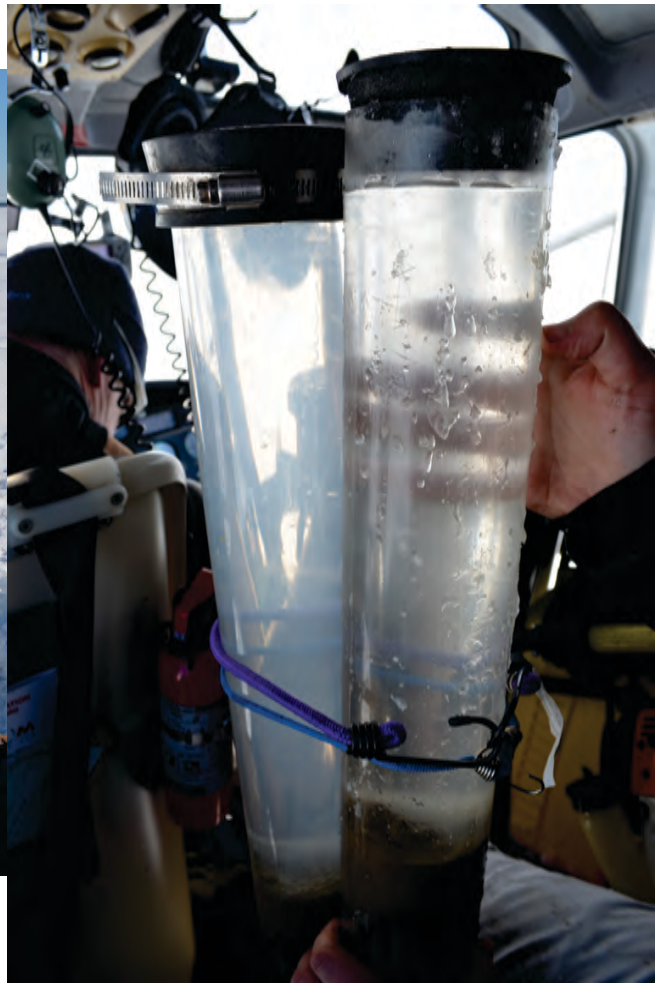
Southern Indian Lake Lacustrine Coring Program

Coordinated Aquatic Monitoring Program (CAMP), Manitoba Hydro, and the Province of Manitoba

7 November 2017



J D MOLLARD AND ASSOCIATES (2010) LIMITED

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7 November 2017

Prepared For:

Russ Schmidt
Coordinated Aquatic Monitoring Program
Manitoba Hydro
360 Portage Avenue
Winnipeg, MB
R3C 0G8

Prepared By:

J.I. Cosford, Ph.D., P.Geo.

J.D. Mollard and Associates (2010) Limited
1720 Avord Tower, 2002 Victoria Avenue
Regina, SK S4P 0R7

Ph: (306) 352-8811 Fx: (306) 352-8820
Email: cosford@jdmollard.com

J D MOLLARD AND ASSOCIATES (2010) LIMITED

J D MOLLARD AND ASSOCIATES (2010) LIMITED
CONSULTING ENGINEERS AND GEOSCIENTISTS

Phone (306) 352-8811 (306) 352-8855
Fax (306) 352-8820
Email: admin@jdmollard.com

1720 Avord Tower, 2002 Victoria Avenue
Regina Saskatchewan Canada
S4P 0R7

www.jdmollard.com

November 7, 2017

Russ Schmidt
Manitoba Hydro
360 Portage Avenue
Winnipeg, MB
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Re: Laboratory analyses of Core 1 from Southern Indian Lake

Dear Russ:

J.D. Mollard and Associates (2010) Limited (JDMA) in collaboration with the Institute of Environmental Change and Society (IECS) at the University of Regina completed an exploratory study of multi-proxy analyses of a lacustrine core collected from Area 4 of Southern Indian Lake. Although the core did not yield a robust ^{210}Pb profile, ^{137}Cs measurements provided distinct peaks that correspond to 1955 and 1964 (along with the 2017 surface) from which we were able to establish an approximate chronology that allowed for determining the pre- and post-impoundment sediments. Proxies analyzed in this study show a decline in littoral habitats after impoundment. While results from this single core may not represent a definitive study on the entire aquatic ecosystem of Southern Indian Lake, this study demonstrates that a multi-proxy approach documents diverse ecosystem changes in Area 4 coeval with the final flooding of Southern Indian Lake, and, consequently, provide an improved understanding of historical change in this northern sub-basin.

Thank you for the opportunity to work on this interesting project. Please let me know if you have any questions, or if you'd like to schedule a meeting or teleconference to discuss the results.

Sincerely,

Jason Cosford, Ph.D., P.Geo.
J.D. Mollard and Associates (2010) Limited

Ph: (306) 352-8811
Email: cosford@jdmollard.com

Table of Contents

1 Introduction

Southern Indian Lake is a large, boreal lake on the Churchill River system in northwestern Manitoba near the lower end of a drainage basin that extends across the northern Prairie Provinces and empties into Hudson Bay at the town of Churchill (Figure 1). In 1976, as part of the Churchill River Diversion (CRD), impoundment of Southern Indian Lake by the Missi Falls control structure on the northeastern outlet raised lake level by 3 m and diverted flow through a southern outlet into the Notigi Reservoir that ultimately joins the Nelson River, where Manitoba Hydro operates several large hydroelectric generating stations (Newbury et al., 1984). Effects of the impoundment of Southern Indian Lake have been studied extensively, including changes in bank erosion (Newbury and McCullough, 1984), nearshore sedimentation (Hecky and McCullough, 1984), disruptions to the aquatic ecosystem (Hecky and Guildford, 1984; Patalas and Salki, 1984), collapse of the lake whitefish (*Coregonus clupeaformis*) commercial fishery (Bodaly et al., 1984), and more recently as part of a Regional Cumulative Effects Assessment (RCEA, 2014).

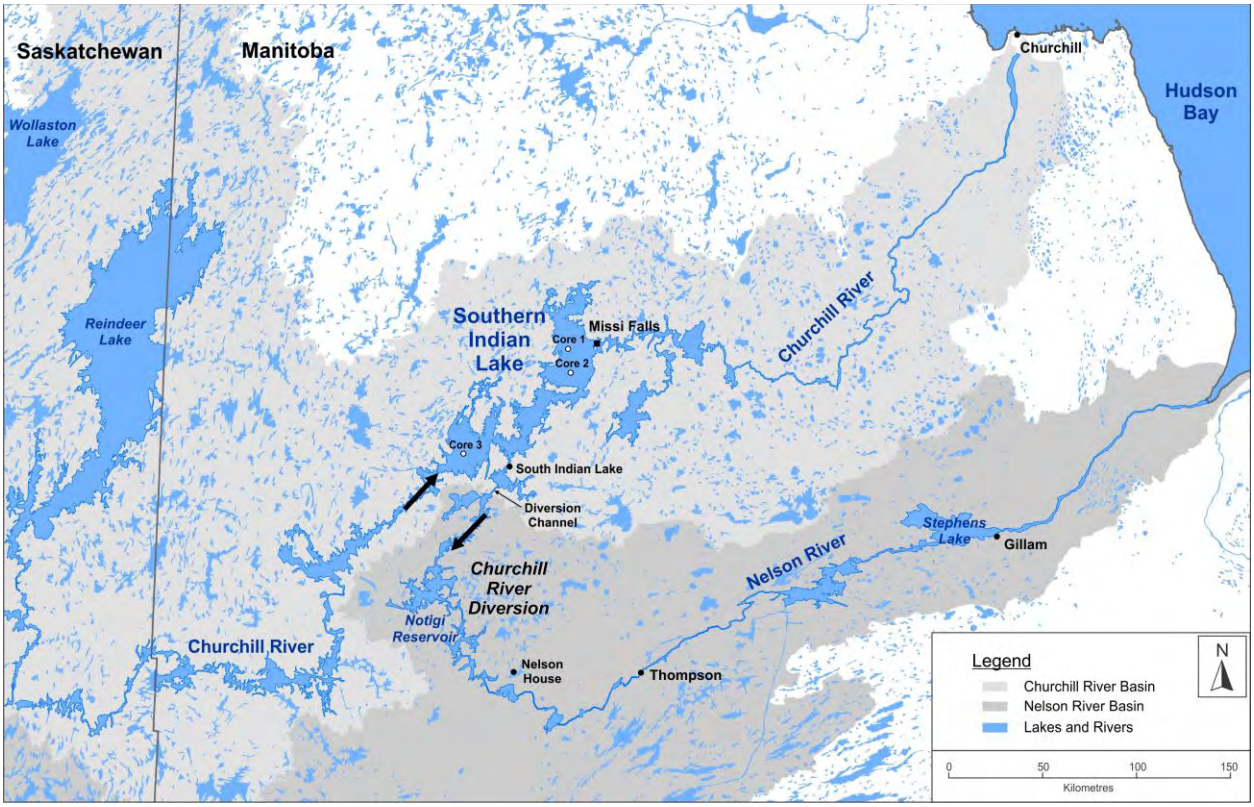

Figure 1: Southern Indian Lake and the Churchill River Diversion.

Under the mandate of the Coordinated Aquatic Monitoring Program (CAMP), the Province of Manitoba and Manitoba Hydro expressed interest in the collection and analysis of lacustrine cores from Southern Indian Lake to help assess past changes and the current state of the aquatic ecosystem. Following discussions with experts at the Institute of Environmental Change and Society (IECS) at the University of Regina, J.D. Mollard and Associates (2010) limited (JDMA) proposed the collection of several lacustrine cores from which to select one core for multi-proxy analyses, with the objective of demonstrating how the use of the multiple fossil proxies can improve understanding of the historical changes in Southern Indian Lake during the past 50 years, and to comment on how these data can be used to interpret changes in Area 4 for a period spanning the pre- and post CRD transition to the present.

The selection of coring sites followed discussions with Don MacDonald (Regional fisheries manager at Manitoba Sustainable Development) and relied on his local knowledge of the lake and of the objectives of the study, along with considerations of water depth and substrate conditions. Area 4 was designated a priority and two locations were identified that exhibited maximum water depth, open water conditions far from the shore and islands, and soft substrate conditions suitable for lacustrine coring. Two cores were collected from Area 4: Core 1 from the central basin and Core 2 from the southern portion of the basin (Figure 2). Area 1 was also identified as an area of interest and one core (Core 3) was collected here following the same considerations (Figure 2). Sampling was completed in late winter to allow access via helicopter and to use the ice as a coring platform (Figure 3 and 4).

Several biological proxies were recommended for analysis, including sediment geochemistry, fossil pigments, fossil diatoms, and fossil cladocera. Physical properties of the sediment (i.e. grain-size and mineralogy) were not included in the laboratory analysis, but descriptions of the sediment were made during subsampling. Smol (2008) provides a description of the biological proxies and their use in paleolimnology, which are summarized here:

Sediment Geochemistry: Carbon (C) and nitrogen (N) content, along with stable isotopes of $\delta^{13}C$ and $\delta^{15}N$ are commonly used in biological studies to represent primary production and nutrient inputs.

Fossil Pigments: Sedimentary pigment concentrations (chlorophylls, carotenoids, etc.) are used as a proxy for gross community composition and for evaluating changes in aquatic primary productivity. Fossil pigments can also be used to determine the changing diversity of aquatic flora.

Fossil Cladocera: Cladocera are tiny crustaceans that comprise a major component of planktonic fauna in lakes. They are the grazers of the water column and a large portion of the diet of fish populations. Fossil cladocera are used to estimate historical fish feeding.

Diatoms: Diatoms are unicellular algae and a common type of phytoplankton. Identification of various diatom communities is used to interpret productivity and aquatic habitats.

The results of the multi-proxy analyses presented in this report are provided by the following researchers from the Institute of Environmental Change and Society (IECS) and the Department of Geology at the University of Regina: Peter Leavitt, Heather Haig, Gavin Simpson, Britt Hesjedal, and Maria Velez.

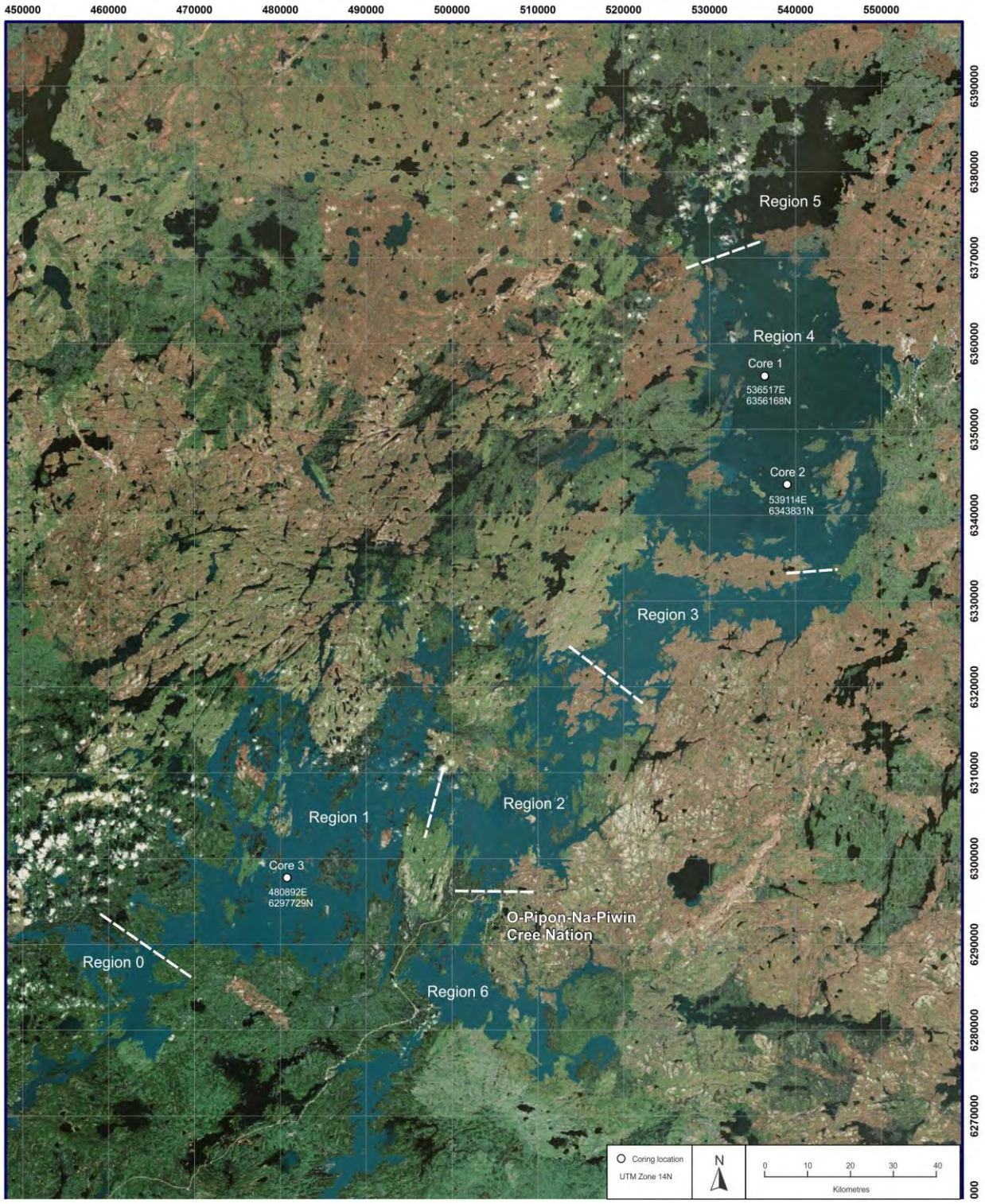

Figure 2: Coring sites in this study on Southern Indian Lake.

2 Methods

2.1 Core Extraction and Subsampling

Surficial sediment cores were collected from Southern Indian Lake during the week of March 18-24, 2017. Lacustrine cores were extracted using a Glew gravity corer with internal core diameters of ~7.6 cm (Glew et al., 2001). This corer worked very well for the water depth and soft substrate encountered at the coring sites. A gravity corer consists of a metal head that attaches to a plastic core recovery tube. Deployed from a rope held at surface, the gravity corer descends through the water column and sinks into the sediment. Additional weights were fitted to assist pushing the coring tube into the sediment. The head of the corer has an opening that allows water to escape as the device is lowered through the water column. Once set in the sediment, a small messenger weight is released from the surface and guided by the rope to the coring head where it then releases a cover that seals the top of the tube, creating vacuum pressure that assists in keeping the sediment in the tube as it ascends through the water column back to the surface. Prior to breaking the surface of the water, a rubber stopper is inserted into the bottom of the tube to prevent sediment from falling out.

After being extracted from the lake, the core tubes were carefully transported to the laboratory space in Thompson, where the sediment in the core tube was extruded and subsampled every 0.25 cm (Figures 5 and 6). The sampled material was placed in Whirl-Pak® bags and kept in a cooler for transport back to the to the University of Regina's Institute of Environmental Change and Society (IECS) for storage at a temperature of ~4°C. Samples were given the following label:

MH-SIL-2017-CX
x.x-x.x cm

This label specifies that the project is for MH (Manitoba Hydro)- SIL (Southern Indian Lake)-2017 (date)-C1 (Core 1, 2 or 3)-depth intervals (e.g. 0-0.25 cm).

Sediments recovered in each of the cores were very soft, grey clay-like and other finely-divided materials. Laminations were not evident during subsampling and the sediment appeared to be largely uniform throughout the cores. No macroscopic (visible) changes in grain-size were evident. While sparse organic detritus was observed in a few subsamples, no discrete layers or significant accumulations of organic material were observed. Viewed from the outside of the core tube, there appeared to be a distinct brownish horizon in the upper portion of the cores (5-10 cm), with more greyish sediment below; however, these colours were not apparent during sectioning of the cores.

Core 1 was selected for multi-proxy analyses in the laboratory based on the core location in the deepest part of the basin in Area 4 and the visible high quality of the sediment core (undisturbed sediment-water interface). Given the expected sedimentation rate for lakes in this region (no more than 1 mm/yr) and the analytcal budget for this preliminary study, a total of 20 subsamples at 1 cm intervals from 0 to 19 cm were used for the multi-proxy analysis. Given the observed sediment chronology (see ^{137}Cs details below), this depth range captured both the pre- and post-impoundment horizon and provided sufficient

resolution to reveal overall trends in the proxy records. Analysis of the sediment from Core 1 began in July 2017.

Following is a summary of the core sites and observations made during the extrusion and sub-sampling of the sediment in the core tubes:

Core 1

- 536517E 6356168N UTM14N
- Central Basin of Area 4
- Initial measurement was 63.5 cm
- 5.25 cm starting to notice colour change
- final measurement 69.5 cm

Core 2

- 539114E 6343831N UTM14N
- Southern Basin Area 4
- Initial measurement 52.75 cm
- 24.25-24.5 cm - irregular surface.
- 35.25 cm added extender and pushed up a small amount and when measured we confirmed that it was ~0.75 cm so the sample is labeled 35.25-36 cm
- 46.5 cm found evergreen needle
- final measurement 53.5 cm

Core 3

- 480892E 6297729N UTM14N
- Area 1
- Initial measurement 61.5 cm
- irregular surface
- 9-9.25 cm more liquid content than the previous samples
- 19-19.5 cm - double sample (0.5 cm)
- 35.25-35.75 cm - double sample (0.5 cm)
- Final sectioning length 60.75cm

Figure 3: Helicopter arrives at coring site 1 in Area 4 of Southern Indian Lake.

Figure 4: Core 1 recovered 69.5 cm of sediment from Area 4.

Figure 5: Sediment cores being transported back to Thompson (Left). Note the clear water and preservation of the sediment-water interface. Cores 2 and 3 returned from the field (Right). Note the distinct brownish horizon in the upper portion of the cores and the greyish sediment below.

Figure 6: Back in the lab, the core was extruded (left) and subsampled (right).

2.2 Sediment Chronology

Radiometric dating using lead-210 (^{210}Pb) and cesium-137 (^{137}Cs) radionuclides was attempted for Core 1. Appleby (2008) provides an overview of dating recent sediments by fallout radionuclides. Given that the sedimentation rate within the reservoir was difficult to predict *a priori* (natural lakes ~1 mm/year; reservoirs >1 cm/year), 15 samples were selected to cover the uppermost 60 cm of Core 1 (total length 69.5 cm after sectioning). Analyses were performed at IECS using low-background gamma counting (Schelske et al., 1994). Samples for ^{210}Pb dating were spaced at 1-3 cm intervals for the first 24 cm of a core and then at larger intervals thereafter.

For each sample, whole sediments were transferred to small plastic containers and freeze-dried for ca. 48 hr at 0.1 Pa. Dried sediments were weighed and placed in plastic vials to ~2 cm tube-height, which were then sealed using a silicone disc and epoxy resin. Samples sat for approximately two weeks to ensure equilibrium for ^{214}Bi was reached. ^{214}Bi was used as a proxy for ^{226}Ra to determine background radioactivity (Schelske et al., 1994). Decay was measured over 80,000 seconds using an Ortec germanium (Gr) crystal-well detector following Schelske et al. (1994), and unsupported and supported ^{210}Pb and ^{137}Cs activities were calculated from the data. Unsupported ^{210}Pb (via ^{214}Bi) activities were interpreted by the constant rate of supply (CRS) model using the unpublished ScienTissiME MATLAB program developed by Mike Scheer.

Approximate chronologies were estimated independently using ^{210}Pb and ^{137}Cs profiles. However, as ^{210}Pb activities were very low, and there was evidence of fluctuations in background estimates of activity (see below), samples were sent for additional analysis at the Paleoecological and Environmental Assessment and Research Laboratory (PEARL) at Queen's University in Kingston, Ontario. The results confirmed very low ^{210}Pb activities and that a reliable chronology could not be established from ^{210}Pb analyses.

An approximate chronology was developed using ^{137}Cs activities alone, based on the assumption that the surface sample was collected in 2017, the mid-core ^{137}Cs peak represented ca. 1964, and the onset of elevated ^{137}Cs activity (beyond background) represented ca. 1955. These last two are known to represent the peak (ca. 1964) and onset (1955) of open-air atomic bomb testing during the 20th century, and have been used as reliable chronological markers in paleolimnological studies worldwide (Schelske et al., 1994). Based on these dates, very approximate estimates of the age of sediment depths was calculated by fitting a shallow quadratic or linear function to the three points.

Due to difficulties in establishing a robust chronology at sub-decadal resolution, interpretations of the timing of historical events should be considered tentative. However, given the very well-defined onset and peak of ^{137}Cs activities, we feel that the approximate chronology presented below would not have been altered greatly by additional ^{210}Pb analyses. The ^{137}Cs data provide a sufficient chronology to approximate the pre- and post-reservoir depth in the core. That said, please note that this approach cannot record sudden changes in the rate of sediment deposition, such as might be expected to occur following conversion of a natural lake to a reservoir.

2.3 Sediment Geochemistry

Whole, freeze-dried sediment was analyzed for carbon (C) and nitrogen (N) content (% dry mass) and stable isotope values ($\delta^{13}C$, $\delta^{15}N$). No attempt was made to removed dissolved inorganic C through acid treatment. For each sample, ~3 mg of sediment was packed into 5x8 mm tin cups for subsequent combustion.

Stable isotope ratios of organic matter C ($\delta^{13}C$) and N ($\delta^{15}N$) and sediment elemental composition (percent C (%C), percent N (%N), and molar C/N ratio) were quantified by a Thermo Scientific Delta V Plus isotope ratio mass spectrometer (IRMS) that was connected to a Costech ECS 4010 Elemental Analyser via a ConFlo IV interface following Savage et al. (2004). All analyses were conducted at the Institute for Environmental Change and Society (IECS) at the University of Regina, Canada. Isotopic ratios were expressed using the standard delta (δ) notation in ‰ relative to Vienna-Pee Dee Belemnite and atmospheric N_2 for C and N, respectively, as follows:

$$\delta_{SAMPLE} = 1000 \times (R_{SAMPLE} \times R^{-1}_{STANDARD}) - 1$$

where R is $^{13}C/^{12}C$ or $^{15}N/^{14}N$. In-house standards of bovine liver and wheat were calibrated to international standards and ran alongside samples during analysis. Duplicate analyses generally agreed to within 0.2‰ for both C and N.

2.4 Fossil Pigments

Fossil pigments provide insight into past algal community composition and abundance within lacustrine systems (Leavitt and Findlay, 1994; Reuss et al., 2010). Algal pigments were isolated using High-Performance Liquid Chromatography (HPLC) and prepared following general methods outlined by Leavitt and Hodgson (2001). Briefly, under low light, freeze-dried sediment (~10 to 120 mg) was added to a 4-dram glass vial and extracted using a solution of 80:15:5 HPLC-grade acetone, methanol, and water (by volume), respectively. The actual amount of sediment added depended on capacity to elicit a visible colour-change, which varied with organic content according to lake and core interval. After extracting for 24 hr at -15°C, supernatants were filtered through a 0.22-μm- pore PTFE filter to remove suspended particulates. Vials were stored at -25°C until analysis.

Pigment extracts were dried under inert N_2 gas. Residues were re-suspended in 500 to 2000 μL of injection solution, depending on pigment concentration. The injection solution contained 3.2 mg L^{-1} of Sudan II, which served as an internal standard, and a 70:25:5 by volume mixture of HPLC-grade acetone, ion-pairing reagent (IPR), and HPLC-grade methanol, respectively. The IPR stock solution was composed of 1.875 g tetra butyl ammonium acetate, 19.25 g “Sigma®” grade ammonium acetate, and 250 ml nanopure H_2O (Leavitt and Hodgson 2001).

Carotenoids, chlorophylls, and derived compounds were isolated using a Hewlett Packard 1100 HPLC system equipped with a photodiode array detector at the IECS. The system was calibrated using authentic standards from the U.S. Environmental Protection Agency and Danish Hydraulic Institute (Denmark), following procedures outlined by Leavitt and Hodgson (2001). Sedimentary pigments were expressed as nmoles g^{-1} organic matter (OM), as was derived from percent C (%C) estimates of whole,

dried sediment. These units account for bias associated with post-depositional sediment diagenesis and are linearly related to measured phytoplankton biomass in whole-lake experiments and decade-long monitoring programs (Leavitt and Hodgson, 2001).

Pigments were tentatively identified by chromographic position and characteristic absorbance spectra (Leavitt and Hodgson 2001). Working standards from vascular plants (Geranium leaf; *Pelargonium* spp.) and *Anabaena* spp. were used to estimate retention times of known biomarkers. Algal biomarkers included the carotenoids fucoxanthin (siliceous algae and some dinoflagellates), alloxanthin (cryptophytes), diatoxanthin (mainly diatoms and some chrysophytes), lutein and zeaxanthin (chlorophytes and cyanobacteria), canthaxanthin (colonial cyanobacteria), echinenone (cyanobacteria), and β-carotene (total algae), whereas broader indicators were provided by the chlorophylls chl-a (total algae) and chl-b (chlorophytes and higher plants), as well as respective degradative products pheophytin (pheo) a and b. Because lutein and zeaxanthin co-eluted during HPLC analysis, their sum was interpreted as indicating the abundance of "total bloom-forming taxa", and instead, chlorophytes were measured from Chl *b* and pheophytin *b*. The ratio of Chl *a* to pheophytin *a* was used as a preservation index to determine the degree of labile pigment degradation (Leavitt and Hodgson 2001). Additional cyanobacterial pigments from colonial taxa (aphanizophyll and myxoxanthophyll) and ultraviolet radiation absorbing compounds (Leavitt et al. 1997) were rarely detected in the study lakes and were not included in further analysis.

2.5 Fossil Diatoms

For each analyzed sediment interval, ~0.3 g of wet sediment was subsampled into a 20-ml glass vial to which was added 30 mL of concentrated H_2O_2 to remove organic matter and carbonate precipitates. Aliquots of known volume were taken from each sample and were pipetted onto coverslips. Coverslips were air-dried for at least 24 hours before being mounted with Zrax® onto glass microscope slides. Diatoms were identified and counted along transects on slides using an Olympus CX41 microscope fitted with a 100x fluotar objective (numerical aperture of objective = 1.3) and using differential interference contrast optics at 1,000 x magnification. Approximately 400 diatom valves were enumerated per slide. Diatoms were usually identified to the species level using the following taxonomic references: Bahls, 2013; Krammer and Lange-Bertalot, 1991a, 1999a, 1999b, 2000. For species ecology, the following references were used: Juluis et al., 1998; Dokulil and Teubner, 2005; Rimet et al., 2009, Cumming et al., 2015; Bunting et al., 2016; and Reavie et al., 2014, 2017.

2.6 Fossil Cladocera

Sample preparation methods followed standard techniques (Korhola and Rautio, 2001) with minor deviations. Approximately 1 g of wet sediment was deflocculated in 10% KOH for ~ 2 hours. The sediment was passed through a 37-µm sieve and rinsed with deionized water. Material from the sieve was transferred to a vial using deionized water and a water bottle. Several drops of ethanol were added to prevent fungal growth and safranin stain was added. Slides were prepared and mounted using a micropipette and glycerol jelly. The proportion of sample analyzed was based on the difference in original sample weights before and after analysis.

Entire slides were enumerated under bright-field illumination at 100-400x magnification. A minimum of 70-100 individuals was counted per interval (Kurek et al., 2010). Due to cladoceran disarticulation after death, each cladoceran body part was tabulated separately. The number of individuals in each taxon was quantified by the most abundant type of remain (e.g. carapace, headshield, postabdomen, post-abdominal claw). Counts were converted to population estimates expressed as fossil concentrations per g dry weight -1 (dwt-1).

Remains were identified to species, where possible, using several different taxonomic sources (Bos, 2001, Sweetman and Smol, 2006; Szeroczyńska and Sarmaja-Korjonen, 2007; Korosi and Smol, 2012a; Korosi and Smol, 2012b). Not all remains could be assigned to the species level. Similarly, the post-abdominal claws of *Daphnia* were rare and may represent several species. The presence/absence of the stout middle pectin on the postabdominal claw was used to separate Daphniids into two species complexes: *Daphnia longispina* complex (stout pectin absent) and *Daphnia pulex* complex (stout pectin present). *Daphnia longispina* complex possibly consists of *Daphnia ambigua*, *Daphnia mendotae*, *Daphnia dentifera, Daphnia dubia,* and *Daphnia longiremis*; while *Daphnia pulex* complex possibly consists of *Daphnia pulex, Daphnia pulicaria, Daphnia catawba,* and *Daphnia minnehaha* (Hebert 1995).

Camptocercus from North America has not been taxonomically studied. Even though there are differences in morphology, it is not clear if *Camptocercus* individuals recovered from North America belong to the same species. Hence, *Camptocercus* was placed into a single category (Szeroczyńska and Zawisza, 2011; Korosi and Smol, 2012c).

Ephippia (winter season eggs of cladoceran) were removed from the cladoceran dataset to avoid duplicate representation of a taxon. To avoid duplication within a core section, cladocerans that were only identifiable at the genus level were removed when cladocerans were identifiable to species level.

3 Laboratory Results

3.1 Radioisotope Geochronology and Sedimentation Rate

^{210}Pb activities exhibited little change with depth, suggesting that the deposition of this atmospherically-derived radioisotope did not conform to standard dating and depositional models. Re-analysis by a second laboratory confirmed very low ^{210}Pb activities and uncertainties in background estimates of activity. ^{210}Pb activities were simply too low to establish a reliable ^{210}Pb chronology.

Estimates of sediment age based on the three-point ^{137}Cs model (2017, 1964, 1955) were used to produce an approximate chronology for Core 1 (Figure 7). ^{137}Cs measurements record a peak at 15.5 cm that is taken as 1964. A ^{137}Cs peak associated with the Chernobyl nuclear accident of 1986 was not observed. Although the dates are fit well by a quadratic model, it is unlikely that this model accurately represents the age of sediments deposited in the first half of the 20th century, and may overestimate rates of deposition during the most recent decades. Consequently, a second estimate of sediment age was developed by assuming a linear rate of deposition between 1964 and the present. Together, these estimates allow us to estimate that the final flooding of SIL in 1976 occurs between 10.8 and 12.1 cm depth (grey band on figure to the right). No corresponding change in the macroscopic (visible) physical properties of the sediment were observed. This band, along with that representing 1964, are used to better interpret the potential causes of historical changes in sediment parameters. As noted above, these approximate ages cannot be used to develop a sub-decadal chronology, and should only be used for interpretation of long-term or major historical events. However, the chronology is sufficient to approximate between sediments deposited before and after reservoir formation.

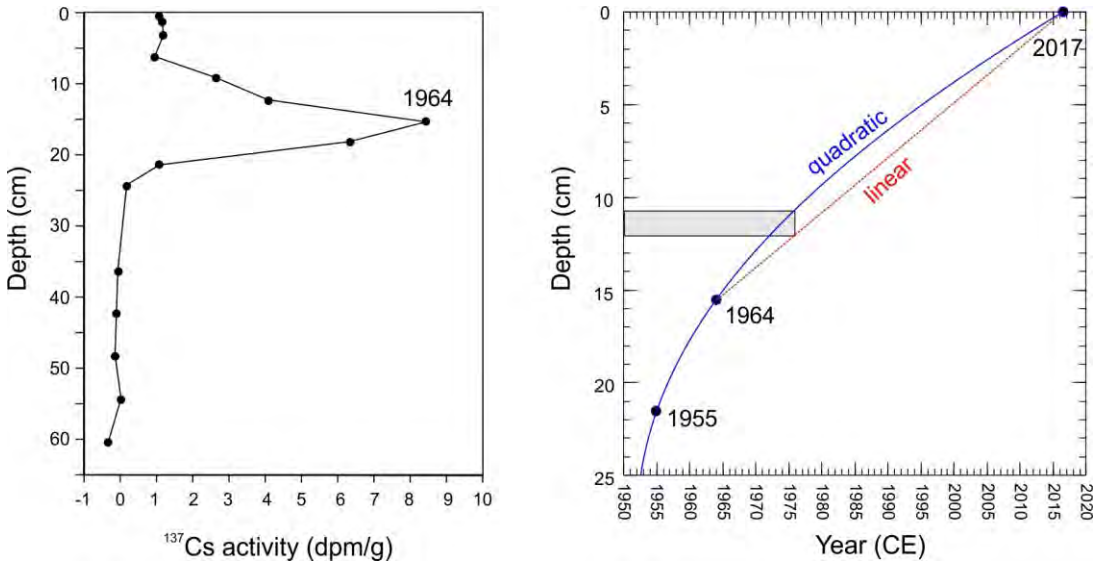

Figure 7: Approximate chronology of Core 1 from Area 4 of Southern Indian Lake based on the known timing of core collection (2017), peak ^{137}Cs deposition (1964) and onset of ^{137}Cs deposition (ca. 1955). ^{137}Cs activity with depth showing peak deposition at 15.5 cm (left). A range of age-depth relationships was provided by fitting a quadratic and linear regression (right). Grey shaded box indicates approximate period of reservoir formation (10.8-12.1 cm depth).

3.2 Sediment Geochemistry

Carbon (C) and nitrogen (N) content (% dry mass) exhibited sharp changes with burial depth in Southern Indian Lake during the latter half of the 20th century (Figure 8). In general, C and N contents rose slowly from the base of the core to ca. 23 cm, peaked briefly during the interval represented by 17-23 cm, then declined sharply, reaching a second stable plateau in the uppermost 10 cm (post 1980). Given that the final formation of the reservoir occurred by ca. 1976, we infer that the sharp decline in both elements likely represents a dilution of organic matter by fine inorganic particulate matter characteristic of the upper portions of the core.

Overall, declines in N content were greater than those of C, resulting in a consistent rise in C/N ratio in the upper 15 cm of Core 1 (Figure 8). Ratios of C/N were stable between 18 cm and 40 cm depth at values (8.5-9.0, by mass), which are strongly indicative of algal organic matter (autochthonous matter) derived from within the lake. Ratios increased to a peak at 5-8 cm depth (ca. 1990), then remained relatively stable at 10.5-11.0 in the uppermost sediments, and which consistent with changes in filterable suspended solids within Area 4 found by Hecky and McCullough (1984). We interpret this sustained increase in C/N to reflect an increased deposition of material from outside the lake, such as terrestrial plants or soil (C/N terrestrial plants ~20 to 25) although we recognize that the timing of the onset increased C/N appears to coincide with the late 1960s or early 1970s. Nonetheless, we infer that the change in C/N does not reflect a variation in the deposition of inorganic C (e.g., inputs from carbonate minerals from eroding banks), as the stable isotope values for C ($\delta^{13}C$) provide little evidence of inorganic C sources (carbonates ca. -5‰).

The isotopic signatures of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) measured in the upper 20 cm of the core, shown in Figure 8, follow similar trends. $\delta^{15}N$ values varied ~1‰ from 4.7-5.6‰ with a small increase in values at about the time of lake impoundment (10.8-12.1 cm). These results suggest that there was little change in N source recorded in these sediments. Overall, $\delta^{15}N$ values in the core (4.7-5.6‰) were similar to those seen when recycled nitrate is the main source of N supplied to the lake (Bunting et al., 2010).

$\delta^{13}C$ values varied between -29 and -30‰ until the uppermost 6-7 cm (ca. 1990), when values exhibited a transient decline of ~1‰. $\delta^{13}C$ values are similar to those expected when phytoplankton photosynthesis is based in the use of respired CO_2 (-30‰) rather than atmospheric CO2 (-10‰).

Results of the analysis of historical changes in elemental composition and stable isotopes of C and N are consistent with an increase in deposition of fine inorganic material ("silt") associated with water level rise, shoreline erosion, and transfer of fine materials to the lake bottom. Such a change would be expected to alter light regimes and affect the suitability of benthic habitats for use by phytobenthos, burrowing infauna, and fish.

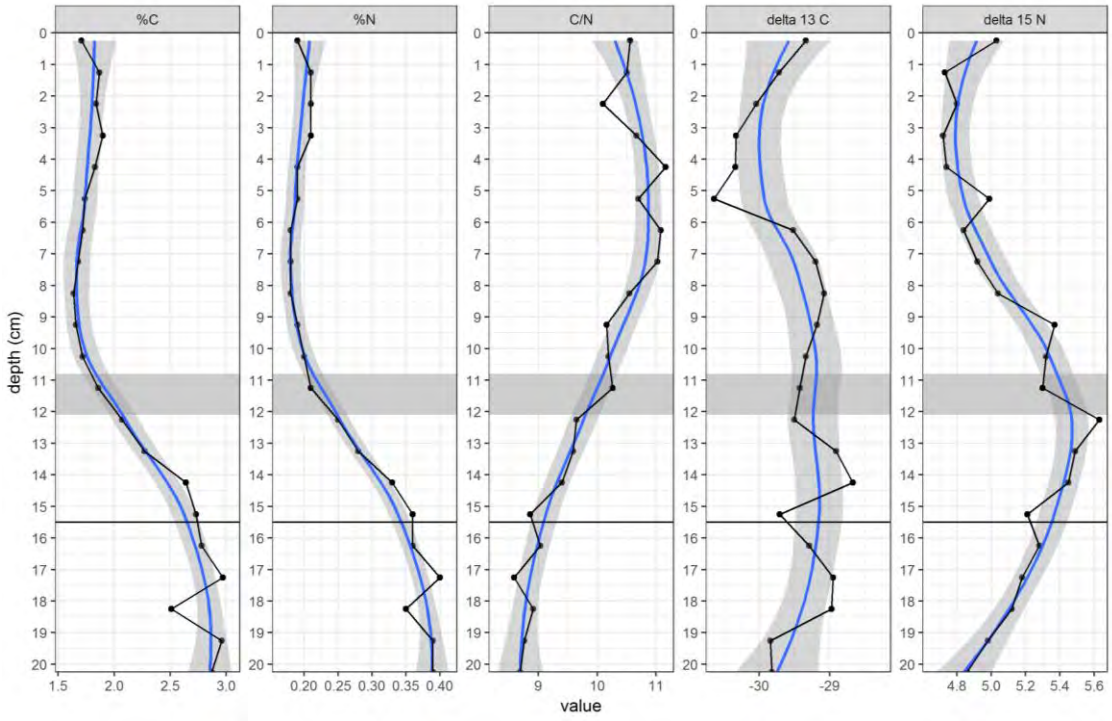

Figure 8: Geochemical stratigraphies from Core 1. Profiles include carbon (C) content (% dry mass), nitrogen (N) content, C/N mass ratios, and stable isotopes of carbon ($\delta^{13}C$, ‰) and nitrogen ($\delta^{15}N$, ‰). Grey shaded box indicates approximate period of reservoir formation. Solid line indicates peak ^{137}Cs deposition in 1964.

3.3 Fossil Pigments

Analysis of fossil carotenoids and chlorophyllous pigments suggested an increase in phytoplankton abundance in the uppermost 10 cm of the core (Figure 9), a period which immediately follows final commissioning of SIL as a reservoir in the late 1970s (10.8-12.1 cm).

Overall, changes in total phytoplankton abundance were only modest when recorded using ubiquitous, chemically-stable pigments (β-carotene, pheophytin *a*), although more pronounced increases were recorded within labile Chlorophyll *a* (Chl *a*). We interpret these latter changes as representing post depositional conversion of Chl *a* to other chlorophyllous pigments rather than reflecting a pronounced increase in lake production, consistent with the increase in ratio of precursor Chl *a* to product pheophytin *a* seen in the upper 10 cm of the core.

Gross algal community composition appears to change following reservoir formation. In particular, chemically-stable pigments indicative of mixotrophic algae increased in the uppermost 10 cm of Core 1, including alloxanthin (cryptophytes), diatoms (diatoxanthin), and chlorophytes (lutein zeaxanthin, Chl *b*, pheophytin *b*). We infer that abundance of colonial cyanobacteria (as myxoxanthophyll) or Nostocales forms of cyanobacteria (canthaxanthin) did not increase in the past 40-50 years.

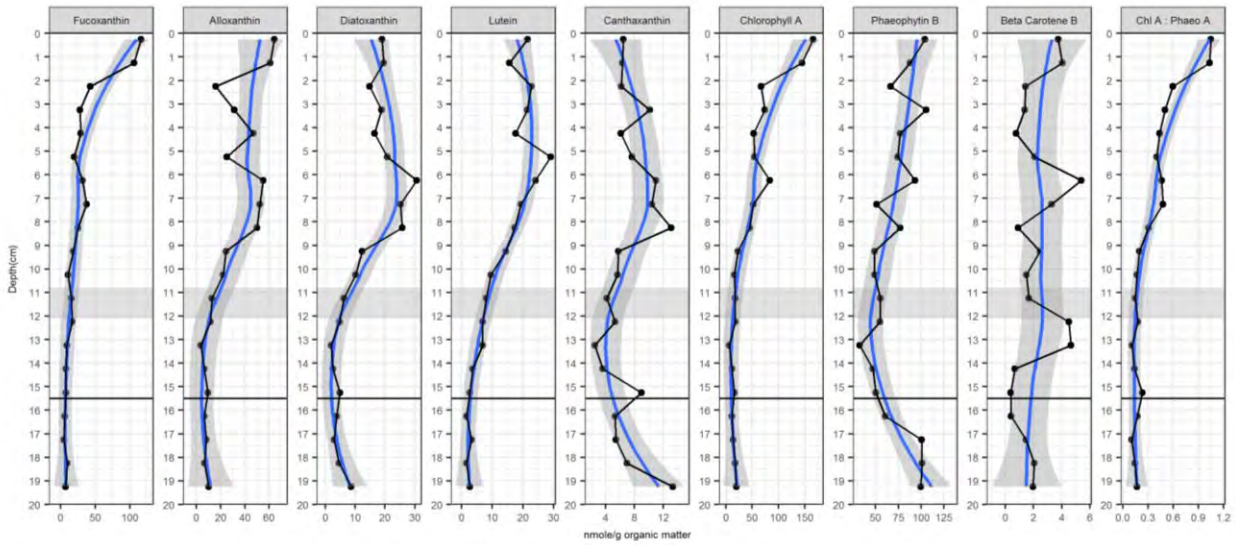

Figure 9: Fossil pigment stratigraphies for carotenoids, chlorophylls and derivatives preserved in Core 1, Southern Indian Lake. Compounds include fucoxanthin (siliceous algae), alloxanthin (cryptophytes), diatoxanthin (diatoms), lutein-zeaxanthin (chlorophytes-cyanobacteria), canthaxanthin (Nostocales cyanobacteria), labile Chl a (total algae and cyanobacteria), pheophytin b (chlorophytes alone), stable β-carotene (total algae and cyanobacteria), and a ratio of pigment preservation (Chl a: pheophytin a). Solid line indicates peak ^{137}Cs deposition in 1964.

Modest increases in algal abundance often follow formation of reservoir in a phenomenon known as a trophic surge (Hecky and Guilford, 1984; Thorton et al., 1990). However, given that larger increases in fossil pigment concentrations were restricted to accessory compounds from non-bloom-forming algae, and that total algal biomass changes were only modest, we infer that reservoir formation did not result in a substantial eutrophication of Southern Indian Lake. Further, we note that some of the apparent increase in carbon-specific pigment content may arise from the decline in C content noted above, and therefore caution for a conservative interpretation of how much increase in phytoplankton abundance may have occurred after reservoir formation.

With this caveat in mind, we note that formation of reservoirs in boreal landscape often result in increased concentrations of DOM in surface waters relative to natural lakes (Hecky and Guilford, 1984), and that often densities of mixotrophic phytoplankton, such as flagellates (alloxanthin) increase in response to elevated DOM (Stevenson et al., 2016).

Densities of mixotrophic taxa have also increased in un-impacted lakes in the western boreal region during the past 50 years (Wolfe and Siver, 2013; Mushet et al., 2017). In those cases, the rise of the mixotrophs appears to be due to a combination of events, including, but not limited to, warmer waters which favour their growth, increased lake stratification which favours smaller taxa, and changes in hydrology and climate which increase the influx of dissolved organic matter. At present, it is not possible to separate the effects of changes in climate from those associated with reservoir formation; however, we do note that that climatic trends to warmer, wetter conditions did not change suddenly in the mid-1970s, and do not generally follow the pattern outlined by historical changes in fossil pigment concentration.

3.4 Fossil Diatoms

Microscopic analysis demonstrated that diatom remains were well preserved throughout the upper 20 cm of Core 1. Table 1 provides a summary of the ecology of the dominant diatoms identified in the core. In general, an increase in clay and detrital particles was observed on the microscope slides with sediments buried between 8 and 12 cm depth (ca. mid-1970s), but these did not obviously correspond to an increase in frustules damage. An increase in amorphous organic matter in the upper 9 cm was also observed microscopically (though not evident visually during subsampling).

Constrained cluster analysis using the CONISS computer program revealed two relatively distinct assemblages of diatoms, corresponding approximately to prior (Zone 1) and after (Zone 2) conversion of SIL to a reservoir (Figure 10). Within Zone 1, there was also a second, more marginal distinction between frustules deposited between ca. 10 cm (ca. 1980) to and ~5 cm (ca. 2000) burial depth.

Diatoms deposited in sediments below ca. 10 cm were composed mainly of planktonic taxa, including large *Aulacoseira* spp. In order of relative (%) abundance, these species include: *A. islandica* (41%), *A. subartica* (19%), and *A. Ambigua* (7.8%). In addition, smaller plantonic centric taxa, such as *Stephanodiscus alpinus* (9.6%) were also present, although *niagarae*, a species common in more productive waters, was only present at very low proportions. Overall, benthic epiphytic species such as *Epithemia*, *Cymbella* and *Gomphonema*, as well as benthic fragilarioids, were most abundant at the base of Zone 1, and declined after the transition to Zone 2. As a result, the ratio of benthic to planktonic diatom species declined strongly in the upper 10 cm of the core, shortly after reservoir formation and concomitant with the presence of fine silt and detrital material in the sediment matrix.

Diatoms assemblages deposited in Zone 2 (ca. 10 - 0 cm) continued to exhibit high proportions of *A. islandica* and *A. subartica* (30 and 20% respectively), although its relative abundance declined following the reservoir formation (ca. 10.1-11.8 cm) in favour of *A. subarctica* (14%) and, secondarily, *A. ambigua* (13%), and *S. alpinus* (8%). The relative abundance of both *Stephanodiscus* species (*S. alpinus, S. niagarae*) increased further in the uppermost 6 cm of sediments (post 1990).

Overall, changes in diatom species assemblages observed in the core are consistent with loss of benthic habitat, possibly due to reduced light penetration, or as a result of deposition of fine particulate material on otherwise stable substrates (Hecky and Guilford, 1984; Wiens and Rosenberg, 1984). The presence of benthic and epiphytic diatoms between 20 and ca. 10 cm, indicates the presence of a littoral environment that disappeared after impoundment and diversion (ca. 10.8-12.1 cm). Similarly, the increase in *Stephanodiscus* spp at the expense of *Aulacoseira* spp. following inundation is consistent with increased stratification and reduced light penetration favouring small centric taxa, which are better able to remain suspended in the photic zone (Kienel et al., 2017). Finally, the rise of taxa characteristic of more productive water (Julius et al., 1998, Dokulil and Teubner, 2005, Buting et al., 2016) in the uppermost 5-6 cm of Core 1 suggests a modest increase in nutrient availability. Because this upper interval consists of recent sediments, the increased nutrient availability may reflect wetter conditions and greater inputs from the Churchill River to the basin over the last 20 years rather than a continued effect of a post-inundation tropic surge. Although we cannot presently distinguish among these mechanisms, the apparently close correspondence between the major transition of species assemblage

and the formation of the SIL reservoir would suggest that changes associated with damming and flooding had a major effect on the relative proportion of benthic and planktonic diatoms.

Table 1: Ecology of the dominant diatoms found in the analyzed core.

Diatom	Ecology
Aulacoseira islandica	Dominated sediments pre-settlement in Lake of the Woods (Reavie et al., 2017) Large, temperate, shallow lakes (Mesotrophic) (Reavie et al., 2014) Oligotrophic to mesotrophic large waters (Dokulil and Teubner, 2005)
Aulacoseira subartica	Meso-eutrophic (Cumming et al., 2015) Pre-settlement (Reavie et al., 2017)
Aulacoseira ambigua	In Lake of the Woods (Raevie et al., 2017)
Stephanodiscus niagarae	Meso-eutrophic (Buting et al., 2017) With *S. alpinus* indicate low temperatures (Julius et al., 1998) In Diefenbaker, it occurs in the initial phase of impoundment (Hall et al., 1998)
Stephanodiscus alpinus	Inhabit Canadian lakes, cold waters. In lakes with pH measured 7.2 to 8.5 and specific conductance measured 92 to 122 µS/cm (Bahls, 2013) Appeared in the re-oligotrophication phase of L. Mondsee (Rimet et al., 2009) Eutrophic and oligotrophic (Dokulil and Teubner, 2005)

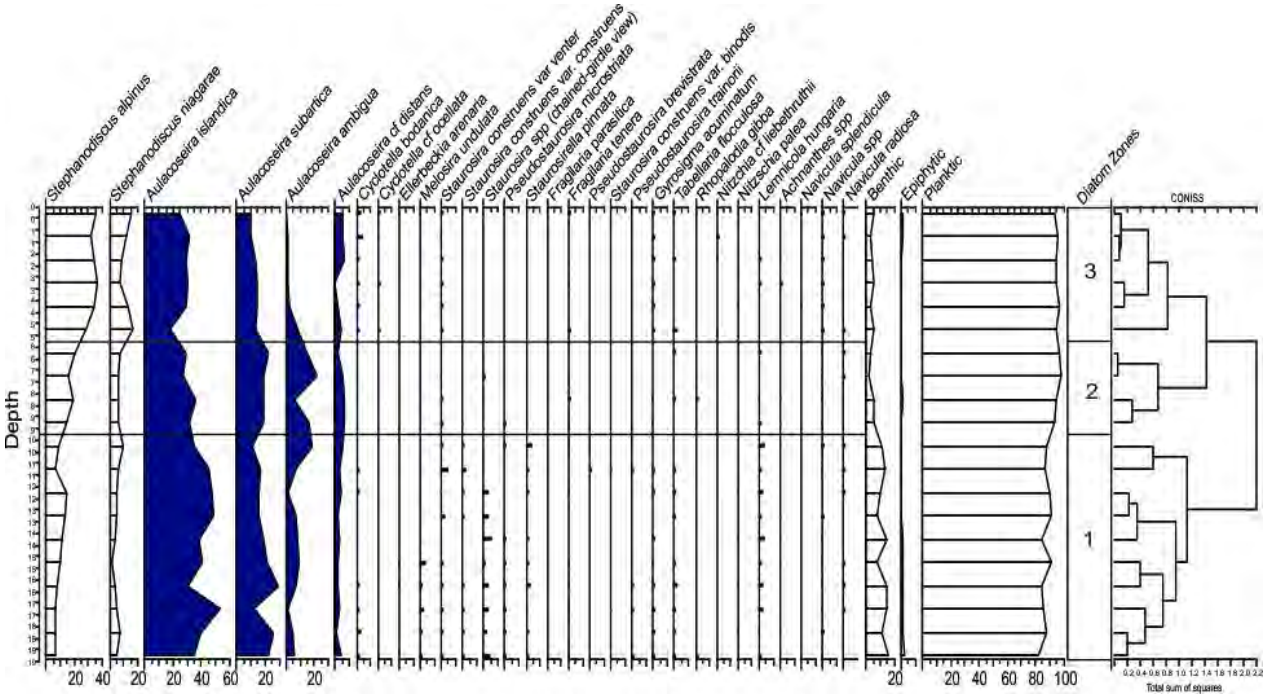

Figure 10: Relative (%) abundance of main diatom taxa in Core 1, Southern Indian Lake. See results for details on species identity and ecology. Figure also includes cluster diagram produced by constrained cluster analysis. Lower line indicates approximate date of SIL reservoir formation, and the demarcation between pre-flooding assemblages (with abundant benthic diatoms) and post-flooding diatom communities (above ca. 10 cm). Two less distinct zones (2 and 3) together comprise Zone 2 in the Results section.

3.5 Fossil Cladocera

The cladoceran community preserved in Core 1 has also undergone substantive changes consistent with a loss of littoral habitat associated with conversion of SIL to a reservoir (Figure 11). In particular, densities of remains from key littoral taxa, including the two predominant chydorid species, declined dramatically between 10 and 13 cm burial depth (ca. 1975). Specifically, concentrations of remains from *Chydorus brevilabris* and *C. gibbus* declined over an order of magnitude to low and stable concentrations in the uppermost 8 cm of sediment (post 1990). Although densities of planktonic taxa, such as small-bodied *Bosmina longirostris* and *B. longispina*, also declined between 10 and 13 cm depth, these populations both rebounded thereafter, and have exhibited few pronounced changes in the uppermost 7-8 cm of sediment. Overall, large-bodied *Daphnia* were rare, and relative abundance of the two bosminiids stable, suggesting that there has been little change in predation regime of Southern Indian Lake (Leavitt et al., 1989).

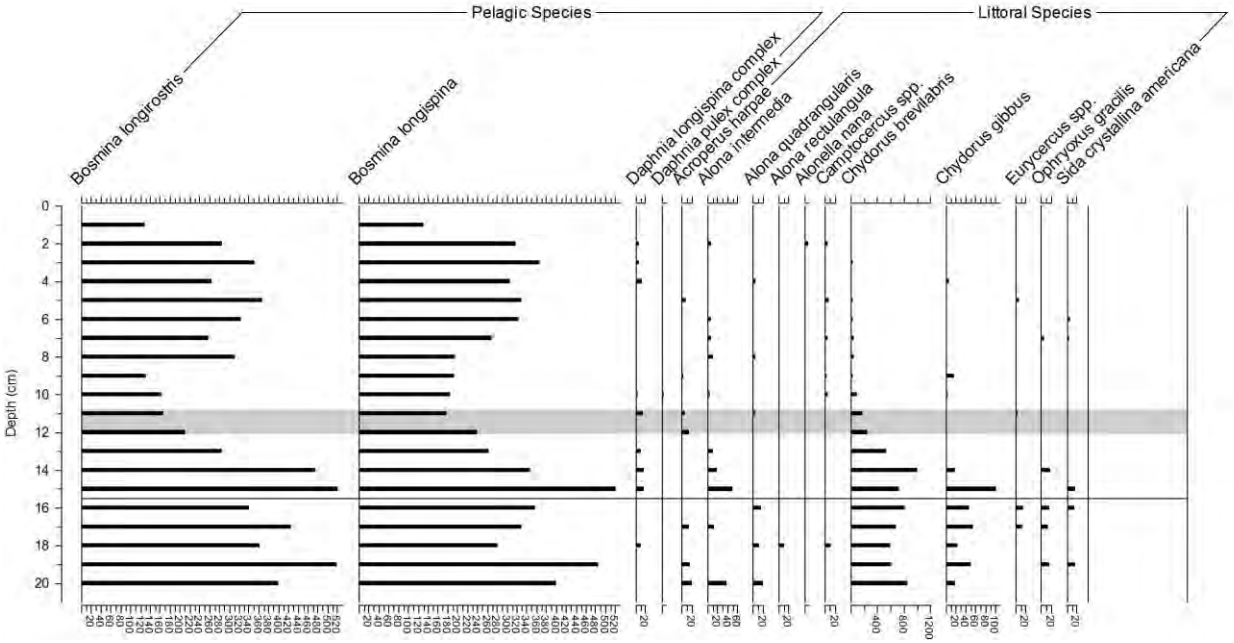

Figure 11: Dry mass-specific concentrations (fossils g-1 dry mass) of main pelagic (*Bosmina* spp) and littoral cladoceran species (*Chydorus* spp.) preserved in Core 1, Southern Indian Lake. See text for further description. Reservoir formation estimated to occur between 10.8 and 12.1 cm depth.

Changes in fossil Cladocera observed in the core are generally consistent with a restructuring of the littoral habitat from 76% bedrock substrate to only 14% bedrock cover due to deposition of fine-grained overburden materials noted by Newbury and McCullough (1984). Timing of the loss of the chydorid species coincides with that of benthic diatoms and the pronounced decline in the C and N content of the sediments as observed in the core, and with the increased deposition of silt reported in the literature. Together, these patterns suggest that increased deposition of silt from eroded material may have eliminated benthic habitats. The fact that neither diatom nor cladoceran populations have recovered since reservoir formation, whereas there is little evidence of pronounced changes in planktonic

communities as a result of damming and inundation, suggests that the physical processes which have altered the shallow water habitats are continuing to present day.

4 Discussion

In this study, we used a combination of geochemical (elements, isotopes), biochemical (pigments) and morphological fossils (diatoms, cladocera) to quantify historical changes in limnological conditions within Southern Indian Lake since the mid-20th century (Figure 12). Although limited to an approximate chronology based on a three-point ^{137}Cs model, the presence of consistent, coherent, and concomitant changes in many proxies allowed a reliable interpretation of the main effects of conversion of Southern Indian Lake to a reservoir during the 1970s.

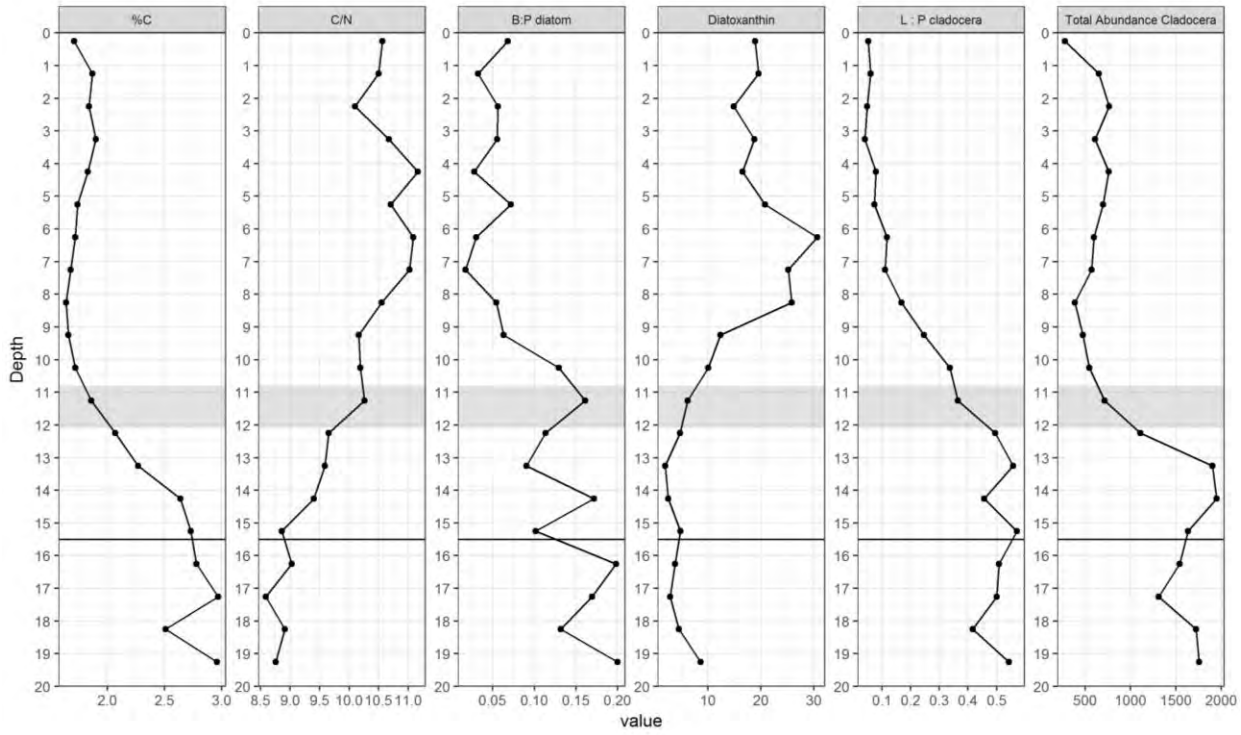

Figure 12: Summary diagram of the main stratigraphic changes in Core 1, Southern Indian Lake.

Overall, it appears that increased erosion and deposition of fine inorganic materials after the inundation of SIL reduced both primary and secondary production in the littoral zone of Area 4. In general, geochemical indices of sediment providence (%C, %N, C/N ratio) were relative stable until just before reservoir formation (ca. 10.8-12.1 cm depth in Core 1), then changed rapidly and permanently thereafter to a new condition with much lower organic matter content, despite slightly increased deposition of unpigmented terrestrial organic matter (C/N). Although total lake production may have increased modestly following reservoir formation (e.g., diatoxanthin in Figure 5), this pattern appears to arise solely from pelagic responses to flooding ("trophic surge") such as seen in other boreal reservoirs. In contrast, the relative (diatom) and absolute (cladoceran) abundances of all littoral taxa declined

sharply in sediments deposited since SIL was converted to a reservoir, relative to fossil assemblages recorded near the mid-20th century (ca. 23-25 cm depth). When combined with the transient decline in pelagic *Bosmina* spp., this loss of littoral Cladocera appears to have resulted in a permanent 3-4 fold decline in secondary production by invertebrates. Loss of resources, combined with changes in shallow water breeding habitats, would be expected to reduce reproduction and productivity of certain fish species within SIL.

5 Closing

J.D. Mollard and Associates (2010) Limited in collaboration with the Institute of Environmental Change and Society (IECS) and the Department of Geology at the University of Regina collected and subsampled three sediment cores from Southern Indian Lake and completed a multi-proxy analysis on one of the cores from Area 4. Samples from the other two coring sites remain in storage at the University of Regina.

Overall, the biological proxies analyzed in this study were consistent in showing a decline in littoral habitats after impoundment. Results presented in this study are most relevant to Area 4, from which Core 1 was extracted. While these results may be consistent with other areas of the lake, caution should be exerted in using the data from this single core to be a definitive statement on changes to the aquatic habitat of the lake. Southern Indian Lake is a large lake with several distinct basins. Additional work would be needed to characterize the differences among the basins and to better understand the aquatic ecosystem.

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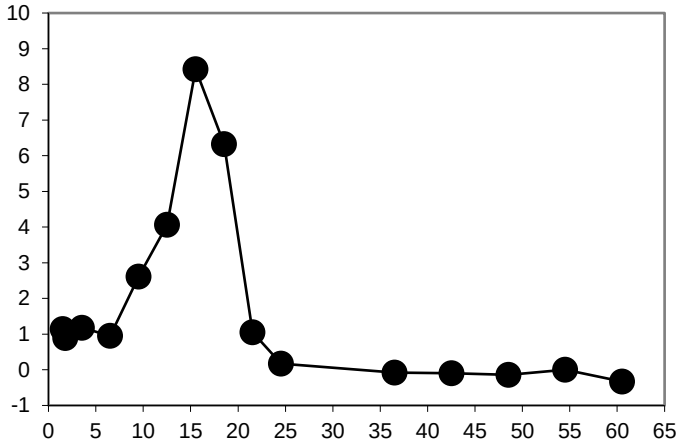
APPENDIX A

Chronology

Depth Interval (cm)	Cs-137 Activity (dpm/g)	Cs-137 Error (1s)
1.525	1.14	0.14
1.775	0.89	0.20
3.525	1.18	0.17
6.525	0.95	0.21
9.525	2.62	0.14
12.525	4.07	0.21
15.525	8.43	0.36
18.525	6.33	0.28
21.525	1.05	0.27
24.525	0.17	0.24
36.525	-0.08	0.14
42.525	-0.10	0.20
48.525	-0.14	0.23
54.525	0.00	0.26
60.525	-0.33	0.19

Cs-137 Profile



Geochemistry

Sample	Wt.[mg]	d15NAIR	d13CVPDB	mgN	mgC	%N	%C	C/N
0.25	4.59	5.03	-29.34	8.66	78.34	0.19	1.71	10.56
1.25	4.69	4.73	-29.72	9.75	87.75	0.21	1.87	10.5
2.25	5.86	4.8	-30.04	12.44	107.7	0.21	1.84	10.1
3.25	5.32	4.72	-30.33	11.04	100.98	0.21	1.9	10.67
4.25	4.57	4.74	-30.34	8.77	83.85	0.19	1.83	11.16
5.25	4.69	4.99	-30.64	8.91	81.68	0.19	1.74	10.7
6.25	4.68	4.84	-29.52	8.48	80.55	0.18	1.72	11.08
7.25	5.94	4.92	-29.2	10.56	99.75	0.18	1.68	11.02
8.25	5.89	5.04	-29.08	10.7	96.75	0.18	1.64	10.55
9.25	5.9	5.37	-29.18	11.23	97.72	0.19	1.66	10.16
10.25	5.46	5.32	-29.34	10.74	93.84	0.2	1.72	10.19
11.25	4.74	5.3	-29.42	10.04	88.3	0.21	1.86	10.26
12.25	5.01	5.63	-29.5	12.51	103.53	0.25	2.07	9.65
13.25	5.63	5.49	-28.91	15.56	127.95	0.28	2.27	9.59
14.25	4.12	5.45	-28.67	13.5	108.82	0.33	2.64	9.4
15.25	5.13	5.21	-29.71	18.47	140.23	0.36	2.73	8.86
16.25	5.71	5.28	-29.29	20.53	158.91	0.36	2.78	9.03
17.25	5.15	5.18	-28.95	20.82	153.19	0.4	2.97	8.59
19.25	4.97	4.98	-29.84	19.6	147.1	0.39	2.96	8.76
20.25	5.08	4.86	-29.82	19.57	145.69	0.39	2.87	8.69
22.25	4.93	4.95	-29.26	17.6	132.73	0.36	2.69	8.8
23.25	4.96	4.65	-30.28	17	127.4	0.34	2.57	8.74
24.25	5.07	4.77	-29.88	16.86	126.45	0.33	2.49	8.75
25.25	5.66	4.75	-29.4	18.95	139.13	0.33	2.46	8.57
26.25	4.39	5.04	-29.68	14.6	112.91	0.33	2.57	9.02
27.25	5.25	4.98	-29.49	17.72	130.66	0.34	2.49	8.6
28.25	5.55	4.85	-28.6	18.33	134.44	0.33	2.42	8.55
18.25	4.81	5.12	-28.97	19.21	146.73	0.35	2.51	8.91
29.25	4.43	5.09	-28.25	15.09	114.03	0.34	2.57	8.81
30.25	4.49	5.05	-29.42	14.96	113.72	0.33	2.53	8.87
21.25	5.44	5.01	-29.64	20.32	150.27	0.34	2.56	8.63
31.25	4.77	4.88	-29.54	15.87	119.76	0.33	2.51	8.81
32.25	4.74	5.13	-29.03	16.34	121.15	0.34	2.56	8.65
33.25	4.09	4.85	-29.56	12.92	102.08	0.32	2.5	9.22
34.25	5.46	5.31	-29	17.59	128.91	0.32	2.36	8.55
35.25	5.72	5.16	-29.43	18.5	134.27	0.32	2.35	8.47
36.25	5.4	5.33	-28.95	17.5	129.41	0.32	2.4	8.63
37.25	5.13	4.97	-29.68	16.93	124.51	0.33	2.43	8.58
38.25	5.8	4.84	-29.23	15.36	115.45	0.33	2.39	8.77
39.25	5.86	4.98	-29.3	18.45	136.67	0.31	2.33	8.64
40.25	4.42	4.83	-29.84	13.81	105.49	0.31	2.39	8.91

Fossil Pigments

Sample Top Depth (cm)	Sample Bottom Depth (cm)	Chl_c1	Chl_c2	Perid	Fuco	Sed_A	Sed_B	Sed_C	Oscil
0.25	0.5	0	0	0	116.00	0	0	1.02	0
1.25	1.5	0	0	0	105.79	0	0	2.59	0
2.25	2.5	0	0	0	42.89	0	0	0.35	0
3.25	3.5	0	0	0	27.68	0	14.93	4.76	0
4.25	4.5	0	0	0	28.75	0	0	0.70	0
5.25	5.5	0	0	0	19.61	0	0	0.20	0
6.25	6.5	0	0	0	31.18	0	0	0.09	0
7.25	7.5	0	0	0	37.60	0	0	0.23	0
8.25	8.5	0	0	0	25.04	0	0	0.16	0
9.25	9.5	0	0	0	18.22	0	0	0.34	0
10.25	10.5	0	0	0	10.66	0	0	0.32	0
11.25	11.5	0	0	0	15.40	0	0	0.14	0
12.25	12.5	0	0	0	16.63	0	0	0.14	0
13.25	13.5	0	0	0	8.92	0	0	0.18	0
14.25	14.5	0	0	0	7.51	0	0	0.05	0
15.25	15.5	0	0	0	7.26	0	0	0.16	0
16.25	16.5	0	0	0	5.83	0	0	0.23	0
17.25	17.5	0	0	0	4.30	0	0	0.23	0
18.25	18.5	0	0	0	9.06	0	0	0.44	0
19.25	19.5	0	0	0	7.14	0	0	1.16	0

Sample Top Depth (cm)	Sample Bottom Depth (cm)	Aphan	Diadino	Sudan	Myxo	Allo	Diato	Lutein	Cantha
0.25	0.5	0	1.44	1653.84	0	64.29	18.91	21.52	6.42
1.25	1.5	0	2.58	1820.84	0	60.99	19.52	15.63	6.33
2.25	2.5	0	2.03	1550.65	0	15.90	14.84	22.64	6.17
3.25	3.5	0	2.30	1734.28	0	31.18	18.77	21.42	10.12
4.25	4.5	0	1.28	1575.00	0	47.05	16.53	17.57	6.07
5.25	5.5	0	1.57	1541.09	0	24.90	20.78	29.03	7.64
6.25	6.5	0	1.92	1725.32	0	55.01	30.64	24.11	10.93
7.25	7.5	0	1.77	1755.04	0	52.32	25.19	19.40	10.38
8.25	8.5	0	1.43	1787.89	0	49.94	25.81	17.36	13.09
9.25	9.5	0	1.34	1646.46	0	24.32	12.34	14.38	5.74
10.25	10.5	0	0.41	1560.10	0	22.16	10.07	9.50	5.61
11.25	11.5	0	0	1602.37	0	12.81	6.15	8.05	4.15
12.25	12.5	0	0	1507.94	0	11.27	4.69	6.86	5.28
13.25	13.5	0	0	1437.04	0	3.73	1.93	6.87	2.50
14.25	14.5	0	0	1501.83	0	6.27	2.45	3.59	3.56
15.25	15.5	0	0	1658.7	0	9.23	4.80	2.70	8.96
16.25	16.5	0	0	1500.36	0	6.24	3.79	1.57	5.28
17.25	17.5	0	0	1594.3	0	7.99	2.86	3.23	5.39
18.25	18.5	0	0	1675.36	0	6.83	4.52	1.61	6.98
19.25	19.5	0	0	1682.07	0	9.99	8.63	2.75	13.32

Sample Top Depth (cm)	Sample Bottom Depth (cm)	Chl_b	Okenone	Chl_a	Chl_ap	Echine	Phaeo_B	Pheo_A	B-car
0.25	0.5	5.43	0	165.88	0	0	104.2	158.3	3.7
1.25	1.5	10.38	0	144.64	0	0	87.8	139.9	4.0
2.25	2.5	4.27	0	66.96	0	0	66.4	112.1	1.4
3.25	3.5	9.38	0	73.61	0	0	105.6	146.1	1.4
4.25	4.5	5.63	0	53.15	0	0	76.8	120.9	0.7
5.25	5.5	4.88	0	54.54	0	0	74.4	134.5	2.1
6.25	6.5	5.23	0	83.02	0	0	93.2	180.4	5.4
7.25	7.5	4.74	0	51.70	0	0	51.2	108.1	3.3
8.25	8.5	8.40	0	44.84	0	0	76.8	147.4	0.9
9.25	9.5	2.40	0	22.78	0	0	48.9	114.1	2.5
10.25	10.5	0.20	0	16.35	0	0	49.0	98.4	1.5
11.25	11.5	0.17	0	17.78	0	0	55.2	119.6	1.7
12.25	12.5	1.41	0	17.75	0	0	54.8	101.2	4.5
13.25	13.5	0.32	0	6.39	0	0	32.5	58.3	4.7
14.25	14.5	0.25	0	11.54	0	0	46.9	82.4	0.7
15.25	15.5	3.80	0	16.21	0	0	50.3	70.0	0.4
16.25	16.5	1.68	0	11.10	0	0	60.8	64.7	0.4
17.25	17.5	3.27	0	13.50	0	0	100.4	130.6	1.5
18.25	18.5	0.23	0	17.46	0	0	101.1	122.7	2.0
19.25	19.5	0.22	0	19.75	0	0	99.7	117.6	2.0

Units = nmole / g organic matter
% organic = % carbon from stable isotope analysis

Diatoms (All)

DEPTHS (cm)	Stephanodiscus alpinus	Stephanodiscus niagarae	Aulacoseira islandica	Aulacoseira subartica	Aulacoseira ambigua	Aulacoseira cf distans	Cyclotella bodanica	Cyclotella cf ocellata	Ellerbeckia arenaria	Melosira undulata	Staurosira construens var venter	Staurosira construens var. construens
0.25-0.51	145	61	102	39	0	20	10	5	0	0	2	0
1.25-1.51	125	46	124	39	5	21	14	3	0	0	1	0
2.25-2.51	124	31	106	47	3	21	7	2	0	0	3	0
3.25-3.51	148	31	124	58	6	0	7	5	0	0	4	0
4.25-4.51	139	52	118	59	12	9	5	3	0	0	3	0
5.25-5.51	116	69	74	53	34	17	7	8	0	0	5	0
6.25-6.51	84	32	120	90	60	7	2	0	0	0	0	0
7.25-7.51	65	27	110	80	90	23	4	2	0	0	1	0
8.25-8.51	81	28	151	77	23	24	2	3	0	0	4	0
9.25-9.51	58	24	128	78	64	26	2	0	0	0	2	1
10.25-10.51	36	36	140	42	74	20	0	0	0	0	5	2
11.25-11.50	27	27	195	72	30	14	7	0	0	0	18	11
12.25-12.51	49	17	165	53	6	15	4	0	0	0	1	4
13.25-13.51	54	22	202	66	27	6	0	0	0	0	7	2
14.25-14.51	45	15	152	74	31	13	2	0	0	0	0	0
15.25-15.51	40	9	168	87	38	5	0	0	3	16	3	0
16.25-16.51	32	17	120	116	26	8	8	0	1	4	6	5
17.25-17.51	30	23	228	55	4	13	6	0	0	8	5	6
18.25-18.51	25	28	162	104	19	2	9	2	0	4	2	3
19.25-19.51	26	20	143	90	26	16	8	3	0	3	6	5

DEPTHS (cm)	Staurosira spp (chained-girdle view)	Pseudostaurosira microstriata	Staurosirella pinnata	Fragilaria parasitica	Fragilaria tenera	Pseudostaurosira brevistrata	Staurosira construens var. binodis	Pseudostaurosira trainorii	Gyrosigma acuminatum	Tabellaria flocculosa	Rhopalodia gibba	Nitzchia cf liebethruthii
0.25-0.51	0	0	0	0	4	0	0	0	4	5	2	4
1.25-1.51	0	0	0	0	0	0	0	0	3	0	0	4
2.25-2.51	0	0	0	0	0	0	0	0	1	2	2	1
3.25-3.51	0	0	0	0	1	0	0	0	5	0	2	0
4.25-4.51	0	0	0	0	0	0	0	0	2	0	0	0
5.25-5.51	0	0	0	0	4	0	0	0	2	6	0	2
6.25-6.51	0	0	0	0	0	0	0	0	0	1	0	0
7.25-7.51	2	0	0	0	0	0	0	0	0	0	0	0
8.25-8.51	0	0	0	0	4	0	0	0	1	1	5	0
9.25-9.51	0	3	2	1	3	0	0	0	1	0	2	0
10.25-10.51	0	2	15	0	1	2	0	0	0	0	0	0
11.25-11.50	0	0	7	0	0	3	1	2	3	1	0	0
12.25-12.51	12	0	5	0	1	0	0	0	1	1	0	0
13.25-13.51	12	0	0	0	0	0	0	0	0	1	1	0
14.25-14.51	20	1	7	0	0	0	0	0	3	0	2	0
15.25-15.51	4	1	6	0	1	0	0	0	1	5	1	0
16.25-16.51	14	1	10	0	3	0	0	3	3	6	1	0
17.25-17.51	15	5	4	0	1	0	1	4	2	1	2	0
18.25-18.51	10	4	7	0	0	0	0	0	3	3	4	0
19.25-19.51	18	4	5	0	2	0	0	3	5	1	6	0

DEPTHS (cm)	Nitzschia palea	Lemnicola hungaria	Achnanthes spp	Navicula splendicula	Navicula spp	Navicula radiosa	Eunotia sudetica	Eunotia spp.	Eunotia pectinalis	Pinnularia gibba	Gomphonema truncatum	Gomphonema angustum
0.25-0.51	0	0	0	0	2	1	0	0	1	0	0	0
1.25-1.51	0	0	0	0	2	1	0	0	0	0	0	0
2.25-2.51	0	4	1	0	4	0	0	0	1	0	0	1
3.25-3.51	0	3	3	0	3	0	0	0	0	0	0	0
4.25-4.51	1	0	0	1	3	0	1	0	0	0	0	0
5.25-5.51	0	0	0	0	2	2	0	0	0	0	0	0
6.25-6.51	0	6	0	0	1	1	0	2	0	1	0	0
7.25-7.51	0	0	0	0	1	1	0	0	0	2	0	0
8.25-8.51	0	1	1	0	1	0	0	0	0	0	0	0
9.25-9.51	0	5	1	0	1	0	1	1	0	0	0	0
10.25-10.51	0	14	1	0	2	1	0	0	0	0	1	0
11.25-11.50	0	5	0	0	1	1	4	0	0	1	0	0
12.25-12.51	1	8	0	0	0	1	0	0	0	0	0	0
13.25-13.51	0	6	1	0	2	0	0	1	0	0	0	0
14.25-14.51	2	16	1	0	1	0	0	1	0	0	0	0
15.25-15.51	0	4	1	0	1	3	0	0	0	0	0	0
16.25-16.51	1	8	0	0	1	1	0	0	0	0	0	0
17.25-17.51	0	10	0	0	1	2	0	0	0	1	0	0
18.25-18.51	2	2	1	0	3	0	0	0	0	0	0	0
19.25-19.51	0	6	0	0	1	0	0	1	0	0	0	0

DEPTHS (cm)	Gompohonema parvulum	Gomphonema gracile	Cymatopleura solea v. apiculata	Epithemia turgida	Epithemia sorex	Epithemia spp.	Epithemia adnata	Epithemia turgida var granulata	Stauroneiss spp.	Gomphonema spp.	Gomphonema grovei	Cymbella cf aspera
0.25-0.51	1	1	0	1	0	0	0	0	0	0	0	0
1.25-1.51	1	0	0	1	0	0	0	0	0	0	0	0
2.25-2.51	0	0	0	0	0	0	0	0	0	0	0	0
3.25-3.51	0	1	0	0	0	0	0	0	0	0	0	0
4.25-4.51	0	0	0	0	0	0	0	0	0	0	0	0
5.25-5.51	0	0	0	4	0	0	0	0	0	0	0	0
6.25-6.51	0	0	0	0	0	0	0	0	0	0	0	0
7.25-7.51	0	0	0	0	0	0	0	0	0	0	0	0
8.25-8.51	1	0	1	3	0	0	0	0	0	0	0	0
9.25-9.51	0	0	0	0	0	0	0	0	0	0	0	0
10.25-10.51	0	0	1	0	0	0	0	0	0	0	0	0
11.25-11.50	0	0	0	1	1	0	0	0	0	0	0	0
12.25-12.51	0	0	0	0	0	0	0	0	0	0	0	0
13.25-13.51	0	0	0	0	0	0	0	1	0	0	0	0
14.25-14.51	1	1	0	3	0	0	0	0	0	0	0	1
15.25-15.51	1	1	0	2	1	1	0	0	0	0	0	0
16.25-16.51	0	0	0	1	1	0	0	0	0	1	0	1
17.25-17.51	0	0	0	1	0	0	0	0	1	0	1	0
18.25-18.51	3	0	1	2	0	0	1	0	0	0	0	0
19.25-19.51	1	0	0	2	0	1	0	0	0	0	1	0

DEPTHS (cm)	Cymbella gracilis	Cymbella spp	Cymbella silesiaca	Pinnularia lata	Sellaphora puppula	Total
0.25-0.51	0	0	2	0	0	412
1.25-1.51	0	2	0	0	0	392
2.25-2.51	0	0	0	0	0	361
3.25-3.51	0	1	0	0	0	402
4.25-4.51	0	0	2	0	0	410
5.25-5.51	0	0	0	0	0	405
6.25-6.51	0	0	0	0	0	407
7.25-7.51	0	0	0	0	0	408
8.25-8.51	0	2	0	0	0	414
9.25-9.51	0	0	1	0	0	405
10.25-10.51	0	0	0	0	0	395
11.25-11.50	0	0	0	0	0	432
12.25-12.51	0	0	0	0	0	344
13.25-13.51	0	1	0	0	0	412
14.25-14.51	0	1	0	0	0	393
15.25-15.51	0	1	2	0	2	408
16.25-16.51	0	0	2	0	1	402
17.25-17.51	0	1	1	0	0	432
18.25-18.51	0	1	0	0	0	407
19.25-19.51	1	2	2	1	0	409

Diatoms (species over 2% relative abundance)

DEPTHS (cm)	Stephanodiscus alpinus	Stephanodiscus niagarae	Aulacoseira islandica	Aulacoseira subartica	Aulacoseira ambigua	Aulacoseira cf distans	Melosira undulata	Staurosira construens var venter	Staurosira spp	Lemnicola hungaria
0.25-0.51	35.2	14.8	24.8	9.5	0.0	4.9	0.0	0.5	0.0	0.0
1.25-1.51	31.9	11.7	31.6	9.9	1.3	5.4	0.0	0.3	0.0	0.0
2.25-2.51	34.3	8.6	29.4	13.0	0.8	5.8	0.0	0.8	0.0	1.1
3.25-3.51	36.8	7.7	30.8	14.4	1.5	0.0	0.0	1.0	0.0	0.7
4.25-4.51	33.9	12.7	28.8	14.4	2.9	2.2	0.0	0.7	0.0	0.0
5.25-5.51	28.6	17.0	18.3	13.1	8.4	4.2	0.0	1.2	0.0	0.0
6.25-6.51	20.6	7.9	29.5	22.1	14.7	1.7	0.0	0.0	0.0	1.5
7.25-7.51	15.9	6.6	27.0	19.6	22.1	5.6	0.0	0.2	0.5	0.0
8.25-8.51	19.6	6.8	36.5	18.6	5.6	5.8	0.0	1.0	0.0	0.2
9.25-9.51	14.3	5.9	31.6	19.3	15.8	6.4	0.0	0.5	0.0	1.2
10.25-10.51	9.1	9.1	35.4	10.6	18.7	5.1	0.0	1.3	0.0	3.5
11.25-11.50	6.3	6.3	45.1	16.7	6.9	3.2	0.0	4.2	0.0	1.2
12.25-12.51	14.2	4.9	48.0	15.4	1.7	4.4	0.0	0.3	3.5	2.3
13.25-13.51	13.1	5.3	49.0	16.0	6.6	1.5	0.0	1.7	2.9	1.5
14.25-14.51	11.5	3.8	38.7	18.8	7.9	3.3	0.0	0.0	5.1	4.1
15.25-15.51	9.8	2.2	41.2	21.3	9.3	1.2	3.9	0.7	1.0	1.0
16.25-16.51	8.0	4.2	29.9	28.9	6.5	2.0	1.0	1.5	3.5	2.0
17.25-17.51	6.9	5.3	52.8	12.7	0.9	3.0	1.9	1.2	3.5	2.3
18.25-18.51	6.1	6.9	39.8	25.6	4.7	0.5	1.0	0.5	2.5	0.5
19.25-19.51	6.4	4.9	35.0	22.0	6.4	3.9	0.7	1.5	4.4	1.5

Diatom Groups

Depth	Planktic	Benthic	PB	Epiphytic
0.25	92.7	6.3	14.7	1
1.25	96.2	3.1	31.4	0.8
2.25	94.5	5.3	17.9	0.3
3.25	94.3	5.2	18	0.5
4.25	96.8	2.7	36.1	0.5
5.25	93.3	6.7	14	0
6.25	97.1	2.9	32.9	0
7.25	98.3	1.7	57.3	0
8.25	94	5.1	18.5	1
9.25	93.8	5.9	15.8	0.2
10.25	88.1	11.4	7.7	0.5
11.25	86.1	13.9	6.2	0
12.25	89.8	10.2	8.8	0
13.25	91.5	8.3	11.1	0.2
14.25	84.5	14.5	5.8	1
15.25	89.7	9.1	9.9	1.2
16.25	82.6	16.4	5	1
17.25	85	14.4	5.9	0.7
18.25	87.2	11.5	7.6	1.2
19.25	81.9	16.4	5	1.7

Caldocera

Depth	Acroperus harpae	Alona intermedia	Alona quadrangularis	Alona rectulangula	Alonella nana	Bosmina longirostris	Bosmina longispina
0.25	2.94	2.94	0	0	2.94	129.45	132.39
1.25	0	6.50	0	0	6.50	285.89	318.38
2.25	0	0	0	0	0	351.68	366.64
3.25	0	0	6.29	0	0	264.25	308.29
4.25	7.52	0	0	0	0	368.38	330.79
5.25	0	7.35	0	0	0	323.54	323.54
6.25	0	5.37	0	0	0	257.84	268.58
7.25	0	10.58	5.29	0	0	312.17	195.77
8.25	4.36	0	0	0	0	130.89	191.97
9.25	0	5.12	0	0	0	163.69	184.16
10.25	5.42	0	5.42	0	0	167.98	178.82
11.25	13.74	0	0	0	0	212.95	240.42
12.25	0	11.43	0	0	0	285.77	262.90
13.25	0	18.30	0	0	0	475.69	347.62
14.25	0	50.43	0	0	0	521.10	521.10
15.25	0	0	15.55	0	0	342.05	357.60
16.25	13.75	13.75	0	0	0	426.37	330.09
17.25	0	0	11.30	11.30	0	361.63	282.52
18.25	16.73	0	0	0	0	518.71	485.25
19.25	19.07	38.15	19.07	0	0	400.56	400.56

Depth	Camptocercus spp.	Chydorus brevilabris	Chydorus gibbus	Daphnia longispina complex	Daphnia pulex complex	Eurycercus spp.	Ophryoxus gracilis	Sida crystallina americana
0.25	0	5.88	0	0	0	0	0	0
1.25	6.50	19.49	0	6.50	0	0	0	0
2.25	0	37.41	0	7.48	0	0	0	0
3.25	0	12.58	6.29	12.58	0	0	0	0
4.25	7.52	37.59	0	0	0	7.52	0	0
5.25	0	36.77	0	0	0	0	0	7.35
6.25	5.37	48.34	0	0	0	0	5.37	5.37
7.25	0	47.62	0	0	0	0	0	0
8.25	4.36	39.27	17.45	0	0	0	0	0
9.25	5.12	102.31	5.12	5.12	5.12	0	0	0
10.25	0	167.98	0	16.26	0	5.42	0	0
11.25	0	247.29	0	0	0	0	0	0
12.25	0	537.24	0	11.43	0	0	0	0
13.25	0	1006.27	18.30	18.30	0	0	18.30	0
14.25	0	722.82	100.86	16.81	0	0	0	16.81
15.25	0	824.03	46.64	0	0	15.55	15.55	15.55
16.25	0	673.94	55.02	0	0	13.75	13.75	0
17.25	11.30	598.95	22.60	11.30	0	0	0	0
18.25	0	619.11	50.20	0	0	0	16.73	16.73
19.25	0	858.34	19.07	0	0	0	0	0

Caldocera

Species	Depth	# Counted	Headshield	Carapace	Postabdomen	Postabdominal Claw (count=#/2)	Ephippia	Mandible	Statoblast	Basal expodite	Second Expodite Segment	Third Expodite	Caudal Furca
Bosmina spp.	0.25	8	8	3	0	0	0	0	0	0	0	0	0
Bosmina longirostris	0.25	44	20	44	0	0	0	0	0	0	0	0	0
Bosmina longispina	0.25	45	45	38	0	0	0	0	0	0	0	0	0
Alonella nana	0.25	1	1	1	0	0	0	0	0	0	0	0	0
Chironomid spp.	0.25	1	0	0	0	0	0	1	0	0	0	0	0
Chydorus brevilabris	0.25	2	2	0	0	0	0	0	0	0	0	0	0
Acroperus harpae	0.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Alona intermedia	0.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Daphnia spp.	0.25	1	0	0	0	0	1	0	0	0	0	0	0
Bosmina longispina	1.25	49	49	38	0.5	0	0	0	0	0	0	0	0
Bosmina spp.	1.25	3	3	1	0	0	0	0	0	0	0	0	0
Bosmina longirostris	1.25	44	28	44	0	0	2	0	0	0	0	0	0
Alona intermedia	1.25	1	1	0	1	1	0	0	0	0	0	0	0
Camptocercus spp.	1.25	1	0	0	1	0	0	0	0	0	0	0	0
Alonella nana	1.25	1	0	1	0	0	0	0	0	0	0	0	0
Daphnia longispina complex	1.25	1	0	0	0	1	0	0	0	0	0	0	0
Chydorus brevilabris	1.25	3	3	1	0	0	0	0	0	0	0	0	0
Chironomid spp.	1.25	3	0	0	0	0	0	3	0	0	0	0	0
Bosmina longispina	2.25	49	37	49	0	0	0	0	0	0	0	0	0
Chironomid spp.	2.25	1	0	0	0	0	0	1	0	0	0	0	0
Daphnia longispina complex	2.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	2.25	5	5	0	0	0	0	0	0	0	0	0	0
Bosmina longirostris	2.25	47	27	47	0	0	1	0	0	0	0	0	0
Bosmina spp.	2.25	10	10	0	0	0	0	0	0	0	0	0	0
Bosmina spp.	3.25	11	11	0	0.5	0	0	0	0	0	0	0	0
Bosmina longispina	3.25	49	32	49	0	0	1	0	0	0	0	0	0
Bosmina longirostris	3.25	42	29	42	0.5	0	0	0	0	0	0	0	0
Chironomid	3.25	4	0	0	0	0	0	4	0	0	0	0	0
Daphnia longispina complex	3.25	2	0	0	0	1.5	0	0	0	0	0	0	0
Chydorus gibbus	3.25	1	1	1	0	0	0	0	0	0	0	0	0
Alona quadrangularis	3.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	3.25	2	1	2	0	0	0	0	0	0	0	0	0
Bosmina longirostris	4.25	49	16	49	0	0	0	0	0	0	0	0	0
Bosmina longispina	4.25	44	38	44	0	0	0	0	0	0	0	0	0
Bosmina spp.	4.25	14	14	6	0	0	0	0	0	0	0	0	0
Chironomid	4.25	2	0	0	0	0	0	2	0	0	0	0	0
Acroperus harpae	4.25	1	1	1	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	4.25	5	0	5	0	0	0	0	0	0	0	0	0
Eurycercus spp.	4.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Camptocercus spp.	4.25	1	0	1	0	0	0	0	0	0	0	0	0
Bosmina longispina	5.25	44	32	44	0	0	0	0	0	0	0	0	0
Bosmina spp.	5.25	4	4	0	0	0	0	0	0	0	0	0	0
Bosmina longirostris	5.25	44	17	44	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	5.25	5	5	3	0	0	0	0	0	0	0	0	0
Daphnia spp.	5.25	1	0	0	0	0	1	0	0	0	0	0	0
Alona intermedia	5.25	1	0	1	0	0	0	0	0	0	0	0	0
Sida crystallina americana	5.25	1	0	0	0	0	0	0	0	0	0	1	0
Bosmina longirostris	6.25	48	21	48	0	0	0	0	0	0	0	0	0
Bosmina longispina	6.25	50	50	33	0	0	0	0	0	0	0	0	0
Ophryoxus gracilis	6.25	1	0	0	0	0.5	0	0	0	0	0	0	0
Bosmina spp.	6.25	3	3	0	0	0	0	0	0	0	0	0	0
Sida crystallina americana	6.25	1	0	0	0	0.5	0	0	0	0	0	0	0

Chydorus brevilabris	6.25	9	4	9	0	0	0	0	0	0	0	0	0
Alona intermedia	6.25	1	1	0	0	0	0	0	0	0	0	0	0
Camptocercus spp.	6.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Bosmina longirostris	7.25	59	12	59	0	0	0	0	0	0	0	0	0
Chironomid spp.	7.25	2	0	0	0	0	0	2	0	0	0	0	0
Bosmina spp.	7.25	3	3	0	0	0	0	0	0	0	0	0	0
Bosmina longispina	7.25	37	29	37	0	0	0	0	0	0	0	0	0
Alona intermedia	7.25	2	2	0	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	7.25	9	3	9	0	0	0	0	0	0	0	0	0
Alona quadrangularis	7.25	1	1	0	0	0	0	0	0	0	0	0	0
Bosmina longirostris	8.25	30	15	30	0	0	0	0	0	0	0	0	0
Bosmina longispina	8.25	44	44	36	0	0	0	0	0	0	0	0	0
Chydorus gibbus	8.25	4	4	0	0	0	0	0	0	0	0	0	0
Chironomid spp.	8.25	4	0	0	0	0	0	4	0	0	0	0	0
Chydorus brevilabris	8.25	9	8	9	0	0	0	0	0	0	0	0	0
Daphnia spp.	8.25	1	0	0	0	0	1	0	0	0	0	0	0
Acroperus harpae	8.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Camptocercus spp.	8.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	9.25	20	19	20	0	0	0	0	0	0	0	0	0
Bosmina longispina	9.25	36	24	36	0	0	0	0	0	0	0	0	0
Bosmina longirostris	9.25	32	7	32	0	0	0	0	0	0	0	0	0
Alona intermedia	9.25	1	0	1	0	0	0	0	0	0	0	0	0
Chironomid spp.	9.25	2	0	0	0	0	0	2	0	0	0	0	0
Chydorus gibbus	9.25	1	1	1	0	0	0	0	0	0	0	0	0
Daphnia longispina complex	9.25	1	0	0	0	1	0	0	0	0	0	0	0
Camptocercus spp.	9.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Daphnia pulex complex	9.25	1	0	0	0	1	0	0	0	0	0	0	0
Bosmina longirostris	10.25	31	12	31	0	0	0	0	0	0	0	0	0
Bosmina longispina	10.25	33	33	33	0	0	0	0	0	0	0	0	0
Daphnia longispina complex	10.25	3	0	0	0	3	0	0	0	0	0	0	0
Chydorus brevilabris	10.25	31	23	31	0	0	0	0	0	0	0	0	0
Acroperus harpae	10.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Alona quadrangularis	10.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Bosmina spp.	10.25	3	3	0	0	0	0	0	0	0	0	0	0
Eurycercus spp.	10.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	11.25	36	36	35	0	0	0	0	0	0	0	0	0
Bosmina longispina	11.25	35	35	23	0	0	0	0	0	0	0	0	0
Bosmina longirostris	11.25	31	12	31	0	0	0	0	0	0	0	0	0
Chironomid spp.	11.25	2	0	0	0	0	0	2	0	0	0	0	0
Acroperus harpae	11.25	2	1	0	1.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	12.25	47	40	47	0	0	0	0	0	0	0	0	0
Bosmina longirostris	12.25	25	17	25	0	0	0	0	0	0	0	0	0
Bosmina longispina	12.25	23	23	17	0	0	0	0	0	0	0	0	0
Alona intermedia	12.25	1	1	1	0.5	0	0	0	0	0	0	0	0
Bosmina spp.	12.25	4	4	0	0	0	0	0	0	0	0	0	0
Daphnia longispina complex	12.25	1	0	0	0	1	1	0	0	0	0	0	0
Chironomid spp.	12.25	1	0	0	0	0	0	1	0	0	0	0	0
Ophryoxus gracilis	13.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chydorus brevilabris	13.25	55	41	55	0	0	0	0	0	0	0	0	0
Bosmina longirostris	13.25	26	9	26	0	0	0	0	0	0	0	0	0
Bosmina longispina	13.25	19	19	19	0	0	0	0	0	0	0	0	0
Chironomid spp.	13.25	2	0	0	0	0	0	2	0	0	0	0	0
Chydorus gibbus	13.25	1	1	0	0	0	0	0	0	0	0	0	0
Alona intermedia	13.25	1	1	0	0	0	0	0	0	0	0	0	0
Daphnia longispina complex	13.25	1	0	0	0	1	0	0	0	0	0	0	0
Bosmina longispina	14.25	31	31	19	0	0	0	0	0	0	0	0	0
Bosmina longirostris	14.25	31	14	31	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	14.25	43	34	43	0	0	0	0	0	0	0	0	0
Alona intermedia	14.25	3	3	2	0	0	0	0	0	0	0	0	0
Chydorus gibbus	14.25	6	6	1	0	0	0	0	0	0	0	0	0
Bosmina spp.	14.25	4	4	0	0	0	0	0	0	0	0	0	0
Chaoborus spp.	14.25	1	0	0	0	0	0	1	0	0	0	0	0
Daphnia longispina complex	14.25	1	0	0	0	1	0	0	0	0	0	0	0
Sida crystallina americana	14.25	1	0	0	0	0.5	0	0	0	0	0	0	0
Bosmina longirostris	15.25	22	22	22	0	0	0	0	0	0	0	0	0

Chydorus brevilabris	15.25	53	45	53	0	0	0	0	0	0	0	0	0
Ophryoxus gracilis	15.25	1	0	0	0	1	0	0	0	0	0	0	0
Bosmina spp.	15.25	5	5	0	0	0	0	0	0	0	0	0	0
Bosmina longispina	15.25	23	21	23	0	0	0	0	0	0	0	0	0
Sida crystallina americana	15.25	1	0	0	0	0	0	0	0	0	0	1	0
Eurycercus spp.	15.25	1	0	1	0	0	0	0	0	0	0	0	0
Chydorus gibbus	15.25	3	3	1	0	0	0	0	0	0	0	0	0
Alona quadrangularis	15.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Chironomid	15.25	1	0	0	0	0	0	1	0	0	0	0	0
Chaoborus spp.	15.25	1	0	0	0	0	0	1	0	0	0	0	0
Bosmina longispina	16.25	24	14	24	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	16.25	49	47	49	0	0	0	0	0	0	0	0	0
Bosmina longirostris	16.25	31	17	31	0	0	0	0	0	0	0	0	0
Acroperus harpae	16.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Bosmina spp.	16.25	5	5	2	0	0	0	0	0	0	0	0	0
Chydorus gibbus	16.25	4	4	1	0	0	0	0	0	0	0	0	0
Eurycercus spp.	16.25	1	0	1	0	0	0	0	0	0	0	0	0
Alona intermedia	16.25	1	1	0	0	0	0	0	0	0	0	0	0
Ophryoxus gracilis	16.25	1	0	0	0	0.5	0	0	0	0	0	0	0
Chydorus brevilabris	17.25	53	39	53	0	0	0	0	0	0	0	0	0
Bosmina longispina	17.25	25	25	17	0	0	0	0	0	0	0	0	0
Bosmina longirostris	17.25	32	19	32	0	0	1	0	0	0	0	0	0
Bosmina spp.	17.25	11	11	1	0	0	0	0	0	0	0	0	0
Camptocercus spp.	17.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Daphnia longispina complex	17.25	1	0	0	0	1	0	0	0	0	0	0	0
Alona rectulangula	17.25	1	0	1	0	0	0	0	0	0	0	0	0
Chydorus gibbus	17.25	2	2	1	0	0	0	0	0	0	0	0	0
Alona quadrangularis	17.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Alona spp.	17.25	1	0	1	0	0	0	0	0	0	0	0	0
Chaoborus spp.	18.25	1	0	0	0	0	0	1	0	0	0	0	0
Bosmina longirostris	18.25	31	11	31	0	0	0	0	0	0	0	0	0
Bosmina longispina	18.25	29	20	29	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	18.25	37	25	37	0	0	0	0	0	0	0	0	0
Bosmina spp.	18.25	5	5	0	0	0	0	0	0	0	0	0	0
Acroperus harpae	18.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Alona spp.	18.25	1	0	1	0	0	0	0	0	0	0	0	0
Sida crystallina americana	18.25	1	0	0	0	0	0	0	0	0	0	0.5	0
Chydorus gibbus	18.25	3	3	0	0	0	0	0	0	0	0	0	0
Ophryoxus gracilis	18.25	1	0	0	0	0.5	0	0	0	0	0	0	0
Bosmina longirostris	19.25	21	10	21	0	0	0	0	0	0	0	0	0
Chydorus brevilabris	19.25	45	26	45	0	0	0	0	0	0	0	0	0
Bosmina longispina	19.25	21	21	14	0	0	0	0	0	0	0	0	0
Bosmina spp.	19.25	4	4	0	0	0	0	0	0	0	0	0	0
Alona intermedia	19.25	2	2	0	0	0	0	0	0	0	0	0	0
Acroperus harpae	19.25	1	0	0	0.5	0	0	0	0	0	0	0	0
Alona quadrangularis	19.25	1	0	1	0	0	0	0	0	0	0	0	0
Chydorus gibbus	19.25	1	1	1	0	0	0	0	0	0	0	0	0