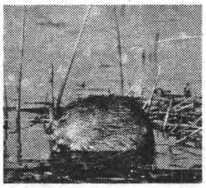
Canada Alberta Northwest Territories

Northern River Basins Study





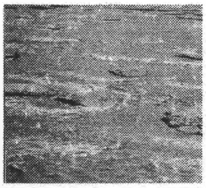



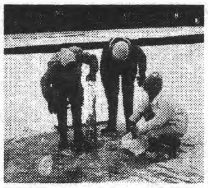


NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 68

GROWTH RATE AND BIOMASS RESPONSES OF PERIPHYTIC ALGAE TO PHOSPHORUS ENRICHMENT

IN EXPERIMENTAL FLUMES, ATHABASCA RIVER, SEASONAL VARIATION 1993 AND 1994



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Northern River Basins Study
under Project 2613-D1

by

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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

NORTHERN RIVER BASINS STUDY
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Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
this publication be subjected to proper and responsible review and be considered for release to the public.

10 Jan 96

(Dr. Fred J. Wrona, Science Director) (Date)

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.
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Jan 8/96

(Dr. P. A. Larkin, Ph.D., Chair) (Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[ ] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

Lucille Partington Jan. 11/96

(Lucille Partington, Co-chair) (Date)

Robert McLeod. 11/01/96

(Robert McLeod, Co-chair) (Date)

GROWTH RATE AND BIOMASS RESPONSES OF PERIPHYTIC ALGAE TO PHOSPHORUS ENRICHMENT IN EXPERIMENTAL FLUMES ATHABASCA RIVER: SEASONAL VARIATION, 1993 and 1994

STUDY PERSPECTIVE

A particular area of concern related to municipal and industrial effluent discharges in the northern river basins is the effect of nutrients (primarily nitrogen and phosphorus) on the aquatic environment. Nutrients enter a river from municipal and industrial effluents, agricultural and timber-harvesting runoff, natural runoff, groundwater sources and tributary inflow. Added nutrients can cause changes in abundance and production of benthic biota and fish. Nutrients may also affect dissolved oxygen concentrations as a result of enhanced plant growth, which is in turn decomposed by bacteria that consume oxygen. The changes to the biological communities resulting from the addition of nutrients and their subsequent effect on the chemical and physical components of the ecosystem is referred to scientifically as eutrophication. Understanding the impacts of nutrients on the aquatic environment is therefore critical for managing industrial and municipal effluent discharges to the Peace, Athabasca and Slave rivers in order to minimize eutrophication and safeguard ecosystem health.

Related Study Questions

4a)	*What are the contents and nature of the contaminants entering the system and what is their distribution and toxicity in the aquatic ecosystem with particular reference to water, sediments and biota?*
5	*Are the substances added to the river by natural and man-made discharges likely to cause deterioration of the water quality?*
13b)	*What are the cumulative effects of man-made discharges on the water and aquatic environment?*

This report presents the results of an experiment conducted in artificial streams (flumes) in which the growth rate and biomass response of periphyton (algae) was studied in relation to phosphorus (P) concentrations in the water. The goal of this study was to determine whether periphyton growth in the Athabasca River is phosphorus limited, and if the degree of phosphorus limitation varied seasonally. The experiment was designed to test periphyton growth and biomass response to a gradient of phosphorus additions during fall and early spring. The flumes were located on-site, adjacent to the Athabasca River at Hinton.

The response of periphyton was compared for phosphorus additions of 0 (control), 1, 10 and 25 µg/L (spring and fall 1994) or 0 (control), 0.1, 0.2, 1, 5, 10, 25 and 50 µg/L (fall 1993). Relative growth rates, as indicated by measuring the buildup of chlorophyll *a*, were similar for all trials with growth rate saturation occurring at 2-5 µg/L P. Comparison of peak biomass data showed that peak biomass levels were also similar for all trials. Phosphorus concentrations required to reach maximum biomass levels were higher than those required to saturate growth rate, but substantial increases in biomass were still observed with small additions (2-5 µg/L) of phosphorus. Such increases in biomass would likely be greater during periods of higher temperature and increased irradiance from sunlight.

These experiments demonstrate that despite changes in absolute biomass and growth rate due to factors such as temperature, the relative response of periphyton to phosphorus enrichment in the Athabasca River at Hinton does not change seasonally. These studies, in addition to similar experiments involving benthic invertebrates, will be used to evaluate food web responses to nutrient and contaminant additions. The results will provide necessary information for setting regulatory guidelines for nutrient loading in the Athabasca River.

REPORT SUMMARY

During fall 1993 and spring and fall 1994, a phosphorus enrichment experiment was run in flow-through troughs located on the Athabasca River at Hinton, Alberta to examine growth rate and biomass response of periphyton to phosphorus (P) additions. P additions of 0 (control), 1, 10, and 25 µg/L (spring and fall 1994) or 0 (control), 0.1, 0.2, 1, 5, 10, 25, and 50 µg/L (fall 1993) were applied to 12 randomly selected troughs from which styrofoam (fall 1993) and tile (spring and fall 1994) substrata were sampled to measure time-course accrual of chlorophyll *a*. Relative specific growth rates ($\mu:\mu_{max}$) were similar for all trials and showed Monod type kinetics with growth rate saturation occurring at 2-5 µg/L soluble reactive phosphorus (SRP). Upper Athabasca $\mu:\mu_{max}$ was similar to values observed in the Thompson River, British Columbia. Comparison of relative peak biomass ($PB:PB_{max}$) data showed that $PB:PB_{max}$ levels were also similar for all trials. Phosphorus concentrations required to reach maximum $PB:PB_{max}$ were higher than those required to saturate $\mu:\mu_{max}$ but relatively substantial increases in biomass were still observed with small additions (3-5 µg/L SRP) of phosphorus. These experiments showed that despite changes in absolute biomass or growth rate due to abiotic factors, (photosynthetically active radiation and temperature), the relative response of periphyton to P enrichment in the Athabasca at Hinton does not change seasonally. Additional experiments conducted further downstream would allow determination of spatial variability in nutrient limitation in the Athabasca River. Results from this and other studies will provide necessary information for setting regulatory guidelines for nutrient loading on the Athabasca River.

ACKNOWLEDGEMENTS

Funding for this project was made available from the Northern River Basins Study. We thank Weldwood of Canada Ltd. for access through mill property and to their chemistry lab, and for providing a site to run the experiment. Field support was provided by Tessa Fauquier and Todd French. Laboratory analyses were completed by Trinh Luong (chlorophyll *a*), Gertie Hutchinson (water chemistry, University of Alberta), and Mary Bolin (periphyton taxonomy). The initial impetus and approach for this experiment was provided by M.L. Bothwell.

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1.0 INTRODUCTION

The limiting effect of nutrients (nitrogen (N) and phosphorus (P)) on aquatic production and the eutrophication of aquatic systems by nutrient addition is well known and has been widely studied (Schindler *et al.,* 1971; Dillon and Rigler, 1974). In the case of lakes, nutrient addition as a result of sewage, industrial or agricultural inputs has been shown to increase primary, benthic invertebrate, zooplankton, and fish production while nutrient abatement can reverse these effects (e.g. Beeton, 1965; Edmondson and Lehman, 1981; Stockner and Shortreed, 1985). Likewise, nutrient addition to streams and rivers has increased periphyton standing crop as well as benthic invertebrate and fish growth rates (Cole, 1973; Peterson *et al.*, 1985; Perrin *et al.*, 1987; Johnston *et al.*, 1990). Fish standing crop for rivers throughout North America has also been found to be correlated with total phosphorus concentrations (Hoyer and Canfield, 1991). One frequently used method to determine nutrient limitation in lotic systems is to examine the effects of augmentation of a limiting nutrient on the growth of periphyton (the attached algae on rocks or sediment) in artificial streams (Kevern et al., 1966; Stockner and Shortreed, 1976; Horner *et al.*, 1983; Bothwell, 1988, 1993; Welch *et al.*, 1992). Although many studies have shown that nitrogen is often limiting or co-limiting for algal growth (Smith, 1982; Dodds *et al.*, 1989), most periphyton communities tend to be P limited (Elwood *et al.*, 1981; Biggs and Close, 1989; Horner *et al.*, 1990; Bothwell, 1993). However, there are discrepancies in the literature about the concentrations of P required to saturate cellular growth rates (Tilman and Kilham, 1976; Brown and Button, 1979) and those resulting in high periphyton biomass *in situ* (Horner *et al.*, 1983; Bothwell, 1985; 1989). Bothwell (1989) attributes this disparity to growth of the periphyton community reaching an asymptote at a P concentration higher than required to saturate growth of individual cells or thin periphyton films. Moreover, there are problems in comparing growth rates and biomass from artificial stream experiments conducted in different geographic locales or at different times of year due to varying effects of physical factors such as light and temperature. To standardize for these abiotic variables, growth and biomass are often expressed as a ratio of the maximum growth or biomass observed in an experiment. These relative specific growth rate and biomass models effectively factor out physical variation between experiments and are useful in comparing responses of periphyton to nutrient addition under varying abiotic regimes (Bothwell, 1988, 1989; Perrin *et al.*, 1995).

The aim of this experiment was to determine: (a) whether periphyton growth in the upper Athabasca River was P limited, and (b) if the degree of P limitation varied seasonally. This work forms part of the Northern River Basins Study (NRBS), a joint study between the governments of Canada, Alberta and the Northwest Territories. The aim of the NRBS is to gather comprehensive information on water quality, fish and fish habitat, riparian vegetation and wildlife, hydrology, and use of aquatic resources for the Peace, Athabasca, and Slave River basins in order to predict and assess the cumulative effects of development on the water and aquatic environment of these basins within Alberta and the Northwest Territories.

Existing water quality data (Sentar Consultants Ltd., 1994) and the results of Perrin *et al.* (1995) and Dale and Chambers (1996) from fall 1993 and spring 1994 artificial stream experiments showed that P is the nutrient limiting periphyton growth in the upper Athabasca River. To assess the seasonality of nutrient limitation in the upper Athabasca River and test the reproducibility of the earlier findings, an experiment was conducted in fall 1994 using artificial streams located beside the Athabasca River at Hinton, Alberta. The results of this experiment will aid in assessing the effect of nutrient loading on periphyton growth in the upper Athabasca River and provide necessary information for setting regulatory guidelines for nutrient loading.

2.0 METHODS AND MATERIALS

2.1 STUDY SITE AND APPARATUS

This experiment was conducted at the Environment Canada study site located at the Weldwood of Canada Ltd. pulp mill in Hinton, Alberta (Figure 1). A detailed description of the study site is given in Perrin *et al.* (1995). The experimental apparatus had a design similar to the experimental troughs research apparatus (EXTRA) facility (Bothwell, 1988) with modifications described by Perrin *et al.* (1995). In general, the apparatus consisted of 12 flow-through troughs (2m long x 19cm wide and 5cm deep) fabricated from clear acrylic. River water was supplied from the mill intake located upstream of the combined municipal and mill discharge at Hinton and pumped into a 1200 L head tank. Modifications to the design of Perrin *et al.* (1995) are outlined in a previous report (Dale and Chambers, 1996).

Water flow in each trough was set at 24 L/min (assuming average water depth of 2 cm above tile surfaces and ignoring inter-tile spaces, this equates to a velocity of approximately 0.1 m/s) and was recalibrated every 2-3 days. Replicate clay tiles (4.5 cm * 4.5 cm * 1.0 cm, top surface = 20.25 cm^2) were placed throughout the length of each trough to provide a substratum for periphyton growth. Tiles were arranged identical to the spring 1994 trial (Dale and Chambers, 1996) and blocked into reaches (27 tiles/reach) to allow testing for effects of scour or sloughing on chlorophyll *a* accrual. This orientation created channels of higher velocity around tiles, similar to flows around natural gravel (Perrin *et al.*, 1995). Extra tiles were placed above and below the experimental reaches to maintain flow continuity for the entirety of the reaches. Troughs were cleaned with a syphon hose to ensure that the sediment between the tiles did not accumulate and cover the tiles. Although sedimentation was less in fall 1994 than spring 1994 due to decreased river flows (Figure 2), it was not possible to eliminate all sedimentation on the tiles.

2.2 EXPERIMENTAL DESIGN

This trial of the experiment was designed to test periphyton growth and biomass response to a gradient of P additions during early winter. An accidental shut down of power and water to the experiment after the initial start date (September 29, 1994) meant that the trial had to be re-run at a later date. This late start date eliminated the possibility of running a second experiment at the Alberta Pacific pulp mill near Athabasca, as outlined in the terms of reference (Appendix A). The trial ran for four weeks (October 24 to November 22, 1994) and consisted of four treatments: a control of zero P-addition and three

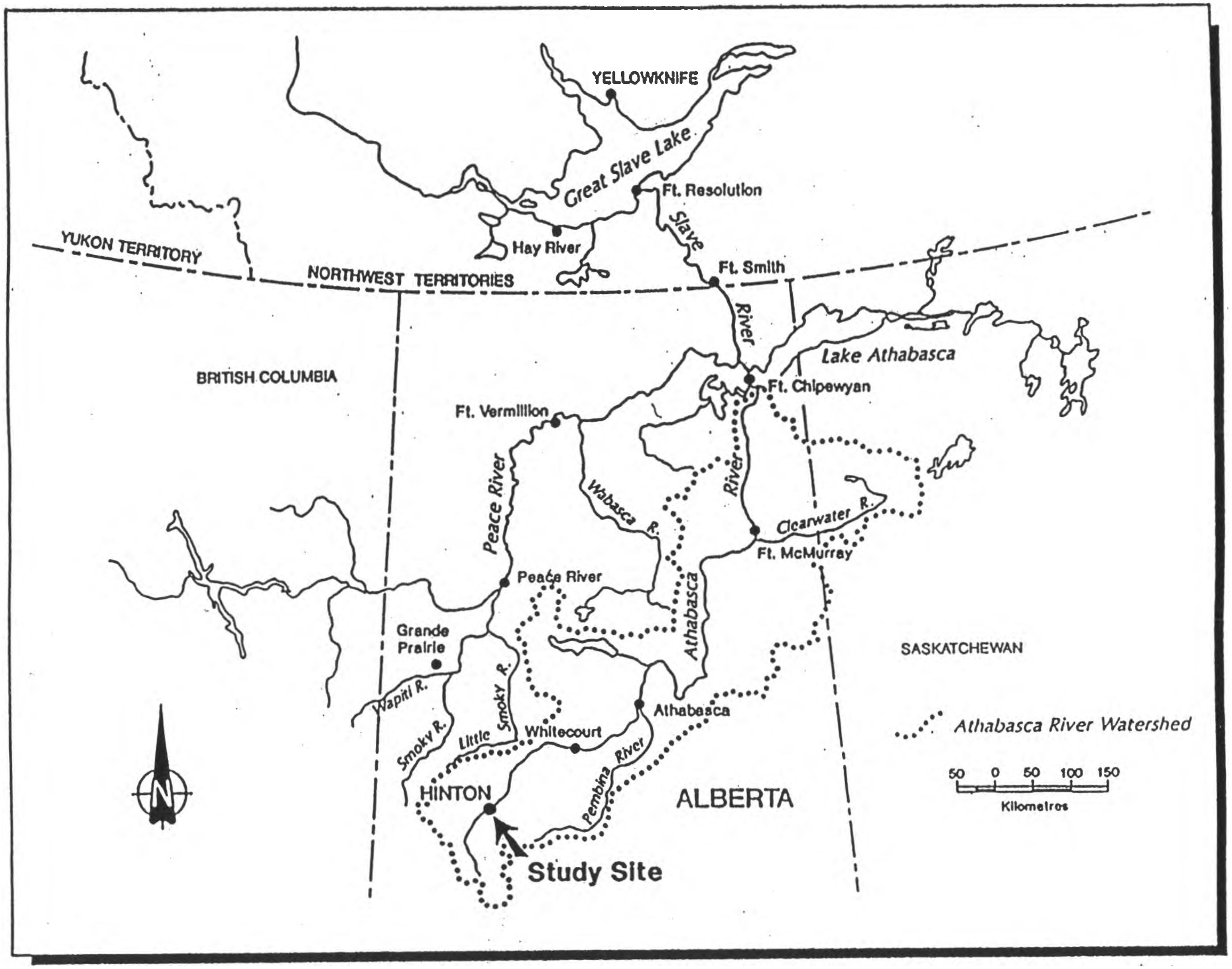

Figure 1. Map of the Athabasca River watershed showing location of study site (from Perrin *et al.*, 1995).

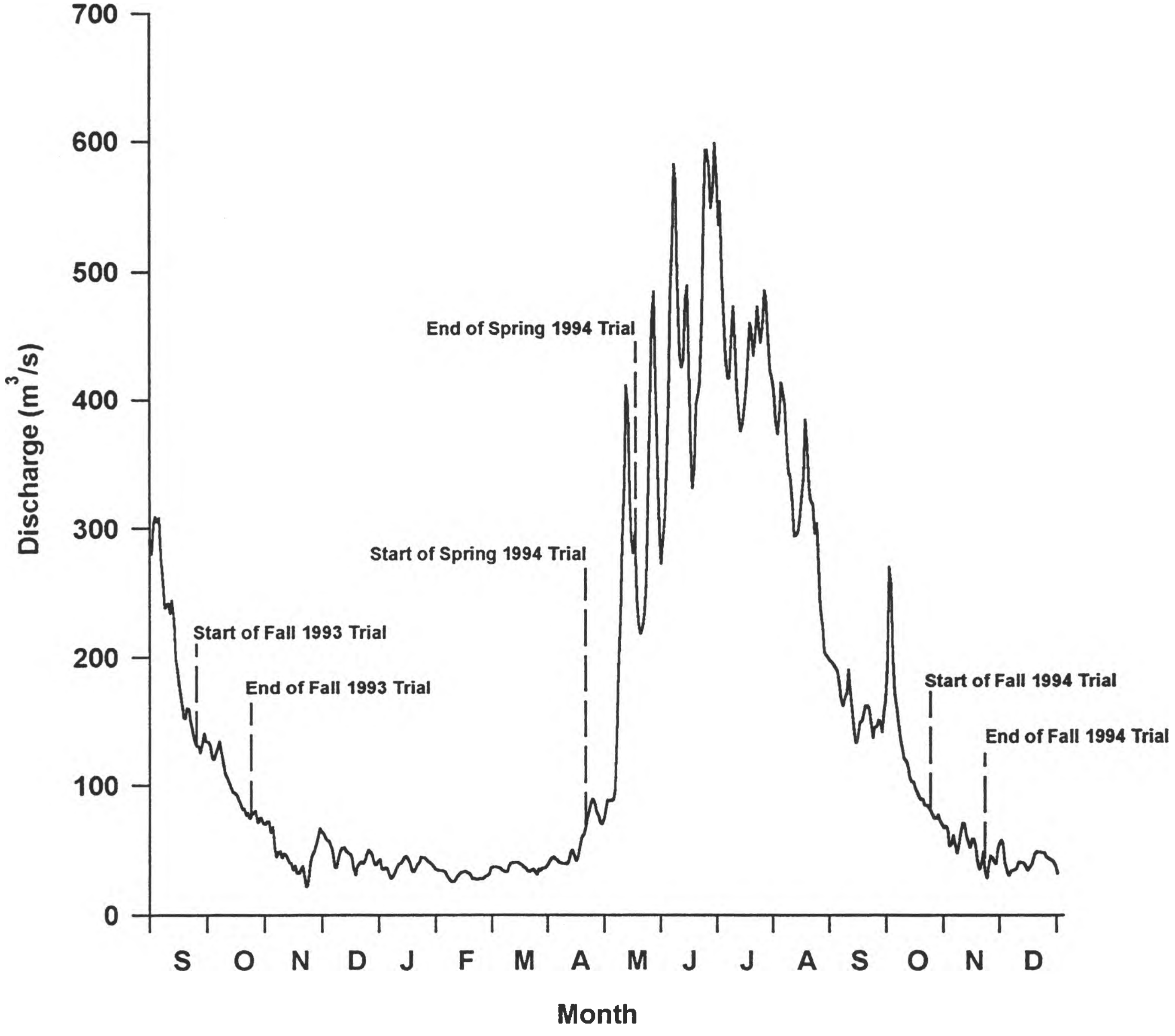

Figure 2. Mean daily discharge for the Athabasca River at Hinton, September 1993 to December 1994, showing start and end dates for the fall 1993, spring 1994, and fall 1994 flume experiments.

experimental addition levels of 1, 10, and 25 µg/L P as K_2HPO_4. Three replicates of each of the four treatments were applied to 12 randomly selected troughs. Stock solutions of 40, 400, and 1000 mg/L P as K_2HPO_4 were continuously metered into the 1, 10, and 25 µg/L treatment troughs respectively, at a rate of 0.6 ml/min using a Technicon Model III metering pump (Pulse Instrumentation, Saskatoon, SK.).

2.3 SAMPLING AND ANALYTICAL PROCEDURES

A Li-Cor LI-1000 data logger with an LII90SA quantum sensor located on a 3 m platform in an unshaded area beside the river was used to measure hourly integrated values of photosynthetically active radiation (PAR). This provided PAR readings that were indicative of conditions at the surface of the Athabasca River at Hinton. Mean daily values of PAR ($E/d/m^2$) were calculated from the hourly data. A Ryan Instruments RTM 2000 thermograph was submerged in the head tank and recorded water temperatures at one hour intervals. Since the residence time in the head tank was only four minutes and the distance from the river intake was approximately 100m, water temperature in the head tank was taken as representative of river conditions. Mean daily temperatures were calculated from the hourly data.

Sampling commenced eight days after the start of the experiment to allow for algal colonization on the tile substrata. Delaying the onset of sampling effectively limits the influence of algal settlement rates on the calculated growth rates (Bothwell, 1983; Bothwell and Jasper, 1983). Subsequent samples were taken at 5-8 day intervals. On the first sampling day, three tiles were randomly selected from each reach (9 tiles/trough) to sample for chlorophyll *a* (chl*a*). A power failure to the heaters and nutrient pumps on day 11, lasting approximately 17 hours, caused ice formation that possibly scoured tiles located along the inside edge of the troughs. However, water flow was not affected by the power outage, thus we continued the experiment. We subsequently sampled two tiles from the centre (unscoured) and two tiles from the edge (possibly ice scoured) of each reach for comparison. Tiles were sampled by scraping the biomass and associated sediment from the top surface of each tile into a scintillation vial. Samples were placed on ice then placed in the dark and frozen at -15° C until analyzed. Chl*a* samples were analyzed by extraction in 90% ethanol at 80° C for 6 minutes. Samples were then cooled for approximately 1/2 hour and concentration was determined fluorometrically according to Nusch (1980). Chl*a* samples taken from styrofoam substrata during the fall 1993 trial that had not been previously examined were analyzed and compared to the spring and fall 1994 trials.

On the last day of the experiment one tile from each trough was sampled for taxonomic analysis. Tiles were scraped using the procedure described above for chl*a* sampling and the biomass was preserved in Lugol's solution for later analysis. Periphyton taxonomy and enumeration were made on spring and fall 1994 samples using an inverted microscope at 500x phase contrast magnification using the Utermohl method. For each sample, 100 cells of the dominant species were counted with a minimum of 300 cells counted in total. Taxonomic results from spring and fall 1994 trials were compared with those from the fall 1993 styrofoam substrate (Perrin *et al.*, 1995).

Water samples were collected from the head tank and the outlet of each trough once a week. Samples from the troughs and de-ionized water used to make the nutrient solutions were analyzed for soluble reactive phosphorus (SRP). Samples from the head tank were analyzed for SRP, nitrate and nitrite (NO_2 + NO_3 (as N)), ammonium (NH_4^+ (as N)), total phosphorus (TP) and total dissolved phosphorus (TDP). All samples were packed on ice and shipped the same day to the University of Alberta for analysis. Samples for P analysis were placed in Nalgene polyethylene bottles and samples for nitrogen analysis were placed in polystyrene bottles. TDP and SRP samples were filtered through pre-washed 0.45 μm Millepore filters; TP and TDP samples were digested and analyzed by Menzel and Corwin's (1965) potassium persulfate method. NO_2 + NO_3 samples were filtered through pre-washed 0.45 μm Millepore membrane filters. NH_4 and NO_2 + NO_3 were analyzed with a Technicon autoanalyzer (Stainton *et al.*, 1977).

2.4 DATA ANALYSIS

All statistical analyses were performed using Minitab for Windows version 10.1 (Minitab, 1994). To test for differences in sloughing rates and any effect of ice scour on chl*a* accrual, analysis of covariance was performed where log chlorophyll *a* concentration was the dependent variable, date was a covariate, P-level and location of tile (edge or centre) were factors, and reach was a blocking factor. Chl*a* data were log transformed to reduce heteroscadicity. To test for effects of nitrogen addition on periphyton growth, an analysis of covariance using orthogonal contrasts was performed on fall 1993 styrofoam data (log chl*a* concentration as the dependent variable, date as a covariate, and treatment as a factor).

Rates of biomass accrual (expressed as the specific net growth rate, k) were determined for each trough by regression analysis for chl*a* data fit to the exponential growth equation:

$$y=(a)10^{kt} \tag{1}$$

where y is the chl*a* concentration (mg/m^2) on day t, a is the initial chl*a* concentration and k is the slope or specific net growth rate. Values of k were divided by log 2 to give the specific growth rate (μ) in units of divisions per day. Specific growth rates were then averaged for treatment replicates to give a mean specific growth rate for each treatment. The mean specific growth rate for each treatment was normalized to the maximum mean growth rate (μ_{max}) attained in the experiment (found in the 10 μg/L P treatment) to give relative specific growth rates ($\mu:\mu_{max}$) as described by Bothwell (1988). Peak biomass was determined as the highest mean chl*a* concentration attained for each treatment. Peak biomass was normalized to the highest peak biomass (PB_{max}) in the experiment (found in the 25 μg/L P treatment) to give relative peak biomass ($PB:PB_{max}$) as described by Bothwell (1989). Differences between fall 1994, spring 1994, and fall 1993 $PB:PB_{max}$ and $\mu:\mu_{max}$ data were determined by comparing the slopes of the linearized data using analysis of covariance with $PB:PB_{max}$ or $\mu:\mu_{max}$ as the dependent variable, square root of P concentration as the independent variable, and trial as the covariate. The square root transformation was used as it reduced heteroscadicity and variability over the log transformation. Periphyton community data were plotted as mean numerical abundance (%) against P-level. The four numerically abundant taxa were plotted with remaining taxa grouped as "other".

3.0 RESULTS

3.1 PHYSICAL AND CHEMICAL ENVIRONMENT

Irradiance fluctuated greatly over the course of the experiment (Figure 3a) reflecting variability in prevailing weather conditions. The maximum PAR value of 25.9 E/d/m^2 occurred on day 6 and the minimum of 1.4 E/d/m^2 occurred on day 23. The mean PAR value for the duration of the experiment was 14.9 E/d/m^2. Based on a vertical attenuation coefficient of 0.891 PAR/m, measured on Oct. 18, 1994 approximately 3 km upstream of the study site (G. Scrimgeour, University of Alberta, pers. comm.), the euphotic zone (defined as 1 % of surface irradiance) extended to 5.2 m, which was greater than the maximum water depth of the Athabasca River at Hinton in the fall. The mean temperature over the duration of the experiment was 0.66 °C. Water temperature dropped rapidly from 4.7 °C on day 3 to 0.01 °C on day 10, then fluctuated around 0 °C for the duration of the experiment (Figure 3 b).

Weekly water chemistry data were averaged for each P treatment and for the head tank to give mean concentrations for the experiment (Table 1). Nutrient concentrations in the head tank averaged 1.3 ± 0.3, 73 ± 6, and 15 ± 4 µg/L (mean ± SE) for SRP, NO_2+NO_3, and NH_4, respectively. SRP concentrations measured in the troughs were relatively close to the desired gradient if the standard errors and inherent variability in the system were considered (Table 1). We used mean SRP concentrations measured for each treatment in our analyses since they represented the true P concentrations of the troughs (Dale and Chambers, 1995). Mean SRP concentrations for the Athabasca River 1.0 km upstream and downstream of the combined pulp mill/city of Hinton effluent outflow were 2.5 ± 0.4 and 4.4 ± 1.3 µg/L, respectively (mid September to mid October, 1994) (C. Podemski, pers. comm., 1995).

P addition (µg/L)	Mean ambient SRP concentration (µg/L) ± SE
Head Tank	1.3 ± 0.3
0	2.3 ± 0.5
1	3.0 ± 0.6
10	13.9 ± 1.3
25	31.2 ± 2.9

Table 1. Mean SRP concentrations for the head tank and the four treatments (October 24-November 22, 1994).

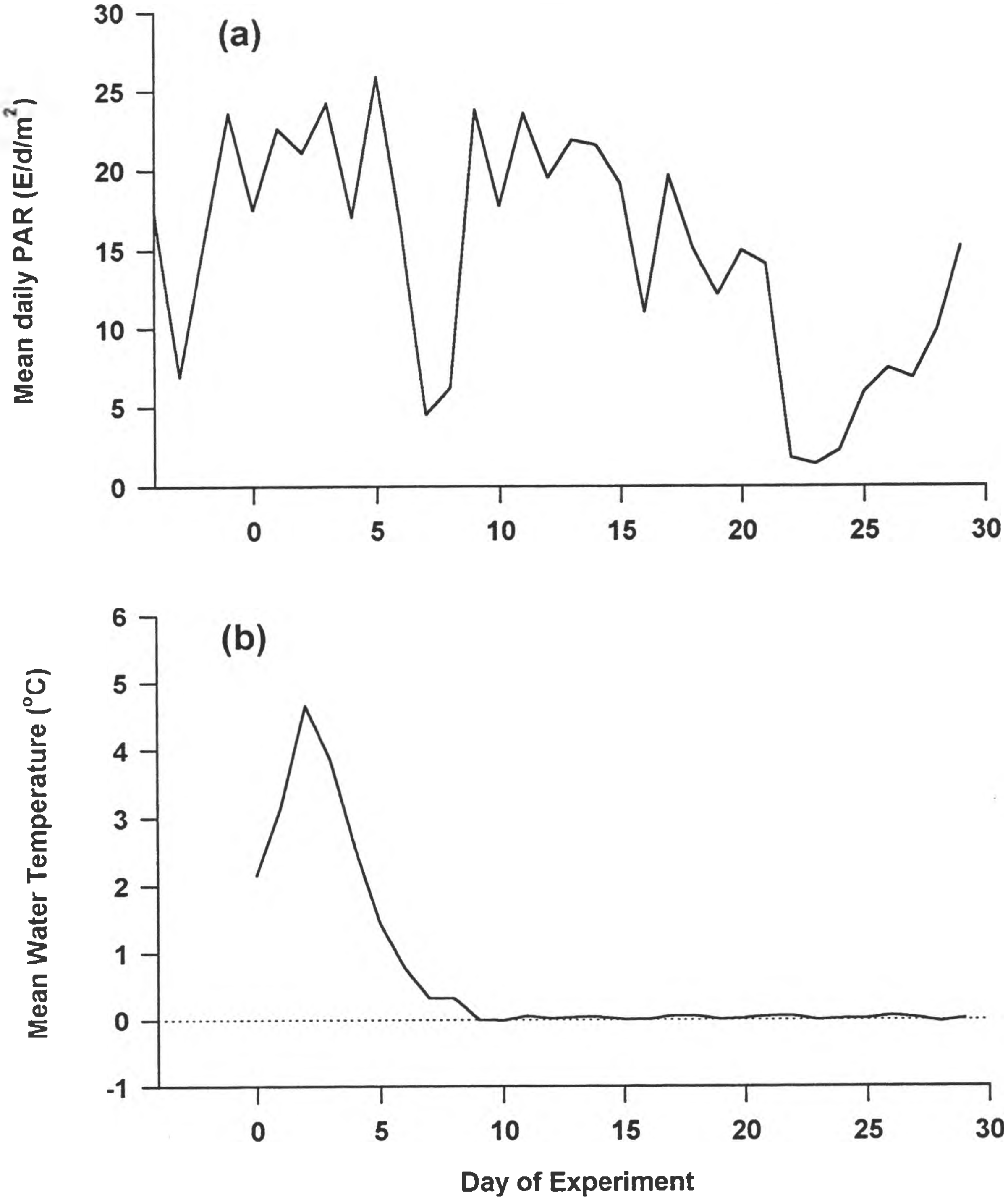

Figure 3. Mean daily: (a) photosynthetically active radiation (PAR), and (b) temperature for flume experiments (Hinton, Alberta; fall 1994). The experiment started on day 0 (October 24, 1994) and finished on day 29 (November 22, 1994).

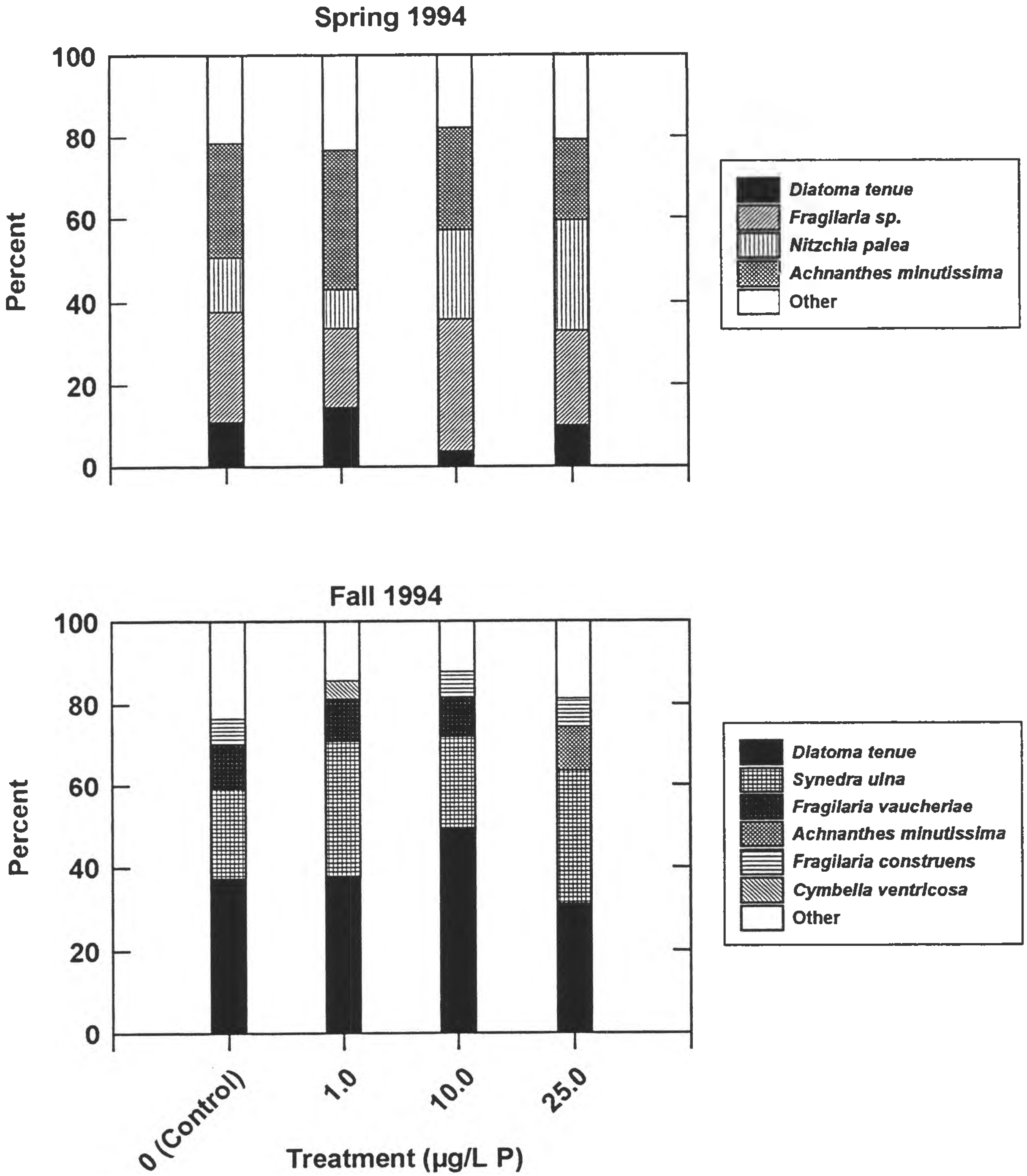

Figure 4. Relative abundance (%) of algal taxa for spring 1994 and fall 1994. The four most abundant taxa are graphed with remaining taxa grouped as "other".

3.2 COMMUNITY COMPOSITION

For both the spring and fall 1994 trials, the periphyton communities consisted entirely of diatoms. Although the numerically dominant species shifted between each trial, there was no change in dominance in relation to the level of added P (Figure 4). Perrin *et al.* (1995) likewise observed that on the styrofoam substrate, diatoms were the only taxa present and species composition did not change with varying P concentration. Most abundant species for fall 1994 included *Diatoma tenue, Synedra ulna*, and *Fragilaria vaucheriae*; *Achnanthes minutissima, Fragilaria sp.*, and *Nitzchia palea* were most abundant during spring 1994; while *Fragilaria vaucheriae*, *Synedra ulna*, *Cymbella sp.*, and *Hannaea arcus* were most abundant during fall 1993 (Perrin *et al.*, 1995). Most of the numerically abundant taxa were present in all trials but their relative contribution varied only slightly between trials. The raw taxonomic data for spring and fall 1994 are given in appendix F.

3.3 GROWTH RATE AND BIOMASS VERSUS PHOSPHORUS

There was no significant difference in biomass accrual between the tiles that were unscoured and those that had possible ice scour ($p = 0.222$). Thus, centre and edge tiles were pooled for each reach. However, there was a significant difference in biomass accrual between the reaches in five of the twelve troughs (two troughs at 10 µg/L P and one trough each in the 0, 1, and 25 µg/L P treatments). In each of these troughs, the lower reach showed significantly higher mean biomass levels than the upper and middle reaches. However, due to the low temperature, differences in mean biomass between reaches within a treatment ranged from only 0.3 to 3.3 mg/m^2. Since the effect was not related to P concentration ($p = .07$), we decided to pool the reach data from each trough as done for a previous trial (Dale and Chambers, 1995).

For all trials, periphyton biomass (expressed as chl*a* concentration) showed exponential growth in the 10 and 25 µg/L treatments (Figure 5). The last sampling period for spring 1994 was not used in the analyses due to the influence of increased sloughing (Dale and Chambers, 1995). Biomass in the 0 (control) and 1 µg/L P treatments showed more linear growth responses (Figure 5). Regression analysis performed on accrual data fit to equation 1 provided specific growth rates (μ). Although μ values for both fall trials were lower than those observed for spring 1994, curvilinear relationships in μ were observed for each trial, suggesting Monod growth kinetics (Bothwell, 1988), with P-saturated μ (inflection point) occurring between 2-5 µg/L SRP (Figure 6 a). The μ value for the 5 µg/L treatment during fall 1993 is probably artificially low, but due to the lack of treatment replication, it is difficult to evaluate whether or not this data point was valid (Perrin *et al.*, 1995). The much lower μ values observed in fall 1994 as opposed to fall 1993 and spring 1994 probably reflect the effect of decreased temperature and PAR (0.66, 7.0, and 9.1 °C, respectively and 14.9, 17.3, and 41.7 E/d/m^2, respectively) on periphyton growth.

The μ values were normalized to μ_{max} (μ:μ_{max}) for each experiment to account for physical differences (light, temperature, and substrate) between the three trials (Figure 6 b). Values of μ_{max} were 0.24, 0.32, and 0.16 div/d at 10 µg/L P addition for fall 1993, spring 1994, and fall 1994, respectively. Analysis of

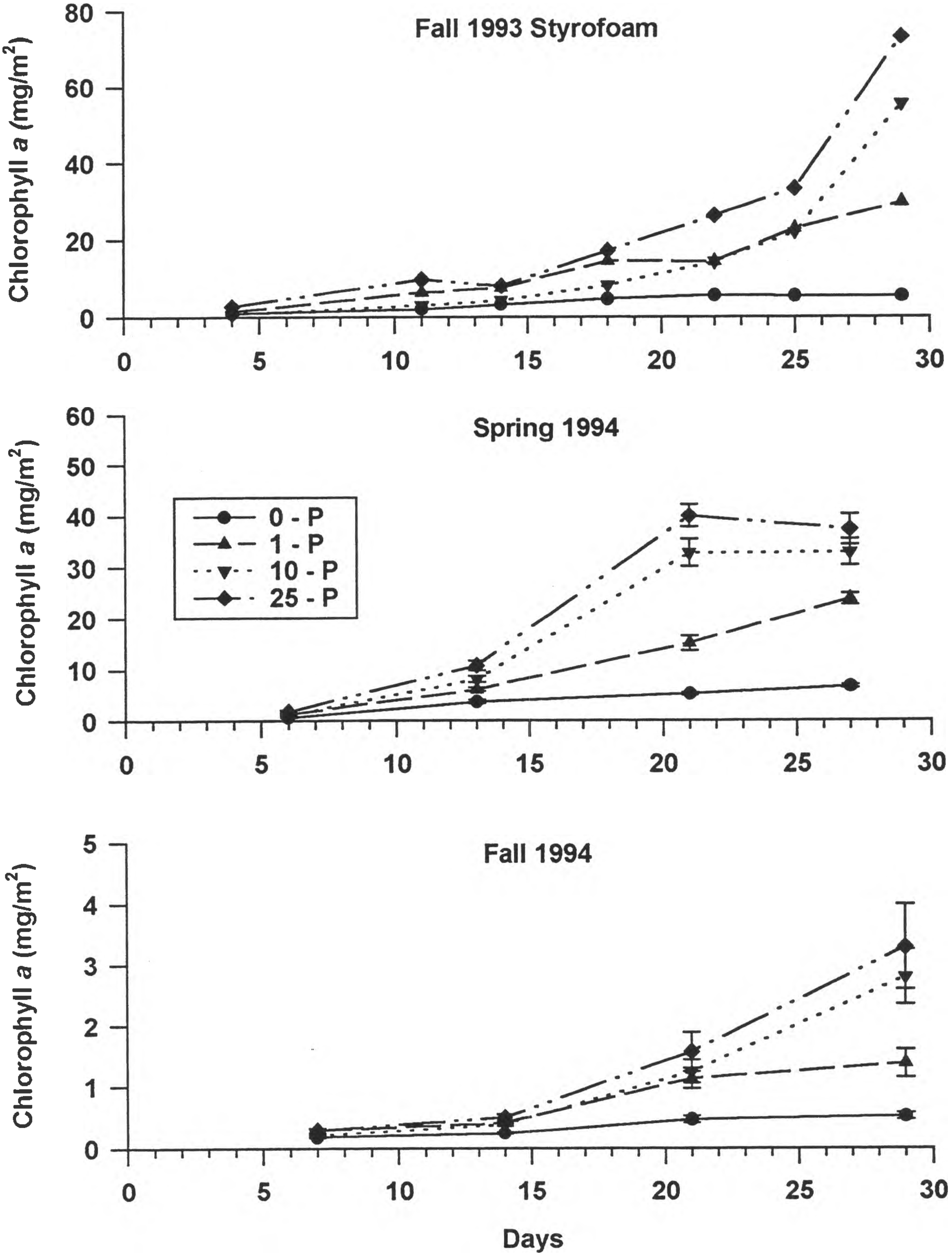

Figure 5. **Time course accrual of algal periphyton biomass measured as chlorophyll *a* on tile substrata for fall 1993, spring 1994, and fall 1994 flume experiment (mean ± SE).**

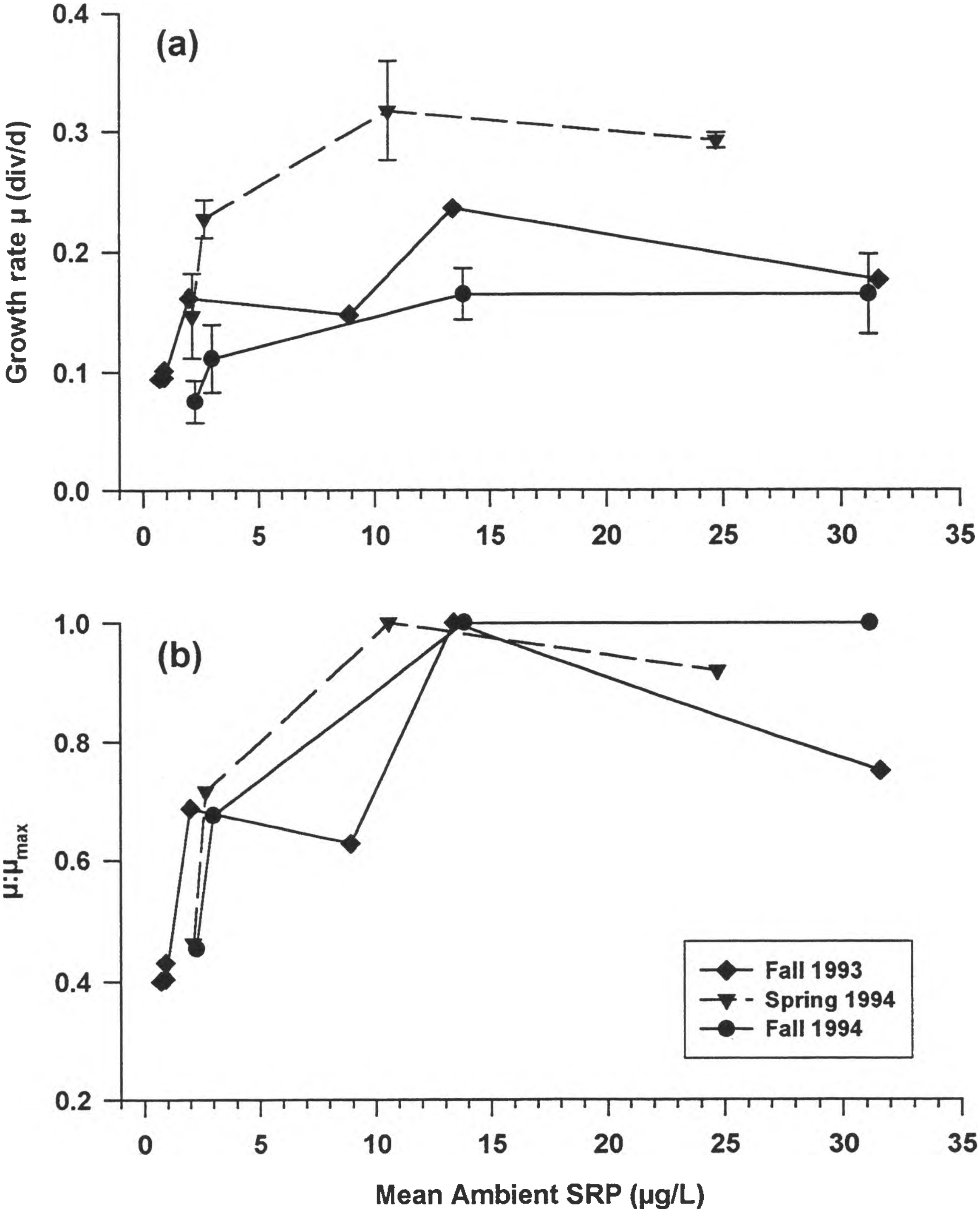

Figure 6. Athabasca River fall 1993, spring 1994, and fall 1994 periphyton growth response to P additions showing: (a) specific cellular growth rates ($\mu \pm$ SE), and (b) relative specific growth rates ($\mu:\mu_{max}$).

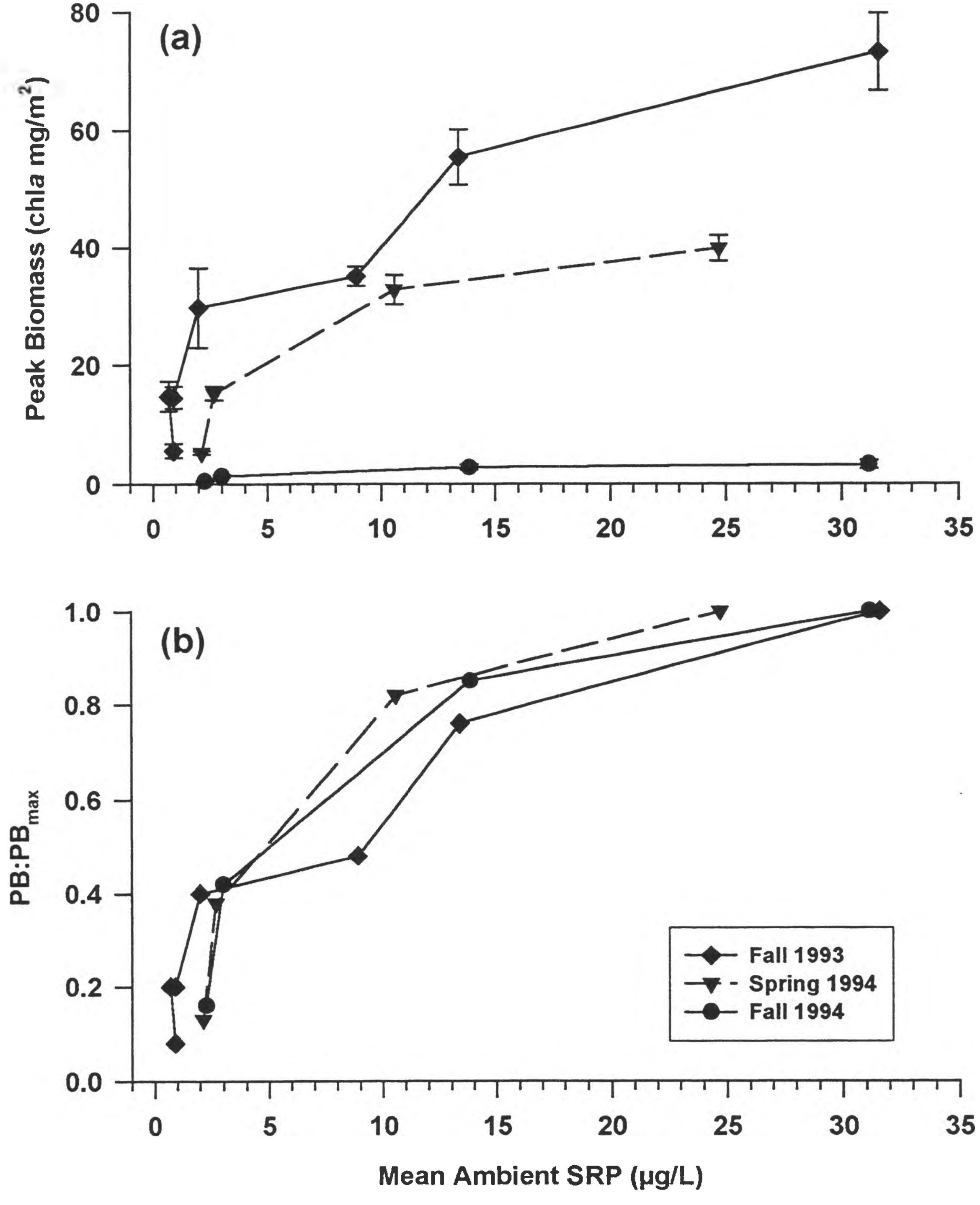

Figure 7. Comparison of fall 1993, spring 1994, and fall 1994 Athabasca periphyton biomass response to P additions showing: (a) peak biomass (PB ± SE), and (b) relative peak biomass (PB:PB$_{max}$).

covariance for $\mu:\mu_{max}$ showed that there was no significant difference in slope ($p = 0.86$) or the y-intercept ($p = 0.50$) between the three trials. Thus, the growth response to P addition was the same for all trials regardless of season or substrata.

Although fall 1993 PB values were higher than spring 1994 for most P additions, the relationship was similar for both trials with the sharpest increases in PB occurring at low SRP concentrations (2-5 µg/L) and maximum PB values occurring at the highest SRP tested (between 25-35 µg/L SRP) (Figure 7 a). The low PB value observed in the fall 5 µg/L treatment seemed to deviate from the other data. However, because of the lack of treatment replication, it is difficult to evaluate whether or not this data point was valid. The fall 1994 PB values were all very low compared to fall 1993 and spring 1994 (Figure 7 a). PB_{max} values occurred in the 25 µg/L troughs and were 73, 40, and 3.3 mg/m^2 for fall 1993, spring 1994, and fall 1994, respectively. When the physical effects of the three trials were factored out by normalizing PB to PB_{max} ($PB:PB_{max}$), the same curvilinear trends were apparent (Figure 7 b). There were no significant differences between the slopes (p= 0.61) or the y-intercepts ($p = 0.84$) of the three trials. This suggests that the periphyton biomass response to increased P concentrations was the same for all trials, regardless of season or substrate. The significant model ($p < 0.001$) produced by regression of the combined data was:

$$PB:PB_{max}=0.008+0.193\sqrt{P} \qquad r^2=.90 \qquad (2)$$

where P is measured SRP concentration.

4.0 DISCUSSION

Periphyton growth in the upper Athabasca River was P limited during spring and fall. Perrin *et al.* (1995) showed that periphytic algal growth on tile substrata in experimental streams on the upper Athabasca River during fall 1993 was not nitrogen-limited. Analysis of covariance performed on fall 1993 styrofoam data also showed that while addition of 100 µg/L N produced moderate but significant ($p = 0.02$) increases in periphyton biomass, there was no significant difference ($p = 0.93$) in biomass between the 50 µg/L P and 50 µg/L P + 100 µg/L N treatments. Perrin *et al.* (1995) showed similar results for fall 1993 tile data and attributed the slight (< 2 mg/m^2) but significant increase in periphyton biomass with N addition alone to differences in colonization between the control and 100 µg/L N troughs. We also observed that initial chl*a* values were less for the control (1.0 mg/m^2) than for the 100 µg/L N troughs (2.4 mg/m^2). While N-limitation was only tested in fall 1993, growth limitation by nitrogen during spring or fall in the upper Athabasca is unlikely since N levels in spring and fall 1994 were similar or slightly higher than fall 1993 (48 ± 9, 67 ± 9, and 73 ± 6 µg/L $NO_2 + NO_3$; and 20 ± 5, 43 ± 30, and 15 ± 4 µg/L NH_4 for fall 1993, spring 1994, and fall 1994, respectively). In addition, *in situ* experiments conducted in fall 1993 and 1994 with nutrient diffusing substrata showed that the Athabasca River upstream of Hinton is P, and not N, limited (Scrimgeour *et al.*, 1995; Scrimgeour and Chambers, in sub. to NRBS).

Our results suggest that growth rate saturation occurred at SRP concentrations of approximately 2 to 5 μg/L. This was based upon extrapolating the initial portion of the μ curves (i.e., before saturation) to levels equal to μ_{max}. Growth-saturating P concentrations for the upper Athabasca River appear to be similar to the levels of 3-4 μg/L SRP required to saturate growth rates in experimental troughs on the Thompson River (Bothwell, 1985; Bothwell *et al.*, 1989). We were, however, unable to obtain accurate estimates of μ at saturation and growth-saturating P concentrations from the upper Athabasca River trials since growth saturated at concentrations intermediate between our treatments of 1 and 10 μg/L P addition. Although the fall 1993 trial had a 5 μg/L treatment intermediate to the 1 and 10 μg/L treatments, μ at saturation was still not apparent due to an artificially low μ value in this treatment. Since there was no replication of treatments during the 1993 trial, we can not determine if this result was caused by some external factor or occurred naturally. However, it is unlikely that μ would show a natural decrease at this P level based on results from higher P concentrations and subsequent trials.

Highest growth rates (μ) occurred during spring 1994, with progressively lower rates during fall 1993 and fall 1994, respectively. These results relate well to the abiotic factors that generally control periphyton growth, namely temperature and PAR. Temperature and PAR values were highest in spring 1994 (9.1 °C and 41.7 $E/d/m^2$) and were progressively lower in fall 1993 (7.0 °C and 17.3 $E/d/m^2$) and fall 1994 (0.66 °C and 14.9 $E/d/m^2$). Bothwell (1988) showed that temperature was the most important physical factor controlling algal growth rates in experimental troughs on the Thompson River. Reduction in shading (i.e., increased PAR) has also been shown to relate to increased algal biomass in streams (Hansmann and Phinney, 1973; Murphy and Hall, 1981), just as reduction in PAR has been found to decrease algal production (McIntire, 1973). Although the spring 1994 trial had the highest growth rates for the Athabasca River, it showed lower growth rates than those seen in similar experiments run at an identical mean temperature on the Thompson River (Bothwell, 1989). The lower μ values in the spring 1994 Athabasca trial may be due to heavy siltation which can decrease algal growth rates by affecting settlement rates, light penetration (Dale and Chambers, 1995), or algal retention (Horner *et al.*, 1990).

Growth rates of periphyton were higher on tile (Perrin *et al.*, 1995) than on styrofoam substrata during fall 1993. Also, periphyton communities were dominated by a green algae (*Chlorella sp.*) on tiles from the fall 1993 trial but consisted entirely of diatoms for the fall 1993 styrofoam, spring 1994, and fall 1994 trials. These findings support Perrin's *et al.* (1995) hypothesis that the higher growth rates on the tile substrate during fall 1993 were due to the presence of a contaminant species. Algal growth rates can vary due to differences in competitive interactions of species in response to manipulation of a limiting nutrient (Tilman *et al.*, 1982). Perrin *et al.* (1995) attributed the higher $\mu:\mu_{max}$ for the fall 1993 Athabasca tile data relative to the Thompson River trial (Bothwell, 1988) to the dominance of *Chlorella sp.* in the Athabasca experiment at P additions > 1 μg/L. In contrast to the effect on growth rate of a shift in dominance from a green algae to diatoms, changes in dominance of diatom species among trials does not appear to affect the growth response to P addition. Changes in growth response would probably only occur with shifts in community composition occurring at higher taxonomic levels such as from diatoms to a green algae, as observed during fall 1993.

When the abiotic influences of temperature and irradiance were factored out by comparing μ to μ_{max}, there was no difference between any of the Athabasca trials in the slopes ($p = 0.86$) or y-intercepts ($p = 0.50$) of the periphyton growth responses to P addition. Our μ:μ_{max} values were similar to those of the Thompson River where diatoms also dominated (Bothwell, 1989). However, Bothwell's (1988) relationship predicting μ_{max} from temperature (T) for 13 trials from the Thompson River:

$$\mu_{max}=0.189+0.0278*T \tag{3}$$

over estimated μ_{max} for the upper Athabasca (measured μ_{max} = 0.24, 0.32 and 0.16 vs predicted μ_{max} = 0.38, 0.44, and 0.21 for fall 1993, spring 1994 and fall 1994, respectively). This supports Perrin's *et al.* (1995) statement that models of periphyton growth and biomass response to nutrient augmentation developed for one river cannot necessarily be extrapolated to another river. The model relating μ_{max} to temperature for the Athabasca data is:

$$\mu_{max}=0.142+0.0175*T \tag{4}$$

However, it should be noted that this analysis is based on only three trials from one location.

The response of peak algal biomass (PB) to P addition represents the net effect of P addition on algal growth, which is important since algal biomass is of a direct concern to environmental managers. Despite higher growth rates, temperature, and PAR during spring 1994, peak biomass was higher for all P levels during the fall 1993 trial. The lower peak biomass in the spring 1994 trial is likely due to increased sloughing which led to the last sampling date being omitted from the analysis (Dale and Chambers, 1995). Thus, periphyton accrued for an additional eight days during the fall trial, allowing final biomass to increase over that of the spring trial. The low peak biomass levels observed during fall 1994 are undoubtedly due to the extremely low mean temperature (0.66 °C) during the trial.

Despite the difference in actual periphyton biomass between the three trials, there was no significant difference in PB:PB_{max} between the spring and fall trials. Thus, the response to P enrichment was similar regardless of season or substrate. For all trials, PB:PB_{max} continued to increase at P concentrations higher than those required to saturate relative specific growth rates (2-5 µg/L SRP). Two phases can be seen in the PB:PB_{max} curves for the upper Athabasca River: a phase of faster biomass accrual occurring at P concentrations lower than 5 µg/L SRP and a phase of slower biomass accrual occurring above 4-5 µg/L. The shift in the PB:PB_{max} curve occurred at a P concentration that was similar to the concentration required for saturation of μ:μ_{max} (2-5 µg/L SRP). Increases in PB:PB_{max} at P concentrations higher than those required to saturate μ:μ_{max} indicate that while growth rates of individual cells and thin periphyton films have saturated, growth of the community as a whole has not (Bothwell, 1989). Bothwell (1989) showed similar results for the Thompson River with Phase I (0-1 µg/L added P) characterized by cellular level (Monod type) kinetics, and Phase II (2-30 µg/L added P) characterized by community level diffusion kinetics.

Although relatively high P concentrations (>15-35 µg/L SRP) are required to reach maximum biomass, substantial increases in periphytic algae can still occur at low P concentrations (2-5 µg/L SRP) with the magnitude of biomass increases due to P enrichment being related to seasonal changes in abiotic factors such as temperature and PAR. $PB:PB_{max}$ can be described as a square root-linear function of ambient SRP concentration (equation 2). Such an equation could prove useful in establishing water quality guidelines for the upper Athabasca River, since algal biomass as a proportion of the maximum potential biomass can be predicted from SRP. However, it should be noted that *in situ* biomass measurements will vary from trough measurements due to factors such as invertebrate grazing, increased flow rates, and attenuation of light due to increased turbidity. Conditions in the experimental streams would probably represent maximum conditions for *in situ* measurements.

In summary, these studies have shown that periphyton growth in the upper Athabasca River is P-limited in spring and fall with growth-rate saturation occurring at concentrations of approximately 2-5 µg/L SRP. The response of algal growth to P addition in the upper Athabasca River is similar to that reported by Bothwell (1988, 1989) for the Thompson River. However, an empirical equation predicting μ_{max} from temperature for the Thompson River did not accurately predict μ_{max} for the upper Athabasca suggesting that periphyton growth and biomass responses to P addition cannot necessarily be extrapolated between rivers. Phosphorus concentrations required to reach maximum PB are higher than those required to saturate growth rates but substantial increases in biomass can still occur with small additions of phosphorus. Such increases in biomass would undoubtedly have the greatest magnitude during periods of higher temperature and PAR. Additional experiments focusing on changes in periphyton growth response to P addition at Hinton and further downstream would elucidate how spatially variable nutrient limitation is in the Athabasca River. These findings will aid in developing water quality guidelines for the Athabasca River.

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APPENDIX A: Terms of Reference

NORTHERN RIVER BASINS STUDY

TERMS OF REFERENCE

Project 2613-D1: Nutrient/Contaminant Impacts on Benthic Biofilm Production

I. Background and Objectives

To make future decisions about the need for different levels of control on developments in the Peace-Athabasca-Slave river basins, basic knowledge is needed about the role of nutrients in the structure and function of the river ecosystems. For example, while existing water chemistry data suggest that benthic biofilm production in the Athabasca River is P-limited, the existing data are inadequate to judge: (1) how severely P-limited the river is (i.e., how strongly periphyton biomass will respond to P-enrichment), (2) whether the river is co-limited by N and P (i.e., the response to P-enrichment will vary with the amount of N added simultaneously), (3) whether the degree or type of nutrient limitation changes seasonally, and (4) how spatially variable nutrient limitation is in the system. The answers to these questions will allow assessment of the effect of nutrient loading on water chemistry and the benthic biofilm in the Athabasca River and provide the necessary information for setting regulatory guidelines for nutrient loading.

In addition to nutrient effects, the interactive effect of nutrients and contaminants on benthic communities must be understood in order to effectively regulate pulp mill loadings. Pulp mills discharge both nutrients and contaminants and, at present, we do not know whether the effect of pulp mill effluent on the benthic biofilm is attributable solely to enrichment or whether contaminants inhibit the enrichment response. This information is essential for assessing how the aquatic ecosystem has been affected by exposure to contaminants (Question 1a) and whether pollutants are causing a deterioration in water quality (Question 5).

Studies were undertaken in September 1993 to determine the effects of added nutrients on biomass (measured as ash-free dry mass and chlorophyll a concentration) and growth rates of the benthic biofilm (NRBS Project #2613-C1). Artificial streams were installed along the banks of the Athabasca River on Weldwood of Canada property near Hinton (NRBS project #2611-B1/C1). Ten artificial streams were supplied with river water taken from upstream of the combined municipal and mill discharge and treated with: (1) no added nutrients (control); (2) 0.1μg/L P; (3) 0.2μg/L P; (4) 1μg/L P; (5) 5μg/L P; (6) 10μg/L P; (7) 25μg/L P; (8) 50μg/L P; (9) 100μg/L N; and (10) 10μg/L N + 50μg/L P. Preliminary results indicate that periphyton biomass increased with increasing P concentrations up to 10μg/L above which biomass remained relatively constant. There was no increase in biomass in response to N addition alone. These results indicate that the Athabasca River upstream of Hinton is phosphorus-limited in the fall.

Addition of phosphorus (as a result of industrial, municipal or agricultural loading) would increase periphyton biomass in the river. Similar experiments were also conducted in the artificial streams in March 1994 (NRBS Project #2613-C2).

The purpose of this project is to repeat these experiments in September 1994 to test the reproducibility of the earlier findings and assess the seasonality of nutrient limitations.

II. Requirements

1. Conduct an experiment in September 1994 at the Weldwood of Canada Ltd., Hinton property in which the growth of the benthic biofilm will be assessed under four regimes: river water alone, and river water + 1.0, 10.0 and 25.0 μg/L P (run in triplicate).
2. If time and weather permit, move the artificial streams to another location (possibly the Athabasca River at AlPac) in late September and undertake an October experiment to test whether phosphorus limitation varies along the length of the river (i.e., by comparing the fall 1994 results from the Hinton and AlPac sites).
3. If time and weather permit, undertake an experiment (as outlined in II.1, above) at the new site to determine the effect of contaminants versus nutrients on benthic biofilm abundance by adding nutrients (N and P) and pulp mill effluent to the artificial streams at dilutions typically found downstream of pulp mill outfalls (0.1, 1:100 and 10% volume: volume concentrations of effluent to river water).

III. Reporting Requirements

1. Prepare an interim report documenting the effects of added nutrients and pulp mill effluent on biomass and growth rates of benthic biofilm. Results from the fall 1994 experiments are to be compared with the results of experiments from the same location in fall 1993 and winter 1994 to determine whether biofilm response to phosphorus addition: (1) is consistent between years for the same season, and (2) varies seasonally.

2. Provide ten copies of the draft report to the component coordinator by March 31, 1995.

3. Three weeks after the receipt of review comments on the draft report, the contractor is to submit ten cerlox bound copies and two unbound, camera-ready originals of the final report to the Component Coordinator. The style and format of the final report is to conform to that outlined in the NRBS Style Manual. A copy of the Style Manual will be supplied to the contractor by the NRBS.

IV. Project Administration

The Scientific Authority for this project is:

Dr. Patricia Chambers
National Hydrology Research Institute
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Saskatoon, Saskatchewan
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phone: (306) 975-5592
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Questions of a scientific nature should be directed to her.

The NRBS Study Office Component Coordinator for this project is:

Greg Wagner
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690 Standard Life Centre
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fax: (403) 422-3055

Administrative questions related to this project should be directed to him.

APPENDIX B: Raw chlorophyll *a* data, Hinton flume experiment fall, 1994.

Note: Troughs 4, 9, &11 = 0 µg/L P; 3,6, &8 = 1 µg/L P; 2,7, &10 = 10 µg/L P; 1, 5, &12 = 25 µg/L P

Date	Trough #	Tile #	Reach	Chla (µg/cm²)	Date	Trough #	Tile #	Reach	Chla (µg/cm²)
31-Oct-94	4	1	L	0.01	14-Nov-94	11	13	U	0.03
31-Oct-94	4	1	M	0.02	14-Nov-94	11	17	L	0.06
31-Oct-94	4	1	U	0.03	14-Nov-94	11	17	M	0.04
31-Oct-94	4	4	L	0.01	14-Nov-94	11	17	U	0.03
31-Oct-94	4	4	M	0.01	14-Nov-94	11	22	L	0.09
31-Oct-94	4	4	U	0.01	14-Nov-94	11	24	M	0.01
31-Oct-94	4	23	L	0.01	14-Nov-94	3	2	L	0.09
31-Oct-94	4	23	M	0.01	14-Nov-94	3	2	M	0.07
31-Oct-94	4	23	U	0.01	14-Nov-94	3	2	U	0.03
31-Oct-94	9	1	L	0.01	14-Nov-94	3	3	M	0.05
31-Oct-94	9	1	M	0.04	14-Nov-94	3	7	U	0.33
31-Oct-94	9	1	U	0.01	14-Nov-94	3	9	L	0.07
31-Oct-94	9	4	L	0.02	14-Nov-94	3	15	L	0.14
31-Oct-94	9	4	M	0.04	14-Nov-94	3	15	U	0.04
31-Oct-94	9	4	U	0.02	14-Nov-94	3	17	L	0.05
31-Oct-94	9	23	L	0.01	14-Nov-94	3	17	M	0.06
31-Oct-94	9	23	M	0.01	14-Nov-94	3	17	U	0.03
31-Oct-94	9	23	U	0.02	14-Nov-94	3	19	M	0.08
31-Oct-94	11	1	L	0.01	14-Nov-94	6	2	L	0.22
31-Oct-94	11	1	M	0.02	14-Nov-94	6	2	M	0.09
31-Oct-94	11	1	U	0.03	14-Nov-94	6	2	U	0.05
31-Oct-94	11	4	L	0.01	14-Nov-94	6	7	L	0.22
31-Oct-94	11	4	M	0.02	14-Nov-94	6	13	M	0.09
31-Oct-94	11	4	U	0.03	14-Nov-94	6	16	U	0.07
31-Oct-94	11	23	L	0.01	14-Nov-94	6	17	L	0.42
31-Oct-94	11	23	M	0.01	14-Nov-94	6	17	M	0.14
31-Oct-94	11	23	U	0.03	14-Nov-94	6	17	U	0.04
31-Oct-94	3	1	L	0.01	14-Nov-94	6	21	L	0.22
31-Oct-94	3	1	M	0.02	14-Nov-94	6	22	U	0.06
31-Oct-94	3	1	U	0.02	14-Nov-94	6	24	M	0.17
31-Oct-94	3	4	L	0.02	14-Nov-94	8	2	L	0.05
31-Oct-94	3	4	M	0.08	14-Nov-94	8	2	M	0.05
31-Oct-94	3	4	U	0.05	14-Nov-94	8	2	U	0.05
31-Oct-94	3	23	L	0.01	14-Nov-94	8	13	U	0.06
31-Oct-94	3	23	M	0.02	14-Nov-94	8	16	L	0.18
31-Oct-94	3	23	U	0.08	14-Nov-94	8	16	M	0.07
31-Oct-94	6	1	L	0.01	14-Nov-94	8	17	L	0.33
31-Oct-94	6	1	M	0.02	14-Nov-94	8	17	M	0.05
31-Oct-94	6	1	U	0.02	14-Nov-94	8	17	U	0.05
31-Oct-94	6	4	L	0.01	14-Nov-94	8	19	U	0.04
31-Oct-94	6	4	M	0.03	14-Nov-94	8	22	L	0.25
31-Oct-94	6	4	U	0.02	14-Nov-94	8	22	M	0.05
31-Oct-94	6	23	L	0.02	14-Nov-94	2	2	L	0.23
31-Oct-94	6	23	M	0.02	14-Nov-94	2	2	M	0.07

31-Oct-94	6	23	U	0.02	14-Nov-94	2	2	U	0.04
31-Oct-94	8	1	L	0.06	14-Nov-94	2	6	U	0.17
31-Oct-94	8	1	M	0.04	14-Nov-94	2	10	M	0.08
31-Oct-94	8	1	U	0.03	14-Nov-94	2	12	U	0.08
31-Oct-94	8	4	L	0.01	14-Nov-94	2	15	L	0.52
31-Oct-94	8	4	M	0.02	14-Nov-94	2	17	L	0.33
31-Oct-94	8	4	U	0.03	14-Nov-94	2	17	M	0.09
31-Oct-94	8	23	L	0.01	14-Nov-94	2	17	U	0.06
31-Oct-94	8	23	M	0.04	14-Nov-94	2	21	L	0.20
31-Oct-94	8	23	U	0.05	14-Nov-94	2	24	M	0.08
31-Oct-94	2	1	L	0.02	14-Nov-94	7	2	L	0.06
31-Oct-94	2	1	M	0.03	14-Nov-94	7	2	M	0.04
31-Oct-94	2	1	U	0.02	14-Nov-94	7	2	U	0.05
31-Oct-94	2	4	L	0.02	14-Nov-94	7	9	U	0.04
31-Oct-94	2	4	M	0.03	14-Nov-94	7	12	M	0.08
31-Oct-94	2	4	U	0.03	14-Nov-94	7	15	L	0.08
31-Oct-94	2	23	L	0.01	14-Nov-94	7	17	L	0.39
31-Oct-94	2	23	M	0.02	14-Nov-94	7	17	M	0.03
31-Oct-94	2	23	U	0.04	14-Nov-94	7	17	U	0.04
31-Oct-94	7	1	L	0.01	14-Nov-94	7	18	L	0.04
31-Oct-94	7	1	M	0.03	14-Nov-94	7	18	M	0.05
31-Oct-94	7	1	U	0.02	14-Nov-94	7	24	U	0.04
31-Oct-94	7	4	L	0.01	14-Nov-94	10	2	L	0.21
31-Oct-94	7	4	M	0.02	14-Nov-94	10	2	M	0.04
31-Oct-94	7	4	U	0.02	14-Nov-94	10	2	U	0.07
31-Oct-94	7	23	L	0.01	14-Nov-94	10	10	L	0.17
31-Oct-94	7	23	M	0.03	14-Nov-94	10	10	U	0.03
31-Oct-94	7	23	U	0.05	14-Nov-94	10	12	M	0.10
31-Oct-94	10	1	L	0.01	14-Nov-94	10	17	L	0.24
31-Oct-94	10	1	M	0.01	14-Nov-94	10	17	M	0.09
31-Oct-94	10	1	U	0.01	14-Nov-94	10	17	U	0.08
31-Oct-94	10	4	L	0.01	14-Nov-94	10	19	M	0.21
31-Oct-94	10	4	M	0.01	14-Nov-94	10	19	U	0.06
31-Oct-94	10	4	U	0.01	14-Nov-94	10	21	L	0.27
31-Oct-94	10	23	L	0.02	14-Nov-94	1	2	L	0.52
31-Oct-94	10	23	M	0.02	14-Nov-94	1	2	M	0.09
31-Oct-94	10	23	U	0.03	14-Nov-94	1	2	U	0.03
31-Oct-94	1	1	L	0.01	14-Nov-94	1	3	L	0.10
31-Oct-94	1	1	M	0.02	14-Nov-94	1	3	M	0.10
31-Oct-94	1	1	U	0.02	14-Nov-94	1	6	L	0.74
31-Oct-94	1	4	L	0.07	14-Nov-94	1	10	M	0.19
31-Oct-94	1	4	M	0.02	14-Nov-94	1	15	U	0.06
31-Oct-94	1	4	U	0.02	14-Nov-94	1	17	L	0.68
31-Oct-94	1	23	L	0.01	14-Nov-94	1	17	M	0.13
31-Oct-94	1	23	M	0.02	14-Nov-94	1	17	U	0.05
31-Oct-94	1	23	U	0.02	14-Nov-94	1	24	U	0.09
31-Oct-94	5	1	L	0.01	14-Nov-94	5	2	L	0.37
31-Oct-94	5	1	M	0.04	14-Nov-94	5	2	M	0.09
31-Oct-94	5	1	U	0.02	14-Nov-94	5	2	U	0.05
31-Oct-94	5	4	L	0.01	14-Nov-94	5	3	U	0.09
31-Oct-94	5	4	M	0.04	14-Nov-94	5	12	L	0.11
31-Oct-94	5	4	U	0.02	14-Nov-94	5	12	U	0.05

31-Oct-94	5	23	L	0.01	14-Nov-94	5	16	M	0.15
31-Oct-94	5	23	M	0.01	14-Nov-94	5	17	L	0.66
31-Oct-94	5	23	U	0.03	14-Nov-94	5	17	M	0.14
31-Oct-94	12	1	L	0.02	14-Nov-94	5	17	U	0.04
31-Oct-94	12	1	M	0.03	14-Nov-94	5	21	L	0.18
31-Oct-94	12	1	U	0.08	14-Nov-94	5	22	M	0.22
31-Oct-94	12	4	L	0.03	14-Nov-94	12	2	L	0.01
31-Oct-94	12	4	M	0.04	14-Nov-94	12	2	M	0.04
31-Oct-94	12	4	U	0.03	14-Nov-94	12	2	U	0.08
31-Oct-94	12	23	L	0.03	14-Nov-94	12	3	M	0.03
31-Oct-94	12	23	M	0.03	14-Nov-94	12	12	L	0.01
31-Oct-94	12	23	U	0.08	14-Nov-94	12	12	U	0.04
07-Nov-94	4	5	L	0.03	14-Nov-94	12	13	L	0.14
07-Nov-94	4	5	M	0.03	14-Nov-94	12	15	M	0.06
07-Nov-94	4	5	U	0.03	14-Nov-94	12	17	L	0.14
07-Nov-94	4	7	M	0.01	14-Nov-94	12	17	M	0.05
07-Nov-94	4	11	L	0.02	14-Nov-94	12	17	U	0.07
07-Nov-94	4	11	M	0.02	14-Nov-94	12	22	U	0.04
07-Nov-94	4	11	U	0.03	22-Nov-94	4	3	L	0.11
07-Nov-94	4	16	L	0.03	22-Nov-94	4	8	L	0.07
07-Nov-94	4	18	M	0.02	22-Nov-94	4	8	M	0.04
07-Nov-94	4	18	U	0.02	22-Nov-94	4	8	U	0.08
07-Nov-94	4	22	U	0.03	22-Nov-94	4	10	M	0.04
07-Nov-94	4	24	L	0.03	22-Nov-94	4	14	L	0.13
07-Nov-94	9	3	M	0.02	22-Nov-94	4	14	M	0.04
07-Nov-94	9	5	L	0.01	22-Nov-94	4	14	U	0.03
07-Nov-94	9	5	M	0.02	22-Nov-94	4	15	L	0.04
07-Nov-94	9	5	U	0.02	22-Nov-94	4	15	U	0.02
07-Nov-94	9	9	L	0.01	22-Nov-94	4	16	U	0.03
07-Nov-94	9	10	U	0.02	22-Nov-94	4	19	M	0.03
07-Nov-94	9	11	L	0.02	22-Nov-94	9	3	L	0.04
07-Nov-94	9	11	M	0.04	22-Nov-94	9	8	L	0.06
07-Nov-94	9	11	U	0.04	22-Nov-94	9	8	M	0.04
07-Nov-94	9	13	M	0.02	22-Nov-94	9	8	U	0.10
07-Nov-94	9	16	L	0.01	22-Nov-94	9	9	M	0.04
07-Nov-94	9	16	U	0.03	22-Nov-94	9	12	M	0.02
07-Nov-94	11	5	L	0.02	22-Nov-94	9	13	U	0.03
07-Nov-94	11	5	M	0.03	22-Nov-94	9	14	L	0.04
07-Nov-94	11	5	U	0.04	22-Nov-94	9	14	M	0.02
07-Nov-94	11	6	L	0.02	22-Nov-94	9	14	U	0.03
07-Nov-94	11	7	M	0.03	22-Nov-94	9	15	U	0.03
07-Nov-94	11	9	M	0.04	22-Nov-94	9	18	L	0.03
07-Nov-94	11	11	L	0.01	22-Nov-94	11	8	L	0.04
07-Nov-94	11	11	M	0.02	22-Nov-94	11	8	M	0.03
07-Nov-94	11	11	U	0.03	22-Nov-94	11	8	U	0.05
07-Nov-94	11	18	L	0.01	22-Nov-94	11	9	L	0.08
07-Nov-94	11	19	U	0.03	22-Nov-94	11	9	U	0.03
07-Nov-94	11	22	U	0.03	22-Nov-94	11	12	M	0.03
07-Nov-94	3	3	L	0.03	22-Nov-94	11	14	L	0.03
07-Nov-94	3	5	L	0.04	22-Nov-94	11	14	M	0.02
07-Nov-94	3	5	M	0.05	22-Nov-94	11	14	U	0.12
07-Nov-94	3	5	U	0.02	22-Nov-94	11	22	M	0.08

07-Nov-94	3	10	M	0.03	22-Nov-94	11	24	L	0.14
07-Nov-94	3	11	L	0.02	22-Nov-94	11	24	U	0.05
07-Nov-94	3	11	M	0.03	22-Nov-94	3	6	L	0.02
07-Nov-94	3	11	U	0.05	22-Nov-94	3	8	L	0.29
07-Nov-94	3	12	U	0.03	22-Nov-94	3	8	M	0.14
07-Nov-94	3	15	M	0.02	22-Nov-94	3	8	U	0.11
07-Nov-94	3	16	U	0.03	22-Nov-94	3	9	M	0.03
07-Nov-94	3	18	L	0.02	22-Nov-94	3	10	L	0.19
07-Nov-94	6	5	L	0.06	22-Nov-94	3	12	M	0.04
07-Nov-94	6	5	M	0.03	22-Nov-94	3	14	L	0.21
07-Nov-94	6	5	U	0.03	22-Nov-94	3	14	M	0.07
07-Nov-94	6	9	U	0.04	22-Nov-94	3	14	U	0.05
07-Nov-94	6	10	M	0.02	22-Nov-94	3	19	U	0.03
07-Nov-94	6	11	L	0.06	22-Nov-94	3	22	U	0.06
07-Nov-94	6	11	M	0.02	22-Nov-94	6	3	L	0.26
07-Nov-94	6	11	U	0.04	22-Nov-94	6	8	L	0.57
07-Nov-94	6	16	L	0.06	22-Nov-94	6	8	M	0.15
07-Nov-94	6	18	U	0.03	22-Nov-94	6	8	U	0.11
07-Nov-94	6	19	M	0.04	22-Nov-94	6	12	M	0.06
07-Nov-94	6	22	L	0.05	22-Nov-94	6	13	U	0.08
07-Nov-94	8	5	L	0.04	22-Nov-94	6	14	L	0.61
07-Nov-94	8	5	M	0.07	22-Nov-94	6	14	M	0.06
07-Nov-94	8	5	U	0.04	22-Nov-94	6	14	U	0.07
07-Nov-94	8	9	L	0.03	22-Nov-94	6	15	L	0.21
07-Nov-94	8	10	M	0.05	22-Nov-94	6	15	U	0.07
07-Nov-94	8	11	L	0.04	22-Nov-94	6	16	M	0.16
07-Nov-94	8	11	M	0.10	22-Nov-94	8	7	L	0.03
07-Nov-94	8	11	U	0.07	22-Nov-94	8	8	L	0.07
07-Nov-94	8	12	M	0.05	22-Nov-94	8	8	M	0.06
07-Nov-94	8	12	U	0.04	22-Nov-94	8	8	U	0.08
07-Nov-94	8	19	L	0.05	22-Nov-94	8	13	M	0.10
07-Nov-94	8	24	U	0.05	22-Nov-94	8	14	L	0.32
07-Nov-94	2	3	L	0.03	22-Nov-94	8	14	M	0.08
07-Nov-94	2	5	L	0.02	22-Nov-94	8	14	U	0.05
07-Nov-94	2	5	M	0.05	22-Nov-94	8	16	U	0.07
07-Nov-94	2	5	U	0.04	22-Nov-94	8	21	L	0.29
07-Nov-94	2	9	M	0.12	22-Nov-94	8	21	M	0.06
07-Nov-94	2	10	L	0.02	22-Nov-94	8	22	U	0.08
07-Nov-94	2	10	U	0.04	22-Nov-94	2	6	L	0.17
07-Nov-94	2	11	L	0.05	22-Nov-94	2	8	L	0.64
07-Nov-94	2	11	M	0.05	22-Nov-94	2	8	M	0.07
07-Nov-94	2	11	U	0.05	22-Nov-94	2	8	U	0.22
07-Nov-94	2	18	M	0.04	22-Nov-94	2	12	L	0.10
07-Nov-94	2	18	U	0.03	22-Nov-94	2	14	L	0.81
07-Nov-94	7	3	L	0.03	22-Nov-94	2	14	M	0.20
07-Nov-94	7	3	M	0.03	22-Nov-94	2	14	U	0.82
07-Nov-94	7	3	U	0.03	22-Nov-94	2	15	M	0.10
07-Nov-94	7	5	L	0.03	22-Nov-94	2	16	M	0.08
07-Nov-94	7	5	M	0.03	22-Nov-94	2	21	U	0.07
07-Nov-94	7	5	U	0.03	22-Nov-94	2	22	U	0.06
07-Nov-94	7	6	M	0.03	22-Nov-94	7	8	L	0.55
07-Nov-94	7	11	L	0.04	22-Nov-94	7	8	M	0.14

07-Nov-94	7	11	M	0.04	22-Nov-94	7	8	U	0.18
07-Nov-94	7	11	U	0.03	22-Nov-94	7	9	L	0.15
07-Nov-94	7	12	U	0.03	22-Nov-94	7	10	U	0.07
07-Nov-94	7	21	L	0.01	22-Nov-94	7	13	U	0.05
07-Nov-94	10	3	M	0.03	22-Nov-94	7	14	L	0.55
07-Nov-94	10	5	L	0.04	22-Nov-94	7	14	M	0.11
07-Nov-94	10	5	M	0.04	22-Nov-94	7	14	U	0.03
07-Nov-94	10	5	U	0.03	22-Nov-94	7	16	M	0.04
07-Nov-94	10	7	U	0.04	22-Nov-94	7	19	L	0.41
07-Nov-94	10	9	M	0.03	22-Nov-94	7	24	M	0.06
07-Nov-94	10	11	L	0.04	22-Nov-94	10	7	L	0.31
07-Nov-94	10	11	M	0.04	22-Nov-94	10	8	L	0.44
07-Nov-94	10	11	U	0.03	22-Nov-94	10	8	M	0.25
07-Nov-94	10	12	L	0.05	22-Nov-94	10	8	U	0.07
07-Nov-94	10	13	L	0.05	22-Nov-94	10	13	U	0.31
07-Nov-94	10	21	U	0.03	22-Nov-94	10	14	L	1.07
07-Nov-94	1	5	L	0.05	22-Nov-94	10	14	M	0.16
07-Nov-94	1	5	M	0.03	22-Nov-94	10	14	U	0.09
07-Nov-94	1	5	U	0.03	22-Nov-94	10	15	U	0.20
07-Nov-94	1	10	L	0.05	22-Nov-94	10	16	M	0.35
07-Nov-94	1	11	L	0.07	22-Nov-94	10	18	L	0.84
07-Nov-94	1	11	U	0.05	22-Nov-94	10	24	M	0.30
07-Nov-94	1	11	M	0.05	22-Nov-94	1	7	M	0.10
07-Nov-94	1	12	M	0.05	22-Nov-94	1	8	L	0.08
07-Nov-94	1	13	U	0.06	22-Nov-94	1	8	M	0.84
07-Nov-94	1	15	L	0.04	22-Nov-94	1	8	U	0.12
07-Nov-94	1	16	U	0.06	22-Nov-94	1	10	U	0.11
07-Nov-94	1	19	M	0.05	22-Nov-94	1	12	U	0.17
07-Nov-94	5	3	L	0.03	22-Nov-94	1	14	L	0.05
07-Nov-94	5	5	L	0.04	22-Nov-94	1	14	M	1.07
07-Nov-94	5	5	M	0.13	22-Nov-94	1	14	U	0.12
07-Nov-94	5	5	U	0.17	22-Nov-94	1	21	L	0.06
07-Nov-94	5	11	L	0.08	22-Nov-94	1	24	L	0.09
07-Nov-94	5	11	M	0.03	22-Nov-94	1	24	M	1.08
07-Nov-94	5	11	U	0.03	22-Nov-94	5	6	L	0.46
07-Nov-94	5	12	M	0.04	22-Nov-94	5	6	M	0.38
07-Nov-94	5	15	L	0.04	22-Nov-94	5	7	U	0.18
07-Nov-94	5	16	U	0.06	22-Nov-94	5	8	L	0.82
07-Nov-94	5	22	U	0.02	22-Nov-94	5	8	M	0.01
07-Nov-94	5	24	M	0.07	22-Nov-94	5	8	U	0.05
07-Nov-94	12	5	L	0.04	22-Nov-94	5	10	L	1.66
07-Nov-94	12	5	M	0.04	22-Nov-94	5	10	U	0.10
07-Nov-94	12	5	U	0.03	22-Nov-94	5	14	L	1.40
07-Nov-94	12	6	M	0.02	22-Nov-94	5	14	M	0.20
07-Nov-94	12	9	L	0.02	22-Nov-94	5	14	U	0.07
07-Nov-94	12	11	L	0.04	22-Nov-94	5	21	M	0.16
07-Nov-94	12	11	M	0.03	22-Nov-94	12	7	M	0.07
07-Nov-94	12	11	U	0.06	22-Nov-94	12	8	L	0.15
07-Nov-94	12	15	L	0.03	22-Nov-94	12	8	M	0.14
07-Nov-94	12	15	U	0.05	22-Nov-94	12	8	U	0.14
07-Nov-94	12	21	M	0.04	22-Nov-94	12	10	L	0.87
07-Nov-94	12	21	U	0.04	22-Nov-94	12	12	M	0.07

14-Nov-94	4	2	L	0.08
14-Nov-94	4	2	M	0.05
14-Nov-94	4	2	U	0.06
14-Nov-94	4	3	U	0.03
14-Nov-94	4	6	M	0.04
14-Nov-94	4	12	U	0.03
14-Nov-94	4	17	L	0.15
14-Nov-94	4	17	M	0.06
14-Nov-94	4	17	U	0.04
14-Nov-94	4	19	L	0.10
14-Nov-94	4	22	L	0.14
14-Nov-94	4	22	M	0.06
14-Nov-94	9	2	L	0.02
14-Nov-94	9	2	M	0.02
14-Nov-94	9	2	U	0.02
14-Nov-94	9	7	M	0.02
14-Nov-94	9	9	U	0.03
14-Nov-94	9	15	L	0.03
14-Nov-94	9	15	M	0.03
14-Nov-94	9	17	L	0.06
14-Nov-94	9	17	M	0.03
14-Nov-94	9	17	U	0.03
14-Nov-94	9	22	L	0.05
14-Nov-94	9	22	U	0.03
14-Nov-94	11	2	L	0.02
14-Nov-94	11	2	M	0.04
14-Nov-94	11	2	U	0.03
14-Nov-94	11	3	L	0.02
14-Nov-94	11	6	M	0.04
14-Nov-94	11	12	U	0.03
22-Nov-94	12	12	U	0.16
22-Nov-94	12	14	L	0.33
22-Nov-94	12	14	M	0.12
22-Nov-94	12	14	U	0.09
22-Nov-94	12	19	L	0.24
22-Nov-94	12	22	U	0.07
27-Nov-94	4	20	L	0.12
27-Nov-94	4	20	M	0.05
27-Nov-94	4	20	U	0.04
27-Nov-94	4	23	L	0.04
27-Nov-94	4	23	M	0.10
27-Nov-94	4	23	U	0.04
27-Nov-94	11	20	M	0.05
27-Nov-94	11	20	U	0.05
27-Nov-94	11	23	U	0.03
27-Nov-94	3	20	L	0.45
27-Nov-94	3	20	M	0.03
27-Nov-94	3	20	U	0.01
27-Nov-94	3	23	L	0.63
27-Nov-94	3	23	M	0.03
27-Nov-94	3	23	U	0.04
27-Nov-94	10	20	L	1.49
27-Nov-94	10	20	M	0.50
27-Nov-94	10	20	U	0.80
27-Nov-94	10	23	L	0.83
27-Nov-94	10	23	M	0.39
27-Nov-94	10	23	U	0.08
27-Nov-94	12	20	U	0.16
27-Nov-94	12	23	U	0.14

APPENDIX C: Raw irradiance data, Hinton flume experiment fall, 1994.

Date	Time	Light (µE/s/m2)	Date	Time	Light (µE/s/m2)	Date	Time	Light (µE/s/m2)
23-Oct-94	400	0.000	02-Nov-94	2000	0.001	15-Nov-94	1100	23.325
23-Oct-94	800	0.006	03-Nov-94	900	2.694	15-Nov-94	1200	54.139
23-Oct-94	900	6.764	03-Nov-94	1000	58.056	15-Nov-94	1300	86.889
23-Oct-94	1000	41.833	03-Nov-94	1100	119.667	15-Nov-94	1400	105.722
23-Oct-94	1100	126.972	03-Nov-94	1200	307.222	15-Nov-94	1500	91.694
23-Oct-94	1200	421.111	03-Nov-94	1300	452.500	15-Nov-94	1600	38.583
23-Oct-94	1300	551.389	03-Nov-94	1400	446.944	15-Nov-94	1700	43.222
23-Oct-94	1400	727.778	03-Nov-94	1500	543.611	15-Nov-94	1800	12.283
23-Oct-94	1500	716.111	03-Nov-94	1600	176.361	15-Nov-94	1900	0.228
23-Oct-94	1600	596.944	03-Nov-94	1700	92.417	15-Nov-94	2200	0.000
23-Oct-94	1700	413.611	03-Nov-94	1800	64.694	15-Nov-94	2300	0.000
23-Oct-94	1800	199.139	03-Nov-94	1900	2.032	16-Nov-94	0	0.001
23-Oct-94	1900	24.039	04-Nov-94	900	1.380	16-Nov-94	100	0.000
23-Oct-94	2000	0.041	04-Nov-94	1000	31.333	16-Nov-94	200	0.001
24-Oct-94	800	0.005	04-Nov-94	1100	129.556	16-Nov-94	300	0.001
24-Oct-94	900	10.992	04-Nov-94	1200	455.556	16-Nov-94	400	0.000
24-Oct-94	1000	65.528	04-Nov-94	1300	621.944	16-Nov-94	500	0.001
24-Oct-94	1100	146.833	04-Nov-94	1400	676.667	16-Nov-94	600	0.002
24-Oct-94	1200	574.167	04-Nov-94	1500	516.667	16-Nov-94	700	0.002
24-Oct-94	1300	582.778	04-Nov-94	1600	421.667	16-Nov-94	800	0.001
24-Oct-94	1400	319.167	04-Nov-94	1700	318.056	16-Nov-94	900	0.012
24-Oct-94	1500	183.000	04-Nov-94	1800	103.111	16-Nov-94	1000	2.423
24-Oct-94	1600	265.889	04-Nov-94	1900	5.444	16-Nov-94	1100	14.456
24-Oct-94	1700	244.250	04-Nov-94	2000	0.001	16-Nov-94	1200	49.083
24-Oct-94	1800	223.694	05-Nov-94	900	1.340	16-Nov-94	1300	104.833
24-Oct-94	1900	20.278	05-Nov-94	1000	43.889	16-Nov-94	1400	66.278
24-Oct-94	2000	0.022	05-Nov-94	1100	153.028	16-Nov-94	1500	102.667
25-Oct-94	800	0.003	05-Nov-94	1200	296.944	16-Nov-94	1600	34.917
25-Oct-94	900	8.111	05-Nov-94	1300	322.778	16-Nov-94	1700	15.639
25-Oct-94	1000	72.639	05-Nov-94	1400	313.333	16-Nov-94	1800	2.444
25-Oct-94	1100	173.500	05-Nov-94	1500	559.444	16-Nov-94	1900	0.056
25-Oct-94	1200	378.333	05-Nov-94	1600	492.778	16-Nov-94	2000	0.001
25-Oct-94	1300	515.278	05-Nov-94	1700	241.972	16-Nov-94	2100	0.001
25-Oct-94	1400	651.389	05-Nov-94	1800	63.361	16-Nov-94	2200	0.001
25-Oct-94	1500	760.556	05-Nov-94	1900	3.539	16-Nov-94	2300	0.002
25-Oct-94	1600	405.000	06-Nov-94	900	0.982	17-Nov-94	0	0.002
25-Oct-94	1700	308.889	06-Nov-94	1000	41.194	17-Nov-94	100	0.002
25-Oct-94	1800	117.639	06-Nov-94	1100	118.611	17-Nov-94	200	0.002
25-Oct-94	1900	17.889	06-Nov-94	1200	355.000	17-Nov-94	300	0.001
25-Oct-94	2000	0.017	06-Nov-94	1300	376.667	17-Nov-94	400	0.001
26-Oct-94	800	0.001	06-Nov-94	1400	638.056	17-Nov-94	500	0.001
26-Oct-94	900	7.997	06-Nov-94	1500	601.944	17-Nov-94	600	0.001
26-Oct-94	1000	64.056	06-Nov-94	1600	427.500	17-Nov-94	700	0.002
26-Oct-94	1100	174.639	06-Nov-94	1700	170.389	17-Nov-94	800	0.002
26-Oct-94	1200	584.722	06-Nov-94	1800	61.111	17-Nov-94	900	0.011
26-Oct-94	1300	500.833	06-Nov-94	1900	2.806	17-Nov-94	1000	2.931

26-Oct-94	1400	735.833	07-Nov-94	900	1.093	17-Nov-94	1100	20.442
26-Oct-94	1500	508.611	07-Nov-94	1000	33.111	17-Nov-94	1200	51.833
26-Oct-94	1600	301.667	07-Nov-94	1100	112.694	17-Nov-94	1300	71.444
26-Oct-94	1700	182.194	07-Nov-94	1200	318.611	17-Nov-94	1400	79.778
26-Oct-94	1800	110.333	07-Nov-94	1300	352.222	17-Nov-94	1500	87.944
26-Oct-94	1900	9.433	07-Nov-94	1400	611.944	17-Nov-94	1600	120.944
26-Oct-94	2000	0.006	07-Nov-94	1500	521.389	17-Nov-94	1700	151.028
27-Oct-94	800	0.002	07-Nov-94	1600	470.278	17-Nov-94	1800	35.111
27-Oct-94	900	7.800	07-Nov-94	1700	277.361	17-Nov-94	1900	0.339
27-Oct-94	1000	55.194	07-Nov-94	1800	51.972	17-Nov-94	2000	0.000
27-Oct-94	1100	188.000	07-Nov-94	1900	2.992	17-Nov-94	2100	0.001
27-Oct-94	1200	492.778	08-Nov-94	900	0.541	17-Nov-94	2200	0.001
27-Oct-94	1300	652.500	08-Nov-94	1000	24.861	17-Nov-94	2300	0.001
27-Oct-94	1400	611.944	08-Nov-94	1100	104.667	18-Nov-94	0	0.001
27-Oct-94	1500	687.778	08-Nov-94	1200	268.528	18-Nov-94	100	0.001
27-Oct-94	1600	497.778	08-Nov-94	1300	288.611	18-Nov-94	200	0.001
27-Oct-94	1700	275.972	08-Nov-94	1400	698.611	18-Nov-94	300	0.002
27-Oct-94	1800	165.139	08-Nov-94	1500	608.056	18-Nov-94	400	0.001
27-Oct-94	1900	13.833	08-Nov-94	1600	309.444	18-Nov-94	500	0.001
27-Oct-94	2000	0.011	08-Nov-94	1700	106.000	18-Nov-94	600	0.001
28-Oct-94	800	0.000	08-Nov-94	1800	31.917	18-Nov-94	700	0.001
28-Oct-94	900	4.622	08-Nov-94	1900	0.885	18-Nov-94	800	0.000
28-Oct-94	1000	56.861	09-Nov-94	900	0.289	18-Nov-94	900	0.019
28-Oct-94	1100	174.194	09-Nov-94	1000	18.978	18-Nov-94	1000	6.781
28-Oct-94	1200	282.222	09-Nov-94	1100	108.972	18-Nov-94	1100	40.861
28-Oct-94	1300	428.333	09-Nov-94	1200	188.500	18-Nov-94	1200	126.528
28-Oct-94	1400	386.944	09-Nov-94	1300	195.000	18-Nov-94	1300	252.611
28-Oct-94	1500	446.111	09-Nov-94	1400	284.444	18-Nov-94	1400	327.778
28-Oct-94	1600	406.111	09-Nov-94	1500	260.083	18-Nov-94	1500	360.000
28-Oct-94	1700	298.611	09-Nov-94	1600	279.167	18-Nov-94	1600	180.111
28-Oct-94	1800	73.000	09-Nov-94	1700	146.583	18-Nov-94	1700	69.472
28-Oct-94	1900	11.500	09-Nov-94	1800	47.917	18-Nov-94	1800	15.019
28-Oct-94	2000	0.007	09-Nov-94	1900	2.327	18-Nov-94	1900	0.170
29-Oct-94	800	0.001	09-Nov-94	2000	0.000	19-Nov-94	0	0.001
29-Oct-94	900	5.969	10-Nov-94	400	0.000	19-Nov-94	100	0.000
29-Oct-94	1000	55.333	10-Nov-94	900	0.180	19-Nov-94	300	0.000
29-Oct-94	1100	144.833	10-Nov-94	1000	11.192	19-Nov-94	400	0.001
29-Oct-94	1200	511.389	10-Nov-94	1100	73.611	19-Nov-94	500	0.001
29-Oct-94	1300	663.056	10-Nov-94	1200	402.222	19-Nov-94	600	0.000
29-Oct-94	1400	717.778	10-Nov-94	1300	436.667	19-Nov-94	700	0.000
29-Oct-94	1500	684.167	10-Nov-94	1400	510.278	19-Nov-94	900	0.042
29-Oct-94	1600	566.389	10-Nov-94	1500	537.778	19-Nov-94	1000	21.519
29-Oct-94	1700	381.667	10-Nov-94	1600	433.333	19-Nov-94	1100	104.056
29-Oct-94	1800	160.250	10-Nov-94	1700	269.944	19-Nov-94	1200	322.222
29-Oct-94	1900	11.322	10-Nov-94	1800	60.528	19-Nov-94	1300	251.222
29-Oct-94	2000	0.005	10-Nov-94	1900	1.976	19-Nov-94	1400	346.667
30-Oct-94	900	1.559	11-Nov-94	900	0.063	19-Nov-94	1500	332.778
30-Oct-94	1000	29.056	11-Nov-94	1000	5.408	19-Nov-94	1600	131.611
30-Oct-94	1100	133.139	11-Nov-94	1100	34.139	19-Nov-94	1700	95.444
30-Oct-94	1200	220.056	11-Nov-94	1200	72.806	19-Nov-94	1800	32.306
30-Oct-94	1300	296.667	11-Nov-94	1300	132.667	19-Nov-94	1900	0.508
30-Oct-94	1400	390.278	11-Nov-94	1400	197.861	19-Nov-94	2300	0.000

30-Oct-94	1500	384.444	11-Nov-94	1500	463.333	20-Nov-94	0	0.001
30-Oct-94	1600	343.333	11-Nov-94	1600	595.278	20-Nov-94	100	0.003
30-Oct-94	1700	323.056	11-Nov-94	1700	354.444	20-Nov-94	200	0.007
30-Oct-94	1800	165.722	11-Nov-94	1800	68.111	20-Nov-94	300	0.007
30-Oct-94	1900	8.286	11-Nov-94	1900	1.397	20-Nov-94	400	0.001
30-Oct-94	2000	0.002	12-Nov-94	900	0.195	20-Nov-94	500	0.000
31-Oct-94	500	0.000	12-Nov-94	1000	13.169	20-Nov-94	600	0.000
31-Oct-94	600	0.000	12-Nov-94	1100	47.500	20-Nov-94	700	0.001
31-Oct-94	700	0.001	12-Nov-94	1200	138.750	20-Nov-94	800	0.000
31-Oct-94	800	0.001	12-Nov-94	1300	253.778	20-Nov-94	900	0.032
31-Oct-94	900	1.480	12-Nov-94	1400	273.028	20-Nov-94	1000	10.614
31-Oct-94	1000	22.792	12-Nov-94	1500	247.083	20-Nov-94	1100	71.444
31-Oct-94	1100	54.750	12-Nov-94	1600	359.722	20-Nov-94	1200	162.583
31-Oct-94	1200	83.167	12-Nov-94	1700	287.778	20-Nov-94	1300	197.472
31-Oct-94	1300	166.167	12-Nov-94	1800	67.806	20-Nov-94	1400	237.472
31-Oct-94	1400	159.917	12-Nov-94	1900	1.801	20-Nov-94	1500	425.000
31-Oct-94	1500	190.833	12-Nov-94	2000	0.000	20-Nov-94	1600	290.000
31-Oct-94	1600	141.556	13-Nov-94	900	0.328	20-Nov-94	1700	164.667
31-Oct-94	1700	104.083	13-Nov-94	1000	27.097	20-Nov-94	1800	24.072
31-Oct-94	1800	67.389	13-Nov-94	1100	77.833	20-Nov-94	1900	0.275
31-Oct-94	1900	3.192	13-Nov-94	1200	307.500	21-Nov-94	200	0.000
31-Oct-94	2000	0.003	13-Nov-94	1300	506.667	21-Nov-94	300	0.000
31-Oct-94	2100	0.002	13-Nov-94	1400	562.222	21-Nov-94	400	0.000
31-Oct-94	2200	0.001	13-Nov-94	1500	331.389	21-Nov-94	500	0.000
31-Oct-94	2300	0.001	13-Nov-94	1600	328.889	21-Nov-94	600	0.000
01-Nov-94	0	0.001	13-Nov-94	1700	232.389	21-Nov-94	700	0.000
01-Nov-94	100	0.002	13-Nov-94	1800	55.167	21-Nov-94	900	0.034
01-Nov-94	200	0.003	13-Nov-94	1900	1.193	21-Nov-94	1000	13.917
01-Nov-94	300	0.000	13-Nov-94	2100	0.001	21-Nov-94	1100	72.694
01-Nov-94	400	0.000	13-Nov-94	2200	0.001	21-Nov-94	1200	198.444
01-Nov-94	700	0.000	13-Nov-94	2300	0.000	21-Nov-94	1300	415.556
01-Nov-94	800	0.000	14-Nov-94	0	0.001	21-Nov-94	1400	465.000
01-Nov-94	900	1.224	14-Nov-94	400	0.000	21-Nov-94	1500	337.500
01-Nov-94	1000	18.969	14-Nov-94	900	0.215	21-Nov-94	1600	290.556
01-Nov-94	1100	105.778	14-Nov-94	1000	30.806	21-Nov-94	1700	125.944
01-Nov-94	1200	168.917	14-Nov-94	1100	83.111	21-Nov-94	1800	21.544
01-Nov-94	1300	240.417	14-Nov-94	1200	316.944	21-Nov-94	1900	0.217
01-Nov-94	1400	238.722	14-Nov-94	1300	495.278	22-Nov-94	900	0.023
01-Nov-94	1500	271.500	14-Nov-94	1400	547.778	22-Nov-94	1000	10.956
01-Nov-94	1600	300.556	14-Nov-94	1500	530.278	22-Nov-94	1100	61.000
01-Nov-94	1700	172.944	14-Nov-94	1600	461.389	22-Nov-94	1200	143.972
01-Nov-94	1800	72.083	14-Nov-94	1700	282.222	22-Nov-94	1300	176.306
01-Nov-94	1900	4.650	14-Nov-94	1800	35.750	22-Nov-94	1400	389.722
01-Nov-94	2000	0.004	14-Nov-94	1900	0.457	22-Nov-94	1500	587.222
01-Nov-94	2100	0.001	14-Nov-94	2000	0.001	22-Nov-94	1600	331.389
01-Nov-94	2200	0.001	14-Nov-94	2100	0.005	22-Nov-94	1700	206.194
01-Nov-94	2300	0.001	14-Nov-94	2200	0.007	22-Nov-94	1800	35.750
02-Nov-94	200	0.001	14-Nov-94	2300	0.005	22-Nov-94	1900	0.198
02-Nov-94	900	2.892	15-Nov-94	0	0.003	23-Nov-94	900	0.017
02-Nov-94	1000	53.389	15-Nov-94	100	0.004	23-Nov-94	1000	13.200
02-Nov-94	1100	122.389	15-Nov-94	200	0.002	23-Nov-94	1100	98.667
02-Nov-94	1200	448.056	15-Nov-94	300	0.001	23-Nov-94	1200	211.833

02-Nov-94	1300	634.444	15-Nov-94	400	0.001	23-Nov-94	1300	155.944
02-Nov-94	1400	684.444	15-Nov-94	500	0.001	23-Nov-94	1400	148.806
02-Nov-94	1500	643.889	15-Nov-94	600	0.001	23-Nov-94	1500	137.111
02-Nov-94	1600	526.944	15-Nov-94	700	0.000	23-Nov-94	1600	195.278
02-Nov-94	1700	343.056	15-Nov-94	800	0.000	23-Nov-94	1700	68.972
02-Nov-94	1800	126.639	15-Nov-94	900	0.024	23-Nov-94	1800	23.844
02-Nov-94	1900	7.228	15-Nov-94	1000	3.883	23-Nov-94	1900	0.228

APPENDIX D: **Raw temperature data, Hinton flume experiment fall, 1994.**

Date	Time	Temp	Date	Time	Temp	Date	Time	Temp
23-Oct-94	00:14:00	2.88	02-Nov-94	17:14:00	-0.01	13-Nov-94	09:14:00	-0.01
23-Oct-94	01:14:00	2.80	02-Nov-94	18:14:00	-0.10	13-Nov-94	10:14:00	0.06
23-Oct-94	02:14:00	2.71	02-Nov-94	19:14:00	-0.10	13-Nov-94	11:14:00	0.23
23-Oct-94	03:14:00	2.62	02-Nov-94	20:14:00	-0.10	13-Nov-94	12:14:00	0.23
23-Oct-94	04:14:00	2.45	02-Nov-94	21:14:00	-0.10	13-Nov-94	13:14:00	0.23
23-Oct-94	05:14:00	2.36	02-Nov-94	22:14:00	-0.18	13-Nov-94	14:14:00	0.06
23-Oct-94	06:14:00	2.28	02-Nov-94	23:14:00	-0.10	13-Nov-94	15:14:00	0.06
23-Oct-94	07:14:00	2.02	03-Nov-94	00:14:00	-0.10	13-Nov-94	16:14:00	0.06
23-Oct-94	08:14:00	1.85	03-Nov-94	01:14:00	-0.10	13-Nov-94	17:14:00	-0.01
23-Oct-94	09:14:00	1.76	03-Nov-94	02:14:00	-0.10	13-Nov-94	18:14:00	-0.01
23-Oct-94	10:14:00	1.68	03-Nov-94	03:14:00	-0.18	13-Nov-94	19:14:00	-0.01
23-Oct-94	11:14:00	1.68	03-Nov-94	04:14:00	-0.10	13-Nov-94	20:14:00	-0.01
23-Oct-94	12:14:00	1.93	03-Nov-94	05:14:00	-0.18	13-Nov-94	21:14:00	-0.01
23-Oct-94	13:14:00	2.10	03-Nov-94	06:14:00	-0.10	13-Nov-94	22:14:00	-0.01
23-Oct-94	14:14:00	2.45	03-Nov-94	07:14:00	-0.10	13-Nov-94	23:14:00	-0.01
23-Oct-94	15:14:00	2.62	03-Nov-94	08:14:00	-0.10	14-Nov-94	00:14:00	-0.01
23-Oct-94	16:14:00	2.71	03-Nov-94	09:14:00	-0.10	14-Nov-94	01:14:00	-0.01
23-Oct-94	17:14:00	2.80	03-Nov-94	10:14:00	0.15	14-Nov-94	02:14:00	-0.01
23-Oct-94	18:14:00	2.80	03-Nov-94	11:14:00	0.15	14-Nov-94	03:14:00	-0.01
23-Oct-94	19:14:00	2.71	03-Nov-94	12:14:00	0.15	14-Nov-94	04:14:00	-0.10
23-Oct-94	20:14:00	2.71	03-Nov-94	13:14:00	0.15	14-Nov-94	05:14:00	-0.01
23-Oct-94	21:14:00	2.71	03-Nov-94	14:14:00	0.15	14-Nov-94	06:14:00	-0.01
23-Oct-94	22:14:00	2.71	03-Nov-94	15:14:00	0.15	14-Nov-94	07:14:00	-0.01
23-Oct-94	23:14:00	2.80	03-Nov-94	16:14:00	0.15	14-Nov-94	08:14:00	-0.01
24-Oct-94	00:14:00	2.88	03-Nov-94	17:14:00	0.06	14-Nov-94	09:14:00	-0.01
24-Oct-94	01:14:00	2.88	03-Nov-94	18:14:00	-0.01	14-Nov-94	10:14:00	0.06
24-Oct-94	02:14:00	2.88	03-Nov-94	19:14:00	-0.01	14-Nov-94	11:14:00	0.23
24-Oct-94	03:14:00	2.71	03-Nov-94	20:14:00	-0.01	14-Nov-94	12:14:00	0.31
24-Oct-94	04:14:00	2.54	03-Nov-94	21:14:00	-0.01	14-Nov-94	13:14:00	0.23
24-Oct-94	05:14:00	2.28	03-Nov-94	22:14:00	-0.01	14-Nov-94	14:14:00	0.23
24-Oct-94	06:14:00	1.93	03-Nov-94	23:14:00	-0.10	14-Nov-94	15:14:00	0.15
24-Oct-94	07:14:00	1.68	04-Nov-94	00:14:00	-0.10	14-Nov-94	16:14:00	0.06
24-Oct-94	08:14:00	1.50	04-Nov-94	01:14:00	-0.01	14-Nov-94	17:14:00	0.06
24-Oct-94	09:14:00	1.33	04-Nov-94	02:14:00	-0.01	14-Nov-94	18:14:00	0.06
24-Oct-94	10:14:00	1.25	04-Nov-94	03:14:00	-0.01	14-Nov-94	19:14:00	0.06
24-Oct-94	11:14:00	1.42	04-Nov-94	04:14:00	-0.01	14-Nov-94	20:14:00	0.06
24-Oct-94	12:14:00	1.59	04-Nov-94	05:14:00	-0.01	14-Nov-94	21:14:00	-0.01
24-Oct-94	13:14:00	1.59	04-Nov-94	06:14:00	-0.01	14-Nov-94	22:14:00	0.06
24-Oct-94	14:14:00	1.68	04-Nov-94	07:14:00	-0.01	14-Nov-94	23:14:00	0.06
24-Oct-94	15:14:00	1.76	04-Nov-94	08:14:00	-0.10	15-Nov-94	00:14:00	0.06
24-Oct-94	16:14:00	1.93	04-Nov-94	09:14:00	-0.01	15-Nov-94	01:14:00	0.06
24-Oct-94	17:14:00	2.10	04-Nov-94	10:14:00	0.23	15-Nov-94	02:14:00	0.06
24-Oct-94	18:14:00	2.28	04-Nov-94	11:14:00	0.31	15-Nov-94	03:14:00	0.06
24-Oct-94	19:14:00	2.45	04-Nov-94	12:14:00	0.40	15-Nov-94	04:14:00	0.06
24-Oct-94	20:14:00	2.54	04-Nov-94	13:14:00	0.40	15-Nov-94	05:14:00	0.06
24-Oct-94	21:14:00	2.71	04-Nov-94	14:14:00	0.15	15-Nov-94	06:14:00	0.15
24-Oct-94	22:14:00	2.88	04-Nov-94	15:14:00	0.15	15-Nov-94	07:14:00	0.15

24-Oct-94	23:14:00	2.97	04-Nov-94	16:14:00	0.06	15-Nov-94	08:14:00	0.15
25-Oct-94	00:14:00	3.06	04-Nov-94	17:14:00	-0.01	15-Nov-94	09:14:00	0.15
25-Oct-94	01:14:00	3.14	04-Nov-94	18:14:00	-0.01	15-Nov-94	10:14:00	0.15
25-Oct-94	02:14:00	3.14	04-Nov-94	19:14:00	-0.01	15-Nov-94	11:14:00	0.06
25-Oct-94	03:14:00	3.14	04-Nov-94	20:14:00	-0.01	15-Nov-94	12:14:00	0.15
25-Oct-94	04:14:00	2.97	04-Nov-94	21:14:00	-0.01	15-Nov-94	13:14:00	0.06
25-Oct-94	05:14:00	2.80	04-Nov-94	22:14:00	-0.01	15-Nov-94	14:14:00	-0.01
25-Oct-94	06:14:00	2.62	04-Nov-94	23:14:00	-0.01	15-Nov-94	15:14:00	0.06
25-Oct-94	07:14:00	2.45	05-Nov-94	00:14:00	-0.01	15-Nov-94	16:14:00	0.06
25-Oct-94	08:14:00	2.36	05-Nov-94	01:14:00	-0.01	15-Nov-94	17:14:00	-0.01
25-Oct-94	09:14:00	2.28	05-Nov-94	02:14:00	-0.01	15-Nov-94	18:14:00	-0.01
25-Oct-94	10:14:00	2.19	05-Nov-94	03:14:00	-0.01	15-Nov-94	19:14:00	-0.01
25-Oct-94	11:14:00	2.45	05-Nov-94	04:14:00	-0.10	15-Nov-94	20:14:00	-0.01
25-Oct-94	12:14:00	2.62	05-Nov-94	05:14:00	-0.10	15-Nov-94	21:14:00	-0.01
25-Oct-94	13:14:00	2.88	05-Nov-94	06:14:00	-0.01	15-Nov-94	22:14:00	-0.01
25-Oct-94	14:14:00	3.23	05-Nov-94	07:14:00	-0.01	15-Nov-94	23:14:00	-0.01
25-Oct-94	15:14:00	3.49	05-Nov-94	08:14:00	-0.01	16-Nov-94	00:14:00	-0.01
25-Oct-94	16:14:00	3.67	05-Nov-94	09:14:00	-0.01	16-Nov-94	01:14:00	-0.01
25-Oct-94	17:14:00	3.75	05-Nov-94	10:14:00	-0.01	16-Nov-94	02:14:00	-0.01
25-Oct-94	18:14:00	3.84	05-Nov-94	11:14:00	0.06	16-Nov-94	03:14:00	-0.01
25-Oct-94	19:14:00	3.84	05-Nov-94	12:14:00	0.15	16-Nov-94	04:14:00	-0.01
25-Oct-94	20:14:00	3.84	05-Nov-94	13:14:00	0.06	16-Nov-94	05:14:00	-0.01
25-Oct-94	21:14:00	3.93	05-Nov-94	14:14:00	0.23	16-Nov-94	06:14:00	-0.01
25-Oct-94	22:14:00	4.10	05-Nov-94	15:14:00	0.15	16-Nov-94	07:14:00	-0.01
25-Oct-94	23:14:00	4.28	05-Nov-94	16:14:00	0.06	16-Nov-94	08:14:00	-0.01
26-Oct-94	00:14:00	4.46	05-Nov-94	17:14:00	0.06	16-Nov-94	09:14:00	-0.01
26-Oct-94	02:14:00	4.72	05-Nov-94	18:14:00	-0.01	16-Nov-94	10:14:00	-0.01
26-Oct-94	03:14:00	4.63	05-Nov-94	19:14:00	-0.01	16-Nov-94	11:14:00	0.06
26-Oct-94	04:14:00	4.54	05-Nov-94	20:14:00	-0.01	16-Nov-94	12:14:00	0.06
26-Oct-94	05:14:00	4.37	05-Nov-94	21:14:00	-0.01	16-Nov-94	13:14:00	0.06
26-Oct-94	06:14:00	4.28	05-Nov-94	22:14:00	-0.01	16-Nov-94	14:14:00	0.06
26-Oct-94	07:14:00	4.19	05-Nov-94	23:14:00	-0.01	16-Nov-94	15:14:00	0.06
26-Oct-94	08:14:00	4.19	06-Nov-94	00:14:00	-0.01	16-Nov-94	16:14:00	-0.01
26-Oct-94	09:14:00	4.10	06-Nov-94	01:14:00	-0.01	16-Nov-94	17:14:00	-0.01
26-Oct-94	10:14:00	4.10	06-Nov-94	02:14:00	-0.01	16-Nov-94	18:14:00	-0.01
26-Oct-94	11:14:00	4.46	06-Nov-94	03:14:00	-0.01	16-Nov-94	19:14:00	-0.01
26-Oct-94	12:14:00	4.54	06-Nov-94	04:14:00	-0.01	16-Nov-94	20:14:00	-0.01
26-Oct-94	13:14:00	4.72	06-Nov-94	05:14:00	-0.01	16-Nov-94	21:14:00	-0.01
26-Oct-94	14:14:00	4.90	06-Nov-94	06:14:00	0.06	16-Nov-94	22:14:00	-0.01
26-Oct-94	15:14:00	4.90	06-Nov-94	07:14:00	0.06	16-Nov-94	23:14:00	-0.01
26-Oct-94	16:14:00	4.90	06-Nov-94	08:14:00	0.06	17-Nov-94	00:14:00	-0.01
26-Oct-94	17:14:00	4.99	06-Nov-94	09:14:00	0.06	17-Nov-94	01:14:00	-0.01
26-Oct-94	18:14:00	4.99	06-Nov-94	10:14:00	0.15	17-Nov-94	02:14:00	-0.01
26-Oct-94	19:14:00	5.08	06-Nov-94	11:14:00	0.06	17-Nov-94	03:14:00	-0.01
26-Oct-94	20:14:00	5.08	06-Nov-94	12:14:00	0.23	17-Nov-94	04:14:00	-0.01
26-Oct-94	21:14:00	5.08	06-Nov-94	13:14:00	0.23	17-Nov-94	05:14:00	-0.01
26-Oct-94	22:14:00	5.08	06-Nov-94	14:14:00	0.23	17-Nov-94	06:14:00	-0.01
26-Oct-94	23:14:00	4.99	06-Nov-94	15:14:00	0.15	17-Nov-94	07:14:00	-0.01
27-Oct-94	00:14:00	4.90	06-Nov-94	16:14:00	0.06	17-Nov-94	08:14:00	0.06
27-Oct-94	01:14:00	4.81	06-Nov-94	17:14:00	-0.01	17-Nov-94	09:14:00	0.06
27-Oct-94	02:14:00	4.63	06-Nov-94	18:14:00	-0.01	17-Nov-94	10:14:00	0.15
27-Oct-94	03:14:00	4.46	06-Nov-94	19:14:00	-0.01	17-Nov-94	11:14:00	0.15

27-Oct-94	04:14:00	4.19	06-Nov-94	20:14:00	-0.01	17-Nov-94	12:14:00	0.06
27-Oct-94	05:14:00	4.02	06-Nov-94	21:14:00	-0.01	17-Nov-94	13:14:00	0.06
27-Oct-94	06:14:00	3.84	06-Nov-94	22:14:00	-0.01	17-Nov-94	14:14:00	0.15
27-Oct-94	07:14:00	3.58	06-Nov-94	23:14:00	-0.01	17-Nov-94	15:14:00	0.15
27-Oct-94	08:14:00	3.40	07-Nov-94	00:14:00	-0.01	17-Nov-94	16:14:00	0.06
27-Oct-94	09:14:00	3.40	07-Nov-94	01:14:00	-0.10	17-Nov-94	17:14:00	0.06
27-Oct-94	10:14:00	3.32	07-Nov-94	02:14:00	-0.10	17-Nov-94	18:14:00	-0.10
27-Oct-94	11:14:00	3.49	07-Nov-94	03:14:00	-0.10	17-Nov-94	19:14:00	-0.10
27-Oct-94	12:14:00	3.58	07-Nov-94	04:14:00	-0.01	17-Nov-94	20:14:00	-0.10
27-Oct-94	13:14:00	3.67	07-Nov-94	05:14:00	-0.01	17-Nov-94	21:14:00	-0.10
27-Oct-94	14:14:00	3.75	07-Nov-94	06:14:00	-0.10	17-Nov-94	22:14:00	-0.10
27-Oct-94	15:14:00	3.75	07-Nov-94	07:14:00	-0.10	17-Nov-94	23:14:00	-0.01
27-Oct-94	16:14:00	3.84	07-Nov-94	08:14:00	-0.01	18-Nov-94	00:14:00	-0.01
27-Oct-94	17:14:00	3.75	07-Nov-94	09:14:00	-0.01	18-Nov-94	01:14:00	-0.10
27-Oct-94	18:14:00	3.75	07-Nov-94	10:14:00	0.15	18-Nov-94	02:14:00	-0.10
27-Oct-94	19:14:00	3.75	07-Nov-94	11:14:00	0.15	18-Nov-94	03:14:00	-0.01
27-Oct-94	20:14:00	3.75	07-Nov-94	12:14:00	0.31	18-Nov-94	04:14:00	-0.01
27-Oct-94	21:14:00	3.75	07-Nov-94	13:14:00	0.31	18-Nov-94	05:14:00	-0.01
27-Oct-94	22:14:00	3.75	07-Nov-94	14:14:00	0.23	18-Nov-94	06:14:00	-0.01
27-Oct-94	23:14:00	3.84	07-Nov-94	15:14:00	0.15	18-Nov-94	07:14:00	0.06
28-Oct-94	00:14:00	3.84	07-Nov-94	16:14:00	0.06	18-Nov-94	08:14:00	0.06
28-Oct-94	01:14:00	3.84	07-Nov-94	17:14:00	0.06	18-Nov-94	09:14:00	0.06
28-Oct-94	02:14:00	3.67	07-Nov-94	18:14:00	0.06	18-Nov-94	10:14:00	0.06
28-Oct-94	03:14:00	3.49	07-Nov-94	19:14:00	0.15	18-Nov-94	11:14:00	0.06
28-Oct-94	04:14:00	3.32	07-Nov-94	20:14:00	-0.01	18-Nov-94	12:14:00	0.15
28-Oct-94	05:14:00	3.06	07-Nov-94	21:14:00	0.06	18-Nov-94	13:14:00	0.15
28-Oct-94	06:14:00	2.71	07-Nov-94	22:14:00	0.15	18-Nov-94	14:14:00	0.06
28-Oct-94	07:14:00	2.54	07-Nov-94	23:14:00	-0.01	18-Nov-94	15:14:00	0.06
28-Oct-94	08:14:00	2.28	08-Nov-94	00:14:00	-0.01	18-Nov-94	16:14:00	-0.01
28-Oct-94	09:14:00	2.10	08-Nov-94	01:14:00	-0.01	18-Nov-94	17:14:00	-0.01
28-Oct-94	10:14:00	2.02	08-Nov-94	02:14:00	-0.01	18-Nov-94	18:14:00	-0.01
28-Oct-94	11:14:00	1.93	08-Nov-94	03:14:00	0.06	18-Nov-94	19:14:00	-0.01
28-Oct-94	12:14:00	1.93	08-Nov-94	04:14:00	-0.01	18-Nov-94	20:14:00	-0.01
28-Oct-94	13:14:00	2.02	08-Nov-94	05:14:00	0.06	18-Nov-94	21:14:00	-0.01
28-Oct-94	14:14:00	2.10	08-Nov-94	06:14:00	-0.01	18-Nov-94	22:14:00	-0.01
28-Oct-94	15:14:00	2.28	08-Nov-94	07:14:00	-0.01	18-Nov-94	23:14:00	0.06
28-Oct-94	16:14:00	2.36	08-Nov-94	08:14:00	-0.01	19-Nov-94	00:14:00	0.06
28-Oct-94	17:14:00	2.36	08-Nov-94	09:14:00	-0.01	19-Nov-94	01:14:00	0.06
28-Oct-94	18:14:00	2.28	08-Nov-94	10:14:00	0.06	19-Nov-94	02:14:00	0.06
28-Oct-94	19:14:00	2.10	08-Nov-94	11:14:00	0.06	19-Nov-94	03:14:00	0.06
28-Oct-94	20:14:00	2.10	08-Nov-94	12:14:00	0.06	19-Nov-94	04:14:00	0.06
28-Oct-94	21:14:00	2.19	08-Nov-94	13:14:00	0.31	19-Nov-94	05:14:00	-0.01
28-Oct-94	22:14:00	2.28	08-Nov-94	14:14:00	0.23	19-Nov-94	06:14:00	0.06
28-Oct-94	23:14:00	2.36	08-Nov-94	15:14:00	0.06	19-Nov-94	07:14:00	0.06
29-Oct-94	00:14:00	2.36	08-Nov-94	16:14:00	0.06	19-Nov-94	08:14:00	0.06
29-Oct-94	01:14:00	2.36	08-Nov-94	17:14:00	-0.01	19-Nov-94	09:14:00	0.06
29-Oct-94	02:14:00	2.28	08-Nov-94	18:14:00	-0.01	19-Nov-94	10:14:00	0.06
29-Oct-94	03:14:00	2.10	08-Nov-94	19:14:00	-0.10	19-Nov-94	11:14:00	0.23
29-Oct-94	04:14:00	2.02	08-Nov-94	20:14:00	-0.10	19-Nov-94	12:14:00	0.15
29-Oct-94	05:14:00	1.76	08-Nov-94	21:14:00	-0.10	19-Nov-94	13:14:00	0.23
29-Oct-94	06:14:00	1.59	08-Nov-94	22:14:00	-0.10	19-Nov-94	14:14:00	0.15
29-Oct-94	07:14:00	1.33	08-Nov-94	23:14:00	-0.10	19-Nov-94	15:14:00	-0.01

29-Oct-94	08:14:00	1.16	09-Nov-94	00:14:00	-0.10	19-Nov-94	16:14:00	-0.01
29-Oct-94	09:14:00	0.99	09-Nov-94	01:14:00	-0.10	19-Nov-94	17:14:00	-0.01
29-Oct-94	10:14:00	0.91	09-Nov-94	02:14:00	-0.01	19-Nov-94	18:14:00	0.06
29-Oct-94	11:14:00	1.08	09-Nov-94	03:14:00	-0.01	19-Nov-94	19:14:00	-0.01
29-Oct-94	12:14:00	1.08	09-Nov-94	04:14:00	-0.01	19-Nov-94	20:14:00	0.06
29-Oct-94	13:14:00	1.08	09-Nov-94	05:14:00	-0.01	19-Nov-94	21:14:00	0.06
29-Oct-94	14:14:00	1.16	09-Nov-94	06:14:00	-0.01	19-Nov-94	22:14:00	0.06
29-Oct-94	15:14:00	1.25	09-Nov-94	07:14:00	-0.01	19-Nov-94	23:14:00	0.06
29-Oct-94	16:14:00	1.42	09-Nov-94	08:14:00	0.06	20-Nov-94	00:14:00	0.06
29-Oct-94	17:14:00	1.50	09-Nov-94	09:14:00	0.06	20-Nov-94	01:14:00	0.06
29-Oct-94	18:14:00	1.33	09-Nov-94	10:14:00	0.06	20-Nov-94	02:14:00	0.06
29-Oct-94	19:14:00	1.25	09-Nov-94	11:14:00	0.06	20-Nov-94	03:14:00	-0.01
29-Oct-94	20:14:00	1.16	09-Nov-94	12:14:00	0.06	20-Nov-94	04:14:00	-0.01
29-Oct-94	21:14:00	1.16	09-Nov-94	13:14:00	0.06	20-Nov-94	05:14:00	-0.01
29-Oct-94	22:14:00	1.16	09-Nov-94	14:14:00	0.15	20-Nov-94	06:14:00	0.06
29-Oct-94	23:14:00	1.16	09-Nov-94	15:14:00	0.06	20-Nov-94	07:14:00	0.06
30-Oct-94	00:14:00	1.16	09-Nov-94	16:14:00	0.06	20-Nov-94	08:14:00	0.06
30-Oct-94	01:14:00	1.16	09-Nov-94	17:14:00	-0.01	20-Nov-94	09:14:00	0.06
30-Oct-94	02:14:00	1.08	09-Nov-94	18:14:00	-0.01	20-Nov-94	10:14:00	0.06
30-Oct-94	03:14:00	0.91	09-Nov-94	19:14:00	-0.01	20-Nov-94	11:14:00	0.06
30-Oct-94	04:14:00	0.74	09-Nov-94	20:14:00	-0.01	20-Nov-94	12:14:00	0.06
30-Oct-94	05:14:00	0.65	09-Nov-94	21:14:00	-0.01	20-Nov-94	13:14:00	0.06
30-Oct-94	06:14:00	0.48	09-Nov-94	22:14:00	-0.01	20-Nov-94	14:14:00	0.15
30-Oct-94	07:14:00	0.40	09-Nov-94	23:14:00	-0.01	20-Nov-94	15:14:00	0.06
30-Oct-94	08:14:00	0.40	10-Nov-94	00:14:00	-0.01	20-Nov-94	16:14:00	0.06
30-Oct-94	09:14:00	0.31	10-Nov-94	01:14:00	-0.10	20-Nov-94	17:14:00	0.06
30-Oct-94	10:14:00	0.31	10-Nov-94	02:14:00	-0.01	20-Nov-94	18:14:00	0.06
30-Oct-94	11:14:00	0.31	10-Nov-94	03:14:00	-0.01	20-Nov-94	19:14:00	-0.01
30-Oct-94	12:14:00	0.48	10-Nov-94	04:14:00	-0.01	20-Nov-94	20:14:00	-0.01
30-Oct-94	13:14:00	0.57	10-Nov-94	05:14:00	-0.01	20-Nov-94	21:14:00	-0.01
30-Oct-94	14:14:00	0.74	10-Nov-94	06:14:00	-0.01	20-Nov-94	22:14:00	-0.01
30-Oct-94	15:14:00	0.91	10-Nov-94	07:14:00	-0.01	20-Nov-94	23:14:00	-0.01
30-Oct-94	16:14:00	0.99	10-Nov-94	08:14:00	-0.01	21-Nov-94	00:14:00	-0.01
30-Oct-94	17:14:00	1.08	10-Nov-94	09:14:00	-0.01	21-Nov-94	01:14:00	-0.01
30-Oct-94	18:14:00	1.08	10-Nov-94	10:14:00	0.06	21-Nov-94	02:14:00	-0.10
30-Oct-94	19:14:00	1.08	10-Nov-94	11:14:00	0.23	21-Nov-94	03:14:00	-0.10
30-Oct-94	20:14:00	1.08	10-Nov-94	12:14:00	0.23	21-Nov-94	04:14:00	-0.10
30-Oct-94	21:14:00	0.99	10-Nov-94	13:14:00	0.31	21-Nov-94	05:14:00	-0.10
30-Oct-94	22:14:00	0.99	10-Nov-94	14:14:00	0.23	21-Nov-94	06:14:00	-0.10
30-Oct-94	23:14:00	0.91	10-Nov-94	15:14:00	0.23	21-Nov-94	07:14:00	-0.10
31-Oct-94	00:14:00	0.91	10-Nov-94	16:14:00	0.15	21-Nov-94	08:14:00	-0.10
31-Oct-94	01:14:00	0.82	10-Nov-94	17:14:00	0.06	21-Nov-94	09:14:00	-0.10
31-Oct-94	02:14:00	0.82	10-Nov-94	18:14:00	0.06	21-Nov-94	10:14:00	-0.10
31-Oct-94	03:14:00	0.74	10-Nov-94	19:14:00	0.06	21-Nov-94	11:14:00	0.06
31-Oct-94	04:14:00	0.57	10-Nov-94	20:14:00	-0.01	21-Nov-94	12:14:00	0.15
31-Oct-94	05:14:00	0.40	10-Nov-94	21:14:00	0.06	21-Nov-94	13:14:00	0.15
31-Oct-94	06:14:00	0.23	10-Nov-94	22:14:00	-0.01	21-Nov-94	14:14:00	0.06
31-Oct-94	07:14:00	0.15	10-Nov-94	23:14:00	-0.01	21-Nov-94	15:14:00	0.06
31-Oct-94	08:14:00	-0.01	11-Nov-94	00:14:00	-0.01	21-Nov-94	16:14:00	-0.01
31-Oct-94	09:14:00	-0.10	11-Nov-94	01:14:00	-0.01	21-Nov-94	17:14:00	-0.01
31-Oct-94	10:14:00	-0.10	11-Nov-94	02:14:00	-0.01	21-Nov-94	18:14:00	0.06
31-Oct-94	11:14:00	-0.10	11-Nov-94	03:14:00	-0.01	21-Nov-94	19:14:00	-0.01

31-Oct-94	12:14:00	-0.01	11-Nov-94	04:14:00	0.06	21-Nov-94	20:14:00	-0.10
31-Oct-94	13:14:00	-0.01	11-Nov-94	05:14:00	-0.01	21-Nov-94	21:14:00	-0.10
31-Oct-94	14:14:00	-0.01	11-Nov-94	06:14:00	0.06	21-Nov-94	22:14:00	-0.10
31-Oct-94	15:14:00	0.06	11-Nov-94	07:14:00	0.06	21-Nov-94	23:14:00	-0.10
31-Oct-94	16:14:00	0.15	11-Nov-94	08:14:00	0.06	22-Nov-94	00:14:00	-0.10
31-Oct-94	17:14:00	0.15	11-Nov-94	09:14:00	0.06	22-Nov-94	01:14:00	-0.10
31-Oct-94	18:14:00	0.31	11-Nov-94	10:14:00	0.06	22-Nov-94	02:14:00	-0.01
31-Oct-94	19:14:00	0.40	11-Nov-94	11:14:00	0.06	22-Nov-94	03:14:00	-0.01
31-Oct-94	20:14:00	0.48	11-Nov-94	12:14:00	0.06	22-Nov-94	04:14:00	-0.01
31-Oct-94	21:14:00	0.57	11-Nov-94	13:14:00	0.15	22-Nov-94	05:14:00	-0.01
31-Oct-94	22:14:00	0.65	11-Nov-94	14:14:00	0.23	22-Nov-94	06:14:00	-0.01
31-Oct-94	23:14:00	0.74	11-Nov-94	15:14:00	0.31	22-Nov-94	07:14:00	-0.01
01-Nov-94	00:14:00	0.74	11-Nov-94	16:14:00	0.31	22-Nov-94	08:14:00	-0.01
01-Nov-94	01:14:00	0.74	11-Nov-94	17:14:00	0.15	22-Nov-94	09:14:00	0.06
01-Nov-94	02:14:00	0.74	11-Nov-94	18:14:00	0.06	22-Nov-94	10:14:00	-0.01
01-Nov-94	03:14:00	0.65	11-Nov-94	19:14:00	0.06	22-Nov-94	11:14:00	0.06
01-Nov-94	04:14:00	0.65	11-Nov-94	20:14:00	-0.01	22-Nov-94	12:14:00	0.06
01-Nov-94	05:14:00	0.57	11-Nov-94	21:14:00	-0.10	22-Nov-94	13:14:00	0.15
01-Nov-94	06:14:00	0.48	11-Nov-94	22:14:00	-0.10	22-Nov-94	14:14:00	0.15
01-Nov-94	07:14:00	0.40	11-Nov-94	23:14:00	-0.10	22-Nov-94	15:14:00	0.06
01-Nov-94	08:14:00	0.31	12-Nov-94	00:14:00	-0.10	22-Nov-94	16:14:00	-0.01
01-Nov-94	09:14:00	0.31	12-Nov-94	01:14:00	-0.10	22-Nov-94	17:14:00	-0.01
01-Nov-94	10:14:00	0.23	12-Nov-94	02:14:00	-0.01	22-Nov-94	18:14:00	0.06
01-Nov-94	11:14:00	0.23	12-Nov-94	03:14:00	-0.01	22-Nov-94	19:14:00	0.15
01-Nov-94	12:14:00	0.23	12-Nov-94	04:14:00	-0.01	22-Nov-94	20:14:00	-0.01
01-Nov-94	13:14:00	0.15	12-Nov-94	05:14:00	-0.01	22-Nov-94	21:14:00	-0.01
01-Nov-94	14:14:00	0.15	12-Nov-94	06:14:00	-0.01	22-Nov-94	22:14:00	-0.01
01-Nov-94	15:14:00	0.15	12-Nov-94	07:14:00	-0.01	22-Nov-94	23:14:00	-0.01
01-Nov-94	16:14:00	0.15	12-Nov-94	08:14:00	-0.01	23-Nov-94	00:14:00	-0.01
01-Nov-94	17:14:00	0.15	12-Nov-94	09:14:00	-0.01	23-Nov-94	01:14:00	-0.10
01-Nov-94	18:14:00	0.15	12-Nov-94	10:14:00	-0.01	23-Nov-94	02:14:00	-0.10
01-Nov-94	19:14:00	0.15	12-Nov-94	11:14:00	-0.01	23-Nov-94	03:14:00	-0.10
01-Nov-94	20:14:00	0.15	12-Nov-94	12:14:00	0.06	23-Nov-94	04:14:00	-0.10
01-Nov-94	21:14:00	0.15	12-Nov-94	13:14:00	0.06	23-Nov-94	05:14:00	-0.10
01-Nov-94	22:14:00	0.15	12-Nov-94	14:14:00	0.15	23-Nov-94	06:14:00	-0.10
01-Nov-94	23:14:00	0.06	12-Nov-94	15:14:00	0.15	23-Nov-94	07:14:00	-0.10
02-Nov-94	00:14:00	0.06	12-Nov-94	16:14:00	0.15	23-Nov-94	08:14:00	-0.10
02-Nov-94	01:14:00	0.06	12-Nov-94	17:14:00	0.06	23-Nov-94	09:14:00	-0.01
02-Nov-94	02:14:00	-0.01	12-Nov-94	18:14:00	-0.01	23-Nov-94	10:14:00	-0.01
02-Nov-94	03:14:00	-0.10	12-Nov-94	19:14:00	-0.01	23-Nov-94	11:14:00	0.15
02-Nov-94	04:14:00	-0.10	12-Nov-94	20:14:00	-0.01	23-Nov-94	12:14:00	0.06
02-Nov-94	05:14:00	-0.10	12-Nov-94	21:14:00	-0.01	23-Nov-94	13:14:00	0.06
02-Nov-94	06:14:00	-0.10	12-Nov-94	22:14:00	-0.01	23-Nov-94	14:14:00	0.06
02-Nov-94	07:14:00	-0.10	12-Nov-94	23:14:00	-0.01	23-Nov-94	15:14:00	0.06
02-Nov-94	08:14:00	-0.10	13-Nov-94	00:14:00	-0.01	23-Nov-94	16:14:00	-0.01
02-Nov-94	09:14:00	-0.10	13-Nov-94	01:14:00	-0.01	23-Nov-94	17:14:00	-0.01
02-Nov-94	10:14:00	0.15	13-Nov-94	02:14:00	-0.01	23-Nov-94	18:14:00	0.06
02-Nov-94	11:14:00	0.31	13-Nov-94	03:14:00	-0.01	23-Nov-94	19:14:00	-0.01
02-Nov-94	12:14:00	0.31	13-Nov-94	04:14:00	-0.01	23-Nov-94	20:14:00	-0.10
02-Nov-94	13:14:00	0.31	13-Nov-94	05:14:00	-0.01	23-Nov-94	21:14:00	-0.10
02-Nov-94	14:14:00	0.23	13-Nov-94	06:14:00	-0.01	23-Nov-94	22:14:00	-0.10
02-Nov-94	15:14:00	0.15	13-Nov-94	07:14:00	-0.01	23-Nov-94	23:14:00	-0.10
02-Nov-94	16:14:00	0.06	13-Nov-94	08:14:00	-0.01			

APPENDIX E: **Raw water chemistry data, Hinton flume experiment fall 1994.**

Trough #	Treatment	Date	NO_2+ NO_3	NH_4	SRP	TP	TDP
1	25	27-Oct-94	-1.0	-1.0	48.5	-1.0	-1.0
2	10	27-Oct-94	-1.0	-1.0	19.0	-1.0	-1.0
3	1	27-Oct-94	-1.0	-1.0	6.5	-1.0	-1.0
4	0	27-Oct-94	-1.0	-1.0	5.3	-1.0	-1.0
5	25	27-Oct-94	-1.0	-1.0	46.9	-1.0	-1.0
6	1	27-Oct-94	-1.0	-1.0	6.3	-1.0	-1.0
7	10	27-Oct-94	-1.0	-1.0	14.8	-1.0	-1.0
8	1	27-Oct-94	-1.0	-1.0	5.8	-1.0	-1.0
9	0	27-Oct-94	-1.0	-1.0	4.9	-1.0	-1.0
10	10	27-Oct-94	-1.0	-1.0	15.9	-1.0	-1.0
11	0	27-Oct-94	-1.0	-1.0	5.3	-1.0	-1.0
12	25	27-Oct-94	-1.0	-1.0	27.5	-1.0	-1.0
1	25	03-Oct-94	-1.0	-1.0	44.1	-1.0	-1.0
2	10	03-Oct-94	-1.0	-1.0	3.5	-1.0	-1.0
3	1	03-Oct-94	-1.0	-1.0	3.3	-1.0	-1.0
4	0	03-Oct-94	-1.0	-1.0	3.5	-1.0	-1.0
5	25	03-Oct-94	-1.0	-1.0	3.6	-1.0	-1.0
6	1	03-Oct-94	-1.0	-1.0	3.2	-1.0	-1.0
7	10	03-Oct-94	-1.0	-1.0	3.4	-1.0	-1.0
8	1	03-Oct-94	-1.0	-1.0	3.2	-1.0	-1.0
9	0	03-Oct-94	-1.0	-1.0	3.7	-1.0	-1.0
10	10	03-Oct-94	-1.0	-1.0	3.5	-1.0	-1.0
11	0	03-Oct-94	-1.0	-1.0	3.5	-1.0	-1.0
12	25	03-Oct-94	-1.0	-1.0	4.5	-1.0	-1.0
1	25	11-Oct-94	-1.0	-1.0	24.1	-1.0	-1.0
2	10	11-Oct-94	-1.0	-1.0	13.6	-1.0	-1.0
3	1	11-Oct-94	-1.0	-1.0	2.7	-1.0	-1.0
4	0	11-Oct-94	-1.0	-1.0	1.8	-1.0	-1.0
5	25	11-Oct-94	-1.0	-1.0	44.7	-1.0	-1.0
6	1	11-Oct-94	-1.0	-1.0	2.8	-1.0	-1.0
7	10	11-Oct-94	-1.0	-1.0	12.3	-1.0	-1.0
8	1	11-Oct-94	-1.0	-1.0	2.7	-1.0	-1.0
9	0	11-Oct-94	-1.0	-1.0	1.8	-1.0	-1.0
10	10	11-Oct-94	-1.0	-1.0	15.0	-1.0	-1.0
11	0	11-Oct-94	-1.0	-1.0	2.6	-1.0	-1.0
12	25	11-Oct-94	-1.0	-1.0	40.8	-1.0	-1.0
1	25	17-Oct-94	-1.0	-1.0	47.9	-1.0	-1.0
2	10	17-Oct-94	-1.0	-1.0	10.9	-1.0	-1.0
3	1	17-Oct-94	-1.0	-1.0	2.3	-1.0	-1.0
4	0	17-Oct-94	-1.0	-1.0	1.6	-1.0	-1.0
5	25	17-Oct-94	-1.0	-1.0	31.1	-1.0	-1.0
6	1	17-Oct-94	-1.0	-1.0	2.7	-1.0	-1.0
7	10	17-Oct-94	-1.0	-1.0	14.8	-1.0	-1.0
8	1	17-Oct-94	-1.0	-1.0	2.7	-1.0	-1.0
9	0	17-Oct-94	-1.0	-1.0	2.1	-1.0	-1.0
10	10	17-Oct-94	-1.0	-1.0	2.0	-1.0	-1.0
11	0	17-Oct-94	-1.0	-1.0	1.7	-1.0	-1.0

12	25	17-Oct-94	-1.0	-1.0	68.1	-1.0	-1.0
1	25	31-Oct-94	-1.0	-1.0	21.6	-1.0	-1.0
2	10	31-Oct-94	-1.0	-1.0	10.0	-1.0	-1.0
3	1	31-Oct-94	-1.0	-1.0	1.7	-1.0	-1.0
4	0	31-Oct-94	-1.0	-1.0	0.6	-1.0	-1.0
5	25	31-Oct-94	-1.0	-1.0	29.1	-1.0	-1.0
6	1	31-Oct-94	-1.0	-1.0	1.8	-1.0	-1.0
7	10	31-Oct-94	-1.0	-1.0	8.9	-1.0	-1.0
8	1	31-Oct-94	-1.0	-1.0	1.5	-1.0	-1.0
9	0	31-Oct-94	-1.0	-1.0	1.0	-1.0	-1.0
10	10	31-Oct-94	-1.0	-1.0	16.4	-1.0	-1.0
11	0	31-Oct-94	-1.0	-1.0	1.4	-1.0	-1.0
12	25	31-Oct-94	-1.0	-1.0	42.9	-1.0	-1.0
1	25	07-Nov-94	-1.0	-1.0	27.8	-1.0	-1.0
2	10	07-Nov-94	-1.0	-1.0	14.1	-1.0	-1.0
3	1	07-Nov-94	-1.0	-1.0	7.0	-1.0	-1.0
4	0	07-Nov-94	-1.0	-1.0	6.1	-1.0	-1.0
5	25	07-Nov-94	-1.0	-1.0	32.6	-1.0	-1.0
6	1	07-Nov-94	-1.0	-1.0	1.9	-1.0	-1.0
7	10	07-Nov-94	-1.0	-1.0	26.2	-1.0	-1.0
8	1	07-Nov-94	-1.0	-1.0	2.2	-1.0	-1.0
9	0	07-Nov-94	-1.0	-1.0	2.0	-1.0	-1.0
10	10	07-Nov-94	-1.0	-1.0	10.9	-1.0	-1.0
11	0	07-Nov-94	-1.0	-1.0	1.6	-1.0	-1.0
12	25	07-Nov-94	-1.0	-1.0	35.0	-1.0	-1.0
1	25	14-Nov-94	-1.0	-1.0	35.2	-1.0	-1.0
2	10	14-Nov-94	-1.0	-1.0	10.2	-1.0	-1.0
3	1	14-Nov-94	-1.0	-1.0	1.7	-1.0	-1.0
4	0	14-Nov-94	-1.0	-1.0	0.6	-1.0	-1.0
5	25	14-Nov-94	-1.0	-1.0	31.7	-1.0	-1.0
6	1	14-Nov-94	-1.0	-1.0	1.5	-1.0	-1.0
7	10	14-Nov-94	-1.0	-1.0	19.2	-1.0	-1.0
8	1	14-Nov-94	-1.0	-1.0	1.3	-1.0	-1.0
9	0	14-Nov-94	-1.0	-1.0	0.5	-1.0	-1.0
10	10	14-Nov-94	-1.0	-1.0	9.8	-1.0	-1.0
11	0	14-Nov-94	-1.0	-1.0	0.3	-1.0	-1.0
12	25	14-Nov-94	-1.0	-1.0	35.2	-1.0	-1.0
1	25	21-Nov-94	-1.0	-1.0	1.1	-1.0	-1.0
2	10	21-Nov-94	-1.0	-1.0	10.4	-1.0	-1.0
3	1	21-Nov-94	-1.0	-1.0	1.3	-1.0	-1.0
4	0	21-Nov-94	-1.0	-1.0	1.7	-1.0	-1.0
5	25	21-Nov-94	-1.0	-1.0	28.3	-1.0	-1.0
6	1	21-Nov-94	-1.0	-1.0	1.9	-1.0	-1.0
7	10	21-Nov-94	-1.0	-1.0	9.4	-1.0	-1.0
8	1	21-Nov-94	-1.0	-1.0	2.6	-1.0	-1.0
9	0	21-Nov-94	-1.0	-1.0	1.6	-1.0	-1.0
10	10	21-Nov-94	-1.0	-1.0	12.6	-1.0	-1.0
11	0	21-Nov-94	-1.0	-1.0	1.0	-1.0	-1.0
12	25	21-Nov-94	-1.0	-1.0	24.0	-1.0	-1.0
HEAD		27-Oct-94	40.8	3.0	5.0	29.6	1.7
HEAD		03-Oct-94	64.7	77.5	3.2	46.5	2.6

HEAD	11-Oct-94	62	21.3	2.0	14.1	3.3
HEAD	17-Oct-94	65.2	-5.0	3.7		
HEAD	31-Oct-94	71.6	16.2	0.9	61.9	4.2
HEAD	07-Nov-94	68.1	5.2	2.0		
HEAD	14-Nov-94	61.1	11.2	0.6		
HEAD	21-Nov-94	90.0	25.6	1.5		

APPENDIX F: Raw taxonomic data, Hinton flume experiment spring and fall, 1994

		Trough											
Division	Species	1	2	3	4	5	6	7	8	9	10	11	12
Chrysophyta - Diatoms													
Spring 1994(million/m^2)	Achnanthes flexella							0.5			0.2		1.3
	Achnanthes minutissima	10.2	60.8	52.5	20.5	15.3	8.3	8.8	8.3	4.1	20.5	6.7	23.2
	Amphipleura pellucida			0.5									
	Amphora ovalis					0.2	0.2						
	Cocconeis placentula			0.9		0.7	1.0	0.5			0.2	0.2	
	Cymatopleura solea											0.2	
	Cymbella caespitosa	0.2				0.5	0.2		0.5				
	Cymbella ventricosa	1.3	2.9	5.1	1.4	2.4	3.8	1.4	3.1		5.7	1.7	2.9
	Diatoma tenue v. elongatum	1.9	8.6	25.8	5.5	14.1	2.6	2.4	1.9	5.0	3.1	1.9	8.9
	Fragilaria crotonensis		7.2	7.5	6.4	1.9	3.3	1.4	1.9	1.2	3.1	1.0	1.9
	Fragilaria sp.	14.9	80.1	25.3	12.4	12.6	4.1	13.8	10.3	8.1	21.7	10.0	29.9
	Gomphonema geminatum		0.7			0.7			0.7		0.5		0.3
	Gomphonema olivaceum	0.6		0.9	0.5	3.3	0.5	1.0	1.7	1.0	1.0	0.7	3.5
	Hannaea arcus	0.2		1.4		1.0	0.5	0.2	1.0	0.5	0.7	0.7	1.0
	Meridion circulare				0.5								
	Navicula sp.		0.7	1.4	0.2	0.7	0.2	1.0	0.5	0.2	0.7	1.4	1.6
	Nitzschia acicularis	0.6	7.9	4.2	2.4	1.2		0.7			2.4	1.9	1.9
	Nitzschia palea	11.1	42.2	15.0	9.5	21.2	2.6	12.2	1.7	2.9	22.4	2.2	32.7
	Opephora sp.	2.9	12.2	0.5		7.6		1.7	0.7	0.5	6.0	0.5	6.7
	Stauroneis sp.								0.2				
	Synedra ulna	1.3	2.1	2.4	0.7	1.4	1.7	0.5	1.0	0.2	0.2		1.0
	Total	45.2	225.4	143.4	60.0	84.8	29.0	46.1	33.5	23.7	88.4	29.1	116.8

Division	Species	2	3.0	4.0	5.0	6.0	8.0	10.0	11.0	12.0
Chrysophyta - Diatoms										
Fall 1994 (million/m^2)	Achnanthes minutissima	0.5	0.1	0.2	0.5	0.1	0.2	0.1	0.1	0.6
	Cymbella caespitosa	0.1				0.1				
	Cymbella cistula				0.1					
	Cymbella ventricosa	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.1
	Diatoma tenue v. elongatum	4.8	1.7	1.8	2.0	2.3	1.1	2.3	0.6	1.2
	Fragilaria construens v. venter			0.4						
	Fragilaria crotonensis	0.6	0.2	0.2	0.5		0.3	0.3	0.1	0.2
	Fragilaria vaucheriae	0.6	0.3	0.5	0.2	0.7	0.4	0.8	0.2	0.2
	Gomphonema geminatum				0.1	0.1				
	Gomphonema olivaceum	0.1	0.1		0.3		0.1	0.1	0.1	0.1
	Hannaea arcus			0.1	0.2	0.2	0.1	0.2		0.1
	Navicula sp.			0.3	0.2	0.2	0.1			
	Nitzschia acicularis	0.1						0.1		
	Synedra ulna	1.5	0.6	1.0	1.6	3.0	0.8	1.7	0.4	1.7
	Total	8.5	3.2	4.8	6.0	6.9	3.3	5.8	1.6	4.2