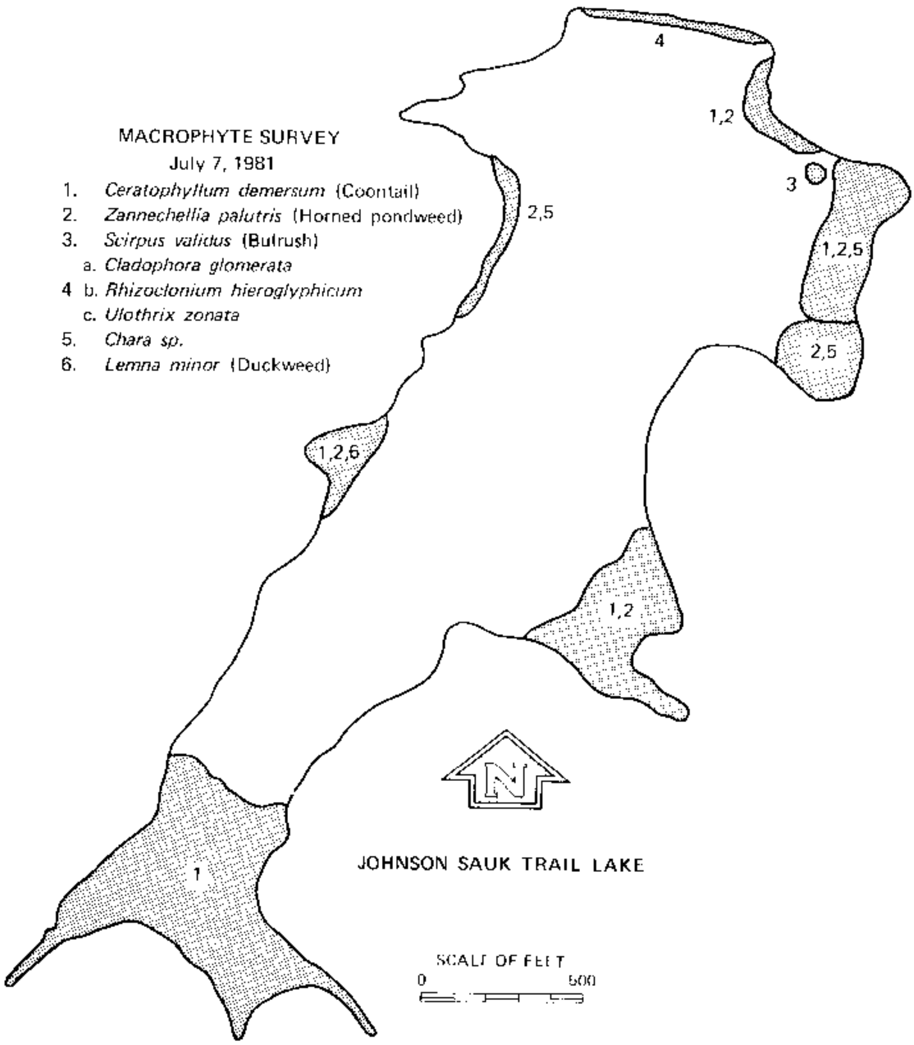


Figure 8. Types and areal extent of macrophytes

Table 1. Morphometric Details regarding Johnson Sauk Trail Lake

Surface area, acres	57.4	(23.2 ha)
Volume, acre-feet	471.5	($0.58 \times 10^6 m^3$)
Mean depth, feet	8.2	(2.50 m)
Maximum depth, feet	23.0	(7.01 m)
Length of shoreline, miles	1.5	(2.41 km)
Average retention time, years	1.96	
Total original capacity loss, percent	13.3	
Annual capacity loss, percent	0.58	
Watershed area, acres	876.1	($3.55 km^2$)

Table 2. Johnson Sauk Trail Lake Watershed Land Uses

	1970		1979	
Type of land use	Area (acres)	Percent of total	Area (acres)	Percent of total
Cropland	323.2	36.9	54.2	6.2
Pasture or grassland	153.1	17.5	351.9	40.2
Woodland	317.8	36.3	352.4	40.2
Recreational development	22.6	2.6	32.0	3.7
Wildlife food plots	0.0	0.0	28.2	3.2
Farmsteads	2.9	0.3	0.0	0.0
Water	56.4	6.4	57.4	6.6
Total	876.1		876.1	

Table 3. Soil Losses in Johnson Sauk Trail Lake Watershed
(Tons per year)

Land use	Total
Cropland	217.95
Grassland, food plots, recreational areas	367.98
Woodland	13.88
Total	599.81

Food plots provide food and habitat for wild animals and birds. Please see the text under LAND USES for explanation.

Table 4. Johnson Sauk Trail Lake Water Quality Characteristics

Parameter	Near surface		Mid-depth		Near bottom	
	Mean	Range	Mean	Range	Mean	Range
Secchi readings (inches)	50	6-103				
Turbidity (NTU)	7.7	0.4-60.2	7.9	1.4-56.8	35.1	1.6-377.0
pH (dimensionless)		7.9-9.6		8.1-9.5		7.6-8.6
Alkalinity	157	67-187	168	139-195	188	126-250
Conductivity (μ mho/cm)	281	98-371	291	185-370	312	214-445
Total phosphate-P	0.07	0.03-0.21	0.09	0.04-0.25	0.30	0.03-0.95
Dissolved phosphate-P	0.02	0.01-0.04	0.03	0.01-0.16	0.16	0.01-0.49
Total ammonia-N	0.19	0.03-0.42	0.30	0.12-1.16	1.03	0.17-3.41
Dissolved ammonia-N	0.13	0.02-0.21	0.25	0.05-1.15	0.87	0.12-2.72
Nitrate-N	0.10	0.03-0.27	0.10	0.03-0.17	0.12	0.05-0.34
Total Kjeldahl-N	1.01	0.52-2.39	1.10	0.57-2.25	1.76	0.75-4.36
Dissolved solids	242	72-296	256	196-306	267	192-306
Total suspended solids	9.3	0-52	12.9	0-83	27.6	0-158
Volatile susp. solids	6.2	0-12	7.6	0-18	8.5	0-22

Note: Values in mg/1 unless otherwise indicated

Table 5. Algal types and Densities, Chlorophyll-a, and Biomass in Johnson Sauk Trail Lake

(Algal densities in counts per milliliter)

Date	BG	G	D	F	O	Total	Chlorophyll-a (μg/l)	Biomass (mm^3/l)
5/12/81	150	45	75			270	20	0.735
5/26/81	280					280	30	0.400
6/09/81	900				5	905	40	3.505
6/23/81	2645	395	100			3140	70	6.406
7/07/81	4630	1200	345	325		6500	80	72.602
7/23/81	5950	735	600	460		7745	67	149.416
8/04/81	8620	870	660	315		10465	53	24.656
8/18/81	20590	495	525	345		21955	40	35.950
0/01/81	10280	360	410	640	390	12080	47	151.411
9/16/81	16000		75		40	16115	40	26.676

Note: BG = blue-greens; G = greens; D = diatoms; F = flagellates; O = others

Table 6. Benthic Macroinvertebrates Collected from Johnson Sauk Trail Lake

(Individuals per square meter)

	Shallow station			
	6/9/81	7/7/81	8/4/81	9/1/81
Ceratopogonidae (biting midge)	43		14	
Chaoborus (phantom midge fly)	158	301	7,894	2,354
Chironomidae (midge fly)	316	14	402	43
Sphaerium (fingernail clam)	14			
Tubificidae (sludge worm)	129	345	301	230
Total	660	660	8,611	2,627
	Deep station			
Chaoborus	2,196	1,091	7,320	8,913
Chironomidae	2,052	2,454	1,220	144
Total	4,248	3,545	8,540	9,057