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Lake Variability and Climate Research in Northwestern Ontario: Study Design and 1985–1986 Data from the Red Lake District

by

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Abstract

FEE, E.J., R.E. HECKY, M.P. STAINTON, P. SANDBERG, L.L. HENDZEL, S.J. GUILDFORD, H.J. KLING, G.K. MCCULLOUGH, C. ANEMA, AND A. SALKI. 1989. Lake variability and climate research in Northwestern Ontario: study design and 1985–1986 data from the Red Lake District. *Can. Tech. Rep. Fish. Aquat. Sci.* 1662: v + 39 p.

The design of the Freshwater Institute "Natural Variability and Climate Research" program is described. Detailed descriptions of field and laboratory methods used at the start of the program are given. Temperature profiles, Secchi disk depths and colors, and water chemistry data were collected from 115 lakes in the Red Lake District of Northwestern Ontario during midsummer 1985; these data are presented. From this one-time survey, six lakes—ranging in surface area from 88 to 34 700 ha but as alike as possible in all other respects—were selected for long-term study. During the ice-free season of 1986, these six lakes were sampled every three weeks for a wide suite of limnological parameters; these data are presented. Bathymetric maps of these six lakes are also presented.

Key words: limnology; natural variability; climate; methods; phytoplankton; chemistry; long-term monitoring; temperature; transparency; phytoplankton photosynthesis, phytoplankton primary production; phytoplankton nutrient deficiency status.

Résumé

FEE, E.J., R.E. HECKY, M.P. STAINTON, P. SANDBERG, L.L. HENDZEL, S.J. GUILDFORD, H.J. KLING, G.K. MCCULLOUGH, C. ANEMA, AND A. SALKI. 1989. Lake variability and climate research in Northwestern Ontario: study design and 1985–1986 data from the Red Lake District. *Can. Tech. Rep. Fish. Aquat. Sci.* 1662: v + 39 p.

On décrit la façon dont a été conçu le programme de recherche sur la "variabilité naturelle et le climat", mis en oeuvre par l'Institut des eaux douces. On décrit en détail les méthodes utilisées en laboratoire et sur le terrain au début du programme. On présente les données sur les profils de température, les profondeurs de disparition du disque de Secchi, la couleur et la chimie de l'eau qui ont été obtenues dans 115 lacs situés dans le District de Red Lake, dans le nord-ouest de l'Ontario, au milieu de l'été 1985. Au cours de ces mesures, on a choisi six lacs—de superficie variant de 88 à 34 700 ha, mais aussi semblables que possible à tous les autres égards—en vue d'effectuer une étude à long terme. En 1986, pendant que la surface était libre de glace, on a prélevé des échantillons dans six lacs à toutes les trois semaines, en vue de déterminer une grande gamme de paramètres limnologiques; on présente les données ainsi obtenues. On présente également les cartes bathymétriques de ces six lacs.

Mots-clés: limnologie; variabilité naturelle; climat; méthodes; phytoplancton; chimie; contrôle à long terme; température; transparence; photosynthèse par le phytoplancton; production primaire du phytoplancton; déficit en éléments nutritifs du phytoplancton.

Introduction

The year-to-year variability of biological, physical, and chemical properties of lakes is a subject of both theoretical interest and practical importance. Theoretical interest lies in the possibility of discovering causal relationships between the magnitude or pattern of temporal variability and physical characteristics of a lake or its drainage basin. That is, it may be possible to predict the magnitude or pattern of temporal variability of a lake from parameters such as superficial geological composition of the drainage basin, basin morphometry (e.g., surface area, shoreline development, mean depth, ratio of epilimnion volume to epilimnion sediment area, etc.), water renewal time, ratio of the area of bogs to the area of uplands in the drainage basin, or position of the lake in its drainage basin (headwater vs downstream).

Understanding how limnological variability is related to parameters that can be derived from maps and standard meteorological data will have three important applications. First, it will allow sampling programs to be designed for individual lakes. Although it is obvious that different sampling regimes are required to characterize environmental impacts accurately in lakes that have different magnitudes or patterns of variability, there is currently no theory available to guide the design of sampling programs. Data collected by well-designed sampling programs will be more reliable and thus of greater utility to resource managers. Second, it will allow estimates to be made of the uncertainty of results calculated from remotely-sensed data. For example, Fee et al. (1987) hypothesize that the variability of the relationship between chlorophyll concentration, which can be measured by remote sensing instruments, and phytoplankton photosynthesis (primary production), which can be calculated from chlorophyll data, is greater in small lakes than in large ones. Since fish yields are quantitatively related to photosynthesis (Nixon 1988), the implication of this hypothesis is that fish yield estimates derived from remotely sensed chlorophyll data will have lower error bounds in large lakes than in small ones. Third, the signal to noise ratio in time series data from long-term monitoring programs that are designed to document the limnological effects of low intensity, long duration phenomena (such as climate change or the long-range transport of atmospheric pollutants) will be higher if efforts can be focused on lakes with low natural variability.

Existing data sets have not been collected for the purpose of determining what factors control natural (inherent) variability of lakes; there are several reasons why these data are not well suited for this purpose. First, existing long-term data sets are available for groups of lakes that are either intensively studied and small (<50 ha in surface area, e.g., lakes in the Experimental Lakes Area (ELA) in northwestern Ontario) or extensively studied and large (>100 000 ha, e.g., the Laurentian great lakes). It is difficult to draw meaningful comparisons between such data sets because of their different spatial and temporal resolutions. Further, the absence of comparable data sets for lakes intermediate in size between these two extremes makes it difficult to develop and test theories. Second, previous research that has resulted in long limnological time series has focused on perturbed lakes. Global environmental threats (such as climate change and the long-range transport of atmospheric pollutants) underscore the need to characterize the structure, function, and variability of a broad spectrum of natural lakes before none are left. That is, it will be difficult to assess the impacts of global phenomena on the health of lakes if we only have data from "sick" lakes. Third, data from different studies have been derived from methods that cannot be directly compared. Indeed, analytical and sampling methods (or both) have been changed over time even in the same laboratory.

The purpose of the FWI "Natural Variability and Climate Research" project is to determine how limnological variability in unperturbed lakes is functionally related to information that can be derived from standard maps (geologic, topographic, and bathymetric) and climatic data available from standard observation networks (meteorological and hydrological). The study is composed of two parts (Fig. 1): 1) the Red Lake part focuses on the effect of lake size, keeping water renewal time constant; and 2) the ELA part focuses on the effect of water renewal, keeping lake size constant. This report presents the rationale used to select lakes for the Red Lake part of the study (the effect of lake size on natural variability). It also presents detailed descriptions of our research methods—which we intend to adhere to as closely as possible for the duration of this study, in an effort to eliminate methodological sources of variance. Finally, the 1985–1986 data obtained in the Red Lake study are archived here.

Field Studies

An ideal area for studying the effect of lake size on natural variability would have the following characteristics: 1) it would be easily accessible so that measurements could be made for at least ten yr at modest cost; 2) it would contain a large number of lakes of various sizes (from <100 to >10 000 ha); 3) it would be sufficiently remote that anthropogenic influences would be negligible; and 4) it would be geologically and meteorologically uniform.

The Red Lake district of northwestern Ontario (51°N, 94°W) matches the characteristics of the ideal study area in the following ways: 1) both major Department of Fisheries and Oceans (DFO) laboratories in this region (the Freshwater Institute in Winnipeg and the Experimental Lakes Area field camp near Kenora, Ontario) are within 150 km (a one hr floatplane flight); 2) it contains thousands of lakes, ranging in size from <1 to 34 700 ha; 3) most of it is only accessible by air and a large part of it is located in Woodland Caribou Wilderness Provincial Park, an extensive pristine wilderness in which development will be closely controlled in the future; and 4) it is all underlain by Canadian Shield bedrock, and experiences a severe temperate climate (cold winters, hot summers).

The field work reported here was performed in two phases. The purpose of the first phase was to determine the range of limnological conditions available in the Red Lake District. This work was completed during July and August of 1985, when 115 lakes, ranging in size from 1 to 34 700 ha (0.01 to 347 km^2) were sampled. The sampled lakes were assigned arbitrary numbers. Figure 2 shows the approximate location of each lake, and Appendix 1 contains the exact map coordinates of each lake. During this phase the following measurements were made: temperature as a function of depth, Secchi disk visibility, Secchi disk color, the volume of plankton captured by the zooplankton net, and water chemistry.

The second (ongoing) phase is long-term monitoring and process-oriented research on six lakes, ranging in surface area from 88 to 34 700 ha. Table 1 summarizes morphometric features of these lakes and bathymetric maps are shown in Fig. 3–8.[1] These lakes were the most similar in shape and putative water turnover time for their respective surface areas in the 1985 survey data. In 1986, we sampled these lakes at three week intervals from mid-May through mid-October, making the following field measurements and laboratory analyses: temperature and light as functions of depth, volume of plankton captured by the zooplankton net, phytoplankton, protozoa, picoplankton, and bacteria biomasses, phytoplankton species composition, water chemistry, chemical composition of seston captured by the phytoplankton net, and alkaline phosphatase activity (indicators of algal nutrient status), and phytoplankton photosynthesis.

[1]The maps of Linge, Musclow, Sydney, and Trout lakes were redrawn from depth charts, contoured in British units, supplied by the Ontario Ministry of Natural Resources; the maps of Green and Orange lakes were drawn from original depth transects obtained with a Furuno F6200 Mark III depth sounder.

Methods

Inconsistent application of sampling or analytical methods significantly degrades the value of long-term datasets. Rigid adherence to identical methods during the course of a study can overcome this problem. In practice, however, this ideal cannot be achieved because such things occur as instruments breaking down and being replaced with newer models, personnel changes (no two people do a procedure in exactly the same way), and more economical methods that give the same or better results becoming available over time. Nevertheless, it is our intention to adhere to the ideal of unchanging methods as closely as possible. As a first step towards this goal, we describe the methods in use at the start of our study in detail here. Any deviations from these methods will be documented in future reports. In this way, we will be made conscious of the potential consequences of changes in methods and will have a detailed record of all their occurrences.

Field Procedures

Most lakes were sampled from a Beaver floatplane, but, in 1985, lakes smaller than 75 ha were sampled from a helicopter. When a floatplane was used, it was anchored as close as possible to the point of maximum depth; the helicopter was not anchored. Samples were taken while standing on the aircraft pontoons. In 1985, the lakes were visited between 08:00 and 17:00 hr and water samples for chemical analysis were held overnight at 4°C. In 1986, sampling started between 07:00 and 09:00 hr and field work was finished four to six hr later. Laboratory analyses were begun no more than two hr after the last sample was taken.

Water sampling

Water samples were taken only from the epilimnia (mixed layers) of the lakes. All analyses on whole water (chemical composition, phytoplankton photosynthesis, plankton taxonomy and biomass, and phytoplankton nutrient deficiency status) were made on subsamples taken from a common epilimnion water sample.

Epilimnion water samples were collected with an integrating sampler made from a rubber stopper, two tubes, and a weight heavy enough to make an empty sampling bottle sink. Water enters the sample bottle through tube 1, which is made of silicon rubber (inside diameter 1 cm). When the stopper is seated in the bottle, this tube extends from the bottom of the stopper to the bottom of the bottle. At the stopper, it connects to a 5 cm piece of rigid nylon tubing that extends through the stopper. Tube 2 serves as an exit path for air. It is a 25 cm piece of hard nylon tubing (i.d. 4 mm) that extends through the stopper to a point just below the stopper inside the bottle. An epoxy-coated lead weight of sufficient mass to submerge the empty sample bottle and that can be clamped onto the bottom of the water bottle completes the sampler. Because the difference in hydrostatic pressure between the place where water enters the sampler (tube 1) and where air exits (tube 2) are constant, the rate of entry of water into the bottle is independent of depth.

Integrated samples were obtained by slowly ($0.1\ m{\cdot}sec^{-1}$) raising and lowering the sampler in the epilimnion until the bottle was full (three to four minutes). The integrating sampler parts were stored in a clean polyethylene bag when not in use. Tube 1 was never touched by hand or allowed to contact any part of the aircraft. Similarly, the line attached to the sampler was stored in a plastic bag and was not allowed to touch the aircraft. To avoid sample contamination, water samples were *never* taken from between the pontoons of the aircraft.

In 1985, samples were integrated from the surface to the bottom of the mixed layer, as determined from the temperature vs depth profile; in 1986, samples were integrated from the surface to a fixed depth of 3 m. In 1985, samples were not analyzed for phytoplankton photosynthesis or nutrient deficiency indicators so we used translucent 2 L polyethylene bottles; in 1986, 4 L polycarbonate bottles completely enclosed in gray PVC plastic (to protect the phytoplankton in the sample from direct exposure to full surface irradiances) were used. Sample bottles were stored in insulated containers during transport to the laboratory.

Temperature

Temperature vs depth measurements were made with resistance thermometers accurate to 0.1°C. In 1985 we used YSI and Montedoro-Whitney (CTU-3B) instruments; in 1986 we used a Flett instrument.

Transparency

Secchi Disk readings were made either in the shade of the aircraft wing or between the aircraft pontoons. We recorded the mean of the depths of disappearance and reappearance of a 25 cm disk with painted black and white quadrants.

In situ transparency profiles were made with cosine-corrected (flat plate) Li-Cor quantum sensors. Readings were taken on the sunny side of the aircraft, being careful that the sensor was not shaded by the pontoons or wings. The cable was held as far away from the pontoon as possible to avoid the influence of reflected light. Readings were made in the following manner: 1) the amount of light in the air was measured; 2) the meter was lowered to the greatest depth where readings were to be taken (usually 10 m) and then raised, taking readings at depth intervals of 1 m; 3) another reading in the air was then taken. If the final reading in the air differed from the first reading in the air by more than ten percent, the entire procedure was repeated. Extinction coefficients were calculated from the statistical regression of the natural logarithm of light (dependent variable) on depth (independent variable); only underwater data points were included in the regression.

Net plankton

Large diameter plankton and seston were sampled with two 1 m long Wisconsin nets (mouth diameter 25 cm, mesh size 73 μm) attached to the ends of a 1 m long metal bar. The retrieval line was attached to the center of the bar. This arrangement ensured that the sampling line did not pass through the axis of either net. Before sampling, the nets were rinsed two or three times with clips removed from the outflow tubes. The clips were then attached to outflow tubes, and the nets were lowered to a depth 1 m above the bottom. This depth was recorded and the net was slowly raised ($0.2\,m{\cdot}sec^{-1}$) to the surface. The nets were rinsed by lowering and raising them at the surface two or three times, being careful to not allow water to enter the mouths of the nets. The contents of the buckets were then emptied into a 250 mL jar. The nets were rinsed twice more with the outflow tubes clamped shut, and the rinse was add to the jar. Formalin solution was then injected into the jar to achieve a final concentration of 5%. Nets were rinsed twice more with the outflow tubes open and were stored in plastic bags.

Small diameter plankton and seston were collected by taking surface tows with a 10 μm mesh net. The sample was placed in a 500 mL polyethylene bottle and stored in an insulated box. At the laboratory, part of this sample was refrigerated until it could be examined qualitatively. The remainder was used for assessing phytoplankton nutrient deficiency status (see below).

Laboratory Procedures

In 1985, the entire 2 L water sample was processed by the chemistry laboratory. In 1986, the 4 L water sample was mixed by inverting it vigorously for 15–20 sec. Using a siphon made of glass and latex rubber tubing, subsamples were extracted in the following order: 1) 1 L in a polyethylene bottle for phytoplankton nutrient deficiency analyses; 2) 1 L in a PYREX bottle for phytoplankton photosynthesis measurements; 3) 1.5 L (three subsamples of 500 mL) in polyethylene bottles for chemical composition analyses; and 4) 500 mL in a polyethylene bottle for plankton biomass and composition determinations. The 4 L sample bottles were cleaned by rinsing them five times in deionized-distilled water. They were then dried by placing them upside down on paper towels.

Phytoplankton photosynthesis

Using a siphon made of silicone rubber, a 60 mL PYREX bottle was filled from the phytoplankton photosynthesis subsample. This was used for determining the concentration of dissolved inorganic carbon using an infrared gas analyzer (see chemistry methods below). A disposable plastic syringe fitted with an in-line disposable cellulose acetate membrane filter (0.45 μm pore size) and a short length of TYGON tubing was then used to add 6 mL of $NaH^{14}CO_3$ stock solution (approx. activity 7.4×10^5 Bq·mL^{-1} = 20 μCu·mL^{-1}) to the remaining phytoplankton photosynthesis subsample. After mixing by gently inverting the bottle, aliquots were dispensed into ten clear and two darkened 60 mL PYREX bottles. These bottles were placed into a light-gradient incubator for three hr. The incubator was a simple rectangular trough made of opaque PVC plastic except at the end next to the light source, which was made of transparent plexiglass (Fig. 9). A 150 watt high-pressure sodium fixture was the light source for the incubator. Because this type of light emits relatively little heat, it was easy to keep the incubator at *in situ* temperatures by adding ice once or twice during the three hr incubation. While the bottles were incubating, the light levels in the incubator were measured at each bottle position with a Biospherical QSP-200 spherical quantum sensor. At the end of the incubation period, the PYREX bottles were removed from the incubator. As they were removed, identical bottles filled with distilled water were inserted in their place so that the light field in the incubator was not altered for the remaining samples. Five mL was removed from each of the incubated PYREX bottles with an automatic pipette and put into glass scintillation vials that already contained 0.5 mL of 0.1 N HCl; the final pH in these scintillation vials was $\approx$ 2.5. Unfixed inorganic ^{14}C was removed from the scintillation vials by bubbling the contents with air for 20 min using the apparatus described by Shearer et al. (1985). In order to determine the exact amount of ^{14}C available for uptake, standards were prepared by pipetting five replicates of 5 mL each from any one of the incubated bottles into scintillation vials containing 150 μL of CO_2 MET (Amersham). Nine mL of Beckman Ready-Solv MP scintillation fluor was added to both the standards and the bubbled samples and their radioactivity was assayed on a Beckman liquid scintillation counter. Standards were counted for one min and samples were counted for 50 min or 10 000 disintegrations, whichever occurred first. After each experiment, the PYREX incubation bottles were cleaned by rinsing them in 0.05 N HCl; they were then rinsed five times in ELA lake water, three times in distilled water, and dried by inverting them on paper towels.

Photosynthesis rates were calculated from DIC concentrations and the radioactivity of the standards and samples using the algorithms in Shearer, et al. (1985). The computer programs described in Fee (1984) were used to calculate photosynthetic parameters (P_m^B = the rate of carbon uptake at saturating irradiances per unit of chlorophyll, and α = the slope of the light limited part of the curve relating photosythetic carbon uptake per unit of chlorophyll to light) from the photosynthetic rates, chlorophyll concentrations, and incubator irradiances. These programs were also used to calculate water column mean irradiances (from input of mixing depth and water transparency data) and *in situ* phytoplankton photosynthesis (from input of calculated photosynthetic parameters and water transparency data). The programs used simulated cloudless irradiances for these calculations.

Plankton analyses

Phyto- and proto-plankton analyses were made from 125 mL of water killed with 1 mL Lugol's iodine solution and preserved in formalin ($\approx$ 2% final concentration). Pico- and bacterioplankton analyses were made from 25 mL of sample preserved in the same concentration of formalin.

Phyto- and proto-plankton were enumerated in 10 mL sedimentation chambers with a Wild m40 inverted microscope using the methods of Utermöhl (1958) and Nauwerck (1963); samples were sedimented for one day. Single cells, colonies, and filaments were measured and counted at magnifications of 200 and 625: half the sedimentation chamber was counted at a magnification of 200 and a complete 200 μm wide strip across the diameter of the chamber was counted at the 625 magnification. If cells were so numerous as to exceed 10 per field, random fields were counted. If the samples were too rich with plankton, only 2 mL were sedimented. This happened most commonly when certain groups (bluegreens and small greens) dominated during the summer.

Bacteria and picoplankton were killed and preserved in 2% formalin and enumerated within 10 days using epifluorescence microscopy. Bacteria were enumerated following the methods of Daley and Hobbie (1975) and Hobbie et al. (1977) and picoplankton according to the method of Caron et al. (1985) using natural autofluorescence. 5 mL of whole lake water was filtered onto a 0.2 μm Nuclepore filter previously stained with Irgalan black. The filter was examined with a Zeiss standard microscope equipped with neofluar objectives and an epifluorescent illumination system containing a 100 w mercury vapor lamp, a bp 450-500 excitation filter, a 528 nm barrier filter and a ft 510 chromatic beam splitter. With this equipment only phycoerythrin containing Cyanophyta fluoresce orange; the other phytoplankton fluoresce red. A second 5 mL of sample was filtered onto a prestained 0.2 μm filter and stained with 50 μL of acridine orange using the same epifluorescent system; this caused the bacteria to fluoresce green and the phytoplankton to fluoresce red.

The dimensions of 15–20 cells of each taxon were measured and used in the calculations of a mean volume on each sampling date. Volumes were computed from measurements of cell dimensions using the formula for the geometric shape or shapes that most closely resembled each taxon (Rott 1981). The specific gravity was assumed to be 1.0 for calculating wet weight biomass from cell volume.

Phytoplankton nutrient deficiency indicators

Seston composition ratios were analyzed for indications of phytoplankton nutrient deficiency status. These measurements were made on samples of both whole water and concentrated net (10 μm mesh) plankton. After thorough agitation to homogenize the sample, subsamples were prefiltered through a 200 μm mesh net to remove large particles (primarily zooplankton). The following filtrations were then made: 1) chlorophyll–250 mL onto an untreated GF/C filter; 2) particulate phosphorus–250 mL onto an ignited GF/C filter; and 3) particulate carbon and nitrogen–250 mL onto an ignited GF/C filter. The filters for chlorophyll and particulate C and N were stored frozen in petri dishes after briefly drying them in air to remove excess moisture (so that the filters won't freeze onto the dishes). The particulate P filters were stored in 16 mL glass vials at room temperature and in the dark. Blanks for suspended C, N, and P using the corresponding filters were prepared on each sampling day. Chemical analyses were made with the methods of Stainton et al. (1977). Nutrient composition ratios were then calculated on an atom:atom basis (μmol·μmol^{-1}) for C:P, C:N, N:P and an atom:weight basis (μmol·μg^{-1}) for C:Chl-a for both the net and whole water samples.

Alkaline phosphatase activity (APA), an indicator of phosphorus deficiency status, was measured on whole water samples with the fluorometric method described by Healey and Hendzel (1979, 1980). APA activity was measured on both unfiltered whole water samples and water passed through a 0.22 μm Millipore filter.

The substrate for APA analysis was ortho-methylfluorescein phosphate (O-MFP) (molecular weight 511, Sigma chemicals). This substrate was prepared by dissolving 5.11 mg O-MFP in 10 mL of autoclaved 10 mM TRIS buffer (pH 8.5) to give a 1.0 mM stock solution. One mL portions were pipetted into plastic scintillation vials and frozen until needed. To use, 1.0 mL of frozen substrate was diluted with 19 mL of Tris buffer. The 10 mM TRIS buffer was prepared by dissolving 1.21 g of TRIS Base (Sigma chemicals), in 1.0 L of distilled water and adjusting the pH to 8.5 with 1.2 N HCl. This was divided into 50 mL portions and autoclaved.

Control medium for the analysis was WC medium (Guillard and Lorenzen 1972) modified in the following ways: 1) phosphorus was replaced with equimolar KCl; 2) $NaNO_3$ was reduced to 200 μM; 3) $Na_2SiO_3 \cdot 9H_2O$ was doubled; 4) trace element solution was halved; 5) TRIS buffer was reduced to 1 mM; and 6) the pH was set at 7.5. After preparation, 10 mL quantities of the medium were put in screw-cap test tubes and autoclaved.

The fluorometer (Turner model 111) was fitted with a door that can hold 5.0 mL fluorometer tubes, and was equipped with a 47B primary filter and a 2A15 secondary filter. 10% and 1% neutral density filters were also at hand. These filters were placed on top of the secondary filter if readings went off-scale (the 10% filter was usually needed for unfiltered samples).

The fluorometer was standardized at least once every field season by dissolving 17.3 mg of O-MF (ortho-methylfluorescein, molecular weight 346, Sigma chemicals) standard in 50 mL of absolute methanol; this can be stored at -5°C until needed. Dilutions for the standard curve were prepared by mixing 1 mL of the standard-methanol mixture with 100 mL of 0.05 N NaOH (1.0 g of NaOH in 500 mL distilled water) to get 10 μM O-MF. Further dilutions were made to obtain the concentrations required for the standard curve (0.001, 0.002, 0.005, 0.01, 0.02, 0.05, and 0.1 μM).

The analysis was done as follows: 1) 4.5 mL each of filtered water (0.22 μm Nuclepore filter), unfiltered water, and control medium were pipetted into clean 5.0 mL fluorometer tubes and placed in a 37°C water bath; 2) 500 μL of O-MFP substrate was added to each tube (final concentration 5 μM O-MFP); 3) the tubes were capped with parafilm and inverted to mix; and 4) fluorescence of each tube was read at least five times during the next hour, zeroing the fluorometer with the control tube before each measurement.

APA rates were calculated by linear regression of fluorescence as a function of time. The difference between the rates of the filtered and unfiltered fractions, normalized to chlorophyll concentration, was taken to be the activity associated with cells (the particulate APA). The limits for the various types and degrees of nutrient deficiency indicated by both the seston composition ratios and APA are summarized in Table 3.

Chemical analyses

While the analytical methods used in 1985 and 1986 were identical, sample handling and quality control protocols were evolving during 1985 and 1986 all were in place until mid-summer 1986. The descriptions below apply to the 1986 samples; exceptions that apply to 1985 are specifically noted.

Constituents analysed: In 1985, water samples were processed and analyzed in the Winnipeg analytical laboratory. In 1986, samples were processed at the Experimental Lakes Area (ELA) laboratory where they were also analyzed for *in situ* DIC (dissolved inorganic carbon). Whole water samples were shipped on ice to the Winnipeg laboratory for analysis of NO_3, NO_2, NH_4, TDN (total dissolved nitrogen), TDP (total dissolved phosphorus), major ions (Na, K, Mg, Ca, Cl, F, SO_4), air-equilibrated pH, conductivity, and alkalinity, Si, DOC (dissolved organic carbon), organic acids, chlorophyll (both by gross fluorescence and HPLC), and a spectrophotometer scan from 200–800 nm on filtered water.

Timing of analyses: It was neither possible nor necessary to perform all analyses immediately after the sample arrived at the laboratory. Analyses were therefore performed in the following order: 1) Within 8 h of sampling, the DIC analysis was initiated; 2) Within 24 h of sampling, NO_3, NO_2, NH_4 analyses were initiated, TDN and TDP digestions were begun, and gross fluorescence chlorophyll extractions were initiated; 3) Within 48 h of sampling, the absorption spectrum was read and stored, TDN, TDP, and gross fluorescence chlorophyll analyses were completed; 4) At an indefinite time after sampling, Na, K, Ca, Mg, Cl, SO_4, Si, suspended C, suspended N, suspended P, DOC, HPLC (high performance liquid chromatography) plant pigments and air-equilibrated alkalinity, pH, and conductivity were analyzed.

Sample containers: Table 2 summarizes the kinds of containers used for holding the various types of samples. It also summarizes the methods used for cleaning each kind of container.

Filters, filtration, and filter handling: The partitioning of dissolved and particulate substances by filtration is a function of the procedures followed and the filters used. Only by strictly adhering to specific protocols can the variance of filtration procedures be minimized.

Whatman GF/C filters (nominal pore size 1.2 μm, 4.25 cm diameter, pre-ignited at 500°C for 16 h) were used in the analyses of suspended solids, suspended carbon and nitrogen, suspended phosphorous, and chlorophyll (gross fluorescence method). These filters have a consistent pore size when new, but the effective pore size decreases as particulates accumulate on the filter surface. Because phosphorous levels in these papers are erratic, each lot was analyzed for phosphorus content prior to use. Lots with more than 1 μg P/4.25 cm filter[2] were used only for suspended C and N and chlorophyll analyses. Ignited filters were stored in glass jars labelled with the lot number and marked as to their suitability for phosphorous analyses. Untreated Nuclepore polycarbonate membrane filters (0.22 μm pore size) were used for HPLC analysis of photosynthetic pigments.

All filtrations were done with Millipore glass funnels and bases. The bases were fitted with stainless steel filter support screens (part number XX1004730). A manifold fitted with a three-way plastic valve that allowed application of vacuum to individual samples was constructed to allow direct collection of the filtrate in 500 mL glass-stoppered PYREX bottles. The filtration apparatus was rinsed with distilled and deionized water prior to the handling of each sample. Filters were placed in the apparatus with Millipore forceps, taking care to place them "right-side" up.[3] Water samples were mixed thoroughly by shaking before subsampling for filtration. Subsample volumes were determined with a glass graduated cylinder. Subsamples were added to the filtration funnel with the vacuum turned **off** and vacuum was left **on** until the filter was just dry (if sample water is poured onto a filter already under vacuum, particulates may accumulate unevenly on the filter). Samples were filtered with vacuums less than 103 kPa (15 lb·in^2). After filtration, samples of particulate were transferred to appropriate containers (plastic petri dishes or glass vials) with Millipore forceps and stored frozen at -10°C.

Sample preparation protocols: Subsamples of 500 mL were siphoned from the field sample and placed in three clean polyethylene bottles (see Table 2 for cleaning procedures) filled just to the shoulder so that a large air bubble remained (this permitted samples to be thoroughly mixed prior to further subsampling). If these samples could not be analyzed immediately they were stored at 4°C and shipped on ice the Winnipeg laboratory. In 1986 another subsample was collected in a 60 mL glass-

[2]This yields a blank of 10 μg·L^{-1} for samples of 100 mL.

[3]The bottom of a GF/C filter is a square mesh grid pattern, while the top is a random matt of glass fibers.

stoppered PYREX bottle for analysis of *in situ* DIC.

In the Winnipeg analytical laboratory one of the 500 mL sample bottles was weighed upon receipt and permanently stored at 4°C (unfiltered archive sample). The following subsamples were removed from one of the other two 500 mL bottles after thoroughly mixing it by shaking: 1) 100 mL was filtered through an ignited Whatman GF/C filter which was placed in a clean plastic petri dish, labelled with sample identifier, volume filtered, and "Particulate C&N" and frozen (-10°C); 2) 100 mL was filtered through an ignited preweighed Whatman GF/C, which was placed in a clean plastic petri dish, and labelled with sample identifier, volume filtered, and "Suspended Solids" (this filter was also used for the analysis of suspended P and suspended Fe). The water resulting from these filtrations was used for the analysis of NO_3, NO_2, NH_4, TDN and TDP. The remaining unfiltered water in this bottle was used for the analysis of air-equilibrated alkalinity.

The second 500 mL sample was used for the analysis of major ions, chlorophyll, DOC, and air-equilibrated pH and conductivity. These subsamples were taken in the following manner: 1) 100 mL was filtered through an ignited GF/C filter, placed in a screw cap vial, and labelled with sample identifier, volume filtered, and "Chlorophyll"; 2) ≈20 mL of unfiltered sample was placed in a polyethylene vial for analysis of soluble reactive silicon; 3) two subsamples of 200 mL were filtered through ignited Whatman GF/C filters, which were placed in plastic petri dishes labelled with a sample identifier, volume filtered, and "Archive Particulates". These filters were then permanently stored at -10°C; they may be used for reanalysis of particulates in the future. The 400 mL of water resulting from these filtrations was subdivided: 1) 125 mL was put in a polyethylene bottle for permanent storage at 4°C (filtered archive sample); 2) ≈20 mL subsamples were put in glass scintillation vials and preserved according to the following table:

Analysis	Preservative
DIC/DOC	100 μL $HgCl_2$
pH/conductivity	none
Cations	100 μL 3N HCl
Anions	none

Analytical methods: If a method is not specifically described here, then the analysis was done according to procedures described by Stainton et al. (1977).

Conductivity and pH methods were designed to measure values at standardized pCO_2 concentrations: the sample (25 mL of unfiltered water) was transferred to an open glass test tube, warmed to 25°C while exposed to atmosphere, the sample was then bubbled twice (first with air, then with nitrogen containing 340 ppm CO_2), and readings were made while the sample was in contact with the atmosphere. Because measurement conditions are standardized, these data will be directly comparable over time, but it must be borne in mind that they do not necessarily represent the particular balance of photosynthesis, respiration, and gas exchange present *in situ* on each sampling date.

Conductance was calibrated with KCl standards having conductances close to those of the samples. pH meters were calibrated with three buffers; an additional distilled-deionized pH standard was run at pH=5.63 and 340 ppm CO_2 to confirm the absence of residual buffer on the electrode and to check electrode performance in dilute solutions.

DIC (dissolved inorganic carbon) was measured using infrared detection of CO_2 sparged from acidified samples. The instrument was calibrated with both bicarbonate and gas mixture standards. The analysis was performed immediately after collecting the subsample (while the phytoplankton photosynthesis samples were being incubated).

DOC (dissolved organic carbon) was measured using an automated instrument that performed a rapid persulphate digestion and analyzed the resulting CO_2 by infrared detection. While the instrument is capable of measuring both DIC and DOC on the same sample during a single analytical cycle, it was found that the $HgCl_2$ used to preserve DOC samples lowered sample pH significantly and caused large losses of CO_2; these two analyses were therefore run on separate subsamples.

Alkalinity was measured using an automated titration system (Titroprocessor). One hundred mL of sample was titrated with 0.01 N HCl using fixed time kinetics to pH 3.7. Alkalinity was calculated using a Gran plot extrapolation.

Chloride, sulphate and organic acids were measured using an ion chromatography system of our own design. Strong acid anions were separated using Dionex fast run columns and a micromembrane suppressor (these columns irreversibly bind humic and fulvic acids) and were detected by conductance. A second measurement of total acid anions (including humics and fulvics) was obtained using a strong acid cation exchange resin and conductance detection. Organic acids (largely fulvics) were calculated as the difference between these two measurements.

Two measurements of chlorophyll were made: gross fluorescence and HPLC (high performance liquid chromatography). The gross fluorescence method is that described in Stainton et al. (1977) with two modifications: 1) solvent was switched from 95% acetone in water to 95% methanol in water in order to realize more complete and consistent extraction of pigments regardless of algal species composition; and 2) samples were extracted under static conditions (with periodic agitation) for 16 h at temperatures between +4 and -10°C. Fluorometers (Turner Model 111) were calibrated against spectrophotometric measurements made on pure chlorophyll-a standards (Sigma). The HPLC method is a modification of one published by Rebeiz et al. (1978). Samples were collected on 0.2 μm polycarbonate membrane filters (Nuclepore) and stored at -10°C. These were extracted with a mixture of methanol:acetone:water (65:30:5) in the dark for 16 h at -10°C. Extracts were filtered through a 0.1 μm nylon membrane filter prior to injection onto a Waters Resolve 15 cm reversed phase column. From six to 12 pigments were separated in ≈12 minutes using the same methanol:acetone:water mixture as eluent. Peaks were detected by fluorescence. The HPLC system was calibrated using pure chlorophyll-a and -b standards (Sigma).

Absorption spectra were measured with a Hewlett Packard model 8450 diode array spectrophotometer. Unfiltered water at room temperature was placed in a 10 cm quartz cuvette and absorbance was measured from 200 to 800 nm (200-400 nm at 1 nm resolution, 402 to 800 nm at 2 nm resolution). The 400 absorbance vs wavelength data points per sample were stored directly on $5\frac{1}{4}''$ floppy disks.

Validation protocols: In addition to employing rigorous and thoroughly documented procedures, we also adopted procedures designed to check routinely both the precision and the accuracy of our analytical methods. These quality control steps will provide continuous indications of data quality and should insulate our results from uncertainties due to methods changes that inevitably occur in long-term research projects.

Ion balance, conductivity, and alkalinity checks: Samples were analyzed for all major cations and anions (Na, K, Mg, Ca, Cl, SO_4, pH, DIC and conductance). These results were used to calculate the balance of cations to anions, the theoretical conductance, and theoretical carbonate alkalinity. These results were used to validate each sample—if any one of them was clearly out of balance, some constituent probably required reanalysis. We have not yet developed rigid criteria for reacting to the results of the above checks. That is, there is no specific ionic imbalance, measured vs calculated conductance or measured vs calculated alkalinity that automatically triggers reanalysis. This decision is made by the operators and is based on experience.

External cross check programs: Ionic balances cannot be used to check the accuracy or precision of trace nutrient analyses. To monitor the performance of our methods for these species, we participated in a LRTAP (long range transport of atmospheric pollutants) inter-laboratory cross-check program. In this program more than 25 participating North American laboratories regularly analyze unknown samples for 20 chemical constituents. Initially we analyzed 10 samples four times per yr. The program has now increased its activity to 10 samples 12 times per yr. The results provide information on the performance of our methods for major ions and nutrients (except for dissolved phosphorous).

Check samples and blanks: This protocol involved repeatedly processing and analyzing individually bottled CHECK and BLANK samples for all of the chemical constituents of interest in this program. The purpose of these procedures was threefold: 1) to document the daily performance of instruments and calibration procedures; 2) to document the stability of archived samples; and 3) to document the frequency and magnitude of sample contamination. The procedures were as follows. At the start of the program, 120 (12 sampling periods, 10 yr) 500 mL samples of hypolimnion water from ELA Lake 239 were placed in cold storage (4°C). When a set of field samples was processed, one of these check samples was also processed and analyzed in the same manner. A second set of 120 samples of D&D (deionized and distilled) H_2O were also prepared at the start of the program and processed along with each set of field samples.

At the conclusion of the program we will have 120 analyses of both the CHECK and BLANK samples. These data will be used to document the continuity of methods. It will also provide us with a record of the stability of 24 chemical constituents over 10 yr in archived samples.

Data Summary

Appendix 1 contains the 1985 station data (surface area, map coordinates, date of sampling, depth at sampling site, surface temperature, mixed layer depth, Secchi disk depth and color, depth of the water column sampled in the zooplankton net tow, and the volume of material captured by the zooplankton net. Appendix 2 contains the water chemistry data for 1985. Appendix 3 contains the 1986 station data (date and time of sampling, depth at sampling site, surface temperature, mixed layer depth, Secchi depth, vertical extinction coefficient, mean water column irradiance and daily integral phytoplankton photosynthesis. Appendix 4 contains the 1986 water chemistry data. Appendix 5 contains the 1986 plankton data. Appendix 6 contains the 1986 temperature vs depth profiles. Appendix 7 contains the 1986 transparency profiles. Appendix 8 contains the 1986 phytoplankton nutrient deficiency indicator data. All data are available from the senior author on $5\frac{1}{4}''$ floppy disks (IBM-PC low density or AT high density) in dBASE III and ASCII formats.

Acknowledgments

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Table 1. Some limnological characteristics of the lakes chosen for long term monitoring in the Red Lake District (51°N, 94°W).

	1	2	3	4	5	6	7	8	9	10	11	12
	A	A_d	τ	z_m	$\bar{z}$	SLD	$\frac{V_e}{A_e}$	k_{25}	z_e	θ_e	SDV	ε
Units :	ha	ha	yr	m	m		m	$\frac{\mu S}{cm}$	m	°C	m	m^{-1}
Green	89	323	13.0	18	7.7	2.02	12.5	28	5.8	18.3	4.95	0.45
Orange	167	1 270	11.6	28	14.4	2.31	20.0	48	5.6	18.9	3.78	0.67
Linge	706	3 687	9.8	22	8.4	2.84	9.1	30	5.8	17.6	3.90	0.67
Musclow	2 219	35 067	7.5	43	19.3	3.64	33.3	43	9.5	16.9	3.98	0.63
Sydney	5 748	55 297	9.5	71	20.0	7.40	20.0	41	6.3	17.3	4.28	0.61
Trout	34 690	106 533	22.3	47	13.7	10.48	14.3	62	10.4	15.5	5.03	0.44

1. A — Lake surface area (net water area)

2. A_d — Area of the drainage basin, including the lake area.

3. τ — Nominal water renewal time, calculated from lake volume, basin area, and maps of mean annual runoff.

4. z_m — Maximum depth.

5. $\bar{z}$ — Mean depth.

6. SLD — Shoreline development (total, including islands).

7. $\frac{V_e}{A_e}$ — Ratio of epilimnion volume to epilimnion sediment area during midsummer.

8. k_{25} — Specific conductance (at 25°C).

9. z_e — June–August 1986 average epilimnion depth.

10. θ_e — June–August 1986 average epilimnion temperature.

11. SDV — June–August 1986 average Secchi disk visibility.

12. ε — June–August 1986 average vertical extinction coefficient.

Table 2. Summary of the types, sizes, and methods of pretreating the various containers used in the processing and storage of water samples for chemical analyses.

Final use	Container size and type	How cleaned prior to use
Unfiltered archive	New 500 mL plastic	rinse: D&D H_2O
Filtered archive	New 125 mL plastic	rinse: D&D H_2O
Nutrients	500 mL plastic	rinses: 0.01N HCl, D&D H_2O, L.239 H_2O
Alkalinity	250 mL plastic	rinses: D&D H_2O, L.239 H_2O
DIC	60 mL PYREX	rinses: D&D H_2O, L.239 H_2O
pH, conductivity	60 mL PYREX	rinses: D&D H_2O, L.239 H_2O
DIC, DOC	Glass scintillation vial	no treatment
pH, conductivity	Glass scintillation vial	no treatment
Major anions	Glass scintillation vial	no treatment
Major cations	Plastic scintillation vial	no treatment
Silicon	Plastic scintillation vial	no treatment

NOTE: "Plastic" = Nalge polyethylene bottle. "D&D H_2O" = Distilled and deionized water. "L.239 H_2O" = ELA Lake 239 water. "PYREX" = glass stoppered reagent bottles. Only new scintillation vials are used. Only new plastic caps are used on all scintillation vials.

Table 3. Algal nutrient deficiency indicators. The ranges of values for each indicator that are associated with the different degrees of nutrient deficiency are derived from the results of laboratory chemostat experiments; this table summarizes values from the literature.

Ratio	Units	Type of Deficiency	Degree of deficiency		
			none	moderate	severe
Susp C:Susp N	μmol$\cdot\mu$mol^{-1}	Nitrogen	< 8.3	8.3–14.6	> 14.6
Susp C:Susp P	μmol$\cdot\mu$mol^{-1}	Phosphorus	< 129	129–258	> 258
Susp N:Susp P	μmol$\cdot\mu$mol^{-1}	Phosphorus	< 22		> 22
Susp C:Chl	μmol$\cdot\mu$g^{-1}	General	< 4.2	4.2–8.3	> 8.3
APA:Chl	μmol P$\cdot$h$^{-1}\cdot\mu$g Chl^{-1}	Phosphorus	< 0.003	0.003 – 0.005	> 0.005

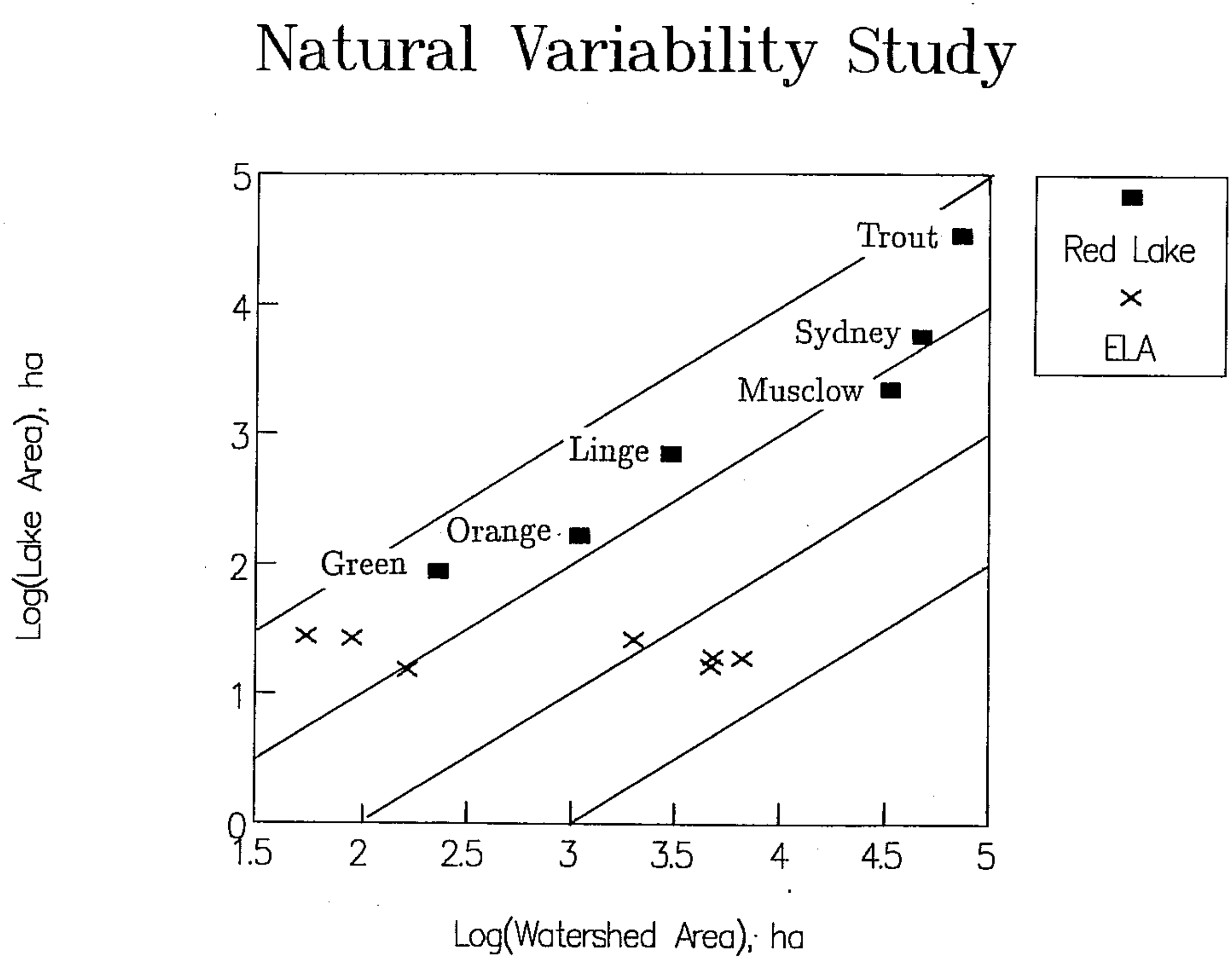


Fig. 1. The overall design of the FWI "Natural Variability and Climate Research" project. Lakes that fall along a single diagonal line have the same water turnover times. The six lakes being studied in the Red Lake District are named.

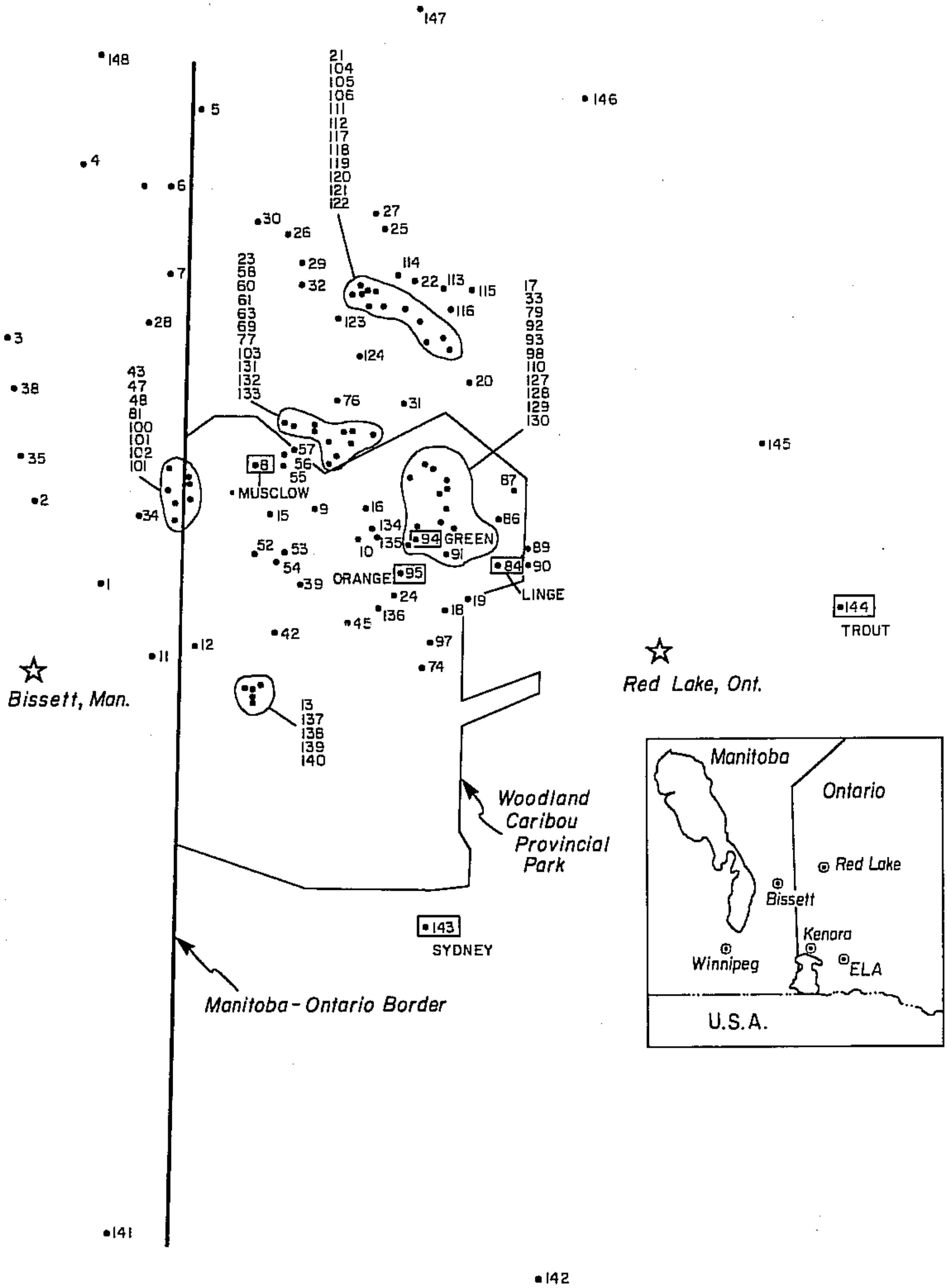


Fig. 2. Map of the Red Lake study district showing locations of the sampled lakes. Individual lakes within enclosed areas are not separately indicated. The six lakes that are named and whose numbers are enclosed in rectangles are those chosen for long-term monitoring.

Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	88.8	
1	83.8	8.63
2	77.8	8.08
3	71.1	7.44
4	66.3	6.87
5	61.4	6.39
6	53.9	5.76
7	43.9	4.88
8	38.6	4.12
9	33.0	3.57
10	27.7	3.03
11	21.3	2.44
12	16.7	1.90
13	12.4	1.45
14	9.58	1.10
15	8.02	0.879
16	6.06	0.702
17	4.39	0.520
18	2.58	0.345
19	0	0.086
		$\Sigma = 68.2$

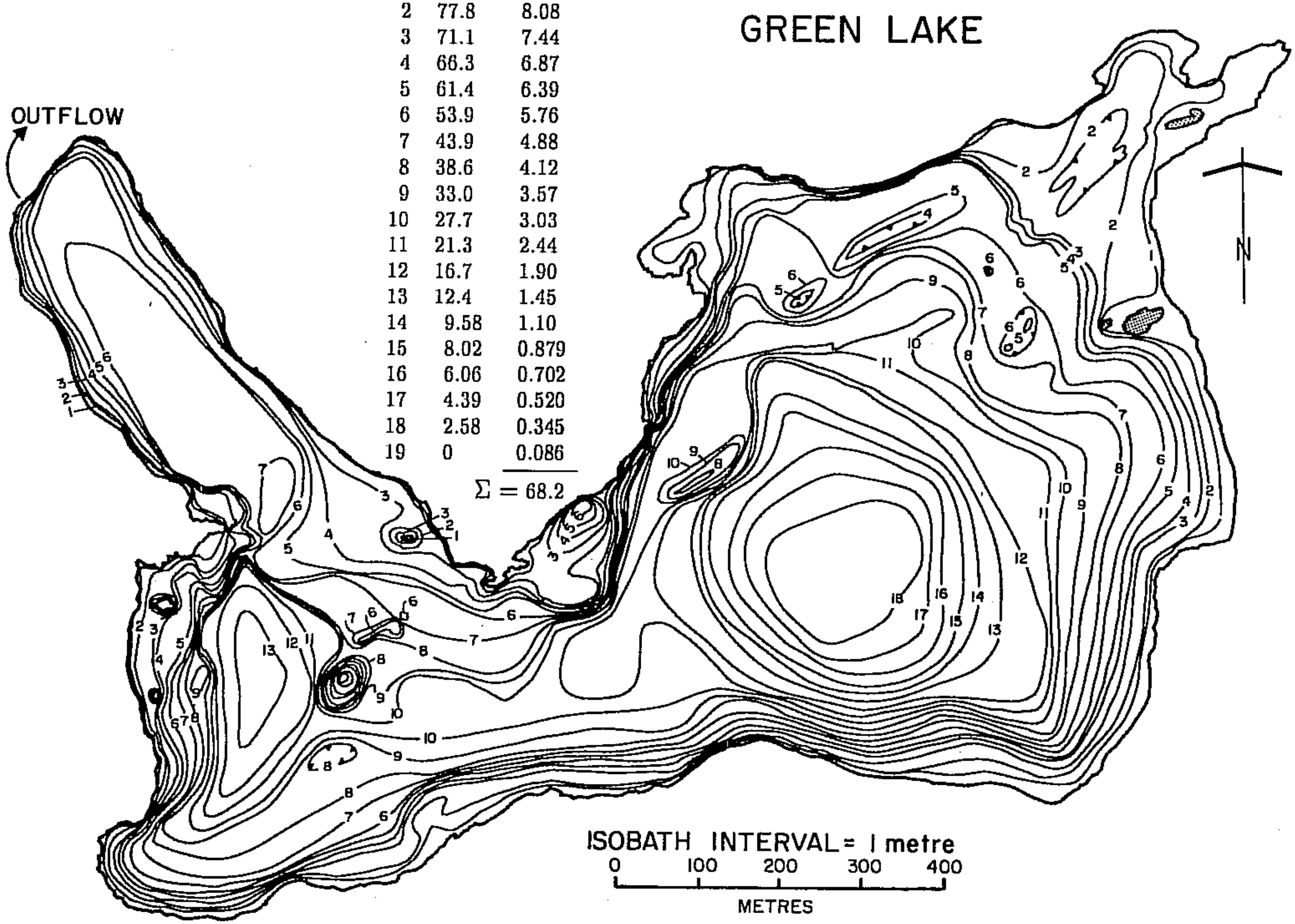
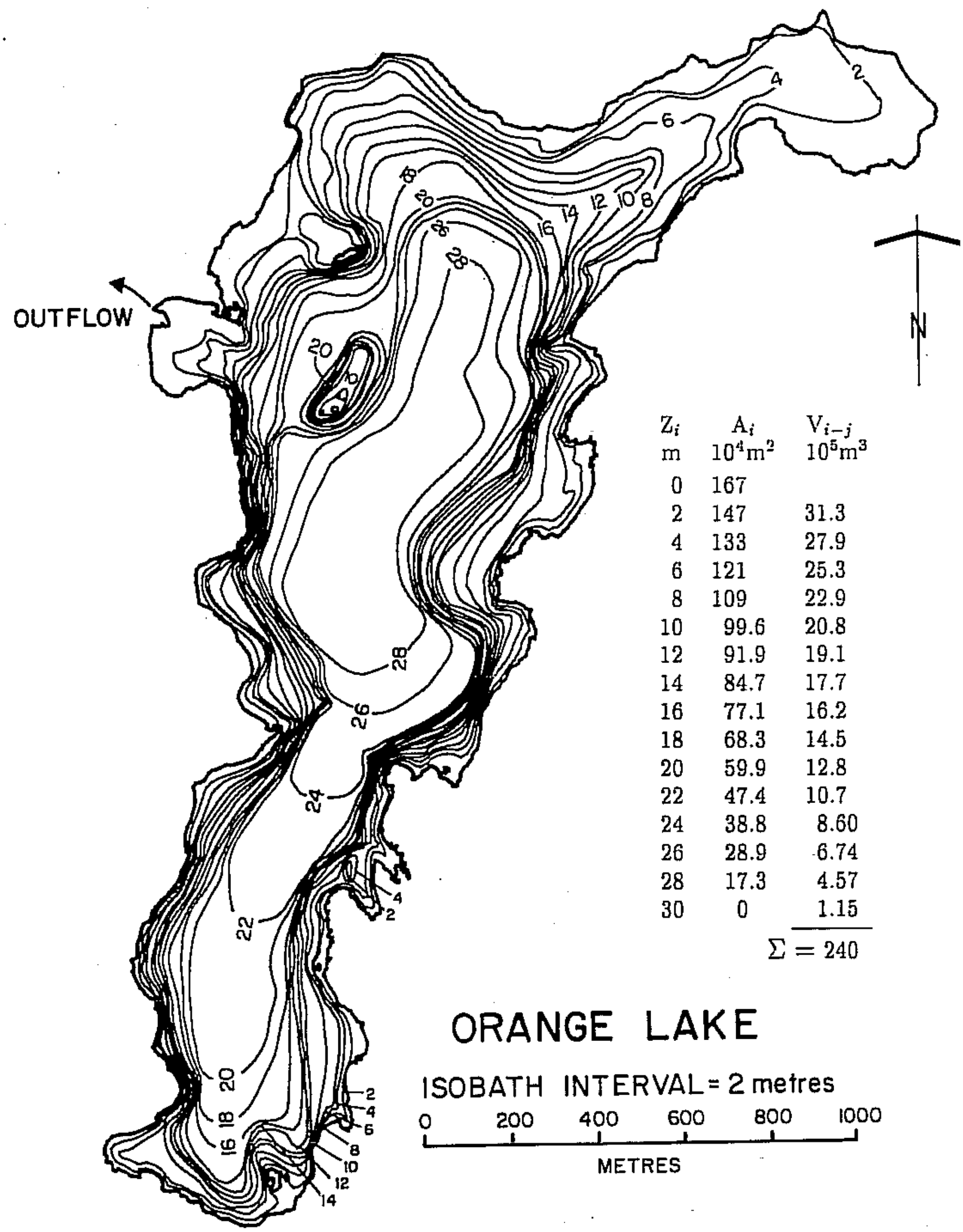
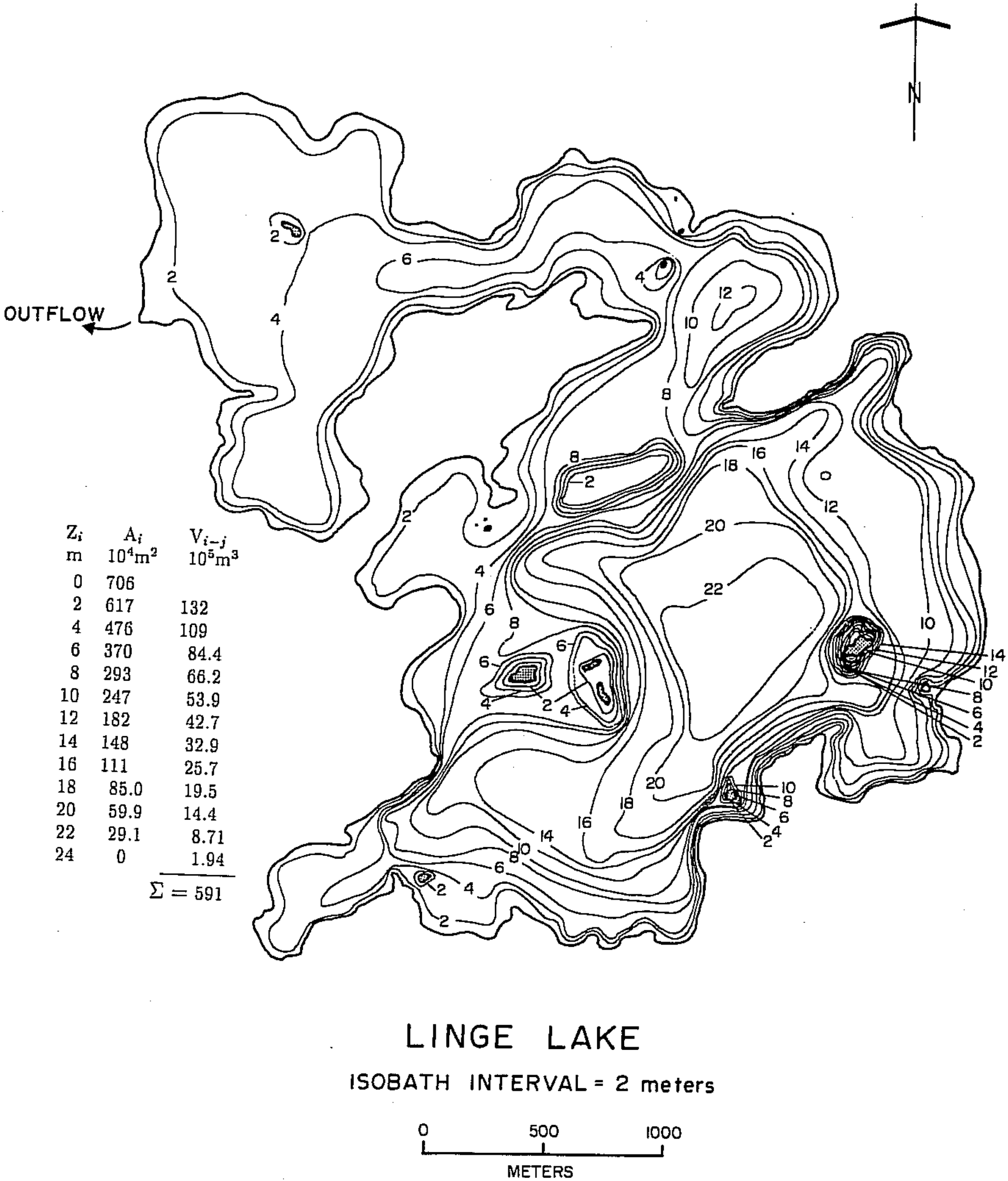


Fig. 3. Bathymetric map of Green Lake. Islands are shaded.



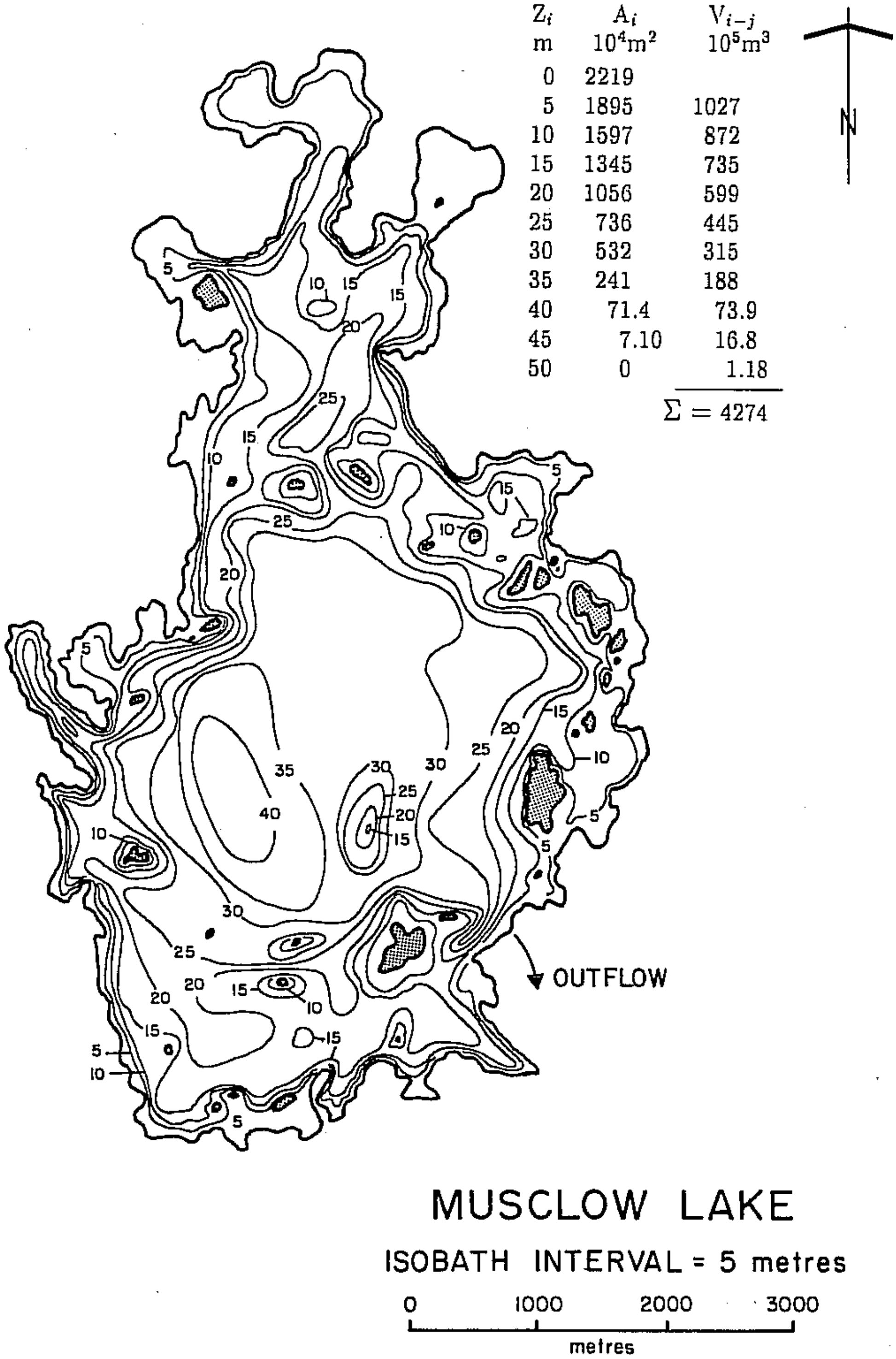
Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	167	
2	147	31.3
4	133	27.9
6	121	25.3
8	109	22.9
10	99.6	20.8
12	91.9	19.1
14	84.7	17.7
16	77.1	16.2
18	68.3	14.5
20	59.9	12.8
22	47.4	10.7
24	38.8	8.60
26	28.9	6.74
28	17.3	4.57
30	0	1.15
		$\Sigma = 240$

Fig. 4. Bathymetric map of Orange Lake.



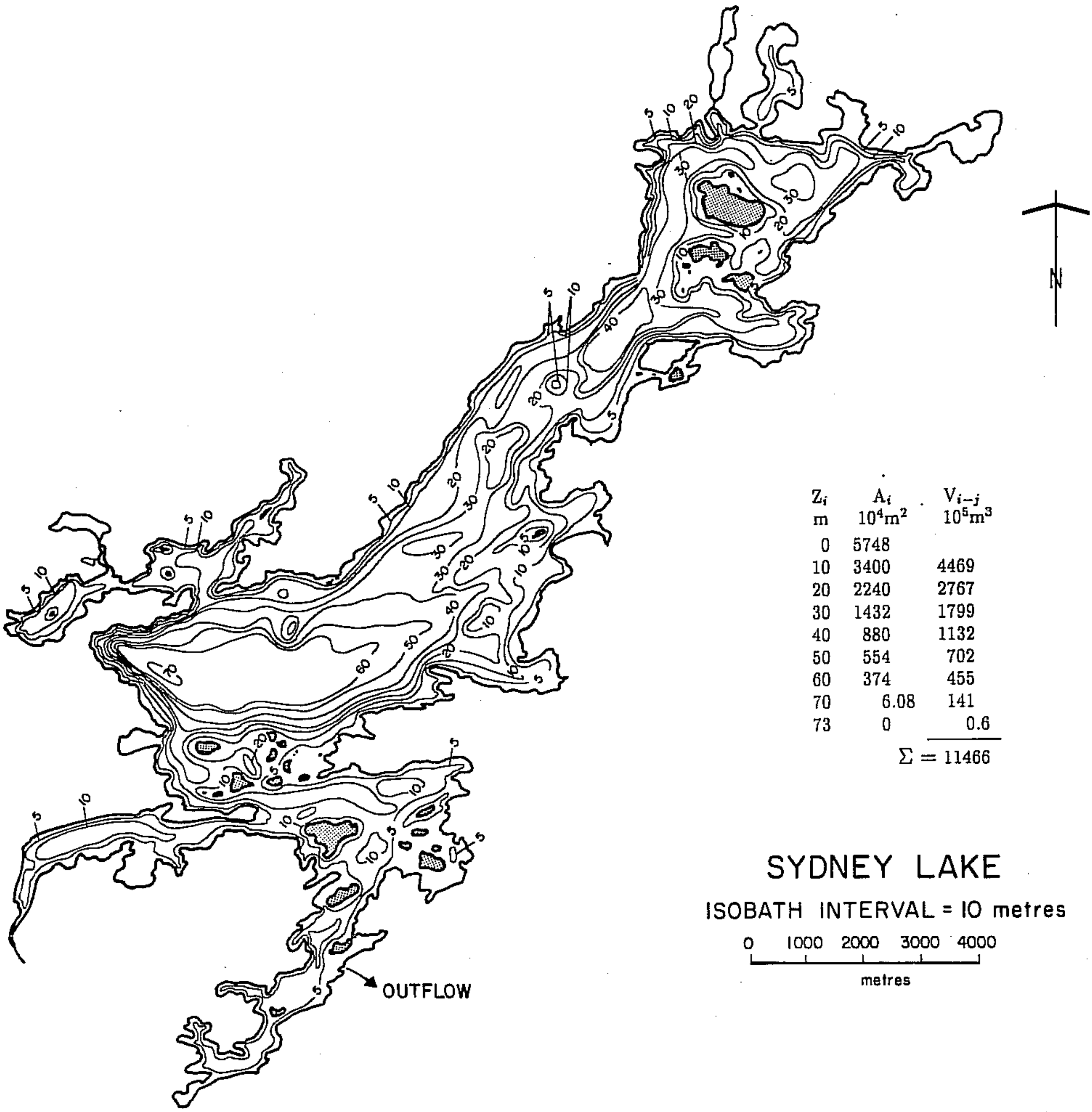
Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	706	
2	617	132
4	476	109
6	370	84.4
8	293	66.2
10	247	53.9
12	182	42.7
14	148	32.9
16	111	25.7
18	85.0	19.5
20	59.9	14.4
22	29.1	8.71
24	0	1.94
		$\Sigma = 591$

Fig. 5. Bathymetric map of Linge Lake. Islands are shaded.



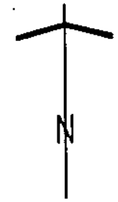
Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	2219	
5	1895	1027
10	1597	872
15	1345	735
20	1056	599
25	736	445
30	532	315
35	241	188
40	71.4	73.9
45	7.10	16.8
50	0	1.18
		$\Sigma = 4274$

Fig. 6. Bathymetric map of Musclow Lake. Islands are shaded.



Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	5748	
10	3400	4469
20	2240	2767
30	1432	1799
40	880	1132
50	554	702
60	374	455
70	6.08	141
73	0	0.6
		$\Sigma = 11466$

Fig. 7. Bathymetric map of Sydney Lake. Islands are shaded.



Z_i m	A_i $10^4 m^2$	V_{i-j} $10^5 m^3$
0	34690	
5	26911	15177
10	18385	11123
15	12291	7528
20	8725	5167
25	6056	3631
30	3632	2368
35	1824	1322
40	836	642
45	200	238
49	0	26.3
		$\Sigma = 47223$

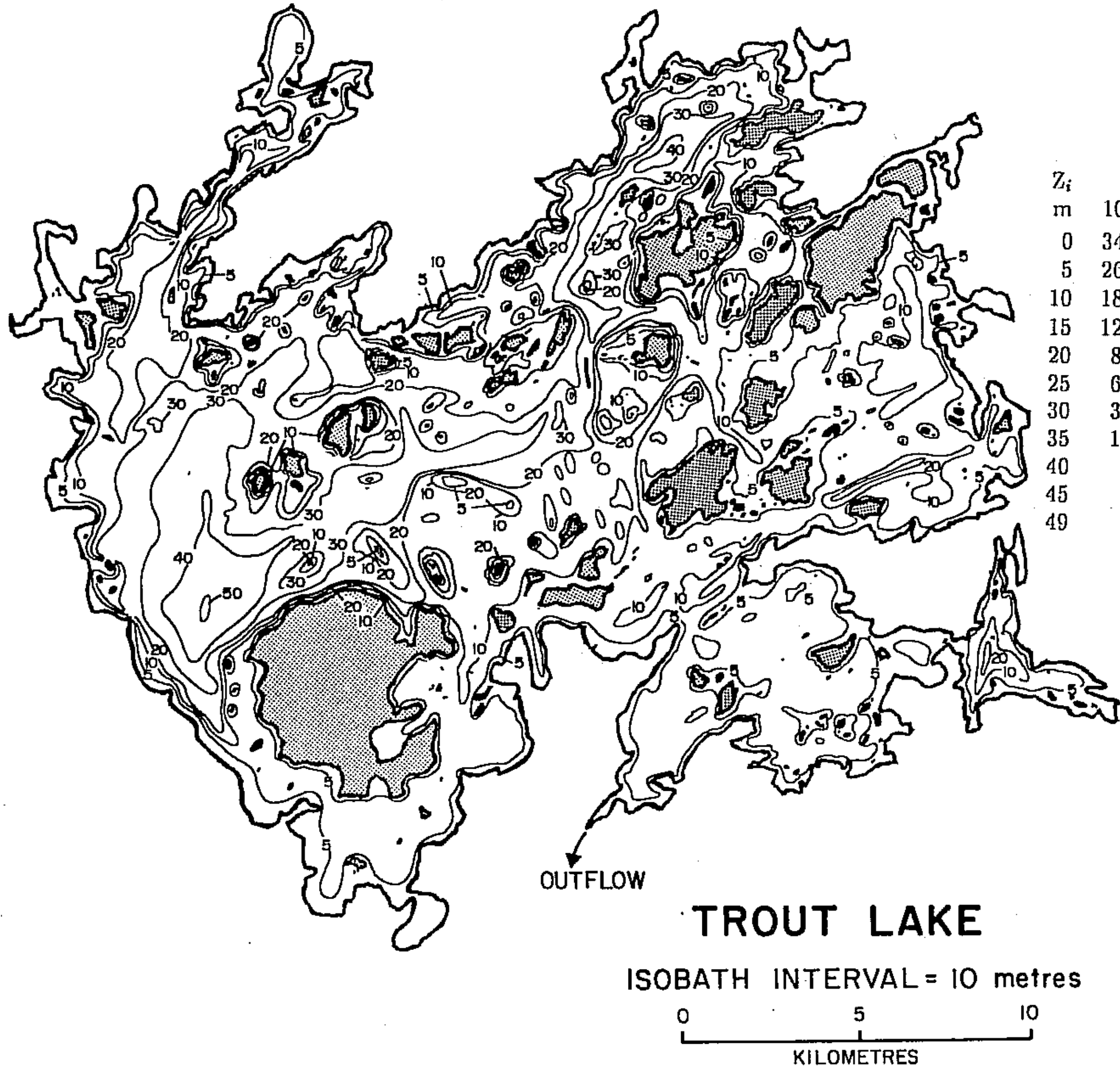


Fig. 8. Bathymetric map of Trout Lake. Islands are shaded.

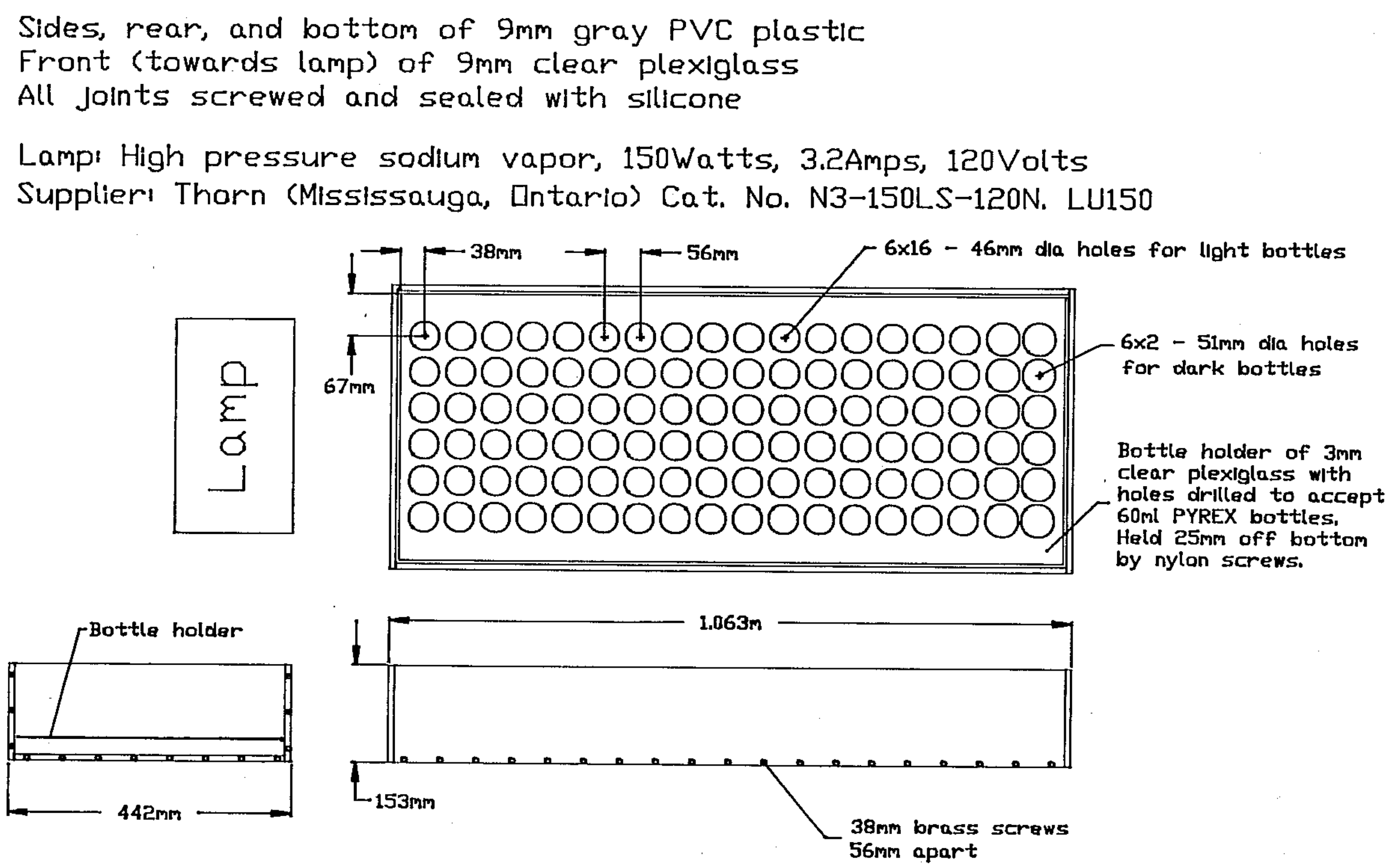


Fig. 9. The incubator used for measuring phytoplankton photosynthesis vs light curves.

Appendix 1. Limnological data from lakes in the Red Lake District collected in 1985. The symbol (!) follows the names of the lakes chosen for long-term study. Key to column headings:

1. Station number
2. DFO lake number
3. Lake name (from official map sheets)
4. Surface area, hectares
5. East-west map coordinate (universal transverse mercator grid)
6. North-south map coordinate (universal transverse mercator grid)
7. Date sampled
8. Time sampled (central daylight time)
9. Depth at station, metres
10. Surface temperature, °C
11. Depth of mixed layer, metres
12. Depth of visibility of Secchi disk, metres
13. Color of Secchi disk 1 metre below surface
14. Depth water column sampled in zooplankton tow, metres
15. Settled volume of material captured by the zooplankton net per m^3 of tow, $mL{\cdot}m^{-3}$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
											Secchi		Net plankton	
Sta No	Lake No	Name	Surface Area	XCoord	YCoord	Date	Time	Depth	Surf Temp	Mixed Depth	Depth	Color	Depth	$mL.m^{-3}$
19	1	Aikens	2297	336250	5673750	16-Jul-85	09:40	26.0	19.2	11.0	3.3	BROWN	20.0	0.6
20	2	South Eagle	708	323750	5689000	16-Jul-85	10:25	4.5	20.8	4.0	1.3	RED	4.0	1.0
2	3	Sasaginnigak	4777	318000	5718750	15-Jul-85	10:15	14.0	18.9	9.0	2.0	BROWN	14.0	0.8
6	4	Family	12180	331000	5751250	15-Jul-85	12:15	7.0	19.3	6.0	2.5	BROWN	6.0	0.6
7	5	Moar	4980	353250	5761250	15-Jul-85	13:00	24.0	20.0	10.0	1.8	BROWN	20.0	0.4
5	6		711	348500	5747500	15-Jul-85	11:50	13.5	19.3	6.0	3.0	BROWN	11.0	1.0
4	7	Dogskin	1716	348000	5731250	15-Jul-85	11:20	7.0	19.8	6.0	2.7	BROWN	6.0	1.8
37	8	Musclow (!)	2219	364750	5696250	17-Jul-85	09:30	36.0			4.2	YELLW	36.0	0.2
38	9	Sabourin	2184	375375	5688500	17-Jul-85	09:58	5.5			2.6	YELLW	4.0	0.5
39	10	Larus	2816	383750	5682750	17-Jul-85	10:25	21.0			3.1	YELLW	20.0	0.4
17	11	Obukowin	1816	345625	5660750	16-Jul-85	08:50	2.0	20.0	2.0	2.0	RED	1.0	13.4
18	12	Carroll	2741	353625	5662750	16-Jul-85	09:13	13.0	18.9	8.0	4.4	GREEN	10.0	0.9
58	13	Donald	1471	365875	5655500	18-Jul-85	08:56	24.0	22.0	5.0	3.8	YELLW	23.0	0.4
53	15	Barclay	887	367500	5687250	17-Jul-85	15:45	13.8			2.5	BROWN	13.0	0.6
40	16	Thicketwood	1040	384875	5688750	17-Jul-85	10:48	24.0			2.1	RED	24.0	0.2
48	17	Bigshell	646	401250	5694000	17-Jul-85	14:04	11.0			2.5	BROWN	10.0	0.5
61	18	Knox	1625	400000	5670000	18-Jul-85	10:20	11.7	21.0	5.0	2.5	BROWN	11.0	0.3
64	19	Peisk	786	405250	5672250	18-Jul-85	11:35	13.5	21.9	4.0	1.9	RED	13.0	0.5
43	20	Roderick	2296	404500	5712250	17-Jul-85	12:05	9.0			4.5	GREEN	8.0	1.0
13	21	McCusker	3251	385000	5725750	15-Jul-85	15:30	40.0	19.0	7.0	6.6	GREEN	38.0	0.3
100	21	McCusker	3251	385000	5725750	19-Aug-85	14:50		15.1	10.0	5.0	GREEN		
12	22	Cairns	5563	393250	5731000	15-Jul-85	15:07	11.5	19.4	9.0	4.8	GREEN	10.0	0.4
41	23	Job	1017	378125	5700500	17-Jul-85	11:10	6.2			2.8	YELLW	5.0	0.9
62	24	Murdock	1881	390500	5673000	18-Jul-85	10:43	14.2	22.4	4.0	2.9	BROWN	13.0	0.2
11	25	Onepine	994	388750	5740250	15-Jul-85	14:45	8.0	20.7	6.0	2.5	BROWN	7.0	1.0
9	26		582	370050	5738750	15-Jul-85	14:00	10.1	19.6	8.0	4.0	GREEN	9.0	1.2
10	27		968	387000	5743000	15-Jul-85	14:26	6.0	20.2	6.0	2.1	BROWN	5.0	2.2
3	28		515	344000	5722000	15-Jul-85	11:00	5.0	20.2	5.0	2.5	GREEN	4.5	1.0
15	29	Spoonbill	1091	373000	5733500	15-Jul-85	16:25	40.0	20.5	7.0	4.0	GREEN	38.0	0.2
8	30	Herod	681	364250	5741250	15-Jul-85	13:45	12.1	20.2	6.0	3.9	GREEN	11.0	0.6
42	31	Mimi	714	391750	5708250	17-Jul-85	11:32	8.0			3.5	GREEN	7.0	2.5
14	32		476	373000	5729500	15-Jul-85	16:00	8.9	20.5	5.0	2.2	BROWN	7.0	0.4
47	33	Burntwood	325	396000	5697250	17-Jul-85	13:41	1.3			1.2	RED	1.0	0.6
16	34	Bushey	296	342000	5686750	15-Jul-85	17:10	2.5	21.3	2.0		BROWN	1.0	14.1
21	35	North Eagle	297	321000	5697125	16-Jul-85	10:45	1.2	20.8	1.2	0.8	RED	1.0	3.2
24	37	Burriss	164	348750	5691250	16-Jul-85	11:52	4.8	21.4	3.5	1.5	RED	3.5	5.1
1	38		266	319000	5710000	15-Jul-85	09:50	5.0	19.6	5.0	2.5	RED	5.0	2.9

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
											Secchi		Net plankton	
Sta No	Lake No	Name	Surface Area	XCoord	YCoord	Date	Time	Depth	Surf Temp	Mixed Depth	Depth	Color	Depth	$mL.m^{-3}$
57	39		343	373375	5675250	17-Jul-85	16:57	5.5			2.8	BROWN	5.0	1.2
77	42		346	368625	5665625	18-Jul-85	17:31	6.6	24.3	4.0	2.5	BROWN	6.0	0.7
22	43		91	349000	5686000	16-Jul-85	11:13	1.2	20.7	1.2	0.8	RED		
76	45		323	382125	5667500	18-Jul-85	17:07	4.7	24.5	3.0	3.1	BROWN	4.0	1.7
27	47		260	352125	5693500	16-Jul-85	13:25	10.5	21.1	4.0	2.0	RED	9.0	1.4
26	48		191	352750	5692750	16-Jul-85	13:05	10.5	20.9	4.0	3.0	BROWN	9.0	0.7
54	52		207	364500	5680000	17-Jul-85	16:06	5.2			2.0	YELLW	4.0	3.0
56	53		161	370000	5679750	17-Jul-85	16:38	6.1			3.5	GREEN	5.0	1.4
55	54		149	368750	5678500	17-Jul-85	16:22	6.8			1.6	RED	6.0	0.7
52	55		209	369625	5696000	17-Jul-85	15:25	8.0			1.4	BROWN	7.0	0.6
51	56		190	370000	5698000	17-Jul-85	15:08	2.6			1.4	BROWN	2.0	1.1
50	57		164	372125	5699000	17-Jul-85	14:49	5.0			1.9	GREEN	4.0	3.7
31	58		236	370000	5704250	16-Jul-85	15:05	13.0	21.0	4.0	3.0	BROWN	12.0	0.4
30	60		78	375500	5703000	16-Jul-85	14:37	15.0	21.4	3.0	2.5	BROWN	14.0	0.3
32	61		84	372250	5703750	16-Jul-85	15:28	12.2	20.8	3.0	1.8	RED	11.0	2.0
109	63		51	376250	5703875	20-Aug-85	11:00	5.0	15.0	5.0	1.5	RED		
34	69		79	383250	5702750	16-Jul-85	16:30	5.1	20.2	4.0	2.0	BROWN	4.0	4.4
59	74	Indian House	941	396250	5659500	18-Jul-85	09:35	10.7	22.0	5.0	2.6	YELLW	10.0	0.5
33	76		75	379625	5708500	16-Jul-85	16:00	8.8	20.9	4.0	2.0	RED	8.0	0.6
35	77		91	386625	5702250	16-Jul-85	16:50	2.1	20.6	1.5	1.8	RED	1.5	4.2
49	79		89	393375	5694500	17-Jul-85	14:24	2.9			1.5	RED	2.0	0.7
28	81		35	348375	5695250	16-Jul-85	13:47	4.8	21.8	3.0	2.2	YELLW	4.0	1.9
65	84	Linge (!)	706	410000	5678750	18-Jul-85	12:25	22.8	21.9	5.0	2.9	YELLW	22.0	0.2
68	86	Olive	231	409750	5687250	18-Jul-85	13:40	8.0	22.8	4.0	2.3	BROWN	7.0	0.3
69	87		91	413375	5692625	18-Jul-85	14:04	6.7	24.0	4.0	1.9	RED	6.0	0.9
67	89		288	416000	5681750	18-Jul-85	13:20	5.3	22.8	4.0	2.1	BROWN	4.0	3.0
66	90		184	415375	5678750	18-Jul-85	12:53	21.1	22.9	4.0	2.4	BROWN	19.0	0.2
71	91	Young	312	401250	5680375	18-Jul-85	14:55	10.9	24.0	4.0	2.0	RED	10.0	0.5
70	92		161	402375	5685250	18-Jul-85	14:30	8.5	24.2	4.0	2.5	BROWN	7.0	1.5
74	93		182	393625	5682000	18-Jul-85	16:22	5.5	23.8	4.0	2.5	RED	5.0	0.6
73	94	Green (!)	88	395500	5683000	18-Jul-85	15:57	17.2	22.4	4.0	4.7	GREEN	16.0	0.5
63	95	Orange (!)	169	392750	5676500	18-Jul-85	11:05	28.5	22.1	4.0	5.0	BROWN	22.0	0.1
60	97		337	398500	5664375	18-Jul-85	09:57	11.5	22.4	4.0	3.6	YELLW	8.0	0.7
72	98		127	399125	5686125	18-Jul-85	15:20	11.2	23.0	3.0	1.9	RED	10.0	0.5
23	100		202	350000	5689000	16-Jul-85	11:30	4.5	20.4	3.0	2.0	BROWN	3.0	1.0
25	101	Artery	588	352500	5689625	16-Jul-85	12:11		20.6	8.0	2.5	BROWN	8.0	1.3
29	102		40	349625	5696000	16-Jul-85	14:05	5.5	21.6	4.0	1.7	BROWN	4.0	0.1
36	103		53	383250	5700750	16-Jul-85	17:12	4.5	20.7	2.5	1.3	RED	3.0	0.6
44	104		331	400000	5718250	17-Jul-85	12:36	9.0			4.0	GREEN	8.0	0.8
45	105		253	399800	5720000	17-Jul-85	12:54	7.3			4.0	GREEN	6.0	1.2
46	106		215	395750	5723250	17-Jul-85	13:09	9.0			3.2	BROWN	8.0	0.8
75	110		59	395750	5685250	18-Jul-85	16:42	8.9	24.0	3.0	2.8	RED	8.0	1.1
86	111		18	396000	5719300	19-Aug-85		4.0	13.3	4.0	1.5	BROWN		
87	112		21	392500	5725500	19-Aug-85		3.0	13.2	3.0	1.5	RED		
88	113		14	399100	5729400	19-Aug-85		1.5	12.0	1.5		BROWN		
89	114		12	391350	5731600	19-Aug-85		6.0	15.0		2.5	GREEN		
90	115		4	404450	5729300	19-Aug-85		5.0	13.0		0.8	RED		
91	116		43	400500	5725400	19-Aug-85	11:30	8.5	16.3	8.5	3.5	GREEN		
92	117		12	387600	5725700	19-Aug-85	12:40	11.5	13.3	3.0	0.8	RED		
93	118		29	387050	5727100	19-Aug-85	12:50	1.9	12.5	1.9	1.2	RED		
94	119		37	385200	5728650	19-Aug-85		12.5	14.7	6.0	4.0	GREEN		
95	120		8	383900	5728200	19-Aug-85	13:10	2.5	13.9	2.5	1.5	RED		
96	121		243	383500	5729500	19-Aug-85	13:15	18.0	15.1	9.0	3.5	GREEN		
97	122		55	383000	5727700	19-Aug-85	13:35	6.5	15.1	6.0	2.8	GREEN		
98	123		8	379350	5723250	19-Aug-85	13:55	4.5	15.1	4.5	2.2	GREEN		
99	124		27	384500	5716500	19-Aug-85	14:35	5.8	16.0	5.8	2.5	GREEN		
103	127		70	400700	5692450	20-Aug-85	09:35	17.5	16.3	10.0	3.5	GREEN		
104	128		52	399200	5691650	20-Aug-85	09:50	10.0	15.1	8.0	2.0	RED		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
											Secchi		Net plankton	
Sta No	Lake No	Name	Surface Area	XCoord	YCoord	Date	Time	Depth	Surf Temp	Mixed Depth	Depth	Color	Depth	$mL.m^{-3}$
105	129		28	400100	5688850	20-Aug-85	10:05	7.0	14.9	5.0	1.5	RED		
106	130		42	397300	5696500	20-Aug-85	10:20	3.0	14.4	3.0	3.0	GREEN		
107	131		30	380350	5698000	20-Aug-85	10:38	3.5	14.4	3.5	1.2	RED		
108	132		13	380850	5702650	20-Aug-85	10:49	12.0	14.3	5.0	2.2	RED		
110	133		34	378100	5696850	20-Aug-85	11:51	4.5	15.2	4.5	2.0	GREEN		
111	134		25	386300	5684800	20-Aug-85	12:04	12.5	14.9	6.0	2.0	BROWN		
112	135		33	387250	5683550	20-Aug-85	12:16	10.5	15.5	8.0	3.5	GREEN		
113	136		11	388700	5670200	20-Aug-85	12:35	5.0	13.8	4.0	1.0	BROWN		
114	137		21	364350	5652800	20-Aug-85	12:55	8.5	15.4	6.0	1.5	RED		
115	138		1	364750	5653350	20-Aug-85	13:00	3.5	15.0	3.5	2.0	GREEN		
116	139		12	364250	5654750	20-Aug-85	13:11	4.0	14.9	4.0	1.7	RED		
117	140		16	363200	5655250	20-Aug-85	13:20	11.5	15.8	5.0	1.7	RED		
78	141	Crowduck	5628	339000	5555000	15-Aug-85	08:37	11.0	18.0	10.0	2.2	GREEN	10.0	0.5
79	142	Wonderland	956	419500	5548500	15-Aug-85	09:30	50.0	17.5	11.0	6.0	GREEN	38.0	0.2
80	143	Sydney (!)	5750	398000	5612000	15-Aug-85	10:30	13.5	16.1	11.0	4.6	GREEN	13.0	0.4
81	144	Trout (!)	34700	475000	5672000	15-Aug-85	12:05	34.2	16.0	15.0	5.0	GREEN	33.0	0.2
82	145	Nungesser	7356	460000	5702000	15-Aug-85	12:30	10.5	17.0	10.5	1.9	RED	9.0	0.4
83	146	Barton	3902	425000	5765000	15-Aug-85	13:30	4.0	16.3	4.0	1.5	RED	3.0	2.0
84	147	Stout	11630	385000	5775000	15-Aug-85	14:00	11.0	17.6	11.0	1.5	RED	10.0	0.3
85	148	Fishing	8883	335000	5775000	15-Aug-85	14:35	50.0	17.3	13.0	2.2	RED	38.0	0.2

Appendix 2. Chemical data from lakes in the Red Lake District collected in 1985. The symbol (!) follows the names of the lakes chosen for long-term monitoring. Key to column headings:

1. Station number
2. DFO lake number
3. Lake name; the lakes chosen for long-term monitoring are marked (!)
4. Suspended nitrogen, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 14.008
5. Total dissolved nitrogen, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 14.008
6. Suspended phosphorus, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 30.975
7. Total dissolved phosphorus, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 30.975
8. Dissolved inorganic carbon, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
9. Dissolved organic carbon, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
10. Suspended carbon, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
11. Chlorophyll-a, $\mu g \cdot L^{-1}$
12. Soluble reactive silica, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 28.09
13. Chloride, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 34.457
14. Sulfate, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 96.07
15. Specific conductance (at 25°C), $\mu Siemens \cdot cm^{-1}$
16. Sodium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 22.991
17. Potassium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 39.1
18. Calcium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 40.08
19. Magnesium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 24.32
20. Iron, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 55.85
21. pH
22. Organic acids, $\mu eq \cdot L^{-1}$
23. Alkalinity, $\mu eq \cdot L^{-1}$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			N		P		C															
Sta No	Lake No	Name	Susp	TD	Susp	TD	DIC	DOC	Susp	Chl	SR Si	Cl	SO_4	Con	Na	K	Ca	Mg	Fe	pH	Org acid	Alk
19	1	Aikens	4.1	24	0.22	0.29	220	640	35	17.4	8	17	24	34	46	14	88	49	0.72	7.23	39	221
20	2	South Eagle	15.8	49	0.89	0.55	270	1550	124	9.2	12	15	16	43	53	19	117	78	5.73	7.19	84	294
2	3	Sasaginnigak	9.8	29	0.37	0.42	170	950	74	8.8	11	12	19	31	50	14	83	45	1.97	7.18	51	184
6	4	Family	6.0	28	0.28	0.39	420	890	45	3.3	32	9	17	52	49	15	169	72	1.25	7.62	52	425
7	5	Moar	6.3	29	0.32	0.42	430	980	47	8.6	41	9	15	53	43	15	179	74	1.97	7.64	59	445
5	6		4.8	26	0.27	0.36	210	720	41	2.1	17	12	15	32	43	18	87	42	1.25	7.21	41	189
4	7	Dogskin	5.1	29	0.34	0.42	170	900	48	2.6	9	9	19	30	48	12	82	39	1.97	7.07	50	174
37	8	Musclow (!)		24	0.18	0.29	330	760		2.2	2	9	19	45	50	15	122	62	0.72	7.45	43	344
38	9	Sabourin	11.6	29	0.31	0.36	280	830	64	4.7	21	12	24	42	53	16	117	56	0.72	7.39	44	297
39	10	Larus	6.1	29	0.26	0.36	350	780	36	2.5	19	12	23	49	53	15	137	70	0.72	7.44	47	373
17	11	Obukowin	7.8	34	0.40	0.45	190	870	69	2.3	12	23	24	34	55	22	87	45	3.22	7.08	57	184
18	12	Carroll	3.2	21	0.19	0.26	200	680	33	3.0	14	15	24	33	43	13	85	48	0.72	7.20	38	204
58	13	Donald	4.5	21	0.18	0.29	190	610	38	1.7	19	15	26	34	41	15	86	50	<.7	7.27	33	220
53	15	Barclay	7.4	31	0.31	0.39	340	830	59	4.7	17	12	22	49	53	16	135	69	0.72	7.66	45	364
40	16	Thicketwood	7.6	29	0.34	0.36	230	910	59	4.7	22	9	22	38	49	14	112	53	1.25	7.29	49	259
48	17	Bigshell	9.9	23	0.23	0.26	180	710	59	3.1	16	9	19	31	43	10	87	38	0.72	7.35	39	207
61	18	Knox	8.2	24	0.62	0.32	290	800	62	5.1	26	9	23	44	56	12	132	60	1.25	7.50	45	332
64	19	Peisk	5.9	25	0.23	0.32	230	1000	50	5.4	59	12	24	40	54	11	122	56	1.97	7.36	56	281
43	20	Roderick	5.1	21	0.56	0.29	190	620	46	2.3	10	9	19	30	41	11	88	32	<.7	7.30	33	206
13	21	McCusker	2.8	19	0.19	0.26	260	510	31	2.1	9	9	19	35	46	13	103	41	0.72	7.54	28	259
100	21	McCusker	4.1	20	0.15	0.29	260	460	42	3.0	9	9	19	35	47	11	100	40	0.72	7.45	27	263
12	22	Cairns	5.8	21	0.21	0.26	310	460	68	2.0	2	9	12	38	43	15	113	42	0.72	7.55	22	305
41	23	Job	7.1	31	0.28	0.32	200	790	60	3.6	8	9	20	32	48	11	89	38	0.72	7.23	43	219
62	24	Murdock	4.9	28	0.22	0.32	290	840	42	4.7	29	12	22	44	53	13	130	62	1.25	7.48	48	330
11	25	Onepine	5.3	26	0.23	0.29	200	770	56	3.0	16	9	19	32	49	13	97	37	1.25	7.39	42	210
9	26		5.9	23	0.23	0.26	260	370	64	2.3	2	12	15	34	53	19	93	35	0.72	7.53	19	258
10	27		8.9	26	0.34	0.32	190	780	83	3.2	19	9	19	31	42	13	90	35	1.25	7.34	41	205
3	28		12.1	39	0.40	0.32	300	760	124	3.6	6	12	17	40	57	18	113	48	0.72	7.34	36	304

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			N		P		C															
Sta No	Lake No	Name	Susp	TD	Susp	TD	DIC	DOC	Susp	Chl	SR Si	Cl	SO_4	Con	Na	K	Ca	Mg	Fe	pH	Org acid	Alk
15	29	Spoonbill	4.2	24	0.17	0.29	230	590	37	1.8	15	9	20	34	49	13	100	40	0.72	7.46	34	227
8	30	Herod	5.0	22	0.23	0.32	220	640	42	2.9	14	12	20	33	50	14	94	38	0.72	7.35	35	223
42	31	Mimi	7.0	29	0.21	0.32	250	520	70	2.2	12	12	17	34	55	13	95	35	<.7	7.41	24	260
14	32		6.6	24	0.21	0.29	180	820	57	2.9	35	12	17	32	45	11	93	39	0.72	7.33	48	195
47	33	Burntwood	6.3	29	0.27	0.32	110	960	55	3.0	22	9	17	24	40	8	70	31	2.51	7.06	53	139
16	34	Bushey	7.0	33	0.52	0.52	340	850	57	4.1	20	20	23	47	52	14	139	69	1.25	7.60	42	357
21	35	North Eagle	13.8	53	0.59	0.55	210	1750	131	8.4	4	12	16	38	56	20	100	74	3.76	7.13	90	249
24	37	Burriss	16.5	45	0.72	0.68	330	1040	118	7.6	14	6	8	39	43	17	103	63	4.48	7.28	58	295
1	38		8.2	36	0.36	0.45	280	840	82	5.1	14	17	26	42	64	18	106	58	1.97	7.37	37	280
57	39		7.5	31	0.28	0.45	280	670	62	3.9	69	9	20	39	51	14	105	55	1.25	7.44	39	295
77	42		7.1	27	0.30	0.32	140	840	72	3.1	12	15	19	29	46	9	80	37	0.72	7.23	43	177
22	43		34.5	46	0.94	0.39	80	1600	379	12.1	21	9	14	25	43	9	67	42	1.97	6.60	83	111
76	45		6.3	30	0.31	0.42	250	750	62	3.6	11	12	23	40	52	12	108	56	1.97	7.50	37	296
27	47		5.4	31	0.31	0.36	170	1020	50	2.7	22	6	14	28	40	13	77	44	2.51	7.22	57	185
26	48		6.4	34	0.26	0.36	420	890	55	3.4	7	6	11	50	53	18	138	88	1.25	7.58	51	422
54	52		10.0	34	0.67	0.36	220	800	106	4.0	14	9	19	35	47	14	98	41	<.7	7.39	38	255
56	53		6.7	35	0.31	0.36	940	690	55	2.5	11	15	14	102	66	31	257	217	<.7	7.89	37	980
55	54		9.1	31	0.39	0.36	110	1020	93	5.7	36	12	17	27	41	12	75	38	2.51	7.17	56	164
52	55		19.8	56	0.61	0.48	560	1250	157	17.0	30	9	9	73	61	25	233	111	1.25	7.94	78	643
51	56		12.4	40	0.63	0.52	250	1150	109	9.3	14	15	15	39	52	12	119	54	1.25	7.42	62	283
50	57		16.7	51	0.52	0.45	510	1000	138	7.0	9	12	12	64	64	25	184	96	0.72	7.79	53	545
31	58		3.1	31	0.14	0.36	180	890	33	1.8	24	15	22	32	51	10	90	38	0.72	7.32	48	194
30	60		8.4	27	0.18	0.32	170	950	77	2.9	42	12	19	31	49	12	90	41	1.25	7.28	50	193
32	61		5.5	32	0.22	0.36	110	1250	53	2.4	49	6	19	27	42	9	79	38	1.97	7.02	69	140
109	63		17.5	43	0.75	0.48	420	1350	111	11.1	23	3	12	52	53	15	157	80	3.76	7.36	76	428
34	69		5.4	24	0.27	0.32	140	820	52	2.9	44	6	17	25	43	9	71	28	0.72	7.13	45	142
59	74	Indian House	8.7	25	0.31	0.29	180	690	85	4.1	7	17	21	32	43	15	88	39	0.72	7.25	36	216
33	76		5.6	25	0.21	0.36	110	1010	50	2.9	25	6	15	23	42	9	69	28	1.25	6.98	55	120
35	77		7.9	29	0.35	0.39	110	880	80	3.2	20	6	14	21	37	8	58	24	2.51	6.97	47	98
49	79		10.7	31	0.43	0.36	140	960	83	5.4	25	9	16	28	42	9	82	37	1.97	7.13	56	180
28	81		9.9	33	0.34	0.32	170	730	89	4.6	5	6	16	27	37	16	64	39	1.25	7.11	34	167
65	84	Linge (!)	5.8	20	0.21	0.26	170	590	56	2.4	20	6	20	30	40	10	86	39	0.72	7.32	31	209
68	86	Olive	5.9	21	0.23	0.26	80	680	55	2.0	33	6	19	20	40	6	56	24	0.72	7.01	37	103
69	87		6.9	27	0.23	0.29	130	860	67	3.6	21	6	16	26	42	8	78	30	3.76	7.15	44	165
67	89		6.2	24	0.21	0.29	140	800	60	2.3	41	6	19	27	41	8	75	32	1.25	7.19	42	169
66	90		5.1	25	0.17	0.26	170	820	58	2.8	49	9	21	32	49	8	92	39	1.25	7.30	44	211
71	91	Young	5.3	28	0.61	0.32	160	920	51	3.8	19	6	19	29	43	9	86	39	2.51	7.18	48	197
70	92		5.7	22	0.19	0.29	70	770	62	2.5	36	6	17	19	34	7	53	25	1.25	6.86	35	95
74	93		5.5	27	0.25	0.32	120	920	54	2.8	34	9	24	28	50	9	71	38	1.25	7.08	47	154
73	94	Green (!)	4.6	21	0.10	0.26	150	500	52	1.1	9	6	23	28	49	9	67	34	0.72	7.19	23	181
63	95	Orange (!)	4.8	20	0.15	0.26	340	660	42	1.9	28	15	27	47	52	14	128	72	0.72	7.54	36	369
60	97		5.0	25	0.18	0.29	180	720	48	2.1	6	12	23	32	46	12	90	41	<.7	7.31	36	219
72	98		5.9	27	0.58	0.29	60	980	58	2.7	48	6	19	19	38	6	48	25	1.97	6.57	49	81
23	100		6.1	31	0.32	0.42	370	860	52	4.0	21	12	21	47	53	16	134	69	1.97	7.52	49	358
25	101	Artery	5.9	29	0.39	0.42	390	810	46	5.3	22	12	21	48	55	15	134	68	1.25	7.44	47	357
29	102		5.1	32	0.40	0.39	170	1020	47	5.3	25	9	18	27	40	19	69	40	1.97	7.09	53	161
36	103		6.3	31	0.28	0.45	110	1250	59	3.5	67	6	16	23	43	7	71	29	6.45	6.83	68	112
44	104		4.6	22	0.19	0.29	200	620	43	2.1	11	9	18	31	46	11	90	34	<.7	7.36	31	216
45	105			23	0.13	0.26	200	610		1.5	17	9	19	31	48	12	92	36	0.72	7.40	32	217
46	106		13.1	31	0.26	0.26	210	760	23	2.2	17	9	15	31	46	13	90	37	1.25	7.36	38	227
75	110		4.4	24	0.18	0.29	90	870	41	1.6	89	6	29	26	52	8	71	34	1.97	6.99	47	132
86	111		14.0	33	0.34	0.36	180	800	141	7.9	39	6	16	26	53	10	69	28	0.72	6.86	40	188
87	112		9.1	30	0.31	0.32	70	1000	97	6.5	32	6	11	18	44	8	47	23	5.01	6.28	86	79
88	113		17.3	59	0.46	0.36	360	1140	163	7.2	15	6	7	43	66	12	130	50	1.25	7.37	74	358
89	114		8.9	24	0.23	0.29	290	620	89	4.8	20	6	11	35	56	13	96	41	1.25	7.22	50	284
90	115		5.6	38	0.30	0.45	180	1850	51	2.7	110	3	12	23	40	8	82	27	10.74	6.02	123	97
91	116		7.1	17	0.19	0.26	440	280	85	2.7	6	6	8	48	54	16	150	43	0.72	7.58	25	422

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			N		P		C															
Sta No	Lake No	Name	Susp	TD	Susp	TD	DIC	DOC	Susp	Chl	SR Si	Cl	SO_4	Con	Na	K	Ca	Mg	Fe	pH	Org acid	Alk
92	117		6.1	32	0.23	0.36	310	1200	72	3.9	66	20	10	41	64	11	132	46	5.01	7.11	101	301
93	118		3.4	47	0.21	0.48	240	1650	39	1.7	61	20	12	38	65	10	130	47	9.49	6.97	137	250
94	119		6.5	21	0.19	0.32	170	600	73	3.5	9	6	14	25	40	9	69	28	0.72	7.11	51	167
95	120		9.1	31	0.32	0.36	80	1140	103	8.1	23	6	17	19	37	5	49	25	5.73	6.12	84	70
96	121		4.6	23	0.17	0.32	160	600	47	3.0	25	9	16	26	41	9	75	32	0.72	7.04	67	161
97	122		11.9	29	0.26	0.29	190	520	139	6.7	7	9	17	27	42	11	67	31	0.72	7.28	21	195
98	123		9.5	23	0.32	0.29	130	730	92	4.8	14	6	12	19	36	7	51	22	1.25	6.84	33	119
99	124		8.9	25	0.30	0.29	110	670	90	5.9	16	6	22	20	42	7	47	26	1.25	6.82	38	87
103	127		3.8	15	0.10	0.23	470	290	43	1.4	3	9	17	57	52	26	150	80	<.7	7.72	19	503
104	128		8.0	28	0.31	0.36	290	880	69	7.6	25	6	19	38	47	15	105	49	2.51	7.02	52	273
105	129		6.4	29	0.23	0.32	190	1000	61	11.3	47	3	16	28	47	11	77	38	3.22	6.96	52	186
106	130			26	0.19	0.26	300	520		11.7	9	6	10	38	54	15	108	42	0.72	7.41	26	322
107	131		54.2	44	0.63	0.39	320	1400	150	13.0	34	6	16	44	68	16	126	67	2.51	7.19	76	342
108	132		13.0	26	0.18	0.23	100	1110	44	2.7	46	9	26	24	54	7	56	31	2.51	6.54	59	95
110	133		17.2	36	0.39	0.32	260	710	163	7.7	13	6	16	35	57	15	92	43	0.72	7.38	31	272
111	134		6.6	24	0.22	0.29	160	1050	70	5.0	92	12	41	35	53	19	89	46	1.97	6.99	61	169
112	135		5.6	24	0.30	0.19	150	580	63	2.7	10	9	32	28	44	15	59	37	0.72	7.18	25	154
113	136		5.3	37	0.22	0.36	120	1750	53	4.5	126	6	41	29	56	10	73	42	10.21	6.28	85	96
114	137		5.5	35	0.23	0.36	280	1350	47	4.7	49	26	24	43	67	14	114	62	5.01	7.15	70	271
115	138		15.8	46	0.40	0.32	100	750	174	8.4	6	6	18	17	24	9	33	25	0.72	6.68	26	77
116	139		8.4	40	0.32	0.26	170	1150	77	9.2	28	6	19	28	41	11	73	41	5.73	6.94	58	166
117	140		5.2	41	0.17	0.23	180	1250	49	4.4	44	6	26	34	55	13	88	51	2.51	7.06	68	200
78	141	Crowduck	11.6	29	0.54	0.39	1950	530	91	8.6	30	20	22	193	105	46	514	388	<.7	8.27	41	1970
79	142	Wonderland	3.3	14	0.10	0.29	270	300	32	1.5	7	9	31	37	51	14	97	45	<.7	7.53	17	255
80	143	Sydney (!)	3.7	17	0.15	0.29	310	430	32	2.2	5	9	30	42	51	18	105	58	<.7	7.48	26	296
81	144	Trout (!)	3.5	11	0.13	0.26	540	290	32	1.7	27	6	26	63	42	16	202	68	<.7	7.83	19	548
82	145	Nungesser	4.9	22	0.30	0.39	260	760	42	3.0	63	6	17	36	44	10	112	44	1.25	7.27	49	263
83	146	Barton	13.5	31	0.57	0.45	480	940	101	10.3	21	9	16	62	47	14	201	93	1.97	7.80	62	531
84	147	Stout	3.6	34	0.23	0.61	410	1000	30	2.1	57	6	12	51	39	13	175	64	2.51	7.57	72	429
85	148	Fishing	3.0	29	0.14	0.39	410	860	32	2.3	31	9	16	52	42	14	167	70	1.25	7.70	56	429

Appendix 3. Limnological data from lakes in the Red Lake District collected in 1986. Key to column headings:

1. Station number
2. Lake name
3. Date sampled
4. Time sampled
5. Depth at station, metres
6. Surface temperature, °C
7. Depth of mixed layer, metres
8. Depth of visibility of Secchi disk, metres
9. Extinction coefficient for photosynthetically availiable irradiance, m^{-1}
10. Mean light intensity in the mixed layer (24 hour mean), $mEin{\cdot}m^{-2}{\cdot}min^{-1}$ (calculated assuming cloudless surface irradiance for the day)
11. Daily integral phytoplankton photosynthesis, $mg\ C{\cdot}m^{-2}{\cdot}d^{-1}$ (calculated assuming cloudless surface irradiance for the day)
12. Depth water column sampled in zooplankton tow, metres
13. Settled volume of material captured by the zooplankton net per m^3 of tow, $mL{\cdot}m^{-3}$

Sta	Lake	Date	Time	Depth	Temp	Zmix	Secchi	e	Ibar	IntPS	Net plankton depth	$mL.m^{-3}$
3	GREEN	05/21/86	09:55	13.0	13.6	4.5	4.6	0.55	21.2	87	13.0	0.9
9	GREEN	06/12/86	09:50	6.0	16.3	4.0	4.8	0.46	27.5	117	6.0	2.9
15	GREEN	07/02/86	10:02	14.0	18.0	5.0	5.6	0.46	20.3	121	13.0	1.0
21	GREEN	07/23/86	08:50	17.0	20.7	6.0	4.2	0.42	16.9	107	15.0	0.7
27	GREEN	08/13/86	10:58	18.5	20.4	6.5	5.2	0.48	14.0	104	17.0	0.7
35	GREEN	09/04/86	10:55	5.5	16.1		3.4	0.48	11.5	161	5.0	0.7
41	GREEN	09/24/86	12:00	18.3	12.9	10.0	3.8	0.48	9.9	132	17.0	0.6
47	GREEN	10/15/86	11:10	4.2	7.4		3.0	0.62	6.0	110	3.5	1.2
4	ORANGE	05/21/86	10:35	28.5	11.8	2.5	4.0	0.66	23.7	258	28.0	0.1
10	ORANGE	06/12/86	10:31	12.0	16.1	5.5	3.7	0.70	15.9	174	12.0	0.5
16	ORANGE	07/02/86	10:30	29.0	18.3	5.0	4.1	0.69	13.6	219	28.0	0.5
22	ORANGE	07/23/86	09:25	28.0	21.1	5.0	3.7	0.56	12.7	173	26.0	1.0
28	ORANGE	08/13/86	11:41	12.0	20.4	5.5	4.4	0.60	10.4	139	12.0	2.2
36	ORANGE	09/04/86	11:17	14.0	16.1	8.0	4.0	0.56	7.8	212	14.0	0.8
42	ORANGE	09/24/86	12:25		13.3		4.0		4.8	131		
48	ORANGE	10/15/86	11:35	15.0	7.5		4.3	0.54	2.8	121	14.0	0.3
8	LINGE	06/12/86	09:00	16.0	14.9	5.0	3.2		12.3	141	16.0	1.1
14	LINGE	07/02/86	09:31	21.5	17.3	6.0	3.9	0.80	13.4	206	20.0	0.6
20	LINGE	07/23/86	08:25	21.0	20.5	6.5	3.8	0.55	12.4	153	20.0	2.1
26	LINGE	08/13/86	10:25	7.0	19.6		4.2	0.67	10.6	229	6.0	3.0
34	LINGE	09/04/86	10:15	4.0	15.8		3.2	0.81	8.1	238	3.5	1.9
40	LINGE	09/24/86	11:30	22.5	12.7	11.5	3.0	0.61	6.8	202	21.0	1.1
46	LINGE	10/15/86	10:42	5.8	8.5		2.8	0.71	4.3	135	5.0	2.6
5	MUSCLOW	05/21/86	11:22	35.0	9.7	1.5	2.8	0.85	11.2	485	35.0	0.2
11	MUSCLOW	06/12/86	11:00		13.0				9.5	258		
17	MUSCLOW	07/02/86	11:05	33.0	17.3	8.0	4.4	0.76	9.1	333	32.0	0.6
23	MUSCLOW	07/23/86	10:00	30.5	19.0	6.5	3.3	0.59	9.8	278	29.0	0.0
29	MUSCLOW	08/13/86	12:20	16.0	19.8	9.5	4.0	0.68	7.2	378		
37	MUSCLOW	09/04/86	12:00	18.0	15.6	14.0	3.5		4.4	295	17.5	0.4
43	MUSCLOW	09/24/86	13:00	10.3	13.1		3.0	0.64	3.1	217	9.0	0.4
49	MUSCLOW	10/15/86	12:05		8.6				1.9	123		
6	SYDNEY	05/21/86	--:--	35.0	10.2	3.5	4.4	0.54	23.9	246	35.0	0.3
12	SYDNEY	06/12/86	--:--	6.0	14.1	5.5	3.2		17.7	182	6.0	0.9
18	SYDNEY	07/02/86	11:58	29.0	16.8	8.0	5.2	0.77	14.2	210	25.0	1.0

1	2	3	4	5	6	7	8	9	10	11	12	13
											Net plankton	
Sta	Lake	Date	Time	Depth	Temp	Zmix	Secchi	e	Ibar	IntPS	depth	$mL.m^{-3}$
24	SYDNEY	07/23/86	11:05		19.6		4.4		15.7	262		
30	SYDNEY	08/13/86	13:25	7.5	20.1	5.5	4.3	0.46	16.6	181		
38	SYDNEY	09/04/86	13:00	8.5	15.9		4.9	0.45	9.3	231	8.0	1.7
44	SYDNEY	09/24/86	13:50	26.0	13.6	13.0	4.2	0.47	6.8	150	26.0	0.4
50	SYDNEY	10/15/86	12:55	5.3	9.4		3.8	0.54	2.6	148.	4.0	0.4
1	TROUT	05/21/86	07:55	20.0	7.3	20.0	7.0	0.41	7.3	314	36.0	0.1
7	TROUT	06/12/86	07:32	19.5	11.8	7.0	4.8		13.2	181	19.0	0.5
13	TROUT	07/02/86	07:31	22.0	14.5	15.5	5.5	0.52	7.8	161	21.0	0.3
19	TROUT	07/23/86	07:10	21.0	17.8	8.0	4.8	0.37	13.2	224	21.0	0.6
25	TROUT	08/13/86	08:55	12.0	18.3	11.0	5.0	0.43	10.9	281	11.0	1.6
33	TROUT	09/04/86	09:08		15.2				7.8	272		
39	TROUT	09/24/86	07:25	20.3	12.7		4.0	0.42	5.7	244	19.0	0.7
45	TROUT	10/15/86	09:10		8.8		4.2	0.42	4.3	201	20.0	0.7

Appendix 4. Chemical data from lakes in the Red Lake District collected in 1986. DIC was analyzed in the ELA laboratory; all other analyses were done in the Winnipeg laboratory. NO_2 data are not reported because it was always below the limit of detection. NH_4 data are not reported because atmospheric contamination is suspected. Key to column headings:

1. Station number
2. Lake name
3. Date sampled
4. Nitrate nitrogen, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 14.008
5. Suspended nitrogen, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 14.008
6. Total dissolved nitrogen, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 14.008
7. Suspended phosphorus, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 30.975
8. Total dissolved phosphorus, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 30.975
9. Dissolved inorganic carbon, (*in situ* values measured at ELA) $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
10. Dissolved organic carbon, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
11. Suspended carbon, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 12.001
12. Soluble reactive silica, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 28.09
13. Chloride, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 34.457
14. Sulfate, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 96.07
15. Suspended iron, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 55.85
16. Specific conductance (at 25°), $\mu Siemens \cdot cm^{-1}$
17. Sodium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 22.991
18. Potassium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 39.1
19. Magnesium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 24.32
20. Calcium, $\mu mol \cdot L^{-1}$; to convert to $\mu g \cdot L^{-1}$ multiply by 40.08
21. pH
22. Alkalinity, $\mu eq \cdot L^{-1}$
23. Organic acids, $\mu eq \cdot L^{-1}$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
				N		P		C			SR			Fe	Con							Org
Sta	Lake	Date	NO_3	Susp	TD	Susp	TD	DIC	DOC	Susp	Si	Cl	SO_4	Susp		Na	K	Mg	Ca	pH	Alk	acid
3	GREEN	21-May-86		5.5		0.16		210	530	62	11.5	8.7	25		27	53	9	37	65	7.17	172	21
9	GREEN	12-Jun-86	0.2	3.9	19	0.16	0.13	200	510	46	10.1	11.6	24		28	50	10	37	65	7.35		17
15	GREEN	02-Jul-86	<.1	6.4	17	0.10	0.16	210	610	35	10.2	5.8	25	376	28	48	9	38	67	7.16		24
21	GREEN	23-Jul-86	<.1	4.8	17	0.13	0.10	210	550	52	9.7	8.7	25		28	55	9	38	68	7.21	175	21
27	GREEN	13-Aug-86	<.1	4.3	13	0.19	0.06	210	530	56	9.1	5.8	27	913	28	48	10	38	66	7.25	176	14
35	GREEN	04-Sep-86	0.1	4.2	17	0.58	0.10	220	520	70	9.3	5.8	27		28	47	9	38	72	7.22	178	15
41	GREEN	24-Sep-86	<.1	4.8	21	0.13	0.10	220	680	54	8.8	5.8	26		28	46	10	38	71	7.24	182	17
47	GREEN	15-Oct-86	<.1	4.6	19	0.16	0.10	230	800	57	9.7	5.8	24		28	44	11	39	75	7.08	180	25
4	ORANGE	21-May-86		5.4		0.13		440	690	57	35.2	8.7	28		47	57	15	79	126	7.48	363	31
10	ORANGE	12-Jun-86	0.1	3.9	19	0.19	0.16	440	640	46	30.2	11.6	27		49	67	15	80	123	7.67		28
16	ORANGE	02-Jul-86	0.1	6.5	21	0.13	0.16	430	620	40	28.2	8.7	27	358	49	56	16	80	132	7.50		33
22	ORANGE	23-Jul-86	<.1	5.5	15	0.13	0.13	450	720	54	25.8	8.7	27		48	58	15	78	131	7.61	373	33
28	ORANGE	13-Aug-86	<.1	4.0	23	0.26	0.06	450	790	49	24.4	8.7	30	591	48	53	15	80	133	7.57	376	25
36	ORANGE	04-Sep-86	0.1	4.3	21	0.16	0.10	440	660	65	25.2	8.7	30		48	50	15	81	136	7.55	376	24
42	ORANGE	24-Sep-86	<.1	4.1	26	0.13	0.10	420	810	46	25.0	5.8	29		48	50	16	80	134	7.27	376	27
48	ORANGE	15-Oct-86	0.5	3.3	19	0.10	0.13	420	980	42	29.2	5.8	27		48	49	17	83	138	7.41	374	34
8	LINGE	12-Jun-86	0.1	4.5	21	0.16		240	610	48	24.4	8.7	20		30	39	10	41	85	7.43		26
14	LINGE	02-Jul-86	<.1	9.3	19	0.19	0.16	240	660	46	24.0	5.8	21	752	30	39	9	41	83	7.22		31
20	LINGE	23-Jul-86	<.1	5.9	21	0.19	0.16	250	650	57	23.6	5.8	21		30	42	9	41	86	7.33	202	31
26	LINGE	13-Aug-86	<.1	5.4	20	0.29	0.10	260	680	57	22.6	5.8	23	1253	30	44	9	42	84	7.36	207	24
34	LINGE	04-Sep-86	0.1	4.8	20	0.16	0.10	260	580	69	23.5	5.8	23		31	41	9	42	91	7.30	210	22
40	LINGE	24-Sep-86	<.1	5.4	19	0.19	0.13	250	770	53	22.1	2.9	22		30	37	9	41	88	7.26	212	24
46	LINGE	15-Oct-86	1.2	4.6	21	0.16	0.13	260	860	49	23.2	5.8	21		30	36	10	44	93	7.07	214	29

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
				N		P			C													
											SR			Fe	Con							Org
Sta	Lake	Date	NO_3	Susp	TD	Susp	TD	DIC	DOC	Susp	Si	Cl	SO_4	Susp		Na	K	Mg	Ca	pH	Alk	acid
5	MUSCLOW	21-May-86		7.6		0.26		390	870	82	1.4	11.6	20		43	54	15	69	120	7.47	332	40
11	MUSCLOW	12-Jun-86	0.8	3.6	27	0.19	0.19	380	740	42	2.0	11.6	19		44	60	15	67	122	7.58		34
17	MUSCLOW	02-Jul-86	0.1	11.4	24	0.26	0.19	380	740	35	2.5	8.7	20	609	44	53	16	67	125	7.45		40
23	MUSCLOW	23-Jul-86	<.1	4.5	27	0.19	0.16	390	790	39	2.4	8.7	20		43	51	14	63	124	7.54	336	39
29	MUSCLOW	13-Aug-86	0.1	4.0	24	0.29	0.13	400	830	39	2.6	8.7	22	573	44	48	15	67	126	7.53	330	32
37	MUSCLOW	04-Sep-86	0.1	3.9	24	0.19	0.16	400	720	52	4.7	8.7	22		44	55	15	68	128	7.55	336	33
43	MUSCLOW	24-Sep-86	<.1	3.9	19	0.19	0.13	400	950	34	5.6	8.7	21		44	46	16	68	128	7.54	342	33
49	MUSCLOW	15-Oct-86	2.4	3.4	25	0.16	0.13	400	1000	35	8.8	8.7	19		45	47	17	71	133	7.39	344	41
6	SYDNEY	21-May-86		5.4		0.16		350	590	65	1.1	8.7	31		41	50	18	63	104	7.45	281	27
12	SYDNEY	12-Jun-86	0.4	2.9	18	0.16	0.16	340	540	38	2.3	11.6	29		41	50	19	62	104	7.53		22
18	SYDNEY	02-Jul-86	0.1	9.0	19	0.10	0.16	340	510	30	1.4	8.7	30	376	41	48	19	62	105	7.47		26
24	SYDNEY	23-Jul-86	<.1	3.8	21	0.10	0.10	360	600	37	1.2	8.7	29		41	50	18	63	105	7.53	294	25
30	SYDNEY	13-Aug-86	<.1	2.9	19	0.26	0.10	350	540	32	0.7	8.7	33	627	41	50	18	63	106	7.52	290	15
38	SYDNEY	04-Sep-86	0.1	3.2	19	0.13	0.13	370	510	42	1.8	8.7	33		41	47	18	63	111	7.41	294	16
44	SYDNEY	24-Sep-86	<.1	2.9	23	0.13	0.10	340	690	27	1.8	8.7	32		41	45	19	63	110	7.49	298	18
50	SYDNEY	15-Oct-86	0.3	4.9	19	0.10	0.13	360	790	27	3.1	8.7	29		42	45	20	66	114	7.41	298	26
1	TROUT	21-May-86		8.1		0.13		670	380	47	29.1	5.8	27		63	44	17	77	205	7.69	550	18
7	TROUT	12-Jun-86	0.1	3.0	13	0.10	0.13	670	340	30	24.7	8.7	26		64	44	17	76	213	7.86		14
13	TROUT	02-Jul-86	0.1	3.6	13	0.10	0.16	670	340	22	23.8	8.7	26	233	62	43	17	74	209	7.48		18
19	TROUT	23-Jul-86	0.1	3.6	12	0.10	0.13	670	390	30	23.1	5.8	26		62	50	16	76	212	7.80	539	17
25	TROUT	13-Aug-86	<.1	3.2	13	0.19	0.06	670	400	31	23.5	5.8	29	501	61	42	16	74	209	7.80	539	8
33	TROUT	04-Sep-86	0.1	2.0	12	0.16	0.06	650	310	42	27.2	5.8	28		62	42	18	76	214	7.72	548	10
39	TROUT	24-Sep-86	0.1	3.1	21	0.13	0.06	670	500	29	29.8	5.8	28		62	39	17	74	212	7.61	550	11
45	TROUT	15-Oct-86	0.2	3.2	14	0.13	0.10	670	660	32	29.4	5.8	26		62	40	18	77	221	7.22	546	16

Appendix 5. Phytoplankton-related data from lakes in the Red Lake District collected in 1986. Key to column headings:

1. Station number
2. Lake name
3. Date sampled
4. Rate of phytoplankton photosynthesis at irradiances optimal for photosynthesis, mg $C \cdot m^{-3} \cdot h^{-1}$
5. Chlorophyll-a, $\mu g \cdot L^{-1}$ (determined with standard fluorometric method)
6. Chlorophyll-a, $\mu g \cdot L^{-1}$ (determined with high performance liquid chromatography method)
7. P_m^B, rate of photosynthesis at optimal irradiances per unit of chlorophyll-a, mg $C \cdot$mg $Chl^{-1} \cdot hr^{-1}$ (calculated with chlorophyll data from column 5)
8. α, slope of photosynthesis per unit of chlorophyll-a vs light curve, mg $C \cdot m^2 \cdot$mg $Chl^{-1} \cdot Ein^{-1}$ (calculated with chlorophyll data from column 5)
9. Phytoplankton biomass, $mg \cdot m^{-3}$
10. Protozoan biomass, $mg \cdot m^{-3}$
11. Picoplankton biomass, $mg \cdot m^{-3}$
12. Bacteria biomass, $mg \cdot m^{-3}$
13. Percent of total phytoplankton biomass made up by Cyanophyceae
14. Percent of total phytoplankton biomass made up by Chlorophyceae
15. Percent of total phytoplankton biomass made up by Euglenophyceae
16. Percent of total phytoplankton biomass made up by Chrysophyceae
17. Percent of total phytoplankton biomass made up by Diatomeae
18. Percent of total phytoplankton biomass made up by Cryptophyceae
19. Percent of total phytoplankton biomass made up by Peridineae

								$mg.m^{-3}$				Phytoplankton						
Sta	Lake	Date	Popt	Chl	HPLC Chl	P_m^B	alpha	Phy	Pro	Pic	Bac	Cya	Chl	Eug	Chr	Dia	Cry	Per
3	GREEN	21-May-86	1.52					1002	72	1	6	10.8	3.1	0.0	64.7	8.8	5.8	6.9
9	GREEN	12-Jun-86	1.82					96	2	30	14	4.5	7.3	0.0	28.0	53.8	6.4	0.0
15	GREEN	02-Jul-86	2.42	0.8	0.53	3.02	3.81	281	19	956	3	21.1	14.8	0.0	41.7	16.5	5.0	0.9
21	GREEN	23-Jul-86	2.32	0.3	0.93	7.75	9.50	243	8	109	129	36.0	5.1	0.0	21.9	28.4	4.2	4.4
27	GREEN	13-Aug-86	2.23	1.8	0.86	1.24	2.08	134	4	125	51	29.4	12.5	0.0	17.9	23.8	3.4	13.0
35	GREEN	04-Sep-86	3.67	1.7	1.15	2.16	4.56	172	28			18.2	12.0	0.3	37.4	22.5	6.2	3.4
41	GREEN	24-Sep-86	3.61	2.3	2.11	1.57	2.91	277	23			15.8	5.1	0.3	25.6	41.8	6.8	4.6
47	GREEN	15-Oct-86	3.59	2.2	1.69	1.63	4.56	418	3			5.0	12.2	0.0	29.4	48.9	4.1	0.4
4	ORANGE	21-May-86	5.86					1773	71	1	3	4.6	7.3	0.0	55.2	13.7	2.3	16.9
10	ORANGE	12-Jun-86	4.09					607	114	6	9	7.6	13.5	0.0	25.5	40.6	11.0	2.0
16	ORANGE	02-Jul-86	5.53	1.4	1.22	3.95	6.30	373	14	165	56	26.4	23.4	0.0	17.9	16.9	13.9	1.6
22	ORANGE	23-Jul-86	5.79	1.5	1.52	3.86	4.17	335	100	50	124	22.5	30.2	0.0	26.5	8.7	7.8	4.3
28	ORANGE	13-Aug-86	5.14	0.7		7.35	8.38	354	4	21	10	13.0	13.5	0.0	51.2	7.2	11.3	3.8
36	ORANGE	04-Sep-86	6.34	2.1	1.57	3.02	5.29	433	23			28.2	9.2	0.0	27.0	15.5	17.7	2.3
42	ORANGE	24-Sep-86	4.53	3.1	1.14	1.46	2.65	253	12			17.6	5.5	0.0	25.2	19.8	15.6	16.3
48	ORANGE	15-Oct-86	4.50	2.9	2.07	1.55	3.74	265	17			20.2	14.3	0.0	30.3	16.7	18.1	0.4
8	LINGE	12-Jun-86	4.01					323	28	41	16	30.9	2.9	0.0	23.4	19.3	12.9	10.5
14	LINGE	02-Jul-86	5.47	1.7	2.15	3.22	4.99	504	13	162		68.1	9.5	0.0	10.4	2.6	8.4	1.0
20	LINGE	23-Jul-86	4.75	1.1	1.63	4.32	5.24	254	19	147	138	33.2	12.5	0.0	26.7	9.9	10.3	7.4
26	LINGE	13-Aug-86	7.00	2.5	1.38	2.80	4.36	231	15	34	3	24.0	21.0	0.0	19.0	24.3	11.6	0.0
34	LINGE	04-Sep-86	8.48	2.7	1.65	3.14	5.71	296	20			19.9	13.4	0.0	13.9	41.4	7.0	4.4
40	LINGE	24-Sep-86	7.44	4.0	2.57	1.86	3.69	583	32			23.6	13.3	0.0	14.5	42.4	5.2	1.0
46	LINGE	15-Oct-86	5.64	4.0	2.15	1.41	3.59	734	3			24.6	4.5	0.0	10.2	56.4	3.2	1.1
5	MUSCLOW	21-May-86	12.97					1466	69		2	0.2	1.2	0.0	6.9	79.4	8.2	4.2
11	MUSCLOW	12-Jun-86	7.08					176	35	6	5	11.8	7.5	0.0	52.4	9.7	18.6	0.0
17	MUSCLOW	02-Jul-86	7.78	3.1	2.25	2.51	4.78	290	10	103	26	39.8	6.0	0.0	41.1	1.1	12.0	0.1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
								$mg.m^{-3}$				Phytoplankton						
Sta	Lake	Date	Popt	Chl	HPLC Chl	P^B_m	alpha	Phy	Pro	Pic	Bac	Cya	Chl	Eug	Chr	Dia	Cry	Per
23	MUSCLOW	23-Jul-86	7.95	3.0	2.25	2.65	3.52	419	10	129	58	48.4	7.8	0.0	28.3	4.7	10.7	0.0
29	MUSCLOW	13-Aug-86	11.86	1.9	3.06	6.24	8.14	260	6	64	6	59.3	7.1	0.0	16.1	0.9	16.7	0.0
37	MUSCLOW	04-Sep-86	10.01	3.5	2.73	2.86	4.51	276	13			21.6	30.3	0.0	28.2	4.3	15.7	0.0
43	MUSCLOW	24-Sep-86	8.61	3.2	3.76	2.69	4.64	226	15			20.6	11.7	0.0	34.4	3.0	28.6	1.7
49	MUSCLOW	15-Oct-86	5.42	3.1	3.92	1.75	3.89	176	36			8.9	10.2	0.0	34.8	9.2	27.4	9.5
6	SYDNEY	21-May-86	4.01					2243	350	2	13	0.3	0.5	0.0	6.6	79.1	7.1	6.4
12	SYDNEY	12-Jun-86	3.43					296	115	9	2	21.6	6.2	0.0	56.3	6.1	8.1	1.7
18	SYDNEY	02-Jul-86	3.89					182	13	56	23	4.9	3.7	0.0	62.1	5.9	21.0	2.4
24	SYDNEY	23-Jul-86	5.75	1.4	1.56	4.11	4.34	257	64	65	39	24.0	4.0	0.0	41.7	18.0	12.2	0.0
30	SYDNEY	13-Aug-86	3.81	1.7	1.54	2.24	3.03	122	27	48	3	18.4	4.8	0.0	39.7	12.2	10.6	14.4
38	SYDNEY	04-Sep-86	5.65	2.1	0.88	2.69	4.53	308	20			38.4	7.7	0.0	10.8	29.0	7.6	6.5
44	SYDNEY	24-Sep-86	4.14	2.1	1.69	1.97	3.85	160	49			19.7	10.1	0.0	60.2	4.8	4.9	0.4
50	SYDNEY	15-Oct-86	4.48	2.8	3.05	1.60	4.00	194	41			8.9	18.0	0.8	34.0	12.6	21.6	4.2
1	TROUT	21-May-86	5.65					458	51	1		1.3	0.2	0.0	39.1	46.5	11.0	1.9
7	TROUT	12-Jun-86	3.82					367	27	4	5	1.6	2.4	0.0	39.8	51.1	5.1	0.0
13	TROUT	02-Jul-86	3.06	1.8	1.07	1.70	2.88	497	14	596	39	7.0	2.6	0.0	57.1	32.2	1.1	0.0
19	TROUT	23-Jul-86	3.39	1.3	1.26	2.61	6.98	475	8	172	13	54.6	4.3	0.0	17.2	16.2	7.7	0.0
25	TROUT	13-Aug-86	5.62	2.0	1.90	2.81	4.13	203	6	46	7	19.4	8.0	0.0	26.2	26.0	12.4	8.0
33	TROUT	04-Sep-86	5.20	1.8	1.08	2.89	6.26	234	7			21.9	10.6	0.0	26.9	31.5	3.0	6.1
39	TROUT	24-Sep-86	6.44	1.7	1.75	3.79	6.01	349	72			38.6	10.0	0.0	14.8	32.9	2.2	1.5
45	TROUT	15-Oct-86	5.47	3.2	3.22	1.71	3.69	391	38			7.6	2.8	0.0	17.7	52.2	16.7	3.0

Appendix 6. Temperature profiles from lakes in the Red Lake District, 1986. The mixed layer depths used for calculating daily mean mixed layer irradiances in Appendix 3 and Table 1 are indicated with an underscore. See the legend to Appendix 3 for the sampling date corresponding to each station number.

Sta	Depth, metres																				
No	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	30	35
Green Lake																				
3	13.6	13.4	12.7	11.9	11.1	10.1	9.0	8.3	7.7	7.4	7.2	6.9	6.8	6.5						
9	16.3		16.2		15.6	14.4	12.7													
15	18.0			18.0	17.9	17.9	15.8	12.6	10.0	8.4	8.0	7.5	7.1	7.0	6.9					
21	20.7	20.7	20.6	20.2	20.0	19.7	18.8	16.1	12.5	10.0	9.0	8.3	7.9	7.4	7.2	7.0				
27	20.4	20.3	20.1	20.0	20.0	19.9	19.8	18.5	13.6	11.4	9.3		7.9		7.1					
32	18.4		18.4	18.5	18.6		18.6	18.7	15.8	10.6	9.5	8.5	7.9	7.5	7.3	7.1				
35	16.1					16.1														
41	12.9										12.6	11.5	8.4	7.7	7.4	7.2				
47	7.4		7.3		7.3															
Orange Lake																				
4	11.8	11.6	11.0	9.8	9.4	9.2	8.5	8.0	7.4	6.5	6.3	6.0	5.8	5.7	5.5	5.5	5.2	4.8		
10	16.1		16.1	15.9		15.4	12.6	9.1	8.1	7.4	6.6	6.3	5.9							
16	18.3		18.3	18.0	17.6	17.1	15.3	12.6	9.7	7.5	6.9	6.5	6.2	6.0	5.9	5.7	5.3	5.2	4.9	
22	21.1	21.1	21.0	21.0	20.6	19.5	17.0	14.0	10.1	8.4	7.6	7.0	6.5	6.2	6.0	5.8	5.2	5.0		
28	20.4	20.1	19.8	19.6	19.4	19.3	16.9	12.5	10.7	10.0	9.0	8.1	7.4							
31	18.5						18.5	17.6	13.4	10.3	8.6	7.5	6.7	6.3	6.0	5.8	5.3	5.1		
36	16.1							16.1	14.5	9.8	7.9		6.5		6.0					
48	7.5			7.4			7.4	7.3	7.2			7.2	7.1			7.1				
Linge Lake																				
8	14.9					14.9	14.8		11.2		9.0		8.5		8.3					
14	17.3					17.3	17.1	15.4	14.2	12.8	11.4	10.1	9.6		8.6		7.2			
20	20.5	20.4	20.2	19.9	19.6	19.4	19.2	18.3	16.5	15.0	13.1	11.0	10.0	9.3	8.8	8.4	7.0			
26	19.6	19.5	19.5	19.4	19.4	19.3	19.3	19.1												
40	12.7											12.7	12.4	12.3	12.3	11.5	7.3			
46	8.5		7.9	7.7		7.7	7.5													
Musclow Lake																				
5	9.7	9.1	8.0	7.8	7.5	7.4	7.3	7.1	6.9	6.9	6.8	6.6	6.2	5.9	5.7	5.5	5.3	5.2	5.1	4.9
11	13.0	12.9																		
17	17.3		17.0		16.7		16.5	16.4	15.6	13.4	13.1	11.8	11.6		9.6		8.5	7.5	6.7	
23	19.0	19.0	18.9	18.9	18.8	18.7	18.7	17.0	16.4	15.1	14.1	13.2	12.4	10.6	9.6	9.1	8.0	7.7	7.2	
29	19.8	19.4	19.0	18.9	18.9	18.8	18.8			18.6	15.2	14.5	13.5	11.8	11.2					
37	15.6													15.6	14.7	10.5				
43	13.1										13.1									
Sydney Lake																				
6	10.2	10.0	9.8	9.3	8.0	7.5	7.4	7.0	6.9	6.8	6.4	6.3	6.0	5.8	5.7	5.6	5.4	5.3	5.0	4.8
12	14.1			14.1	13.9	13.8	12.7													
18	16.8		16.4		16.2		16.0	15.9	15.6	13.8	12.8	12.1	10.9	10.5	10.1		8.1	7.5	7.0	
24	19.6	19.4	19.1	18.7																
30	20.1	19.7	19.3	19.0	19.0	18.8	17.1	16.8												
38	15.9								15.8											
44	13.6	13.4	13.3	13.2	13.1					13.0			12.9	12.7	11.6	10.7	9.4	8.6		
50	9.4		9.3	9.2	9.1	9.1														
Trout Lake																				
1	7.3	7.0	6.6	5.9	5.4	4.9	4.7	4.6	4.5		4.5					4.4	4.4			
7	11.8							10.6			10.1			9.5		8.8	8.3			
13	14.5												14.5	14.2	13.8	13.4	11.4			
19	17.8		17.8	17.7	17.6	17.6	17.4	17.0	15.6	15.0	14.0	13.8	13.7	13.3	13.1	13.0	11.9			
25	18.3			18.3	18.2	18.2	18.1			18.1	18.0	17.8	17.2							
39	12.7																12.7			
45	8.8																	8.8		

Appendix 7. Transparency data (% of surface light) from lakes in the Red Lake District, 1986. See the legend to Appendix 3 for the sampling date corresponding to each station number.

Sta No	depth, metres 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Green Lake																
3	100	53.00	28.00	16.00	9.50	5.30	3.15	1.90	1.06	0.64	0.38					
9	100	78.75	39.38	26.25	15.75	9.63	6.56									
15	100	50.00	28.67	18.67	11.67	7.33	4.60	3.00	1.87	1.27	0.93					
21	100	53.55	30.65	20.00	12.58	8.39	5.65	3.68	2.42	1.68	1.16	0.90	0.74			
27	100	40.32	26.08	16.13	9.95	6.34	4.24	2.79	1.61	0.90	0.49					
32	100	50.88	31.18	19.12	12.21	8.26	5.24	3.47	2.21	1.26	0.68					
35	100	44.05	22.62	13.57	9.05	6.19										
41	100	47.50	27.50	16.67	10.00	6.33	4.07	2.58	1.67	1.08	0.62	0.33	0.16			
47	100	45.45	23.94	12.42	7.27											
Orange Lake																
4	100	44.80	20.53	8.40	4.29	2.46	1.26	0.67	0.35	0.20	0.11					
10	100	56.88	21.88	11.81	5.95	2.98	1.49	0.79								
16	100	36.67	18.00	9.00	4.27	2.07	1.07	0.53	0.28	0.15	0.08	0.05				
22	100	31.52	15.22	8.26	4.78	2.65	1.63	1.09	0.83	0.67						
28	100	29.41	14.12	7.35	4.12	2.35	1.41	0.71	0.39	0.28						
36	100	31.49	17.02	10.85	5.70	3.28	1.83	1.09	0.60	0.38						
48	100	38.17	18.93	9.87	5.65	3.31	2.02	1.20	0.70	0.43	0.27					
Linge Lake																
14	100	38.40	19.20	8.80	4.00	1.92	0.84	0.32	0.04							
20	100	35.00	17.00	9.17	5.00	3.03	1.87	1.30	0.97	0.85	0.75					
26	100	35.00	16.67	8.33	4.40	2.33	1.20									
34	100	36.46	14.06	6.67												
40	100	34.03	16.27	8.55	4.69	2.42	1.31	0.76	0.42	0.24	0.13					
46	100	34.39	16.93	8.04	4.07	2.06										
Musclow Lake																
5	100	32.17	13.91	6.43	2.70	0.90	0.39	0.17	0.08	0.04	0.02					
17	100	37.58	16.36	7.58	3.82	1.82	0.88	0.39	0.17	0.06						
23	100	31.00	15.00	7.30	3.80	2.20	1.34	0.94	0.74	0.62	0.58					
29	100	33.13	17.61	7.95	4.15	2.10	1.13									
43	100	30.84	15.23	7.85	2.86	1.85	1.05	0.56	0.30	0.19	0.10					
Sydney Lake																
6	100	54.44	29.55	17.11	9.72	5.60	3.34	1.98	1.17	0.73						
18	100	58.82	30.59	17.65	9.41	4.12	1.47	0.56	0.32							
30	100	46.08	30.58	19.99	12.16	7.29	4.67									
38	100	50.94	23.58	14.53	8.49	5.66	3.96	2.45								
44	100	48.08	23.08	13.85	8.27	5.21	3.25	2.15	1.40	1.00						
50	100	45.53	25.29	14.79	8.56	5.18										
Trout Lake																
1	100	42.00	23.80	14.00	9.38	5.88	3.78	2.41	1.54	1.05	0.70	0.48	0.32	0.22	0.15	0.09
13	100	43.75	22.50	13.13	8.38	5.13	3.00	1.81	1.08	0.59	0.39	0.29				
19	100	46.67	25.56	15.11	9.33	5.78	4.29	2.89	2.16	1.62	1.27	1.04	0.91			
25	100	50.45	30.63	18.02	10.81	6.94	4.69	3.24	2.39	1.58	0.97					
39	100	47.22	28.13	18.25	11.51	7.54	4.96	3.41	2.34	1.59						
45	100	48.59	30.28	19.72	12.32	8.03	5.21	3.52	2.54	1.62	1.06					

Appendix 8. Phytoplankton nutrient status data collected from lakes in the Red Lake District, 1986. Key to column headings:

1. Station number
2. Date sampled
3. Lake name
4. Net sample (suspended carbon):(chlorophyll a) ratio, $\mu mol \cdot \mu g^{-1}$
5. Net sample (suspended C):(suspended N) ratio, $\mu mol \cdot \mu mol^{-1}$
6. Net sample (suspended N):(suspended P) ratio, $\mu mol \cdot \mu mol^{-1}$
7. Net sample (suspended C):(suspended P) ratio, $\mu mol \cdot \mu mol^{-1}$
8. Whole water sample chlorophyll a, $\mu g \cdot L^{-1}$
9. Whole water sample (suspended carbon):(chlorophyll a) ratio, $\mu mol \cdot \mu g^{-1}$
10. Whole water sample (suspended C):(suspended N) ratio, $\mu mol \cdot \mu mol^{-1}$
11. Whole water sample (suspended N):(suspended P) ratio, $\mu mol \cdot \mu mol^{-1}$
12. Whole water sample (suspended C):(suspended P) ratio, $\mu mol \cdot \mu mol^{-1}$
13. Whole water sample (total) alkaline phosphatase activity, $\mu mol\ P \cdot L^{-1} \cdot h^{-1}$
14. Filtered water sample (soluble) alkaline phosphatase activity, $\mu mol\ P \cdot L^{-1} \cdot h^{-1}$
15. Particulate alkaline phosphatase activity normalized to chlorophyll, $\mu mol\ P \cdot h^{-1} \cdot \mu g\ Chl^{-1}$

1	2	3	4	5	6	7	8	9	10	11	12	13	14 APA	15
Sta	Date	Lake	C:Chl	C:N	N:P	C:P	Chl	C:Chl	C:N	N:P	C:P	Tot	Sol	Part
3	21-May-86	GREEN	59.5	8.8	19	162					385	0.197	0.057	
9	12-Jun-86	GREEN	8.9	10.8	19	200			11.9	24	284	0.152	0.033	
15	02-Jul-86	GREEN	12.4	10.1	24	243	0.8	43.9	5.5	66	364	0.209	0.053	0.195
21	23-Jul-86	GREEN	24.5	13.1	13	173	0.3	166.7	11.0	37	410	0.161	0.032	0.430
27	13-Aug-86	GREEN	20.3	12.7	19	248	1.8	30.9	13.0	22	287	0.145	0.031	0.063
41	24-Sep-86	GREEN	20.3	15.2	33	496	2.3	23.8	11.3	37	416	0.152	0.037	0.050
47	15-Oct-86	GREEN	18.1	12.3	33	410	2.2	26.0	12.4	30	374	0.170	0.042	0.058
4	21-May-86	ORANGE	19.8	8.5	21	183			10.4	42	437	0.174	0.058	
10	12-Jun-86	ORANGE	8.3	9.8	22	217			11.7	20	237	0.207	0.031	
16	02-Jul-86	ORANGE	7.7	9.9	29	290	1.4	28.7	6.1	50	311	0.284	0.094	0.136
22	23-Jul-86	ORANGE	11.7	11.3	13	145	1.5	36.2	9.9	43	416	0.294	0.045	0.166
28	13-Aug-86	ORANGE	8.5	14.2	22	319	0.7	69.4	12.3	15	190	0.206	0.049	0.224
36	04-Sep-86	ORANGE	13.0	13.1	62	807	2.1	30.9				0.221	0.054	0.080
42	24-Sep-86	ORANGE	16.7	16.0	33	527	3.1	14.9	11.1	37	403	0.172	0.038	0.043
48	15-Oct-86	ORANGE	11.3	11.1	37	416	2.9	14.4	12.7	31	385	0.120	0.043	0.027
2	21-May-86	LINGE	32.1	8.8	24	206								
8	12-Jun-86	LINGE	7.3	8.8	27	235			10.7	28	300	0.112	0.022	
14	02-Jul-86	LINGE	7.2	9.1	22	203	1.7	26.9			237	0.174	0.052	0.072
20	23-Jul-86	LINGE	8.1	10.8	15	158	1.1	52.1	9.6	31	293	0.180	0.037	0.130
26	13-Aug-86	LINGE	7.7	10.6	44	461	2.5	22.5	10.4	19	196	0.175	0.031	0.058
34	04-Sep-86	LINGE	9.7	10.6	37	397	2.7	26.0	24.3	18	430	0.172	0.048	0.046
40	24-Sep-86	LINGE	10.5	13.7	31	423	4.0	13.2	10.0	28	275	0.147	0.033	0.029
46	15-Oct-86	LINGE	11.7	10.2	33	331	4.0	12.3	10.8	27	287	0.100	0.039	0.015
5	21-May-86	MUSCLOW	17.7	12.0	23	275			10.8	29	315	0.065	0.039	
11	12-Jun-86	MUSCLOW	6.7	8.3	21	178			11.9	18	219	0.059	0.017	
17	02-Jul-86	MUSCLOW	4.3	8.0	28	226	3.1	11.3			136	0.152	0.054	0.032
23	23-Jul-86	MUSCLOW	6.1	9.1	26	237	3.0	13.0	8.7	23	202	0.126	0.034	0.031
29	13-Aug-86	MUSCLOW	4.3	8.7	22	191	1.9	20.8	9.8	14	135	0.160	0.035	0.066
37	04-Sep-86	MUSCLOW	7.3	9.6	54	516	3.5	15.2				0.136	0.053	0.024
43	24-Sep-86	MUSCLOW	8.4	12.4	24	297	3.2	10.7	8.8	20	177	0.080	0.038	0.013
49	15-Oct-86	MUSCLOW	11.6	10.1	17	176	3.1	11.3	10.2	20	203	0.046	0.037	0.003

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
												APA		
Sta	Date	Lake	C:Chl	C:N	N:P	C:P	Chl	C:Chl	C:N	N:P	C:P	Tot	Sol	Part
6	21-May-86	SYDNEY	23.8	14.8	33	496			12.2	33	403	0.099	0.046	
12	12-Jun-86	SYDNEY	8.3	9.8	24	235			13.4	18	237	0.076	0.015	
18	02-Jul-86	SYDNEY	6.0	10.6	20	215					311	0.080	0.009	
24	23-Jul-86	SYDNEY	9.2	11.3	25	278	1.4	26.0	9.7	39	380	0.112	0.029	0.059
30	13-Aug-86	SYDNEY	9.6	12.2	23	278	1.7	18.5	11.1	11	122	0.095	0.029	0.039
38	04-Sep-86	SYDNEY	10.5	10.9	52	574	2.1	20.8				0.099	0.054	0.021
44	24-Sep-86	SYDNEY	12.4	13.7	23	315	2.1	13.0	9.6	20	190	0.072	0.033	0.019
50	15-Oct-86	SYDNEY	10.7	10.1	24	246	2.8	9.5	5.5	45	248	0.043	0.032	0.004
1	21-May-86	TROUT	36.2	10.7	34	364			5.7	63	364	0.088	0.035	
7	12-Jun-86	TROUT	11.4	10.7	32	344			10.0	31	311	0.071	0.020	
13	02-Jul-86	TROUT	8.4	8.5	20	168	1.8	12.1	6.1	37	224	0.103	0.036	0.037
19	23-Jul-86	TROUT	11.0	9.8	30	300	1.3	23.1	8.4	37	311	0.130	0.027	0.079
25	13-Aug-86	TROUT	7.8	10.0	33	331	2.0	15.4	9.6	17	159	0.114	0.022	0.046
33	04-Sep-86	TROUT	9.8	11.1	27	304	1.8	23.8				0.097	0.046	0.028
39	24-Sep-86	TROUT	9.2	12.2	16	196	1.7	17.0	9.5	21	200	0.050	0.023	0.016
45	15-Oct-86	TROUT	9.7	9.8	21	206	3.2	10.2	10.1	25	251	0.039	0.034	0.002