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# WATER QUALITY MONITORING IN REPRESENTATIVE FISH LAKES 1979 AND 1980

by

David Zappetillo
Harlan Fierstine
David Pederson

## ABSTRACT

Water chemistry, aquatic vegetation, algae, temperature and dissolved oxygen information was gathered from 15 representative fish lakes in the summers of 1979 and 1980. The lake represented 5 major ecological classifications and ranged in size from 72 to 2,873 ha. Water chemistry parameters measured were: total phosphorus (ppm); water clarity (cm); total alkalinity (ppm); ammonia nitrogen (ppm); and pH from which trophic state indices (TSI) were calculated. The TSI ranged from 35-75 with any value over 60 being considered eutrophic (Carlson 1977). The lakes where the TSI exceeded 60 both years were Big Pine, Johanna, Nokay, Long, Pokegama, Shields and White Iron. Aquatic plant distribution and species composition showed changes between 1979 and 1980 in a majority of the lakes. Algae populations in lakes sampled in 1979 and 1980 were dominated by blue-green and yellow-green algae, which indicated water quality problems. Algae standing crop, as measured by chlorophyll "a" concentration, showed little difference between 1979 and 1980. Temperature and dissolved oxygen profiles at the deepest station showed little change for each sampled lake, although changes were noted in isolated bays or areas affected by some external factor.

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## INTRODUCTION

A Water Quality Monitoring Program was started in 1973 to establish a limnological data base on representative fish lakes and to monitor chemical and biological changes on a continuing basis. The factors used in selecting the 15 fish lakes studied during this program were previous studies, common water quality problems and/or being representative of an ecological classification.

Moyle (1956) has shown that there is a direct relationship between lake location, water fertility, aquatic vegetation and fish populations. This study was an attempt to assist fisheries managers to better understand these relationships and to help predict changes in fish populations by changes in water chemistry and aquatic vegetation on ecologically similar fish lakes. Monitoring will be continued to collect year-to-year trends and other changes in water quality.

## METHODS

Chemical, physical and biological parameters were measured on 15 selected lakes. Sampling procedure prior to 1979 was to gather information on 5 of 15 selected lakes during spring turnover and summer stagnation on a 3 year rotation. During 1979 and 1980, all study lakes were sampled once during summer stagnation. This sampling routine was initiated so that all lakes could be sampled each year.

### Water Sample Stations

A minimum of three and a maximum of eight water sampling stations were selected, depending on the number and depth of each individual basin within the lake (Appendix Figs. 1-15). At each water sampling station, water clarity, surface-to-bottom profiles of water temperature

and dissolved oxygen concentrations were measured. In addition, water samples were collected for water chemistry, chlorophyll "a" and algal identification. Water clarity was measured to the nearest whole cm by means of a Secchi disc while a Yellow Springs temperature-dissolved oxygen meter was used to measure temperature and dissolved oxygen profiles.

Water samples were collected by using an integrated water sampler described by Shearer (1978). The integrated water samples were taken from a depth of 4.5 m or from the thermocline (whichever was less) to the surface. Surface water samples were also collected in 1979 from five lakes for a comparison of chemical parameters between surface and composite samples. Water samples were preserved with chloroform, cooled and transported to the Chemistry Laboratory where total phosphorus (ppm), total alkalinity (ppm), ammonia nitrogen (ppm) and pH were determined. Values for each chemical parameter were determined by standard laboratory methods and procedures (EPA Manual 1979). Total alkalinity and ammonia nitrogen for each lake was compared year to year using the paired "t" test at 0.01, 0.05 and 0.10 levels. The values with "less than" notations were excluded from the comparisons.

Carlson (1977) correlated Secchi disc (SD), total phosphorus (TP) and chlorophyll "a" (Chl) concentrations to obtain a numerical trophic state index (TSI). The TSI is based on how Secchi disc depths, total phosphorus and chlorophyll "a" are related to algae biomass and is calculated by the following formula (Carlson 1977):

$$TSI\ (SD) = 10\ (6 - \frac{\log SD}{\log 2});\ TSI\ (TP) = 10\ (6 - \frac{\log TP}{\log 2})$$

and

$$TSI\ (Chl) = 10\ (6 - \frac{2.04 - 0.68 \log Chl}{\log 2})$$

The basic assumption made when using TSI for each of the parameters is that for Secchi disc the value is a result of algae interference with light transparency; total phosphorus is the major limiting factor for algal growth and the chlorophyll "a" value must be corrected for pheophytin. The values for TSI range from 0-100 with any lake over 60 being considered eutrophic. The TSI was selected for use in the Water Quality Monitoring Program because of its simplicity and development from Minnesota lake data.

When transforming the Secchi disc values to TSI, a correction was made to adjust for bog stain which was found in some lakes. Brezonik (1978) made modifications to Carlson's basic formula to adjust for turbidity and color by using the reciprocal of the Secchi disc value minus a constant. Peterson (MnDNR, personal communication 1979) modified Brezonik's work by adjusting for water color with number constants for northeastern Minnesota to fit the basic information obtained in the present study. The adjustments were needed as Carlson (1977) states: "all parameters when transformed to the trophic scale should have the same value. Any divergency from this value by one or more parameters demands investigation." For the purpose of this report, if the range of TSI values overlap they are considered to have the same value.

Aquatic Vegetation

Based on the available habitat within each lake basin, 3-13

aquatic vegetation sampling stations were established (Appendix Figs. 1-15). Starting at the 1.5 m contour, a weed grapple was tossed 4 times in different directions with sampling proceeding lakeward at 1.5 m contour intervals until no more vegetation was found. The techniques described by Jessen and Lound (1962) for sampling submerged aquatic vegetation were used to determine species composition (average recovery), percent occurrence and relative abundance. Average recovery is a number indicating a plant's abundance at stations where it is found and is calculated by dividing the number of times a plant is collected by each toss of the grapple and by the number of stations at which it is found. Relative density is a word description of a plant's average recovery. The terms used are constant for various recoveries according to the following ranges:

| Average Recovery | Relative Density |
|---|---|
| 1.0 to 1.5 | Sparse |
| 1.6 to 2.0 | Scattered |
| 2.1 to 3.0 | Moderate |
| 3.1 to 4.0 | Lush |

Percent occurrence is the number of stations where a plant is found divided by the total number of sampling stations. The statistical method used in comparing percent occurrence is the Student "t" test (Sokal and Rohlf 1969).

Plankton Algae

A composite plankton algae sample was collected from each of the 15 lakes sampled in 1979 and 1980. A Wisconsin-style plankton net was used to collect a 4.6 m vertical tow sample from each water sample station and samples from each station were combined to yield a composite sample for each lake. Algae samples were preserved with Lugol's

solution and transported to the laboratory.

For identification and counting, the samples were shaken vigorously and an aliquot was withdrawn and introduced into a sedimentation chamber. After sedimentation (usually overnight), algae were identified to genus. Major keys used to identify algae to genus were from Prescott (1962, 1970). Several fields from three to four subsamples were examined and the number of each genera of algae was recorded. The counting units utilized were:

Unicells - - - - - - - - - - - Each cell
Diatoms- - - - - - - - - - - - Each complete frustule
Filaments- - - - - - - - - - - Each filament
Discrete colonies- - - - - - Each 4-8-16-32-64 cell colony
Indiscrete colonies- - - - - Every 8 cells
Dense colonies - - - - - - - Every 50 cells
Dinobryon- - - - - - - - - - Each lorica.

Examples of discrete colonies include Pandorina spp., Volvox spp. and Oocystis spp; indiscrete colonial forms include Merismopedia spp., Chroococcus spp. and Crucigenis spp.; and dense colonies include Microcystis spp. and Aphanocapsa spp.

Estimates of algae productivity were obtained by chlorophyll "a" analysis. Samples for chlorophyll "a" analysis were obtained at each water sample station by the same procedure used to collect composite water samples for chemical analysis. Surface samples were collected in 1979 from four lakes for a comparison of chlorophyll "a" in surface and composite samples from the same locations. Samples were placed in containers where light was excluded, preserved by refrigeration and analyzed at the Chemistry Laboratory.

## RESULTS

Study lakes are represented by a soft-water walleye, hard-water walleye, bass-panfish and bass-panfish-roughfish ecological classification (Table 1). Lake areas ranged from 72 (Long Lake) to 2,873 ha (Lake Minnewaska).

### Water Chemistry

The TSI values for chlorophyll "a" ranged from <41 (Trout Lake) to 67 (Shields Lake) in 1979 and <41 (Trout and Snowbank Lakes) to 83 (Long Lake) in 1980. The TSI values for Secchi disc ranged from 35 (Trout Lake) to 69 (Colby Lake) in 1979 and 36 (Trout Lake) to 72 (Long Lake) in 1980. The TSI values for phosphorus ranged from <37 (Pokegama Lake) to 76 (Shields Lake) in 1979 and <37 (Wilson, Trout and Pokegama Lakes) to 87 (Long Lake) in 1980 (Table 2).

Comparison of total alkalinity from year to year from all lakes sampled showed significant changes. Bear Island, Big Pine, Colby, Detroit, Minnewaska, Pokegama, Snowbank, White Iron and Wilson Lakes showed significant decreases ($p < 0.01$) between 1979 to 1980 while Johanna Lake showed significant increases ($p < 0.10$). The total alkalinity ranged from 25 (Trout and Snowbank Lakes) to 240 ppm (Minnewaska Lake) in 1979 and <20 ppm (Trout Lake) to 225 ppm (Minnewaska Lake) in 1980 (Table 3).

No statistical comparisons of pH values were made. The pH measurements ranged from 6.8 (Snowbank Lake) to 8.7 (Minnewaska and Nokay Lakes) in 1979 and 6.6 (Bear Island Lake) to 8.6 (Detroit Lake) in 1980 (Table 4).

When comparing ammonia from year to year, the elimination of the "less than" figures resulted in Long, Pokegama and Snowbank Lakes being

Table 1. Lakes monitored in 1979 and 1980.

| Lake | Ident. no. | County | Area (ha) [a] | No. of stations | | Depth (m) | Ecological classification | Sampling dates | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Water | Veg. | | | 1979 | 1980 |
| Bear Island | 69-115 | St. Louis | 799 | 4 | (7) | 22.0 | Soft-water Walleye | 8/8 | 8/6 |
| Big Pine | 56-130 | Otter Tail | 1933 | 4 | (9) | 22.9 | Hard-water Walleye | 8/2 | 7/29-30 |
| Colby | 69-249 | St. Louis | 216 | 3 | (7) | 10.4 | Soft-water Walleye | 8/15 | 8/13 |
| Detroit | 3-381 | Becker | 1202 | 6 | (9) | 25.0 | Hard-water Walleye | 7/31-8/1 | 7/28-29 |
| Frances | 40-57 | LeSueur | 352 | 3 | (5) | 15.5 | Bass, Panfish | 7/26 | 7/24 |
| Johanna | 62-78 | Ramsey | 80 | 3 | (4) | 12.5 | Bass, Panfish | 7/24 | 7/22 |
| Long | 62-67 | Ramsey | 72 | 3 | (7) | 7.9 | Bass, Panfish | 7/23 | 7/21 |
| Minnewaska | 61-130 | Pope | 2880 | 4 | (6) | 9.8 | Hard-water Walleye | 7/30 | 7/30-31 |
| Nokay | 18-104 | Crow Wing | 267 | 3 | (4) | 12.8 | Bass, Panfish | 8/22 | 8/20 |
| Pokegama | 31-532 | Itasca | 2678 | 8 | (12) | 34.1 | Hard-water Walleye | 8/20-21 | 8/18-19 |
| Shields | 66-55 | Rice | 376 | 3 | (7) | 12.8 | Bass, Panfish Rough fish | 7/25 | 7/23 |
| Snowbank | 38-529 | Lake | 1754 | 5 | (8) | 44.2 | Lake Trout | 8/14 | 8/12 |
| Trout | 16-49 | Cook | 106 | 3 | (3) | 21.3 | Lake Trout | 8/6 | 8/4 |
| White Iron | 69-4 | St. Louis, Lake | 1389 | 4 | (13) | 14.3 | Soft-water Walleye | 8/9, 13 | 8/11 |
| Wilson | 38-47 | Lake | 245 | 3 | (4) | 14.0 | Soft-water Walleye | 8/7 | 8/5 |

[a] Area and maximum depth of each lake is from lake files.

Table 2. Trophic state index (TSI) values (average and range for stations) for chlorophyll "a" (Chl), Secchi disc (SD) and total phosphorus (TP), 1979 and 1980.

| Lake | TSI (Chl) | | TSI (SD) | | TSI (TP) | |
|---|---|---|---|---|---|---|
| | 1979 | 1980 | 1979 | 1980 | 1979 | 1980 |
| Bear Island | 44 (42-45) | 46 (45-46) | 51 (49-53) | 48 (48-49) | 44 (43-48) | 39 (37-41) |
| Big Pine | 61 (59-62) | 62 (62-63) | 52 (51-52) | 57 (55-58) | 56 (54-57) | 55 (54-57) |
| Colby | 44 (42-45) | 48 (46-50) | 67 (66-69) | 58 (57-58) | 55 (52-60) | 50 (49-51) |
| Detroit | 50 (47-53) | 51 (48-53) | 47 (44-49) | 48 (45-50) | 50 (49-52) | 45 (44-46) |
| Frances | 55 (55-56) | 56 (55-57) | 52 (50-55) | 59 (58-60) | 49 (49-51) | 55 (54-57) |
| Johanna | 58 (58-59) | 51 (51-52) | 53 (52-54) | 49 (48-51) | 67 (60-74) | 52 (51-52) |
| Long | 65 (64-65) | 76 (67-83) | 59 (57-60) | 67 (65-72) | 69 (62-75) | 75 (59-87) |
| Minnewaska | 54 (53-55) | 57 (56-58) | 54 (53-55) | 57 (55-58) | 56 (55-57) | 57 (54-59) |
| Nokay | 60 (59-61) | 58 (55-60) | 54 (54) | 53 (53) | 52 (51-54) | 47 (46-48) |
| Pokegama | 43 (41-44) | 43 (41-46) | 44 (42-45) | 46 (44-50) | <37 (<37) | 37 (<37-37) |
| Shields | 66 (64-67) | 73 (73) | 60 (59-62) | 66 (65-67) | 67 (59-76) | 69 (68-70) |
| Snowbank | 43 (42-44) | <41 (<41) | 37 (37-39) | 39 (39-40) | 44 (41-50) | 42 (37-46) |
| Trout | <41 (<41) | <41 (<41) | 36 (35-37) | 36 (36-37) | 40 (37-41) | <37 (<37) |
| White Iron | 46 (42-48) | 46 (45-46) | 57 (57) | 54 (53-55) | 52 (51-54) | 50 (46-54) |
| Wilson | 42 (42) | 41 (41) | 41 (40-42) | 43 (42-43) | 41 (37-43) | 40 (<37-41) |

Table 3. Total alkalinity (ppm) of lakes sampled summer, 1974-1980. [a]

| Lake | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|
| Bear Island | 18.0 [b] (17.5-20.0) | | | 26.0 [b] (25.0-27.5) | | 29.0 [b] (28.0-30.0) | 25.0 (25.0) |
| Big Pine | | 186.5 (182.5-190.0) | | | 182.4 [b] (178.0-190.0) | 191.7 [b] (188.0-195.0) | 172.0 (172.0) |
| Colby | | 43.3 [b] (42.5-45.0) | | | 37.0 [b] (35.0-38.0) | 50.0 [c] (48.0-52.0) | 42.0 (42.0) |
| Detroit | | 188.7 [c] (182.5-195.0) | | | 166.2 (132.0-175.0) | 196.3 (192.0-200.0) | 175.5 (170.0-180.0) |
| Frances | | | | 130.6 [d] (130.0-132.5) | | 134.0 (132.0-135.0) | 127.7 (125.0-130.0) |
| Johanna | | | | 109.2 [c] (107.5-110.0) | | 97.7 [d] (95.0-100.0) | 102.0 (102.0) |
| Long | | | 126.7 (125.0-127.5) | | | 144.3 (135.0-163.0) | 121.3 (120.0-122.0) |
| Minnewaska | | | 236.7 (232.5-240.0) | | | 240.0 (240.0) | 223.5 (220.0-225.0) |
| Nokay | | | 116.2 [c] (115.0-117.5) | | | 123.0 (122.0-125.0) | 122.0 (122.0) |
| Pokegama | 125.0 (115.0-130.0) | | | 127.8 [b] (122.5-132.5) | | 136.8 (135.0-138.0) | 125.0 (122.0-128.0) |
| Shields | | 129.1 (120.0-142.5) | | | 141.7 [b] (140.0-145.0) | 134.0 [c] (132.0-135.0) | 138.0 (138.0) |
| Snowbank | 15.6 [b] (10.0-17.5) | | | 22.5 (22.5) | | 25.0 (25.0) | 20.8 (20.0-22.0) |
| Trout | | | 20.8 [c] (20.0-22.5) | | | 25.0 (25.0) | <20.0 |
| White Iron | | 28.5 [b] (25.0-32.5) | | | 19.6 (15.0-25.0) | 30.0 (30.0) | 28.0 (28.0) |
| Wilson | | | 25.0 (15.0-32.5) | | | 28.0 (28.0) | 20.7 (20.0-22.0) |

[a] = compared with next year of measurement

[b] = significant at 1% level

[c] = significant at 5% level

[d] = significant at 10% level

Table 4. Surface pH measurements of lakes sampled summer, 1974 - 1980.

| Lake | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|
| Bear Island | (6.90-7.30) | -- | -- | (7.30-7.50) | -- | (7.00-7.10) | (6.65-6.75) |
| Big Pine | --[a] | (7.70-8.70) | -- | -- | (8.25-8.60) | (8.05-8.15) | (8.10-8.30) |
| Colby | -- | (7.25) | -- | -- | (6.90-7.05) | (7.05-7.15) | (7.20) |
| Detroit | -- | (8.40-8.60) | -- | -- | (8.20-8.70) | (8.30-8.50) | (8.20-8.60) |
| Frances | (8.10) | -- | -- | (8.80-8.90) | -- | (7.95-8.40) | (8.10-8.25) |
| Johanna | (8.30) | -- | -- | (7.90-8.80) | -- | (7.60-7.90) | (8.25) |
| Long | -- | -- | (8.00-8.65) | -- | -- | (8.15-8.60) | (8.00-8.20) |
| Minnewaska | -- | -- | (8.77) | -- | -- | (8.60-8.70) | (8.55) |
| Nokay | -- | -- | (8.50) | -- | -- | (8.50-8.70) | (8.00-8.10) |
| Pokegama | (8.30-8.50) | -- | -- | (8.60-8.80) | -- | (8.50-8.60) | (8.15-8.25) |
| Shields | -- | (8.40-9.20) | -- | -- | (8.60-8.65) | (7.65-7.80) | (8.15-8.20) |
| Snowbank | (7.00-7.40) | -- | -- | (7.50-7.70) | -- | (6.80-6.90) | (6.90-7.00) |
| Trout | -- | -- | (7.33) | -- | -- | (7.10-7.15) | (6.70-7.30) |
| White Iron | -- | (7.10-7.30) | -- | -- | (7.00-7.80) | (7.10-7.20) | (7.00-7.10) |
| Wilson | -- | -- | (8.40) | -- | -- | (6.95-7.00) | (6.75-6.90) |

[a]No data collected

the only lakes showing a significant change ($p < 0.01$). The ammonia nitrogen ranged from <0.025 ppm (Colby, Detroit, Frances, Johanna, Long, Minnewaska, Nokay, Pokegama, Snowbank, Trout and White Iron Lakes) to 0.087 (Long Lake) in 1979 and <0.025 ppm (Bear Island, Colby, Johanna, Long, Pokegama, Shields, Snowbank, Trout and Wilson Lakes) to 0.118 ppm (Detroit Lake) in 1980 (Table 5).

Water clarity measurements (Secchi disc) ranged from 55 (Colby Lake) to 580 cm (Trout Lake) in 1979 and 60 (Shields Lake) to 545 cm (Trout Lake) in 1980 (Table 6). No statistical comparisons were made on water clarity between 1979 and 1980.

Chlorophyll "a" measurements ranged from <3.0 (Trout Lake) to 42.6 ppb (Shields Lake) in 1979 and <3.0 (Snowbank and Trout Lakes) to 208.0 ppb (Long Lake) in 1980 (Table 7). No statistical comparisons were made on chlorophyll "a" between 1979 and 1980.

Aquatic Vegetation

Except for Long and Trout Lakes, all lakes showed changes from previous years in plant composition at various depths, percent occurrence or maximum depth to which plants were found. All lakes sampled, except Long and Trout Lakes, had one or more significant changes in macrophyte species present and percent occurrence. The lakes that showed an increase in the depth to which plants grew in 1979 were Colby, Pokegama and Wilson Lakes while a decrease in depth was seen in Johanna Lake. In 1980, Big Pine, Colby, Detroit, Johanna and Shields Lakes showed an increase in plant depth while Minnewaska, Pokegama and Wilson Lakes showed depth decreases. (Appendix, Tables 1-15).

The aquatic plants most often found in hard-water lakes were bushy pondweed (Najas flexilis), coontail (Ceratophyllum demersum), water

Table 5. Ammonia nitrogen (ppm) for lakes sampled summer, 1974-1980.

| Lake | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|
| Bear Island | .13 (<.05-.13) | | | .056 (.024-.180) | | .035 (.034-.038) | <.025 (<.025) |
| Big Pine | | .020 (<.020-.020) | | | <.025 (<.025) | .030 (.029-.032) | .049 (.041-.061) |
| Colby | | .063 (.054-.073) | | | .069 (.060-.075) | .034 (<.025-.034) | <.025 (<.025) |
| Detroit | | <.020 (<.020) | | | .086 (<.025-.086) | .030 (<.025-.035) | .079 (.052-.118) |
| Frances | | | | .036 (.026-.052) | | <.025 (<.025) | .056 (.052-.062) |
| Johanna | | | | <.020 (<.020) | | <.025 (<.025) | <.025 (<.025) |
| Long | | | .615[a] (.600-.635) | | | .059 (<.025-.087) | .052 (<0.25-.052) |
| Minnewaska | | | .124 (.075-.235) | | | .033 (<.025-.040) | .042 (.037-.045) |
| Nokay | | | .071 (.060-.085) | | | <.025 (<.025) | .043 (.040-.047) |
| Pokegama | .24[b] (<.05-.62) | | | .024 (<.020-.036) | | <.025 (<.025) | .032 (<.025-.040) |
| Shields | | .257 (.075-.550) | | | | .052 (.048-.055) | .043 (<.025-.043) |
| Snowbank | .10[a] (.08-.11) | | | .023 (<.020-.025) | | <.025 (<.025) | <.025 (<.025) |
| Trout | | | .070 (.070) | | | <.025 (<.025) | <.025 (<.025) |
| White Iron | | <.020 (<.020) | | | | .027 (<.025-.028) | .034 (.032-.035) |
| Wilson | | | <.02 (<.02) | | | .025 (.025-.026) | <.025 (<.025) |

[a] = Significant at 1% level

[b] = Significant at 5% level

Note: Changes between 1979 and 1980 were not tested for statistical significance because of the large number of less than (<) values.

Table 6. Secchi disc (cm) of lakes sampled summer, 1974-1980.

| Lake | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|
| Bear Island | 221 (213-227) | --- | --- | 287 (274-290) | --- | 182 (160-210) | 226 (217-235) |
| Big Pine | ---[a] | 91 (91) | --- | --- | 102 (90-110) | 177 (172-185) | 126 (115-145) |
| Colby | --- | 61 (61) | --- | --- | 53 (50-60) | 60 (55-65) | 114 (110-120) |
| Detroit | --- | 127 (122-137) | --- | --- | 167 (160-190) | 253 (210-300) | 226 (197-290) |
| Frances | 152 (137-168) | --- | --- | 123 (110-137) | --- | 172 (140-195) | 105 (100-113) |
| Johanna | 137 (137) | --- | --- | 172 (168-174) | --- | 161 (148-169) | 213 (190-230) |
| Long | --- | --- | 47 (20-61) | --- | --- | 110 (100-120) | 62 (45-71) |
| Minnewaska | --- | --- | 206 (138-229) | --- | --- | 155 (145-165) | 127 (112-143) |
| Nokay | --- | --- | 172 (168-183) | --- | --- | 150 (150) | 165 (165) |
| Pokegama | 295 (274-335) | --- | --- | 333 (305-350) | --- | 312 (290-360) | 262 (207-300) |
| Shields | --- | 71 (46-91) | --- | --- | 120 (120) | 103 (90-109) | 67 (60-70) |
| Snowbank | 518 (503-533) | --- | --- | 440 (427-457) | --- | 480 (425-500) | 426 (415-430) |
| Trout | --- | --- | 640+ (640+) | --- | --- | 543 (500-580) | 522 (500-545) |
| White Iron | --- | 180 (152-198) | --- | --- | 106 (90-110) | 120 (120) | 155 (140-160) |
| Wilson | --- | --- | 412 (366-442) | --- | --- | 368 (350-385) | 335 (330-341) |

[a] --- No data available

Table 7. Chlorophyll "a" (ppb) concentrations for lakes sampled during July and August, 1979 and 1980.

| Lake | 1979 | 1980 |
|---|---|---|
| Bear Island | 3.8 (3.1-4.4) | 4.6 (4.3-4.9) |
| Big Pine | 22.2 (18.6-24.0) | 25.4 (23.8-27.0) |
| Colby | 3.8 [a] (3.4-4.2) | 6.0 [a] (4.6-7.4) |
| Detroit | 7.0 [b] (5.3-9.6) | 7.7 (6.0-10.0) |
| Frances | 12.4 (12.0-13.0) | 14.0 (12.1-15.1) |
| Johanna | 16.9 (15.6-18.6) | 8.2 (7.8-8.7) |
| Long | 32.4 [b] (29.9-34.9) | 99.3 (40.5-208.0) |
| Minnewaska | 10.6 (9.6-12.4) | 15.5 (13.6-16.4) |
| Nokay | 20.4 (18.4-21.8) | 15.6 (12.5-20.1) |
| Pokegama | 3.6 [a] (3.0-4.1) | 3.7 [a] (3.0-4.8) |
| Shields | 35.5 (29.2-42.6) | 73.9 (73.3-74.7) |
| Snowbank | 3.5 (3.1-3.8) | <3.0 |
| Trout | <3.0 | <3.0 |
| White Iron | 4.7 [a] (3.3-5.9) | 4.8 [a] (4.5-5.0) |
| Wilson | 3.2 (3.2) | 3.0 [a] (3.0) |

[a] Some samples below the detection limit (3.0 ppb) for chlorophyll "a". These are not included in the mean.

[b] No determination for some sampling stations.

milfoil (Myrophyllum exalbescens), claspingleaf pondweed (Potamogeton richardsonii), filamentous algae (several genera) and Chara spp. (only one) while in soft-water lakes the aquatic plants most often found were bushy pondweed, Nitella spp., water milfoil and filamentous algae (Table 8).

Algae

Up until 1977, a word was used to describe the relative abundance of algae in each sample (Johnson 1974; Gates 1975; Zappetillo 1976). In 1978, because of the subjectivity of this word description method, the quantitative method of number of algae/l of lake water was used (Zappetillo 1977; 1978). In 1979, the method was again changed because of high numbers and other difficulties. Algal abundance now is shown as the percentage of the population each species represents. Algae (phytoplankton) found in the 15 lakes in 1979 and 1980 are presented in Appendix Table 16.

In each of the 15 lakes, one group of algae made up a large percentage of the population. In all lakes sampled in 1979, except Colby, Pokegama, Trout and White Iron, blue-green algae (Cyanophyta) made up the highest percentage of the algae population with yellow-green algae (Chrysophyta) second in abundance. The remaining percentage of the population was made up by the other algal divisions (Chlorophyta Pyrrophyta and Englenophyta). In some lakes, for example, Trout Lake, these divisions had a higher number of individual genera present.

In the blue-green algae group, one genus (Chroococcus) when found in the lake, consistently had the highest percentage. Other genera that had high percentages in the blue-green algae group were Phor-

Table 8. Common and scientific names of sampled submerged, floating-leaf and emergent vegetation.

| Common name | Scientific name |
|---|---|
| Submerged | |
| Coontail | *Ceratophyllum demersum* |
| Chara | *Chara* spp. |
| Water moss | *Drepanocladus* spp. |
| Canada waterweed | *Elodea canadensis* |
| Western waterweed | *Elodea occidentalis* |
| Juncus | *Juncus* spp. |
| Water marigold | *Megalodonta beckii* |
| Water milfoil | *Myriophyllum excalbescens* |
| Bushy pondweed | *Najas flexilis* |
| Spiny naiad | *Najas marina* |
| Nitella | *Nitella* spp. |
| Northern pondweed | *Potamogeton alpinus* |
| Largeleaf pondweed | *Potamogeton amplifolius* |
| Berchtolds pondweed | *Potamogeton Berchtoldi* |
| Curlyleaf pondweed | *Potamogeton crispus* |
| Nuttalls pondweed | *Potamogeton epihydrus* |
| Variable pondweed | *Potamogeton gramineus* |
| Illinois pondweed | *Potamogeton illinoensis* |
| Floating-leaf pondweed | *Potamogeton natans* |
| Bluntleaf pondweed | *Potamogeton obtusifolius* |
| Sago pondweed | *Potamogeton pectinatus* |
| Whitestem pondweed | *Potamogeton praelongus* |
| Claspingleaf pondweed | *Potamogeton Richardsonii* |
| Robbins pondweed | *Potamogeton robbinsii* |
| Snailseed (spiral) pondweed | *Potamogeton Spirullis* |
| Narrowleaf pondweed | *Potamogeton strictifolius* |
| Largesheath pondweed | *Potamogeton vaginatus* |
| Flatstem pondweed | *Potamogeton zosteriformis* |
| White water buttercup | *Ranunculus* spp. |
| Submerged bulrush | *Scirpus subterminalis* |

Table 8. Continued.

| Common name | Scientific name |
|---|---|
| Greater bladderwort | *Utricularia vulgaris* |
| Wild celery | *Vallisneria americana* |
| Floating-leaf | |
| Water shield | *Brasenia schreberi* |
| Lesser duckweed | *Lemna minor* |
| Star duckweed | *Lemna trisulca* |
| Little yellow waterlily | *Nuphar microphyllum* |
| Yellow waterlily | *Nuphar variegatum* |
| Little white waterlily | *Nymphaea tetragona* |
| White waterlily | *Nymphaea tuberosa* |
| Floating-leaf burreed | *Sparganium fluctuans* |
| Emergent | |
| Sedge | *Carex* spp. |
| Spikerush | *Eleocharis palustris* |
| Horsetail | *Equisetum* spp. |
| Blueglag | *Iris versicolor* |
| Purple loosestrife | *Lythrum salicaria* |
| Reed canary grass | *Philaris arundenacea* |
| Phragmites | *Phragmites* spp. |
| smartweed | *Polygonum* spp. |
| Stiff wapato | *Sagittaria rigida* |
| Arrowhead | *Sagittaria* spp. |
| Hardstem bulrush | *Scirpus acutus* |
| River bulrush | *Scirpus fluviatalis* |
| Bayonet grass | *Scirpus paludosus* |
| Bulrush | *Scirpus* spp. |
| Giant burreed | *Sparganium eurycarpum* |
| Common cattail | *Typha latifolia* |
| Wild rice | *Zizania aquatica* |

midium, Aphanizomenon , Anabaena and Aphanocapsa . The yellow-green algae group had Tabellaria , Melosire , Dinobryon , Asterionella and Fragilaria composing the majority of the population.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen profiles from the deepest station at each lake sampled in 1979 and 1980 are graphically presented in Appendix Figs. 16-30. Except for Colby, Detroit, Long and Pokegama Lakes, the profiles from the deepest station were representative of the rest of the lake. In the above lakes, there were station(s) where the oxygen or temperature profiles differed from the deepest stations.

Station 3 on Colby Lake (Appendix, Fig. 3) is located in a bay separated from the main lake by a narrow channel. A pumping station for a power plant which pumps water from Whitewater Reservoir into Colby Lake is located on the bay. In 1979, there was an increase of dissolved oxygen of 1-2 ppm between the depths of 4 and 6 m. This increase also was noted in 1975 and 1978 summer sampling. The temperature profile in 1979 and the dissolved oxygen profile in 1980 for station 3 was the same as those for Stations 1 and 2.

Station 6 on Detroit Lake (Appendix, Fig. 4) is located in Curfman Lake or Deadshot Bay which is separated from the main lake basin by County Road 24. For 1979 and 1980, the thermocline in this bay occurred at 4 m which is shallower than the thermocline at the other stations in Detroit lake.

Long Lake (Appendix, Fig. 9) is divided into two basins by a narrow arm of shallow water. Station 3 is located in the north basin where Rice Creek has its inlet and outlet. The thermocline in 1979 and 1980 occurred at a depth approximately 1 m shallower at Station 3 than

at Stations 1 and 2 in the south basin.

Stations 7 and 8 of Pokegama Lake (Appendix, Fig. 10) are located in the southeast arm of the lake which is separated from the rest of the lake by U.S. Highway 169. The thermocline at these two stations occurs 2 to 3 m shallower than at other stations in the lake. Stations 5 and 6 are located in the south arm of Pokegama Lake, where in 1979 and 1980 they maintained approximately 3 ppm dissolved oxygen to the bottom. Dissolved oxygen at the other stations dropped to 1 ppm or lower before or at the bottom of the lake.

## DISCUSSION

### Water Chemistry

A major criticism of Carlson's TSI work is with the water clarity (Secchi disc) formula (Brezonik 1978), which does not take into account the effects of suspended solids (turbidity) or organic color (bog stain). Of the 15 lakes sampled in 1979 and 1980, Bear Island, Colby and White Iron Lakes had bog stained water. It was evident from the average TSI for water clarity (51, 67 and 57 for Bear island, Colby and White Iron Lakes, respectively in 1979 and 48, 58 and 54 for the same lakes, respectively in 1980) that organic color was masking the true TSI. Using Peterson's modification (MnDNR, personnel communication 1975), the TSI for Bear Island, Colby and White Iron Lakes water clarity was adjusted to 44, 52 and 47, respectively in 1979 and 42, 48 and 45, respectively in 1980. These numbers have a better correlation with TSI figures for total phosphorus and chlorophyll "a".

The modifications were necessary because each lake was evaluated based on the diversion from the TSI value. When using the TSI values

for determining the investigational needs of a lake, the summer algal biomass is thought to have a greater influence on the Secchi disc and chlorophyll "a" TSI values than the total phosphorus TSI value, thus they were emphasized. The lakes where the divergence of the TSI values for chlorophyll "a" and Secchi disc in 1979 indicated the need for further investigation were Big Pine, Colby, Johanna, Long, Nokay, Shields and Snowbank Lakes. When the TSI value for total phosphorus in 1979 is added to the evaluation, the additional lakes needing investigation are Pokegama and White Iron Lakes. Based on the divergence of 1980 TSI values for chlorophyll "a" and Secchi disc, Bear Island and Frances Lakes are also included.

Total alkalinity and ammonia nitrogen were included to obtain more insight on problem lakes and areas. The lakes that showed significant changes in 1979 when compared to previous date for ammonia nitrogen and total alkalinity also showed significant changes in 1980. In general, increases in 1979 for ammonia nitrogen and total alkalinity were followed by a similar decrease in 1980. If ammonia nitrogen and total alkalinity levels in the study lakes over the entire sampling period (1974-1980) are considered, very little change has occurred.

Johanna and Shields Lakes, where the 1979 TSI values indicated a study was needed, had significant changes in their chemical and biological parameters in 1979. It is not truly understood why these changes occurred in these lakes and not the other sample lakes. It is theorized that the interrelationship between water fertility and aquatic macrophytes could be at fault. Total alkalinity significantly ($p < 0.05$) decreased and the phosphorus values caused the TSI to indicate a need for further investigation in Johanna Lake. This in turn affected

other chemical parameters, which caused a reduction in macrophyte growth. Shields Lake had increases in ammonia nitrogen and phosphorus TSI and plankton algae. This could indicate that Shields Lake, unlike Johanna Lake, had more internal recycling of nutrients, or the algae was fixing atmospheric nitrogen and releasing it into the water, along with phosphorus during decomposition. In 1980, the chemical and biological parameters measured in Johanna and Shields Lake returned to pre-1979 levels, which in turn makes 1979 an unusual year.

Aquatic Vegetation

Water clarity, nutrient load, algae and aquatic vegetation are interrelated parameters. In Johanna Lake in 1979, these interrelationships did not follow expected patterns and aquatic vegetation virtually disappeared from the lake. In 1980, the aquatic vegetation returned to the depth of previous years (1973 and 1977). In 1980, the algae composition was more diverse, with an increase in water clarity and pH over 1979 data. It is speculated that the changes may be related to herbicide treatments. Approximately 12 ha of Lake Johanna have been treated with aquatic herbicides in each of the past several years. None of the sampling stations were within the treatment areas.

Other examples of lakes showing changes in species composition and depth to which plants grew between 1979 and 1980 were Pokegema and Minnewaska Lakes. Rooted vegetation was found at the 7.6 m contour in Pokegama Lake in 1979 but not in 1980. In 1979, water moss and coontail dominated the 4.5 m contour in Minnewaska lake but in 1980 coontail was the dominant species at that depth while water moss was not found. These changes reflect species competition from one year to the next or the early establishment of a plant at a given depth because of

light penetration or other environmental condition.

Algae

Algae are indicators of water quality. Species composition and abundance gives clues as to the presence or absence of various nutrients or pollutants. However, algae should not be the sole criterion in judging water quality. Algae can only show that a problem exists or reinforce other indicators of a problem. If species composition and algal abundance were the sole criteria used for the lakes sampled in 1979 and 1980, every lake would be considered to have a water quality problem.

Blue-green algae are indicators of eutrophic water. When blue-green algae are the dominant division present, the lake is generally recognized as having a water quality problem. Johanna Lake in 1979 is an example of an algae population dominated by blue-green algae.

Yellow-green and green algae are generally recognized as indicators of mesotrophic or oligotrophic water. When yellow-green or green algae are the dominant division present, the lake is generally recognized as having good water quality. Bear Island and Big Pine Lakes, in 1980, are examples of algae populations dominated by yellow-green and green algae.

Chlorophyll "a" concentration, which measures algal standing crop, was measured before and after plankton net filtration in 1979. There was little change in the chlorophyll "a" concentration before and after filtration, indicating that the majority of algae making up the chlorophyll "a" concentration were nannoplankton. Collection techniques, difficulty in identification and the time required to analyze a large sample resulted in few nannoplankton species being identified. The

chlorophyll "a" concentration in 1980 closely followed increases or decreases in the algae biomass.

Chlorophyll "a" can indicate possible changes in other water quality parameters within a lake. If the chlorophyll "a" value decreases, a prediction can be made that the Secchi disc value will increase; aquatic vegetation will increase; and nitrogen and phosphorus levels will increase or decrease depending on the quantity of the rooted aquatic vegetation. An example of these interactions can be seen with Lake Johanna in 1980. Lake Johanna's chlorophyll "a" concentration decreased over 8 ppb from 1979; Secchi disc measurement and rooted aquatic vegetation increased; and nitrogen and phosphorus concentrations showed little change. The reverse occurred in 1980 in Shields Lake where the chlorophyll "a" concentration increased over 38 ppb from 1979; Secchi disc measurements decreased; rooted aquatic vegetation; and nitrogen and phosphorus concentrations had little change.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen are both dependent on weather conditions, with any changes best noted in the epilimnion. The changes in thermocline that were seen between 1979 and 1980 in some lakes were generally in isolated bays or areas affected by a major river or some other external factor as noted previously. The change in Station 3, Colby Lake is due to oxygenated water from the epilimnion being pumped from the Whitewater Reservoir. Station 6 Detroit Lake and Stations 7 and 8, Pokegama Lake are examples of the effects of wave action and warming on the thermocline because of being isolated and shallow. Without further study on Stations 5 and 6 Pokegama Lake no explanation

can be given as to why these stations had 3 ppm oxygen to the bottom. Long Lake Station 3 is an example of how a creek or river can affect a small bay or lake. Rice Creek has a large watershed, which results in the creek carrying large quantities of organic matter. The additional organic matter has an effect on water temperature and oxygen of the receiving water, thus impacting the temperature and oxygen profiles of the isolated bays.

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# A P P E N D I X

Table 1. Vegetation abundance in Bear Island Lake, St. Louis County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/3/77 | 8/8/79 | 8/16/80 | 8/8/79 | 8/16/80 | 8/8/79 | 8/16/80 |
| SUBMERGED | | | | | | | |
| Filamentous algae | --[a] | 14 | 14 | 4.0 | 4.0 | L[b] | L |
| Water marigold | -- | 14 | -- | 1.0 | -- | S[c] | -- |
| Water milfoil | 14 | -- | P[d] | -- | -- | -- | -- |
| Nitella spp. | -- | 14 | 29 | 2.0 | 1.5 | SC[e] | S |
| Nuttalls pondweed | -- | -- | P | -- | -- | -- | -- |
| Variable pondweed | 29 f | -- f | 29 | -- | 2.0 | -- | SC |
| Floating-leaf pondweed | 29 | P | P | -- | -- | -- | -- |
| Whitestem pondweed | P | P | 14 | -- | 2.0 | -- | SC |
| Claspingleaf pondweed | 14 | 14 | P | 2.0 | -- | SC | -- |
| Robbins pondweed | -- | 14 | -- | 3.0 | -- | M | -- |
| Narrowleaf pondweed | 29 | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | 14 | -- | P | -- | -- | -- | -- |
| Greater bladderwort | -- | P f | -- | -- | -- | -- | -- |
| Wild celery | 29 | 29 f | -- | 3.5 | -- | L | -- |
| FLOATING-LEAF | | | | | | | |
| Little yellow waterlily | 29 | 14 | 14 | 1.0 | 2.0 | S | SC |
| Yellow waterlily | -- | -- | P | -- | -- | -- | -- |
| White waterlily | -- | P | P | -- | -- | -- | -- |
| Floating-leaf burreed | P | P | 14 | -- | 3.0 | -- | M[g] |
| EMERGENT | | | | | | | |
| Spikerush | -- | P | P | -- | -- | -- | -- |
| Arrowhead | -- | -- | P | -- | -- | -- | -- |
| Common cattail | -- | -- | P | -- | -- | -- | -- |

[a] -- = Not found
[b] L = Lush
[c] S = Sparce
[d] P = Present
[e] Sc = Scattered
f = Significant at 10% level
[g] M = Moderate
h = Significant at 5% level

Table 1. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/3/77 | 8/8/79 | 8/16/80 | 8/8/79 | 8/16/80 | 8/8/79 | 8/16/80 |
| SUBMERGED | | | | | | | |
| Coontail | | 14 | -- | 1.0 | -- | S | -- |
| Filamentous algae | | -- | f 29 | -- | 3.0 | -- | M |
| No plants were sampled in 1977 | | | | | | | |

Table 2. Vegetation abundance in Big Pine Lake, Otter Tail County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/15/78 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | 22 | 22 | 22 | 1.0 | 1.5 | S | S |
| Chara spp. | 100 | 100 | 89 | 3.7 | 4.0 | L | L |
| Water moss | -- | -- | P | -- | -- | -- | -- |
| Canada waterweed | 11 | 11 | -- | 2.0 | -- | SC | -- |
| Filamentous algae | 33 | 67 | 67 | 2.2 | 1.7 | M | SC |
| Juncus spp. | -- | -- | 11 | -- | 2.0 | -- | SC |
| Water milfoil | 22 | 22 | 33 | 2.5 | 2.7 | M | M |
| Bushy pondweed | 67 | 67 | 67 | 2.3 | 2.3 | M | M |
| Variable pondweed | 22 f | -- | -- | -- | -- | -- | -- |
| Sago pondweed | -- | -- | P | -- | -- | -- | -- |
| Whitestem pondweed | 11 | -- | f 22 | -- | 1.0 | -- | S |
| Claspingleaf pondweed | 22 | 22 | 22 | 1.0 | 2.0 | S | SC |
| Narrowleaf pondweed | 44 h | -- | 11 | -- | 1.0 | -- | S |
| Largesheath pondweed | -- | 11 | -- | 1.0 | -- | S | -- |
| Flatstem pondweed | 56 | 67 | 44 | 2.2 | 2.0 | M | SC |
| Bladderwort | -- | -- | f 22 | -- | 1.0 | -- | S |
| Wild celery | 11 | 11 | 11 | 4.0 | 1.0 | L | S |
| FLOATING-LEAF | | | | | | | |
| Lesser duckweed | -- | -- | P | -- | -- | -- | -- |
| Star duckweed | 22 | 22 | 33 | 2.0 | 2.3 | SC | M |
| Yellow waterlily | -- | -- | P | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Hardstem bulrush | -- | P | P | -- | -- | -- | -- |
| Wild rice | P | P | P | -- | -- | -- | -- |

Table 2. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|
| | 8/15/78 | | 8/2/79 | | 7/30/80 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 |
| SUBMERGED | | | | | | | | | |
| Coontail | 22 | f | -- | | 11 | -- | 1.0 | -- | S |
| Chara spp. | 78 | f | 100 | | 89 | 3.0 | 2.9 | M | M |
| Filamentous algae | 44 | | 44 | | 44 | 2.0 | 2.8 | SC | M |
| Water milfoil | 11 | | 11 | | -- | 1.0 | -- | S | -- |
| Bushy pondweed | 67 | h | -- | h | 67 | -- | 2.8 | S | M |
| Whitestem pondweed | -- | | -- | | 11 | -- | 1.0 | -- | S |
| Claspingleaf pondweed | -- | | 11 | | -- | 1.0 | -- | S | -- |
| Flatstem pondweed | 78 | | 67 | | 67 | 2.0 | 2.3 | SC | M |
| Wild celery | -- | | -- | | 11 | -- | 1.0 | -- | S |
| FLOATING-LEAF | | | | | | | | | |
| Star duckweed | 22 | | 11 | | 33 | 3.0 | 1.3 | M | S |

Table 2. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/15/78 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- | -- | 11 | -- | 1.0 | -- | S |
| Chara spp. | -- | -- | f 33 | -- | 1.7 | -- | SC |
| Filamentous algae | -- | -- | 11 | -- | 2.0 | -- | SC |
| Bushy pondweed | -- | -- | 11 | -- | 1.0 | -- | S |
| Flatstem pondweed | -- | -- | f 33 | -- | 1.7 | -- | SC |

Table 2. Continued, 5.9 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/15/78 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 | 8/2/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Chara spp. | -- | -- | 11 | -- | 1.0 | -- | S |
| Bushy pondweed | -- | -- | 11 | -- | 3.0 | -- | M |

See Table 1 for explanation of letters.

Table 3. Vegetation abundance in Colby Lake, St. Louis County, 1.5 m contour.

| Species | Percent Occurrence | | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8/1/78 | | 8/15/79 | | 8/13/80 | | 8/15/79 | 8/13/80 | 8/15/79 | 8/13/80 |
| SUBMERGED | | | | | | | | | | |
| Coontail | -- | | -- | | P | | -- | -- | -- | -- |
| Water moss | -- | | -- | f | 29 | | -- | 1.0 | -- | S |
| Filamentous algae | -- | | -- | | 14 | | -- | 1.0 | -- | S |
| Juncus spp. | -- | | P | | -- | | -- | -- | -- | -- |
| Water milfoil | 43 | h | -- | | -- | | -- | -- | -- | -- |
| Bushy pondweed | 29 | | 29 | | 57 | | 1.5 | 2.3 | S | M |
| Nitella spp. | -- | f | 29 | f | -- | | 1.0 | -- | S | -- |
| Berchtold's pondweed | -- | | -- | | P | | -- | -- | -- | -- |
| Variable pondweed | 71 | | 29 | | 14 | | 1.0 | 1.0 | S | S |
| Floating-leaf pondweed | -- | | P | | -- | | -- | -- | -- | -- |
| Snailseed pondweed | -- | | -- | | 14 | | -- | 2.0 | -- | SC |
| Greater bladderwort | P | | -- | | 14 | | -- | 2.0 | -- | SC |
| Wild celery | 29 | | 14 | | P | | 1.0 | -- | S | -- |
| FLOATING-LEAF | | | | | | | | | | |
| Water shield | -- | | -- | | P | | -- | -- | -- | -- |
| Little yellow waterlily | 86 | h | 29 | | P | | 1.0 | -- | -- | -- |
| Yellow waterlily | P | | 29 | | 14 | | 1.0 | 1.0 | -- | S |
| Floating-leaf burreed | 100 | f | 71 | h | 14 | | 1.0 | 1.0 | S | S |
| EMERGENT | | | | | | | | | | |
| Equisetum | -- | | -- | | P | | -- | -- | -- | -- |
| Blue flag | -- | | -- | | P | | -- | -- | -- | -- |
| Stiff wapato | -- | | -- | | P | | -- | -- | -- | -- |
| Hardstem bulrush | P | | P | | P | | -- | -- | -- | -- |
| Bulrush spp. | -- | | -- | | P | | -- | -- | -- | -- |
| Bayonet grass | -- | | -- | | P | | -- | -- | -- | -- |
| Common cattail | -- | | -- | | P | | -- | -- | -- | -- |
| Wild rice | P | | -- | | -- | | -- | -- | -- | -- |

Table 3. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/1/78 | 8/15/79 | 8/13/80 | 8/15/79 | 8/13/80 | 8/15/79 | 8/13/80 |
| SUBMERGED | | | | | | | |
| Water moss | -- | f | 29 | -- | 2.0 | -- | SC |
| Filamentous algae | 14 | | -- | 1.0 | -- | S | -- |
| Bushy pondweed | 14 | | 14 | 1.0 | 2.0 | S | SC |
| Greater bladderwort | 14 | | -- | 1.0 | -- | S | -- |
| | No plants collected in 1978 | | | | | | |

Table 3. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/1/78 | 8/15/79 | 8/13/80 | 8/15/79 | 8/13/80 | 8/15/79 | 8/13/80 |
| SUBMERGED | | | | | | | |
| Water moss | -- | | 14 | -- | 2.0 | -- | SC |
| | No plants collected in 1978 | | | | | | |

See Table 1 for explanation of letters.

Table 4. Vegetation abundance in Detroit Lake, Becker County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/21/78 | 8/1/79 | 7/30/80 | 8/1/79 | 7/30/80 | 8/1/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | 33 | 22 | 33 | 2.5 | 2.3 | M | M |
| Chara spp. | 100 | 100 | 89 | 3.7 | 3.4 | L | L |
| Water moss | 11 | 11 | 11 | 1.0 | 1.0 | S | S |
| Canada waterweed | -- | 11 | 11 | 1.0 | 1.0 | S | S |
| Juncus spp. | -- | f 22 | f -- | 2.0 | -- | SC | -- |
| Water milfoil | 44 | 33 | 44 | 1.0 | 1.5 | S | S |
| Bushy pondweed | 44 | 22 | 22 | 2.0 | 1.5 | SC | S |
| Nitella spp. | -- | -- | P | -- | -- | -- | -- |
| Northern pondweed | 11 | -- | -- | -- | -- | -- | -- |
| Curlyleaf pondweed | -- | 11 | P | 4.0 | -- | L | -- |
| Variable pondweed | 11 | 22 | f -- | 2.0 | -- | SC | -- |
| Illinois pondweed | 11 | -- | -- | -- | -- | -- | -- |
| Floating-leaf pondweed | -- | P | -- | -- | -- | -- | -- |
| Sago pondweed | 11 | 11 | P | 2.0 | -- | SC | -- |
| Whitestem pondweed | 22 | 22 | 56 | 2.0 | 1.6 | SC | SC |
| Claspingleaf pondweed | -- | 11 | 33 | 1.0 | 1.0 | S | S |
| Largesheath pondweed | -- | f 22 | f -- | 1.5 | -- | SC | -- |
| Flatstem pondweed | 11 | 44 | 33 | 2.3 | 2.0 | M | SC |
| Water bulrush | 11 | -- | -- | -- | -- | -- | -- |
| Greater Bladderwort | 22 | 22 | 33 | 1.5 | 2.0 | SC | SC |
| Wild celery | 33 | 22 | 11 | 1.0 | 1.0 | S | S |
| Filamentous algae | 33 | 22 | 11 | 3.0 | 2.0 | M | SC |
| FLOATING-LEAF | | | | | | | |
| Star duckweed | -- | 11 | 11 | 2.0 | 1.0 | SC | S |
| EMERGENT | | | | | | | |
| Arrowhead | -- | -- | P | -- | -- | -- | -- |
| Hardstem bulrush | 11 | P | P | -- | -- | -- | -- |
| Common cattail | -- | -- | P | -- | -- | -- | -- |
| Wild rice | -- | -- | P | -- | -- | -- | -- |

Table 4. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/21/78 | 8/1/79 | 7/30/80 | 8/1/79 | 7/30/80 | 8/1/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | 67 | 67 | 67 | 2.7 | 2.2 | M | M |
| Chara spp. | 78 | 67 | 89 | 3.0 | 2.3 | M | M |
| Water moss | 11 | 22 | 33 | 1.3 | 1.7 | S | SC |
| Canada waterweed | 11 | -- | -- | -- | -- | -- | -- |
| Filamentous algae | 11 | 11 | 33 | 3.0 | 2.3 | M | M |
| Juncus spp. | 11 | 11 | -- | 1.0 | -- | S | -- |
| Water marigold | 11 | 11 | -- | 3.0 | -- | M | -- |
| Water milfoil | 78 | 56 | 33 | 1.6 | 1.0 | SC | S |
| Bushy pondweed | 89 h | 11 f | 56 | 1.0 | 1.2 | S | S |
| Curlyleaf pondweed | 11 | -- f | 22 | -- | 1.0 | -- | S |
| Variable pondweed | 11 | -- | -- | -- | -- | -- | -- |
| Sago pondweed | 22 f | -- | -- | -- | -- | -- | -- |
| Whitestem pondweed | 33 | 44 | 78 | 1.5 | 1.1 | SC | S |
| Claspingleaf pondweed | -- | 11 | -- | 2.0 | -- | SC | -- |
| Narrowleaf pondweed | -- | -- f | 22 | -- | 1.5 | -- | S |
| Largesheath pondweed | -- f | 22 f | -- | 1.3 | -- | S | -- |
| Flatstem pondweed | 89 | 100 | 89 | 2.4 | 2.1 | M | M |
| Greater bladderwort | 44 f | 22 | 33 | 1.5 | 2.0 | SC | SC |
| Wild celery | 44 | 44 | 22 | 1.5 | 2.0 | SC | SC |

Table 4. Continued, 4.4 m contour.

| Species | Percent Occurrence 8/21/78 | 8/1/79 | 7/30/80 | Average Recovery 8/1/79 | 7/30/80 | Density 8/1/79 | 7/30/80 |
|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | |
| Coontail | 56 | 44 | 56 | 1.8 | 2.8 | SC | M |
| Chara spp. | 33 | 44 | 33 | 2.0 | 2.7 | SC | M |
| Water moss | 11 | 22 | f -- | 2.0 | -- | SC | -- |
| Canada waterweed | 11 | 11 | 11 | 1.0 | 1.0 | S | S |
| Filamentous algae | 22 | 22 | 22 | 3.0 | 3.0 | M | M |
| Water marigold | 11 | 11 | -- | 1.0 | -- | S | -- |
| Water milfoil | -- | -- | f 33 | -- | 1.0 | -- | S |
| Bushy pondweed | 22 | 22 | f -- | 1.0 | -- | S | -- |
| Whitestem pondweed | 33 | 11 | -- | 1.0 | -- | S | -- |
| Narrowleaf pondweed | -- | -- | 11 | -- | 2.0 | -- | SC |
| Largesheath pondweed | -- | 11 | -- | 2.0 | -- | SC | -- |
| Greater bladderwort | -- | 11 | 11 | 1.0 | 4.0 | S | L |
| Wild celery | -- | -- | f 22 | -- | 1.5 | -- | S |
| FLOATING-LEAF | | | | | | | |
| Star duckweed | 11 | 11 | -- | 1.0 | -- | S | -- |

Table 4. Continued, 5.9 m contour.

| Species | Percent Occurrence 8/21/78 | 8/1/79 | 7/30/80 | Average Recovery 8/1/79 | 7/30/80 | Density 8/1/79 | 7/30/80 |
|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | |
| Coontail | -- | -- | 11 | -- | 4.0 | -- | L |
| Chara spp. | -- | -- | f 33 | -- | 1.0 | -- | S |
| Water moss | -- | -- | 11 | -- | 1.0 | -- | S |
| Filamentous algae | -- | -- | f 22 | -- | 2.0 | -- | SC |
| Bushy pondweed | -- | -- | 11 | -- | 1.0 | -- | S |
| Nitella spp. | -- | -- | 11 | -- | 1.0 | -- | S |
| Flatstem pondweed | -- | -- | 11 | -- | 1.0 | -- | S |
| FLOATING-LEAF | | | | | | | |
| Star duckweed | -- | -- | 11 | -- | 1.0 | -- | S |

See Table 1 for explanation of letters.

Table 5. Vegetation abundance in Frances Lake, LeSueur County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/14/77 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 |
| SUBMERGED | | | | | | | |
| Coontail | 60 f | 100 h | 40 | 2.6 | 3.0 | M | M |
| Chara spp. | 40 | 60 | f 100 | 2.3 | 3.2 | M | L |
| Water moss | -- | P | P | -- | -- | -- | -- |
| Canada waterweed | 20 | 20 | -- | 3.0 | -- | M | -- |
| Western waterweed | -- | -- | P | -- | -- | -- | -- |
| Water marigold | -- h | 60 h | -- | 1.7 | -- | S | -- |
| Water milfoil | 80 | 60 | 60 | 3.3 | 2.3 | L | M |
| Bushy pondweed | 60 | 40 | 80 | 2.0 | 2.8 | SC | M |
| Largeleaf pondweed | 20 | 60 | 60 | 1.3 | 2.0 | S | SC |
| Curlyleaf pondweed | -- | P | P | -- | -- | -- | -- |
| Variable pondweed | 60 h | -- | -- | -- | -- | -- | -- |
| Sago pondweed | -- | -- | 20 | -- | 1.0 | -- | S |
| Whitestem pondweed | 20 | -- | -- | -- | -- | -- | -- |
| Claspingleaf pondweed | 60 | 60 | 60 | 1.3 | 2.0 | S | SC |
| Narrowleaf pondweed | 20 | 40 | f -- | 2.0 | -- | SC | -- |
| Flatstem pondweed | 60 | 60 | 80 | 2.7 | 1.8 | M | SC |
| Greater bladderwort | -- | -- | 20 | -- | 1.0 | -- | S |
| Wild celery | 60 | 40 | 60 | 3.0 | 1.7 | M | SC |
| FLOATING-LEAF | | | | | | | |
| Little yellow waterlily | -- | P | -- | -- | -- | -- | -- |
| Yellow waterlily | -- | -- | P | -- | -- | -- | -- |
| Little white waterlily | -- | P | P | -- | -- | -- | -- |
| White waterlily | -- | P | P | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Arrowhead | -- | P | -- | -- | -- | -- | -- |
| Hardstem bulrush | -- | P | P | -- | -- | -- | -- |
| River bulrush | -- | P | -- | -- | -- | -- | -- |
| Common cattail | -- | P | P | -- | -- | -- | -- |

Table 5. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/14/77 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 |
| SUBMERGED | | | | | | | |
| Coontail | 80 | 100 | 80 | 2.4 | 2.0 | M | SC |
| Chara spp. | 20 | 20 | 20 | 4.0 | 1.0 | L | -- |
| Water moss | -- f | 40 | 60 | 1.3 | 1.0 | S | S |
| Canada waterweed | -- | 20 | -- | 2.0 | -- | SC | -- |
| Western waterweed | -- | -- | 20 | -- | 1.0 | -- | S |
| Water milfoil | 60 | 60 | 60 | 1.6 | 1.0 | S | S |
| Bushy pondweed | 20 | -- | -- | -- | -- | -- | -- |
| Curlyleaf pondweed | 20 | 20 | 20 | 1.0 | 1.0 | S | S |
| Sago pondweed | -- | 20 | -- | 1.0 | -- | S | -- |
| Claspingleaf pondweed | -- | 20 | 00 | 3.0 | -- | M | -- |
| Flatstem pondweed | 40 h | 100 f | 60 | 2.8 | 2.0 | -- | SC |
| Greater bladderwort | -- | -- f | 40 | -- | 1.0 | -- | S |
| Wild celery | -- | 20 | 20 | 1.0 | 1.0 | S | S |

Table 5. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/14/77 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 | 7/26/79 | 7/24/80 |
| SUBMERGED | | | | | | | |
| Coontail | 40 f | -- | -- | -- | -- | -- | -- |
| Chara spp. | 20 | -- | -- | -- | -- | -- | -- |
| Water moss | -- f | 40 | 40 | 3.5 | 1.5 | L | S |
| Flatstem pondweed | 40 | 20 | 20 | 1.0 | 1.0 | S | S |
| Greater bladderwort | -- | -- | 20 | -- | 3.0 | -- | M |

See Table 1 for explanation of letters.

Table 6. Vegetation abundance in Lake Johanna, Ramsey County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/12/77 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 |
| SUBMERGED | | | | | | | |
| Coontail | 75 | 75 | 75 | 2.7 | 3.3 | M | L |
| Chara spp. | 100 h | 25 | 75 | 1.0 | 4.0 | S | L |
| Filamentous algae | 25 | -- | 25 | -- | 3.0 | -- | M |
| Water milfoil | 100 h | 25 | 25 | 1.0 | 1.0 | S | S |
| Bushy pondweed | 50 f | -- | 25 | -- | 2.0 | -- | SC |
| Curlyleaf pondweed | 25 | -- | 25 | -- | 1.0 | -- | S |
| Claspingleaf pondweed | -- | 25 | -- | 1.0 | -- | S | -- |
| Narrowleaf pondweed | 50 f | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | 25 | -- | f 50 | -- | 2.5 | -- | M |
| Wild celery | 25 | -- | -- | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Bulrush | P | P | -- | -- | -- | -- | -- |

Table 6. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/12/77 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 |
| SUBMERGED | | | | | | | |
| Coontail | 100 h | -- | h 75 | -- | 1.3 | -- | S |
| Chara spp. | 50 f | -- | f 50 | -- | 2.0 | -- | SC |
| Filamentous algae | 25 | -- | h 75 | -- | 3.3 | -- | L |
| Water milfoil | 100 f | -- | h 75 | -- | 1.3 | -- | S |
| Curlyleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Wild celery | 25 | -- | -- | -- | -- | -- | -- |

Table 6. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/12/77 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 |
| SUBMERGED | | | | | | | |
| Coontail | 100 h | -- | -- | -- | -- | -- | -- |
| Chara spp. | 25 | -- | -- | -- | -- | -- | -- |
| Filamentous algae | 25 | -- | h 100 | -- | 2.8 | -- | M |
| Water milfoil | 75 h | -- | -- | -- | -- | -- | -- |
| Curlyleaf pondweed | 50 f | -- | -- | -- | -- | -- | -- |

Table 6. Continued, 5.9 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/12/77 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 | 7/24/79 | 7/22/80 |
| SUBMERGED | | | | | | | |
| Coontail | 75 h | -- | 25 | -- | 1.0 | -- | S |
| Filamentous algae | -- | -- | 25 | -- | 2.0 | -- | SC |
| Curlyleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | 25 | -- | -- | -- | -- | -- | -- |

See Table 1 for explanation of letter.

Table 7. Vegetation abundance in Long Lake, Ramsey County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/20/76 | 7/23/79 | 7/21/80 | 7/23/79 | 7/21/80 | 7/23/79 | 7/21/80 |
| SUBMERGED | | | | | | | |
| Curlyleaf pondweed | 29 | 29 | 57 | 3.0 | 1.8 | M | SC |
| Flatstem pondweed | -- | 14 | -- | 4.0 | -- | L | -- |
| FLOATING-LEAF | | | | | | | |
| Duckweed | -- | P | -- | -- | -- | -- | -- |
| Yellow waterlily | P | P | P | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Purple loosestrife | -- | -- | P | -- | -- | -- | -- |
| Reed canary grass | -- | -- | P | -- | -- | -- | -- |
| Smartweed spp. | -- | -- | P | -- | -- | -- | -- |
| Common cattail | P | P | P | -- | -- | -- | -- |

See Table 1 for explanation of letters.

Table 8. Vegetation abundance in Minnewaska Lake, Pope County, 1.5 m contour.

| Species | Percent Occurrence 7/27/76 | | 7/30/79 | | 7/30/80 | Average Recovery 7/30/79 | 7/30/80 | Density 7/30/79 | 7/30/80 |
|---|---|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | | | |
| Coontail | 33 | f | -- | | P | -- | -- | -- | -- |
| Chara spp. | 100 | | 100 | | 100 | 4.0 | 4.0 | L | L |
| Water moss | -- | | 17 | | -- | 2.0 | -- | SC | -- |
| Filamentous algae | 33 | | 50 | h | -- | 3.0 | -- | M | -- |
| Water milfoil | -- | | 17 | | P | 1.0 | -- | S | -- |
| Spiny naiad | -- | | -- | | P | -- | -- | -- | -- |
| Curlyleaf pondweed | -- | | -- | | P | -- | -- | -- | -- |
| Claspingleaf pondweed | -- | | 17 | | P | 1.0 | -- | S | -- |
| Flatstem pondweed | -- | | -- | | P | -- | -- | -- | -- |
| Submerged bulrush | 33 | | 17 | | -- | 2.0 | -- | SC | -- |
| EMERGENT | | | | | | | | | |
| Hardstem bulrush | 17 | | P | | P | -- | -- | -- | -- |

Table 8. Continued, 3.0 m contour.

| Species | Percent Occurrence 7/27/76 | | 7/30/79 | | 7/30/80 | Average Recovery 7/30/79 | 7/30/80 | Density 7/30/79 | 7/30/80 |
|---|---|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | | | |
| Coontail | 50 | | 50 | | 50 | 2.7 | 2.7 | M | M |
| Chara spp. | -- | h | 100 | | 83 | 2.8 | 2.8 | M | M |
| Filamentous algae | 33 | | 67 | h | -- | 1.8 | -- | SC | M |
| Water milfoil | 50 | | 33 | | 50 | 2.0 | 2.3 | SC | M |
| Bushy pondweed | 67 | h | -- | | -- | -- | -- | -- | -- |
| Spiny naiad | 33 | | 33 | | 17 | 1.0 | 3.0 | S | M |
| Curlyleaf pondweed | 33 | f | -- | | 17 | -- | 1.0 | -- | S |
| Claspingleaf pondweed | -- | | -- | | 17 | -- | 1.0 | -- | S |
| Narrowleaf pondweed | 100 | h | -- | | -- | -- | -- | -- | -- |
| Flatstem pondweed | -- | h | 67 | | 67 | 1.8 | 2.5 | SC | M |
| Submerged bulrush | 33 | | 33 | h | -- | 1.0 | -- | S | — |

Table 8. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/27/76 | 7/30/79 | 7/30/80 | 7/30/79 | 7/30/80 | 7/30/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- f | 33 | 33 | 2.3 | 1.0 | M | S |
| Chara spp. | 50 h | -- | 17 | -- | 4.0 | -- | L |
| Water moss | -- | 17 | -- | 1.0 | -- | S | -- |
| Water milfoil | -- | -- | 17 | -- | 1.0 | -- | S |
| Spiny naiad | -- | -- | 17 | -- | 1.0 | -- | S |
| Curlyleaf pondweed | -- | 17 | 17 | 1.0 | 1.0 | S | S |
| Narrowleaf pondweed | 50 h | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | -- | 17 | 17 | 2.0 | 3.0 | SC | M |
| Submerged bulrush | 17 | -- | -- | -- | -- | -- | -- |

Table 8. Continued, 5.9 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/27/76 | 7/30/79 | 7/30/80 | 7/30/79 | 7/30/80 | 7/30/79 | 7/30/80 |
| SUBMERGED | | | | | | | |
| Coontail | 17 | 17 | -- | 1.0 | -- | S | -- |

See Table 1 for explanation of letters.

Table 9. Vegetation abundance in Nokay Lake, Crow Wing County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/2/76 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- h | 100 | 100 | 3.5 | 3.8 | L | L |
| Chara spp. | 50 | 50 | 75 | 2.0 | 1.7 | SC | SC |
| Canada waterweed | 75 h | -- | -- | -- | -- | -- | -- |
| Filamentous algae | -- | -- | 25 | -- | 1.0 | -- | S |
| Bushy pondweed | -- f | 50 | 75 | 3.5 | 2.3 | L | M |
| Largeleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Floating-leaf pondweed | P | P | -- | -- | -- | -- | -- |
| Sago pondweed | -- | -- | h 75 | -- | 1.7 | -- | SC |
| Whitestem pondweed | -- | 25 | 25 | 1.0 | 1.0 | S | S |
| Claspingleaf pondweed | 75 | 75 | 75 | 3.0 | 1.7 | M | SC |
| Narrowleaf pondweed | 100 h | -- | -- | -- | -- | -- | -- |
| Largesheath pondweed | -- f | 50 | f -- | 2.5 | -- | M | -- |
| Flatstem pondweed | 100 | 100 | 100 | 3.3 | 4.0 | L | L |
| Greater bladderwort | -- | -- | 25 | -- | 2.0 | -- | SC |
| Wild celery | 50 | 50 | 50 | 3.6 | 2.5 | L | M |
| FLOATING-LEAF | | | | | | | |
| Yellow waterlily | P | P | P | -- | -- | -- | -- |
| White waterlily | -- | -- | P | -- | -- | -- | -- |
| Floating-leaf burreed | P | -- | -- | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Phragmites | -- | -- | P | -- | -- | -- | -- |
| Arrowhead | -- | -- | P | -- | -- | -- | -- |
| Hardstem bulrush | P | P | P | -- | -- | -- | -- |
| Common cattail | 100 h | -- | -- | -- | -- | -- | -- |

Table 9. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/2/76 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 |
| SUBMERGED | | | | | | | |
| Coontail | 100 | 75 | 75 | 2.0 | 2.0 | SC | SC |
| Chara spp. | -- | -- | 25 | -- | 1.0 | -- | S |
| Filamentous algae | -- | -- | f 50 | -- | 3.0 | -- | M |
| Water milfoil | 25 | -- | 25 | -- | 2.0 | -- | SC |
| Bushy pondweed | -- | 25 | -- | 1.0 | -- | S | -- |
| Claspingleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Narrowleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Largesheath pondweed | -- | 25 | -- | 1.0 | -- | S | S |
| Flatstem pondweed | 100 | 100 | 100 | 2.3 | 1.5 | M | S |
| Wild celery | 25 | 50 | 25 | 2.0 | 1.0 | SC | S |

Table 9. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/2/76 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 | 8/22/79 | 8/20/80 |
| SUBMERGED | | | | | | | |
| Coontail | 75 | 25 | 25 | 1.0 | 1.0 | S | S |
| Filamentous algae | -- | -- | h 75 | -- | 2.0 | -- | SC |
| Narrowleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | 75 | h -- | -- | -- | -- | -- | -- |
| Wild celery | 25 | -- | -- | -- | -- | -- | -- |
| FLOATING LEAF | | | | | | | |
| Star duckweed | -- | 25 | -- | 1.0 | -- | S | -- |

See Table 1 for explanation of letters

Table 10. Vegetation abundance in Pokegama Lake, Itasca County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/26/77 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 |
| SUBMERGED | | | | | | | |
| Coontail | 8 | 8 | P | 1.0 | -- | S | -- |
| Chara spp. | 100 | 100 | 100 | 3.8 | 3.8 | L | L |
| Canada waterweed | 17 f | -- | P | -- | -- | -- | -- |
| Filamentous algae | -- | -- | P | -- | -- | -- | -- |
| Water marigold | -- f | 17 f | -- | 1.0 | -- | S | -- |
| Water milfoil | 25 | 17 | 33 | 1.5 | 1.5 | S | S |
| Bushy pondweed | 58 | 83 | 58 | 2.5 | 2.3 | M | M |
| Largeleaf pondweed | 17 | 42 | 17 | 1.6 | 1.0 | SC | S |
| Variable pondweed | 58 | 67 | 67 | 2.4 | 2.3 | M | M |
| Floating-leaf pondweed | P | 8 | P | 1.0 | -- | S | -- |
| Sago pondweed | -- | 8 | 17 | 1.0 | 1.0 | S | S |
| Whitestem pondweed | -- | -- f | 17 | -- | 2.5 | -- | M |
| Claspingleaf pondweed | 50 | 50 | 25 | 1.3 | 2.0 | S | SC |
| Narrowleaf pondweed | 25 h | -- f | 17 | -- | 1.0 | -- | S |
| Flatstem pondweed | 42 | 33 | 33 | 2.3 | 2.8 | M | M |
| Whitewater buttercup | -- | -- | P | -- | -- | -- | -- |
| Greater bladderwort | 17 | 17 | 33 | 2.5 | 1.8 | M | SC |
| Wild celery | 67 f | 25 | 42 | 2.7 | 2.6 | M | M |
| FLOATING-LEAF | | | | | | | |
| Yellow waterlily | -- | P | -- | -- | -- | -- | -- |
| Little yellow waterlily | -- | P | -- | -- | -- | -- | -- |
| White waterlily | P | P | -- | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Hardstem bulrush | P | P | P | -- | -- | -- | -- |
| Common cattail | -- | P | P | -- | -- | -- | -- |

Table 10. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|
| | 7/26/77 | | 8/21/79 | | 8/19/80 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 |
| SUBMERGED | | | | | | | | | |
| Coontail | 17 | | 50 | | 50 | 2.3 | 2.3 | M | M |
| Chara spp. | 92 | | 75 | | 75 | 2.8 | 3.1 | M | L |
| Canada waterweed | 33 | | 42 | | 17 | 2.6 | 2.0 | M | SC |
| Filamentous algae | -- | | 8 | | 17 | 1.0 | 1.5 | S | S |
| Water marigold | -- | h | 42 | f | -- | 1.8 | -- | SC | -- |
| Water milfoil | 58 | | 58 | | 50 | 2.1 | 1.5 | M | S |
| Bushy pondweed | 83 | | 92 | | 67 | 2.3 | 2.3 | M | M |
| Nitella spp. | -- | f | 17 | f | -- | 1.0 | -- | S | -- |
| Largeleaf pondweed | 42 | h | -- | | 8 | -- | 2.0 | -- | SC |
| Variable pondweed | 33 | | 8 | | 17 | 1.0 | 2.0 | S | SC |
| Floating-leaf pondweed | -- | | 8 | | -- | 1.0 | -- | S | -- |
| Sago pondweed | -- | | 8 | | 8 | 2.0 | 3.0 | SC | M |
| Whitestem pondweed | 8 | | -- | h | 58 | -- | 1.4 | -- | S |
| Claspingleaf pondweed | 67 | | 33 | | 25 | 1.9 | 1.3 | SC | S |
| Narrowleaf pondweed | 25 | h | -- | | 8 | -- | 1.0 | -- | S |
| Flatstem pondweed | 75 | | 75 | | 67 | 2.6 | 2.1 | M | M |
| White water buttercup | -- | | -- | h | 33 | -- | 1.5 | -- | S |
| Greater bladderwort | 42 | f | 8 | | 25 | 1.0 | 1.0 | S | S |
| Wild celery | 50 | | 42 | | 42 | 1.6 | 2.0 | SC | SC |

Table 10. Continued , 4.4 m contour.

| Species | Percent Occurrence | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|
| | 7/26/77 | | 8/21/79 | | 8/19/80 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 |
| SUBMERGED | | | | | | | | | |
| Coontail | 42 | | 67 | | 42 | 1.6 | 1.8 | SC | SC |
| Chara spp. | 67 | | 33 | | 58 | 1.5 | 2.3 | S | M |
| Canada waterweed | 25 | h | -- | h | 25 | -- | 2.3 | -- | M |
| Filamentous algae | 17 | | 17 | | 33 | 1.0 | 1.8 | S | SC |
| Water marigold | -- | f | 17 | f | -- | 1.5 | -- | S | -- |
| Water milfoil | 42 | | 17 | | 8 | 1.0 | 1.0 | S | S |
| Bushy pondweed | 83 | | 50 | | 33 | 1.8 | 2.3 | SC | M |
| Nitella spp. | -- | h | 25 | h | -- | 3.0 | -- | M | -- |
| Variable pondweed | 25 | h | -- | | -- | -- | -- | -- | -- |
| Sago pondweed | -- | | 8 | | -- | 1.0 | -- | S | -- |
| Whitestem pondweed | 17 | f | -- | | 8 | -- | 3.0 | -- | M |
| Claspingleaf pondweed | 42 | f | 8 | | -- | 1.0 | -- | S | -- |
| Flatstem pondweed | 50 | | 42 | | 50 | 1.6 | 1.5 | SC | -- |
| Greater bladderwort | 25 | h | -- | | 8 | -- | 1.0 | SC | S |
| Wild celery | 25 | h | -- | h | 25 | -- | 1.0 | -- | S |

Table 10. Continued, 5.9 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/26/77 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- f | 17 f | -- | 2.5 | -- | M | -- |
| Chara spp. | 8 | -- | 8 | -- | 1.0 | -- | S |
| Canada waterweed | -- f | 17 f | -- | 1.0 | -- | S | -- |
| Filamentous algae | -- h | 25 | 17 | 3.5 | 2.5 | L | M |
| Water milfoil | -- | 8 | -- | 2.0 | -- | SC | -- |
| Bushy pondweed | 8 | 17 | 8 | 1.0 | 1.0 | S | S |
| Nitella spp. | -- | 8 | -- | 3.0 | -- | M | -- |
| Flatstem spp. | -- | 8 | 8 | 1.0 | 1.0 | S | S |

Table 10. Continued, 7.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 7/26/77 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 | 8/21/79 | 8/19/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- | 8 | -- | 1.0 | -- | S | -- |
| Canada waterweed | -- | 8 | -- | 1.0 | -- | S | -- |
| Bushy pondweed | -- | 8 | -- | 1.0 | -- | S | -- |

See Table 1 for explanation of letters.

Table 11. Vegetation abundance in Shields Lake, Rice County, 1.5 m contour.

| Species | Percent Occurrence | | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7/26/78 | | 7/25/79 | | 7/23/80 | | 7/25/79 | 7/23/80 | 7/25/79 | 7/23/80 |
| SUBMERGED | | | | | | | | | | |
| Coontail | 57 | | 29 | f | -- | | 1.0 | -- | S | -- |
| Canada waterweed | 86 | | 57 | h | -- | | 1.5 | -- | S | -- |
| Filamentous algae | 43 | h | -- | f | 29 | | -- | 2.0 | -- | SC |
| Curlyleaf pondweed | 57 | | 14 | | 14 | | 1.0 | 1.0 | -- | S |
| Sago pondweed | 71 | h | -- | | -- | | -- | -- | -- | -- |
| Claspingleaf pondweed | 71 | | 57 | h | -- | | 1.5 | -- | S | -- |
| Narrowleaf pondweed | -- | f | 29 | f | -- | | 1.0 | -- | S | -- |
| Wild celery | 43 | | 43 | h | -- | | 1.0 | -- | S | -- |
| FLOATING-LEAF | | | | | | | | | | |
| Yellow waterlily | P | | P | | P | | -- | -- | -- | -- |
| White waterlily | P | | P | | P | | -- | -- | -- | -- |
| EMERGENT | | | | | | | | | | |
| Phragmites spp. | -- | | -- | | P | | -- | -- | -- | -- |
| Hardstem bulrush | -- | | P | | P | | -- | -- | -- | -- |
| River bulrush | P | | -- | | -- | | -- | -- | -- | -- |
| Common cattail | P | | P | | P | | -- | -- | -- | -- |

Table 11. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7/26/78 | | 7/25/79 | | 7/23/80 | | 7/25/79 | 7/23/80 | 7/25/79 | 7/23/80 |
| SUBMERGED | | | | | | | | | | |
| Canada waterweed | 14 | | -- | | -- | | -- | -- | -- | -- |
| Filamentous algae | 43 | | -- | h | 29 | | -- | 3.5 | -- | L |

See Table 1 for explanation of letters.

Table 12. Vegetation abundance in Snowbank Lake, Lake County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/10/77 | 8/14/79 | 8/12/80 | 8/14/79 | 8/12/80 | 8/10/79 | 8/12/80 |
| SUBMERGED | | | | | | | |
| Coontail | 14 | -- | 13 | -- | 1.0 | -- | S |
| Canada waterweed | 14 | 12 | 25 | 2.0 | 3.0 | SC | M |
| Filamentous algae | 29 f | -- h | 25 | -- | 2.5 | -- | M |
| Juncus spp. | -- | -- | 13 | -- | 3.0 | -- | M |
| Water marigold | -- | 12 | -- | 3.0 | -- | M | -- |
| Water milfoil | 14 | -- h | 25 | -- | 3.0 | -- | M |
| Bushy pondweed | 29 f | -- h | 25 | -- | 2.0 | -- | SC |
| Nitella spp. | 29 | 12 | -- | 2.0 | -- | SC | -- |
| Largeleaf pondweed | 14 | -- | -- | -- | -- | -- | -- |
| Variable pondweed | 14 | 12 | P | 1.0 | -- | S | -- |
| Floating-leaf pondweed | 14 | -- | -- | -- | -- | -- | -- |
| Bluntleaf pondweed | -- | 12 | 25 | 2.0 | 2.0 | SC | SC |
| Whitestem pondweed | -- | -- | 13 | -- | 2.0 | -- | SC |
| Flatstem pondweed | 43 h | -- | -- | -- | -- | -- | -- |
| White water buttercup | -- | -- | 13 | -- | 1.0 | -- | S |
| Wild celery | -- | -- | 13 | -- | 1.0 | -- | S |
| Unidentified spp. | -- | -- | 13 | -- | 2.0 | -- | SC |
| FLOATING-LEAF | | | | | | | |
| Water shield | 14 | -- | -- | -- | -- | -- | -- |
| Little white waterlily | -- | P | P | -- | -- | -- | -- |
| White waterlily | P | P | P | -- | -- | -- | -- |
| Floating-leaf burreed | P | P | P | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Spikerush | 14 | -- | -- | -- | -- | -- | -- |
| Arrowhead | -- | P | P | -- | -- | -- | -- |
| Giant burreed | -- | -- | P | -- | -- | -- | -- |
| Common cattail | -- | -- | P | -- | -- | -- | -- |
| Wild rice | P | P | P | -- | -- | -- | -- |

Table 12. Continued, 3.0 m contour.

| Species | Percent Occurrence 8/10/77 | | 8/14/79 | | 8/12/80 | Average Recovery 8/14/79 | 8/12/80 | Density 8/14/79 | 8/12/80 |
|---|---|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | | | |
| Coontail | -- | | P | | -- | -- | -- | -- | -- |
| Canada waterweed | 29 | | 12 | | -- | 3.0 | -- | M | -- |
| Filamentous algae | 14 | | -- | f | 25 | -- | 4.0 | -- | L |
| Water milfoil | 14 | | 12 | | -- | 1.0 | -- | S | -- |
| Bushy pondweed | 14 | | 12 | | -- | 2.0 | -- | SC | -- |
| Nitella spp. | 29 | | 29 | f | -- | 1.5 | -- | S | -- |
| Variable pondweed | 14 | | 12 | | -- | 1.0 | -- | S | -- |
| Bluntleaf pondweed | -- | f | 29 | | 13 | 1.5 | 4.0 | S | L |
| Robbins pondweed | -- | h | 38 | | 13 | 3.3 | 4.0 | L | L |
| Flatstem pondweed | 29 | f | -- | | -- | -- | -- | -- | -- |
| Wild celery | -- | | 12 | | -- | 1.0 | -- | S | -- |
| Unidentified spp. | -- | | -- | | 13 | -- | 2.0 | -- | SC |

Table 12. Continued, 4.4 m contour.

| Species | Percent Occurrence 8/10/77 | | 8/14/79 | | 8/12/80 | Average Recovery 8/14/79 | 8/12/80 | Density 8/14/79 | 8/12/80 |
|---|---|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | | | |
| Canada waterweed | 29 | f | -- | | -- | -- | -- | -- | -- |
| Filamentous algae | 14 | | 25 | | 17 | 2.0 | 3.5 | SC | L |
| Water milfoil | 14 | | -- | | -- | -- | -- | -- | -- |
| Bushy pondweed | 14 | | -- | | -- | -- | -- | -- | -- |
| Nitella spp. | 29 | | 12 | | -- | 2.0 | -- | SC | -- |
| Variable pondweed | 14 | | -- | | -- | -- | -- | -- | -- |
| Bluntleaf pondweed | -- | | 12 | | -- | 1.0 | -- | S | -- |
| Robbins pondweed | -- | | -- | | 13 | -- | 1.0 | -- | S |
| Flatstem pondweed | 29 | f | -- | | -- | -- | -- | -- | -- |

See Table 1 for explanation of letters.

Table 13. Vegetation abundance in Trout Lake, Cook County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/9/76 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| *Chara* spp. | 33 | -- | -- | -- | -- | -- | -- |
| Water milfoil | 33 | 33 | 100 | 2.0 | 2.0 | SC | SC |
| *Nitella* spp. | 67 | 100 | 33 | 1.0 | 1.0 | S | S |
| Variable pondweed | -- | 33 | -- | 3.0 | -- | M | -- |
| Bluntleaf pondweed | 67 | -- | 33 | -- | 1.0 | -- | S |
| Narrowleaf pondweed | 33 | -- | P | -- | -- | -- | -- |
| FLOATING-LEAF | | | | | | | |
| Little yellow waterlily | -- | P | -- | -- | -- | -- | -- |
| Yellow waterlily | -- | P | -- | -- | -- | -- | -- |
| EMERGENT | | | | | | | |
| Spikerush | -- | P | -- | -- | -- | -- | -- |
| *Equisetum* spp. | -- | -- | P | -- | -- | -- | -- |

Table 13. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/9/76 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| *Chara* spp. | 33 | -- | -- | -- | -- | -- | -- |
| Water milfoil | -- | 67 | 66 | 1.5 | 2.5 | S | M |
| *Nitella* spp. | 33 | 33 | 100 | 3.0 | 2.7 | M | M |
| Largeleaf pondweed | P | -- | -- | -- | -- | -- | -- |
| Variable pondweed | -- | 33 | -- | 1.0 | -- | S | -- |
| Narrowleaf pondweed | 67 | -- | 33 | -- | 1.0 | -- | S |

Table 13. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/9/76 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| Water moss | 33 | -- | -- | -- | -- | -- | -- |
| Nitella spp. | 100 | 67 | 100 | 2.5 | 2.7 | M | M |
| Bluntleaf pondweed | -- | 33 | 33 | 3.0 | 1.0 | M | S |
| Narrowleaf pondweed | 67 | -- | -- | -- | -- | -- | -- |

Table 13. Continued, 5.9 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/9/76 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 | 8/6/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| Water milfoil | -- | 33 | -- | 1.0 | -- | S | -- |
| Nitella spp. | 33 | 33 | 33 | 2.0 | 1.0 | SC | S |
| Narrowleaf pondweed | 33 | -- | -- | -- | -- | -- | -- |

See Table 1 for explanation of letters.

Table 14. Vegetation abundance in White Iron Lake, St. Louis County, 1.5 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/8/78 | 8/9/79 | 8/11/80 | 8/9/79 | 8/11/80 | 8/9/79 | 8/11/80 |
| SUBMERGED | | | | | | | |
| Coontail | -- | 8 | 8 | 3.0 | 1.0 | M | S |
| Chara spp. | 8 | -- | -- | -- | -- | -- | -- |
| Water moss | 8 | 15 f | -- | 1.5 | -- | S | -- |
| Filamentous algae | 15 | 23 | 15 | 1.7 | 1.5 | SC | S |
| Bushy pondweed | -- | f 15 | 8 | 1.0 | 1.0 | S | S |
| Nitella spp. | -- | f 15 | 31 | 2.0 | 2.3 | SC | M |
| Variable pondweed | -- | -- | f 15 | -- | 1.5 | -- | S |
| Floating-leaf pondweed | -- | 8 | -- | 1.0 | -- | S | -- |
| Bluntleaf pondweed | -- | f 15 | 31 | 1.5 | 1.0 | S | S |
| Clasping leaf pondweed | 15 | P | -- | -- | -- | -- | -- |
| Snailseed (spiral) pondweed | 15 | f -- | -- | -- | -- | -- | -- |
| Flatstem pondweed | -- | -- | 8 | -- | 2.0 | -- | SC |
| White water buttercup | P | -- | P | -- | -- | -- | -- |
| Wild celery | -- | h 23 | 23 | 2.3 | 1.0 | M | S |
| FLOATING-LEAF | | | | | | | |
| Little yellow waterlily | P | P | P | -- | -- | -- | -- |
| Yellow waterlily | -- | f 15 | 8 | 1.0 | 3.0 | S | M |
| White waterlily | -- | 8 | P | 1.0 | -- | S | -- |
| EMERGENT | | | | | | | |
| Sedge spp. | -- | -- | P | -- | -- | -- | -- |
| Spikerush | -- | P | P | -- | -- | -- | -- |
| Phragmites spp. | -- | -- | P | -- | -- | -- | -- |
| Stiff wapato | P | -- | -- | -- | -- | -- | -- |
| Arrowhead | -- | P | P | -- | -- | -- | -- |
| Hardstem bulrush | -- | P | P | -- | -- | -- | -- |
| Woolgrass | -- | -- | P | -- | -- | -- | -- |
| Wild rice | -- | p | P | -- | -- | -- | -- |

Table 14. Continued, 3.0 m contour.

| Species | Percent Occurrence 8/8/78 | 8/9/79 | 8/11/80 | Average Recovery 8/9/79 | 8/11/80 | Density 8/9/79 | 8/11/80 |
|---|---|---|---|---|---|---|---|
| SUBMERGED | | | | | | | |
| Nitella spp. | -- | -- | f 15 | -- | 3.0 | -- | M |

See Table 1 for explanation of letters.

Table 15. Vegetation abundance in Wilson Lake, Lake County, 1.5 m contour.

| Species | Percent Occurrence | | | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|---|---|
| | 8/16/76 | | 8/7/79 | | 8/5/80 | 8/7/79 | 8/5/80 | 8/7/79 | 8/4/80 |
| SUBMERGED | | | | | | | | | |
| Coontail | -- | | -- | | 25 | -- | 1.0 | -- | S |
| Filamentous algae | -- | f | 50 | f | -- | 1.5 | -- | S | -- |
| Juncus spp. | -- | | -- | f | 75 | -- | 1.7 | -- | SC |
| Water milfoil | 50 | f | -- | | -- | -- | -- | -- | -- |
| Bushy pondweed | 50 | f | -- | f | 50 | -- | 1.0 | -- | S |
| Nitella spp. | 25 | | 50 | | P | 1.5 | -- | S | -- |
| Largeleaf pondweed | 25 | | -- | | -- | -- | -- | -- | -- |
| Variable pondweed | 25 | | -- | | 25 | -- | 2.0 | -- | SC |
| Bluntleaf pondweed | -- | | 25 | | -- | 1.0 | -- | S | -- |
| Claspingleaf pondweed | 25 | | -- | | 25 | -- | 1.0 | -- | S |
| Robbins pondweed | 25 | | -- | | -- | -- | -- | -- | -- |
| Wild celery | -- | | -- | | P | -- | -- | -- | -- |
| FLOATING-LEAF | | | | | | | | | |
| Little yellow waterlily | -- | | P | | -- | -- | -- | -- | -- |
| Floating-leaf burreed | -- | | P | | -- | -- | -- | -- | -- |
| EMERGENT | | | | | | | | | |
| Spikerush | -- | | -- | | P | -- | -- | -- | -- |
| Arrowhead | -- | | P | | P | -- | -- | -- | -- |
| Common cattail | -- | | P | | P | -- | -- | -- | -- |

Table 15. Continued, 3.0 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/16/76 | 8/7/79 | 8/5/80 | 8/7/79 | 8/5/80 | 8/7/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| Filamentous algae | -- | 25 | -- | 4.0 | -- | L | -- |
| Juncus spp. | -- | -- | 25 | -- | 4.0 | -- | L |
| Water milfoil | 25 | 25 | -- | 2.0 | -- | SC | -- |
| Bushy pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Nitella spp. | -- | -- | f 50 | -- | 2.3 | -- | M |
| Variable pondweed | 50 | 25 | 25 | 3.0 | 1.0 | M | S |
| Robbins pondweed | -- | 25 | -- | 2.0 | -- | SC | -- |
| Narrowleaf pondweed | 25 | -- | -- | -- | -- | -- | -- |
| Greater bladderwort | -- | 25 | -- | 1.0 | -- | S | -- |
| Wild celery | -- | -- | 25 | -- | 1.0 | -- | S |
| EMERGENT | | | | | | | |
| Stiff wapato | 25 | -- | -- | -- | -- | -- | -- |

Table 15. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/17/76 | 8/7/79 | 8/5/80 | 8/7/79 | 8/5/80 | 8/7/79 | 8/5/80 |
| SUBMERGED | | | | | | | |
| Juncus spp. | -- | -- | 25 | -- | 1.0 | -- | S |
| Bushy pondweed | -- | 25 | -- | 1.0 | -- | S | -- |
| Nitella spp. | -- | f 50 | 75 | 2.0 | 1.3 | SC | S |
| Variable pondweed | -- | 25 | -- | 1.0 | -- | S | -- |
| Claspingleaf pondweed | -- | P | -- | -- | -- | -- | -- |

Table 15. Continued, 4.4 m contour.

| Species | Percent Occurrence | | | Average Recovery | | Density | |
|---|---|---|---|---|---|---|---|
| | 8/16/76 | 8/7/79 | 8/5/80 | 8/7/79 | 8/5/80 | 8/7/79 | 8/4/80 |
| SUBMERGED | | | | | | | |
| *Nitella* spp. | -- | 25 | -- | 1.0 | -- | S | -- |

See Table 1 for explanation of letters.

Table 16. Phytoplankton as a percentage of the total population present in vertical tow samples collected July and August, 1979 and 1980. (sheet 1 of 15)

BEAR ISLAND LAKE, St. Louis County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 8 August 1979 | *Anabaena* | *Randorina* | | *Asterionella* | *Trachelomonas*-0.2 |
| | *Aphanocapsa*-1.7 | | | *Dinobryon*-1.0 | |
| | *Chroococcus*-45.8 | | | *Fragilaria* | |
| | *Coelosphaerium*-0.5 | | | *Melosira*-3.1 | |
| | *Gomphosphaeria* | | | *Tabellaria*-17.4 | |
| | *Merismopedia*-0.2 | | | | |
| | *Microcystis* | | | | |
| | *Phormidium*-30.0 | | | | |
| 6 August 1980 | *Anabaena*-1.2 | *Ankistrodesmus*-0.6 | *Ceratium*-1.2 | *Actinocyclus*-1.2 | *Trachelomonas*-1.8 |
| | *Aphanizomenon*-2.4 | *Chlamydomonas*-2.4 | | *Asterionella*-1.8 | |
| | *Aphanocapsa*-1.8 | *Cosmarium* | | *Dinobryon*-20.5 | |
| | *Aphanothece*-4.8 | *Gonatozygon* | | *Eunotia* | |
| | *Chroococcus*-22.3 | *Micrasterias* | | *Fragilaria*-4.2 | |
| | *Coelosphaerium* | *Pediastrum*-0.6 | | *Melosira*-6.0 | |
| | *Gomphosphaeria*-3.0 | *Scenedesmus* | | *Navicula* | |
| | *Merismopedia*-3.0 | *Staurastrum*-4.2 | | *Pinnularia* | |
| | *Microcystis*-1.2 | *Ulothrix*-1.2 | | *Synedra*-0.6 | |
| | *Oscillatoria*-0.6 | *Xanthidium* | | *Synura* [a] -1.8 | |
| | *Synechococcus*-0.6 | | | *Tabellaria*-10.8 | |

[a] *Synura* colonies were broken up. Seventy-seven (77) cells were recorded as 3 colonies.

Table 16. Continued.
(sheet 2 of 15)

BIG PINE LAKE, Otter Tail County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 2 August 1979 | *Anabaena*-5.2 | *Ankistrodesmus* | *Ceratium*-2.5 | *Fragilaria*-0.2 | *Phacus*-0.2 |
| | *Aphanizomenon*-11.6 | *Pediastrum* | *Dinobryon*-3.2 | *Melosira*-3.7 | *Trachelomonas*-0.2 |
| | *Aphanocapsa*-0.2 | | | *Tabellaria*-1.2 | |
| | *Chroococcus*-64.4 | | | | |
| | *Coelosphaerium* | | | | |
| | *Lyngbya*-5.2 | | | | |
| | *Microcystis*-2.0 | | | | |
| | *Oscillatoria* | | | | |
| | *Phormidium* | | | | |
| 29 July 1980 | *Anabaena*-2.7 | *Chlamydomonas*-0.3 | *Ceratium*-1.1 | *Cocconeis*-0.3 | |
| | *Aphanizomenon*-2.1 | *Closteriopsis*-0.2 | *Peridinium* | *Coscindiscus* | |
| | *Aphanocapsa* | *Pediastrum* | | *Dinobryon*-40.8 | |
| | *Chroococcus*-27.2 | *Penium* | | *Eunotia*-0.2 | |
| | *Coelosphaerium*-0.2 | *Straurastrum* | | *Fragilaria*-0.3 | |
| | *Lyngbya*-3.4 | | | *Melosira*-7.9 | |
| | *Merismopedia*-0.2 | | | *Navicula*-4.2 | |
| | *Microcystis*-0.6 | | | *Ochromonas*-0.3 | |
| | *Oscillatoria*-5.1 | | | *Rhizosolenia*-0.2 | |
| | *Phormidium*-2.7 | | | *Stephanodiscus* | |
| | | | | *Stipitococcus* | |
| | | | | *Tabellaria* | |

Table 16. Continued.
(sheet 3 of 15)

COLBY LAKE, St. Louis County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 15 August 1979 | *Anabaena*-2.8 | *Chlamydomonas*-5.7 | *Ceratium* | *Asterionella* | *Trachelomonas*-5.7 |
| | *Aphanocapsa* | *Mougeotia*-2.8 | | *Denticula* | |
| | *Lyngbya*-1.4 | | | *Dinobryon*-32.8 | |
| | *Phormidium*-12.8 | | | *Hantzchia* | |
| | | | | *Melosira*-4.3 | |
| | | | | *Tabellaria*-31.4 | |
| 13 August 1980 | *Anabaena*-14.3 | *Chlamydomonas*-1.7 | *Ceratium*-4.3 | *Asterionella*-2.2 | *Trachelomonas*-2.6 |
| | *Aphanizomenon*-9.5 | *Staurastrum*-1.3 | | *Dinobryon*-16.5 | |
| | *Aphanothece*-0.4 | | | *Fragilaria*-0.9 | |
| | *Chroococcus*-40.7 | | | *Melosira*-3.0 | |
| | *Gomphosphaeria*-0.4 | | | *Navicula*-0.9 | |
| | *Lyngbya* | | | *Tabellaria*-0.9 | |
| | *Oscillatoria*-0.4 | | | | |

Table 16. Continued.
(sheet 4 of 15)

DETROIT LAKE, Becker County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 31 July 1979 | *Anabaena*-1.7 | *Crucigenia* | *Ceratium* | *Cymbella* | *Euglena* |
| | *Aphanizomenon* | *Lagerheimia* | *Glenodinium*-0.2 | *Diatomella* | *Phacus*-0.8 |
| | *Aphanocapsa*-0.1 | *Pediastrum* | | *Dinobryon*-29.2 | *Trachelomonas*-1.1 |
| | *Chroococcus*-63.8 | *Scenedesmus*-0.2 | | *Fragilaria*-1.3 | |
| | *Coelosphaerium* | *Tetraëdron*-0.2 | | *Gyrosigma* | |
| | *Lyngbya*-0.6 | | | *Melosira* | |
| | *Merismopedia* | | | *Navicula* | |
| | *Microcystis*-0.7 | | | | |
| | *Oscillatoria*-0.1 | | | | |
| | *Spirulina* | | | | |
| 28 July 1980 | *Anabaena*-8.4 | *Crucigenia*-1.0 | *Ceratium*-0.4 | *Achnanthes*-0.2 | *Trachelomonas*-2.1 |
| | *Chroococcus*-69.5 | *Pediastrum*-0.2 | *Glenodinium* | *Asterionella* | |
| | *Coelosphaerium*-0.2 | *Staurastrum* | | *Cocconeis*-0.2 | |
| | *Lyngbya*-1.8 | *Tetraëdon*-0.3 | | *Cymbella* | |
| | *Microcystis*-0.8 | | | *Dinobryon*-5.5 | |
| | *Oscillatoria*-3.7 | | | *Fragilaria*-2.4 | |
| | | | | *Gyrosigma* | |
| | | | | *Melosira*-2.4 | |
| | | | | *Navicula* | |
| | | | | *Rhizosolenia*-0.4 | |
| | | | | *Stephanodiscus*-0.3 | |
| | | | | *Synedra*-0.2 | |
| | | | | *Tabellaria* | |

Table 16. Continued.
(sheet 5 of 15)

FRANCES LAKE, LeSueur County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 26 July 1979 | *Anabaena*-0.2 | *Chlamydomonas* | *Ceratium*-0.6 | *Cymbella* | *Phacus* |
| | *Aphanocapsa*-1.7 | *Pediastrum* | *Glenodinium* | *Dinobryon*-2.9 | |
| | *Chroococcus*-63.7 | *Staurastrum* | | *Fragilaria* | |
| | *Coelosphaerium* | | | *Melosira*-26.3 | |
| | *Gomphosphaeria*-0.2 | | | | |
| | *Lyngbya*-0.8 | | | | |
| | *Merismopedia* | | | | |
| | *Microcystis*-3.5 | | | | |
| | *Oscillatoria* | | | | |
| | *Phormidium* | | | | |
| 24 July 1980 | *Anabaena*-0.3 | *Actinastrum* | *Ceratium*-1.9 | *Cocconeis*-0.3 | |
| | *Aphanizomenon*-1.1 | *Chodatella*-0.3 | *Peridinium*-0.3 | *Cymbella* | |
| | *Aphanocapsa*-2.2 | *Closteriopsis* | | *Dinobryon*-0.3 | |
| | *Chroococcus*-58.1 | *Gloeocystis* | | *Eunotia* | |
| | *Coelosphaerium*-0.3 | *Pediastrum*-0.3 | | *Fragilaria*-0.3 | |
| | *Gomphosphaeria*-0.3 | *Pleurotaenium* | | *Gyrosigma* | |
| | *Lyngbya*-4.3 | *Staurastrum*-0.5 | | *Melosira*-12.6 | |
| | *Merismopedia*-1.9 | | | *Navicula*-0.3 | |
| | *Microcystis*-4.3 | | | *Stephanodiscus* | |
| | *Oscillatoria*-6.5 | | | *Surirella* | |
| | *Synechococcus*-4.0 | | | *Tabellaria* | |

Table 16. Continued.
(sheet 6 of 15)

LAKE JOHANNA, Ramsey County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 24 July 1979 | *Anabaena*-1.1 | *Pediastrum*-0.2 | *Ceratium*-0.6 | *Asterionella* | *Trachelomonas*-0.1 |
| | *Aphanizomenon*-44.4 | *Scenedesmus* | | *Fragilaria* | |
| | *Chroococcus*-37.7 | *Staurastrum*-0.1 | | *Gyrosigma* | |
| | *Coelosphaerium*-0.3 | | | *Melosira*-15.3 | |
| | *Gomphosphaeria*-0.1 | | | *Navicula*-0.1 | |
| | | | | *Stephanodiscus* | |
| 22 July 1980 | *Anabaena*-17.8 | *Ankistrodesmus* | *Ceratium* | *Cymbella* | *Trachelomonas*-0.7 |
| | *Aphanizomenon*-9.6 | *Chlamydomonas*-13.4 | | *Dinobryon*-2.2 | |
| | *Chroococcus*-21.9 | *Cosmarium* | | *Eunotia* | |
| | *Coelosphaerium*-3.7 | *Nephrocytium* | | *Fragilaria*-0.4 | |
| | *Dactylococcopis* | *Pediastrum*-0.7 | | *Gyrosigma* | |
| | *Gomphosphaeria*-7.1 | *Spirogyra* | | *Melosira*-2.9 | |
| | *Lyngbya* | *Staurastrum*-1.5 | | *Navicula* | |
| | *Merismopedia*-1.1 | | | *Stephanodiscus*-0.4 | |
| | *Microcystis* | | | *Synedra* | |
| | *Oscillatoria*-0.7 | | | | |
| | *Synechococcus*-11.2 | | | | |

Table 16. Continued.
(sheet 7 of 15)

LONG LAKE, Ramsey County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 23 July 1979[b] | *Anabaena* | *Crucigenia* | *Ceratium* | *Asterionella* | |
| | *Aphanizomenon* | *Pediastrum* | | *Fragilaria* | |
| | *Chroococcus* | *Staurastrum* | | *Melosira* | |
| | *Coelosphaerium* | *Ulothrix* | | *Navicula* | |
| | *Microcystis* | | | | |
| | *Phormidium* | | | | |
| 21 July 1980 | *Anabaena*-12.6 | *Actinastrum*-2.1 | *Ceratium* | *Cocconeis* | |
| | *Aphanizomenon*-10.9 | *Ankistrodesmus*-0.7 | | *Cymbella* | |
| | *Aphanocapsa*-0.7 | *Crucigenia*-1.2 | | *Eunotia* | |
| | *Chroococcus*-6.7 | *Pediastrum*-0.7 | | *Fragilaria* | |
| | *Coelosphaerium*-0.2 | *Penium* | | *Melosira*-42.8 | |
| | *Merismopedia*-4.3 | *Scenedesmus*-0.5 | | *Navicula*-0.7 | |
| | *Microcystis*-0.5 | *Schroederia*-0.5 | | *Stephanodiscus* | |
| | *Oscillatoria*-14.5 | *Staurastrum* | | *Synedra* | |
| | *Phormidium*-0.? | | | *Tabellaria* | |
| | *Spirulina* | | | | |
| | *Synechococcus*-0.2 | | | | |

[b] The algae from the 1979 samples were badly broken making a reliable count difficult.

Table 16. Continued.
(sheet 8 of 15)

MINNEWASKA LAKE, Pope County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 30 July 1979 | *Anabaena*-0.7 | *Ankistrodesmus* | *Ceratium* | *Dinobryon*-0.3 | *Trachelomonas*-0.2 |
| | *Aphanocapsa*-1.2 | *Chlamydomonas*-0.3 | | *Fragilaria* | |
| | *Chroococcus*-90.2 | *Cosmarium* | | *Gyrosigma* | |
| | *Gomphosphaeria*-0.2 | *Oocystis* | | *Melosira*-0.5 | |
| | *Lyngbya*-3.1 | *Pediastrum* | | *Navicula* | |
| | *Merismopedia*-0.3 | *Scenedesmus* | | *Opephora* | |
| | *Microcystis*-2.3 | *Staurastrum* | | *Rhizoselenia* | |
| | *Oscillatoria*-0.5 | *Tetraëdron* | | | |
| | *Phormidium* | *Ulothrix* | | | |
| 31 July 1980 | *Anabaena*-7.0 | *Gloeocystis* | *Ceratium*-1.3 | *Cymbella* | *Trachelomonas*-0.2 |
| | *Aphanizomenon*-5.6 | *Pediastrum*-0.2 | *Glenodinium*-0.2 | *Diatomella* | |
| | *Chroococcus*-40.8 | *Staurastrum*-0.2 | | *Dinobryon* | |
| | *Gomphosphaeria*-0.9 | *Tetraëdon* | | *Fragilaria*-6.3 | |
| | *Lyngbya*-3.8 | | | *Gyrosigma* | |
| | *Merismopedia*-0.4 | | | *Melosira*-11.7 | |
| | *Microcystis*-6.3 | | | *Navicula*-0.7 | |
| | *Oscillatoria*-5.6 | | | *Rhizosolenia*-2.7 | |
| | *Phormidium*-4.7 | | | *Stephanodiscus* | |
| | | | | *Synedra*-1.3 | |

Table 16. Continued.
(sheet 9 of 15)

NOKAY LAKE, Crow Wing County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 22 August 1979 | *Anabaena*-2.5 | *Actinastrum*-0.2 | *Ceratium*-0.9 | *Dinobryon*-1.1 | *Trachelomonas*-1.6 |
| | *Anacystis* | *Cerasterias* | | *Fragilaria*-17.1 | |
| | *Aphanizomenon*-3.1 | *Chlorella*-0.7 | | *Melosira*-5.6 | |
| | *Chroococcus*-67.1 | *Pediastrum* | | *Stephanodiscus* | |
| | *Coelosphaerium* | *Scenedesmus* | | *Tabellaria* | |
| | *Lyngbya* | *Staurastrum* | | | |
| | *Microcystis* | | | | |
| 20 August 1980 | *Anabaena*-18.4 | *Pediastrum* | *Ceratium*-3.1 | *Asterionella*-0.3 | *Trachelomonas*-1.1 |
| | *Chroococcus*-39.2 | | | *Dinobryon*-18.2 | |
| | *Coelosphaerium* | | | *Fragilaria*-1.1 | |
| | *Gomphosphaeria*-0.2 | | | *Melosira*-9.5 | |
| | *Lyngbya* | | | *Navicula* | |
| | *Microcystis*-3.4 | | | *Stephanodiscus*-0.2 | |
| | *Oscillatoria*-4.9 | | | *Synedra*-0.3 | |
| | | | | *Tabellaria* | |

Table 16. Continued.
(sheet 10 of 15)

POKEGAMA LAKE, Itasca County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 20 August 1979 | *Anabaena*-8.8 | *Chlamydomonas* | *Ceratium*-2.2 | *Asterionella*-3.9 | *Euglena* |
| | *Aphanocapsa*-1.6 | *Staurastrum* | | *Dinobryon*-54.1 | *Trachelomonas*-3.9 |
| | *Chroococcus*-18.8 | *Ulothrix*-2.8 | | *Fragilaria* | |
| | *Coelosphaerium* | | | *Melosira*-1.1 | |
| | *Lyngbya*-0.6 | | | *Tabellaria*-2.2 | |
| | *Oscillatoria* | | | | |
| | *Spirulina* | | | | |
| 18 August 1980 | *Anabaena*-11.1 | *Chlamydomonas*-7.2 | *Ceratium*-6.1 | *Asterionella* | *Trachelomonas*-1.1 |
| | *Aphanizomenon* | *Cosmarium* | | *Dinobryon*-31.1 | |
| | *Aphanocapsa*-1.1 | *Pediastrum* | | *Fragilaria*-0.6 | |
| | *Chroococcus*-16.4 | *Quadrigula* | | *Gyrosigma* | |
| | *Coelosphaerium* | *Ulothrix* | | *Melosira*-0.8 | |
| | *Gloeotrichia*-1.1 | | | *Navicula*-0.8 | |
| | *Lyngbya*-1.7 | | | *Nitzschia* | |
| | *Oscillatoria*-3.8 | | | *Ochromonas*-0.8 | |
| | *Phormidium*-0.3 | | | *Rhizosolenia*-3.9 | |
| | *Rhabdoderma* | | | *Stephanodiscus* | |
| | *Synechococcus*-11.7 | | | *Synedra* | |
| | | | | *Tabellaria*-0.3 | |

Table 16. Continued.
(sheet 11 of 15)

SHIELDS LAKE, Rice County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 25 July 1979 | *Anabaena* | *Ankistrodesmus* | *Ceratium* | *Dinobryon* | |
| | *Aphanizomenon* | *Pediastrum* | | *Fragilaria* | |
| | *Aphanocapsa* | *Ulothrix* | | *Melosira* | |
| | *Chroococcus* | | | *Stephanodiscus* | |
| | *Coelosphaerium* | | | | |
| | *Merismopedia* | | | | |
| | *Microcystis* | | | | |
| | *Phormidium* | | | | |
| 23 July 1980 | *Anabaena*-3.9 | *Actinastrum*-0.3 | *Ceratium* | *Eunotia* | *Trachelomonas*-0.3 |
| | *Aphanizomenon*-8.4 | *Ankistrodesmus*-0.2 | | *Fragilaria*-0.6 | |
| | *Aphanocapsa*-1.3 | *Characium* | | *Melosira*-50.0 | |
| | *Chroococcus*-20.9 | *Chlamydomonas*-1.1 | | *Navicula*-0.6 | |
| | *Coelosphaerium*-0.3 | *Cosmarium*-0.2 | | *Nitzschia* | |
| | *Gomphosphaeria*-4.9 | *Eudorina*-0.2 | | *Stephanodiscus*-0.2 | |
| | *Lyngbya* | *Pediastrum*-0.5 | | *Surirella* | |
| | *Merismopedia*-0.5 | *Penium*-0.2 | | *Synedra*-0.3 | |
| | *Microcystis*-1.4 | *Scenedesmus* | | | |
| | *Oscillatoria*-0.8 | *Schroederia*-0.2 | | | |
| | *Spirulina*-1.1 | *Selenastrum* | | | |
| | *Synechococcus*-1.1 | *Staurastrum*-0.9 | | | |

Table 16. Continued.
(sheet 12 of 15)

SNOWBANK LAKE, Lake County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 14 August 1979 | *Anabaena*-3.2 | *Golenkinia* | *Ceratium* | *Asterionella* | |
| | *Aphanizomenon*-50.0 | *Pediastrum* | | *Dinobryon*-14.2 | |
| | *Aphanocapsa*-1.4 | *Quadrigula* | | *Fragilaria* | |
| | *Coelosphaerium* | *Scenedesmus* | | *Melosira* | |
| | *Gloeotrichia* | *Spondylosium* | | *Rhizosolenia*-0.9 | |
| | *Lyngbya* | *Staurastrum* | | *Tabellaria*-30.3 | |
| | | *Ulothrix* | | | |
| 12 August 1980 | *Anabena*-8.9 | *Ankistrodesmus*-2.2 | *Ceratium*-0.6 | *Asterionella*-8.9 | *Phacus* |
| | *Aphanizomenon*-25.0 | *Chlamydomonas*-14.4 | | *Diatoma*-0.6 | *Trachelomonas* |
| | *Aphanothece*-0.6 | *Gloeocystis* | | *Dinobryon*-1.7 | |
| | *Chroococcus*-2.2 | *Kirchneriella* | | *Fragilaria*-0.6 | |
| | *Coelosphaerium* | *Spondylosium* | | *Melosira*-0.6 | |
| | *Gloeotrichia*-6.1 | *Staurastrum*-3.3 | | *Navicula*-1.1 | |
| | *Gomphosphaeria*-1.7 | *Ulothrix*-0.6 | | *Rhizosolenia*-1.1 | |
| | *Merismopedia* | | | *Stauroneis* | |
| | *Microcystis*-0.6 | | | *Stephanodiscus*-0.6 | |
| | *Oscillatoria*-4.4 | | | *Synedra*-2.8 | |
| | *Phormidium*-5.0 | | | *Tabellaria*-6.1 | |
| | *Spirulina*-0.6 | | | | |

Table 16. Continued.
(sheet 13 of 15).

TROUT LAKE, Cook County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 6 August 1979 | *Anabaena*-18.2 | *Arthrodesmus* | *Ceratium* | *Asterionella*-35.4 | *Trachelomonas* |
| | *Aphanocapsa*-13.2 | *Chlamydomonas* | | *Dinobryon*-6.6 | |
| | *Coelosphaerium* | *Cosmarium* | | *Melosira* | |
| | *Gloeotrichia* | *Dimorphococcus* | | *Navicula* | |
| | *Lyngbya* | *Euastrum* | | *Rhopalodia* | |
| | *Merismopedia* | *Kirchneriella* | | *Tabellaria*-26.5 | |
| | *Oscillatoria* | *Quadrigula* | | | |
| | | *Scenedesmus* | | | |
| | | *Spondylosium* | | | |
| | | *Tetradesmus* | | | |
| | | *Tetraëdron* | | | |
| 4 August 1980 | *Anabaena*-5.9 | *Actinastrum* | *Ceratium*-0.9 | *Asterionella*-23.9 | *Trachelomonas* |
| | *Aphanizomenon*-2.7 | *Ankistrodesmus* | | *Cymbella* | |
| | *Aphanothece*-0.5 | *Chlamydomonas*-5.4 | | *Dinobryon* | |
| | *Aphanocapsa*-4.5 | *Cosmarium* | | *Eunotia* | |
| | *Chroococcus*-8.6 | *Cruicigenia* | | *Fragilaria*-0.5 | |
| | *Gloeotrichia* | *Dimorphococcus* | | *Melosira*-12.2 | |
| | *Gomphosphaerium*-0.5 | *Mougeotia* | | *Navicula*-0.5 | |
| | *Lyngbya* | *Pediastrum*-0.9 | | *Stipitococcus*-30.8 | |
| | *Merismopedia*-0.5 | *Quadrigula* | | *Synedra* | |
| | *Oscillatoria* | *Spondylosium*-0.5 | | *Tabellaria* | |
| | *Phormidium* | *Staurastrum*-0.5 | | | |
| | *Rhabdoderma* | *Tetradesmus* | | | |
| | *Synechococcus*-0.9 | *Xanthidium* | | | |

Table 16. Continued.
(sheet 14 of 15)

WHITE IRON LAKE, St. Louis County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 13 August 1979 | *Anabaena*-4.4 | *Chlamydomonas*-0.6 | *Ceratium*-0.3 | *Asterionella*-31.5 | *Euglena* |
| | *Aphanocapsa*-0.3 | *Spondylosium* | | *Dinobryon* | *Phacus*-5.0 |
| | *Chroococcus*-10.9 | *Ulothrix*-1.9 | | *Fragilaria*-28.0 | *Trachelomonas*-1.6 |
| | *Coelosphaerium* | | | *Melosira*-2.2 | |
| | *Microcystis* | | | *Tabellaria*-13.4 | |
| 11 August 1980 | *Anabaena*-5.9 | *Actinastrum* | *Ceratium*-1.1 | *Asterionella*-5.4 | *Trachelomonas*-0.5 |
| | *Aphanizomenon*-1.6 | *Botryococcus*-0.5 | | *Dinobryon*-22.7 | |
| | *Aphanocapsa*-0.5 | *Carteria*-7.6 | | *Eunotia* | |
| | *Chroococcus*-12.9 | *Chlamydomonas*-2.2 | | *Fragilaria*-1.1 | |
| | *Coelosphaerium*-0.5 | *Crucigenia* | | *Gyrosigma* | |
| | *Gomphosphaeria*-2.7 | *Pediastrum*-0.5 | | *Melosira*-3.2 | |
| | *Merismopedia*-0.5 | *Spirogyra*-0.5 | | *Navicula* | |
| | *Microcystis*-0.5 | *Spondylosium*-1.1 | | *Stephanodiscus*-0.5 | |
| | *Oscillatoria*-21.6 | *Staurastrum*-0.5 | | *Stipitococcus*-1.1 | |
| | *Phormidium*-0.5 | *Tetraëdon* | | *Synedra* | |
| | *Synechococcus*-1.1 | *Ulothrix* | | *Synura*[C] -0.5 | |
| | | *Xanthidium* | | *Tabellaria*-2.2 | |

[C]Fourteen (14) individual *Synura* cells were counted as 1 colony.

Table 16. Continued.
(sheet 15 of 15)

WILSON LAKE, Lake County

| | Division Cyanophyta | Division Chlorophyta | Division Pyrrophyta | Division Chrysophyta | Division Euglenophyta |
|---|---|---|---|---|---|
| 7 August 1979 | *Anabaena*-2.3 | *Chlamydomonas*-0.1 | *Ceratium*-0.3 | *Asterionella*-3.4 | *Phacus*-0.1 |
| | *Aphanocapsa*-0.3 | | | *Chrysosphaerella*-1.2 | *Trachelomonas*-0.2 |
| | *Chroococcus*-75.7 | | | *Dinobryon*-12.2 | |
| | *Coelosphaerium*-0.6 | | | *Fragilaria* | |
| | *Lyngbya*-0.1 | | | *Melosira*-2.6 | |
| | *Merismopedia* | | | *Navicula* | |
| | | | | *Stephanodiscus* | |
| | | | | *Tabellaria*-0.6 | |
| 5 August 1980 | *Anabaena*-1.2 | *Chlamydomonas*-4.4 | *Ceratium*-0.8 | *Asterionella*-3.2 | *Trachelomonas*-1.2 |
| | *Aphanizomenon*-32.7 | *Cosmarium* | | *Chrysosphaerella*[d] -7.2 | |
| | *Chroococcus*-5.2 | *Tetraëdon* | | *Dinobryon*-21.9 | |
| | *Coelosphaerium*-3.2 | | | *Fragilaria*-1.6 | |
| | *Lyngbya* | | | *Melosira*-1.9 | |
| | *Microcystis* | | | *Navicula*-1.6 | |
| | *Oscillatoria* | | | *Stephanodiscus*-0.8 | |
| | *Ulothrix* | | | *Synedra* | |
| | | | | *Synura*-6.4 | |
| | | | | *Tabellaria* | |
| | | | | *Uroglena*-6.8 | |

[d]Sample was badly broken up. Fifty (50) individual *Chrysosphaerella* cells observed were counted as one colony.

Figure 1. Sampling locations in Bear Island Lake (69-115), St. Louis County.

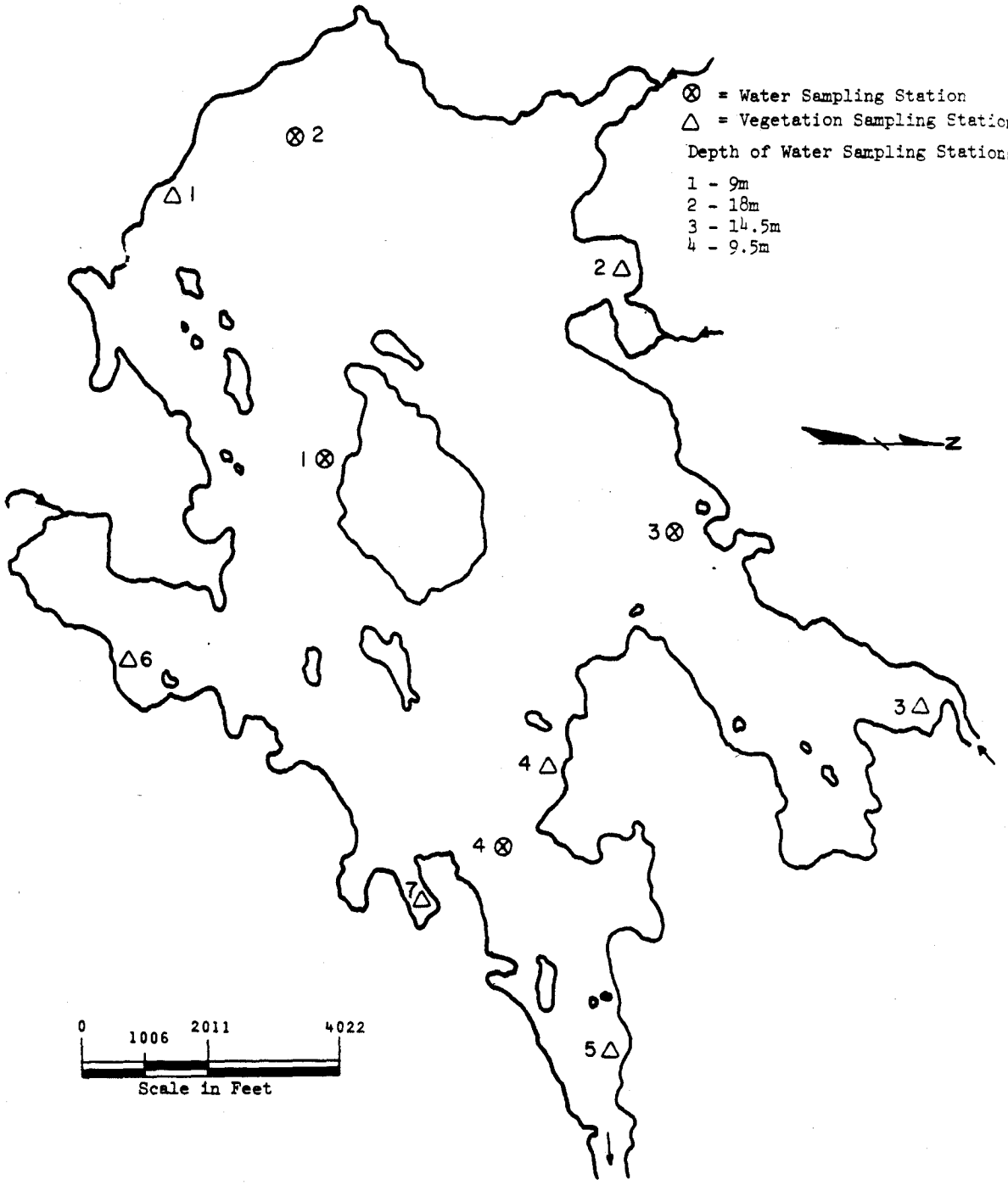


Figure 2. Sampling locations in Big Pine Lake (56-130), Otter Tail County.

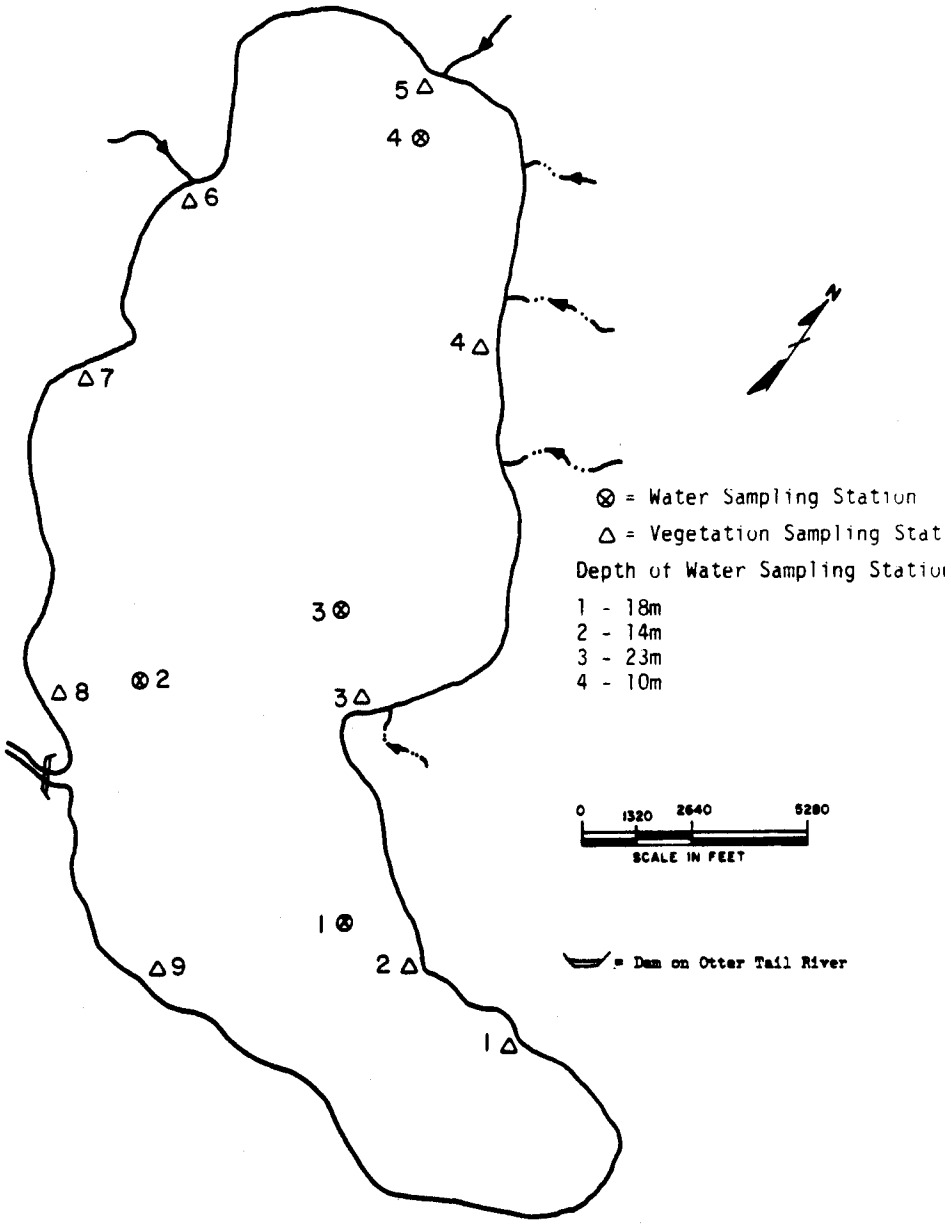


Figure 3. Sampling locations in Colby Lake (69-249), St. Louis County.

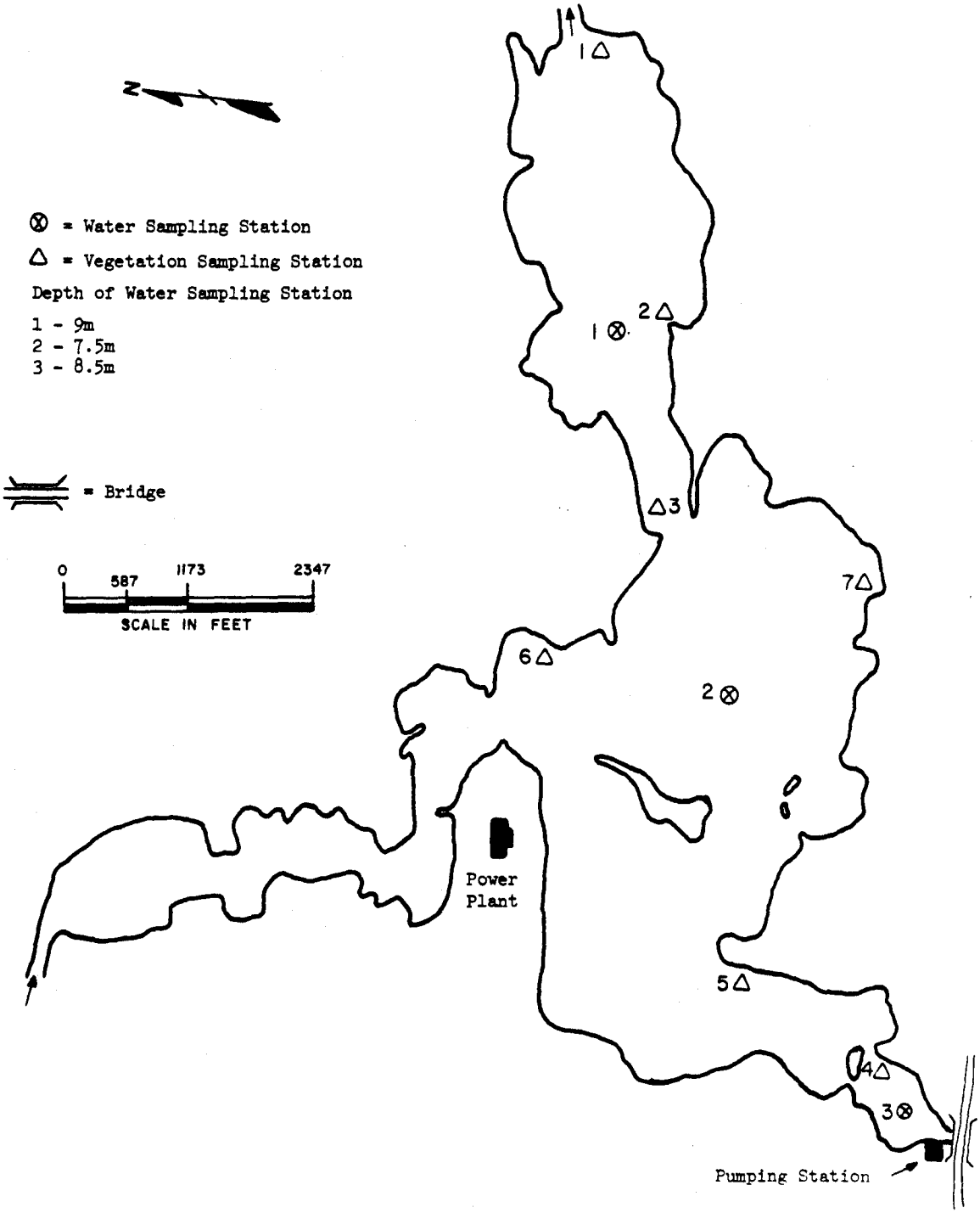


Figure 4. Sampling locations in Detroit Lake (3-381), Becker County.

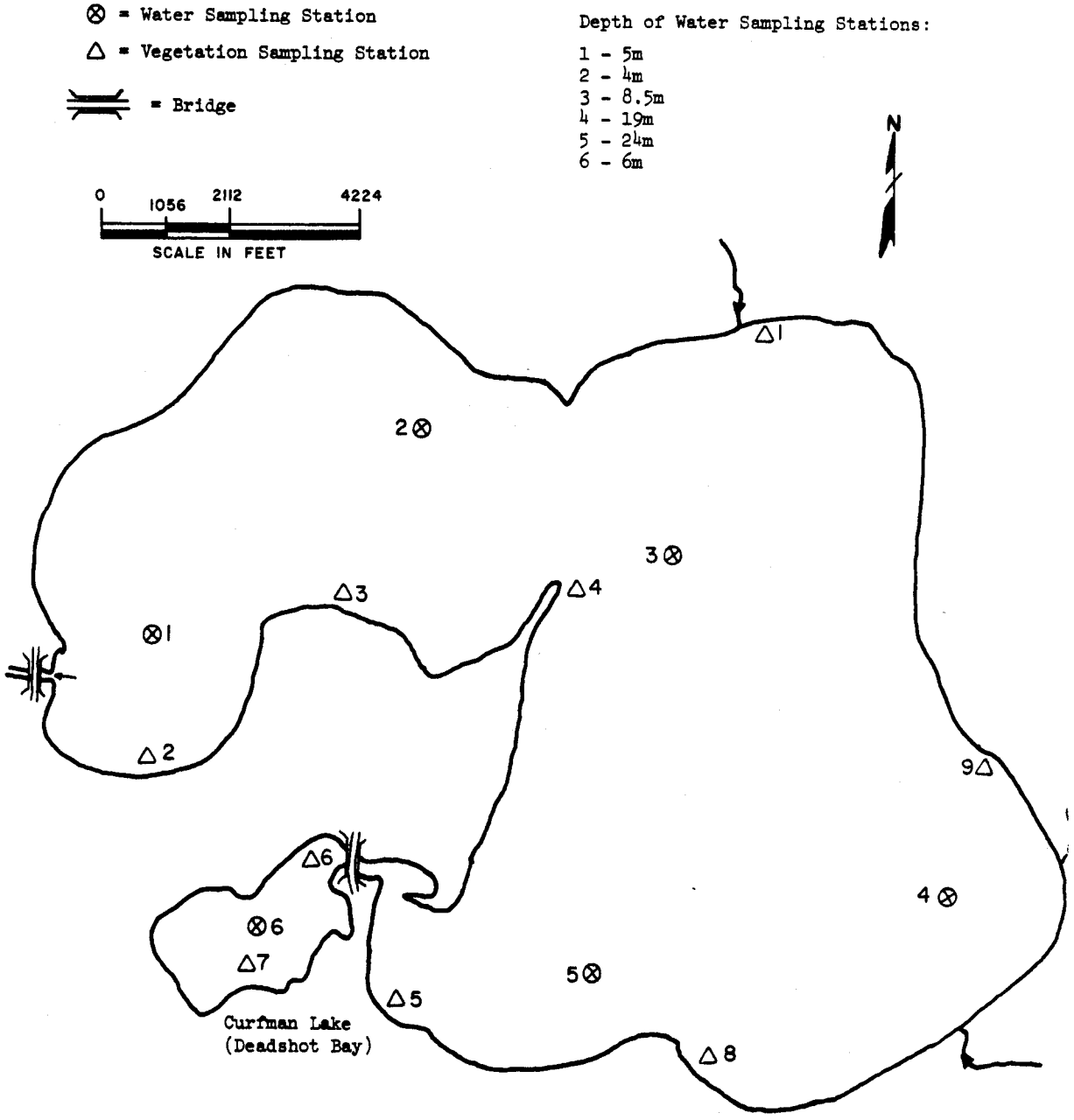


Figure 5. Sampling locations in Frances Lake (40-57), LeSueur County.

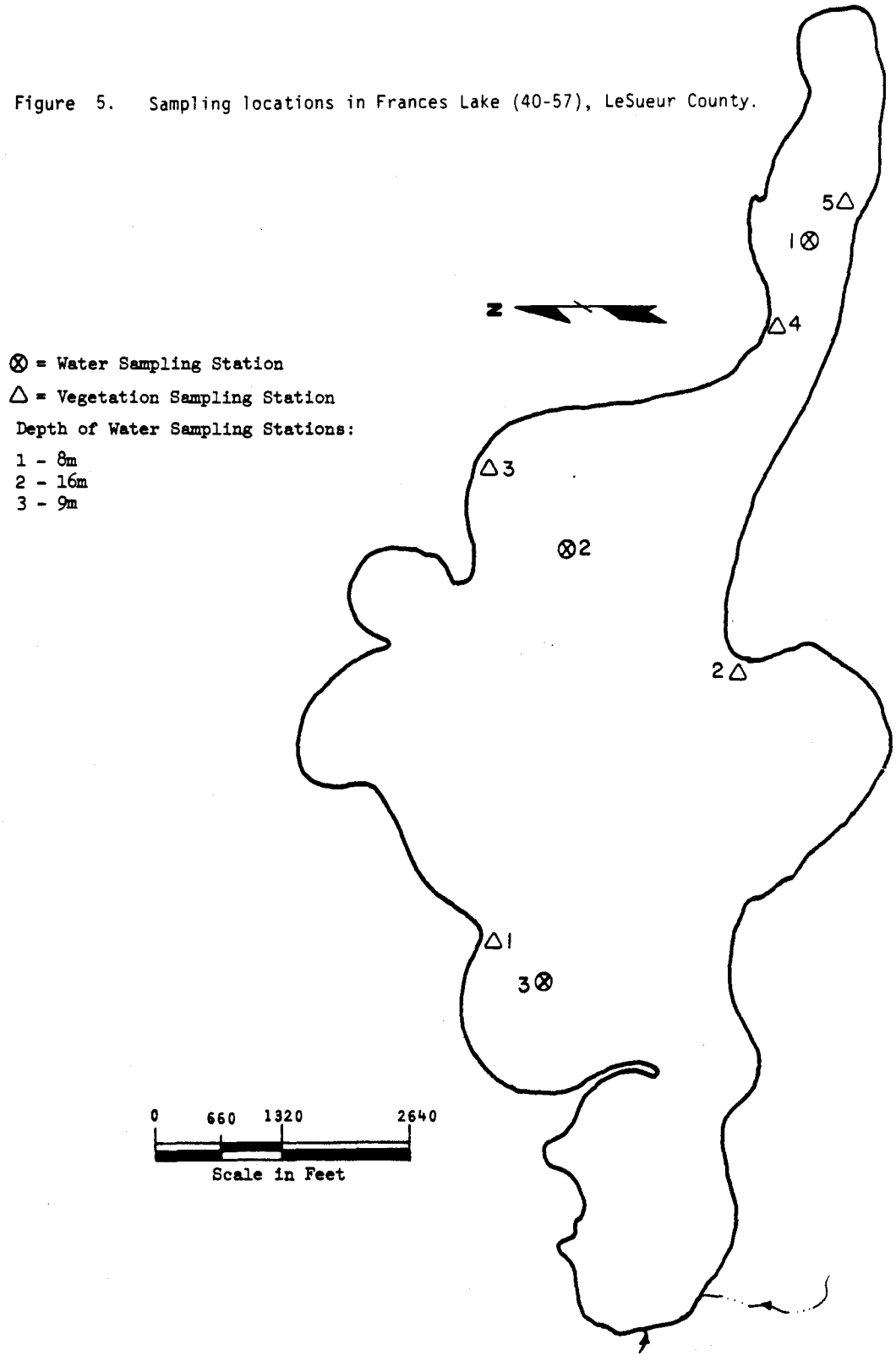


Figure 6. Sampling locations in Johanna Lake (62-78), Ramsey County.

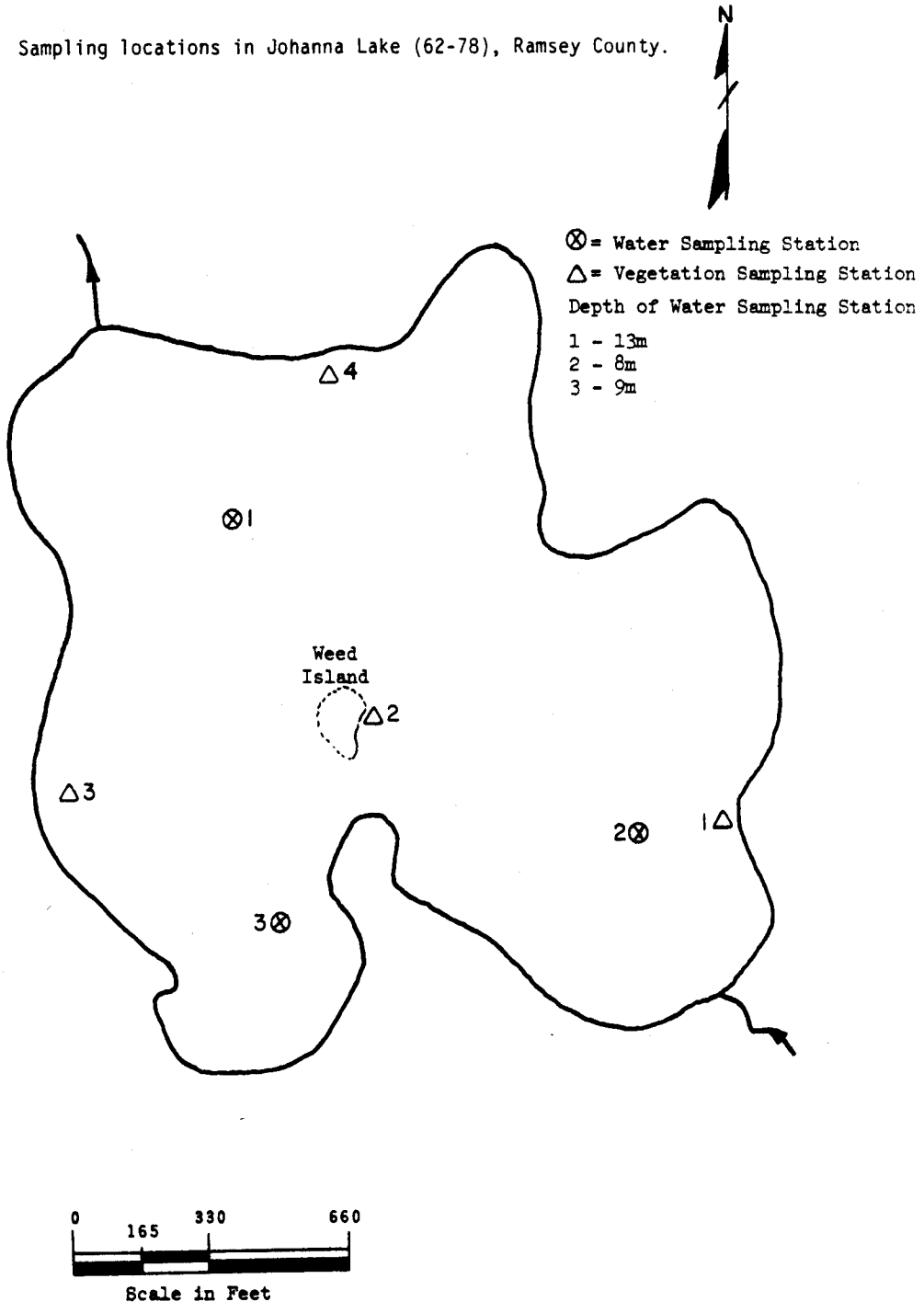


Figure 7. Sampling locations in Long Lake (62-67), Ramsey County.

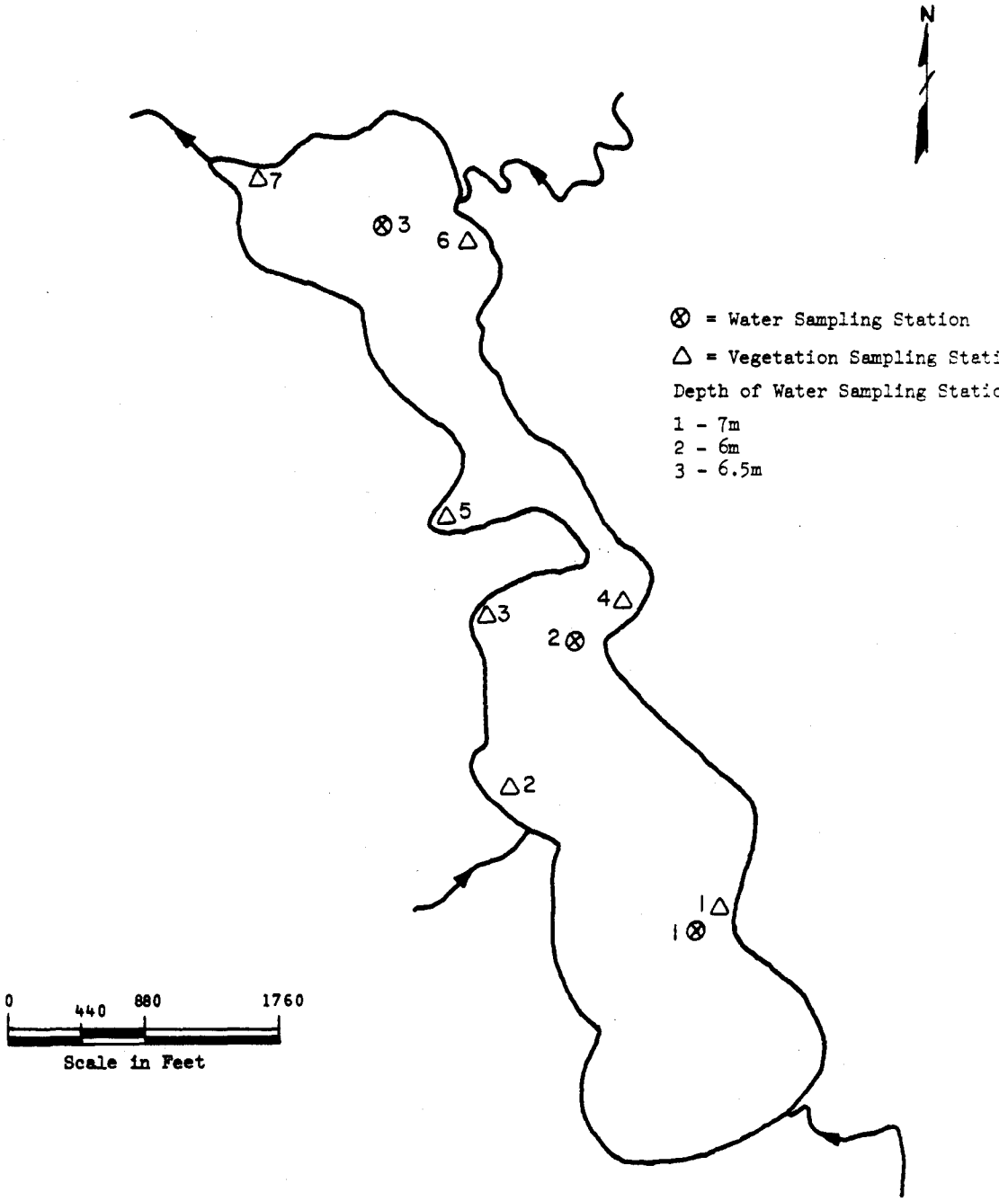


Figure 8. Sampling locations in Minnewaska Lake (6-100), Pope County.

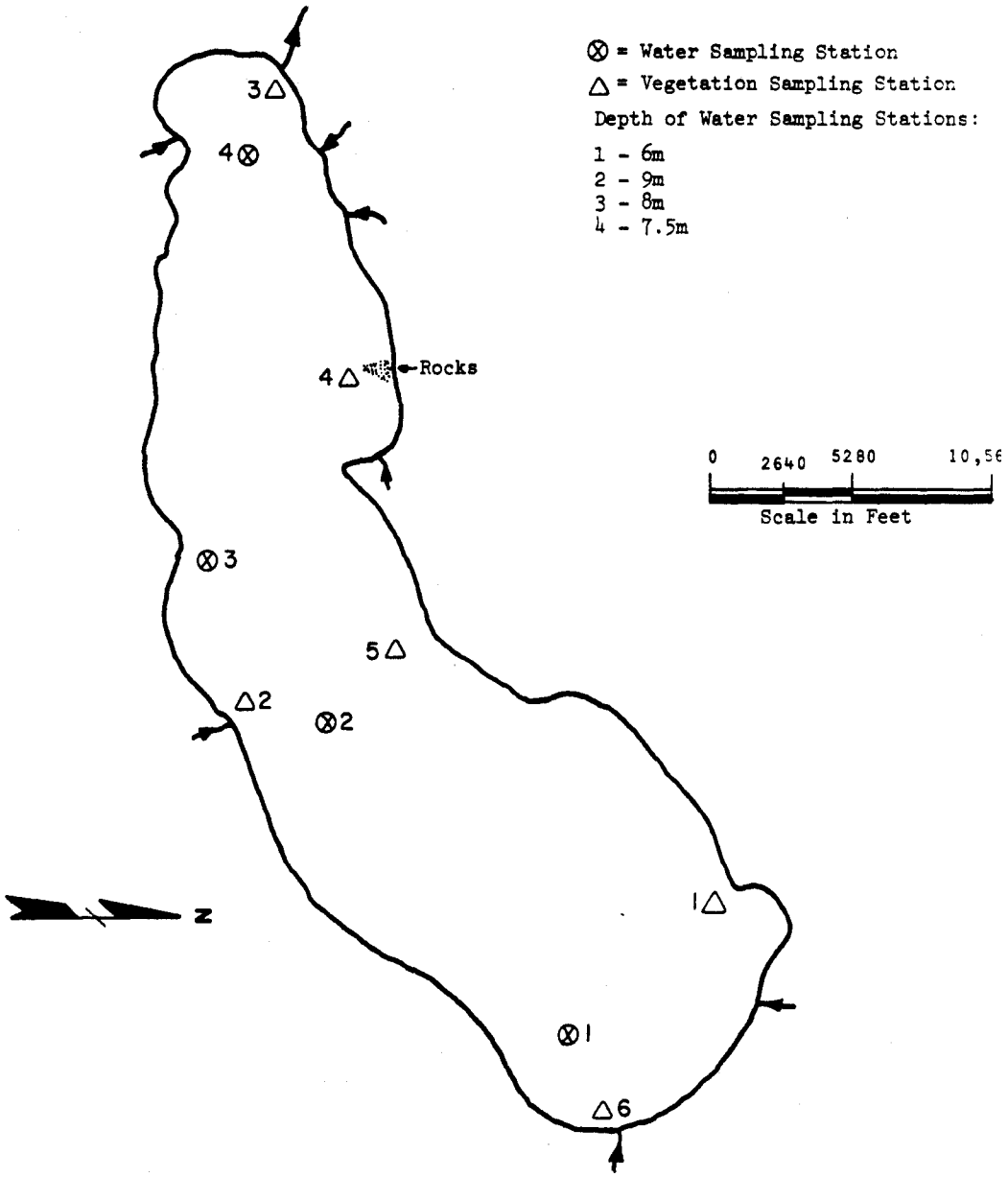
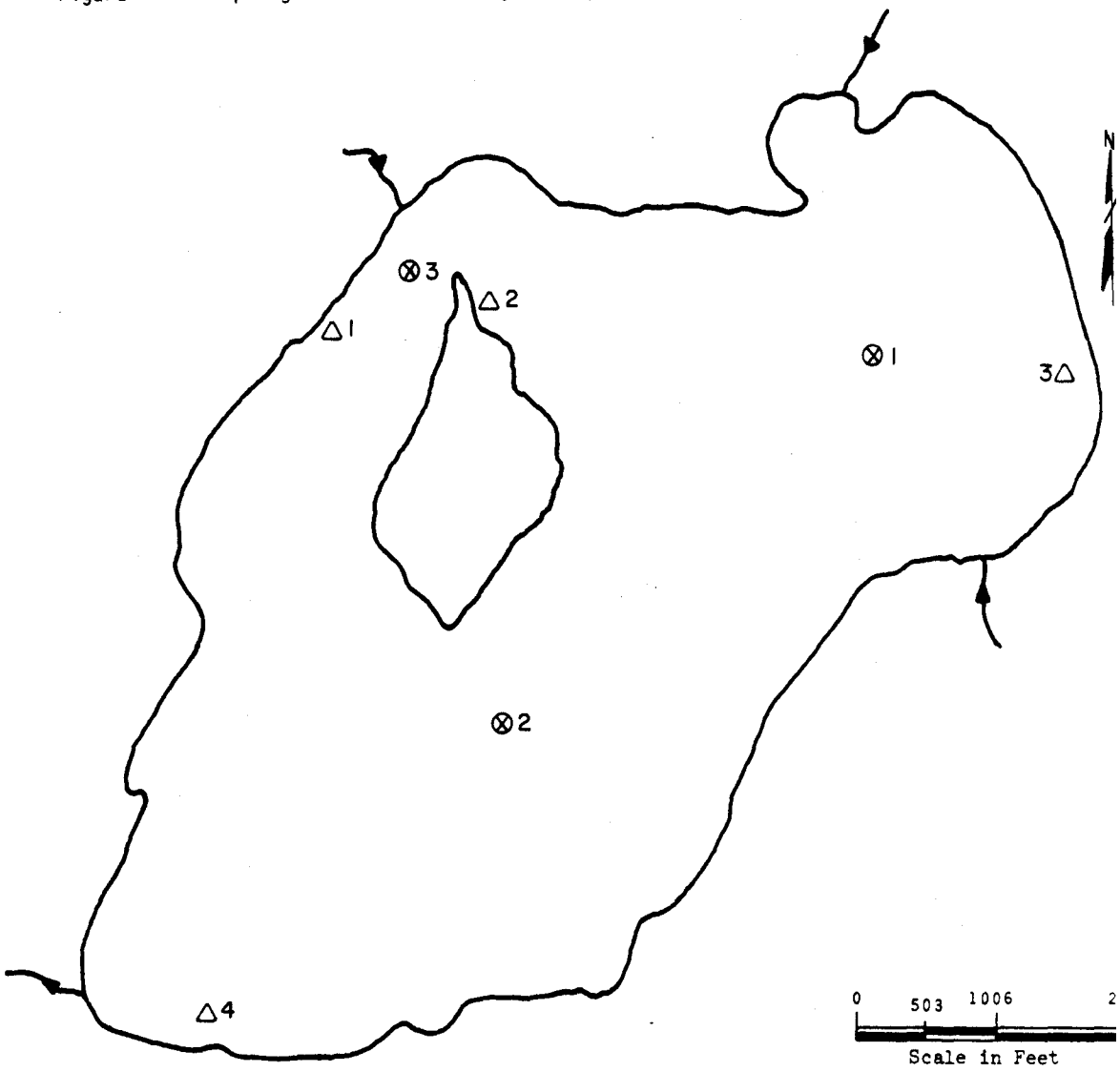


Figure 9. Sampling locations in Nokay Lake (18-104), Crow Wing County.




Depth of Water Sampling Stations:

1 - 12.5m
2 - 9m
3 - 5m

⊗ = Water Sampling Station
△ = Vegetation Sampling Station

Figure 10. Sampling locations in Pokegama Lake (31-532), Itasca County.

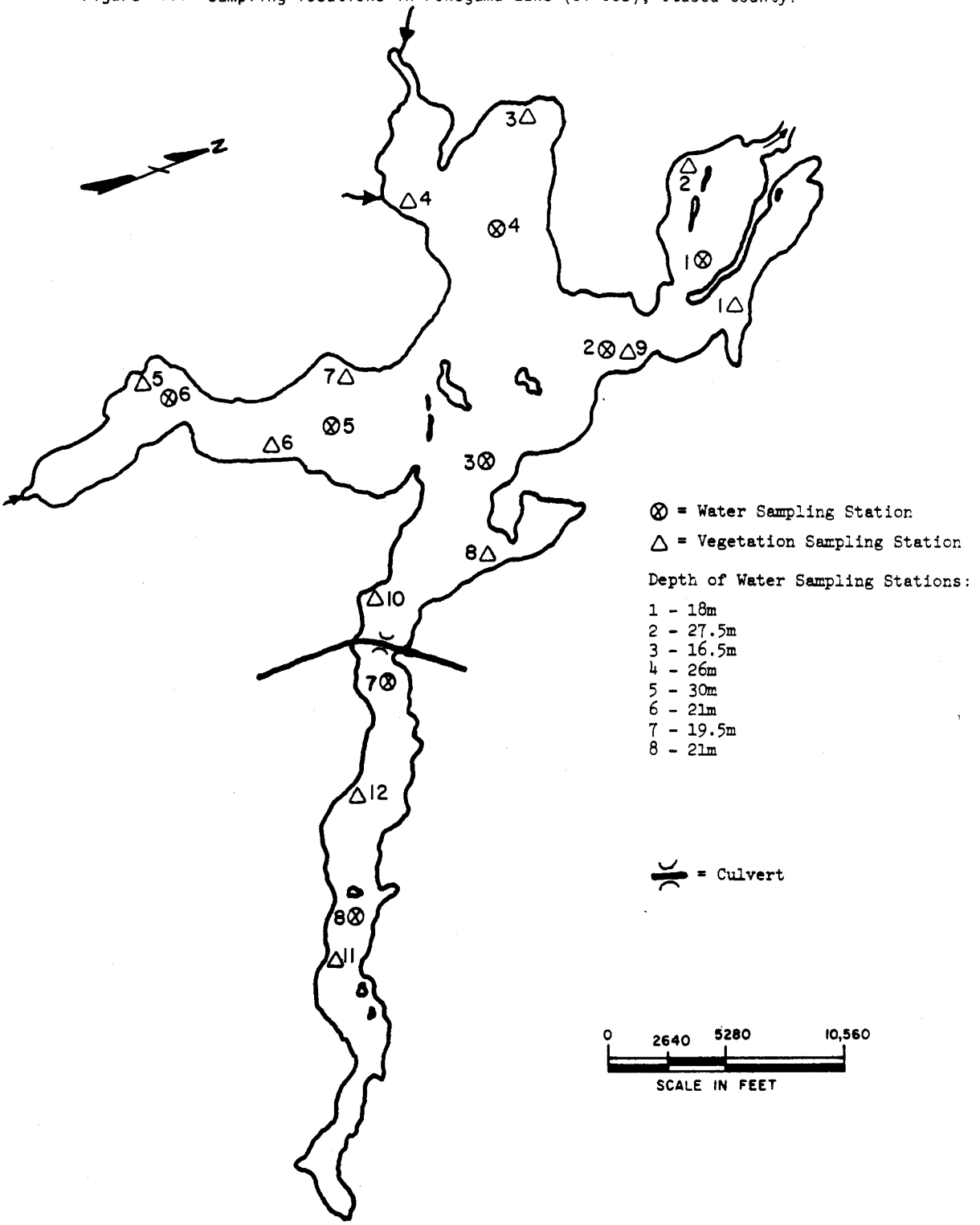


Figure 11. Sampling locations in Shields Lake (66-55), Rice County.

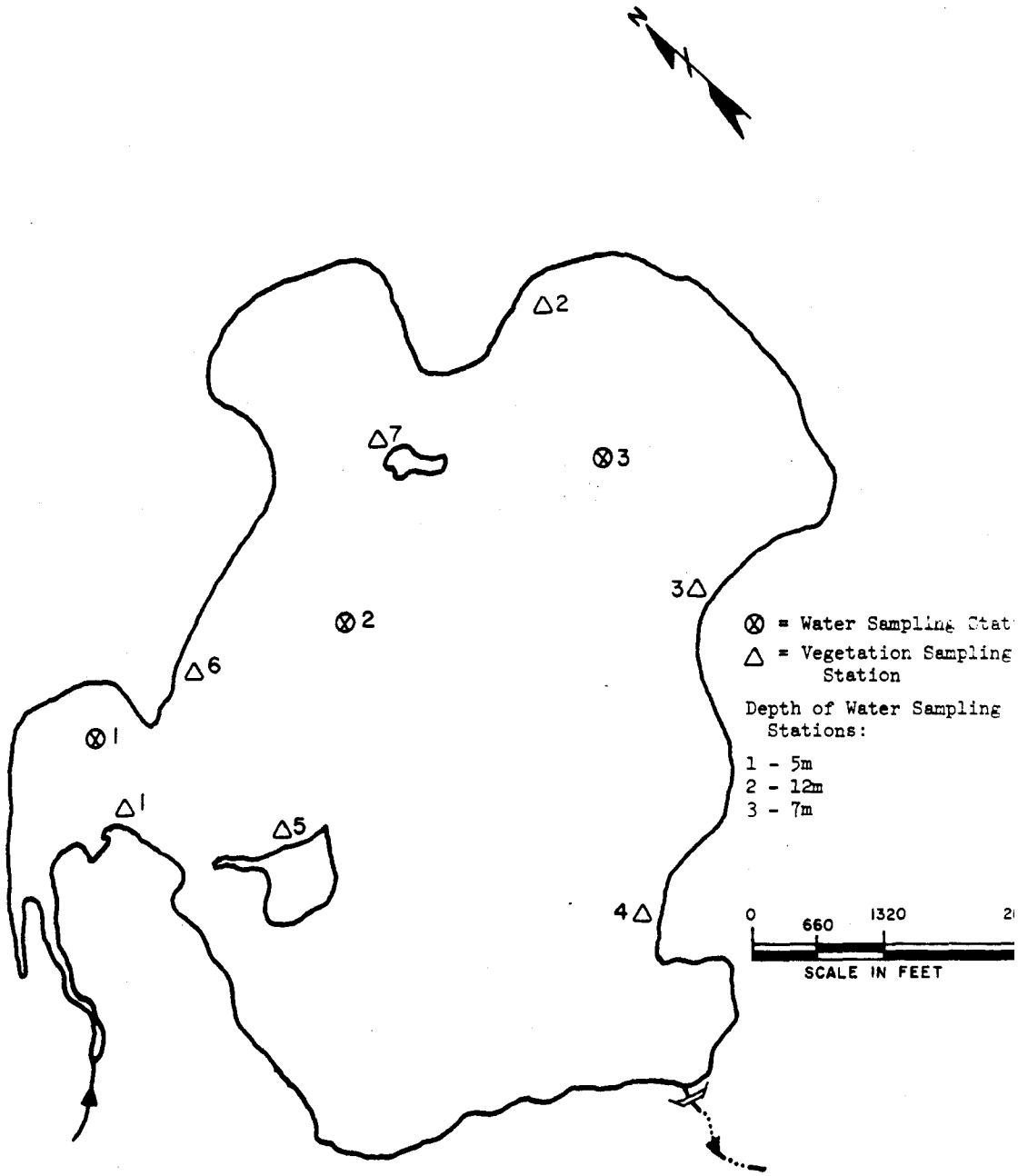


Figure 12. Sampling locations in Snowbank Lake (18-313), Lake County.

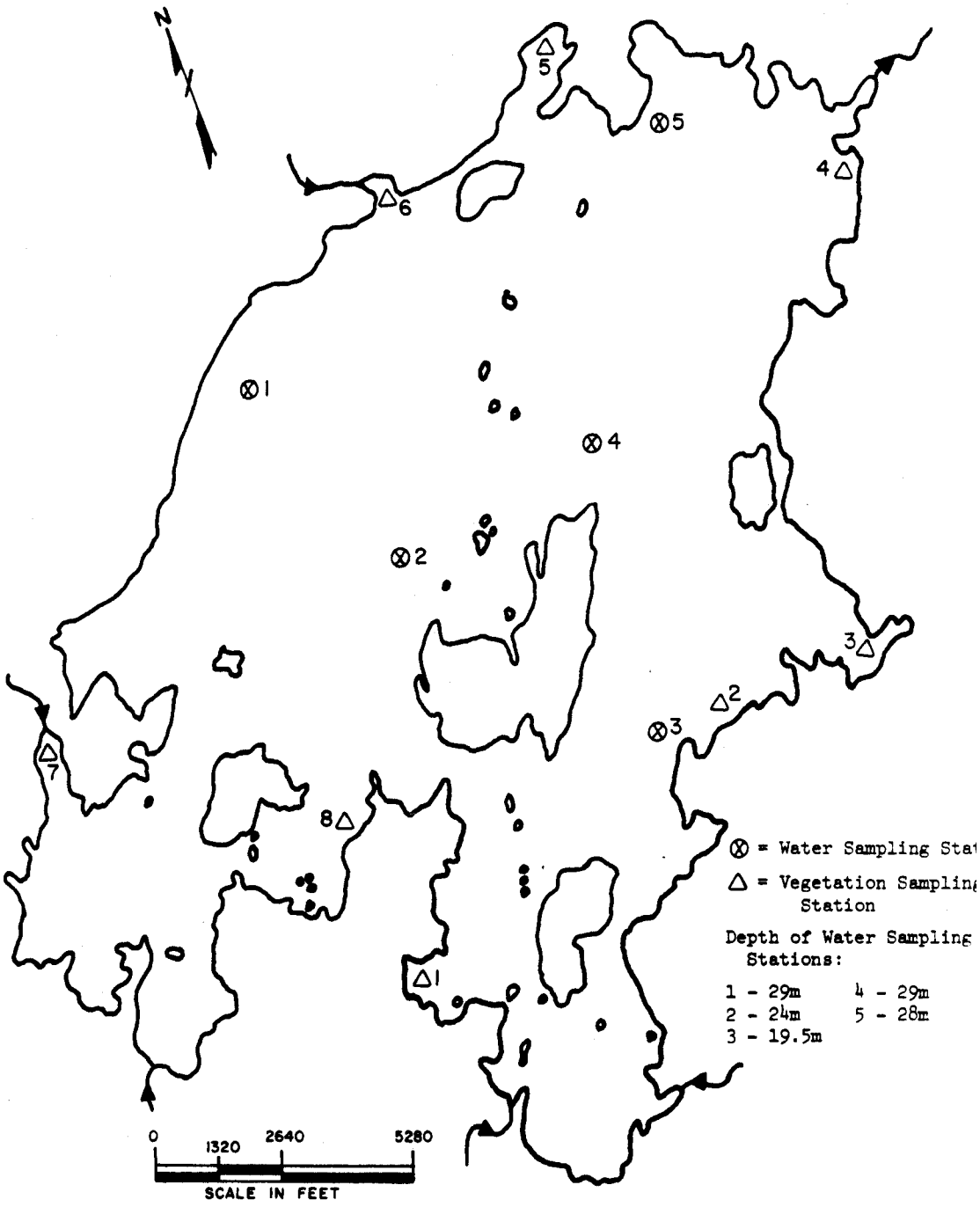
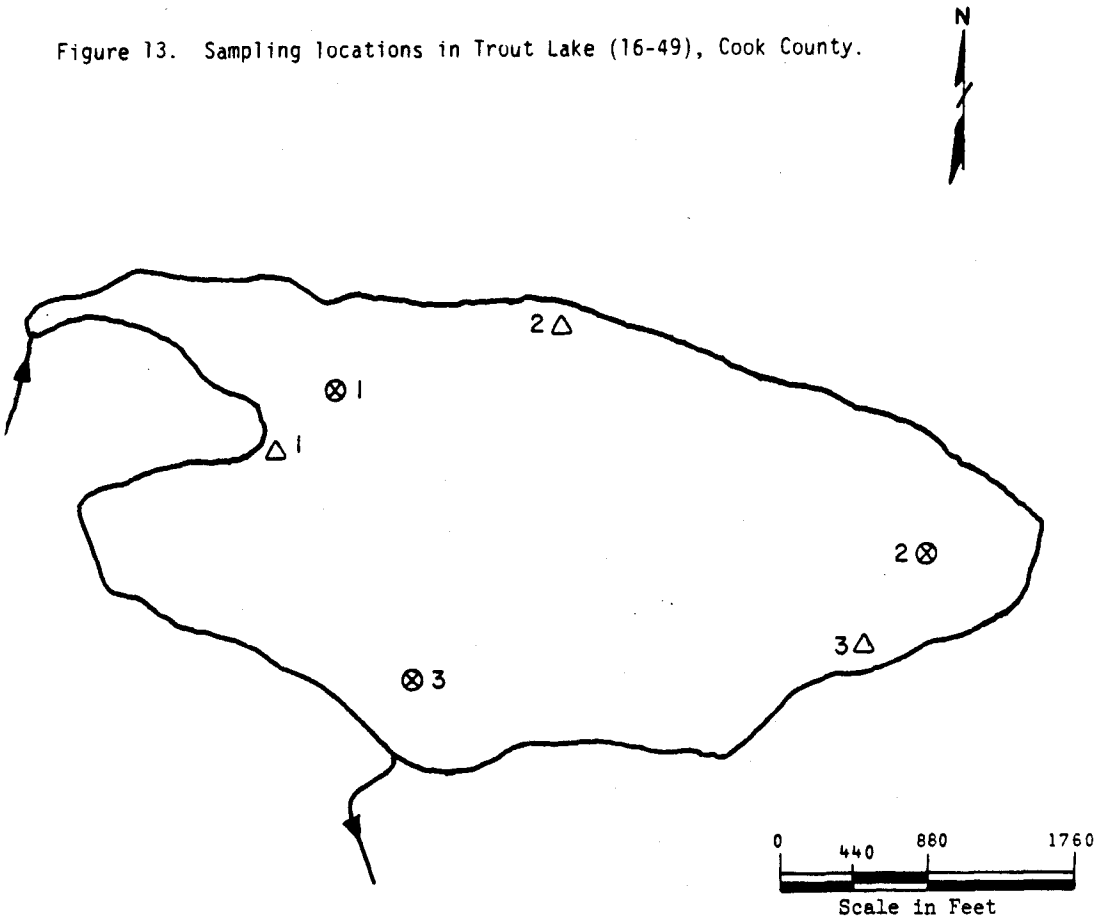


Figure 13. Sampling locations in Trout Lake (16-49), Cook County.




Depth of Water Sampling Stations:

1 - 8m
2 - 20m
3 - 18.5m

⊗ = Water Sampling Station

△ = Vegetation Sampling Station

Figure 14. Sampling locations in White Iron Lake (69-4), St. Louis County.

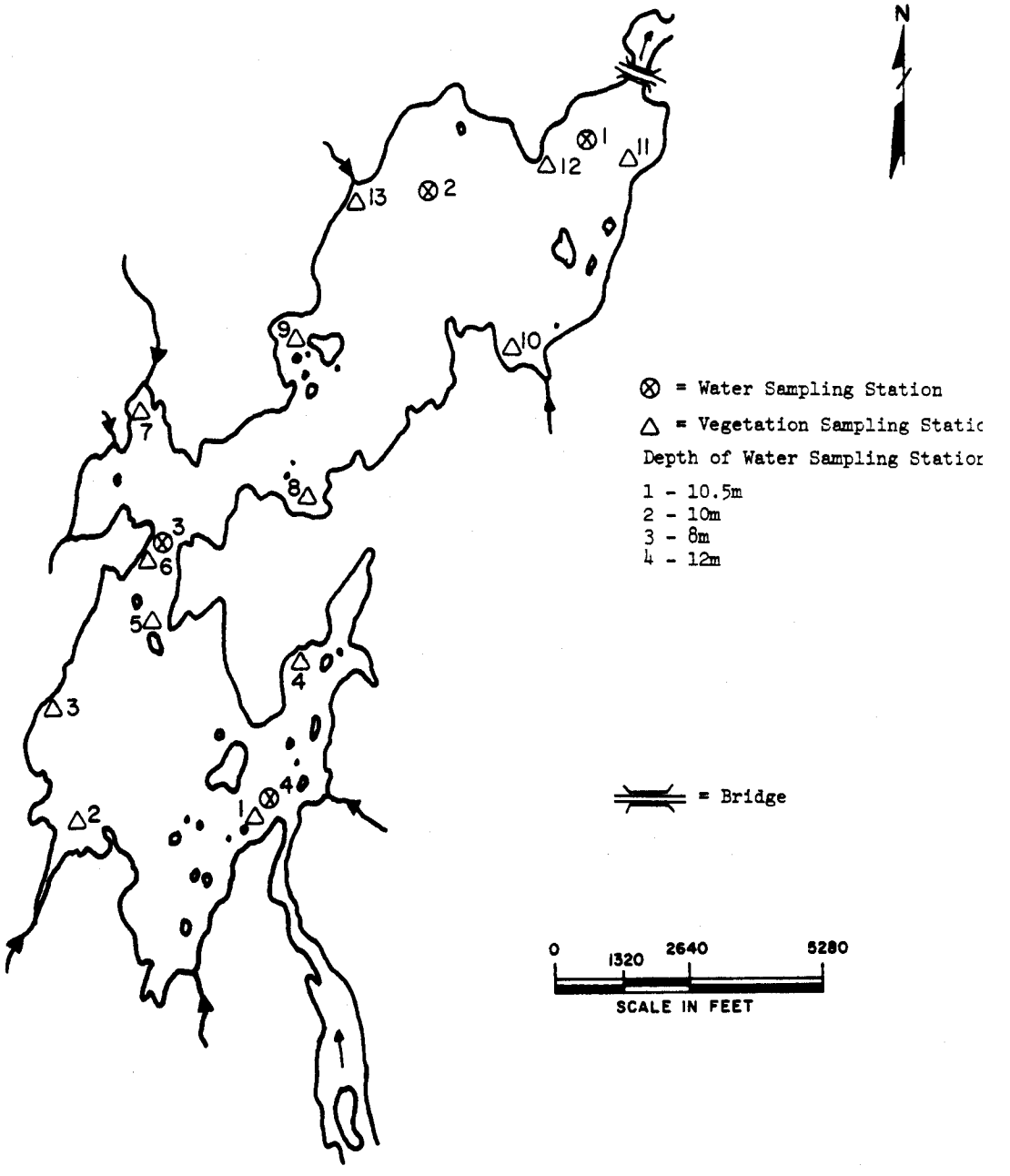


Figure 15. Sampling locations in Wilson Lake (38-47), Lake County.

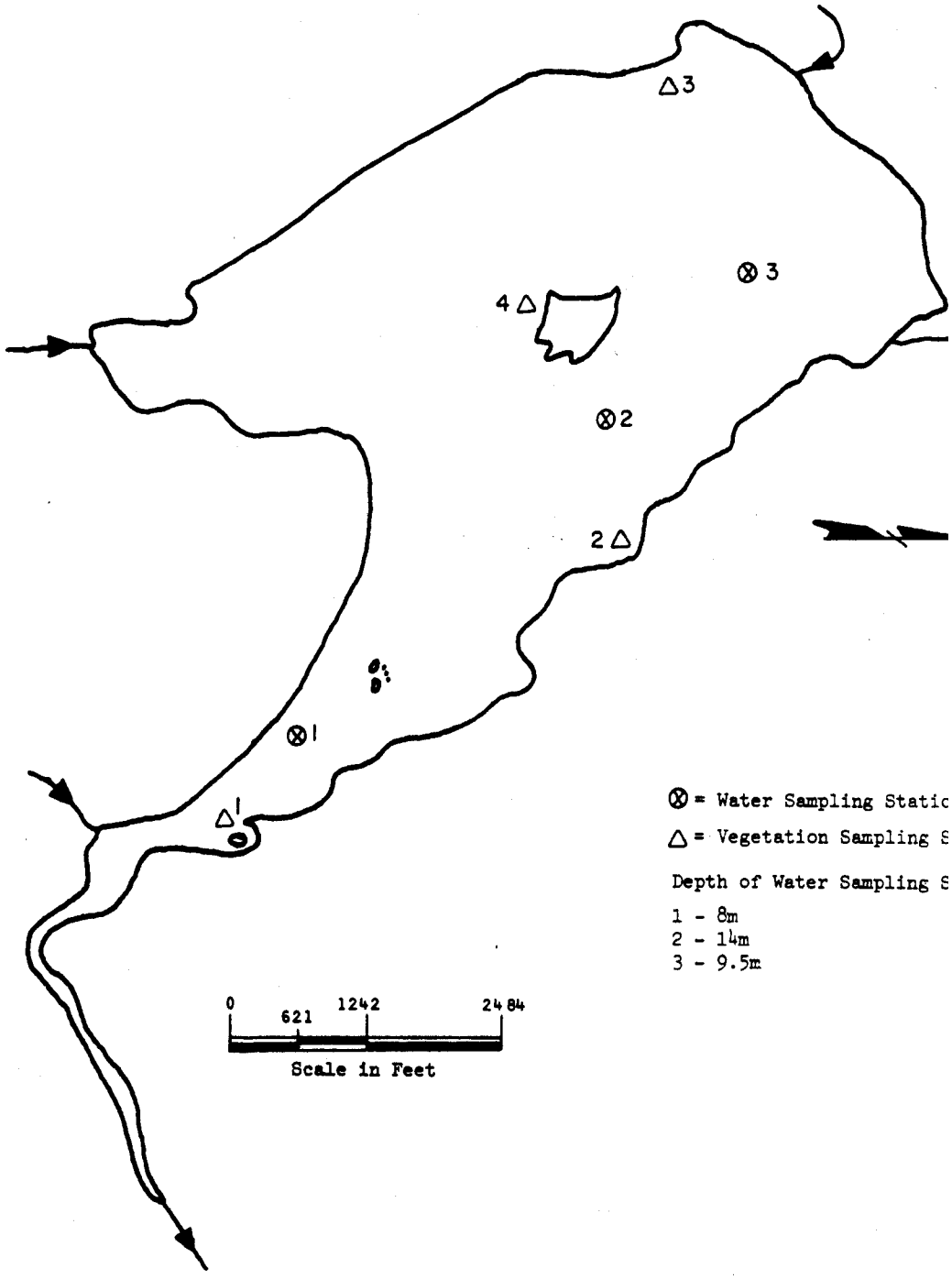


Figure 16. Temperature and dissolved oxygen profiles for Bear Island Lake (Station 2), St. Louis County, Minnesota.

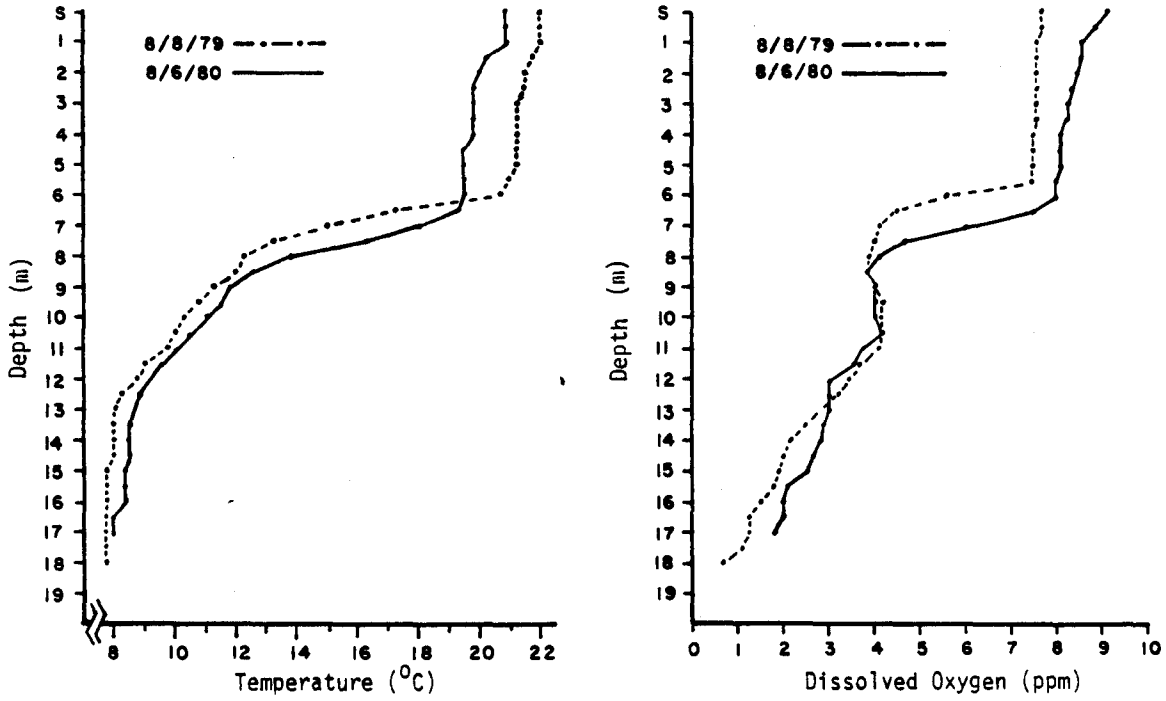



Figure 17. Temperature and dissolved oxygen profiles for Big Pine Lake (Station 3), Otter Tail County, Minnesota.

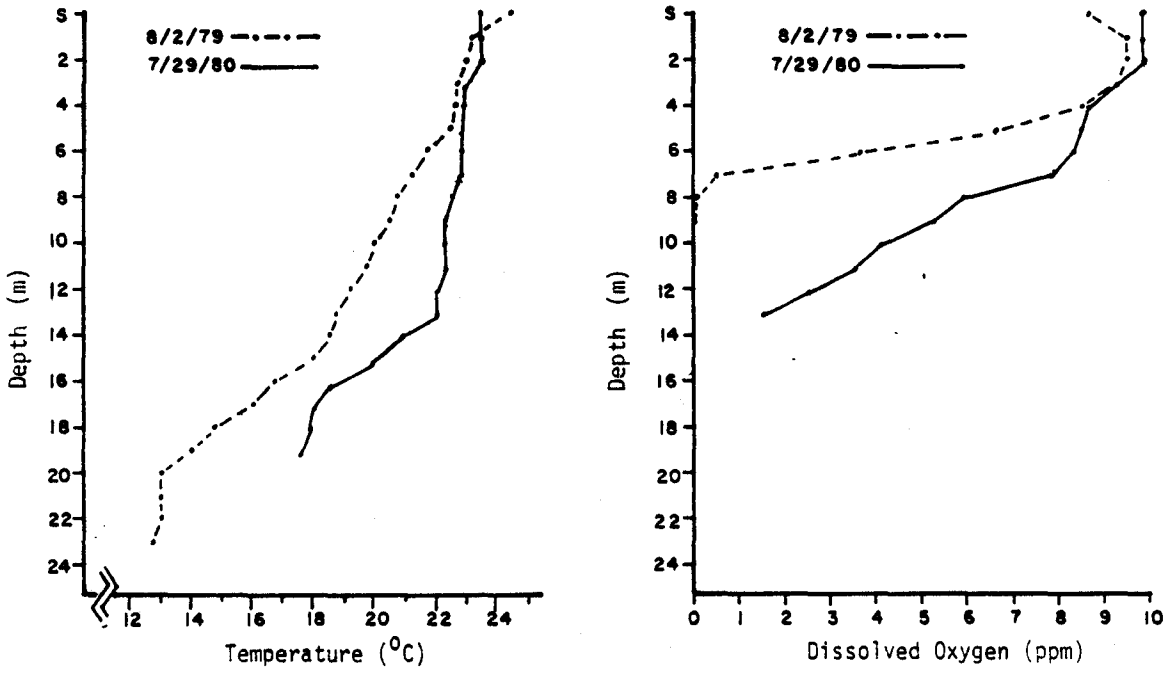


Figure 18. Temperature and dissolved oxygen profiles for Colby Lake (Station 1) St. Louis County, Minnesota.

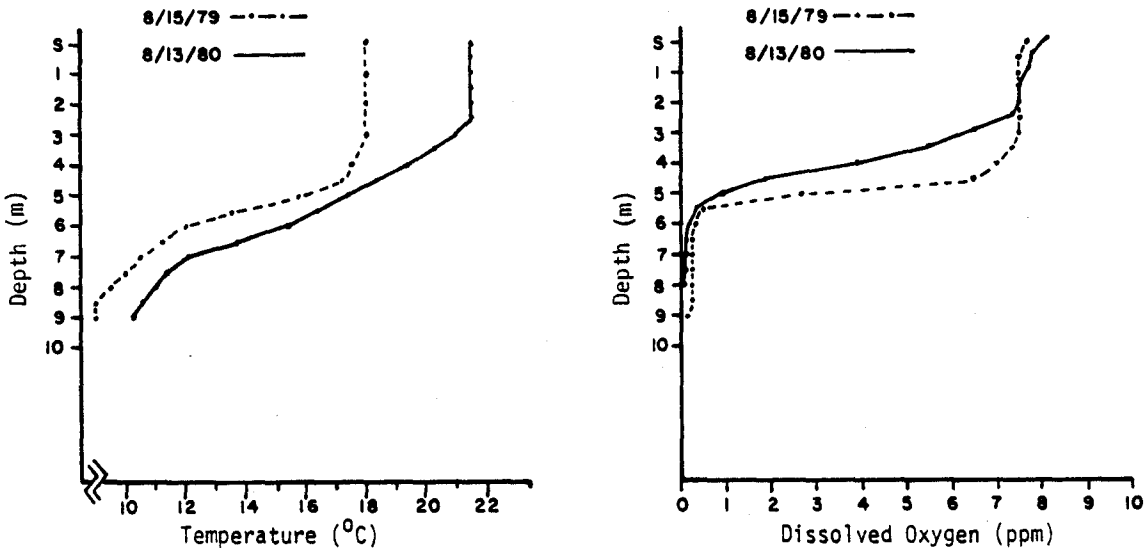



Figure 19. Temperature and dissolved oxygen profiles for Detroit Lake (Station 5), Becker County, Minnesota.

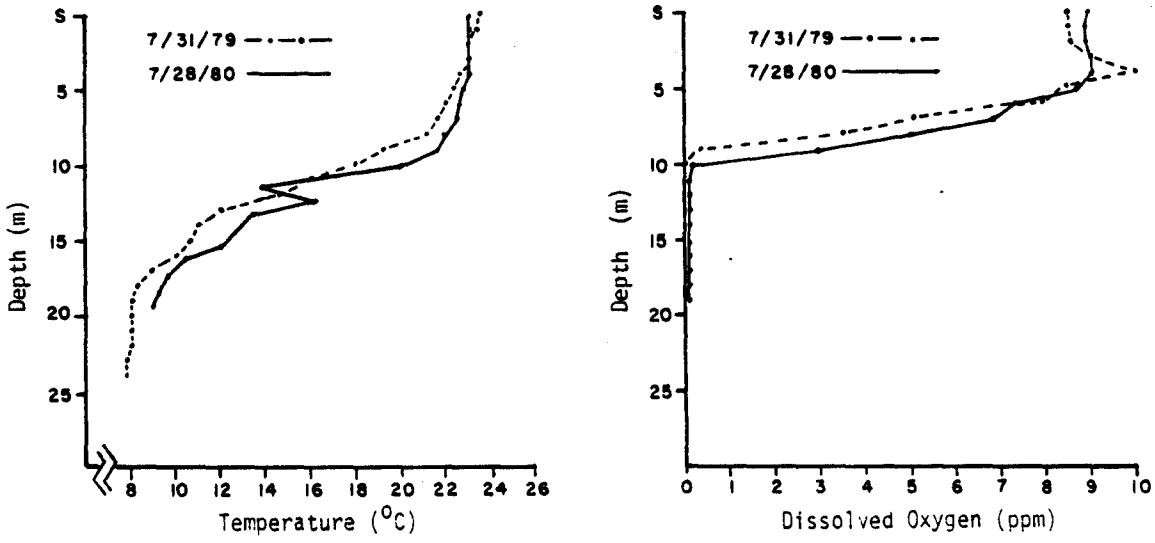


Figure 20. Temperature and dissolved oxygen profiles for Frances Lake (Station 2), LeSueur County, Minnesota.

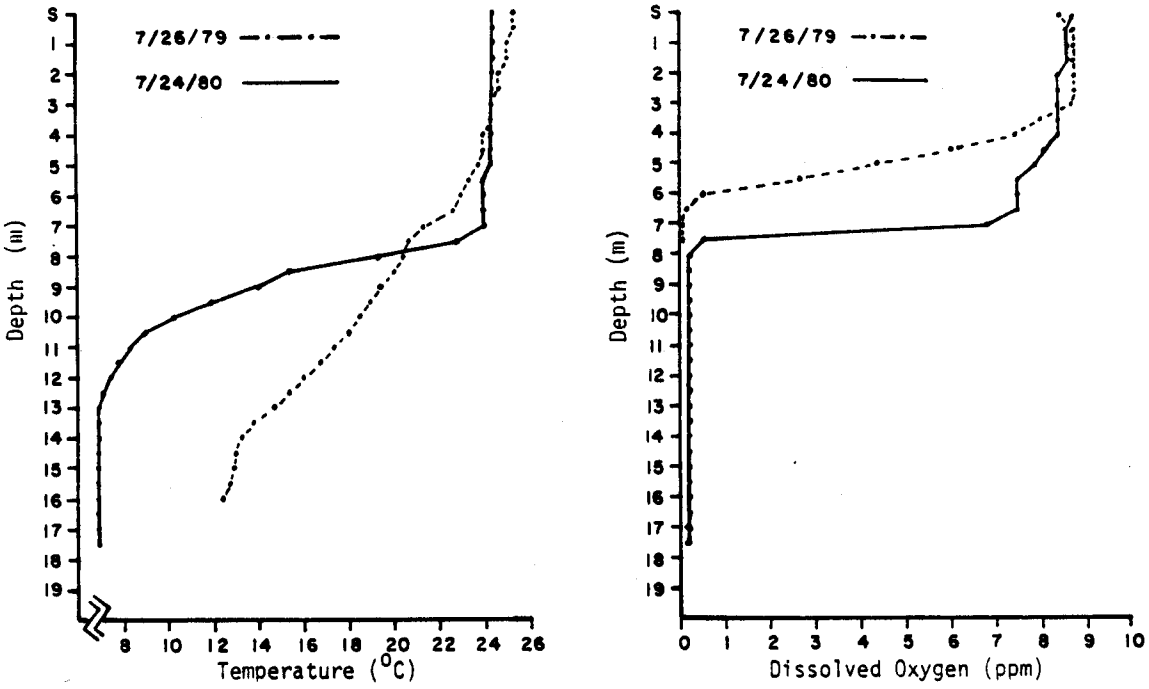



Figure 21. Temperature and dissolved oxygen profiles for Lake Johanna (Station 1), Ramsey County, Minnesota.

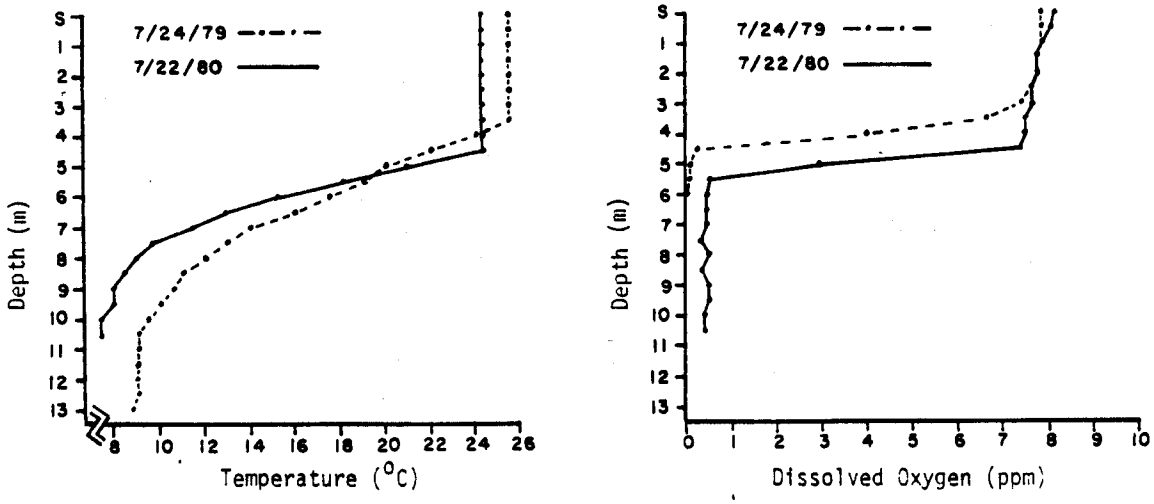


Figure 22. Temperature and dissolved oxygen profiles for Long Lake (Station 1), Ramsey County, Minnesota.

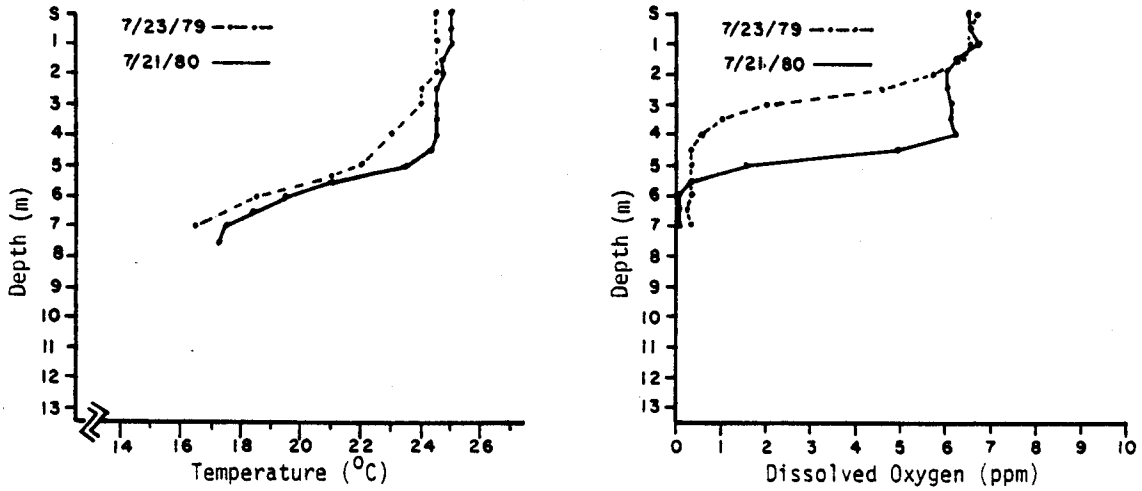



Figure 23. Temperature and dissolved oxygen profiles for Lake Minnewaska (Station 2), Pope County, Minnesota.

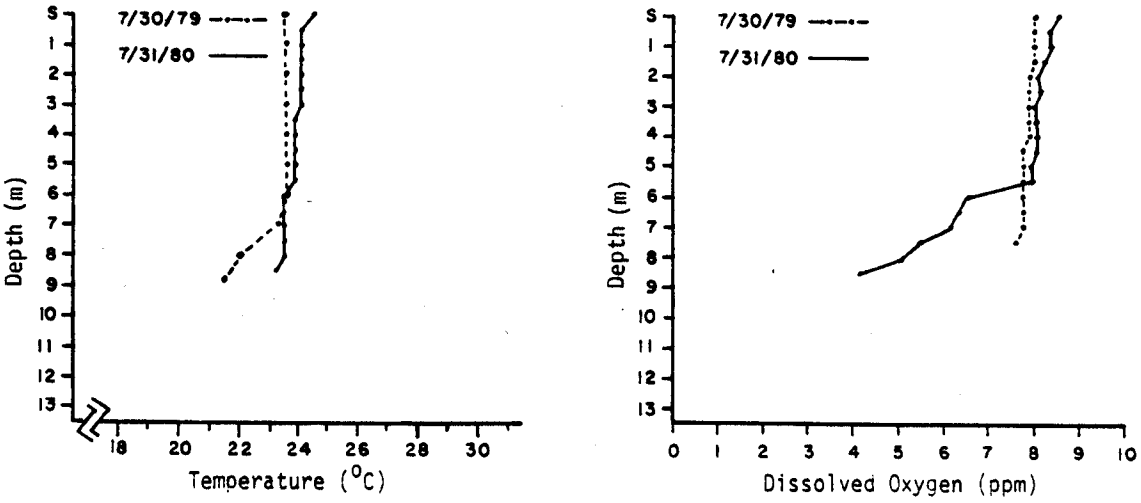


Figure 24. Temperature and dissolved oxygen profiles for Nokay Lake (Station 1), Crow Wing County, Minnesota.

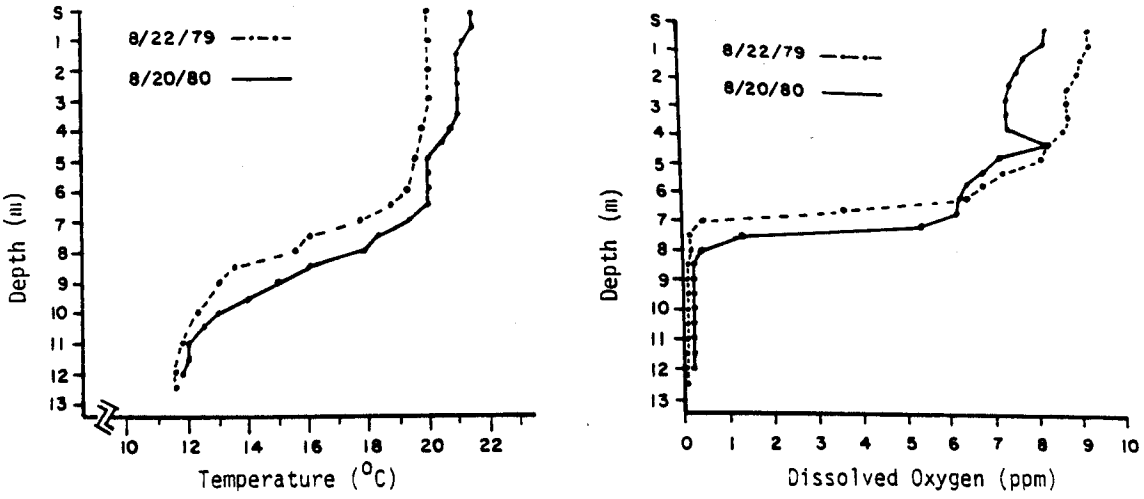



Figure 25. Temperature and dissolved oxygen profiles for Pokegama Lake (Station 5), Itasca County, Minnesota.

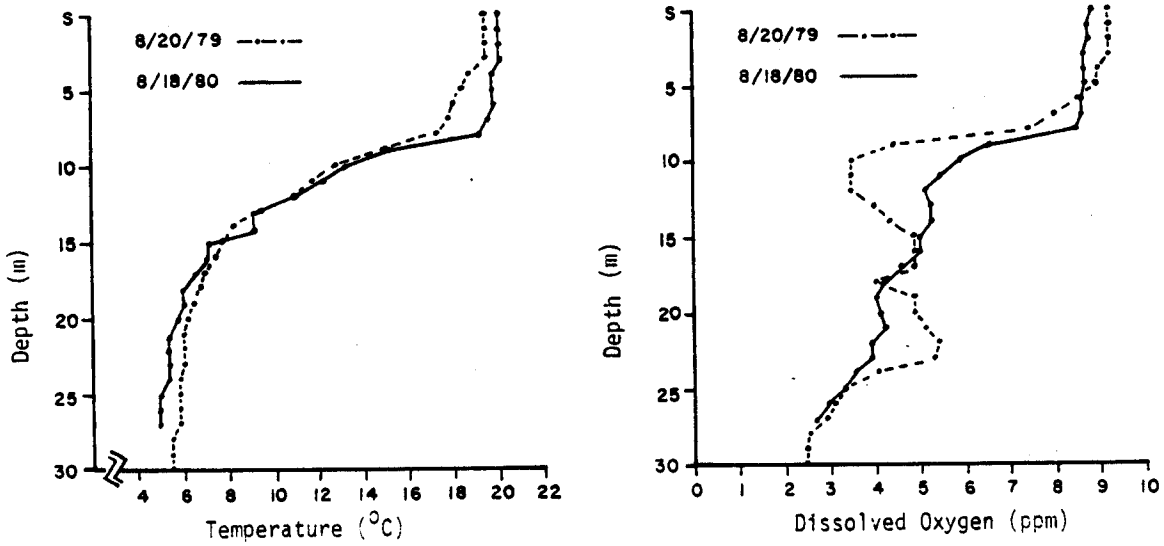


Figure 26. Temperature and dissolved oxygen profiles for Shields Lake (Station 2), Rice County, Minnesota.

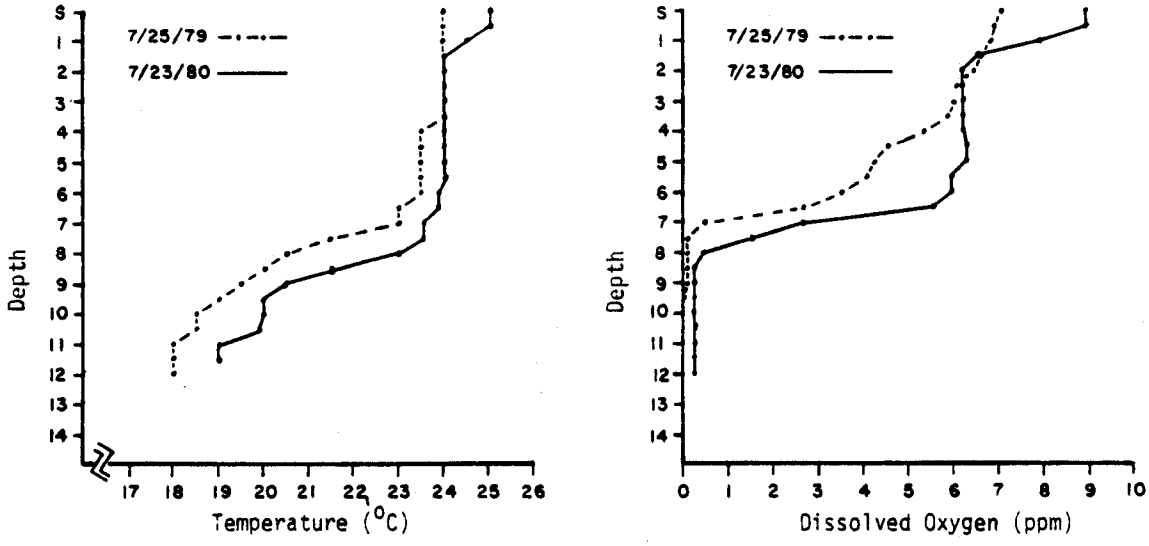



Figure 27. Temperature and dissolved oxygen profiles for Snowbank Lake (Station 1), Lake County, Minnesota.

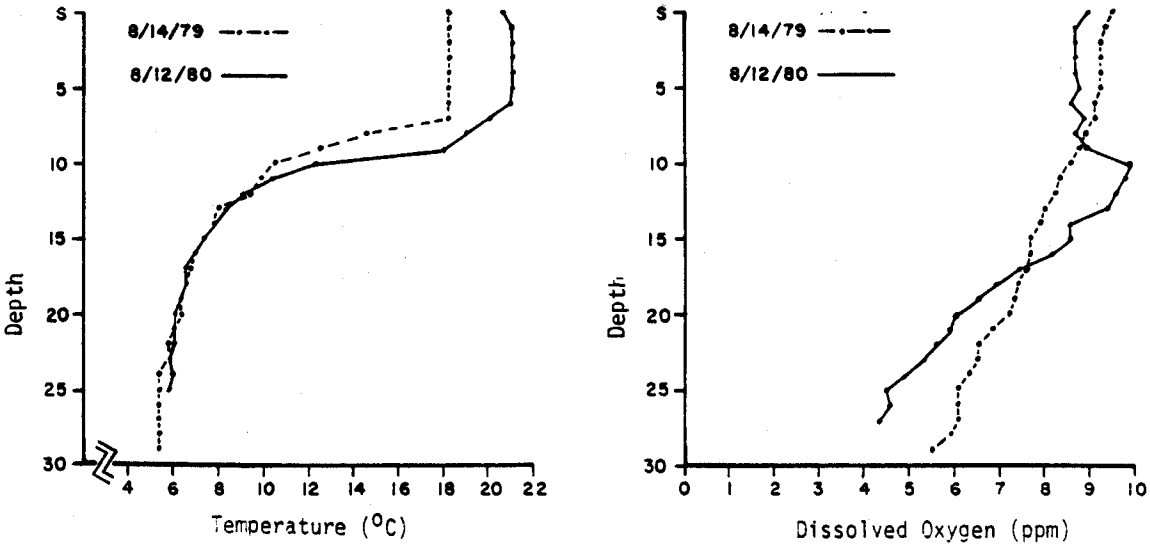


Figure 28. Temperature and dissolved oxygen profiles for Trout Lake (Station 2), Cook County, Minnesota.

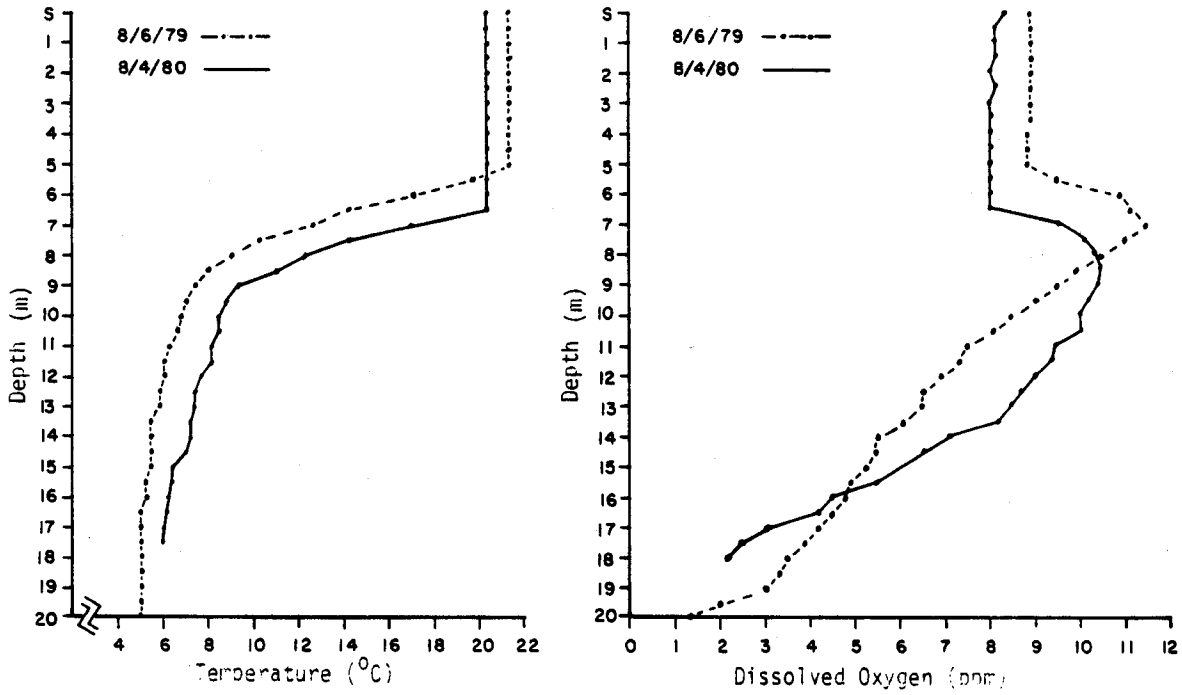



Figure 29. Temperature and dissolved oxygen profiles for White Iron Lake (Station 4), St. Louis and Lake Counties, Minnesota.

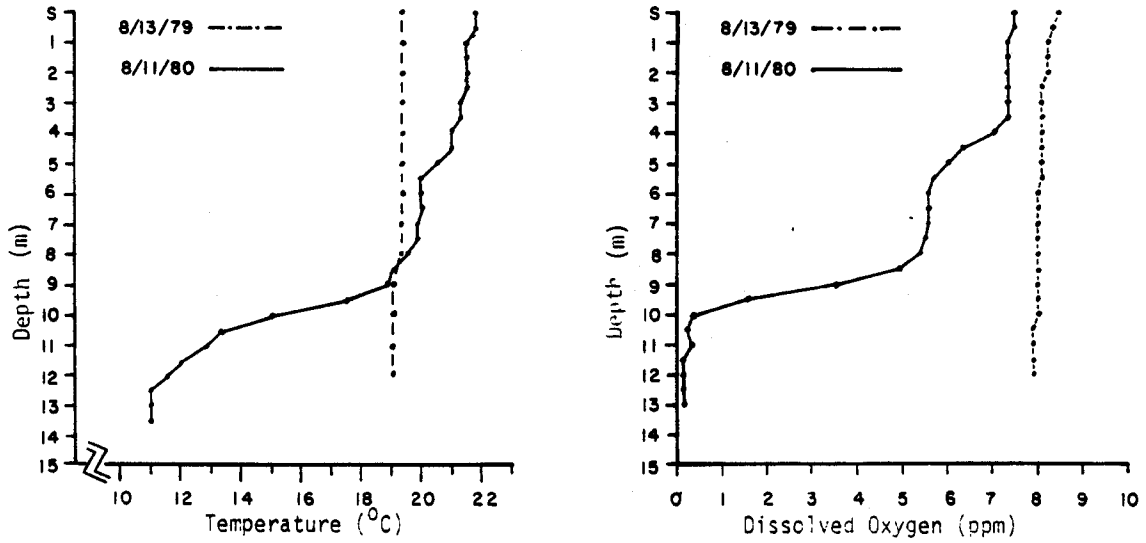


Figure 30. Temperature and dissolved oxygen profiles for Wilson Lake (Station 2), Lake County, Minnesota.