ASSESSMENT OF CHANGES IN TOTAL PHOSPHORUS IN CHIEF LAKE, B.C: A PALEOLIMNOLOGICAL ASSESSMENT (March 2003)

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BACKGROUND

A sediment core was retrieved from Chief Lake with a modified K-B corer (internal diameter ~7.62 cm) on January 28, 2003 by Bruce Carmichael and colleagues. A 46.5-cm core was retrieved from a depth of 5.8 meters. Samples were sectioned into 0.5 cm intervals and shipped to Queen's University on January 29, 2003, where they were stored in our coldroom at 4 °C. All the samples were weighed to determine the total wet weight of sediment prior to subsampling for ^{210}Pb analyses. Twenty intervals were subsampled for diatoms every two cm from 0.5 to 38.5 cm. Nineteen intervals, spaced at 1-cm intervals for the top 6 cm, then 2 cm to 12 cm, and then 4 cm to the bottom of the core, were prepared for ^{210}Pb analysis (see below) and then counted on the gamma counter facilities at PEARL, Queen's University.

METHODS

<u>210-Pb Dating and Percent Organic Matter</u>

The wet weight of the sediment was determined for all the subsections of the core that were shipped to Queen's. Nineteen samples were dried in the freeze drier at PEARL (24 hr. cycle). Dry weight of the sediment and percent water was determined. Dry sediment was then precisely weighed into a plastic tube for gamma spectroscopy. These samples were then sealed with epoxy and allowed to sit for three weeks in order for ^{214}Bi to equalize for determination of supported ^{210}Pb used in estimating core chronology. Activities of ^{210}Pb, ^{137}Cs and supported ^{210}Pb (via ^{214}Bi) were determined for each sample. These spectra were then used to estimate the chronology of the core.

The activities (in disintegrations per minute/gram) of ^{210}Pb, ^{137}Cs and ^{214}Bi were determined using the procedures outlined in Schelske et al. (1994). These values were converted into picoCuries/gram for use in the Binford program (see below). Unsupported ^{210}Pb was calculated by subtracting supported ^{210}Pb (as determined by the average ^{214}Bi counts from all samples within each of the cores) from the total ^{210}Pb activity at each level. The sediment chronology and sedimentation rates were calculated using the constant rate of supply (CRS) model (Appleby and Oldfield, 1978) from the estimates of ^{210}Pb activities and estimates of cumulative dry mass (Binford, 1990). See Appendix B for a summary of ^{210}Pb calculations (B-1), and the dating output file from the CRS model (B-2).

Percent organic matter was determined for all nineteen of the samples that were ^{210}Pb dated (Appendix A) using standard loss-on-ignition methods (Dean, 1974). A known quantity of dried sediment (recorded to four decimal places) was heated to 550°C for 2 hours. The difference between the dry weight of the sediment and the weight of sediment remaining after ignition was used to estimate the percent of organic matter in each sediment sample.

<u>Diatom Preparation and Enumeration</u>

Slides for diatom analysis were prepared using standard techniques (Cumming et al. 1995). Briefly, a small amount of wet sediment was suspended in a 50:50 (molar) mixture of sulfuric and nitric acid in a 20-ml glass vial for 24 hr. prior to being submersed at 70°C in a hot water bath for 5 hr. The remaining sediment material was settled for a period of 24 hr, at which time the acid above the sample was removed. The sample was rinsed with distilled water and allowed to settle once again for 24 hrs. The procedure was repeated approximately 10 times until the sample was acid free (litmus test). The samples were settled onto coverslips in a series of four 100% dilutions, which when dry, were mounted onto glass slides using a high-resolution mounting media called Naphrax®. For each sample, at least 400 diatom valves were enumerated with a Leica DMRB microscope equipped with DIC optics at 1000X magnification (numerical aperature of objective = 1.3). These analyses were based on the references of Krammer and Lange-Bertalot (1986, 1988, 1991a,b), Patrick and Reimer (1966, 1975) and Cumming et al. (1995).

Diatom-based Reconstructions of Total Phosphorus

Inferences of total phosphorus from the diatom assemblages in the core are based on a phosphorus model developed from 111 freshwater lakes from the 219 lakes sampled by Wilson et al. (1996). This model is based on estimates of the optima of taxa from weighted-averaging regression on non-transformed relative percentage data. The coefficient of determination (r^2) of this model is 0.66, and the jackknifed r^2 is 0.47. This model is superior to the earlier models developed by Reavie et al. (1995) for several reasons including its better predictive ability and the larger number of samples which provide more analogs for downcore reconstructions.

The total phosphorus inferences (Fig. 1E) were critically assessed to determine: 1) if they tracked the main direction of variation in the diatom species assemblages (Fig. 1D); and 2) to assess if the assemblages encountered in the core are well represented in the modern-day samples (Fig. 1F). If the diatom-based phosphorus reconstructions match the main direction of variation in the diatom assemblages in the core, then we can be fairly confident that the diatoms are tracking changes that are related to phosphorus. If the correlation between the main direction of variation and the diatom-inferred phosphorus values is weak or nonexistent, then other environmental variables (e.g. water depth, conductivity, turbulence, etc), or interactions between environmental variables, are likely responsible for the observed changes in diatom assemblages.

Determination of the Main Direction of Variation

The main direction of variation in the diatom assemblages in the core was determined from the first axis scores from a principal components analysis (PCA) ordination using non-transformed species abundance data (Fig. 1D). A PCA was chosen to represent the main direction of variation of the diatom assemblages in these cores based on the small gradient length (< 1.5 standard deviation units) obtained in an initial detrended correspondence analysis (DCA) ordination.

Analog Analysis of Diatom Assemblages

The reliability of the total phosphorus inferences in the core assumes that the diatom assemblage encountered downcore are well represented in our modern diatom assemblages. To determine if appropriate analogs existed for the core samples, we determined which samples in our present-day dataset of 111 lakes most resembled each of the downcore samples. This determination was based on a squared chord dissimilarity coefficient between all species found in each of the core samples. The best match between downcore and modern samples was compared with the distribution of best match between modern samples. Any downcore samples that were more dissimilar than 80% of the modern distribution were deemed to be a 'poor analog'. Similarly, any downcore samples that were more dissimilar than 95% of the modern distribution were deemed to have 'no analog' in our present-day dataset. If the downcore assemblages have good representation in modern samples, more confidence can be placed in the reconstruction. If modern analogs do not exist or are poor, then caution must be placed in reconstructions from these downcore samples.

RESULTS AND DISCUSSION

^{210}Pb Profile, Sedimentation Rates and Organic Matter

The ^{210}Pb activity of the Chief Lake core was low and did not show an exponential decay with core depth (Fig. 1A), suggesting either variations in sediment deposition and/or mixing of the core had occurred. The former may be related to changes in nutrient loading and/or changes due to disturbances in the Chief Lake watershed. The ^{137}Cs profile suggests that cesium has been mobile within the sediments, which is common in organic sediments (Fig. 2). Although there is not a distinct peak in the ^{137}Cs profile, the rise at around 25 cm does indicate that the sediment deposits before this point are older than 1963. In more inorganic sediment, a distinct peak in ^{137}Cs activity occurs and can serve as an independent marker for 1963, since this is when atmospheric testing of nuclear weapons peaked.

Results from the CRS model suggest that sedimentation rates increased in the late 1990s (1997-1998 ^{210}Pb estimated dates), as well as in the most recent sediments (Fig. 1B). However, because sedimentation rates can vary across a lake basin caution must be placed on interpreting sedimentation rates from one core in the basin. Analysis of organic matter (OM) from the core indicates relatively high organic sediments (35-46% OM), with gradual increases since 1600 AD from the low of 35% to 45-46% since approximately 1970 (Fig. 1C). Increases in organic matter can be attributed to several factors including increased in-lake production of organic matter, increased inwash of organic matter, or decreases in the load of inorganic matter to the lake. It is hard to determine which of these factors may be of the greatest influence given there is little change in the diatom flora since the start of this record (see below).

Diatom Assemblage Changes and Analyses

One hundred and four diatom taxa were documented in the core from Chief Lake. The majority of these taxa were rare (< 1-3% maximum abundance, Appendix C). The dominant taxa throughout the last 300 to 400 years were small benthic *Fragilaria* (*F. pinnata*, *F. construens*, *F. brevistriata*) and the eutrophic planktonic *Aulacoseira ambigua*.

Cluster analysis suggested three periods of diatom assemblages in the past 300 to 400 years, however, the total sum of squares was extremely low, suggesting that there has been little change in the assemblage over this time period (Fig. 3), so these zones are not presented. The flora has been dominated by the benthic *Fragilaria pinnata* throughout this period, with subdominants of *Aulacoseira ambigua* and *Fragilaria construens*. Minor changes in the diatom assemblage include a small increase in *Asterionella formosa* (meso-eutrophic planktonic) starting around 18 cm (approximate date of 1965), similarly small increases in the eutrophic planktonic *Stephanodiscus niagara* starting around 22 cm (approximate date of 1948) and small increases in *Tabellaria* species at about the same time.

Diatom-inferred total phosphorus (TP) estimates indicate small fluctuations in TP between 10 μgL^{-1} to 11 μgL^{-1} (Fig. 1E). The correlation between the main direction of variation in taxa (i.e. PCA axis 1 scores) (Fig. 1D) and the log TP inferences is very low ($r = 0.23$) indicating that the minor changes seen in the diatom assemblages are not consistent with changes in inferred TP.

Analog analysis suggests that all samples had extremely good analogs in the calibration set of modern diatom assemblages (Fig. 1F) providing evidence that the TP inferences are reliable.

Summary

In summary, the TP levels of Chief Lake have varied little over the past 300 to 400 years (10-11 μgL^{-1}). The diatom flora has remained relatively stable throughout this time being dominated by mesotrophic benthic taxa (*Fragilaria pinnata, Fragilaria construens* and *Fragilaria brevistriata*) and the eutrophic planktonic *Aulacoseira ambigua*.

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FIGURE CAPTIONS

Figure 1. Summary diagram for Chief Lake showing: A) total ^{210}Pb activity; B) the sediment accumulation rate; C) the change in the percent of organic matter in the core; D) the main direction of variation in the diatom assemblage data; E) diatom-based estimated of late-summer total phosphorus; and F) analog analysis showing the dissimilarity between present-day and downcore samples (any sample that has a squared chord distance > 0.8 was determined to be a poor analog, whereas any sample with a squared chord distance greater than 1.1 was determined to have no analog in the modern dataset).

Figure 2. ^{210}Pb profile and ^{137}Cs profile for Chief Lake.

Figure 3. Stratigraphy of the most abundant diatom taxa found in the sediment core from Chief Lake, B.C. (see Appendix C-1 for a complete list of taxa and the relative percentage data). The diatom taxa are arranged in order of increasing late-summer total phosphorus (TP) optima.

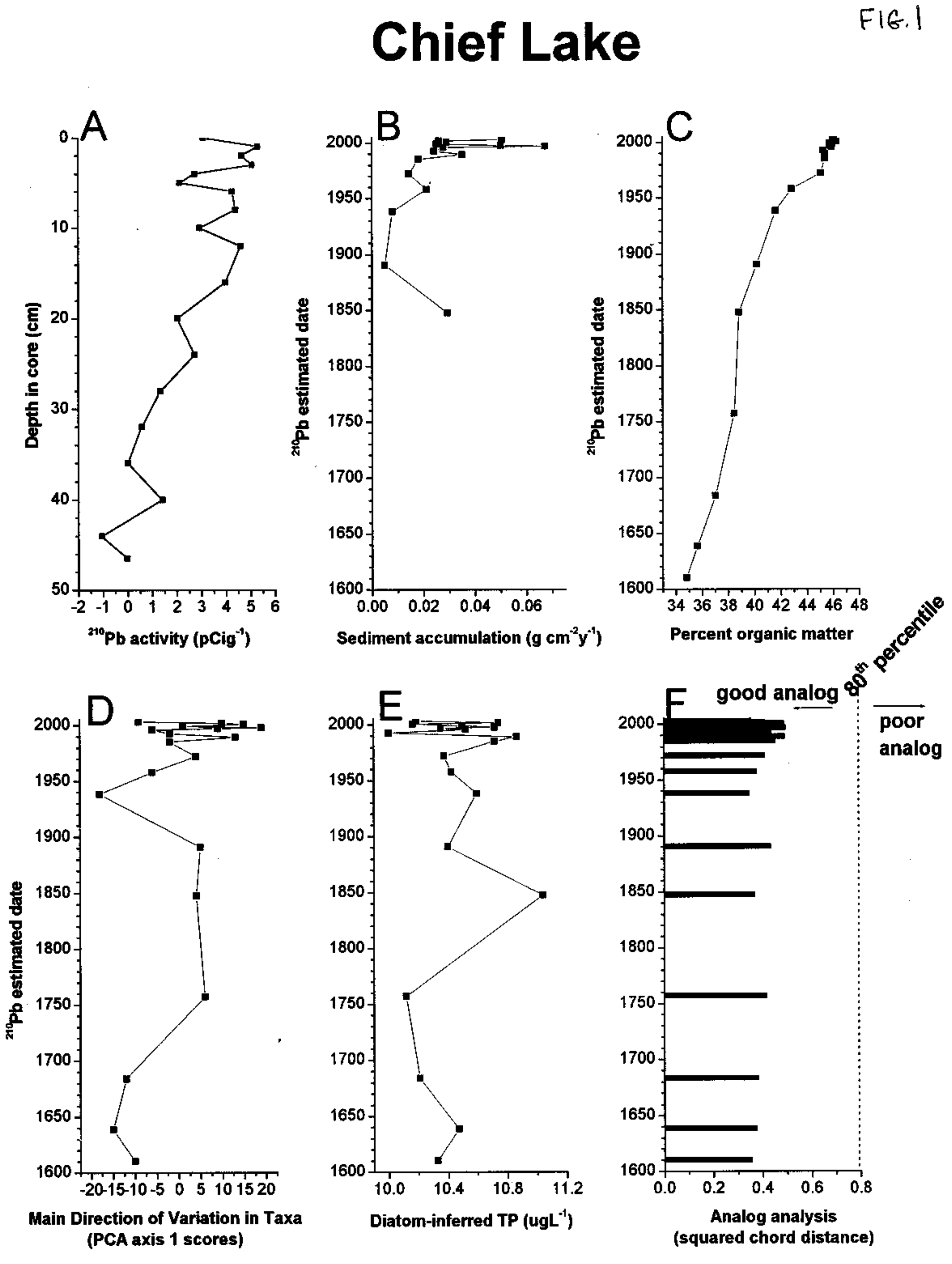


FIG. 1
Chief Lake
A
B
C
D
E
F
Depth in core (cm)
210Pb activity (pCig-1)
210Pb estimated date
Sediment accumulation (g cm-2y-1)
Percent organic matter
Main Direction of Variation in Taxa (PCA axis 1 scores)
Diatom-inferred TP (ugL-1)
Analog analysis (squared chord distance)
good analog
80th percentile
poor analog

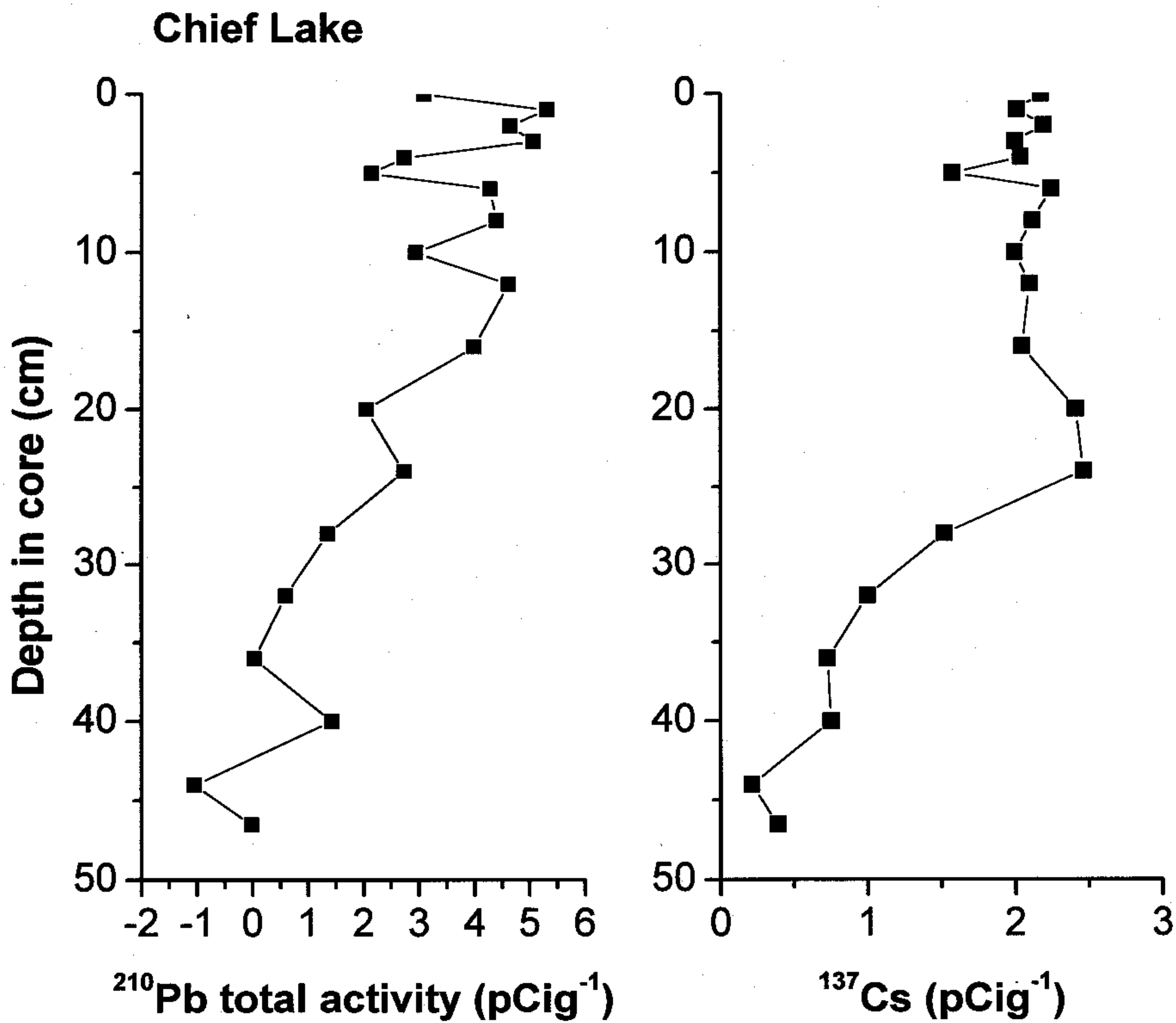
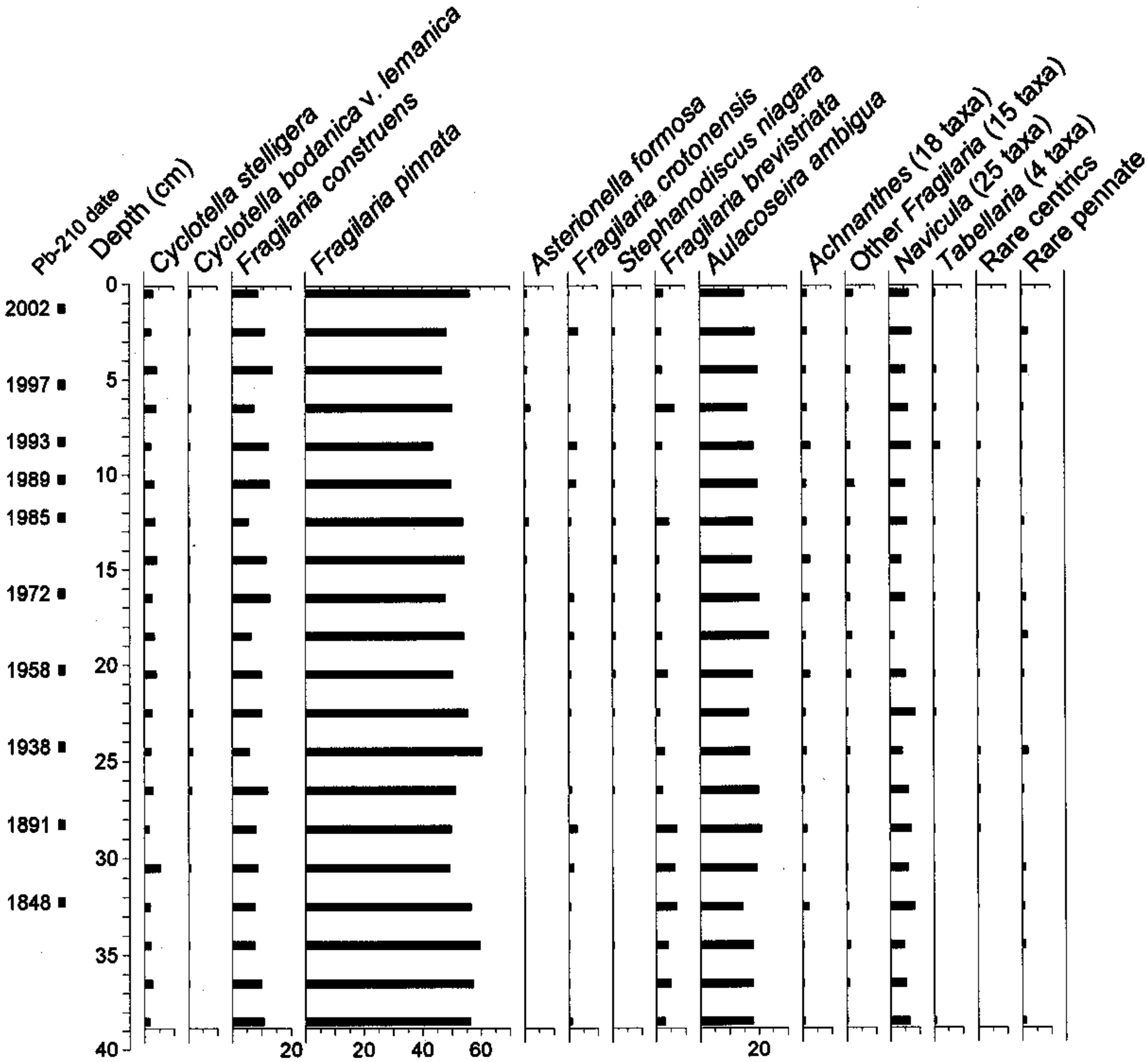

Chief Lake
Depth in core (cm)
0
10
20
30
40
50
-2 -1 0 1 2 3 4 5 6
210Pb total activity (pCig-1)
0
10
20
30
40
50
0 1 2 3
137Cs (pCig-1)

FIG. 2

Chief Lake, B.C.

FIG. 3



Appendix A

Summary File Chief Lake

Pb210 and LOI summary

* = extrapoloted dates

INTTOP (cm)	INTBOT (cm)	137Cs (pCig-1)	Pb210Act (pCi/g)	estimated AD date	SEDRAT (g/cm2/yr)	LOI(550C) %organic
0	0.5	2.1800	3.0790	2003	0.0507	46.03
1	1.5	2.0130	5.3073	2002	0.0261	46.11
2	2.5	2.1962	4.6440	2000	0.0291	46.29
3	3.5	2.0009	5.0656	1999	0.0251	45.76
4	4.5	2.0377	2.7290	1998	0.0501	45.95
5	5.5	1.5775	2.1359	1997	0.0674	45.80
6	6.5	2.2487	4.2749	1996	0.0278	45.90
8	8.5	2.1215	4.3917	1993	0.0242	45.28
10	10.5	1.9980	2.9378	1989	0.0351	45.40
12	12.5	2.1010	4.6066	1985	0.0182	45.41
16	16.5	2.0491	3.9812	1972	0.0143	45.05
20	20.5	2.4124	2.0416	1958	0.0212	42.85
24	24.5	2.4651	2.7273	1938	0.0079	41.63
28	28.5	1.5183	1.3388	1891	0.005	40.20
32	32.5	0.9949	0.5824	1848	0.0294	38.86
36	36.5	0.7261	0.0231	1757		38.46
40	40.5	0.7497	1.4136	1684		37.03
44	44.5	0.2118	-1.0512	1639		35.65
46.5	47	0.3898	-0.0225	1610		34.81

Diatom analyses

Depth (c TOP	Depth (c BOTTOM	estimated AD date	log TP	TP	PCA Axis 1	ANALOG min. sq.chord
0.5	1	2002.4	1.008	10.186	-9	0.3552
2.5	3	1999.7	1.031	10.740	10	0.4091
4.5	5	1997.4	1.007	10.162	15	0.4869
6.5	7	1995.1	1.021	10.495	1	0.3608
8.5	9	1991.7	1.030	10.715	19	0.4180
10.5	11	1988.2	1.015	10.351	9	0.4928
12.5	13	1983.5	1.022	10.520	-6	0.4300
14.5	15	1977.0	1.000	10.000	-2	0.4372
16.5	17	1970.3	1.036	10.864	13	0.4902
18.5	19	1963.2	1.030	10.715	-2	0.4514
20.5	21	1955.4	1.016	10.375	4	0.4097
22.5	23	1945.6	1.018	10.423	-6	0.3769
24.5	25	1932.2	1.025	10.593	-18	0.3464
26.5	27	1908.6	1.017	10.399	5	0.4340
28.5	29	1885.4	1.043	11.041	4	0.3689
30.5	31	1863.9	1.005	10.116	6	0.4160
32.5	33	1836.4	1.009	10.209	-12	0.3835
34.5	35	1791.2	1.020	10.471	-15	0.3746
36.5	37	1745.9	1.014	10.328	-10	0.3553
38.5	39	1700.7	1.019	10.447	-6	0.3818

Appendix B-1

Chief Lake - Pb210

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

1 dps= 1Becquerrel

INTTOP (cm)	INTBOT (cm)	Pb-210 (dps/g) activity	Std dev Pb-210 (dps/g)	214Bi (dps/g)	137Cs (dps/g)	137Cs (pCIg-1)	Pb210 activity (pCIg-1)	Std dev Pb-210 (pCIg-1)	214Bi (pCIg-1)	Rho (g cm-3)
0	0.5	0.113924	0.008117	0.021645	0.080659	2.1800	3.0790	0.2194	0.5850	0.0358
1	1.5	0.19637	0.007449	0.003367	0.074482	2.0130	5.3073	0.2013	0.0910	0.0352
2	2.5	0.171829	0.010933	0.002791	0.081258	2.1962	4.6440	0.2955	0.0754	0.0427
3	3.5	0.187429	0.011428	0.032322	0.074034	2.0009	5.0656	0.3089	0.8736	0.0413
4	4.5	0.100972	0.008163	0.005945	0.075396	2.0377	2.7290	0.2206	0.1607	0.0374
5	5.5	0.079028	0.006586	0.009647	0.058368	1.5775	2.1359	0.1780	0.2607	0.0421
6	6.5	0.158172	0.009984	0.037934	0.083201	2.2487	4.2749	0.2698	1.0252	0.0462
8	8.5	0.162493	0.010156	0.015873	0.078496	2.1215	4.3917	0.2745	0.4290	0.0432
10	10.5	0.1087	0.00808	-0.01107	0.073927	1.9980	2.9378	0.2184	-0.2992	0.0523
12	12.5	0.170445	0.010316	0.043419	0.077738	2.1010	4.6066	0.2788	1.1735	0.0494
16	16.5	0.147303	0.009392	0.027606	0.075817	2.0491	3.9812	0.2538	0.7461	0.0572
20	20.5	0.075541	0.006339	0.034901	0.089257	2.4124	2.0416	0.1713	0.9433	0.0644
24	24.5	0.100911	0.007694	0.020585	0.09121	2.4651	2.7273	0.2080	0.5564	0.0636
28	28.5	0.049535	0.004834	0.040202	0.056178	1.5183	1.3388	0.1307	1.0865	0.0983
32	32.5	0.02155	0.003079	0.037619	0.03661	0.9849	0.5824	0.0832	1.0167	0.0636
36	36.5	0.000853	0.000196	0.018849	0.026866	0.7261	0.0231	0.0053	0.5094	0.0693
40	40.5	0.052301	0.005283	0.013868	0.027739	0.7497	1.4136	0.1428	0.3753	0.0637
44	44.5	-0.0389	0.006483	0.008594	0.007836	0.2118	-1.0512	0.1752	0.2323	0.0790
46.5	47	-0.00083	0.000186	0.020843	0.014422	0.3898	-0.0225	0.0050	0.5633	0.0679

BINFORD FILE INPUTS FOR CALCULATIONS OF DATES AND SEDIMENTATION RATES

Chief
C1
19.00
0.4055

INTTOP (cm)	INTBOT (cm)	Pb210 Total (pCIg-1)	Pb210 Unsup. (pCIg-1)	Rho (g cm-3)	OM proportion	CUMTOP (g cm-2)	CUMBOT (g cm-2)	std Pb210 (pCIg-1)
0	0.5	3.0790	2.5314	0.0358	0.46	0.0000	0.0179	0.2194
1	1.5	5.3073	4.7597	0.0352	0.46	0.0346	0.0522	0.2013
2	2.5	4.6440	4.0964	0.0427	0.46	0.0720	0.0934	0.2955
3	3.5	5.0656	4.5181	0.0413	0.46	0.1144	0.1351	0.3089
4	4.5	2.7290	2.1814	0.0374	0.46	0.1556	0.1742	0.2206
5	5.5	2.1359	1.5883	0.0421	0.46	0.1956	0.2168	0.1780
6	6.5	4.2749	3.7273	0.0462	0.46	0.2419	0.2650	0.2698
8	8.5	4.3917	3.8441	0.0432	0.45	0.3356	0.3572	0.2745
10	10.5	2.9378	2.3903	0.0523	0.45	0.4282	0.4543	0.2184
12	12.5	4.6066	4.0590	0.0494	0.45	0.5305	0.5552	0.2788
16	16.5	3.9812	3.4336	0.0572	0.45	0.7452	0.7738	0.2538
20	20.5	2.0416	1.4940	0.0644	0.43	0.9870	1.0193	0.1713
24	24.5	2.7273	2.1797	0.0636	0.42	1.2443	1.2761	0.2080
28	28.5	1.3388	0.7912	0.0983	0.40	1.5374	1.5865	0.1307
32	32.5	0.5824	0.0348	0.0636	0.39	1.8251	1.8569	0.0832
36	36.5	0.2000	0.0000	0.0693	0.38	2.0837	2.1183	0.0053
40	40.5	0.2000	0.0000	0.0637	0.37	2.3568	2.3887	0.1428
44	44.5	0.2000	0.0000	0.0790	0.36	2.6453	2.6848	0.1752
46.5	47	0.2000	0.0000	0.0679	0.35	2.8459	2.8798	0.0050

Appendix B-2

YOU ARE ANALYZING CORE C1 FROM LAKE Chief

THE DATA ARE:

INTTOP	INTBOT	PB210ACT	UNSUPACT	RHO	PERCORG	CUMMASST	CUMMASSB	SDACT
0.0	0.5	3.07900	2.53140	0.03580	0.460	0.0000	0.0179	0.2194
1.0	1.5	5.30730	4.75970	0.03520	0.460	0.0346	0.0522	0.2013
2.0	2.5	4.64400	4.09640	0.04270	0.460	0.0720	0.0934	0.2955
3.0	3.5	5.06560	4.51810	0.04130	0.460	0.1144	0.1351	0.3089
4.0	4.5	2.72900	2.18140	0.03740	0.460	0.1556	0.1742	0.2206
5.0	5.5	2.13590	1.58830	0.04210	0.460	0.1956	0.2166	0.1780
6.0	6.5	4.27490	3.72730	0.04620	0.460	0.2419	0.2650	0.2698
8.0	8.5	4.39170	3.84410	0.04320	0.450	0.3356	0.3572	0.2745
10.0	10.5	2.93780	2.39030	0.05230	0.450	0.4282	0.4543	0.2184
12.0	12.5	4.60660	4.05900	0.04940	0.450	0.5305	0.5552	0.2788
16.0	16.5	3.98120	3.43360	0.05720	0.450	0.7452	0.7738	0.2538
20.0	20.5	2.04160	1.49400	0.06440	0.430	0.9870	1.0193	0.1713
24.0	24.5	2.72730	2.17970	0.06360	0.420	1.2443	1.2761	0.2080
28.0	28.5	1.33880	0.79120	0.09830	0.400	1.5374	1.5865	0.1307
32.0	32.5	0.58240	0.03480	0.06360	0.390	1.8251	1.8569	0.0832
36.0	36.5	0.20000	0.00000	0.06930	0.380	2.0837	2.1183	0.0053
40.0	40.5	0.20000	0.00000	0.06370	0.370	2.3568	2.3887	0.1428
44.0	44.5	0.20000	0.00000	0.07900	0.360	2.6453	2.6848	0.1752
46.5	47.0	0.20000	0.00000	0.06790	0.350	2.8459	2.8798	0.0050

STANDARD DEVIATION OF SUPPORTED PB-210 = 0.4055

Pb-210 dates for Lake Chief core C1

INTTOP	INTBOT	MIDINT	TTOP	SDTTOP	TBOT	SDTBOT	SEDRATE	SDSEDRT	SUMTOP
0.0	0.5	0.2	0.00	1.21	0.35	1.21	0.0507	0.0171	4.1440
1.0	1.5	1.2	0.85	1.22	1.52	1.23	0.0261	0.0090	4.0361
2.0	2.5	2.2	2.22	1.25	2.96	1.26	0.0291	0.0107	3.8667
3.0	3.5	3.2	3.74	1.27	4.56	1.29	0.0251	0.0096	3.6889
4.0	4.5	4.2	5.13	1.30	5.50	1.31	0.0501	0.0183	3.5322
5.0	5.5	5.2	5.85	1.32	6.16	1.32	0.0674	0.0243	3.4544
6.0	6.5	6.2	6.68	1.33	7.52	1.35	0.0278	0.0109	3.3653
8.0	8.5	8.2	10.10	1.41	11.00	1.43	0.0242	0.0100	3.0255
10.0	10.5	10.2	13.45	1.50	14.20	1.52	0.0351	0.0147	2.7256
12.0	12.5	12.2	17.23	1.61	18.59	1.66	0.0182	0.0086	2.4234
16.0	16.5	16.2	29.99	2.11	31.99	2.20	0.0143	0.0084	1.6285
20.0	20.5	20.2	44.43	2.92	45.95	3.01	0.0212	0.0144	1.0389
24.0	24.5	24.2	62.91	4.58	66.96	5.09	0.0079	0.0081	0.5844
28.0	28.5	28.2	107.32	14.72	117.22	19.03	0.0050	0.0113	0.1466
32.0	32.5	32.2	154.85	45.03	155.93	44.69	0.0294	0.1055	0.0334

Execution terminated : 0

C:\PB210>

Appendix C

Chief Lake - Ministry - Carmichael
Analyst: KR Laird

Taxa	Interval (cm) 0.5-1.0	2.5-3.0	4.5-5.0	6.5-7.0	8.5-9.0	10.5-11.0	12.5-13.0	14.5-15.0	16.5-17.0	18.5-19.0	20.5-21	22.5-23.0	24.5-25.0	26.5-27.0	28.5-29.0	30.5-31.0	32.5-33.0	34.5-35.0	36.5-37	38.5-39.0
Achnanthes calcar	0.43	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes clevei	0.21	0.25	0.25	0.24	0.24	0.00	0.00	0.00	0.25	0.00	0.20	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Achnanthes exigua	0.43	0.00	0.25	0.48	0.00	0.00	0.25	0.00	1.24	0.00	0.41	0.00	0.47	0.00	0.23	0.00	0.71	0.00	0.00	0.23
Achnanthes flexella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes joursacense	0.00	0.00	0.00	0.00	0.24	0.48	0.00	0.25	0.00	0.00	0.41	0.00	0.23	0.22	0.23	0.00	0.24	0.00	0.00	0.00
Achnanthes lanceolata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23
Achnanthes lanceolata v. dubia	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	1.02	0.23	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00
Achnanthes lanceolata spp. freq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes laterostrata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes linearis	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes minutissima	0.00	0.00	0.75	0.48	0.97	0.00	0.74	1.23	0.50	1.21	0.41	0.00	0.47	0.00	0.45	0.00	0.00	0.23	0.00	0.23
Achnanthes oestrupii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes peragalli	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes pusilla	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.24	0.00	0.00	0.00
Achnanthes rossii	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes subatomoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.25	0.00	0.00	0.23	0.71	0.00	0.50	0.00
Achnanthes suchlandtii	0.00	0.00	0.00	0.00	0.24	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00
Achnanthes spp	0.64	0.25	0.25	0.48	0.49	0.24	0.25	0.49	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00
Amphora libyca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00
Amphora pediculus	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Amphora spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterionella formosa	0.00	1.48	1.00	1.93	0.73	0.48	1.47	0.74	0.50	0.48	0.20	0.23	0.23	0.22	0.00	0.00	0.00	0.00	0.25	0.00
Aulacoseira ambigua	15.20	18.72	19.90	16.14	18.45	19.78	18.14	17.53	20.30	23.67	17.99	16.40	16.98	20.04	21.09	19.39	14.29	18.10	17.87	18.06
Aulacoseira cf. distans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.24	0.00	0.00	0.00
Aulacoseira spp.	0.21	0.00	0.25	0.48	0.97	0.72	0.25	0.25	0.50	0.24	0.61	0.00	0.70	0.43	0.45	0.00	0.00	0.00	0.00	0.00
Cocconeis neothumensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocconeis spp.	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Cyclostephanos cf. tholiformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyclotella bodanica v. lemanica	1.07	0.49	0.25	0.96	0.73	0.00	0.74	0.49	0.50	0.00	0.41	1.35	1.40	1.08	0.23	0.70	0.00	0.46	0.25	0.00
Cyclotella stelligera	3.00	2.22	4.23	4.10	2.18	3.37	3.68	4.20	2.72	3.38	4.07	2.48	2.09	2.80	1.59	5.37	1.90	2.09	2.73	1.81
Cymbella gracilis	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella minuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella naviculiformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.46	0.00	0.68
Cymbella silesiaca	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00
Cymbella sinuata	0.00	0.00	0.00	0.48	0.24	0.00	0.25	0.00	0.25	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.47	0.00	0.00	0.00	0.00	0.23	0.00	0.00
Diploneis elliptica	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eunotia incisa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eunotia spp.	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria bicapitata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria brevistriata	2.57	1.72	1.99	6.51	2.18	0.24	4.41	0.99	1.24	1.83	4.67	1.35	2.79	2.16	7.03	6.31	6.90	3.94	4.96	2.93
Fragilaria capucina fo. gracilis	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria capucina fo. mesolepta	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria construens	8.78	11.08	13.08	7.47	12.38	12.77	5.64	11.60	12.87	8.52	9.98	10.16	5.61	12.07	7.94	8.88	7.86	7.89	9.93	10.84
Fragilaria construens v. venter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria crotonensis	0.21	3.20	0.25	0.72	2.91	2.41	0.74	0.00	1.73	1.09	0.81	0.68	0.23	0.86	2.72	1.64	0.71	0.23	0.25	0.00
Fragilaria exigua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.24	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.23
Fragilaria lapponica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria leptostriata	0.00	0.00	0.00	0.00	0.24	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.23	0.00	0.00
Fragilaria mazamaensis	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria nanana	0.00	0.00	0.00	0.00	0.73	0.24	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria cf. neoproducta	0.00	0.00	0.00	0.24	0.00	0.24	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria parasitica	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria parasitica v. subconstricta	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria pinnata	58.10	48.28	46.52	50.12	43.69	49.64	53.92	54.32	47.77	54.11	50.41	56.53	60.47	51.29	48.66	49.07	56.43	59.63	57.32	56.21
Fragilaria cf. robusta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00
Fragilaria cf. tenera	1.93	0.25	1.00	0.48	0.49	0.72	0.00	0.49	0.25	1.45	0.41	0.23	0.23	0.22	0.00	0.00	0.00	0.23	0.50	0.00
Fragilaria spp.	0.43	0.00	0.50	0.00	0.00	0.24	1.23	0.74	0.00	0.24	0.00	0.00	0.47	0.00	0.00	0.23	0.24	0.46	0.25	0.00
Gomphonema cf. gracile	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gomphonema parvulum	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gomphonema spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.93	0.43	0.00	0.23	0.00	0.00	0.00	0.00
Meridion circulare	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Navicula cf. aboensis	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula absoluta	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.25	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cryptocephala	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cryptotenella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula explanata	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00
Navicula ignota	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula laevissima	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.23	0.25	0.23
Navicula laterostrata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula minima	0.43	1.23	0.25	0.72	1.48	0.48	0.00	0.25	0.00	0.00	0.41	1.81	1.16	0.43	0.91	0.70	0.24	0.23	0.74	0.23
Navicula porifera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.45	0.00	0.24	0.00	0.00	0.00
Navicula pseudoscutiformis	0.64	0.00	0.50	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.24	0.00	0.00	0.00
Navicula pseudoventralis	1.07	1.48	0.00	0.00	0.49	0.00	0.00	0.49	0.25	0.00	0.61	0.90	0.47	0.00	1.36	0.23	0.00	0.46	0.00	1.13
Navicula pupula	0.86	0.00	0.00	0.24	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.23	0.24	0.00	0.00	0.00
Navicula radiosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula schoenfeldii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.43	0.23	0.00	0.24	0.00	0.00	0.23
Navicula seminulum	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula aff. vitulis	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cf. soodensis	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula submuralis	0.21	0.74	0.25	1.45	2.67	0.00	0.49	0.74	0.50	0.24	0.61	1.81	0.70	1.51	1.81	1.40	3.10	1.16	1.99	1.13
Navicula subrotundata	0.00	0.49	0.75	0.24	0.97	1.20	0.00	0.00	0.74	0.00	2.03	0.23	0.23	1.08	0.23	0.00	0.24	0.00	0.50	0.68
Navicula aff. utermoehlii	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.23	0.00	0.45
Navicula vitabunda	0.43	0.00	0.25	0.24	0.49	0.72	0.25	0.00	0.00	0.24	0.00	0.45	0.93	0.22	0.23	0.47	1.19	0.00	0.74	0.45
Navicula villosa	0.00	0.49	0.75	0.49	0.97	1.20	1.72	0.49	0.74	0.00	0.00	0.45	0.23	1.08	0.23	0.70	0.95	0.23	0.74	0.68
Navicula sp.PI19, F13-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.47	0.24	0.00	0.00	0.00
Navicula spp.	2.36	2.71	2.74	1.93	0.24	1.45	1.47	1.23	2.23	0.72	1.02	2.83	0.23	0.65	0.91	1.64	1.43	2.09	0.25	1.36
Neidium affine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia dissipata v. media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia spp.	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnularia interrupta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Pinnularia maior	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnularia microstauron	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Simonsenia delognei	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stauroneis spp.	0.00	0.49	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stauroneis phoenicenteron	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00
Stephanodiscus niagarae	0.43	0.74	0.25	0.96	0.97	0.72	0.98	1.48	0.74	0.97	1.02	0.68	0.23	0.43	0.00	0.00	0.00	0.23	0.00	0.00
Stephanodiscus parvus	0.00	0.00	0.25	0.00	0.24	0.24	0.00	0.00	0.25	0.24	0.00	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Synedra delicatissima v. angustissima	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tabellaria fenestrata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tabellaria flocculosa str. 3p	0.64	0.00	0.00	0.96	2.43	0.00	0.25	0.00	0.25	0.24	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tabellaria flocculosa str. IV	0.00	0.00	1.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.41	0.45	0.00	0.00	0.23	0.23	0.00	0.00	0.00	0.68
Tabellaria ventricosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central area unknown	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.22	0.00	0.00	0.00	0.00	0.00	0.00