Province of British Columbia

Ministry of Environment and Parks

Waste Management
Northern Region
Bag 5000
Smithers, B.C.
V0J 2N0
Telephone: (604) 847-7260

December 1, 1986

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RE: THE ATTACHED REPORT ON LAKELSE LAKE

This report shows the major weed beds and weed-water-sediment nutrient relationships at Lakelse Lake. These matters were investigated at my request in order to enhance our understanding of the lake as a habitat, and to identify which weed beds require protection. It also serves as further background for future comparisons of nutrient relationships brought on by lakeshore development. This report is an important addition to our growing understanding of the lake, and is related to the water quality objectives for the lake which we recently developed and are now approved by the Deputy Minister.

B. D. Wilkes
Head, Environmental Section
Northern Region

BDW/dm

attachment

cc: Pat Warrington

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THE DISTRIBUTION OF AQUATIC VEGETATION IN LAKELSE LAKE AND THE PARTITIONING OF NUTRIENTS AMONG SEDIMENTS, WATER AND PLANT TISSUE

P. Warrington

Resource Quality Section
Water Management Branch
Ministry of Environment and Parks
Victoria, B.C.

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ABSTRACT

The aquatic vegetation of Lakelse Lake was surveyed and mapped by communities. Only four species were present in quantities covering more than 0.1% of the area of the lake; these are Hippuris vulgaris (0.4%), Equisetum fluviatile (2.6%), Scirpus lacustris (2.8%) and Potamogeton robbinsii (9.2%).

Tissue samples of these four species and samples of water and sediment were analyzed to determine their relative importance to the nutrient budget of Lakelse Lake during the peak of the growing season. Total sediments held between 82.1% and 99.9% of each nutrient measured; water and plant tissue were relatively insignificant. The amount of each nutrient in Lakelse found in aquatic plant tissues was from 70 to 170 times as much as that found in the phytoplankton, for all nutrients measured except iron. For iron there was 640 times as much in aquatic plants as in the phytoplankton.

INTRODUCTION

A Fisheries and Marine Services report on Lakelse Lake was published by T.R. Cleugh, et al (1978). It dealt with chemical, biological and physical characteristics of Lakelse Lake and is a general background document on most aspects of this lake. A better reference for aspects of water quality is the report by McKean (1986). The treatments of aquatic plants in these reports was not adequate and field work was carried out in July 1984 to fill this data gap. The vegetation survey and mapping presented and discussed in this report will serve as background values against which any future change can be compared, and provides an inventory of the aquatic plant resources of Lakelse Lake and their role as nutrient sinks.

This report was requested by the regional staff as part of a complete study on Lakelse Lake. There was a need to know the value of aquatic plants, for fish habitat, and their relative value in the nutrient cycle of Lakelse Lake. Now that the vegetation distribution is known and the water chemistry has been documented by McKean (1986), the next step can be initiated. Fish trapping or observations need to be made in and adjacent to each of the major vegetation zones, and other main habitats of Lakelse Lake, to determine how many of each species frequent each of the defined habitats. This would indicate the relative values of each of these habitats, for each species of fish in Lakelse Lake. These values should be determined before any vegetation management, enhancement or control is carried out in Lakelse Lake.

METHODS

Water, plant tissue and sediment samples were analyzed from each of the major aquatic plant associations, and from the pelagic zone of Lakelse Lake, to quantify the relative importance of aquatic plants in the nutrient budget of Lakelse Lake. This was a static, one-time estimate, of the partitioning of nutrients, which occurred in late July, 1984. It does not address the dynamics of nutrient flow and exchange rates. Several samples were lost or contaminated in transit to the laboratory and analyses are not available; estimates were made where appropriate. It is believed that the missing data is insignificant to the total nutrient budget of Lakelse Lake. Although some numbers would change slightly if these data were included, no major trends or conclusions should be altered. Lower detection limits for the elements would have a noticeable effect on some of the values in Tables 7 to 13. The data presented are rough, order-of-magnitude estimates, in most cases based on only one sample. These data serve primarily as a guide to further sampling and analyses, and as an indication of general trends in Lakelse Lake.

A sediment depth of 10 cm is assumed in all calculations as it was roughly in this zone that samples were taken and most plant roots were found. If it should be found that the active nutrient pool extends to a greater depth, then appropriate corrections would have to be made in the relative contributions of the sediment to the total nutrient budget of Lakelse Lake. However, this would not alter any trends since the sediment contribution already approaches 100% for most elements.

The dry:wet weight ratio of the pelagic sediments was not measured but was estimated from the percent volatiles by comparison with the relationship between percent volatiles and percent moisture found in sediments of other B.C. Lakes (McKean, unpublished data).

Figures 1 and 2 are redrawn from a bathymetric map of Lakelse Lake produced by the Fish and Wildlife Branch in 1968, from 1950 survey data. A

more recent bathymetric map is available, Cleugh et al (1978), which is based on more transects and has 5 foot contour intervals; but it has more detail than was required for this report. There is little significant difference in these two maps except for details in the deepest part of the lake.

The vegetation survey was carried out by boating all around the lake and identifying the species found in each association. The extent and location of each weed bed was determined from aerial photographs and copied onto the bathymetric maps, Figure 1 and 2, or onto detailed maps of specific areas of the lake, Figures 2 to 8.

RESULTS

Direct measurements of the nutrients incorporated in the phytoplankton of Lakelse Lake were not made for this report. The August value of 270.5 mg/m^3, Table 16 in Cleugh (1978), was used. The estimates of typical phytoplankton analyses were taken from Table A1 in Vallentyne (1974). The pertinent values, as a percent of the wet biomass of the phytoplankton, are: nitrogen-0.7, phosphorus-0.08, calcium-0.4, potassium-0.3, magnesium-0.07 and iron-0.02.

As noted in Tables 4, 72% or 88 118 578 m^3 of the water in Lakelse Lake is found in the photic zone, shallower than 9 m or 2 secchi depths. This result is calculated from the data in Table 8 of Cleugh (1978). Multiplying the cubic meters of water in the phytoplankton zone, as reported here, 88 118 578 by the concentration of phytoplankton reported above, 270.5 mg/-m^3, one can calculate that there could be 23 836 kg of phytoplankton in Lakelse Lake in the peak growing season, as reported in Table 1.

Using the estimates for Vallentyne (1974) above, the value of 23 886 kg/lake of phytoplankton as calculated from Cleugh (1978) and the area and volume figures from Table 4 one can calcualte the contribution of phytoplankton to the per m^3, per m^2 and per lake quantities of nutrients in Lakelse Lake. These data are entered in Tables 7 to 12.

Tables 1 to 6 give details on the apportionment of areas and volumes in Lakelse Lake associated with each of the four major aquatic plant species and the pelagic zone. They also give the conversion factors used to calculate the per m^2, per m^3 and per lake total loads of each element by habitat. This latter data is presented in Tables 7 to 13 for water, plant tissue and sediment components of the lake, for the nutrients K, P, Mg, Fe, Ca, Al and Kjeldahl N. Analyses of other elements were done but are not presented here; most were below detection limits everywhater except in the sediments.

Aquatic vegetation is generally limited to about two Secchi depths by light penetration. Below this depth respiration exceeds photosynthesis in most species and no net plant growth is possible. The measured Secchi depths in Lakelse Lake have a mean of 4.5 m (4.9-1.5) and thus the light limiting depth for aquatic plants is about 9 m. This was also assumed to be the depth limit for phytoplankton. For rooted emergent aquatic plants, 6 m is a more common lower limit since the plants can rarely reach the surface from any greater depth. For non-emergent plants, such as Chara or Isoetes, the Secchi depth may be the limiting factor. These two species have been observed growing to a depth of about 20 m in very clear oligotrophic lakes.

As indicated in Table 2, about 69% of the Lakelse surface area was shallower than 9 m and 51% was shallower than 6 m. However, only about 15% of the area was covered by the four dominant species of aquatic plants, and perhaps another 5% by other species; thus most of the potential habitat for aquatic plants was not being utilized. Except for the extensive Potamogeton robbinsii beds at the south end of the lake, almost all aquatic vegetation in Lakelse Lake was confined to areas shallower than the 2 m contour. Some factors other than light penetration or habitat at suitable depth must be responsible for limiting vegetation cover in Lakelse Lake. Few Secchi depth measurements have been made but these indicate that Secchi depths were relatiely deep in the summer growing season and shallowest during spring runoff and should not limit plant growth. The lake is well flushed, five times per year, and virtually all of the flushing occurs during the May to September growing season with virtually none during the winter dormant season.

Although the physical characteristics were not studied, the sediments appear to be quite adequate for plant growth in terms of nutrient content. Low phosphorus levels in the water combined with the high flushing in the growing season should limit the growth of phytoplankton and non-rooted plants like Lemna and Ceratophyllum. This should not affect rooted plants, however, which derive most of their nutrients from the sediments. The absence of Ceratophyllum, Lemna and other non-rooted species of aquatic plants in Lakelse Lake, low phytoplankton densities, and relatively large beds of rooted aquatic plants corroborate these ideas. It is not known, however, why more of the available littoral area is not colonized by aquatic plants.

As indicated in Figures 1-8, and described in the legends to these Figures, most of the vegetation was found in a narrow band around the shore since most of the littoral areas drop off quite quickly. The exception was the south end where an extensive shallows has been built up by several inflowing streams. Most of the vegetative cover in Lakelse Lake was found here, including most species as well as the most variable or complex plant communities. This is a normal pattern for such lakes and is found repeatedly in lake surveys. The streams provide suitable habitats in terms of depth, particle size and nutrients; the habitats are maintained and replenished regularly by the streams. The extensive area covered by Potamogeton robbinisii is also quite typical and often found where extensive, shallows occur. Under these conditions no sign of the plants is visible at the surface and they do not affect boating and swimming. They are often, as here, among the most significant plant communities in a lake due to the area of coverage and high plant density or biomass.

Tables 7 to 13 display the partitioning of nutrients among water, vegetation and sediment. The Kjeldahl nitrogen density, on a per square meter basis, is highest in sediments, next highest in plant tissue and lowest in the water column. This same pattern, which is quite typical for most lakes, holds for total phosphorus and total potassium. For calcium and magnesium the order is highest in sediments, next in the water column and lowest in

plant tissue. Iron and aluminum are highest in the sediments and about the same in plant tissue and the water column. The percentage of the total amount of a given element found in Lakelse Lake, which was found in plant tissue varied from less than 0.1 to 2.6; the percentage in the water column from 0.1 to 17.6; and the percentage in the sediments from 82.1 to 99.9. The mean and (median) values of the percentage, found in plant tissue was 0.73 (0.2), found in the water column was 4.23 (0.7), and found in the sediments was 95.4 (98.5). Since 84 percent (75.4 to 93.4) of the total amount of any element was found in the pelagic zone sediments one could estimate the total amount in Lakelse Lake quite closely from only one pelagic zone sample.

REFERENCES

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2. Vallentyne, J.R. 1974. The Algal Bowl; Lakes and Man. Miscellaneous Special Publications 22. Department of the Environment, Fisheries and Marine Service, Ottawa.

3. McKean, C.J.P. 1986. Lakelse Lake Water Quality Assessment and Objectives. Ministry of Environment, Province of British Columbia.

TABLE 1

TISSUE BIOMASS OF THE FOUR MAJOR AQUATIC PLANT SPECIES AND THE PHYTOPLANKTON FOUND IN LAKELSE LAKE

Species	Percent Dry Weight	Dry Weight		Wet Weight	
		g/m^2	Mg/lake	kg/m^2	Mg/lake
Scirpus lacustris	11	479	183	4.22	1640
Equisetum fluviatile	14	410	153	2.95	1101
Potamogeton robbinsii	11	550	715	5.22	6786
Hippuris vulgaris	8	290	15.6	3.63	195
Phytoplankton	-	-	-	-	23.84

TABLE 2

AREAL COVERAGE OF LAKELSE LAKE BY AQUATIC PLANTS AND WATER OF SPECIFIED DEPTHS

Region	Area	
	m^2	m^2%
Hippuris vulgaris bed	53 700	0.4
Equisetum fluviatile bed	373 189	2.6
Scirpus lacustris bed	388 688	2.8
Potamogeton robbinsii bed	1 300 010	9.2
Area covered by aquatic plants	2 115 527	15.0
Pelagic area	12 021 541	85.0
Total area	14 137 068	100.0
Area less than 2 m deep	2 512 449	17.8
Area less than 6 m deep	7 189 410	50.9
Area less than 9 m deep	9 802 662	69.3

TABLE 3

SEDIMENT QUANTITIES IN DIFFERENT HABITATS OF LAKELSE LAKE

Habitat	Percent Dry Weight	Dry Weight		Wet Weight	
		kg/m²	Gg/lake	kg/m²	Gg/lake
Scirpus lacustris bed	x 61.4	x 93.4	36.3	x 152	59.1
Potamogeton robbinsii bed	15.0	17.0	22.0	113	147
Hippuris vulgaris bed	24.9	27.5	1.47	110	5.93
Pelagic zone	34.0	36.3	440	108	1300
Total lake	x 33.1	x 35.3	500	x 107	1510

TABLE 4

WATER QUANTITIES IN DIFFERENT HABITATS OF LAKELSE LAKE

Habitat	Mean Depth (m)	Square Meters of Coverage	Cubic Meters
Scirpus lacustris bed	1.0	388 688	388 688
Equisetum fluviatile bed	0.5	373 189	186 595
Potamogeton robbinsii bed	3.0	1 300 010	3 900 030
Hippuris vulgaris bed	0.5	53 700	26 850
Pelagic zone	9.1	12 021 541	108 762 280
Total lake	8.0	14 137 068	113 096 540
Photic zone (less than 9 m or 2 secchi depths	-	-	88 118 578

TABLE 5

CONVERSION FACTORS FOR PER M^2 LOADINGS OF NUTRIENTS IN LAKELSE LAKE

Habitat	Nutrient Source-[1]		
	Tissue	Sediment	Water
Scirpus lacustris bed	4.70×10^{-1}	9.34×10^{1}	1.0
Equisetum fluviatile bed	4.10×10^{-1}	---	5.0×10^{-1}
Potamogeton robbinsii bed	5.50×10^{-1}	1.70×10^{1}	3.0
Hippuris vulgaris bed	2.90×10^{-1}	2.75×10^{1}	5.0×10^{-1}
Pelagic zone	---	3.66×10^{1}	9.1

1. Factor x mg/g of tissue equals g nutrient per square meter.
   Factor x mg/g of sediment equals g nutrient per square meter.
   Factor x mg/L of water equals g nutrient per square meter.

TABLE 6

CONVERSION FACTORS FOR TOTAL NUTRIENT LOADINGS IN LAKELSE LAKE

Habitat	Nutrient Source-[1]		
	Tissue	Sediment	Water
Scirpus lacustris bed	1.83×10^{5}	3.63×10^{7}	3.89×10^{5}
Equisetum fluviatile bed	1.53×10^{5}	---	1.87×10^{5}
Potamogeton robbinsii bed	7.15×10^{5}	2.20×10^{7}	3.90×10^{6}
Hippuris vulgaris bed	1.56×10^{4}	1.47×10^{6}	2.69×10^{4}
Pelagic zone	---	4.40×10^{8}	1.0876×10^{8}

1. Factor x mg/g of tissue equals g nutrient per lake.
   Factor x mg/g of sediment equals g nutrient per lake.
   Factor x mg/L of water equals g nutrient per lake.

TABLE 7

KJELDAHL NITROGEN IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		6.04	2.35×10^6	0.2
	Equisetum fluviatile		9.35	3.49×10^6	0.3
	Potamogeton robbinsii		9.74	1.27×10^7	1.2
	Hippuris vulgaris		4.06	2.18×10^5	<0.1
	Total tissue		x8.87	1.88×10^7	1.7
Lake Sediment	Scirpus lacustris		1.17×10^2	4.54×10^7	4.1
	Potamogeton robbinsii		4.87×10^1	6.33×10^7	5.8
	Hippuris vulgaris		1.84×10^2	9.85×10^6	0.9
	Pelagic zone		x7.90×10^1	9.50×10^8	86.4
	Total sediments		x7.56×10^1	1.07×10^9	97.3
Water Column	Scirpus lacustris	1.30×10^{-1}	1.30×10^{-1}	5.05×10^4	<0.1
	Equisetum fluviatile	2.00×10^{-1}	1.00×10^{-1}	3.73×10^4	<0.1
	Potamogeton robbinsii	x1.50×10^{-1}	x4.50×10^{-1}	5.85×10^5	0.1
	Hippuris vulgaris	7.50×10^{-1}	3.75×10^{-1}	2.01×10^4	<0.1
	Pelagic zone	x6.00×10^{-2}	x5.46×10^{-1}	6.53×10^6	0.6
	Total water column	x6.38×10^{-2}	x5.11×10^{-1}	7.22×10^6	0.7
Phytoplankton	less than 9 m depth	1.89×10^{-3}	x1.18×10^{-2}	1.67×10^5	<0.1
Total	Whole Lake		x7.75×10^1	1.10×10^9	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^9, Mg:10^6, kg:10^3, g:10^0, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 8
TOTAL PHOSPHORUS IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		8.18×10^{-1}	3.18×10^{5}	0.05
	Equisetum fluviatile		8.20×10^{-1}	3.06×10^{5}	0.05
	Potamogeton robbinsii		5.46×10^{-1}	7.10×10^{5}	0.1
	Hippuris vulgaris		4.81×10^{-1}	2.59×10^{4}	<0.1
	Total tissue		$\times 6.43 \times 10^{-1}$	1.36×10^{6}	0.2
Lake Sediment	Scirpus lacustris		6.33×10^{1}	2.45×10^{7}	4.2
	Potamogeton robbinsii		1.42×10^{1}	1.85×10^{7}	3.2
	Hippuris vulgaris		2.16×10^{1}	1.15×10^{6}	0.2
	Pelagic zone		$\times 4.43 \times 10^{1}$	5.32×10^{8}	91.9
	Total sediments		$\times 4.08 \times 10^{1}$	5.76×10^{8}	99.5
Water Column	Scirpus lacustris	9.00×10^{-3}	9.00×10^{-3}	3.50×10^{3}	<0.1
	Equisetum fluviatile	1.60×10^{-2}	8.00×10^{-3}	2.99×10^{3}	<0.1
	Potamogeton robbinsii	$\times 1.40 \times 10^{-2}$	$\times 4.20 \times 10^{-2}$	5.46×10^{4}	<0.1
	Hippuris vulgaris	5.50×10^{-2}	2.75×10^{-2}	1.48×10^{3}	<0.1
	Pelagic zone	$\times 1.40 \times 10^{-2}$	$\times 1.27 \times 10^{-1}$	1.52×10^{6}	0.3
	Total water column	$\times 1.40 \times 10^{-2}$	$\times 1.12 \times 10^{-1}$	1.58×10^{6}	0.3
Phytoplankton	less than 9 m depth	1.73×10^{-5}	$\times 1.35 \times 10^{-3}$	1.91×10^{4}	<0.1
Total	Whole Lake		$\times 4.10 \times 10^{1}$	5.79×10^{8}	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^{9}, Mg:10^{6}, kg:10^{3}, g:10^{0}, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 9
TOTAL POTASSIUM IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		7.83	3.04×10^6	0.6
	Equisetum fluviatile		8.90	3.32×10^6	0.7
	Potamogeton robbinsii		4.49	5.83×10^6	1.2
	Hippuris vulgaris		4.99	2.68×10^5	<0.1
	Total tissue		x5.89	1.25×10^7	2.6
Lake Sediment	Scirpus lacustris		3.31×10^1	1.29×10^7	2.6
	Potamogeton robbinsii		8.45	1.10×10^7	2.3
	Hippuris vulgaris		9.61	5.15×10^5	<0.1
	Pelagic zone		$x3.38 \times 10^1$	4.07×10^8	83.2
	Total sediments		$x3.05 \times 10^1$	4.31×10^8	88.1
Water Column	Scirpus lacustris	3.00×10^{-1}	3.00×10^{-1}	1.17×10^5	<0.1
	Equisetum fluviatile	4.00×10^{-1}	2.00×10^{-1}	7.46×10^4	<0.1
	Potamogeton robbinsii	$x4.00 \times 10^{-1}$	x1.20	1.56×10^6	0.3
	Hippuris vulgaris	1.00	5.00×10^{-1}	2.69×10^4	<0.1
	Pelagic zone	$x4.00 \times 10^{-1}$	x3.64	4.35×10^7	8.9
	Total water column	$x3.85 \times 10^{-1}$	x3.20	4.53×10^7	9.3
Phytoplankton	less than 9 m depth	8.12×10^{-4}	$x5.06 \times 10^{-3}$	7.15×10^4	<0.1
Total	Whole Lake		$x3.46 \times 10^1$	4.89×10^7	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^9, Mg:10^6, kg:10^3, g:10^0, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 10

TOTAL CALCIUM IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		6.49×10^{-1}	2.52×10^{5}	<0.1
	Equisetum fluviatile		6.68	2.49×10^{6}	0.1
	Potamogeton robbinsii		5.37	6.98×10^{6}	0.2
	Hippuris vulgaris		3.89	2.09×10^{5}	<0.1
	Total tissue		x4.69	9.93×10^{6}	0.3
Lake Sediment	Scirpus lacustris		4.04×10^{2}	1.57×10^{8}	3.5
	Potamogeton robbinsii		1.07×10^{2}	1.33×10^{8}	3.0
	Hippuris vulgaris		1.81×10^{2}	9.69×10^{6}	<0.2
	Pelagic zone		$x2.80 \times 10^{2}$	3.37×10^{9}	75.4
	Total sediments		$x2.60 \times 10^{2}$	3.67×10^{9}	82.1
Water Column	Scirpus lacustris	7.31	7.31	2.84×10^{6}	0.1
	Equisetum fluviatile	1.08×10^{1}	5.40	2.02×10^{6}	0.1
	Potamogeton robbinsii	x8.37	$x2.51 \times 10^{1}$	3.26×10^{7}	0.7
	Hippuris vulgaris	2.94×10^{1}	1.47×10^{1}	7.89×10^{5}	<0.1
	Pelagic zone	x6.90	$x6.28 \times 10^{1}$	7.50×10^{8}	16.8
	Total water column	x6.9	$x5.57 \times 10^{1}$	7.87×10^{8}	17.6
Phytoplankton	less than 9 m depth	1.08×10^{-3}	$x6.74 \times 10^{-3}$	9.53×10^{4}	<0.1
Total	Whole Lake		$x3.16 \times 10^{2}$	4.47×10^{9}	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^{9}, Mg:10^{6}, kg:10^{3}, g:10^{0}, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 11
TOTAL MAGNESIUM IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		3.14×10^{-1}	1.22×10^{5}	<0.1
	Equisetum fluviatile		8.24×10^{-1}	3.08×10^{5}	<0.1
	Potamogeton robbinsii		9.57×10^{-1}	1.24×10^{6}	<0.1
	Hippuris vulgaris		6.47×10^{-1}	3.47×10^{4}	<0.1
	Total tissue		$\times 8.06 \times 10^{-1}$	1.70×10^{6}	<0.1
Lake Sediment	Scirpus lacustris		5.71×10^{2}	2.22×10^{8}	3.4
	Potamogeton robbinsii		1.30×10^{2}	1.68×10^{8}	2.6
	Hippuris vulgaris		1.81×10^{2}	9.70×10^{6}	0.2
	Pelagic zone		$\times 5.05 \times 10^{2}$	6.07×10^{9}	92.4
	Total sediments		$\times 4.58 \times 10^{2}$	6.47×10^{9}	98.5
Water Column	Scirpus lacustris	8.30×10^{-1}	8.30×10^{-1}	3.23×10^{5}	<0.1
	Equisetum fluviatile	1.08	5.40×10^{-1}	2.02×10^{5}	<0.1
	Potamogeton robbinsii	$\times 8.40 \times 10^{-1}$	$\times 2.52$	3.28×10^{6}	0.1
	Hippuris vulgaris	3.08	1.54	8.27×10^{4}	<0.1
	Pelagic zone	$\times 8.71 \times 10^{-1}$	$\times 7.92$	9.46×10^{7}	1.4
	Total water column	$\times 8.71 \times 10^{-1}$	$\times 6.97$	9.85×10^{7}	1.5
Phytoplankton	less than 9 m depth	1.89×10^{-4}	$\times 1.18 \times 10^{-3}$	1.67×10^{4}	<0.1
Total	Whole Lake		$\times 4.65 \times 10^{2}$	6.57×10^{9}	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^{9}, Mg:10^{6}, kg:10^{3}, g:10^{0}, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 12
TOTAL IRON IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		3.27×10^{-1}	1.27×10^{5}	<0.1
	Equisetum fluviatile		1.74×10^{-1}	6.50×10^{4}	<0.1
	Potamogeton robbinsii		2.20	2.86×10^{6}	<0.1
	Hippuris vulgaris		9.28×10^{-1}	4.98×10^{4}	<0.1
	Total tissue		x1.44	3.04×10^{6}	<0.1
Lake Sediment	Scirpus lacustris		2.04×10^{3}	7.91×10^{8}	3.8
	Potamogeton robbinsii		4.05×10^{2}	5.27×10^{8}	2.5
	Hippuris vulgaris		5.90×10^{2}	3.16×10^{7}	0.2
	Pelagic zone		$x1.63 \times 10^{3}$	1.97×10^{10}	93.4
	Total sediments		$x1.49 \times 10^{3}$	2.10×10^{10}	99.9
Water Column	Scirpus lacustris	4.70×10^{-1}	4.70×10^{-1}	1.83×10^{5}	<0.1
	Equisetum fluviatile	4.40×10^{-1}	2.20×10^{-1}	8.21×10^{4}	<0.1
	Potamogeton robbinsii	$x3.50 \times 10^{-1}$	x1.05	1.37×10^{6}	<0.1
	Hippuris vulgaris	4.10×10^{-1}	2.05×10^{2}	1.10×10^{4}	<0.1
	Pelagic zone	$x2.40 \times 10^{-1}$	x2.18	2.61×10^{7}	0.1
	Total water column	$x2.45 \times 10^{-1}$	x1.96	2.77×10^{7}	0.1
Phytoplankton	less than 9 m depth	5.41×10^{-5}	$x3.37 \times 10^{-4}$	4.77×10^{3}	<0.1
Total	Whole Lake		$x1.49 \times 10^{3}$	2.11×10^{10}	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^{9}, Mg:10^{6}, kg:10^{3}, g:10^{0}, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 13

TOTAL ALUMINUM IN LAKELSE LAKE

Source	Habitat	Quantity in Grams			% of the lake total
		per m^3	per m^2	per lake	
Aquatic Plant Tissue	Scirpus lacustris		8.01×10^{-2}	3.12×10^{4}	<0.1
	Equisetum fluviatile		5.74×10^{-2}	2.14×10^{4}	<0.1
	Potamogeton robbinsii		6.49×10^{-1}	8.44×10^{5}	<0.1
	Hippuris vulgaris		3.07×10^{-1}	1.65×10^{4}	<0.1
	Total tissue		$\times 4.32 \times 10^{-1}$	9.13×10^{5}	<0.1
Lake Sediment	Scirpus lacustris		1.20×10^{3}	4.67×10^{8}	4.6
	Potamogeton robbinsii		2.25×10^{2}	2.93×10^{8}	3.0
	Hippuris vulgaris		3.32×10^{2}	1.78×10^{7}	0.2
	Pelagic zone		$\times 7.59 \times 10^{2}$	9.12×10^{9}	92.1
	Total sediments		$\times 7.00 \times 10^{2}$	9.90×10^{9}	99.9
Water Column	Scirpus lacustris	$<2.00 \times 10^{-2}$	$<2.00 \times 10^{-2}$	$<7.77 \times 10^{3}$	<0.1
	Equisetum fluviatile	$<2.00 \times 10^{-2}$	$<1.00 \times 10^{-2}$	$<3.73 \times 10^{3}$	<0.1
	Potamogeton robbinsii	$\times<2.00 \times 10^{-2}$	$\times<6.00 \times 10^{-2}$	$<7.80 \times 10^{4}$	<0.1
	Hippuris vulgaris	1.60×10^{-1}	8.00×10^{-2}	4.30×10^{3}	<0.1
	Pelagic zone	$\times 1.00 \times 10^{-1}$	$\times 9.10 \times 10^{-1}$	1.09×10^{7}	0.1
	Total water column	$\times<9.72 \times 10^{-2}$	$\times<7.77 \times 10^{-1}$	$<1.10 \times 10^{7}$	0.1
Phytoplankton	less than 9 m depth	no data	no data	no data	no data
Total	Whole Lake		$\times<7.01 \times 10^{2}$	$<9.91 \times 10^{9}$	100.0

Phytoplankton contributions are less than 0.1% of the lake total.
No allowance is made for zooplankton which is low, Cleugh (1978), fish, invertebrates or other species of plants. All are expected to be negligible compared to the tabulated values.

Gg:10^{9}, Mg:10^{6}, kg:10^{3}, g:10^{0}, mg:10^{-3}, µg:10^{-6}, ng:10^{-9}.

TABLE 14

SPECIES LIST:AQUATIC PLANTS IN LAKELSE LAKE - JULY 1984

Potamogeton richardsonii

Potamogeton gramineus

Potamogeton zosteriformis

Potamogeton robbinsii

Potamogeton berchtoldii/freisii

Potamogeton epihydrus

Potamogeton natans

Potamogeton praelongus

Potamogeton pectinatus

Myriophyllum exalbescens

Myriophyllum verticillatus

Utricularia vulgaris

Utricularia intermedia

Ranunculus aquatilis

Ranunculus flabellaris

Najas flexilis

Callitriche heterophylla

Sparganium emersum

Nuphar polysepalum

Equisetum fluviatile

Typha latifolia

Menyanthes trifoliata

Hippuris vulgaris

Alisma plantago-aquatica

Scirpus lacustris

Scirpus subterminalis

Isoetes sp.

Chara sp.

Carex sp.

Glyceria sp.

Nitella sp.

LEGENDS FOR FIGURES 1 TO 7

These are descriptions of the coded vegetation zones on these maps.

Code	Description
1.	This is a surfacing mat of Sparganium emersum and Potamogeton richardsonii.
2.	Very sparse and isolated clumps of Isoetes sp. and Chara sp. are found here.
3.	Out to the 2 m contour, on the edge of an old fluvial fan, there are extensive submerged beds of Potamogeton gramineus, P. richardsonii and P. zosteriformis. There is an adjacent Scirpus lacustris bed.
4.	There is a surfacing bed of Nuphar polysepalum with Carex sp. and Equisetum fluviatile as a marginal fringe along the shore. Submerged in deeper water there is Ranunculus aquatilis, Sparganium emersum, Potamogeton robbinsii, P. zosteriformis, P. berchtoldii and P. epihydrus.
5.	Waterlily Bay is full of logs and debris. There is a marginal fringe of Typha latifolia and deeper areas contain Isoetes, Potamogeton richardsonii and P. zosteriformis.
6.	All along the shoreline from the boat launch to Waterlily Bay there is sparse and sporadic occurrence of Potamogeton robbinsii and P. gramineus out to about 2 m.
7.	This area is mostly bare but has a little submerged Potamogeton richardsonii and Sparganium emersum.
8.	Primarily this is a Scirpus lacustris bed. There is some Typha latifolia and Equisetum fluviatile along the shoreline and a little Potamogeton robbinsii and P. gramineus scattered throughout.
9.	There is a submerged carpet of Scirpus subterminalis and Potamogeton gramineus.
10.	The zone has a surfacing mat of Glyceria sp.
11.	There is a very low density of submerged Scirpus subterminalis and Isoetes.
12.	There are scattered clumps of Scirpus lacustris, Isoetes, Sparganium and Potamogeton gramineus.

LEGENDS FOR FIGURES 1 TO 7 (Continued)

Code	Description
13.	The bottom is mostly bare and sandy with a few scattered clumps of Scirpus lacustris.
14.	This Scirpus lacustris bed is of fairly low density but runs along the entire shore as far as the last point before the Lakelse River. The sediments gradually become less sandy and more silty as one progresses south. The last half or so has some Equisetum fluviatile beds along the shore behind the Scirpus bed. In the open patches within the Scirpus bed are Isoetes and Scirpus subterminalis. The Scirpus lacustris was not flowering or fruiting in the predominantly sandy north end of the bed but gradually more and more flowering and fruiting plants were encountered as one went southwards and the sediment became more silty. Soundings determined that the edge of the Scirpus lacustris bed was at a fairly consistent 2 m for its entire length. Just off the Scirpus bed, out to about 3 m, there are sporadic beds of Potamogeton gramineus, P. robbinsii and P. richardsonii.
15.	Just off the point south of the boat launch beach the dominant plant is Scirpus subterminalis but there are patches of emergent grasses, Potamogeton natans and submerged P. robbinsii.
16.	From site 15 along to Granite Creek the shallow shelf has a sparse mixture of Isoetes, Scirpus subterminalis, Potamogeton robbinsii and P. gramineus. The P. robbinsii is generally in deeper water out to 2 m; the P. gramineus may occur in occasional large beds. Some very shallow, rocky areas contain only Isoetes and mussels.
17.	From Granite Creek to the Hot Springs drainage channels, the littoral shelf is broad and shallow. It is nearly bare with occasional patches of Potamogeton richardsonii and Scirpus subterminalis.
18.	This drainage channel from the Hot Springs area was blocked at the mouth by a new two foot high beaver dam and choked with Nuphar polysepalum and Potamogeton natans.
19.	The southernmost drainage channel was blocked by a four foot high beaver dam that was leaking over the top, and had little growth in it but smelled of sulphur.
20.	In this site just off the mouth of the northernmost Hot Springs channel there was a dense bed of Nuphar polysepalum, Potamogeton natans and Myriophyllum verticillatum.
21.	On the point just south of Scully Creek there is a surfacing bed of Glyceria.

LEGENDS FOR FIGURES 1 TO 7 (Continued)

Code	Description
22.	Surrounding the Glyceria patch of zone 21 is a low density Nuphar polysepalum bed.
23.	There is a small creek mouth at this point which has a small but quite diverse flora consisting of Nuphar polysepalum. Nitella, Myriophyllum exalbescens, Utricularia vulgaris, U. intermedia, Potamogeton natans, P. berchtoldii or P. friesii, and Ranunculus flabellaris. Similar mixed populations occur in occasional open areas in the Equisetum bed and are labelled zone 24.
24.	See 23.
25.	This open water area has Najas flexilis, Utricularia vulgaris, Potamogeton natans, P. gramineus, P. robbinsii, Scirpus subterminalis, and Chara.
26.	The raised, relatively dry area is mostly non-aquatic wetland plants such as Carex, Myrica gale, and Spiraea douglasii.
27.	These areas are fairly dense beds of Scirpus lacustris.
28.	The broad band out to about 1 m in depth is predominantly Equisetum fluviatile in quite high density. In the occasional open or low density areas other communities (23,24,25,27) may occur.
29.	This is a narrow channel or band along the lake margin of open, deeper, water inside the main emergent vegetation beds. It is densely vegetated with submerged and floating leaved plants such as Nuphar polysepalum, Myriophyllum exalbescens, Potamogeton epihydrus and Menyanthes trifoliata. Small numbers of many other species also occur here.
30.	Off the Equisetum bed, out to about 3-4 m, the bottom is densely covered in a mat of submerged Potamogeton robbinsii. In shallower areas there are sporadic surfacing plants of P. praelongus, P. richardsonii and P. zosteriformis.
31.	These are beds of semi-aquatic grasses.
32.	These are surfacing beds of Hippuris vulgaris.
33	These are beds of Nuphar polysepalum.

LEGENDS FOR FIGURES 1 TO 7 (Continued)

Code	Description
34.	This band of vegetation is a mixture of Equisetum fluviatile, Hippuris vulgaris and Menyanthes trifoliata. There are small numbers of other species such as Utricularia intermedia, Potamogeton gramineus and mosses. The water is very shallow here and plant densities very high; there is no access for small fish.
35.	This bed is almost entirely Potamogeton berchtoldii or P. freisii.
36.	The bay is covered on the bottom with Potamogeton pectinatus and lesser amounts of Myriophyllum exalbescens and Glyceria. There are scattered specimens of Najas flexilis, Callitriche heterophylla, Ranunculus flabellaris, Nuphar polysepalum and Alisma plantago-aquatica in the bay as well.
37.	This region is mostly Potamogeton robbinsii but also contains Myriophyllum exalbescens, Potamogeton richardsonii, P. pectinatus, Hippuris vulgaris, Najas flexilis, Scirpus subterminalis and Callitriche heterophylla.

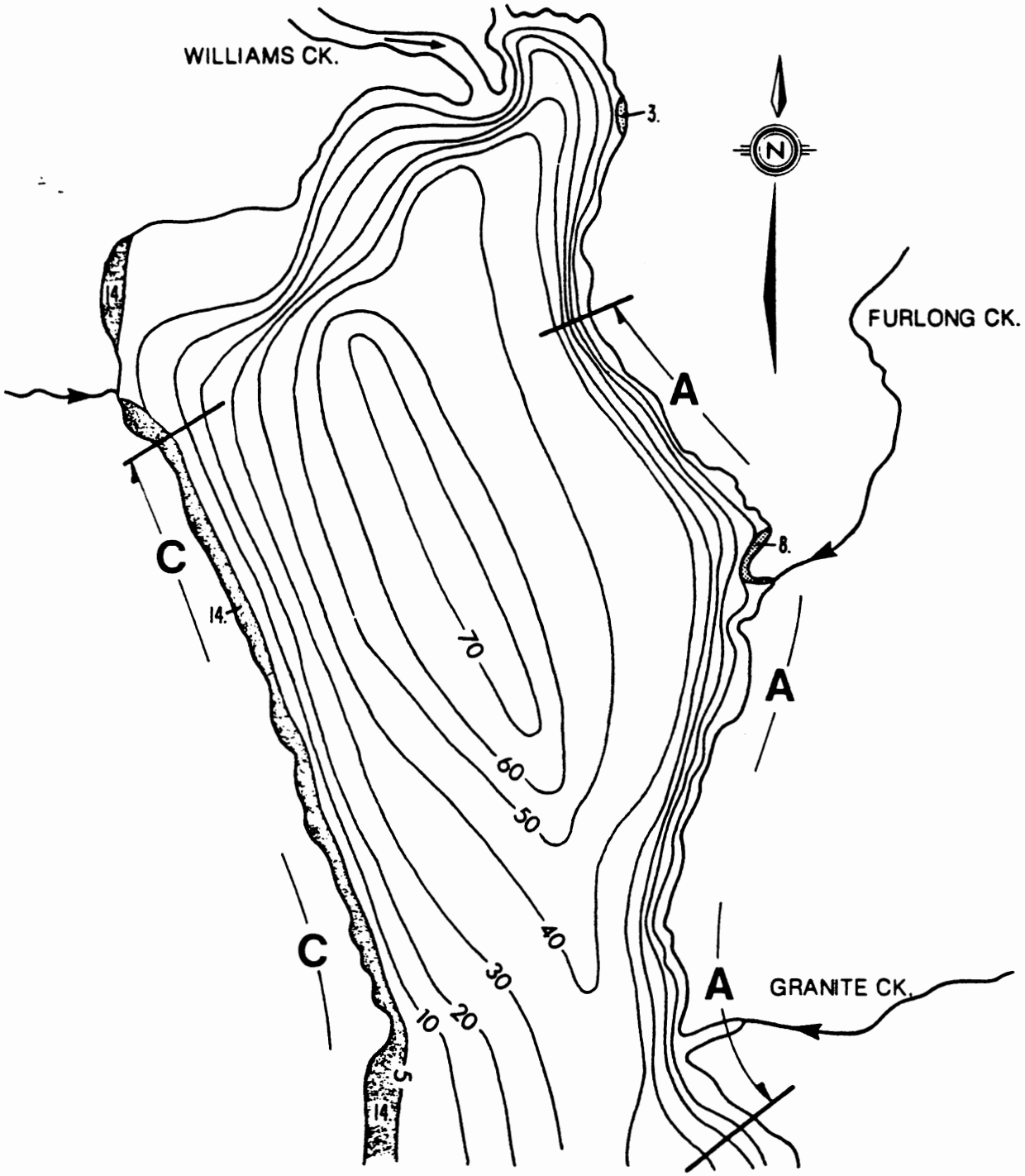

FIGURE 1 Bathymetric Map of the north end of Lakelse Lake

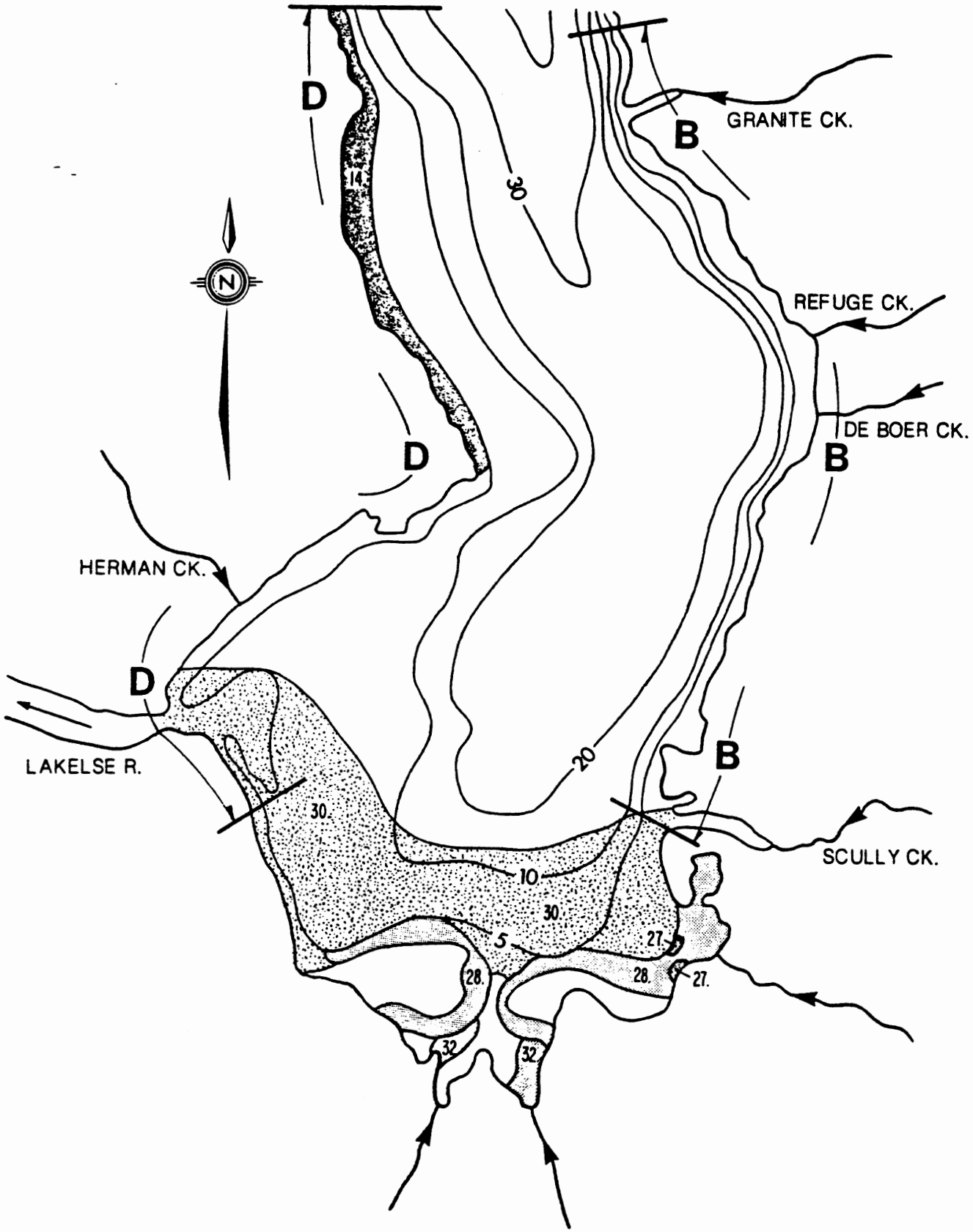

FIGURE 2 Bathymetric Map of the south end of Lakelse Lake

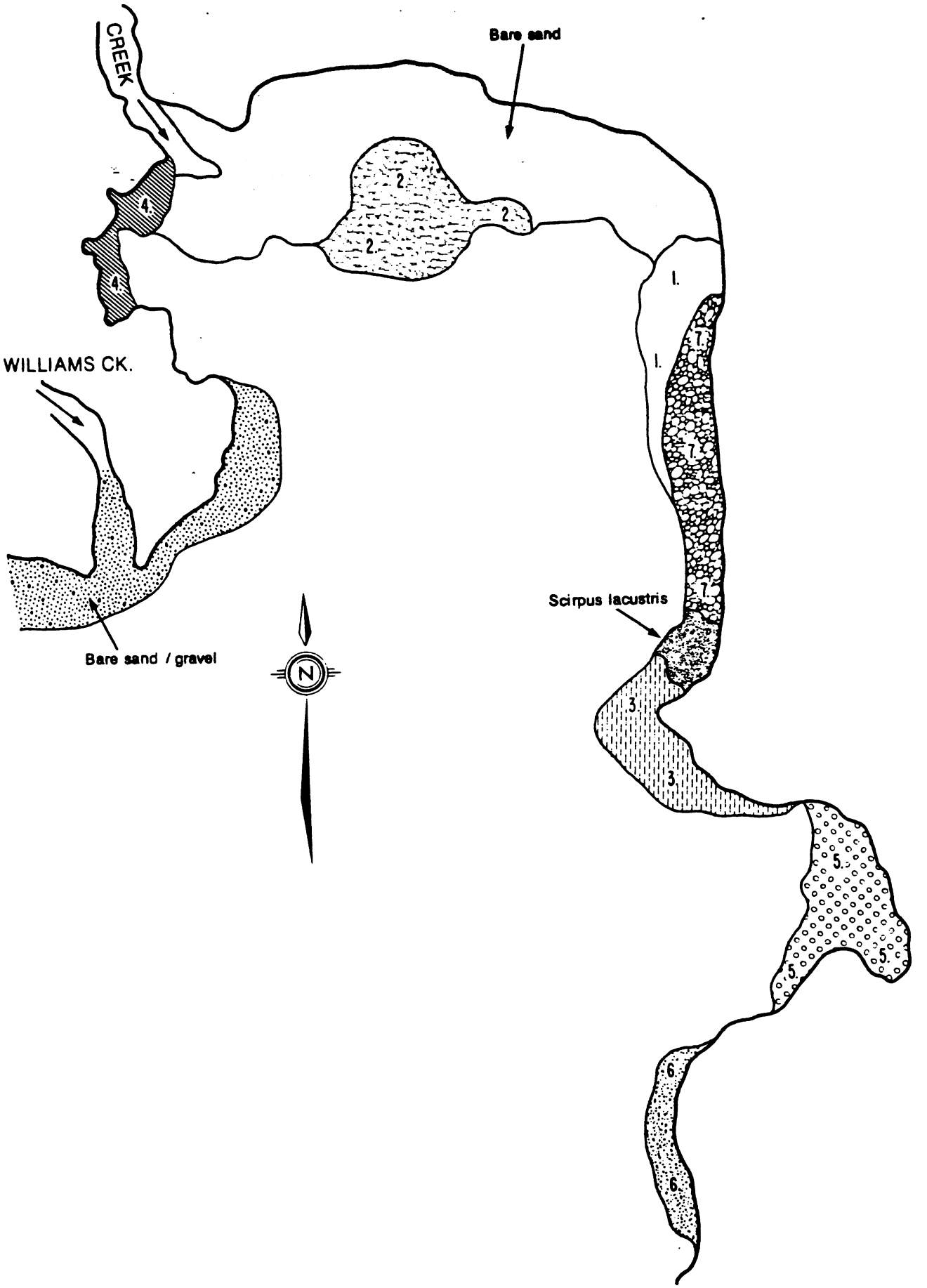

FIGURE 3 Aquatic Vegetation Map of the northeast corner of Lakelse Lake

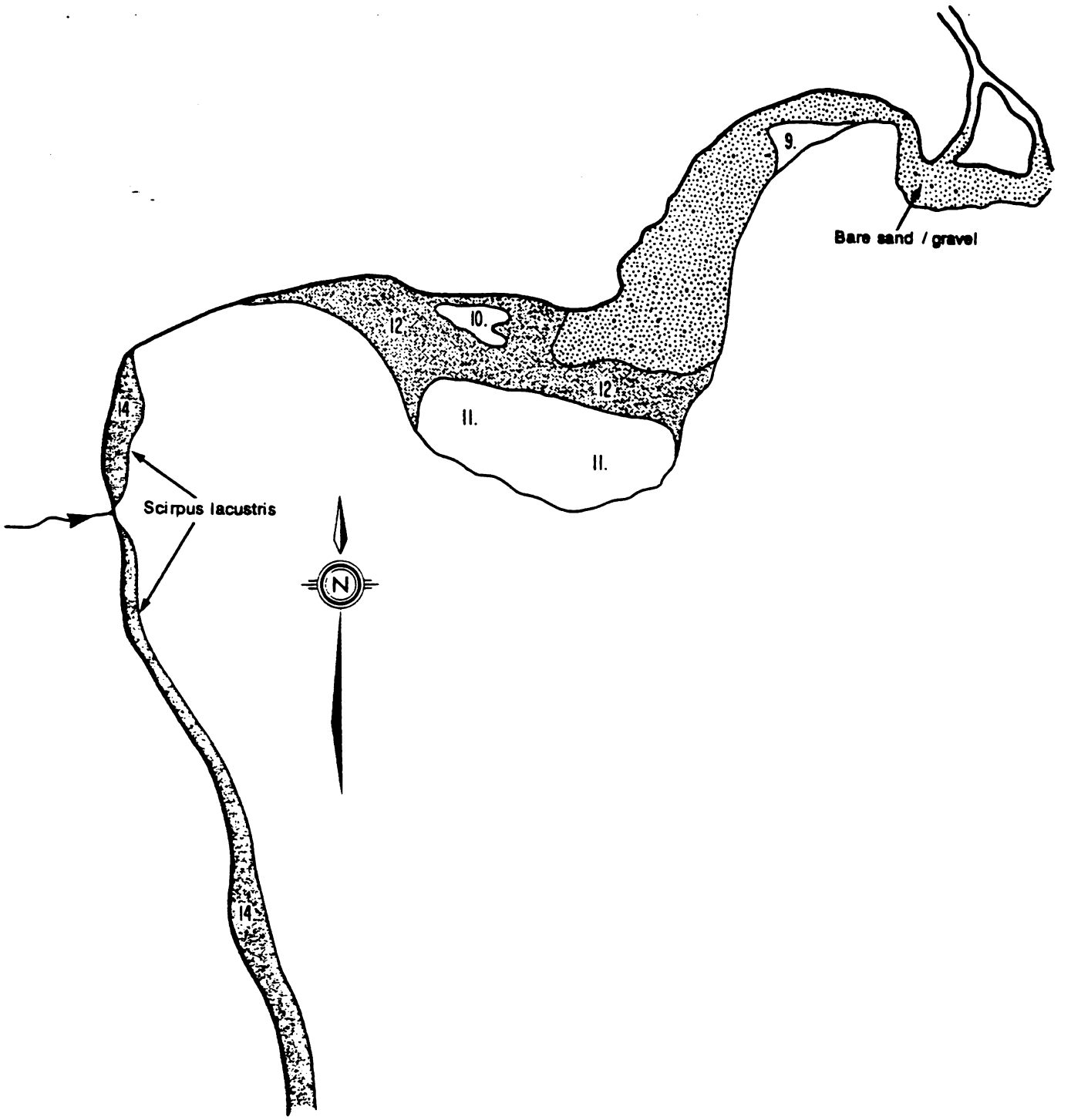

FIGURE 4 Aquatic Vegetation Map of the northwest corner of Lakelse Lake

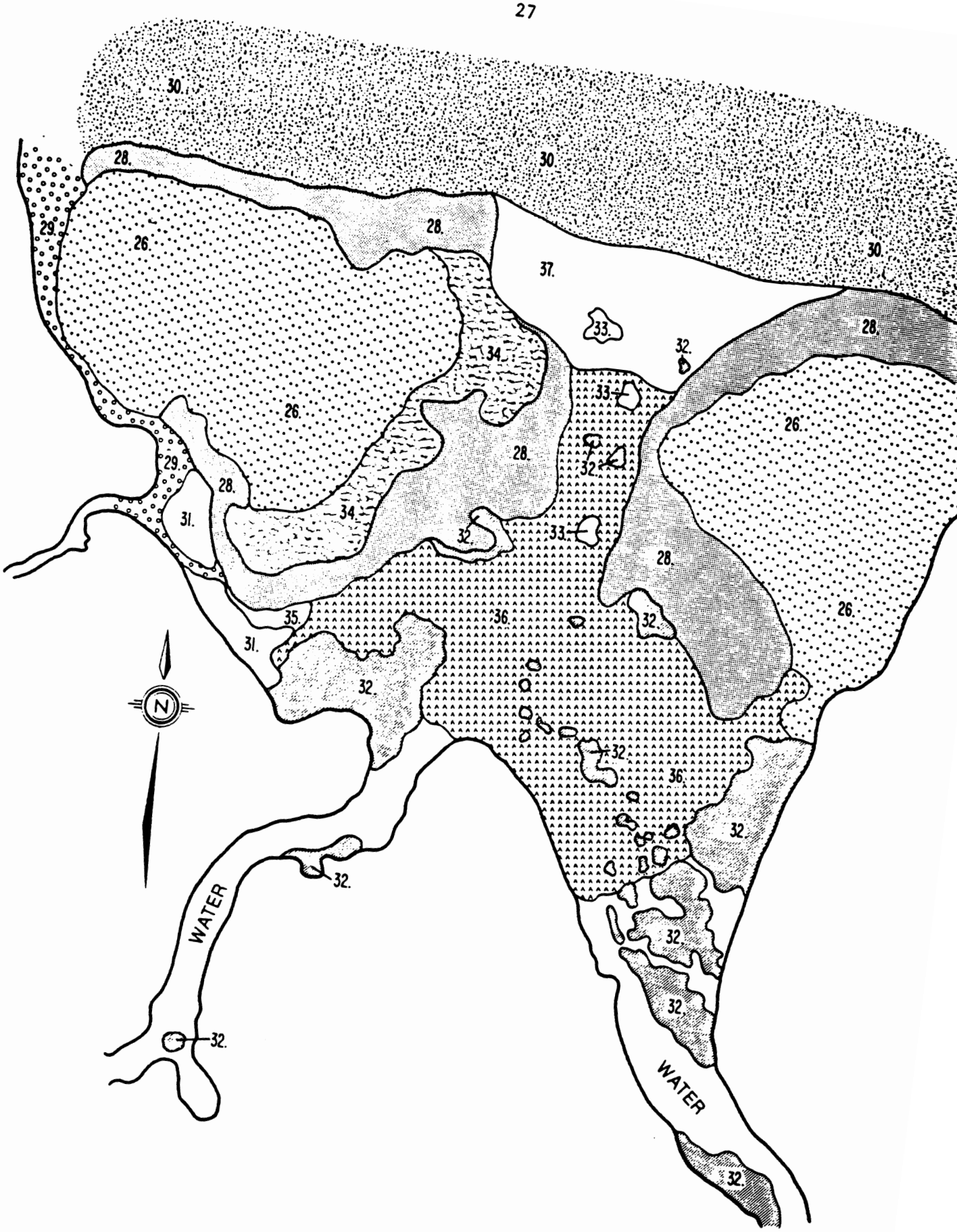

FIGURE 5 Aquatic Vegetation Map of the southwest corner of Lakelse Lake

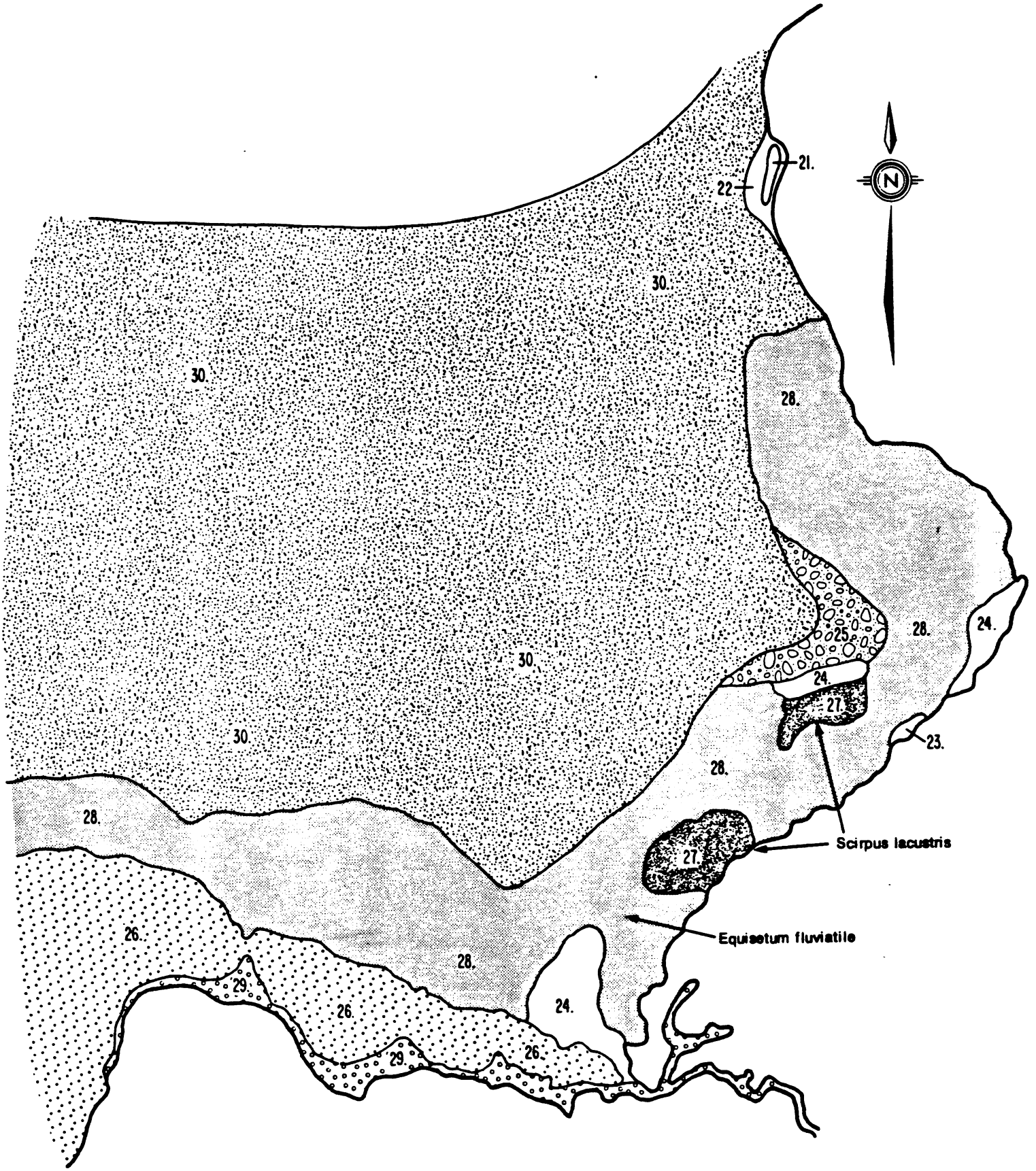

FIGURE 6 Aquatic Vegetation Map of the southeast corner of Lakelse Lake

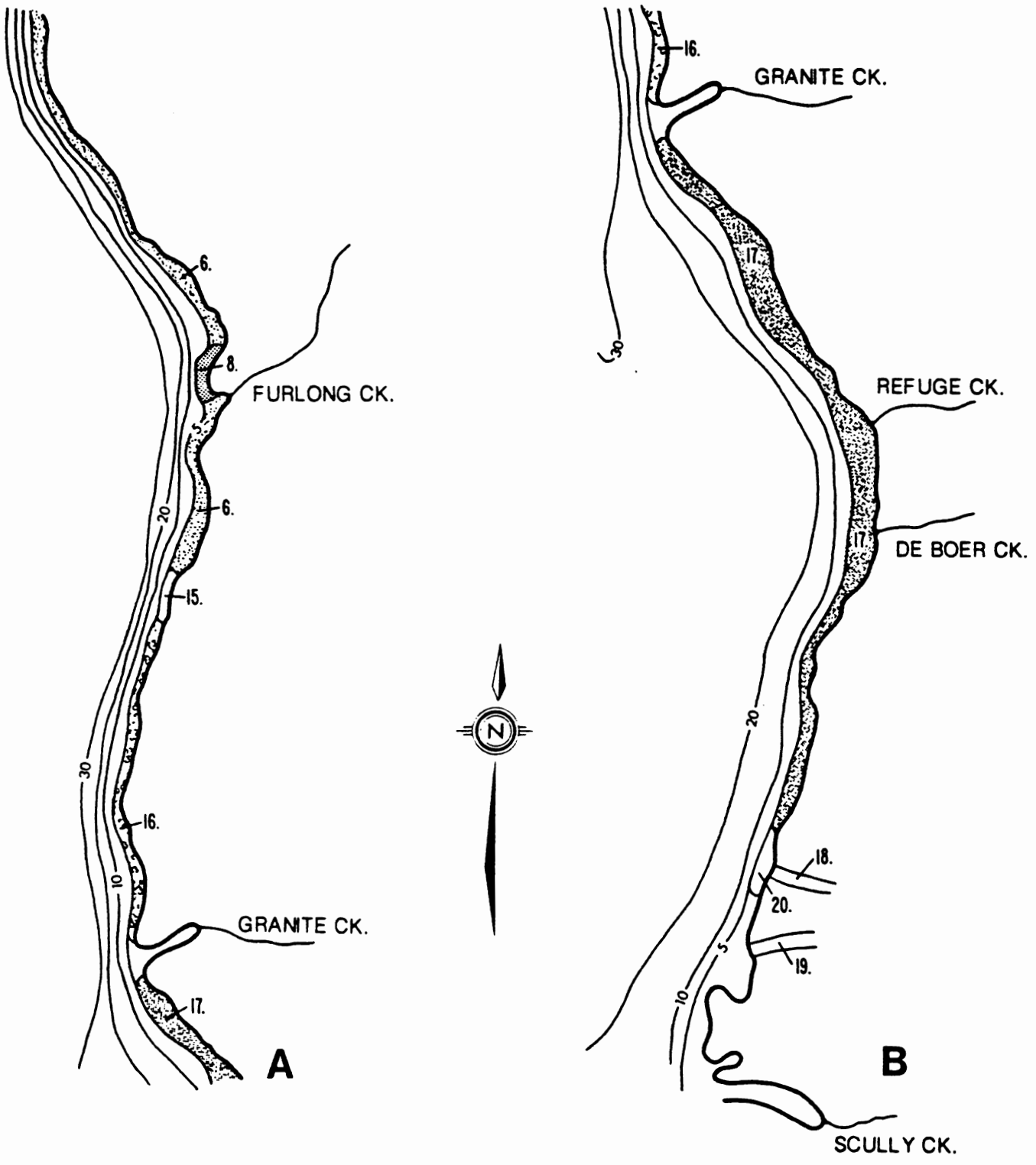

FIGURE 7 Aquatic Vegetation Map of the east shore of Lakelse Lake

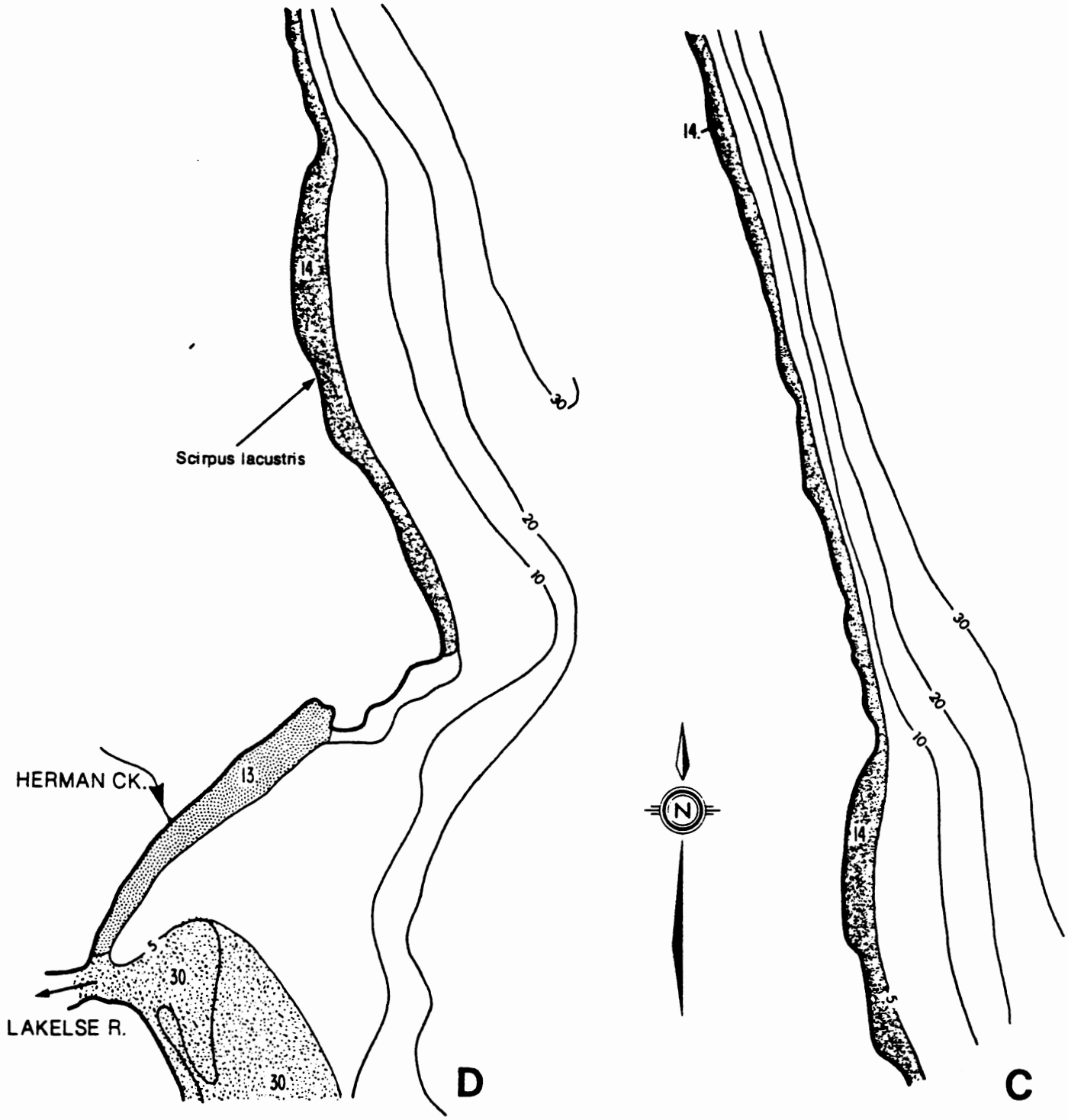

FIGURE 8 Aquatic Vegetation Map of the west shore of Lakelse Lake