LIMNOLOGICAL INVENTORY OF THE SEASIDE ADJUNCT KEJIMKUJIK NATIONAL PARK

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Prepared by

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1. SUMMARY

The Seaside Adjunct to Kejimkujik National Park contains six freshwater lakes. These systems are described in terms of their morphology, physics, chemistry and biology. The major emphasis has been placed on determining the morphological and chemical characteristics since these determine to a large extent the physical and biological characteristics.

All of the lakes within the Adjunct are dystrophic and are characterized by darkly stained waters containing high levels of dissolved organic acids, low pH, poor buffering capacity and low nutrient levels. The biomass and diversity of organisms contained in these systems is low.

2. INTRODUCTION

The Seaside Adjunct to Kejimkujik National Park was acquired by Environment Canada Parks in 1985. As part of the development of a park Management Plan, the Acadia Centre for Estuarine Research was commissioned to provide a preliminary resource survey of the freshwater lakes located within the Adjunct. This report presents the results of this survey which was carried out during two site visits on June 12-16, 1987 and July 10-11, 1987.

2.1 Study Objectives

The primary objective of the resource survey was to obtain basic information on the major morphological, physical, chemical and biological characteristics of each system. Because of the limited financial resources available for this study, an exhaustive resource inventory was not possible. Priority was given to obtaining information on the morphological and chemical characteristics of each lake since these factors are the most basic in terms of controlling both the physical and biological characteristics of a lake.

2.2 Acknowledgements

Mike Brylinsky was principal investigator for this project. Peggy Crawford-Kellock was responsible for field preparation and laboratory analysis and assisted in report preparation. Reg Newell and Ruth Newell assisted in the bathymetric surveys and collection and identification of aquatic macrophytes. Mike Shaffelburg and Jerome Mazier assisted in field work. Park staff, particularly Dan Reive and Cliff Drysdale, provided advice and logistic support when required.

3. STUDY AREA

3.1 Location and Access

The major freshwater resources within the Adjunct consist of six lakes. Figure 1 shows the location of each lake along with the boundaries of the drainage basin surrounding each lake, and Table 1 lists each lake along with its longitude and latitude. The drainage basins of both Forbes and Flat Lake lie partly outside the boundaries of the Park. The remaining lakes have drainage basins contained wholly within the boundaries of the Adjunct.

Access to each lake is in most cases limited to small foot paths, most of which are located along the borders of streams and creeks leading into or out of each lake. Forbes Lake, however, is an exception and can be reached by all terrain vehicles along a cart trail originating at a roadway located outside the boundary of the Adjunct. Round Lake can be reached from along the boundary lines of the Park which provide relatively wide trails. None of the lakes is accessible by canoe or small watercraft via streams entering or exiting the lakes.

3.2 Geological Features and Lake Origins

The geology of the Adjunct has been summarized by Hunter and Associates (1987). The major geological features consist of a foundation of undeformed, Permo-Carboniferous plutonic rocks composed primarily of slates, greywackes and granites. Drumlin formations are rare, most bedrock being overlain by a shallow layer of glacial till. The overlying vegetation is composed predominantly of a mixed hardwood-softwood forest of which red maple and white spruce are the dominant species.

Most of the lakes of the Adjunct appear to have been formed as a result of ice scouring and the erosional and depositional effects associated with glacial ice movements. The morphology of Round Lake suggests that it may be a kettle lake formed by the deposition of glacial till around an ice block broken off a retreating glacier.

3.3 Climatic Features

Average climatic conditions at a weather station located at Western Head, N.S. (about 20 km northeast of the Adjunct) have been tabulated and summarized by the Environment Canada Atmospheric Environmental Service (Table 2). Air temperatures range from a mean daily minimum of about 2.7°C to a mean daily maximum of about 11.5°C. The lowest mean monthly temperature of -3.7°C occurs in March and the highest mean monthly temperature of 10.9°C occurs in August. Total annual precipitation averages about 130 cm of which approximately 110 cm fall as rain and the

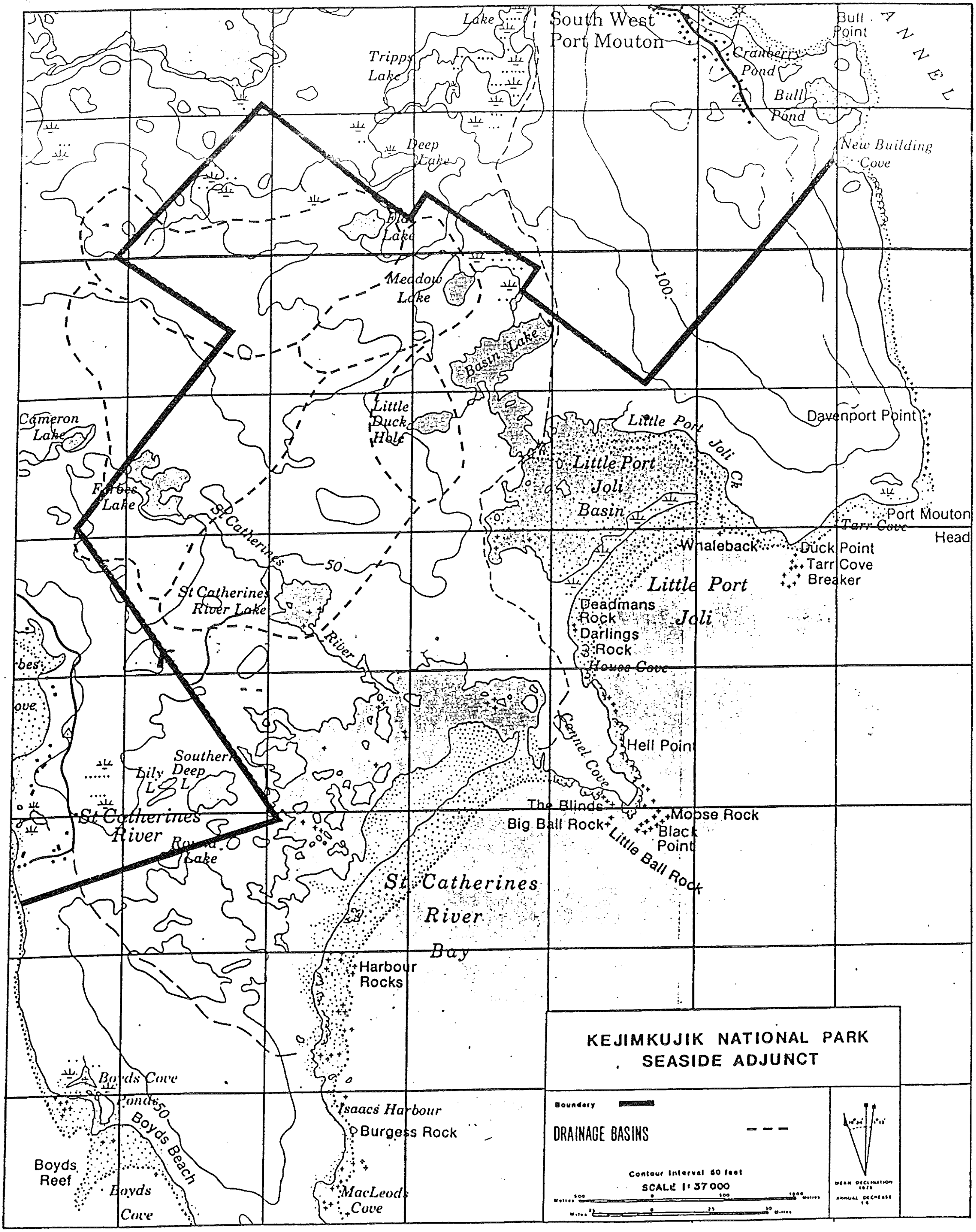

Figure 1. Location of lakes contained within the Seaside Adjunct

Table 1. Lakes located within the Seaside Adjunct

Lake	Longitude	Latitude
St. Catherines River Lake	43^{o} 85' 50" N	64^{o} 84' 00" W
Forbes Lake	43^{o} 86' 50"	64^{o} 85' 00"
Flat Lake	43^{o} 88' 00"	64^{o} 83' 50"
Meadow Lake	43^{o} 87' 50"	64^{o} 82' 50"
Little Duck Hole	43^{o} 86' 75"	64^{o} 82' 75"
Round Lake	43^{o} 84' 00"	64^{o} 85' 00"

remainder as snow. There is relatively little monthly variation in precipitation although June and July tend to be dryer and January and November wetter than other months. High humidity and frequent fog are characteristic of the Adjunct as a result of its close proximity to the ocean and results in moderating climatic conditions and lessening the transition between seasons. Winters are relatively mild and short, summers cool and short, and both spring and fall tend to be long and cool.

3.4 Related Studies

There exist no published studies dealing with the lakes located within or immediately near the Adjunct. There have been a number of studies dealing with the terrestrial systems of the Adjunct that provide information on the vegetational characteristics of the drainage basins surrounding each lake. Mailman (1979) provided an initial biophysical classification of the Adjunct prior to acquisition by Environment Canada Parks. Hunter and Associates (1987) provided a more intensive biophysical analysis which produced an Ecological Land Classification of the Adjunct.

Although not specific to the Adjunct, many of the lakes within the nearby Kejimkujik National Park at Maitland Bridge, N.S. have received considerable study and a number of reports are available from Parks Canada. These provide good background data describing the nature of lakes and other freshwater systems located in the general area of southwestern Nova Scotia.

Table 2. Average climatic conditions at Western Head, N.S. (from Environment Canada Atmospheric Environment Service)

WESTERN HEAD (AUT) 43° 59'N 64° 40'W 9 m	JAN JAN	FEB FÉV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DÉC
Daily Maximum Temperature	1.0	0.6	3.5	7.7	11.6	15.2	17.5	18.7	17.3	13.5	8.6	3.5
Daily Minimum Temperature	-6.9	-7.3	-3.7	0.3	4.3	7.6	9.9	10.9	9.7	5.4	1.4	-4.5
Daily Temperature	-3.0	-3.4	-0.1	3.9	8.0	11.3	13.8	14.8	13.6	9.4	5.0	-0.5
Standard Deviation, Daily Temperature	1.7	1.6	0.9	0.8	0.8	1.2	1.0	1.2	1.0	1.2	1.2	1.7
Extreme Maximum Temperature	11.1	10.6	14.4	23.3	27.8	33.9	33.9	30.0	30.0	27.2	20.0	12.2
Years of Record	16	16	16	16	16	16	16	16	17	17	17	17
Extreme Minimum Temperature	-22.2	-23.3	-16.7	-8.3	-4.4	1.7	4.4	5.0	0.0	-4.4	-10.0	-18.3
Years of Record	16	16	16	16	16	16	16	16	17	17	17	17
Rainfall	108.6	75.7	83.3	95.8	104.0	80.8	78.5	100.5	98.1	117.6	154.0	111.7
Snowfall	40.8	56.1	36.1	14.0	2.3	0.0	0.0	0.0	0.0	2.3	3.9	41.8
Total Precipitation	141.5	123.4	115.6	107.6	106.1	80.8	78.5	100.5	98.1	121.1	158.4	150.6
Standard Deviation, Total Precipitation	40.8	47.4	40.7	37.1	48.9	27.3	45.2	61.1	71.5	67.2	86.3	47.6
Greatest Rainfall in 24 hours	42.7	48.0	75.2	77.5	50.3	63.5	53.6	172.7	108.7	122.2	92.5	76.5
Years of Record	16	16	16	16	16	16	16	16	17	17	17	17
Greatest Snowfall in 24 hours	33.0	59.2	40.4	27.4	27.2	0.0	0.0	0.0	0.0	41.9	10.4	44.2
Years of Record	16	16	16	16	16	16	16	16	17	17	17	17
Greatest Precipitation in 24 hours	42.7	53.3	81.5	77.5	50.3	63.5	53.6	172.7	108.7	122.2	92.5	76.5
Years of Record	16	16	16	16	16	16	16	16	17	17	17	17
Days with Rain	9	7	9	12	13	12	10	12	10	11	13	12
Days with Snow	10	8	7	4	0	0	0	0	0	0	2	8
Days with Precipitation	16	13	13	13	13	12	10	12	10	11	14	17

4. METHODOLOGY

4.1 Field Procedures

Each lake was visited once during either June 12-16, 1987 (St. Catherines River Lake, Round Lake, Little Duck Hole, Meadow Lake) or July 10-11, 1987 (Flat Lake, Forbes Lake).

An initial bathymetric survey was conducted by traversing the lake along predetermined transects and measuring depths with a marked lead-line. Secchi depth readings and general observations on the types and distribution of sediments and aquatic macrophytes were also made at this time. A single station was then established at the deepest point of the lake. Temperature and conductivity profiles were then made using a YSI S-C-T meter to determine if there was any evidence of water column stratification. If stratification was not evident, water samples for chemical and chlorophyll *a* analyses were taken from the surface. If there was evidence of water stratification, water samples were taken from both surface and bottom waters. Ten-minute horizontal zooplankton tows were made using a 160 um net and samples were preserved in 10% buffered formalin.

4.2 Laboratory Procedures

Morphological parameters for each lake were determined using standard cartometric procedures (Eckblad, 1978; Wetzel, 1983). Surface area of lakes and drainage basins were measured planimetrically on 1:10,000 scale contour maps. Flushing rates were calculated assuming an annual precipitation rate of 130 cm. Chemical analyses were performed using HACH kit methodology. Chlorophyll *a* analyses were performed using the acetone extraction method and concentrations calculated according to the tri-colorimetric equations presented in Lund (1974).

5. RESULTS

5.1 Morphology

The morphological characteristics of each lake are summarized in Table 3. Appendix A presents bathymetric maps of each lake. Tables 4 to 9 present the surface area, volume, stratum interface areas and partial volumes as they vary with depth for each lake. Figures 2 to 7 present volume and area curves and Figures 8 to 13 present hypsographic curves for each lake.

None of the lakes are very large or deep. All have surface areas <1 ha and, except for Forbes Lake, mean depths <2 m. Forbes Lake, although not the largest in area, is the deepest with an average depth of 2.2 m and a maximum depth of about 7 m. Forbes Lake also has the greatest volume and shoreline length. The latter results in the largest value for shoreline development, which reflects its irregular shape containing numerous coves and land protrusions. Most of the other lakes are roughly circular or eliptical in shape and exhibit values of shoreline development near to 1.0. Values for development of volume, an index that reflects the shape of the basin of a lake, indicate that most approach a conical shape (the value of a perfect cone would be 0.33). Flat Lake and Little Duck Hole, because of relatively large areas of uniform depth above the 1 m contour, depart the furtherest from a conical shape.

The total surface area of all lakes combined is about 3.3 ha which represents <2% of the total area of the Adjunct.

5.2 Flushing Rates and Times

The drainage basin area, volume, and flushing rate and time of each lake is presented in Table 10. Although none of the lakes exhibit particularly high or low flushing rates, there is considerable variability among the different lakes. Because the ratio of lake volume to drainage basin area varies considerably, flushing rates are not solely dependent on lake volume. Flat Lake, which has the smallest volume, also has the highest flushing rate at >54 times/yr. Meadow and Duck Lakes, which are intermediate in volume, have the lowest flushing rates at about 10 and 14 times/yr respectively. Because of its relatively large drainage basin, St. Catherines River Lake, the second largest in volume, also exhibits the second highest flushing rate at about 30 times/yr.

5.3 Water Transparency

Because of the difficulty of carrying heavy equipment to the lakes, a light meter was not available to determine the light attenuation characteristics of each lake. Secchi disc readings

Table 3. Morphometric characteristics of lakes located within the Seaside Adjunct

	St. Catherines River Lake	Forbes Lake	Flat Lake	Meadow Lake	Little Duck Hole	Round Lake
Surface Area (m^2)	81,071	69,911	49,204	48,066	43,282	37,223
Volume (m^3)	104,900	151,400	32,600	86,320	67,700	37,540
Mean Depth (m)	1.3	2.2	0.7	1.8	1.6	1.0
Maximum Depth (m)	3.0	7.0	2.5	5.0	3.0	3.0
Maximum Length (m)	442	442	250	235	325	205
Maximum Breadth (m)	408	300	170	165	113	190
Shoreline Length (m)	1,604	2,590	745	774	764	581
Development of Volume[a]	0.43	0.31	0.28	0.36	0.53	0.33
Relative Depth[b]	0.93	2.34	1.00	2.02	1.28	1.38
Shoreline Development[c]	1.59	2.76	0.95	1.00	1.04	0.85

[a]Development of Volume - ratio of mean to maximum depth

[b]Relative Depth - the maximum depth as a percentage of the mean depth calculated as follows:

$$\text{relative depth} = \frac{50\ \bar{z}m \sqrt{\pi}}{\sqrt{Ao}}$$

where $\bar{z}m$ = maximum depth
Ao = surface area

[c]Shoreline Development - the ratio of the length of the shoreline to the length of the circumference of a circle of equal area to that of the water, body calculated as follows:

$$\text{shoreline development} = \frac{L}{2\sqrt{\pi Ao}}$$

where L = shoreline length
Ao = surface area

Table 4. Surface area, volume, stratum, interface areas and partial volumes of St. Catherines River Lake

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	81,071	100.0	0 -0.5	36,500	34.8
0.5	71,389	88.1	0.5-1.0	30,200	28.8
1.0	56,235	69.4	1.0-1.5	21,000	20.0
1.5	29,814	36.8	1.5-2.0	11,500	11.0
2.0	1,969	2.4	2.0-2.5	5,200	5.0
2.5	437	0.5	2.5-3.0	500	0.5
			Total	104,900	

Table 5. Surface area, volume, stratum interface areas and partial volumes of Forbes Lake

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	69,911	100.0	0-1	54,000	35.7
1	47,154	67.4	1-2	45,000	29.7
2	46,334	66.3	2-3	33,200	21.9
3	22,593	32.3	3-4	12,000	7.9
4	6,455	9.2	4-5	4,200	2.7
5	1,750	2.5	5-6	2,000	1.3
6	1,149	1.6	6-7	1,000	0.7
			Total	151,400	

Table 6. Surface area, volume, stratum interface areas and partial volumes of Flat Lake

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	49,204	100.0	0 -0.5	16,600	50.9
0.5	16,311	35.3	0.5-1.0	7,300	22.4
1.0	13,212	28.6	1.0-1.5	5,540	17.0
1.5	10,479	22.7	1.5-2.0	2,960	9.1
2.0	1,139	2.5	2.0-2.5	200	0.6
			Total	32,600	

Table 7. Surface area, volume, stratum interface areas and partial volumes of Meadow Lake

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	48,066	100.0	0-1	38,000	44.0
1	29,887	62.2	1-2	33,200	38.5
2	17,222	35.8	2-3	10,400	12.0
3	5,649	11.8	3-4	3,600	4.2
4	1,230	2.6	4-5	1,120	1.3
			Total	86,320	

Table 8. Surface area, volume, stratum interface areas and partial volumes of Little Duck Hole.

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	43,282	100.0	0 -0.5	20,200	29.8
0.5	37,131	85.8	0.5-1.0	16,200	23.9
1.0	29,842	68.9	1.0-1.5	13,400	19.8
1.5	24,466	56.5	1.5-2.0	11,000	16.2
2.0	20,092	46.4	2.0-2.5	6,000	8.9
2.5	547	1.3	2.5-3.0	900	1.3
			Total	67,700	

Table 9. Surface area, volume, stratum interface areas and partial volumes of Round Lake.

Depth (m)	Area m^2	Area % of Total	Stratum (m)	Volume m^3	Volume % of Total
0	37,223	100.0	0 -0.5	25,330	67.5
0.5	25,195	67.7	0.5-1.0	7,900	21.0
1.0	11,800	31.7	1.0-1.5	3,500	9.3
1.5	3,964	10.6	1.5-2.0	600	1.6
2.0	1,321	3.5	2.0-2.5	200	0.5
2.5	866	2.3	2.5-3.0	10	0.1
			Total	37,540	

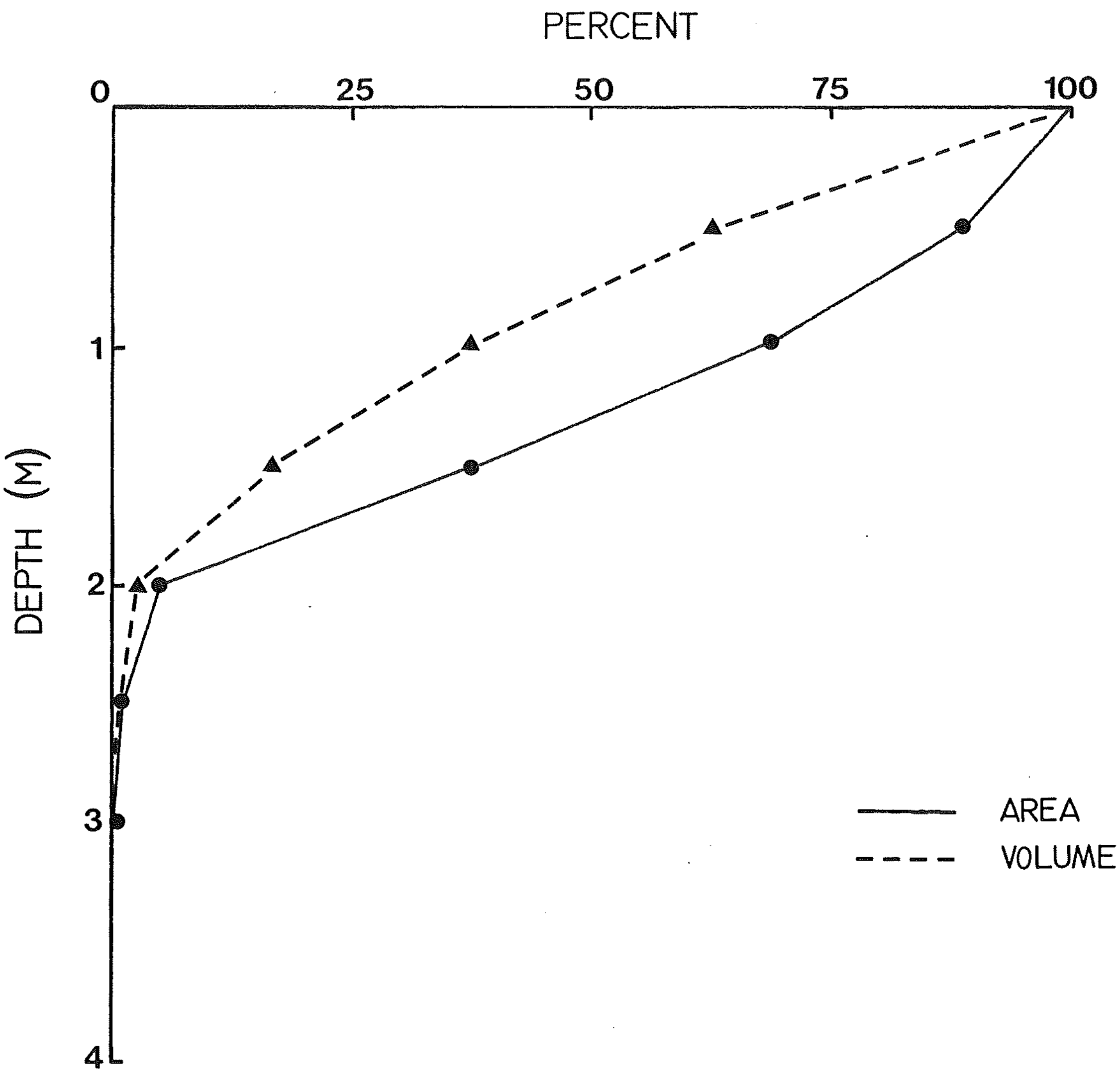

Figure 2. Volume and area curves for St. Catherines River Lake

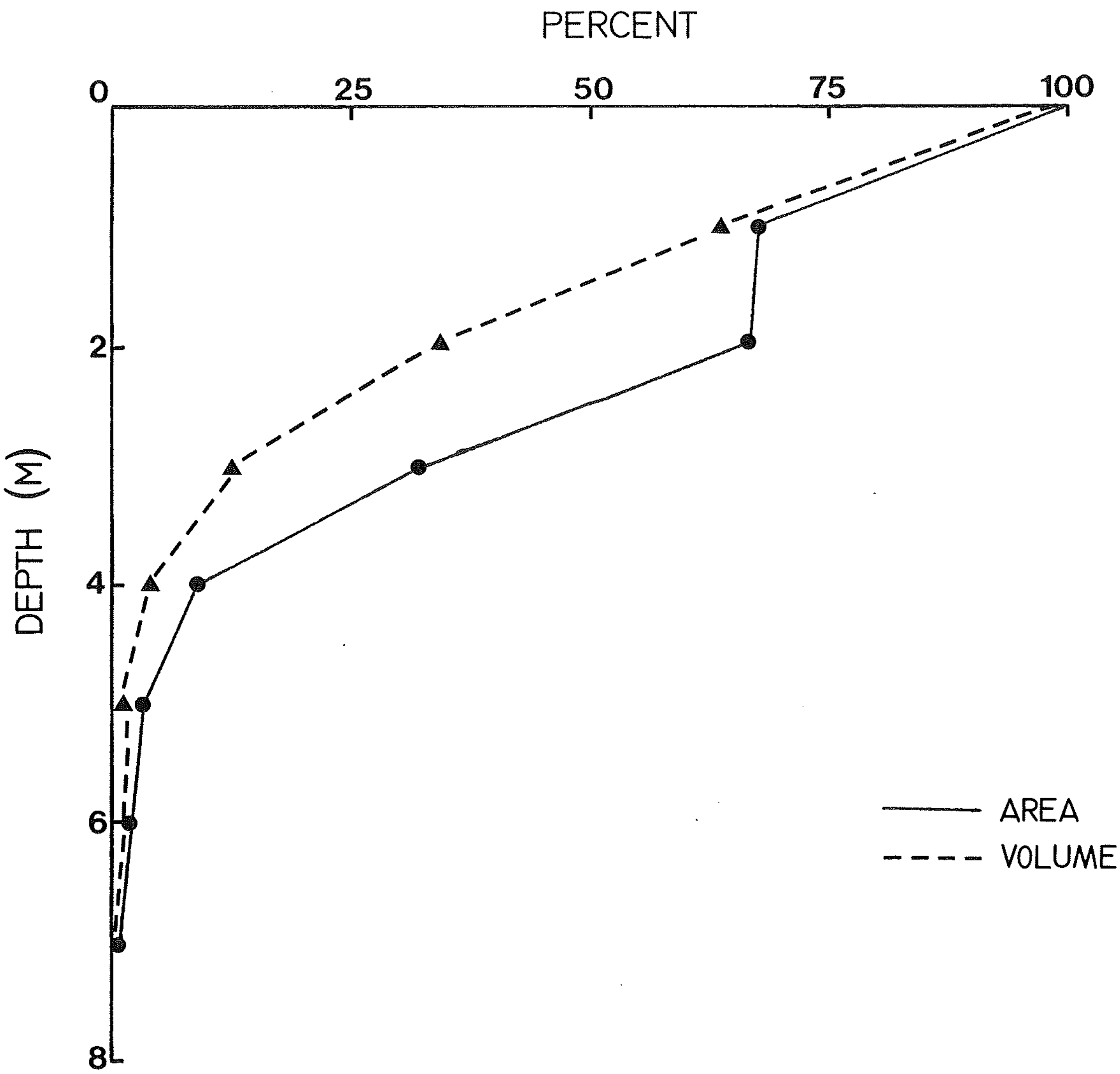

Figure 3. Volume and area curves for Forbes Lake

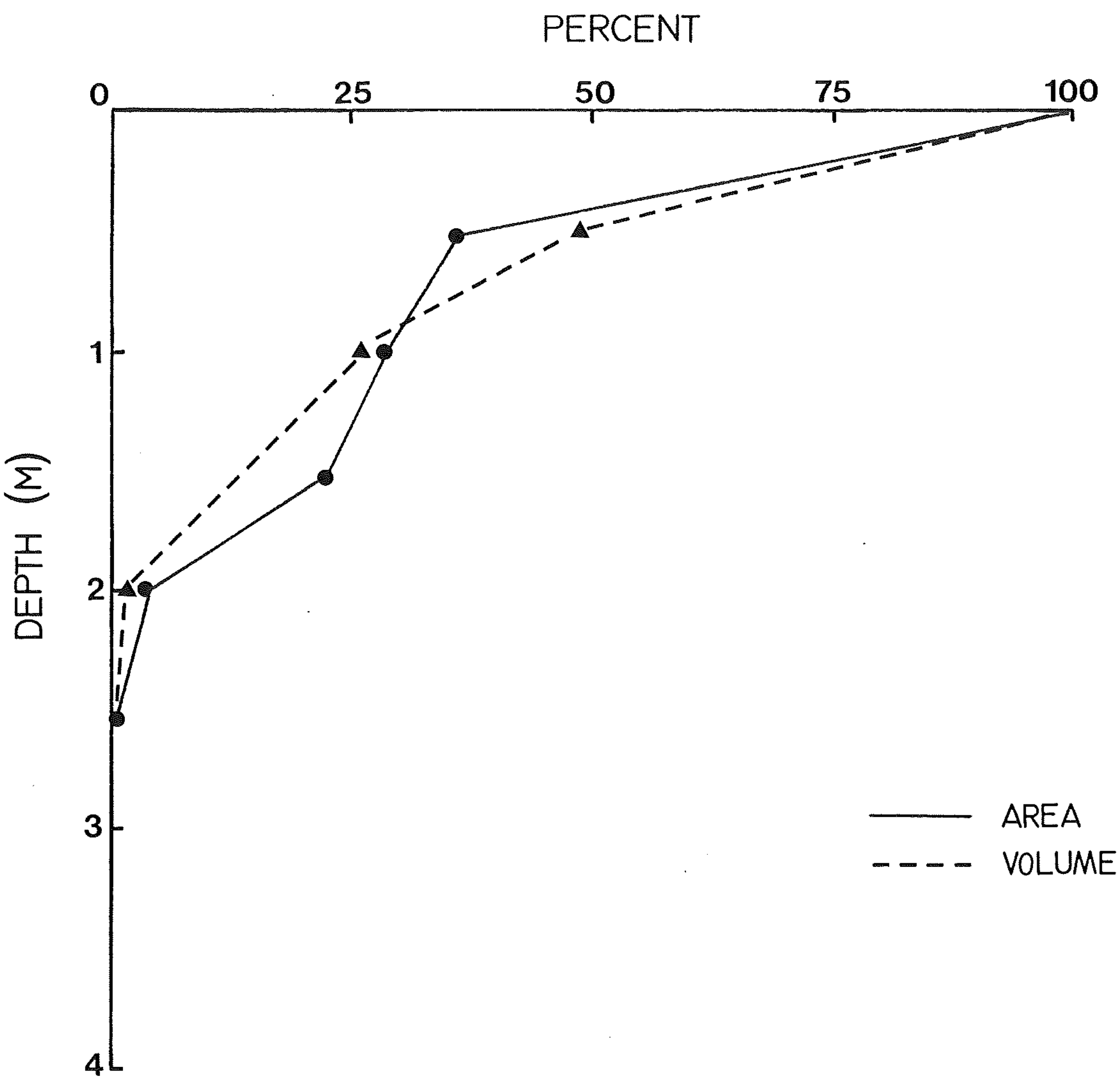

Figure 4. Volume and area curves for Flat Lake

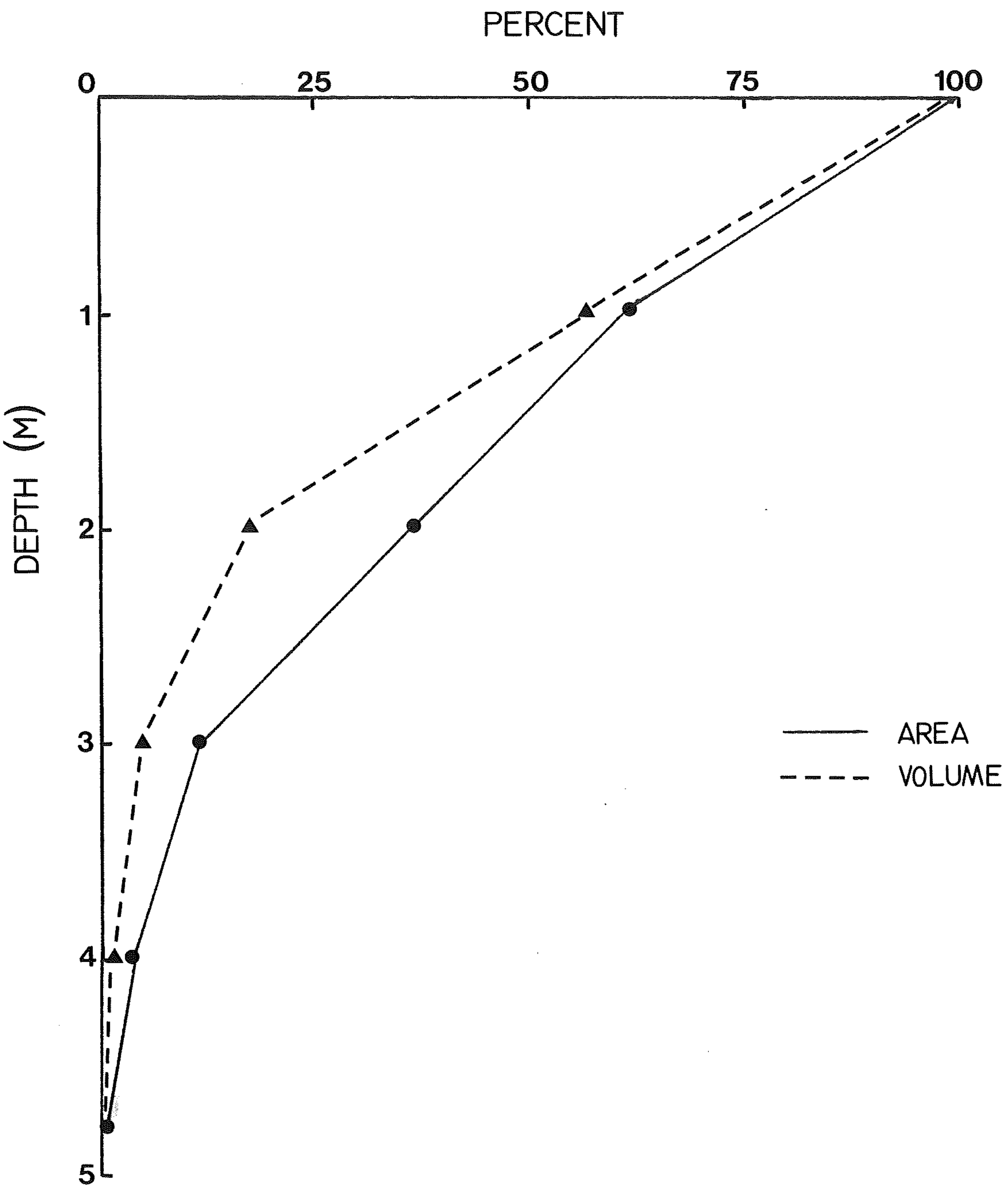

Figure 5. Volume and area curves for Meadow Lake

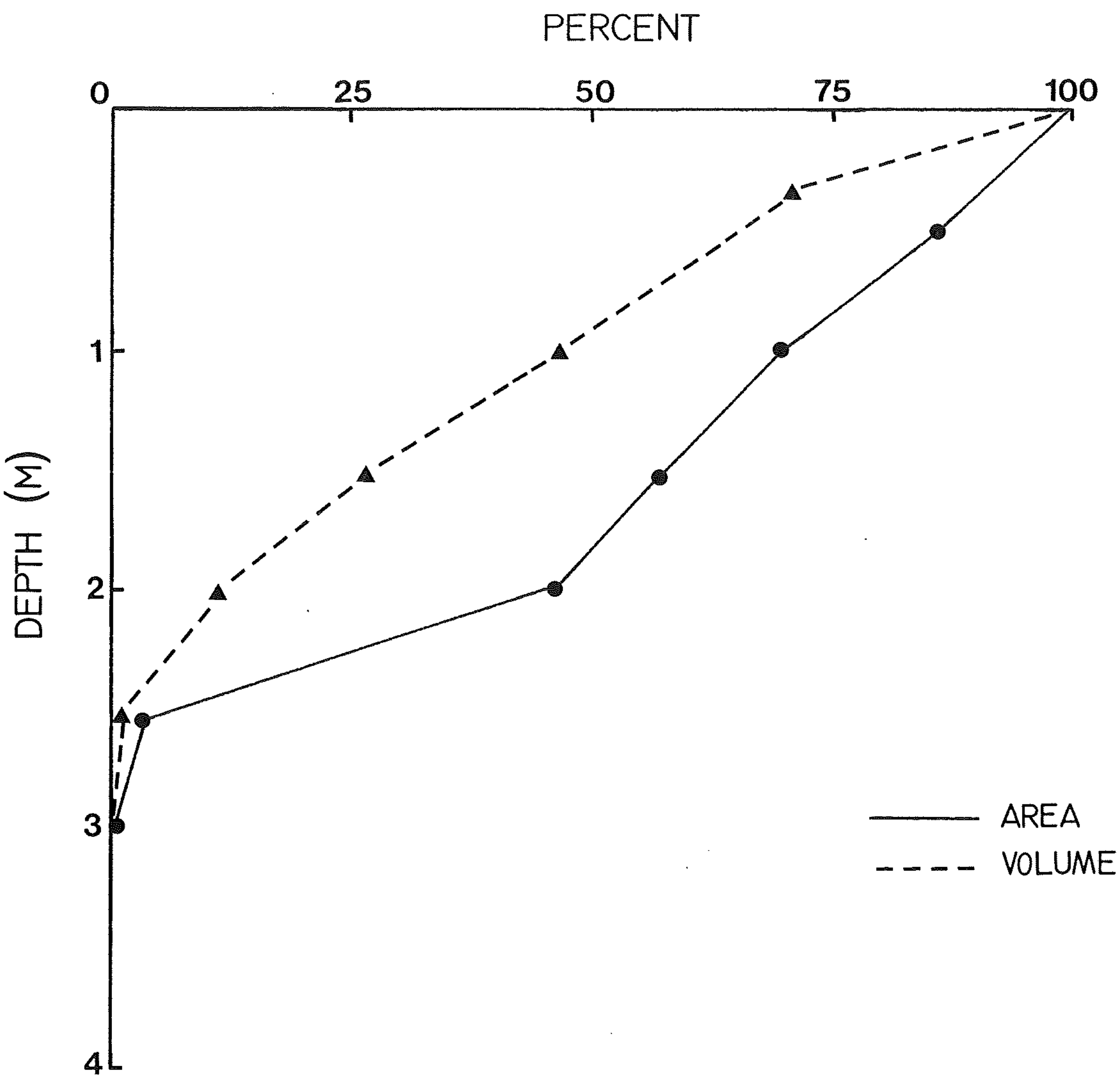

Figure 6. Volume and area curves for Little Duck Hole

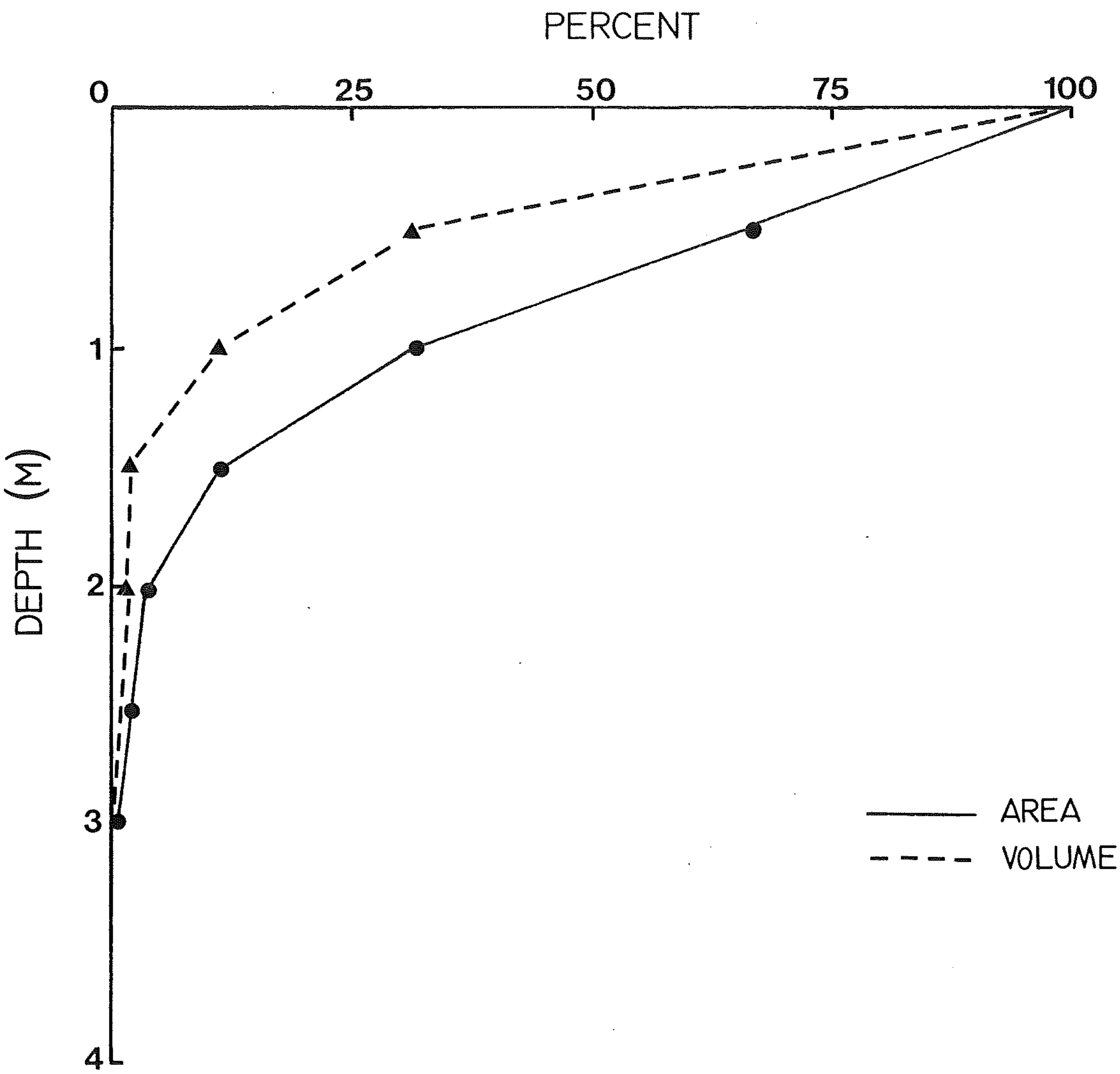

Figure 7. Volume and area curves for Round Lake

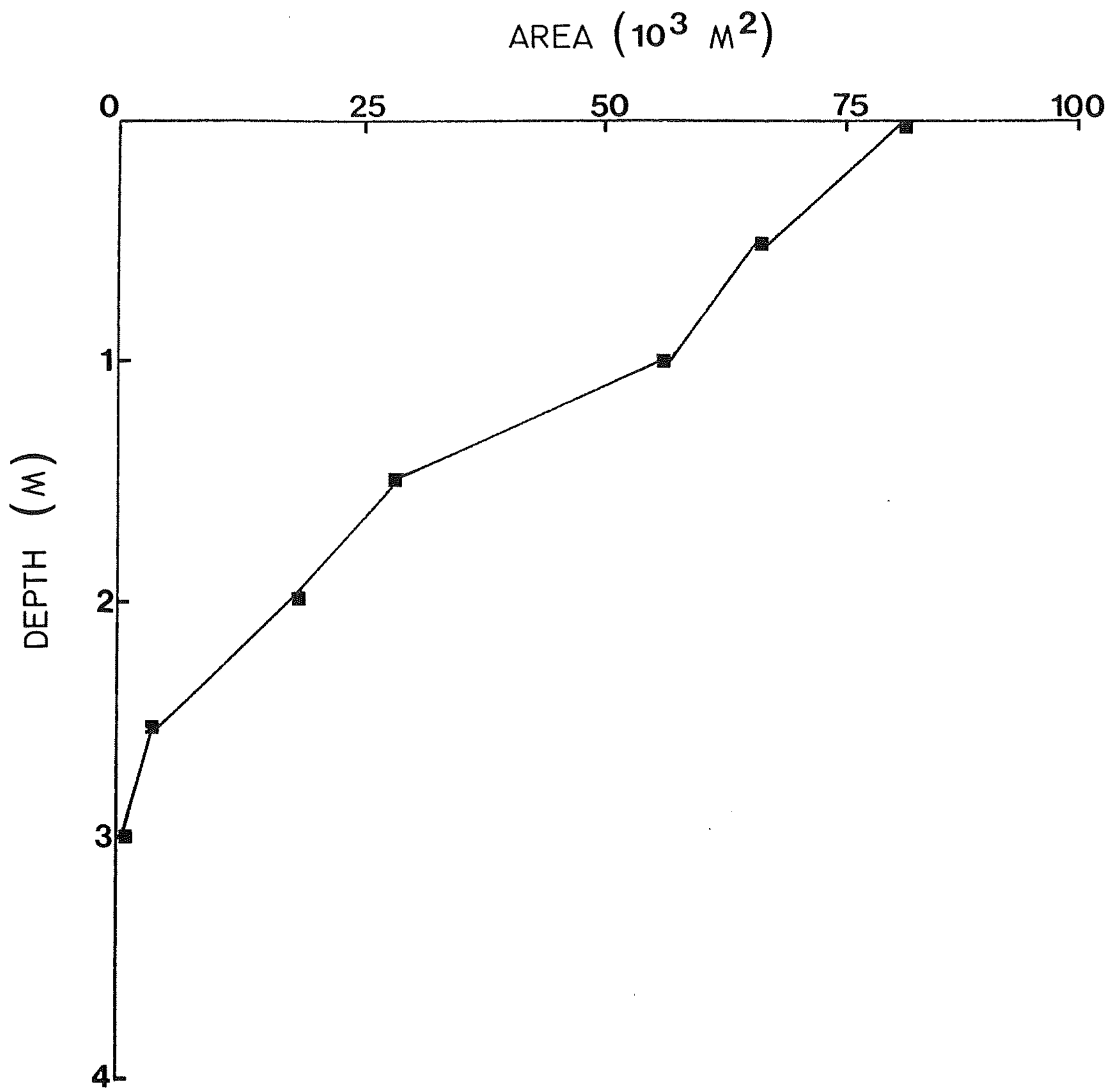

Figure 8. Hypsographic curve for St. Catherines River Lake

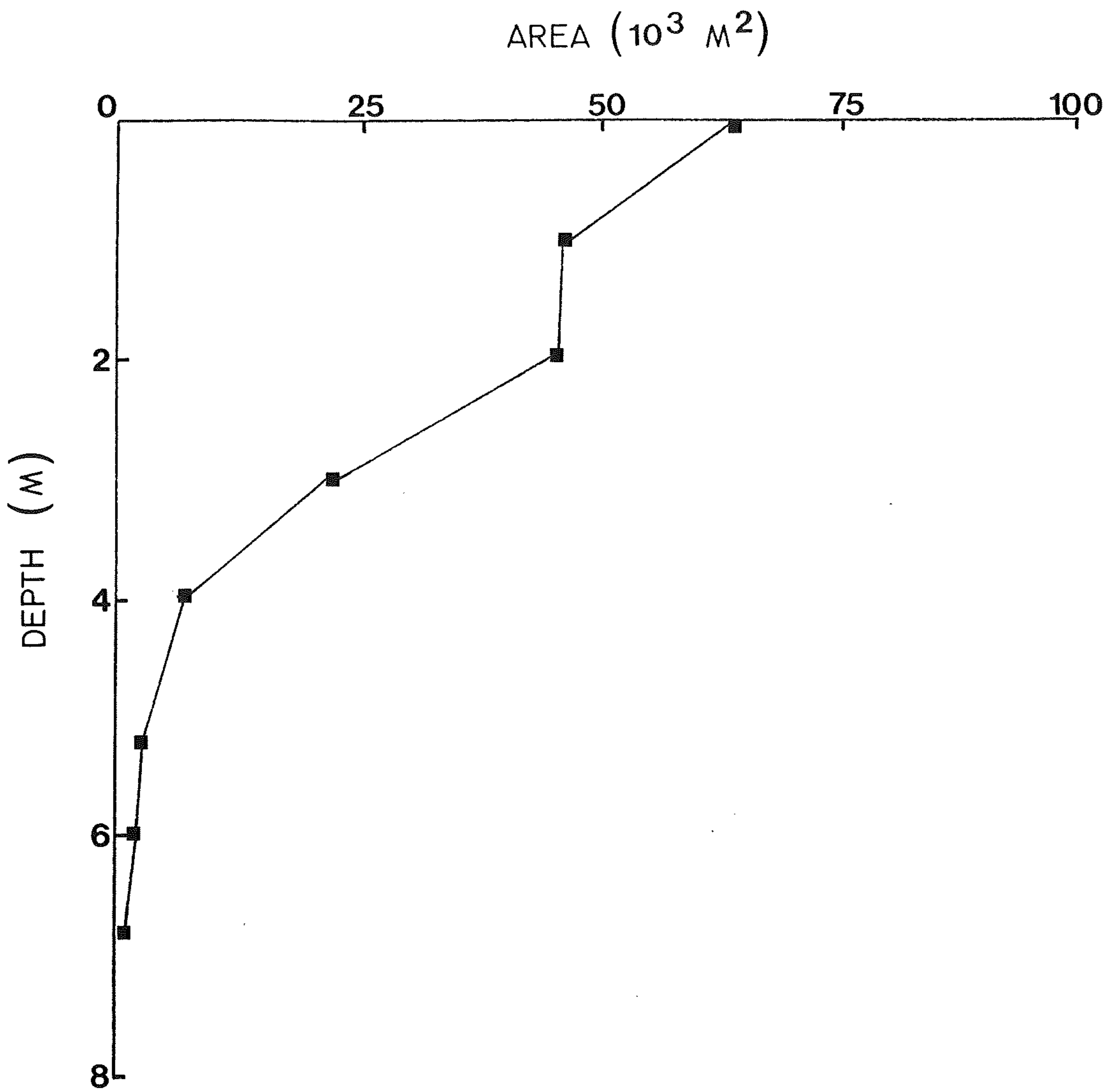

Figure 9. Hypsographic curve for Forbes Lake

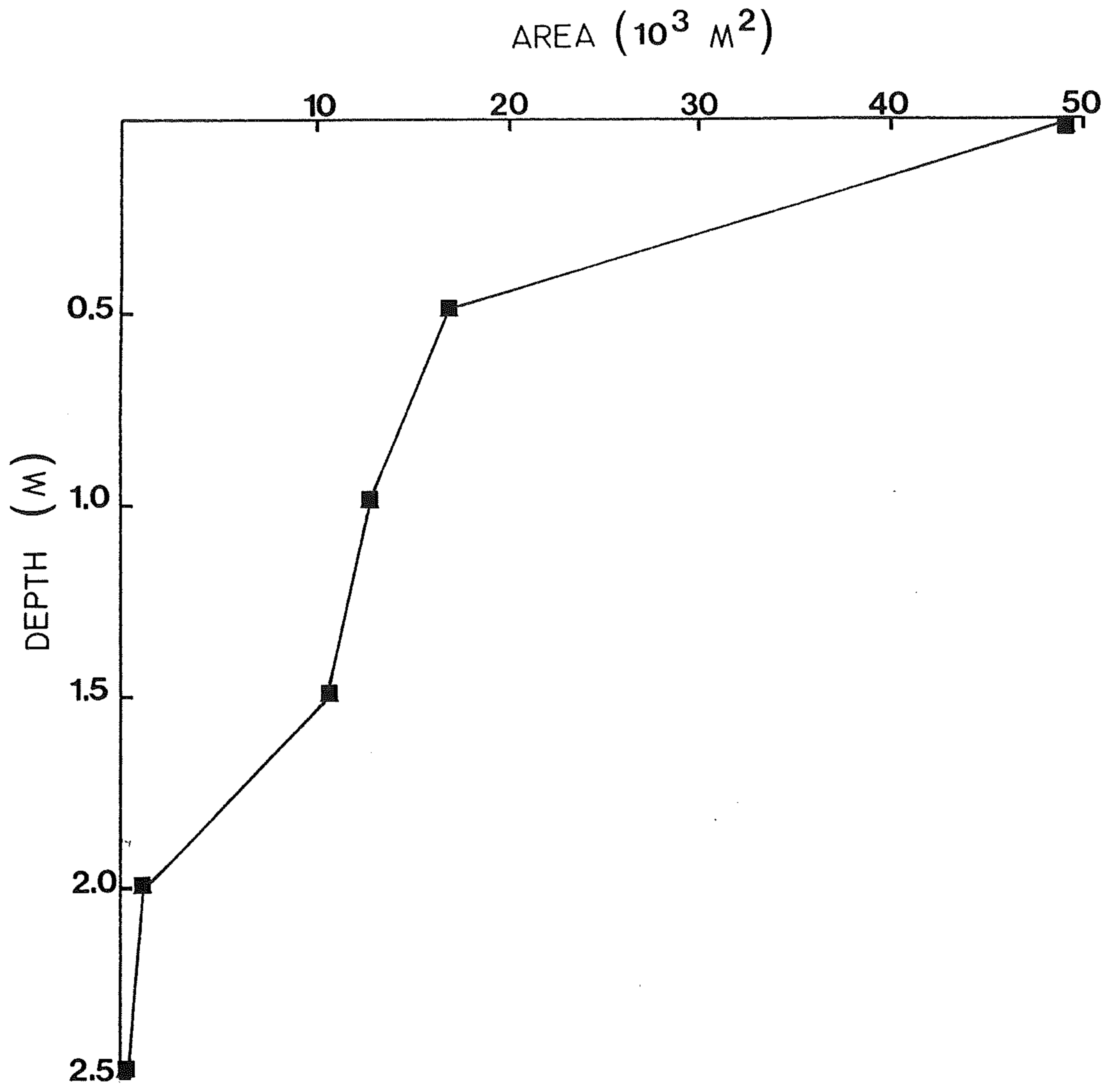

Figure 10. Hypsographic curve for Flat Lake

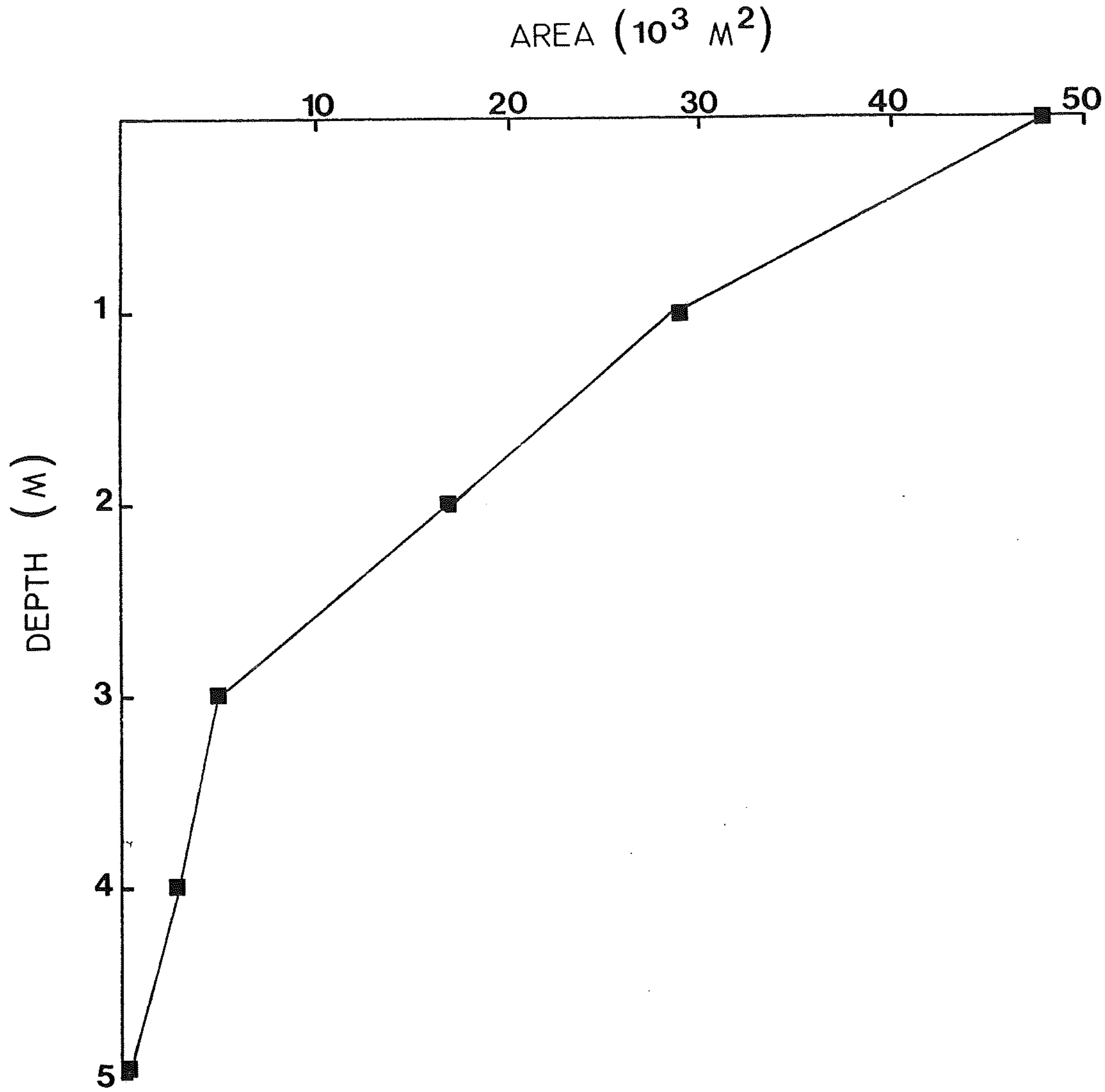

Figure 11. Hypsographic curve for Meadow Lake

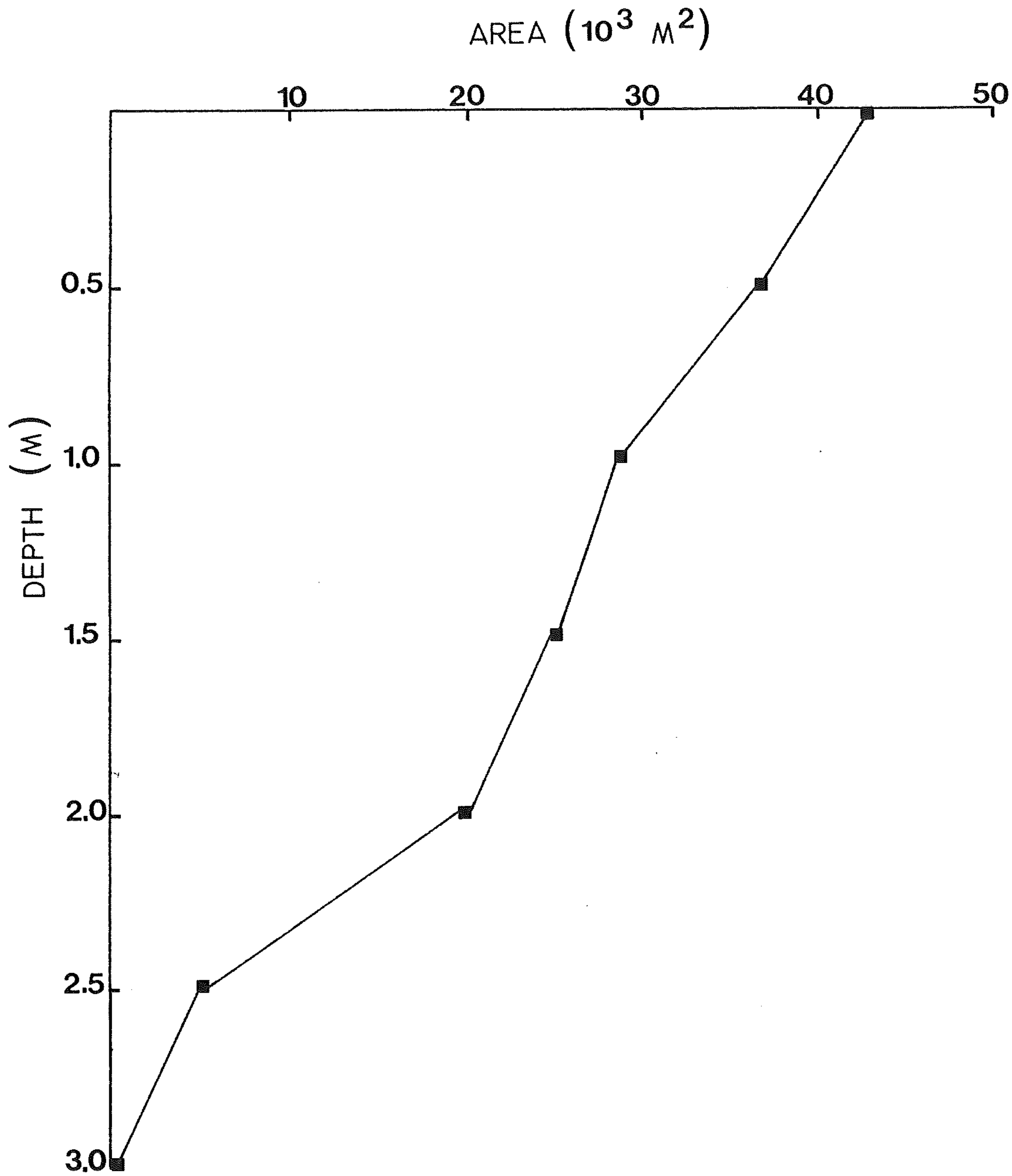

Figure 12. Hypsographic curve for Little Duck Hole

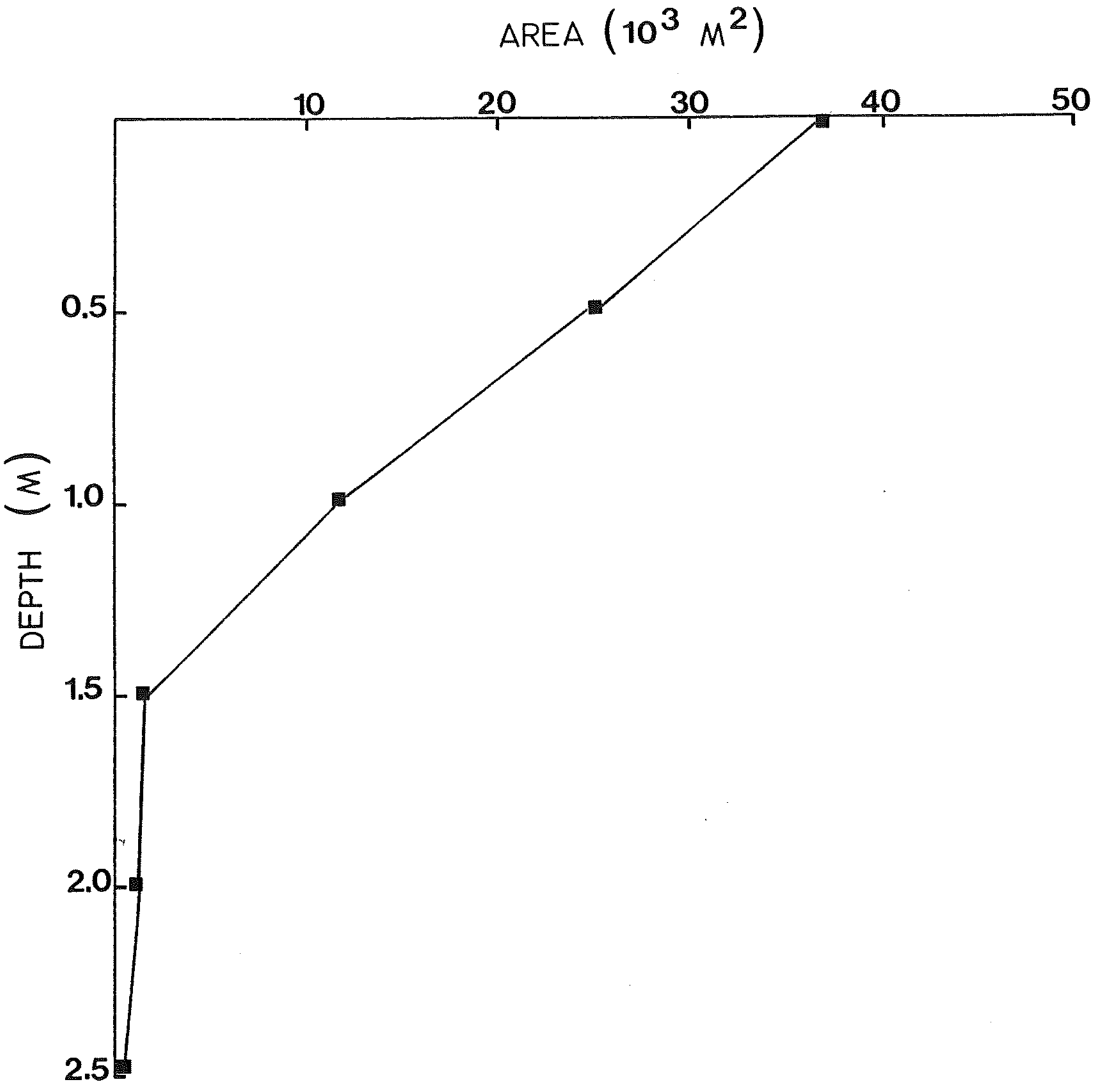

Figure 13. Hypsographic curve for Round Lake

Table 10. Drainage basin areas and flushing rates and flushing times

	Volume (m^3)	Drainage Basin Area (m^2)	Volume of Ppt.* (m^3/yr)	Flushing Rate (times/yr)	Flushing Time (days)
St. Catherines	104,900	2,366,000	3,075,800	29.32	12.45
Forbes	151,400	1,726,000	2,243,800	14.82	24.63
Flat	32,600	1,357,000	1,764,100	54.11	6.75
Meadow	86,320	665,000	864,500	10.02	36.45
Little Duck	67,700	727,000	945,100	13.96	26.15
Round	37,540	460,000	598,000	15.93	22.91

*Based on an average annual precipitation rate of 130 cm were made however, and, although crude, can be used to obtain an approximate indication of euphotic zone depths. In general, euphotic zone depths are about three times Secchi depth readings. Table 11 presents the results obtained at each lake. There was relatively little variation between lakes, most readings falling between 1.5-2.0 m. These observations indicate that, with the exception of the deepest parts of Forbes lake, sufficient light penetrates to the bottom to allow photosynthesis by benthic plants. In addition, despite the rapid attenuation of light typical of brown water systems, the lakes are shallow enough to allow net phytoplankton growth within the entire water column.

5.4 Temperature

Surface water temperatures at the time of the site visits ranged between 14.6 and 25.5^{o}C (Table 11). With the exception of Forbes Lake there was no indication of thermal stratification within the water column. Forbes Lake had a thermocline which began at about 2 m and extended to about 5.5 m (Figure 14). Since this lake was visited only once it is difficult to comment on the stability of this stratification. However, the depth of the lake together with its irregular shape which would inhibit wind induced mixing as a result of the limited fetch, suggest that it could be a common characteristic of this lake. The other lakes, which are much shallower, probably exhibit only intermittent stratification during periods of hot calm weather, if at all, and are probably polymictic (mixing at irregular intervals more frequent than twice per year) which would not result in permanent stratification.

5.5 Sediments

Visual examination of sediment types revealed very little variation within or between each lake. Sediments were composed of a fine brown organic material of the *dy*[a] type which is characteristic of brown-water dystrophic lakes. There was no indication of anaerobic conditions within the sediments.

5.6 Chemical Characteristics

The chemistry of all lakes was found to be similar and typical of low nutrient, infertile, acidic brown-water lakes (Table 12). Conductivity, total hardness and inorganic micronutrient concentrations are extremely low. Inorganic phosphorous is particularly low and is probably the most important limiting micronutrient. Although silicate concentrations are also low, it should be noted that measurements were made during the spring and summer when much of the silicate present could be bound up in diatoms (the chemical technique for

[a]A bottom deposit of precipitated humic colloids.

Table 11. Surface temperatures, Secchi depth readings and chlorophyll *a* concentrations

Lake	Temp. (^{o}C)	Secchi Depth (m)	Chlorophyll *a* (ug/1)
St. Catherines	15.8	1.5	2.5
Forbes	21.5	1.5	1.3
Flat	25.5	2.0	2.1
Meadow	20.0	1.5	2.6
Little Duck Hole	19.2	1.7	3.3
Round Lake	14.6	1.7	2.2

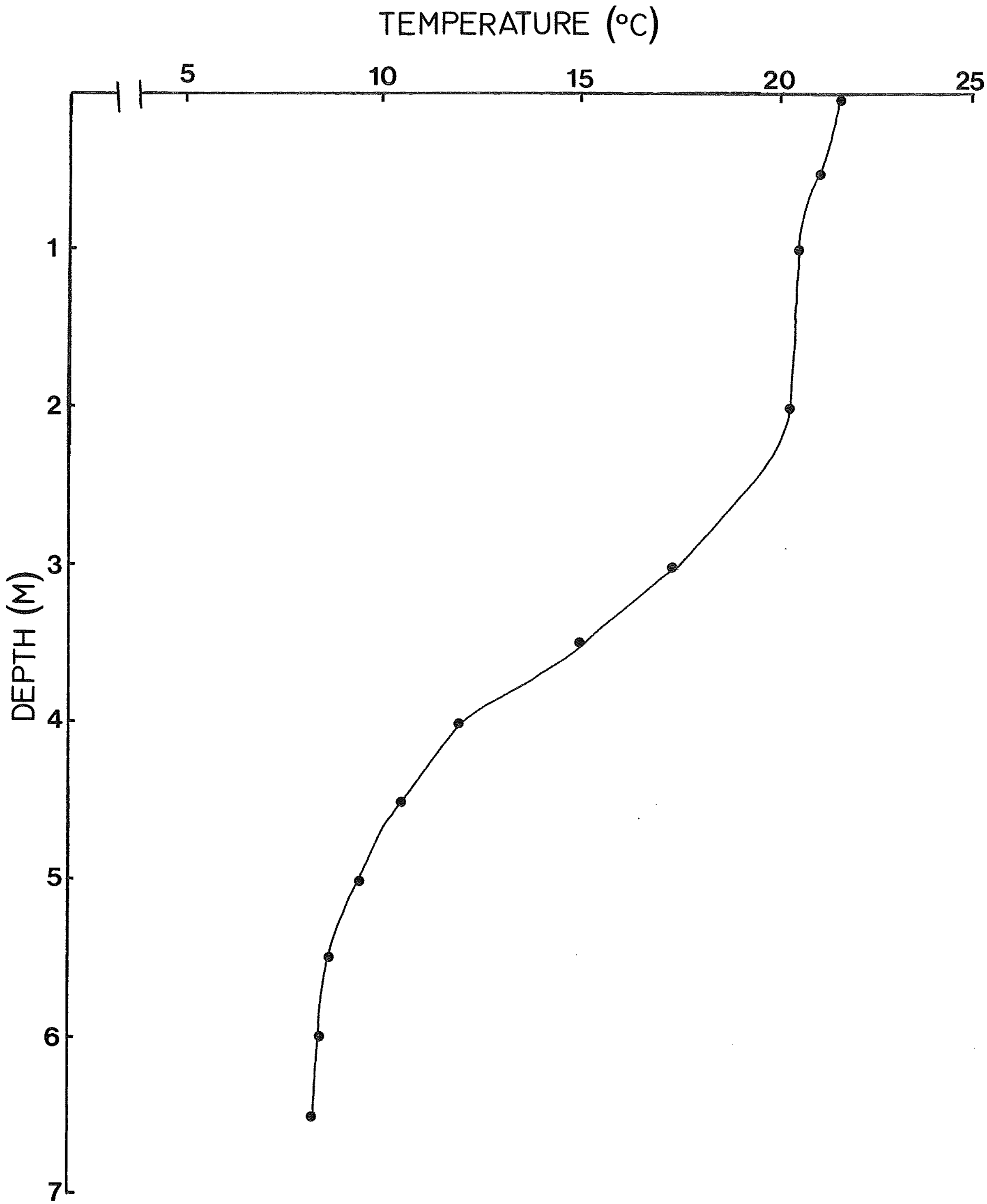

Figure 14. Temperature profile at Forbes Lake on July 10, 1987

Table 12. Chemical characteristics

Lake	Depth (m)	Conductivity (umhos/1)	Total Hardness (mg/1)	Alkalinity (mg $CaCo_3$/1)	pH	Dissolved Oxygen (mg/1)	Oxygen % SAT	Reactive Silicate (mg/1)	Nitrate (mg/1)	Total Phosphorous mg/1	Ortho-phosphate mg/1
Flat	0	50	2	0	4.80	7.30	91.4	<0.1	5.5	0.3	0.2
	5	49	2	0	4.75	7.25	91.3	–	–	–	–
Forbes	0	43	2	0	4.95	8.10	95.0	<0.1	4.0	0.5	0.3
Meadow	0	46	2	0	4.30	8.90	100.6	<0.1	5.0	0.4	0.1
Round	0	58	6	0	3.95	8.40	86.1	0.1	27.0	8.0	0.3
St. Catherines	0	49	2	0	4.70	8.72	91.5	0.4	30.0	0.5	0.2
Little Duck Hole	0	48	2	0	4.35	8.60	93.2	<0.1	21.2	0.3	0.1

determination of reactive silicate does not measure bound silicate). pH values ranged between 3.95-4.80 and alkalinity was essentially zero indicating that these lakes are very susceptible to the affects of atmospheric acid deposition and contain virtually no free carbon dioxide. Oxygen concentrations were always high (>85% saturation) and there was no indication of anaerobic conditions ever developing, even within the hypolimnion of Forbes Lake where the presence of a thermocline would inhibit the introduction of atmospheric oxygen to bottom waters.

5.7 Biological Characteristics

Although exhaustive sampling of the lake biota was not attempted, chlorophyll *a* concentrations, zooplankton collections, and aquatic macrophyte observations indicated that both species diversity and biomass of aquatic organisms is low in all lakes. Chlorophyll *a* concentrations were always <4 ug/1, and it is possible that even these estimates are high as a result of the often erroneously high values obtained when measuring chlorophyll levels in brown-water systems. The zooplankton community consisted primarily of copepods with lesser numbers of cladocerans and rotifers. The most prominant copepod was *Diaptomus minutus*. *Bosmina sp.* and *Keratella sp.* were the most common cladocerans and rotifers respectively.

A total of 13 species of macrophytes were identified. All lakes contained *Sphagnum sp.* on the bottom and *Nuphar variegatum* was the most dominant floating macrophyte in all lakes. Meadow and Forbes Lakes had the greatest diversity of macrophytes.

No attempt was made to determine species composition of the phytoplankton, benthos and nekton communities.

Table 13. Major aquatic macrophyte species observed at each lake

Species	Meadow Lake	Flat Lake	Round Lake	St. Catherines	Forbes	Little Duck
Batrochospermum sp.	X		X		X	
Nuphar variegatum	X	X	X	X	X	X
Nymphaea odorata		X			X	
Sphagnum sp.	X	X	X	X	X	X
Pontederia cordata	X	X			X	X
Utricularia geminiscapca	X			X	X	
Lobelia dortmanna					X	
Eriocaulon septangulare	X	X	X		X	
Lysimachia terrestris	X				X	
Carex rostrata var. utriculata	X	X	X			X
Dulichium arundinaceum	X					
Pallavicinia sp.			X		X	
Fontinalis sp.						X

Table 14. Major zooplankton species collected at each lake

	Flat Lake	Forbes	Meadow Lake	Round Lake	St. Catherines	Little Duck
Diaptomus minutus	X	X	X	X		
Epischura nordenskioldi	X	X	X	X		
Cyclops	X	X	X			
Sida	X	X	X			
Bosmina	X	X	X	X		
Holopedium gibberum				X		
Polyphemus pediculus	X			X		
Keratella	X	X				

Table 15. List of taxa taken in zooplankton tows

Phylum Porifera	Spongilla sp.
Phylum Nematoda	unidentified
Phylum Rotifera	Keratella sp.
Phylum Annelida	
Class Oligochaeta	unidentified
Phylum Arthropoda	
Class Crustacea	
Order Copepoda	Diaptomus minutus Epischura nordenskioldi Cyclops sp.
Order Cladocera	Bosmina (prob. coregoni) Sida (prob. crystallina) Polyphemus pediculus Holopedium gibberum Graptolebris testudinaria Pleuroxus (prob. hastatus) Alona (prob. quadrangularis) Acroperus harpae Daphnia sp.
Subclass Ostracoda	unidentified
Class Insecta	
Order Hemiptera	Family Corixidae (adults)
Order Diptera	Family Chironomidae (larvae)
Order Trichoptera	(larvae)
Order Odonata	prob. Family Coenagrionidae (naiads)
Order Coleoptera	Family Dytiscidae (larvae) Gyrinus sp. (naiads)
Class Arachnida	unidentified
Phylum Chordata	
Class Amphibia	unidentified (larvae)

6. DISCUSSION

6.1 General Overview

The lakes contained within the Seaside Adjunct are all typical brown-water dystrophic lakes of the type characteristically found in areas of poor soil development and drainage basins dominated by coniferous vegetation. These lakes tend to be naturally acidic as a result of the input of humic acids leached from decomposing coniferous vegetation and the presence of a soil type that lacks leachable salts, particularly calcium and bicarbonates, and therefore exports little buffering capacity to these systems.

In addition to imparting a brown color which attenuates light rapidly, the humic substances entering these lakes often complex micronutrients making them unavailable to both phytoplankton and macrophytes. As a result, both light and nutrient availability are low and autochothonous production (i.e., originating within the lake) within the lakes remains low. With the possible exception of Forbes Lake, it is doubtful that any of the lakes undergo thermal stratification, and there is little chance that nutrients entering the lakes have the opportunity to settle out into an unflushed hypolimnion and the chance that nutrient concentrations could build up over long time periods is improbable.

Organisms that could exist on allochothonous inputs (i.e., originating outside the lake), which may be significant energy inputs in these systems because of their small size and therefore greater proximity of the water mass to the shoreline where these inputs originate, are subject to an environment of low pH and acidic conditions. As a result these lakes are relatively unproductive in terms of both primary producers and consumers and, with the current trend towards decreasing pH resulting from atmospheric acid deposition, they will probably become less productive in the future unless alterations with the drainage basins of the lakes result in increased buffering capacity or nutrient input.

6.2 Evaluation of Freshwater Resources

6.2.1 Ecological Significance/Uniqueness/ Scientific Inportance

All of the lakes within the Adjunct are dystrophic and represent a class of lakes that, although quite common in the Atlantic Maritimes as well as other parts of the world where coniferous vegetation is common, have not been well studied. The acidic brown-waters contained within these lakes impart a number of unique characteristics with respect to the functional aspects of these systems. Both light and nutrient availability are low and allochothonous production limited, making the input of autochothonous materials, particularly dissolved organic compounds, potentially important energy sources. In the past, these materials, composed largely of humic and fluvic acids, have been considered relatively refractory and generally unimportant as an energy source for aquatic organisms. However, more recent studies have shown that a considerable diversity of organisms, primarily fungi and bacteria, are often present in these systems and, although their metabolic rates are not particularly high, they are now suspected of playing an important role in the energetics of those systems. As such, these lakes are interesting and unique systems for studying the potential pathways of energy transfer in highly organic waters.

6.2.2 Interpretive Value

Considerable potential for interpretation exists within the lakes of the Adjunct. Although most of the lakes probably have their origins in glacial recession events, the details of the events may exhibit considerable variation. For example, as mentioned previously, Round Lake may represent a kettle lake which, although a result of glacial activity, represents an event quite different from glacial scouring. In addition, the morphology of the lakes varies and although this may be partly a result of glacial activity, it may also be related to the successional stage occupied by each of the lakes. This would provide an interesting topic for study.

Perhaps the greatest opportunity for interpretation of the lakes of the Adjunct lies in a comparative study of these lakes with those located within the Kejimkujik National Park at Maitland Bridge, N.S. The latter have been relatively well studied and there exists considerable diversity among them in terms of morphology, chemistry, physics and biology. It would be interesting to determine how the lakes of the Adjunct fit within some of the continua exhibited by those lakes. Topics for comparison could include successional stage, pH levels, nutrient concentration, mixing type and aquatic macrophyte species composition.

6.2.3 Recreational Potential and Constraints

The recreational potential of the lakes within the Adjunct appears to be quite limited when viewed from the more traditional recreational uses of freshwater systems. None of the lakes have natural beaches and the darkly stained waters are generally uninviting for swimming. In addition, the soft bottoms of fine organic sediments makes wading difficult and generally unpleasant. With the possible exception of Forbes Lake, which has the easiest access and the most irregular shoreline, canoeing within the lakes is relatively uninteresting and access, especially if carrying a canoe or small boat, is difficult. The opportunity for fishing is probably also limited. It is doubtful if any of the lakes have substantial fish populations and those that may would most likely have populations that are already stressed as a result of the acidic conditions.

Perhaps the major attraction of the lakes is as focal points for day-hikes or overnight camping trips since they do provide an interesting change in habitat from the mixed forest that occupies most of the upland area of the Adjunct.

Although we did not observe any waterfowl on or near the lakes during our site visits, it is probable that considerable opportunity for birding activities exist, especially during periods of spring and fall migrations. The general habitat conditions around both Meadow Lake and Little Duck Hole suggest that some nesting activities may occur at these sites. Indeed, Little Duck Hole's name implies that waterfowl frequent this site.

6.2.4 Preservation/Management

The general policy of lands managed by Environment Canada Parks is to maintain their natural characteristics. In this respect management is mainly preventative in nature and involves making the area usable to visitors without placing undue strain on the natural evolutionary processes occurring within the Park systems. For the freshwater systems of the Adjunct, as with any freshwater system, major attention should be placed on evaluation of any changes that may occur within the drainage basins. Major impacts on freshwater basins are usually the result of alterations in drainage basins as opposed to activities that directly affect the water body. In this regard, preservation and management should firstly concern itself with activities that alter the drainage basins. In particular, for those lakes that have parts of the drainage basin located outside of Park boundaries (Forbes and Flat Lake) a cooperative relationship should be developed with the land owners to insure that activities detrimental to the these lakes do not occur.

Of considerable importance would be consideration of activities that would lead to increased nutrient inputs into lakes since this would undoubtedly have the greatest influence on the nature of these systems. Runoff of fertilizer from agriculture and/or forestry operations as well as improperly treated sewage originating within or outside the Park should be avoided.

Other activities that should be carefully considered include urban developments and agriculture and forestry operations that may result in erosion and silting or alteration of stream inputs, and runoff of herbicides and pesticides.

With respect to activities that directly affect the water bodies themselves, careful consideration should be given to the input of sewage which would become a problem if plans for the development of campsites around the lakes are being considered.

6.3 Monitoring Suggestions

As indicated in the previous section, the greatest potential for changes occurring in the lakes of the Adjunct arises from potential alterations within the drainage basins. As such, the most important monitoring activities should centre on careful observation of potential changes within watersheds. Particular attention should be paid to urban development and sewage disposal systems in drainage basins located outside the boundaries of the Adjunct as well as on agriculture and forestry operations in these same areas.

Within the Park itself, careful consideration should be given to road construction and forestry operations, including maintenance of boundary lines, with respect to the potential these activities would have in terms of both erosion and nutrient inputs.

If the development of recreational facilities proceeds within the Park, the effect on watersheds should be carefully considered and monitored, particularly in terms of increased nutrient inputs. For sewage in particular, small inputs of nutrients may have a large affect on the lakes, particularly the smaller ones, because of the low nutrient levels natural to these systems.

The lakes of the Adjunct should be integrated into the LRTAP programme presently being carried out at Maitland Bridge, N.S. Bimonthly water samples of all lakes for total hardness, conductivity, alkalinity, and pH determinations would not require too great an effort and would provide a good data base for the continual evaluation of the affects of atmospheric acid deposition which is probably the most critical factor presently affecting the biological characteristics of these systems.

6.4 Suggestions for Future Research

As noted in the Introduction, the financial resources available for this study were limited and only a basic survey was possible. Emphasis was placed on obtaining information on the morphological and chemical characteristics of each lake since it is these factors that determine to a large extent the physical and biological characteristics. Although sampling and observations of the biological communities present were made, this was far from exhaustive. Future research should concentrate on obtaining a more intensive survey of the biota in terms of both species composition and productivity. In particular, information should be gathered on phytoplankton composition and production, benthic community composition, and the kinds of fish populations present in each lake.

Other information that would be useful in evaluating the resource potential of these lakes is an indication of water quality characteristics during winter conditions, particularly oxygen levels in those lakes having dense benthic macrophyte populations.

A study examining seasonal variations in nutrient levels, particularly silicate, phosphorous and available carbon is also necessary to fully understand the factors that control autochothonous production and the factors most likely to be limiting in each system. This should be considered in terms of seasonal variations in flushing rates and the presence and frequency of stratification events.

With respect to the interactions between lakes and how events in one may affect others it would be useful to survey the creek and stream systems within the Adjunct to determine the amounts of water carried between lakes, the nature of changes in water quality as water moves between lakes, and the input/output characteristics of each lake.

The streams and creeks within the Adjunct should be the subject of study in terms of the types of biological communities present.

7. REFERENCES

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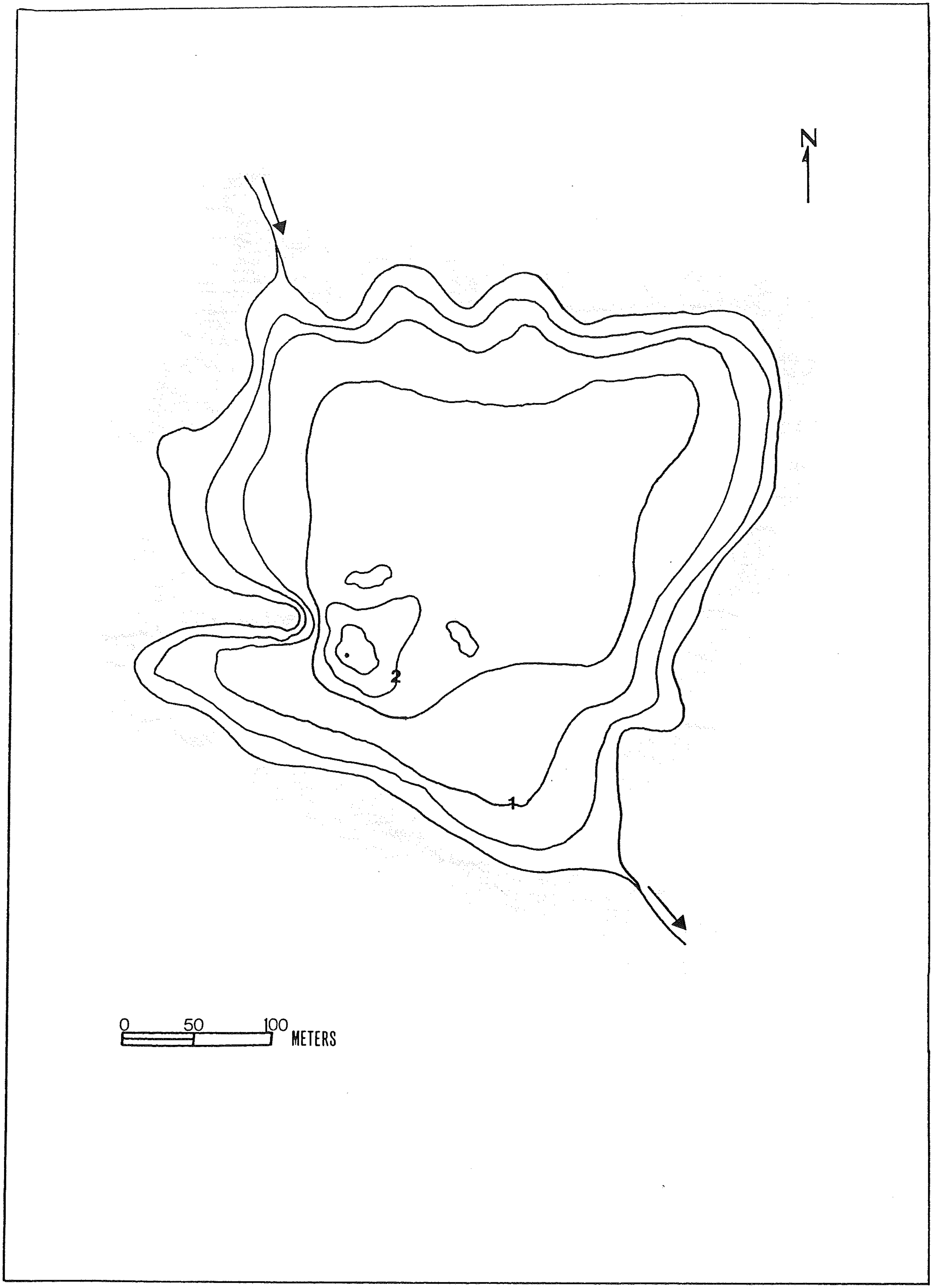
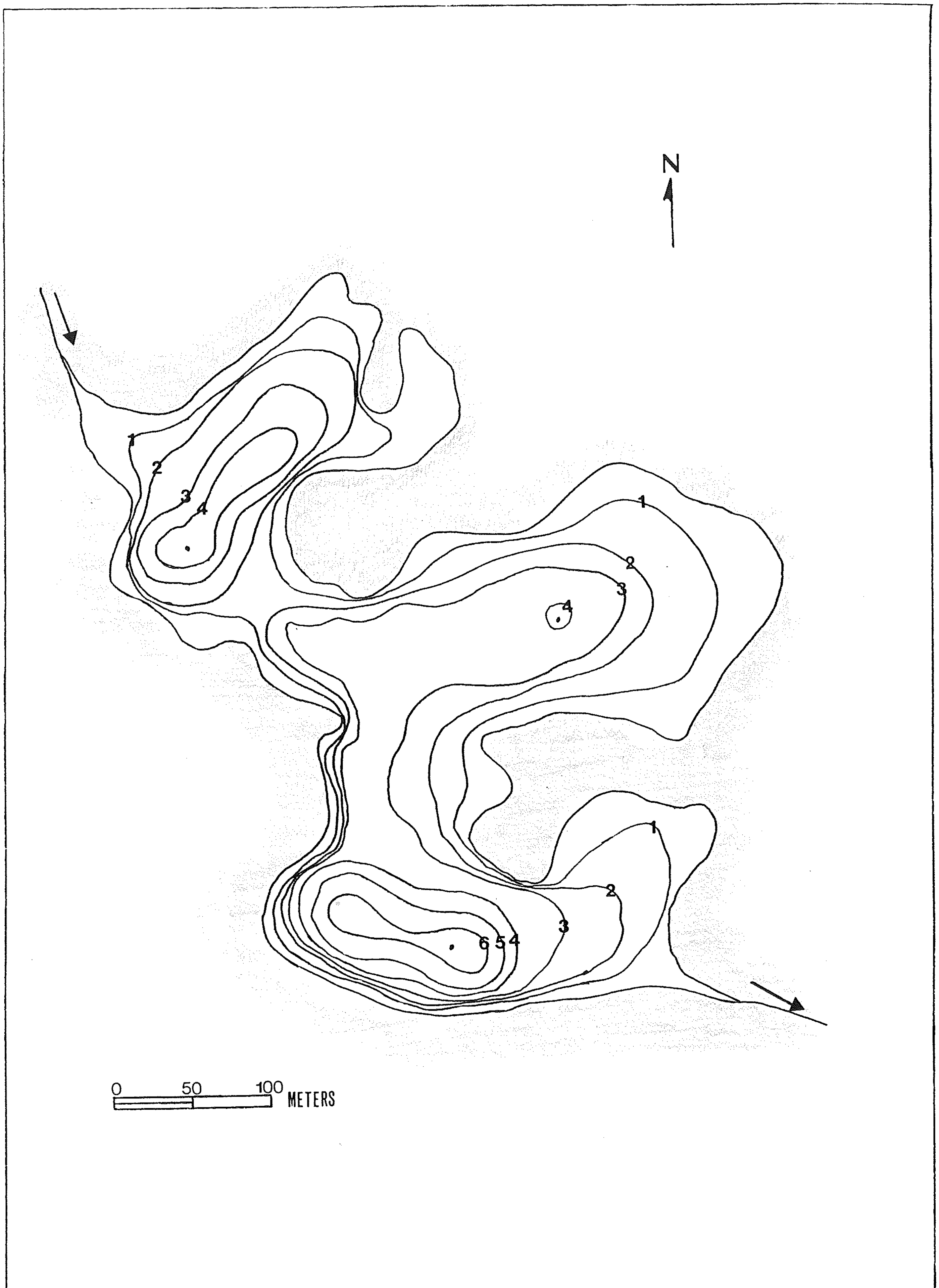
8. APPENDICES

Appendix A: Bathymetric Maps



St. Catherines River Lake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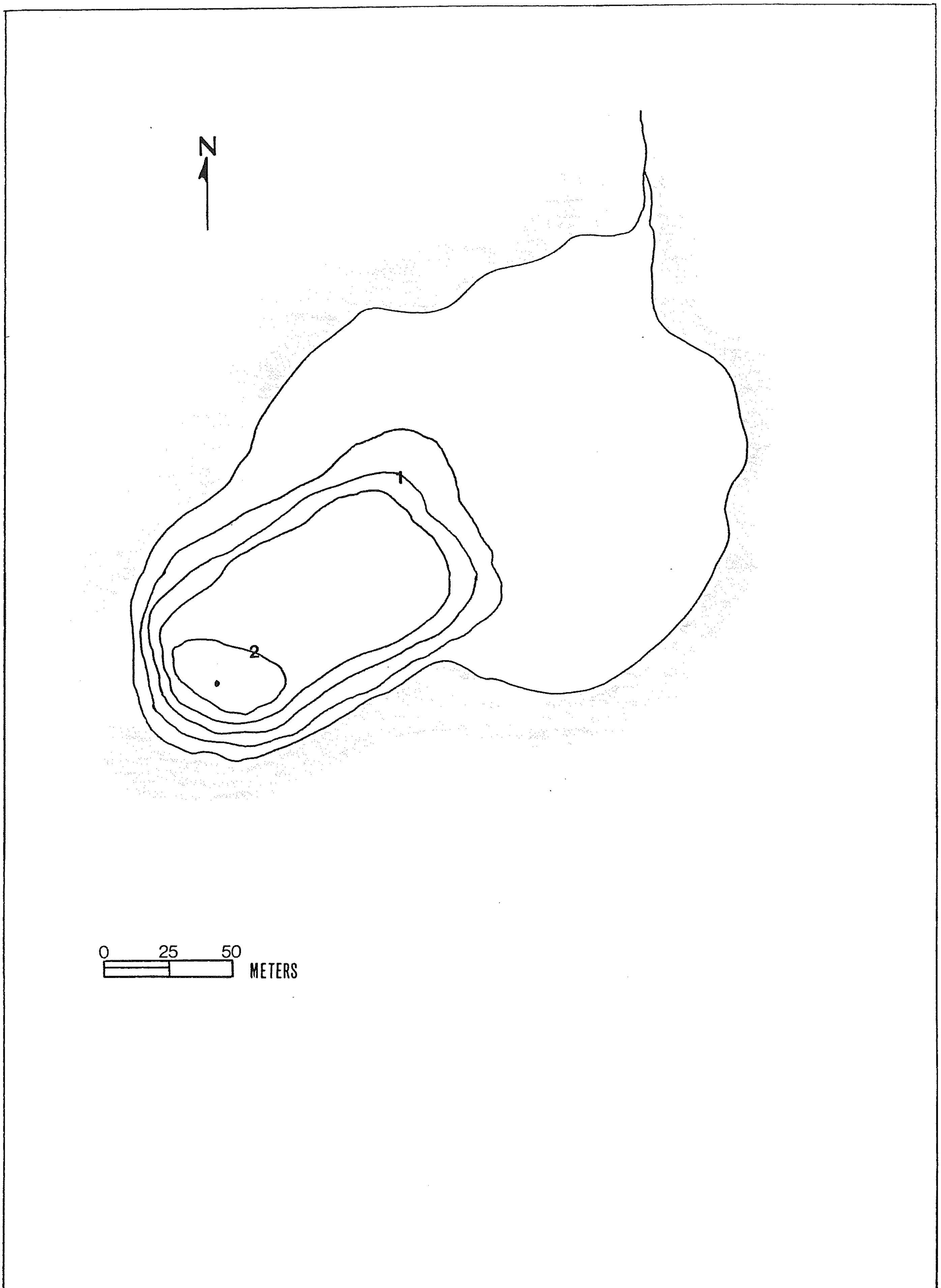
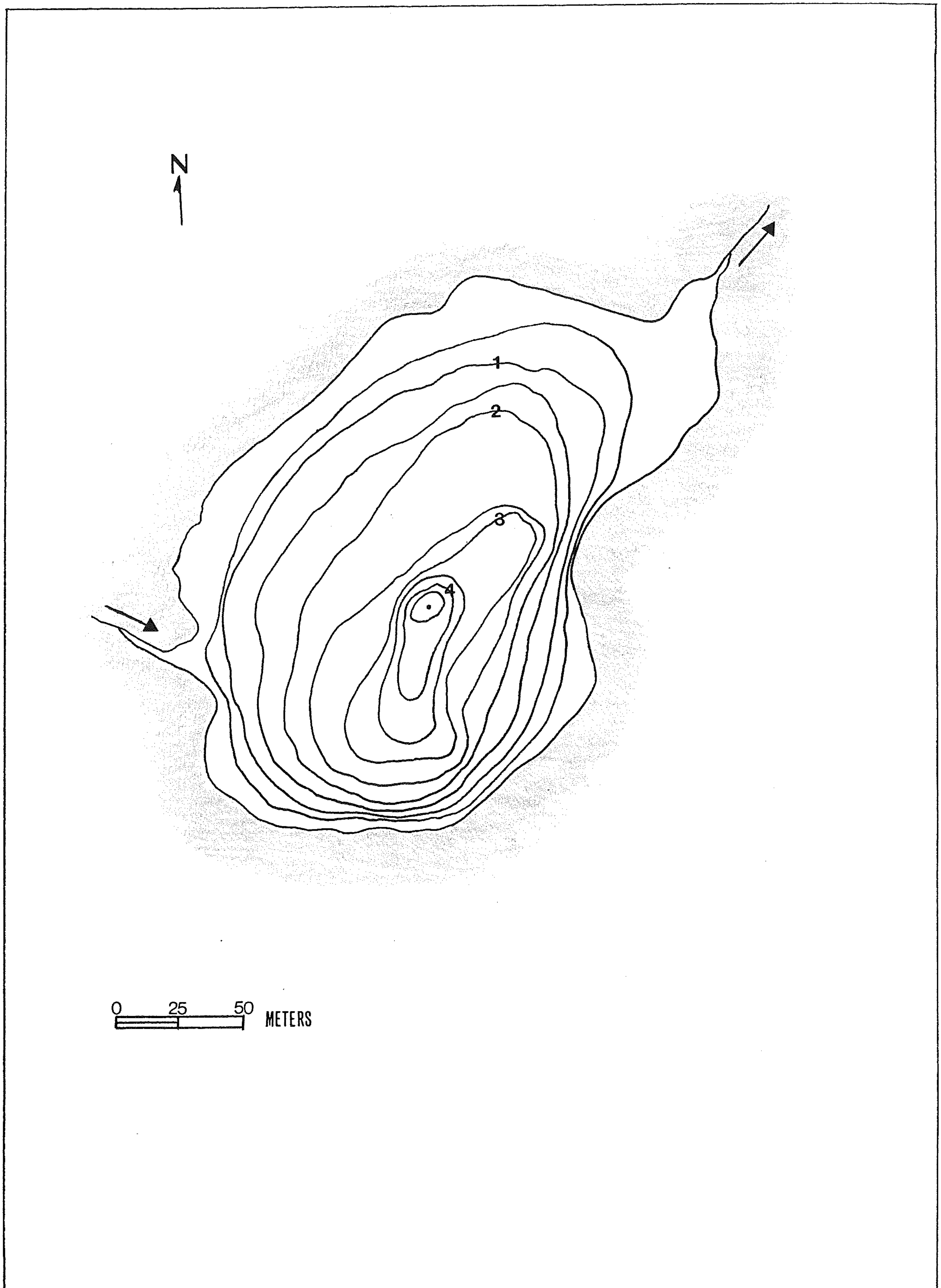


Flat Lake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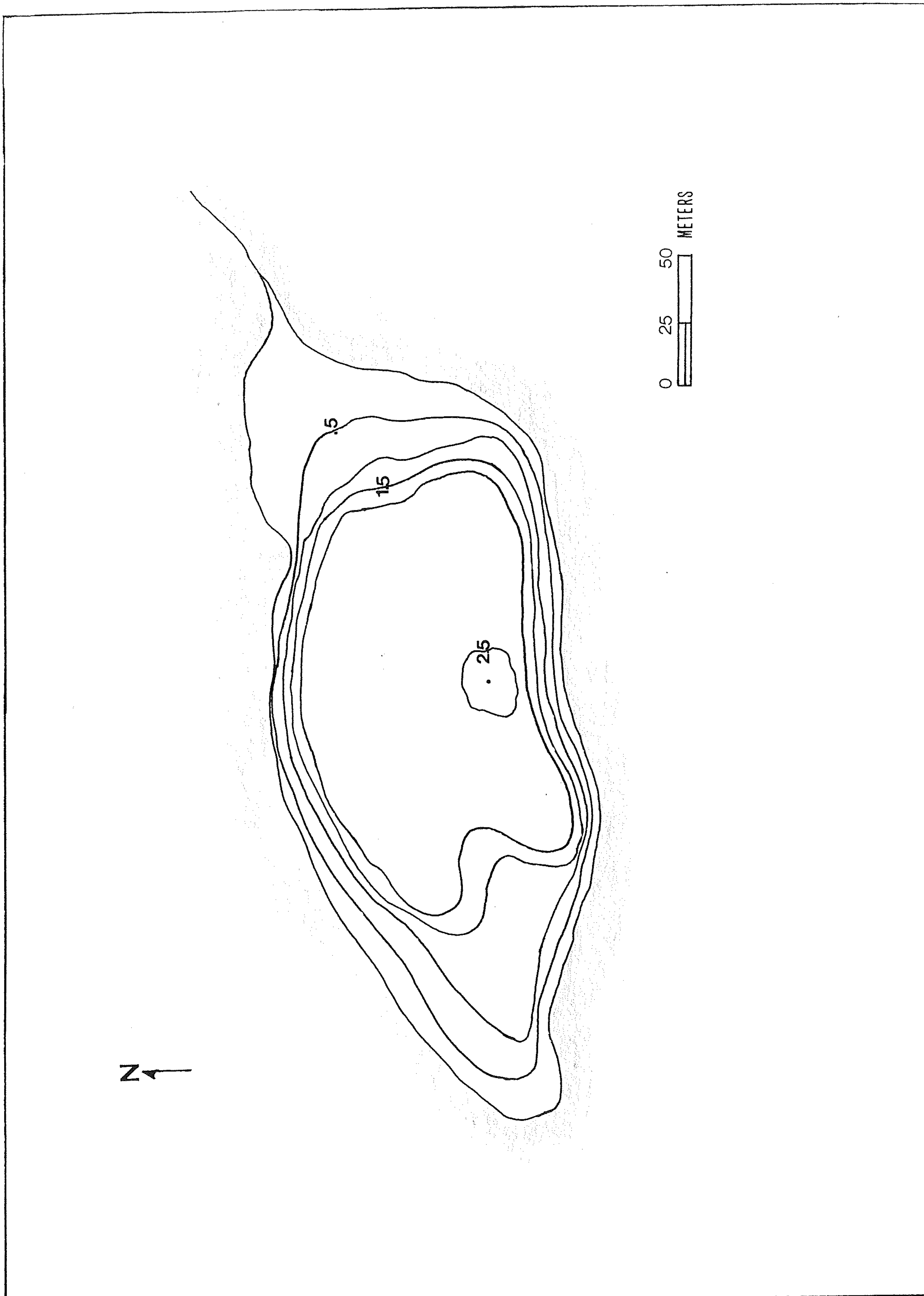
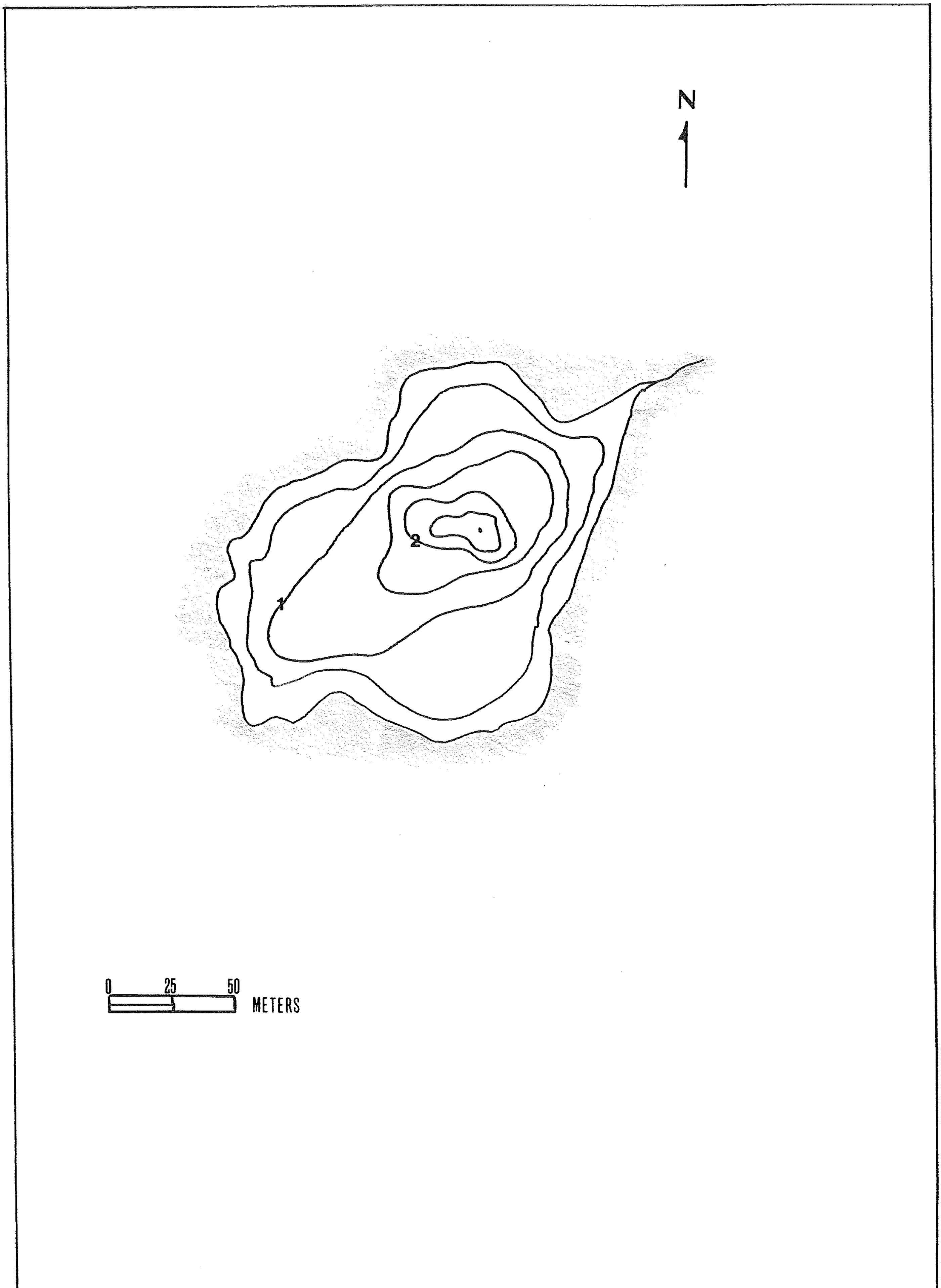


Little Duck Hole



Round Lake

Appendix B. List of samples and organisms collected

Sample No.: 1
Location: St. Catherines Lake
Date: June 12, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

- Diaptomus minutus
- Epischura nordenskioldi
- Nauplii
- Copepodites
- Sida sp.
- Bosmina sp.
- Keratella
- Nematode (unidentified)
- Ostracods (unidentified)
- Foraminiferans (unidentified)

Sample No.: 2
Location: Round Lake
Date: June 14, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

- Diaptomus minutus (416)
- Epischura nordenskioldi (2)
- Nauplii (8)
- Copepodites (353)
- Graptolebris testudinaria(1)
- Bosmina sp. (282)
- Holopedium gibberum (11)
- Polyphemus pediculus (1)
- Daphnia sp.
- Caddisfly larvae

Sample No.: 3
Location: Little Duck Hole
Date: June 16, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

- Diaptomus minutus (55)
- Nauplii (54)
- Copepodites (140)
- Graptolebris testudinaria(8)
- Bosmina sp. (104)
- Polyphemus pediculus (5)
- Alona sp.
- Pleuroxus sp.
- Epischura nordenskioldi
- Caddisfly larvae
- Chironomid larvae
- Water Boatmen
- Tadpoles (unidentified)

Sample No.: 4
Location: Meadow Lake
Date: June 16, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

Diaptomus minutus	(132)
Epischura nordenskioldi	(9)
Cyclops sp.	(19)
Nauplii	(2)
Copepodites	(473)
Bosmina sp.	
Sida sp.	(9)
Spongilla sp.	

Sample No.: 5
Location: Flat Lake
Date: July 11, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

Diaptomus minutus	(168)
Epischura nordenskioldi	(6)
Nauplii	(229)
Copepodites	(367)
Graptolebris testudinaria	(1)
Bosmina sp.	(56)
Polyphemus pediculus	(13)
Sida sp.	(3)
Pleuroxus sp.	
Keratella	
Cyclops sp.	
Water Boatmen	
Water Mite (unidentified)	

Sample No.: 6.1
Location: Forbes Lake
Date: July 10, 1987
Type of Sample: Horizontal Zooplankton Tow
Specimens Collected:

Diaptomus minutus	(461)
Epischura nordenskioldi	(7)
Cyclops sp.	(5)
Nauplii	(4)
Copepodites	(206)
Graptolebris testudinaria	(4)
Bosmina sp.	(82)
Polyphemus pediculus	(1)
Sida sp.	(7)
Keratella sp.	(1)
Oligochaetes (unidentified)	(3)
Alona sp.	
Spongilla sp.	
Cladoceran (unidentified)	

Sample No.: 6.2
Location: Forbes Lake
Date: July 10, 1987
Type of Sample: Seine
Specimens Collected:

- Caddisfly larvae
- Dragonfly naiad (Family Coenagrionidae)
- Chironomid larvae
- Water Beetle larvae (Family Dytiscidae)
- Water Beetle larvae (Gyrinus sp.)
- Water Boatmen adults (several genera)
- Tadpoles (unidentified)
- Oligochaetes (unidentified)