Lake Tahoe Water Quality Investigations

Algal Bioassay • Phytoplankton • Atmospheric Nutrient Deposition • Periphyton

May 1, 2002 - March 31, 2004

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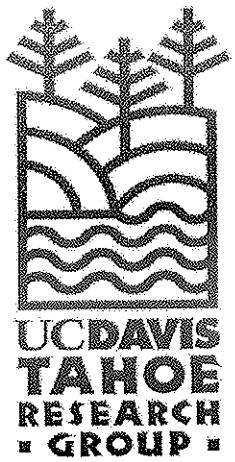
Lahontan Regional Water Quality Control Board



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Project Overview

The following document is our draft final report for work completed during the 22 month Agreement No. 01-175-160-0 Revised; Lake Tahoe Water Quality Investigations by the U.C. Davis-Tahoe Research Group (TRG).

The purpose of this contract was to provide the TRG with supplemental operating funds to continue their limnological/water quality studies of Lake Tahoe. Emphasis was placed on monitoring related to atmospheric deposition of nutrients, phytoplankton enumeration and identification, algal growth bioassays and periphyton biomass sampling.

The focus of this $150,000 per year effort was primarily to ensure the continued collection of key water quality related data; this was primarily a data collection project. For the topics of algal growth bioassays and phytoplankton enumeration and identification we provide a comprehensive summary of the collected data, referring to the historic data base when appropriate. For periphyton, we provide a more extensive evaluation as specified in the scope of work. The work on atmospheric deposition of nutrients was intended as a data collection exercise – no attempt was made in this report to summarize all the data.

These data, and the rich historical Tahoe data base as collected over the years by the TRG and other groups is currently being used to support the Tahoe TMDL. Atmospheric deposition data is being analyzed for the Lake Tahoe Atmospheric Deposition Project (California Air Resources Control Board); algal bioassay and phytoplankton enumeration data is being used in the Lake Clarity Model (UCD), and the periphyton results are currently part of the Adaptive Management Framework discussions. In addition to the direct use of this data in these environmental research and planning efforts, it is also used to support scientific journal publications as needed. While the scope of work called for analysis of zooplankton in addition to phytoplankton, our effort was placed on phytoplankton in order to provide data for the Lake Clarity Model. Samples for zooplankton were collected in the field, preserved, and archived for future analysis when necessary. The number of phytoplankton samples analyzed exceeded the combined requirement for phytoplankton and zooplankton.

The format of this report is arranged by work task. The Appendix includes each of the detailed Quarterly Progress Reports.

Task	% Completion
1 – Project Management	100
2 – Quality Assurance	100
3 - Algal Growth Bioassays	100
4 – Plankton Analysis	100
5 – Atmospheric Deposition of Nutrients	100
6 - Periphyton	100
7 - Reporting	100

Task 1. Project Management and Administration

Project management included, sampling coordination, sampling design, discussions with staff, assist in data evaluation, interfacing with agency staff, and incorporation of data into other Tahoe Basin research/monitoring projects (e.g. Clarity Model, TMDL Research Program, etc.). In addition to this overall project coordination, each of the tasks required specific management.

Task 2. Project Quality Assurance

Standardized QA/QC practices for each component, as specified in the TRG QA/QC Manual were followed (M. Janik, E. Byron, D. Hunter and J. Reuter. 1990. Lake Tahoe Interagency Monitoring Program: Quality Assurance Manual, 2nd Edition. Division of Environmental Studies, Univ. California, Davis. 75 p.). Appendix A contains the periphyton QAPP that was developed for this contract.

Task 3 – Algal Growth Bioassays

Introduction

Bioassays of Lake Tahoe water have linked nutrient additions to stimulated algal growth. Many factors contribute to nutrient loading at Lake Tahoe, e.g. land disturbance, urbanization, increase in impervious surfaces, erosion, atmospheric deposition, fertilizer application, groundwater, loss of natural' filters such as wetlands and riparian corridors, etc. Current results from the optical portion of the Lake Tahoe Clarity Model suggest that between 1999-2003, approximately 20-30% of the measured Secchi depth could bee explained by algal particles. Therefore it is important to control the growth these phytoplankton algae where possible by reducing nitrogen and phosphorus loading.

The response of Lake Tahoe water to nitrogen and phosphorus enrichment has been tested using algal bioassays since the 1960s. Goldman et al. (1993) presented a 25-year record of bioassays conducted at Lake Tahoe showing that a decadal scale transition from N and P co-limitation to primarily P limitation occurred around 1980. In this study, the authors examined the long-term set of 110 bioassays (1967-1992) that tested response to either N or P additions alone, for the presence of trends on the decadal scale. In earlier tests (1967-1981), stimulation of growth was observed in about 45% of the N bioassays and also in about 25% of the P bioassays. In later tests (1982-1992), P stimulation was observed more frequently (nearly 90% of the P bioassays), while N stimulation was rare (occurring in 7% of the N bioassays).

Algal bioassays are experiments in which small amounts of nutrients or other chemicals are added to algae under controlled conditions, with the change in growth directly measured. The bioassays most commonly done at Tahoe since the 1960s have been (3-7) day in duration and utilize the natural phytoplankton community. These assemblages, obtained directly from the lake, are used since they are adapted to the nutrient supply conditions in the lake and include the naturally diverse composition of algal species (which may also have differing nutritional needs). Enrichment bioassays provide an indication of nutrient limitation. A nutrient is said to be "limiting" when it is in shortest supply relative to phytoplankton needs and therefore its abundance controls the growth of the organism. In extrapolation of the bioassay results to the lake as a whole consideration must be given to the fact that these small-scale bioassays eliminate many important nutrient fluxes and alter the physical, chemical and biological environment. However, since (1) the euphotic zone of Lake Tahoe is not significantly influenced by nutrient processing in the bottom sediments, (2) the residence time for nutrients can be on the order of decades, and (3) top-down or biological processes do not appear to regulate algal biomass, the results of these bioassays are considered to be highly relevant.

The long record of bioassays for Lake Tahoe, using a consistent method, has proved extremely useful for evaluating long-term changes. When combined with lake chemistry data, and information on atmospheric and watershed nutrient loading ratios, these simple enrichment bioassays have provided valuable complementary evidence on the temporal dynamics of nutrient limitation in the lake.

Monitoring Objectives

The objective of the funding for this task was to continue the performance of the algal bioassays in a manner consistent with the historical approach. While it is our intent to do a 10-year update of the Goldman et al. 1993 analysis of the entire data set, that is not the purpose here. That, more complete analysis will include all data since 1967.

Methodology Overview

In a typical bioassay, lake water is collected from the upper photic zone (0-20 m water was used for these bioassays), pre-filtered through 80 μm mesh netting to remove the larger zooplankton and returned to the lab. The water is distributed among experimental flasks to which small amounts of N (20 μg N/L) or P (10 μg P/L) or the combination of both are added. One set of flasks is left as a "control" and all treatments are triplicated. The flasks are then placed in a laboratory incubator under fluorescent lighting at ambient lake temperature and day length, and growth response of phytoplankton is measured over a period ranging from 3-7 days. Relative growth was assessed by measuring changes in algal biomass (i.e. fluorescence or chlorophyll a). Treatments are "stimulatory" if the mean growth response exceeds the control at the $p=0.05$ level of significance.

Summary of Results

The details and statistical evaluation of each of the individual bioassay are presented in Table 3. In this summary we evaluate 16 separate bioassay experiments – six were conducted in 2002 (February, April, June, August, October and December, nine were conducted in 2003 (January, February, April, May, June, July, August, October and December) and one was conducted in 2004 (January). At about 6-8 per year, this rate is much higher than used in the 1993 evaluation (see Table 1).

Treatments during the 2002-early 2004 study included a control, N20 (same as N with a 20 μg/L final concentration), P2, P10, N20P2, and N20P10. This amounted to a total of 96 treatments (including controls) for the 16 individual bioassay experiments.

While we are extremely hesitant to compare the short 2002-03, 2-year data set with the much longer 1982-1992, 11-year data set, the cursory comparison suggests that while the number of instances of N (alone)-only stimulation still remains low, the relative number of dates when P (alone)-stimulation may have dropped off (Table 2). We need to put this into context with the 1993-2001 data set, but the instances of single nutrient biostimulation could be less than in previous years. This observation is tempered by the fact that in all (100%)of the bioassay experiments a combination of N+P was stimulatory reinforcing the fact that Lake Tahoe phytoplankton is still nutrient deficient and that controls are important.

Table 1—Summary of long-term change in nutrient limitation in Lake Tahoe to a phosphorus stimulated system (from Goldman et al. 1993) and the current 2002-early 2004 data. Values in parentheses indicate percent of bioassays for period that were stimulatory. We refer to this as the 2002-03 since only January of 2004 was run at the time this report was written. Note that data for the entire 35-year period of record (including 1993-2001) will be published separately. It was not part of this contract.

	Not Stimulatory	Stimulatory	Total
	NO_3 bioassays		
1967-81	16	12 (43%)	28
1982-92	29	2 (6%)	31
2002-03	12	3[a] (19%)	16
	PO_4^3 bioassays		
1967-81	14	5 (26%)	19
1982-92	4	28 (87%)	32
2002-03	8	8 (50%)	16

[a] A fourth sample (12/3/03 bioassay) barely showed N-stimulation (107% of control) and was excluded. Due to the small difference from control and uncertainty about whether to include an anomalously high P replicate in the statistics, we chose not to include this marginal value here.

P limitation was more prevalent during the winter during this period of study (with the exception of 12/3/03). The winter period in the lake is characterized by an absence of strong thermal stratification and active mixing upward of deeper lake water. During the summer period of 2002, N and P appeared to be co-limiting, while during summer of 2003, N alone was limiting with the combination of N+P causing even greater growth. In previous summer bioassays, co-limitation or P limitation has been observed. Summer nutrient responses may be more dynamic than winter (when P limitation appears to be prevalent) and are likely related to particular conditions associated with each summer's thermal stratification in the lake. The intended updated analysis of all long-term bioassay data will be useful to further determine patterns of nutrient limitation as related to physical, biological and chemical conditions in the lake.

Table 2 – Summary of N and P bioassay treatment responses as % of control done in (a) 2002, (b) 2003, and (c) 2004. Treatment responses statistically significantly different from the control at the p≤.05 level are indicated with borders and shading.

(a) 2002 Bioassays

	2/7/02	4/1/02	6/12/02	8/30/02	10/28/02	12/30/02
Control	100	100	100	100	100	100
N20	104	97	101	101	93	101
P2	154	-	-	108	-	116
P10	135	157	104	100	113	110
N20P2	139	-	-	157	151	118
N20P10	138	178	180	231	238	116

(b) 2003 Bioassays

	1/30/03	2/26/03	4/8/03	5/21/03	6/16/03	7/10/03	8/29/03	10/20/03	12/3/03
Control	100	100	100	100	100	100	100	100	100
N20	101	98	102	138	116	141	129	101	107
P2	112	129	168	101	99	100	100	100	98
P10	114	134	181	98	104	106	105	106	104
N20P2	141	136	178	253	248	221	196	187	124
N20P10	159	147	190	264	297	317	280	334	142

(c) 2004 Bioassays

	1/5/04
Control	100
N20	100
P2	133
P10	135
N20P2	132
N20P10	134

Table 3 – Presentation of details of results from individual algal growth bioassay experiments.

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 6/12/02.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. (p≤.05) Response ="*"
Control	12.9	0.5	3		
N(20)	13.0	0.3	3	101	
P(10)	13.4	0.2	3	104	
N(20)P(10)	23.2	1.3	3	180	*
Fe(5)Citrate	12.4	0.7	3	97	

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 8/30/02.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	10.0	0.1	3		
N(20)	10.1	1.0	3	101	
P(2)	10.8	1.0	3	108	
P(10)	10.0	0.4	3	100	
Fe(5)Citrate	7.7	0.5	3	77	*
N(20)P(2)	15.7	1.3	3	157	*
N(20)P(10)	23.1	1.0	3	231	*
N(20)P(10)Fe(5)Cit.	38.0	2.9	3	380	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 10/28/02.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	8.8	0.4	3		
N(20)	8.2	0.7	3	93	
P(10)	9.9	0.9	3	113	*
Fe(5)Citrate	8.3	0.3	3	94	
N(20)P(2)	13.3	0.1	3	151	*
N(20)P(10)	20.9	0.4	3	238	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 12/30/02.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.270	0.003	3		
N(20)	0.274	0.002	3	101	
P(2)	0.312	0.011	3	116	*
P(10)	0.298	0.007	3	110	*
N(20)P(2)	0.319	0.008	3	118	*
N(20)P(10)	0.312	0.007	3	116	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 1/30/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.456	0.024	3		
N(20)	0.461	0.008	3	101	
P(2)	0.512	0.011	3	112	*
P(10)	0.521	0.014	3	114	*
N(20)P(2)	0.642	0.011	3	141	*
N(20)P(10)	0.726	0.011	3	159	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 2/26/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.387	0.010	3		
N(20)	0.378	0.003	3	98	
P(2)	0.498	0.010	3	129	*
P(10)	0.519	0.024	3	134	*
N(20)P(2)	0.528	0.014	3	136	*
N(20)P(10)	0.569	0.014	3	147	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 4/8/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.329	0.007	3		
N(20)	0.335	0.006	3	102	
P(2)	0.552	0.020	3	168	*
P(10)	0.595	0.023	3	181	*
N(20)P(2)	0.584	0.013	3	178	*
N(20)P(10)	0.624	0.032	3	190	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 5/21/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.414	0.007	3		
N(20)	0.571	0.011	3	138	*
P(2)	0.417	0.015	3	101	
P(10)	0.408	0.032	3	98	
N(20)P(2)	1.049	0.070	3	253	*
N(20)P(10)	1.095	0.064	2	264	*

Note, the N(20)P(10) treatment had one replicate which was unusually high on the final day, i.e. fluorescence values for this treatment were 1.14, 1.05, and 1.52. The high value of 1.52 was not used in the ANOVA or mean. If this value is included in the ANOVA, the N(20) response (138%) then is not be statistically different from the control.

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 6/16/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.343	0.021	3		
N(20)	0.397	0.017	3	116	
P(2)	0.341	0.018	3	99	
P(10)	0.358	0.014	3	104	
N(20)P(2)	0.851	0.041	3	248	*
N(20)P(10)	1.018	0.062	3	297	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 7/10/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.235	0.015	3		
N(20)	0.331	0.013	3	141	*
P(2)	0.235	0.011	3	100	
P(10)	0.249	0.007	3	106	
N(20)P(2)	0.519	0.023	3	221	*
N(20)P(10)	0.747	0.047	3	317	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 8/29/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.317	0.026	3		
N(20)	0.408	0.002	3	129	*
P(2)	0.317	0.016	3	100	
P(10)	0.334	0.016	3	105	
N(20)P(2)	0.621	0.012	3	196	*
N(20)P(10)	0.886	0.009	2	280	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 10/20/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.216	0.022	3		
N(20)	0.218	0.007	3	101	
P(2)	0.217	0.017	3	100	
P(10)	0.228	0.012	3	106	
N(20)P(2)	0.404	0.010	3	187	*
N(20)P(10)	0.721	0.039	3	334	*

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 12/3/03.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.382	0.015	3		
N(20)	0.408	0.018	3	107	* >see note
P(2)	0.376	0.003	3	98	
P(10)	0.396	0.006	3	104	
N(20)P(2)	0.474	0.010	3	124	*
N(20)P(10)	0.543	0.006	2	142	*

Note- An anomalous high value for P10 treatment was excluded in the statistical analysis (ANOVA) to determine statistical difference from the control in the above. If the anomalous high value (0.508) for the P10 treatment is included the ANOVA, the P10 fluorescence mean then becomes 0.433, Std. Dev. 0.065 and % of Control 113%. Only the N20P2 and N20P10 treatment responses are significantly different from the control if the anomalous value is included in the ANOVA.

Results of bioassay using 2,5,8,11,14,17,20m lake water collected 1/5/04.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.398	0.004	3		
N(20)	0.399	0.013	3	100	
P(2)	0.528	0.012	3	133	*
P(10)	0.536	0.022	3	135	*
N(20)P(2)	0.524	0.007	3	132	*
N(20)P(10)	0.535	0.010	3	134	*

Task 4 – Phytoplankton Community Analysis

Phytoplankton hold a key position in lake biology. As primary producers they are the first step in a tiered food web. For oligotrophic Lake Tahoe, the relatively sparse phytoplankton abundance has a large impact on the success of higher trophic levels. Algal health, distribution, and abundance are indicators of changes throughout the system, both physical and biological. This report summarizes the performance of the phytoplankton communities for two years, 2002-2003.

Methods

Phytoplankton samples were collected from the Index station once every ten days for two years. On each sampling date two composite samples were collected. The first was called the Secchi composite which was comprised of water from the Secchi depth to the surface, usually depths shallower than 20M. The second composite was the euphotic zone composite which included water from depths 105M to the surface. Once a month six additional samples were collected from the discrete depths of 5, 20, 40, 60, 75, 90M. All water was preserved with an iodine preservative. Samples were counted within 2 months of sampling.

The samples were counted using the inverted-microscope method (Utermöhl method) which was introduced in the early 1930's. Sedimentation towers were combined with plate chambers. Generally 100 ml of sample water was poured into the sedimentation tower and the phytoplankton was allowed to settle for 7 days. The sedimentation tower was then slid off of the counting chamber. The chamber was covered with a glass cover plate. The chambers were counted on a Wild M40 phase contrast compound microscope.

The microscope stage stops were set at 1 cm. Generally the entire 1cm2 of area was viewed with low magnification (150X). The largest and most rare cells were counted. Higher magnification (600X) was used to view chamber transects (strips). Particles ≤1μm could be viewed, however, only identifiable cells 4μm or larger were counted. Living cells were counted and identified to the most specific level of taxonomy that was possible. Counts were recorded onto paper, along with drawings, measurements and photographs. The information was later entered into a SQL database management program.

Year 2002 (see Figure 1)

The year began with a relatively high phytoplankton biovolume. Both diatoms and cryptophytes shared dominance equally in a well-mixed euphotic zone. The spring diatom peak occurred in February and was less distinct than in previous years. The pennate diatom *Synedra radians* and the centric diatom *Cyclotella ocellata* shared dominance. The diatoms were found at all depths in the euphotic zone. The ensuing diatom crash (late April) was also less dramatic than in previous years While the diatom populations decreased, their collective biovolume never fell below 20 μg/L. With possibly an infusion of nutrients, it is easy to see that diatom populations recovered rapidly from this low. By early May the diatom biovolume rivaled numbers seen during the earlier diatom peak. However, the diatom community had transitioned with *Asterionella formosa* and *Stephanodiscus alpina* sharing dominance at all the euphotic depths.

This second diatom peak was different because of a shared dominance with cryptophytes and chrysophytes. Numerically, the chrysophytes were the most abundant.
The combined biovolume of all phytoplankton in early June (116 µg/L) was the 2002 biovolume peak.

The lake started to thermally stratify in May. The phytoplankton communities divided into niches where the conditions best favored their continued growth. The deep chlorophyll maximum began to form in early May and was stable by June. Most of the phytoplankton biomass was located in deeper water. The same communities that formed the May peak in the surface waters could now be found in waters 60M and below (Cryptophytes, *Asterionella formosa, Stephanodiscus alpina and Synedra radians*). The upper waters (<20M) were populated with Chrysophytes and the small centric diatom *Cyclotella glomerata*. As the summer progressed, *Cyclotella glomerata* attained remarkably high abundance.

The overall phytoplankton biovolume for the summer was unusually strong and consistent. It was not until mid-August that populations began to diminish. Diatoms were dominant throughout the summer and early fall but other phytoplankton groups contributed significantly to the biovolume total.

One additional observation that might have had some impact on the visibility in surface waters was the presence of identifiable algal detritus. The chrysophyte, *Dinobryon bavaricum*, was found living throughout the water column in high numbers in May and June. The cell itself is a flagellate housed inside a siliceous structure called a lorica. The overall contribution of *Dinobryon sp.* to the biovolume in May and June was slight since the flagellates were so small. However, it should be noted that the lorica structures remained in the water column for most of the summer. These structures were not counted because the cells were not "alive". Nevertheless, the loricas were numerous and distinctive particulates in the samples.

The autumn phytoplankton community was transitional. The physical processes of thermocline breakdown and mixing controlled assemblage changes. The October samples reflect a stratified water column. As in the summer, the biovolume was less in the surface waters and greater in the deep chlorophyll maximum. Evidence of mixing in the surface waters could be seen in early November. The mixing continued and by December the assemblage composition and species richness were identical throughout the euphotic zone.

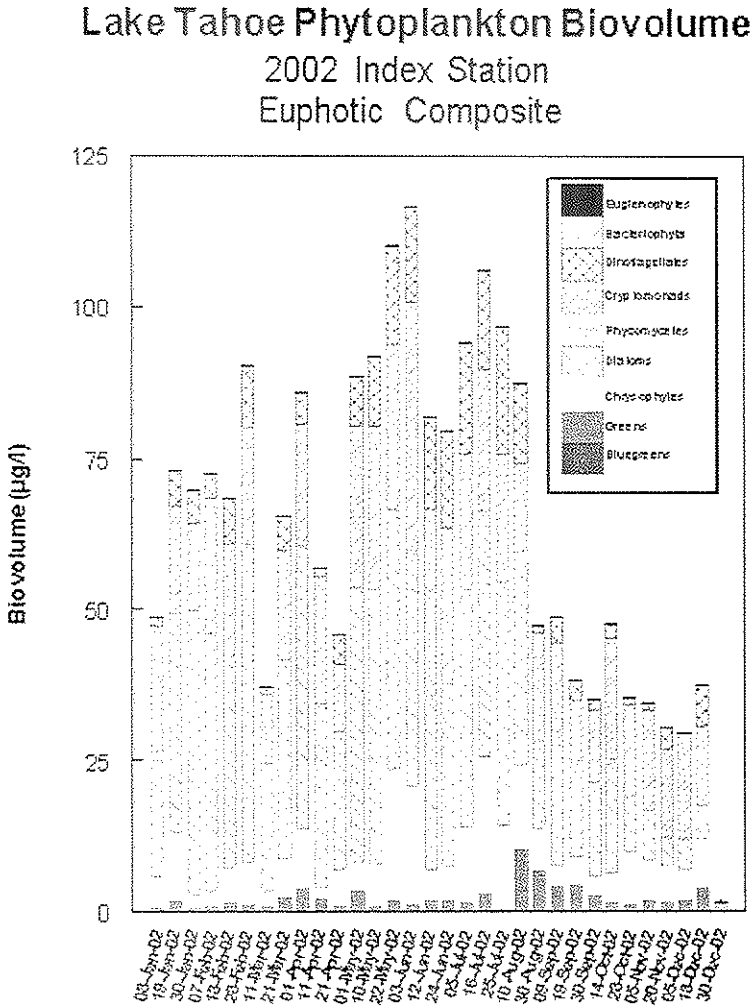

Figure 1

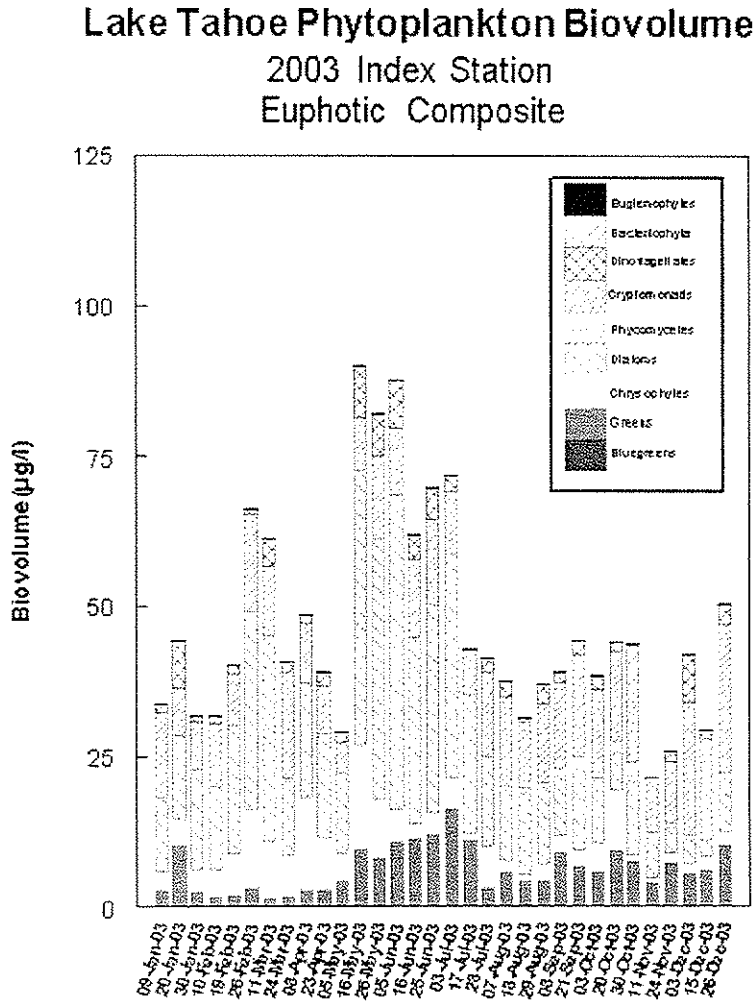

Figure 2

The total phytoplankton biovolume began to decline in September and that trend continued through October and November, with the lowest biovolume of the year in early December. The phytoplankton communities appeared to be in poor health, dying. The community composition did not change. The physical conditions of the water were not advantageous to new growth and no one algal species was dominant. In December, the phytoplankton assemblage took a more defined direction and Cryptomonads were clearly dominant.

The species richness (number of species identified) remained high even though the biovolume decreased. One exception was the euphotic composite (0–105M), sampled on December 30, 2002, which had a total of only 13 identified species (annual low). However, the Secchi composite (0 – 20M) sampled on that same day, by contrast, had 36 species (annual high).

A notable observation was that samples had an unusually high amount of detrital particulates, both large and small. Empty diatom frustules and *Dinobryon sp.* loricas littered the counting chambers.

Year 2003 (see Figure 2)

The phytoplankton community from December – February was in a winter-time mode typified by low biovolume and high diversity. Turbulent waters and higher nutrient availability were favorable to many phytoplankton but the low light conditions limited growth. The phytoplankton biovolume remained low until the middle of February 2003. Gradually phytoplankton communities started to grow with diatoms and small flagellated chrysophytes leading the way.

Most planktonic growth and biovolume was found in the surface waters (<20M) for December and January. Beginning in February, the phytoplankton biovolume seemed to be higher in the deep water but it was not a strong trend. The water column was nearly isothermal so seasonal storms could have easily disrupted any trend in distribution.

The phytoplankton community was quite interesting during the winter months. While the overall biovolume was low and somewhat insignificant when compared to other times of the annual cycle, it was the equality of shared dominance that was remarkable. Cryptomonads (*Rhodomonas lacustris*) and heavier planktonic diatoms were found in the surface waters where growth conditions were favorable. Typically this is the only time of year that these phytoplankton types are found in shallow waters. In January and February, the diatoms *Cyclotella ocellata* and *Achnanthes microcephala* were growing in abundance. Also, small flagellates (chrysophytes) grew to rather high numbers. Most of the communities were healthy and viable. The samples had detrital particulates but were generally clearer than at other times of the year.

As seen in 2002, the diatom peaks were bimodal. The first peak, seen in late February, was only 33 µg/L diatom biovolume. The dominant diatom was the centric *Cyclotella ocellata.* Thereafter, the diatom abundance and biovolume decreased until a second peak in early May. The second peak was more substantial, with diatom biovolume reaching 46 µg/L (53% of the total community). Both *Cyclotella ocellata* and *Cyclotella stelligera* were dominant during this peak period. Indeed, the spring phytoplankton assemblage was marked by its unusual shared

dominance between algal groups. Chrysophytes, in particular, were abundant (~20% of total sample biovolume). The annual biovolume peak was seen in early May with 90µg/L. The phytoplankton biovolume was evenly distributed throughout the euphotic depths. The species richness remained consistent, with an average of 29 species per sample.

Stratified waters were well established by June. Waters shallower than 20M had lower algal biovolume and species richness. The chlorophyll maximum was located at 40-60M in the early summer.

The summer phytoplankton community was marked by lower than usual biovolume (73 µg/L June to 35µg/L August). Similar to previous summer assemblages, the diatoms accounted for greater than 50% of the community, in terms of biovolume and abundance. Secondary dominance was shared between Cryptophytes (small flagellates) and Chlorophytes (greens).

The summer diatoms were dominated by two species of *Cyclotella*. *Cyclotella stelligera* and *Cyclotella glomerata* had the ability to survive in warm, light saturated, nutrient-deficient surface water conditions. They were the dominant species in the upper 20m throughout the summer. In July one pennate, *Achnanthes microcephala,* became numerically important at the mid-range depths. The highest abundance and biovolume of algae was at 60M. Once again, *Cyclotella ocellata* was the biovolume dominant. By August the diatom biovolume had decreased. The highest abundance was at 75M and the highest diatom biovolume was at 90M. These numbers reflected a community that was sinking out of the euphotic zone. The average species richness during the summer months was 31 species per sample.

In the autumn of 2003 total phytoplankton biovolume was fairly constant (40 µg/L). This was similar to biovolume totals seen in 2002. Biovolume began to drop off significantly by early November (21 µg/L). The phytoplankton community was not dominated by any one group of phytoplankton. Similar to the autumn of 2002, the biovolume was low, with high diversity. The species richness was 41 species per sample in late September.

The phytoplankton vertical distribution in September looked identical to the distribution from summer. *Cyclotella sp.* continued their dominance in the surface waters. In early October there was evidence of mixing in the surface with the decrease in *Cyclotella sp.* and the appearance of *Rhodomonas lacustris*, a species that resides in the deep chlorophyll maximum during the summer. *Cyclotella sp.* continued as the diatom dominant throughout the autumn.

The November and December samples had a higher than normal detritus content. The particles were definitely organic but the source could not be identified. Most of the particles were in the Secchi region but could be found throughout the upper 100M.
The quantity of particles was alarming, affecting the volume of phytoplankton sample that was settled.

Summary

The phytoplankton average biovolume for 2002 (64 µg/L) was the highest value since 1995. The phytoplankton average biovolume for 2003 was less (46 µg/L), more like the years just prior to 2002.

The phytoplankton communities were quite variable from one year to the next. These two years (2002 & 2003) were good examples. There was a loose pattern of phytoplankton progression throughout the year. However, it seemed to be driven mostly by seasonal climate changes and physical/chemical characteristics of the water column. Every spring there was a diatom bloom. However, the timing of the bloom, the magnitude, and most importantly, the diatom species that dominated, was not predictable.

The bimodal diatom peaks seen in both 2002 and 2003 were atypical to the annual patterns seen in previous years. Usually there is only one diatom peak in the spring. At that time, diatoms comprise over 60% of the total phytoplankton assemblage in March and April. However, in both 2002 and 2003 the first diatom bloom was seen early, in February, followed by low diatom biovolume in March and April. The second peak was seen in May extending into July. The diatoms, while dominant, were not the only algal groups contributing to these second biovolume peaks. The diatoms accounted for only 50% of the total phytoplankton assemblage.

Diatoms were the dominant algae in Lake Tahoe but their relative importance, as measured by their standing stock, was diminishing. In 2002 the phytoplankton dominance was shared between three groups: diatoms, cryptomonads, and chrysophytes. In 2003, once again, the diatoms shared dominance. The chrysophytes, however, did not perform as well as previous years. Instead, the chlorophytes, for the first time, were relatively competitive in terms of biovolume and abundance.

The species richness (# species/sample) was used as a qualitative index of diversity. Over the past decade in Lake Tahoe this index number has gradually increased. In 2002 there was an average of 29 species per sample and in 2003 there was an average of 32 species per sample. The increased diversity could be a function of niche diversification.

The high species richness seen in 2003 was a direct result of the strong performance in green algae (chlorophytes). As a group, the greens had their best performance of **any** year. The green algae ranged from 15-23% of the total biovolume. Compare this to 2002, where the greens ranged from 4-15%. Changes in this group of phytoplankton may have the strongest long-term implications for the trophic level of Lake Tahoe. In most instances, green algae are considered indicators which reflect increased eutrophication.

Phytoplankton are important in many ways to the current research. Phytoplankton, being particulates, affect water clarity. Phytoplankton, as plants, reflect the system's productivity. Phytoplankton, viewed only from the context of community complexity, are indicators of trophic changes in Lake Tahoe.

Task 5. Atmospheric Deposition of Nitrogen and Phosphorus

Summary

The historical TRG data shows that atmospheric deposition of nitrogen, and to a lesser extent phosphorus is an important source of nutrients to the lake. The TRG has estimated that atmospheric deposition contributes about 234 metric tons of nitrogen and 12.4 metric tons of total phosphorus to the lake per year. This amounts to about 56% of the total nitrogen input and 27% of the total phosphorus input into the lake during a year. Increased deposition of nitrogen from anthropogenic sources was concluded by the TRG to be the cause of a fundamental shift in nutrient limitation in Lake Tahoe from N and P co-limitation to primarily P limitation. Monitoring of atmospheric deposition is crucial to understanding it's role in degradation of the lake and for use in watershed management.

The TRG has maintained an atmospheric deposition monitoring program with sites both in the watershed and on the lake surface for an extended period. Two stations have been monitored in Ward Valley, one at about 2200 m in the North Bowl of Ward has been in operation since the early 1970's, and the other station near the mouth of Ward Creek has been in operation since the early 1980's. Other stations have also been monitored by the TRG around the lake including stations in the watershed at: South Shore (Meyers or Bijou), the east shore (Glenbrook), the north shore (Incline Village or Tahoe Vista). A monitoring program to determine atmospheric deposition directly to the lake was begun in the 1980's and has continued through to the present. Atmospheric deposition collectors have been placed out on lake buoys with a primary monitoring station established at mid-lake. Additional atmospheric monitoring stations have been placed on the lake at various locations through time. Information collected from all these stations has proved valuable in assessing the importance of atmospheric loading of nutrients to the lake. It has also provided a historical record of precipitation amounts and water quality in the Ward Valley watershed. This data may be may also be valuable for providing information on past and current trends in atmospheric deposition.

The funding provided for Task 5 monitoring was to allow for atmospheric monitoring at 3 primary stations: the Upper Ward Valley station, the lower Ward Lake Level station, and the Mid-lake station. Thirty samples per year were to be collected at each site for this two-year study. Due to the importance of atmospheric deposition data collected from the lake surface we also monitored deposition at two additional sites between the mid-lake station and the west and northwest shores. The total number of samples actually collected in Task 5 (306) greatly exceeded the 180 proposed in the original plan. The high number was partly a result of monitoring these additional sites, but also a result of both Wet and Dry deposition being monitored at the Ward Lake Level station, as well as both Snow Tube and Dry-Bulk deposition being monitored at the Mid-lake station. Due to concurrent studies also being done on atmospheric sources of nutrients by the California Air Resources Board (CARB) we felt it particularly important to provide as much available information on deposition as possible during this period. The original Task 5 plan also called for analysis of ammonium (NH4-N), nitrate (NO3-N), soluble reactive phosphorus (SRP), total Kjeldahl nitrogen (TKN), and total phosphorus (TP). In addition we also analyzed all samples for total dissolved phosphorus (DP) and pH was analyzed in wet precipitation and lake buoy Dry-bulk samples.

Stations and Methods

Upper Ward Valley Bench Station

This station is located in the north bowl of Ward Valley at 2200m elevation. It consists of a NovaLynx electrically-heated 8 inch tipping bucket rain/snow gage (TBG) located on a tower approximately 5 meters above an open meadow. The TBG top lies at the center of an alter-type wind screen. A datalogger connected to the TBG is used to record each 0.01 inch of precipitation. The TBG was modified so that precipitation could also be caught for measurement. This station also has a Snow Tube (ST) affixed to one pole of the tower. The Snow Tube consists of an approximately 4 1/2 foot length of 8 inch diameter PVC pipe, with a 8 inch diameter cap, and clean plastic liner bag is inserted to allow collection of precipitation. The ST orifice is at the same height as the TBG, but lies outside the alter-type wind screen.

Samples were usually collected from this station on an event-basis (i.e. after each storm). However some samples collected, caught multiple events or consisted of dry deposition samples into a dry Snow Tube after one or more weeks. Precipitation caught in the ST was usually used for analysis. Occasionally water caught by the TBG was analyzed if the ST sample was not available or was compromised.

Lower Ward Valley Lake Level Station

This station is located slightly south of the Ward Creek mouth on an estate, approximately 75-100 m back from the lake edge. It consists of a NovaLynx electrically-heated 8 inch diameter tipping bucket gage (TBG) located approximately 8 feet above the ground on a tower. The TBG was modified so that precipitation could also be caught for measurement. A datalogger connected to the TBG records each 0.01 inch of precipitation. This station also has an Aerochem Metrics model 301 wet/dry deposition sampler. This sampler contains two deposition collection buckets and moveable lid, which automatically covers one, or the other buckets depending on whether precipitation is detected by a sensor. A 3 ½ gallon standard HDPE plastic bucket is used in the Wet-side of the sampler. This "Wet bucket" is covered by the lid during dry periods and exposed when wet precipitation is detected during a storm event. The Dry-side contains a modified HDPE bucket with reduced side-wall height, filled with 4 liters of deionized water, (and contains a heater in winter). This "Dry-bucket" is exposed during dry periods and covered by the lid when precipitation is detected. Wet samples are collected from this station also on an event basis, or as wet buckets fill with snow. Dry samples are collected about every 7-10 days and are usually coordinated with lake buoy Dry-Bulk sample collection.

Mid-lake Buoy Station

This station is located in the northern middle portion of the lake. The station was located on a large anchored PVC spar buoy in earlier studies. During the current study the station was located first on a large plastic raft (TR-2) (coordinates 39 09.290 N and120° 00.020 W) and later on a large buoy (TB-1) slightly further north (coordinates 39° 09.180 N and 120° 00.020 W)). The collector consists of a HDPE plastic bucket similar to the Aerochem Metrics modified dry collector. It is filled with 4 liters of deionized water when placed out. However, the bucket also contains plastic baffles to dampen splash from the bucket. Unlike the Dry bucket, this collector

collects both wet and dry deposition and therefore is called a Dry-Bulk collector. The station also contains a Snow Tube for collection of wet precipitation and a small basic rain gage for verification of precipitation amounts. Sample collection from this station is done as much as possible on a regular basis (7-10 days if possible), however, lake conditions and weather govern frequency to a large extent. The raft/buoy also has a variety of scientific instrumentation for NASA's studies on the lake in addition to the atmospheric deposition collectors.

Intermediate (TR-3) Station

This station (coordinates 39° 08.283 N and 120° 04.833W) was located southwest of the mid-lake station, between the Mid-lake buoy and the lower Ward Valley station. This station similar to the Mid-lake station had been supported on a large spar buoy in past studies (previously called the Intermediate Buoy), but was located on a large plastic raft (TR-3) in the current study. The station contained a Dry-Bulk sampler similar to that used on the Mid-lake station. Samples were collected on the same frequency as the Mid-lake samples. During the study the location of this raft was shifted further south by NASA /TRG to site TB-3. Sampling at this site was discontinued and shifted to a buoy further north (TB-4).

Northwest Lake (TB-4) Station

Station TB-4 (coordinates 39° 09.300 N and 120° 04.330 W) was located between the mid-lake (TB-1) station and Tahoe City. This was desirable since it provided a second collection site to compare with Mid-lake data. Also, since the California Air Resources Board (CARB) maintained an air monitoring station at the TRG lab near Tahoe City, information from this site between mid-lake and Tahoe City was hoped to provide additional useful information. The station contained a Dry-Bulk sampler similar to that used on the Mid-lake station. Samples were collected on the same frequency as the Mid-lake samples. The station was supported on a large buoy (TB-4). The buoy has a variety of scientific instrumentation for NASA's studies on the lake in addition to the atmospheric deposition collectors. (Note for more detailed methods at the different stations see the TRG's Standard Operating Procedures for precipitation monitoring).

Results

The data from this monitoring provides important information on nutrient loading from atmospheric deposition in the watershed and onto the lake surface. This data also provides information on precipitation water quality in the basin and amounts. We soon hope to complete a thorough analysis of this data together with the historical TRG atmospheric deposition data as part of LTIMP related work. The following provides a brief overview of the data collected during the current study period and results.

Tables 1-6 present a summary of samples collected and analyses completed for the atmospheric deposition task, from 5/1/02 through 2/10/04. A total of 306 precipitation samples were collected: 56 Snow Tube or Tipping Bucket Gage Bulk samples were collected from the Upper Ward Valley Bench station; 126 samples were collected from the Ward Lake Level Station (56 Wet + 70 Dry deposition samples); 78 samples were collected from the Mid-lake station (27

Snow Tube + 51 Dry-Bulk samples); 12 Dry-Bulk samples from station TR3; and 34 Dry-Bulk samples were collected from the Northwest Buoy (TB-4).

Table 1a. Precipitation amounts N, P and H concentrations in bulk deposition at the upper Ward Valley "Bench" station 5/1/02-2/10/04.

Table 1a. Samp. No.	Ward Bench Collection Date-Time	Bulk Precip. (in.)		Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (µg/l)	(Conc.) TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
1	5/1/02 15:10	1.83		S	ST	4.96	10.96	187.78	195.06	283.03	2.04	2.75	6.73	
2	5/22/02 14:15	1.68		SR	ST	5.01	9.77	91.47	133.08	216.56	1.59	10.39	13.99	
3	6/4/02 16:20	0		DF	ST	NA	NA	12.66	16.93	63.52	1.36	4.89	15.57	1
4	6/10/02 15:20	0.03		RS	ST	NA	NA	391.24	329.58	NA	NA	NA	NA	
5	7/17/02 11:50	0.02		R	ST	NA	NA	124.54	121.86	NA	80.44	105.10	190.71	2
6	7/22/02 16:40	0.11		R	ST	NA	NA	620.85	488.58	NA	95.45	127.26	NA	
-	9/9/02 13:00	0.01		R	ST	C	C	C	C	C	C	C	C	3
7	9/30/02 13:30	0		DF	ST	NA	NA	13.90	8.90	77.04	0.45	3.36	7.02	4
-	10/4/02 17:00	0.01		RS	ST	NA	NA	NA	NA	NA	NA	NA	NA	
8	10/30/02 16:30	0.14		RH	ST	NA	NA	678.79	531.40	NA	3.64	6.13	NA	
9	11/8/02 10:25	5.27	+	RS	TBG	4.93	11.75	110.91	29.03	186.93	11.84	12.27	22.20	5
10	11/12/02 12:00	7.11		RS	TBG	5.10	7.94	60.61	32.43	617.45	4.10	6.14	8.82	5
11	11/14/02 15:50	0.11		RS	ST	NA	NA	116.11	79.23	NA	4.10	5.83	NA	
12	11/27/02 11:25	0		DF	ST	NA	NA	10.78	12.44	216.01	1.82	3.38	4.26	1
13	12/12/02 17:00	0.64		S	ST	4.93	11.75	167.94	101.11	163.90	1.82	3.38	7.30	
14	12/14/02 11:55	5.28		RS	TBG	5.10	7.94	53.87	24.04	83.20	0.91	2.45	1.84	6
15	12/18/02 17:10	7.33		S	ST	5.10	7.94	18.48	15.11	NA	1.37	2.15	2.45	7
16	12/23/02 17:10	2.09		S	ST	5.20	6.31	28.24	12.23	94.75	0.68	1.84	3.95	
17	12/29/02 16:15	4.21		RS	ST	5.01	9.77	39.01	10.74	110.03	0.91	2.15	3.04	
18	1/2/03 16:20	1.9		S	TBG	5.21	6.17	57.59	34.98	100.39	1.37	2.76	2.45	8
19	1/17/03 15:41	1.07		RS	ST	4.81	15.49	78.54	38.67	407.07	0.68	1.52	5.78	
20	1/28/03 16:30	3.91		RS	ST	4.93	11.75	64.65	22.32	77.55	0.45	1.22	3.04	
21	2/3/03 17:20	0.61		RS	ST	5.01	9.77	64.72	31.83	139.75	0.23	2.13	3.65	
22	2/24/03 14:00	2.6		S?	ST	5.00	10.00	54.16	33.63	86.74	2.94	5.18	2.44	
23	3/4/03 15:15	0.85		S	ST	4.90	12.59	222.97	193.98	237.93	2.26	2.44	3.36	
24	3/12/03 15:20	0.08		RH	ST	NA	NA	253.81	194.99	NA	6.82	13.27	NA	
25	3/20/03 16:20	2.98		RS	ST	5.21	6.17	78.17	99.90	181.44	2.95	4.88	4.59	
26	3/28/03 10:10	3.83		RS	TBG	5.21	6.17	67.00	99.45	115.25	2.27	2.13	2.75	9
27	4/7/03 12:15	2.96		S	ST	5.10	7.94	87.85	84.63	125.76	2.27	3.35	5.81	
28	4/14/03 15:55	4.98		S	TBG	5.40	3.98	53.23	102.15	101.21	0.45	2.13	3.06	10
29	4/23/03 17:55	0.96		SR	ST	5.17	6.76	192.89	548.59	298.72	0.68	7.54	5.81	
30	5/6/03 11:05	6.36		RS	ST	5.10	7.94	NA	NA	NA	NA	NA	NA	
31	5/13/03 15:15	1.13	+	S	TBG	5.10	7.94	187.65	177.45	244.67	0.23	5.64	8.93	69
32	6/13/03 15:30	0		DF	ST	NA	NA	27.50	NA	NA	NA	92.89	NA	70

Table 1a cont'd.

Samp. No.	Ward Bench Collection Date-Time	Bulk Precip. (in.)		Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
								(Conc.)						
33	6/24/03 16:55	0.45		RHG	ST	4.60	25.12	341.02	883.15	11996.15	188.52	395.39	NA	
34	7/26/03 13:25	0.07		R	ST	NA	NA	1093.75	1306.54	NA	195.10	220.19	NA	71
35	8/4/03 14:15	0.51		R	ST	4.50	31.62	330.17	239.78	727.66	1.36	13.11	30.95	
36	8/22/03 16:50	0.87		R	ST	4.60	25.12	482.95	656.49	1070.05	3.02	6.58	19.01	
37	9/3/03 11:15	0.14		R	ST	NA	NA	920.75	720.87	NA	3.26	17.55	NA	
38	9/12/03 17:25	0.04		R	TBG	NA	NA	1853.01	552.40	NA	1.15	39.18	NA	
39	10/1/03 13:20	*		DF	ST	NA	NA	14.14	60.14	161.43	30.46	52.32	66.17	72
40	10/28/03 16:20	*		DF	ST	NA	NA	12.76	31.23	492.73	17.66	57.09	95.30	73
41	11/2/03 10:35	0.9	÷	S	ST	4.47	33.88	72.37	132.33	NA	6.42	19.55	52.87	74
42	11/4/03 14:45	0.76		S	ST	5.07	8.51	122.07	153.37	NA	3.48	7.76	17.83	
43	11/10/03 15:00	1.42		RS	ST	5.11	7.76	50.66	62.20	NA	2.55	6.52	16.60	
44	11/19/03 16:05	1.33		RS	ST	5.00	10.00	79.31	82.27	216.17	7.69	7.47	11.08	
45	11/25/03 16:05	0.13		S	ST	NA	NA	1276.90	1164.41	NA	9.17	10.27	NA	
46	12/2/03 13:30	0.69		RS	ST	NA	NA	43.19	74.35	NA	1.83	270.27	288.70	
47	12/8/03 13:00	6.98		RS	ST	5.25	5.62	61.88	23.72	NA	3.87	13.82	16.89	
48	12/11/03 12:15	2.66		S	ST	5.30	5.01	33.36	0.00	NA	3.42	14.43	19.66	
49	12/15/03 12:40	2.86		RS	ST	5.10	7.94	23.85	23.52	NA	3.19	12.90	14.74	
50	12/22/03 16:00	1.19	÷	RS	ST	4.90	12.59	113.45	26.22	NA	NA	NA	1.59	75
51	12/26/03 15:15	4.49	÷	RS	TBG	5.27	5.37	58.75	23.99	NA	0.23	NA	3.81	76
52	12/30/03 16:30	3.56		S	ST	5.00	10.00	42.54	5.36	NA	0.23	NA	2.54	
53	1/2/04 15:15	3.5		S	ST	5.20	6.31	91.17	48.03	NA	0.23	NA	NA	
54	1/8/04 16:35	1.34		RS	ST	NA	NA	67.87	16.19	NA	0.23	NA	NA	77
55	1/21/04 16:25	0.02		S	ST	NA	NA	375.81	216.17	NA	NA	NA	NA	
56	2/10/04 16:50	4.21		S	ST	5.09	8.13	NA	NA	NA	0.69	NA	NA	

Table 1b. Precipitation N, P, and H loads in bulk deposition at the upper Ward Valley "Bench" station 1 May 2002 to 10 February 2004.

Samp. No.	Ward Bench Collection Date-Time	Precip. (in.)		Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	5/1/02 15:10	1.83		S	5.10	87.28	90.67	131.56	0.95	1.28	3.13	
2	5/22/02 14:15	1.68		SR	4.17	39.03	56.79	92.41	0.68	4.43	5.97	
3	6/4/02 16:20	0		DF	NA	1.95	2.61	9.79	0.21	0.75	2.40	1
4	6/10/02 15:20	0.03		RS	NA	2.98	2.51	NA	NA	NA	NA	
5	7/17/02 11:50	0.02		R	NA	0.63	0.62	NA	0.41	0.53	0.97	2
6	7/22/02 16:40	0.11		R	NA	17.35	13.65	NA	2.67	3.56	NA	
-	9/9/02 13:00	0.01		R	C	C	C	C	C	C	C	3
7	9/30/01 13:30	0		DF	NA	4.29	2.74	23.76	0.14	1.04	2.16	4
-	10/4/02 17:00	0.01		RS	NA	NA	NA	NA	NA	NA	NA	
8	10/30/02 16:30	0.14		RH	NA	24.14	18.90	NA	0.13	0.22	NA	
9	11/8/02 10:25	5.27	+	RS	15.73	148.46	38.86	250.22	15.85	16.42	29.72	5
10	11/12/02 12:00	7.11		RS	14.35	109.46	58.57	1115.08	7.40	11.09	15.93	5
11	11/14/02 15:50	0.11		RS	NA	3.24	2.21	NA	0.11	0.16	NA	
12	11/27/02 11:25	0		DF	NA	1.66	1.92	33.30	0.28	0.52	0.66	1
13	12/12/02 17:00	0.64		S	1.91	27.30	16.44	26.64	0.30	0.55	1.19	
14	12/14/02 11:55	5.28		RS	10.65	72.25	32.24	111.58	1.22	3.29	2.47	6
15	12/18/02 17:10	7.33		S	14.79	34.41	28.13	NA	2.55	4.00	4.56	7
16	12/23/02 17:10	2.09		S	3.35	14.99	6.49	50.30	0.36	0.98	2.10	
17	12/29/02 16:15	4.21		RS	10.45	41.71	11.48	117.66	0.97	2.30	3.25	
18	1/2/03 16:20	1.9		S	2.98	27.79	16.88	48.45	0.66	1.33	1.18	8
19	1/17/03 15:41	1.07		RS	4.21	21.35	10.51	110.63	0.18	0.41	1.57	
20	1/28/03 16:30	3.91		RS	11.67	64.21	22.17	77.02	0.45	1.21	3.02	
21	2/3/03 17:20	0.61		RS	1.51	10.03	4.93	21.65	0.04	0.33	0.57	
22	2/24/03 14:00	2.6		S?	6.60	35.77	22.21	57.28	1.94	3.42	1.61	
23	3/4/03 15:15	0.85		S	2.72	48.14	41.88	51.37	0.49	0.53	0.73	
24	3/12/03 15:20	0.08		RH	NA	5.16	3.96	NA	0.14	0.27	NA	
25	3/20/03 16:20	2.98		RS	4.67	59.17	75.62	137.34	2.23	3.69	3.47	
26	3/28/03 10:10	3.83		RS	6.00	65.18	96.75	112.12	2.21	2.07	2.68	9
27	4/7/03 12:15	2.96		S	5.97	66.05	63.63	94.55	1.71	2.52	4.37	
28	4/14/03 15:55	4.98		S	5.04	67.33	129.21	128.02	0.57	2.69	3.87	10
29	4/23/03 17:55	0.96		SR	1.65	47.03	133.77	72.84	0.17	1.84	1.42	
30	5/6/03 11:05	6.36		RS	12.83	NA	NA	NA	NA	NA	NA	
31	5/13/03 15:15	1.13	+	S	2.28	53.86	50.93	70.23	0.07	1.62	2.56	69
32	6/13/03 15:30	0		DF	NA	8.48	NA	NA	NA	28.63	NA	70

Table 1b Cont'd.

Samp. No.	Ward Bench Collection Date-Time	Bulk Precip. (in.)		Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
33	6/24/03 16:55	0.45		RHG	2.87	38.98	100.94	1371.16	21.55	45.19	NA	
34	7/26/03 13:25	0.07		R	NA	19.45	23.23	NA	3.47	3.91	NA	71
35	8/4/03 14:15	0.51		R	4.10	42.77	31.06	94.26	0.18	1.70	4.01	
36	8/22/03 16:50	0.87		R	5.55	106.72	145.07	236.46	0.67	1.45	4.20	
37	9/3/03 11:15	0.14		R	NA	32.74	25.63	NA	0.12	0.62	NA	
38	9/12/03 17:25	0.04		R	NA	18.83	5.61	NA	0.01	0.40	NA	
39	10/1/03 13:20	*		DF	NA	2.18	9.27	24.88	4.69	8.06	10.20	72
40	10/28/03 16:20	*		DF	NA	1.97	4.81	75.94	2.72	8.80	14.69	73
41	11/2/03 10:35	0.9	+	S	7.75	16.54	30.25	NA	1.47	4.47	12.09	74
42	11/4/03 14:45	0.76		S	1.64	23.56	29.61	NA	0.67	1.50	3.44	
43	11/10/03 15:00	1.42		RS	2.80	18.27	22.43	NA	0.92	2.35	5.99	
44	11/19/03 16:05	1.33		RS	3.38	26.79	27.79	73.03	2.60	2.52	3.74	
45	11/25/03 16:05	0.13		S	NA	42.16	38.45	NA	0.30	0.34	NA	
46	12/2/03 13:30	0.69		RS	NA	7.57	13.03	NA	0.32	47.37	50.60	
47	12/8/03 13:00	6.98		RS	9.97	109.71	42.05	NA	6.86	24.50	29.94	
48	12/11/03 12:15	2.66		S	3.39	22.54	0.00	NA	2.31	9.75	13.28	
49	12/15/03 12:40	2.86		RS	5.77	17.33	17.09	NA	2.32	9.37	10.71	
50	12/22/03 16:00	1.19	+	RS	3.81	34.29	7.93	NA	NA	NA	0.48	75
51	12/26/03 15:15	4.49	+	RS	6.12	67.00	27.36	NA	0.26	NA	4.35	76
52	12/30/03 16:30	3.56		S	9.04	38.47	4.85	NA	0.21	NA	2.30	
53	1/2/04 15:15	3.5		S	5.61	81.05	42.70	NA	0.20	NA	NA	
54	1/8/04 16:35	1.34		RS	NA	23.10	5.51	NA	0.08	NA	NA	77
55	1/21/04 16:25	0.02		S	NA	1.91	1.10	NA	NA	NA	NA	
56	2/10/04 16:50	4.21		S	8.69	NA	NA	NA	0.74	NA	NA	

Table 2a. Precipitation amounts, pH, N and P concentrations in wet deposition at the Ward Valley lake level station 5/1/02-2/10/04.

Table 2a. Samp. No.	Ward Lake Level Collection Date-Time	Wet Precip. (in.)	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (µg/l)	(Conc.) TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
1	5/1/02 14:35	1.14	S	WET	5.10	7.94	135.27	148.94	202.51	2.27	4.28	7.30	
2	5/22/02 13:35	0.78	SR	WET	5.42	3.80	126.30	176.44	284.54	2.50	3.36	9.47	
-	6/10/02 16:00	0.02		WET	C	C	C	C	C	C	C	C	11
-	7/17/02 10:45	0.15		WET	7.57	C	C	C	C	C	C	C	11
3	7/22/02 17:10	0.22	R	WET	4.41	38.90	467.53	238.57	378.75	1.36	1.83	6.72	
4	9/9/02 13:45	0.03	R	WET	NA	NA	NA	NA	NA	NA	NA	NA	
5	10/4/02 14:15	0.03	RS	WET	NA	NA	NA	NA	NA	NA	NA	NA	
6	10/30/02 17:00	0.1	RH	WET	NA	NA	661.67	376.80	584.59	15.60	170.61	310.22	
7	11/12/02 13:00	7.58	RS	WET	5.10	7.94	35.45	17.23	97.43	4.44	6.14	11.86	
8	11/14/02 16:25	0.06	R	WET	NA	NA	107.75	95.17	NA	2.96	4.30	NA	
-	11/27/02 12:10	0.01	NA	WET	NA	NA	198.77	2.68	NA	NA	NA	NA	
9	12/12/02 17:40	0.17	S	WET	4.99	10.23	299.47	118.56	654.27	2.96	4.91	10.34	
10	12/14/02 9:35	3.06	R	WET	5.00	10.00	12.28	8.19	NA	4.33	6.75	6.12	
11	12/15/02 17:45	1.86	S	WET	5.09	8.13	16.94	21.48	116.60	1.59	2.45	2.45	12
12	12/16/02 17:30	2.14	S	WET	5.22	6.03	16.84	7.98	NA	0.91	1.84	2.14	13
13	12/17/02 16:10	0.78	S	WET	5.10	7.94	22.18	11.38	142.58	0.91	1.84	1.84	
14	12/18/02 18:30	0.15	S	WET	NA	NA	72.29	84.54	356.26	2.50	3.99	3.95	
15	12/20/02 17:40	0.99	S	WET	NA	NA	40.21	15.63	151.10	1.37	2.76	6.08	
16	12/23/02 17:40	0.41	S	WET	5.13	7.41	33.87	10.53	4.22	0.68	1.84	3.04	
17	12/29/02 17:00	2.13	S	WET	5.29	5.13	51.10	8.62	225.60	1.82	3.07	3.65	14
18	12/31/02 14:20	1.27	S	WET	5.22	6.03	44.07	15.21	368.86	1.37	2.15	5.47	15
-	1/2/03 17:10	0.01	S	WET	NA	NA	NA	NA	NA	NA	NA	NA	
19	1/17/03 16:25	0.75	RS	WET	5.04	9.12	50.16	25.56	82.33	0.90	2.13	3.95	
20	1/28/03 17:05	1.86	RS	WET	4.90	12.59	91.03	17.68	NA	1.36	1.83	NA	
21	2/3/03 17:40	0.25	RS	WET	5.20	6.31	45.80	16.39	99.52	0.23	1.22	6.08	
22	2/24/03 14:30	1.38	RS	WET	5.30	5.01	35.39	11.97	54.17	1.81	2.44	4.27	
23	3/4/03 15:50	0.38	S	WET	5.20	6.31	267.98	196.66	217.19	2.26	2.13	5.50	
24	3/12/03 14:45	0.03	RH	WET	NA	NA	165.95	86.59	NA	3.64	15.68	NA	
25	3/20/03 16:50	2.28	RS	WET	5.29	5.13	39.93	36.48	92.44	9.41	3.81	5.50	
26	3/26/03 20:55	1.81	R	WET	5.10	7.94	47.27	47.70	29.31	1.81	3.05	3.67	
27	4/2/03 16:45	0.89	S	WET	4.90	12.59	55.09	43.21	105.14	4.99	7.93	6.42	16
28	4/7/03 12:30	0.78	S	WET	5.00	10.00	55.09	65.45	74.90	1.36	3.05	2.30	
29	4/13/03 14:00	3.05	S	WET	5.10	7.94	23.08	43.44	56.49	8.39	2.13	2.75	17
30	4/14/03 16:45	0.32	S	WET	5.30	5.01	47.09	126.53	47.72	1.59	3.35	4.59	
-	4/23/03 16:45	0.27	S	WET	NA	NA	NA	NA	NA	NA	NA	NA	18

Table 2a Cont'd.

Samp. No.	Ward Lake Level Collection Date-Time	Wet Precip. (in.)		Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (µg/l)	(Conc.) TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
31	4/30/03 18:00	2.46		S	WET	5.20	6.31	54.49	83.98	74.69	1.63	4.70	19.65	
32	5/7/03 15:00	1.02		RS	WET	5.20	6.31	64.01	55.05	119.58	1.63	4.39	5.15	
33	5/13/03 15:40	0.32		S	WET	4.92	12.02	133.74	96.56	23.46	1.40	5.02	7.73	
34	6/5/03 15:00	0.01			WET	NA	NA	29.29	23.35	NA	NA	NA	NA	
35	6/24/03 17:25	0.65		RHG	WET	4.51	30.90	363.50	283.98	908.07	2.79	16.93	30.61	
36	7/31/03 15:05	0.23		R	WET	7.10	0.08	54.50	28.71	NA	22.46	12.96	38.31	78
37	8/4/03 13:45	0.26		R	WET	5.09	8.13	232.51	132.71	233.62	0.91	1.52	3.68	
38	8/22/03 17:20	0.82		R	WET	5.20	6.31	241.19	340.38	490.82	0.47	4.08	16.43	
39	9/3/03 11:55	0.15		R	WET	NA	NA	369.94	212.80	388.57	0.47	5.33	43.17	
40	9/12/03 17:50	0.21		R	WET	5.02	9.55	519.57	496.60	665.90	1.15	6.27	12.00	
41	11/2/03 11:15	2.34		S	WET	5.10	7.94	105.31	171.35	NA	3.48	6.83	8.30	79
42	11/4/03 15:20	0.27		S	WET	NA	NA	386.59	314.53	NA	24.77	153.89	NA	80
43	11/10/03 15:30	0.85		RS	WET	5.30	5.01	28.95	38.71	NA	15.79	17.38	25.21	81
44	11/19/03 16:35	0.38		RS	WET	5.99	1.02	NA	13.00	NA	157.95	211.30	255.46	82
45	11/25/03 16:30	0.03		R?S	WET	NA	NA	1033.44	919.63	NA	27.52	32.69	NA	
46	12/2/03 14:00	0.45		RS	WET	NA	NA	46.71	52.36	82.98	1.38	8.31	10.46	
47	12/8/03 13:30	3.27	+	RS	WET	5.10	7.94	35.15	12.59	NA	3.42	NA	1.91	83
48	12/11/03 11:45	1.55		S	WET	5.31	4.90	24.21	13.30	NA	3.19	13.82	17.51	84
49	12/15/03 12:00	1.67		RS	WET	5.01	9.77	16.68	15.68	NA	3.65	13.51	16.89	85
50	12/22/03 16:45	0.60		RS	WET	5.10	7.94	129.66	27.70	NA	NA	NA	2.86	
51	12/26/03 14:40	3.41		RS	WET	5.21	6.17	55.71	6.54	NA	NA	NA	1.59	86
52	12/30/03 17:05	2.02		S	WET	NA	NA	74.96	22.09	NA	NA	NA	NA	87
53	1/2/04 14:20	1.60		S	WET	5.10	7.94	81.04	23.52	NA	0.23	NA	9.71	88
54	1/5/04 16:20	0.44		S	WET	5.21	6.17	NA	NA	NA	NA	NA	NA	89
55	1/8/04 17:15	0.30		RS	WET	NA	NA	38.49	13.38	103.16	0.23	NA	NA	90
-	1/21/04 16:55	0.00		S	WET	NA	NA	NA	NA	NA	NA	NA	NA	
56	2/10/04 17:25	1.99		RS	WET	5.10	7.94	NA	NA	NA	NA	NA	NA	91

Table 2b. Precipitation N, P and H loads in wet deposition at the Ward Valley lake level station 1 May 2002 to 10 February 2004.

Table 2b. Samp. No.	Ward Lake Level Collection Date-Time	Wet Precip. (in.)	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	5/1/02 14:35	1.14	S	2.30	39.17	43.13	58.64	0.66	1.24	2.11	
2	5/22/02 13:35	0.78	SR	0.75	25.02	34.96	56.37	0.50	0.67	1.88	
-	6/10/02 16:00	0.02		C	C	C	C	C	C	C	11
-	7/17/02 10:45	0.15		C	C	C	C	C	C	C	11
3	7/22/02 17:10	0.22	R	2.17	26.13	13.33	21.16	0.08	0.10	0.38	
4	9/9/02 13:45	0.03	R	NA	NA	NA	NA	NA	NA	NA	
5	10/4/02 14:15	0.03	RS	NA	NA	NA	NA	NA	NA	NA	
6	10/30/02 17:00	0.10	RH	NA	16.81	9.57	14.85	0.40	4.33	7.88	
7	11/12/02 13:00	7.58	RS	15.29	68.25	33.17	187.58	8.55	11.82	22.83	
8	11/14/02 16:25	0.06	R	NA	1.64	1.45	NA	0.05	0.07	NA	
-	11/27/02 12:10	0.01	NA	NA	0.50	0.01	NA	NA	NA	NA	
9	12/12/02 17:40	0.17	S	0.44	12.93	5.12	28.25	0.13	0.21	0.45	
10	12/14/02 9:35	3.06	R	7.77	9.54	6.37	NA	3.37	5.25	4.76	
11	12/15/02 17:45	1.86	S	3.84	8.00	10.15	55.09	0.75	1.16	1.16	12
12	12/16/02 17:30	2.14	S	3.28	9.15	4.34	NA	0.49	1.00	1.16	13
13	12/17/02 16:10	0.78	S	1.57	4.39	2.25	28.25	0.18	0.36	0.36	
14	12/18/02 18:30	0.15	S	NA	2.75	3.22	13.57	0.10	0.15	0.15	
15	12/20/02 17:40	0.99	S	NA	10.11	3.93	38.00	0.34	0.69	1.53	
16	12/23/02 17:40	0.41	S	0.77	3.53	1.10	0.44	0.07	0.19	0.32	
17	12/29/02 17:00	2.13	S	2.77	27.65	4.66	122.05	0.98	1.66	1.97	14
18	12/31/02 14:20	1.27	S	1.94	14.22	4.91	118.99	0.44	0.69	1.76	15
-	1/2/03 17:10	0.01	S	NA	NA	NA	NA	NA	NA	NA	
19	1/17/03 16:25	0.75	RS	1.74	9.56	4.87	15.68	0.17	0.41	0.75	
20	1/28/03 17:05	1.86	RS	5.95	43.01	8.35	NA	0.64	0.86	NA	
21	2/3/03 17:40	0.25	RS	0.40	2.91	1.04	6.32	0.01	0.08	0.39	
22	2/24/03 14:30	1.38	RS	1.76	12.40	4.20	18.99	0.63	0.86	1.50	
23	3/4/03 15:50	0.38	S	0.61	25.87	18.98	20.96	0.22	0.21	0.53	
24	3/12/03 14:45	0.03	RH	NA	1.26	0.66	NA	0.03	0.12	NA	
25	3/20/03 16:50	2.28	RS	2.97	23.12	21.13	53.53	5.45	2.21	3.19	
26	3/26/03 20:55	1.81	R	3.65	21.73	21.93	13.47	0.83	1.40	1.69	
27	4/2/03 16:45	0.89	S	2.85	12.45	9.77	23.77	1.13	1.79	1.45	16
28	4/7/03 12:30	0.78	S	1.98	10.91	12.97	14.84	0.27	0.60	0.46	
29	4/13/03 14:00	3.05	S	6.15	17.88	33.65	43.76	6.50	1.65	2.13	17
30	4/14/03 16:45	0.32	S	0.41	3.83	10.28	3.88	0.13	0.27	0.37	
-	4/23/03 16:45	0.27	S	NA	NA	NA	NA	NA	NA	NA	18

Table 2b Cont'd. Ward Lake Level

Samp. No.	Collection Date-Time	Wet Precip. (in.)		Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes	Samp. No.
31	4/30/03 18:00	2.46		S	3.94	34.05	52.47	46.67	1.02	2.94	12.28		
32	5/7/03 15:00	1.02		RS	1.63	16.58	14.26	30.98	0.42	1.14	1.33		
33	5/13/03 15:40	0.32		S	0.98	10.87	7.85	1.91	0.11	0.41	0.63		
34	6/5/03 15:00	0.01			NA	0.07	0.06	NA	NA	NA	NA		
35	6/24/03 17:25	0.65		RHG	5.10	60.01	46.89	149.92	0.46	2.80	5.05		
36	7/31/03 15:05	0.23		R	C	C	C	C	C	C	C	78	
37	8/4/03 13:45	0.26		R	0.53	15.23	8.69	15.30	0.06	0.10	0.24		
38	8/22/03 17:20	0.82		R	1.32	50.36	71.07	102.47	0.10	0.85	3.43		
39	9/3/03 11:55	0.15		R	NA	13.84	7.96	14.54	0.02	0.20	1.62		
40	9/12/03 17:50	0.21		R	0.50	27.14	25.94	34.78	0.06	0.33	0.63		
41	11/2/03 11:15	2.34		S	4.71	62.49	101.68	NA	2.06	4.05	4.93	79	
42	11/4/03 15:20	0.27		S	NA	26.81	21.81	NA	1.72	10.67	NA	80	
43	11/10/03 15:30	0.85		RS	1.09	6.28	8.40	NA	3.43	3.77	5.47	81	
44	11/19/03 16:35	0.38		RS	C	C	C	C	C	C	C	82	
45	11/25/03 16:30	0.03		R?S	NA	7.09	6.31	NA	0.19	0.22	NA		
46	12/2/03 14:00	0.45		RS	NA	5.28	5.92	9.38	0.16	0.94	1.18		
47	12/8/03 13:30	3.27	+	RS	6.60	29.19	10.46	NA	2.84	NA	1.59	83	
48	12/11/03 11:45	1.55		S	1.93	9.55	5.24	NA	1.26	5.45	6.90	84	
49	12/15/03 12:00	1.67		RS	4.13	7.06	6.63	NA	1.54	5.72	7.14	85	
50	12/22/03 16:45	0.60		RS	1.21	19.71	4.21	NA	NA	NA	0.43		
51	12/26/03 14:40	3.41		RS	5.34	48.26	5.66	NA	NA	NA	1.38	86	
52	12/30/03 17:05	2.02		S	NA	38.47	11.34	NA	NA	NA	NA	87	
53	1/2/04 14:20	1.60		S	3.22	32.85	9.54	NA	0.09	NA	3.94	88	
54	1/5/04 16:20	0.44		S	0.69	NA	NA	NA	NA	NA	NA	89	
55	1/8/04 17:15	0.30		RS	NA	2.93	1.02	7.86	0.02	NA	NA	90	
-	1/21/04 16:55	0.00		S	NA	NA	NA	NA	NA	NA	NA		
56	2/10/04 17:25	1.99		RS	4.01	NA	NA	NA	0.58	NA	NA	91	

Table 3a. N and P concentrations in dry deposition at the Ward Valley lake level station 5/1/02-2/10/04.

Samp. No.	Table 3a. Start Date-Time	Ward Lake Level Collection Date-Time	Dry Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	(Conc.) NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
1	4/19/02 13:25	5/2/02 13:40	2.160	DF	DRY	NA	NA	43.45	18.63	114.39	2.73	3.36	9.62	
2	5/2/02 13:40	5/17/02 14:00	1.025	DF	DRY	NA	NA	7.74	4.24	211.20	1.59	5.19	28.70	19
3	5/17/02 14:00	5/30/02 18:15	1.655	DF	DRY	NA	NA	178.01	112.56	NA	4.54	2.44	NA	20
4	5/30/02 18:15	6/11/02 13:20	2.210	DF	DRY	NA	NA	17.68	2.76	362.40	4.32	7.94	24.64	21
5	6/11/02 13:20	6/24/02 15:10	1.816	DF	DRY	NA	NA	4.57	4.88	96.26	1.59	5.81	36.41	21
6	6/24/02 15:10	7/5/02 9:50	1.945	DF	DRY	NA	NA	6.51	3.39	2292.69	3.18	18.33	85.80	21,22
7	7/5/02 9:50	7/17/02 10:45	1.678	DF	DRY	NA	NA	9.85	4.88	788.09	4.77	5.81	289.12	21
8	7/17/02 10:45	7/24/02 11:30	0.910	DF	DRY	NA	NA	14.95	10.16	151.98	3.18	5.19	9.73	21
9	7/24/02 11:30	8/2/02 18:50	1.933	DF	DRY	NA	NA	18.35	3.54	150.64	0.68	5.43	8.86	21
10	8/2/02 18:50	8/9/02 11:45	2.920	DF	DRY	NA	NA	26.54	10.10	139.99	1.37	2.76	6.69	21
11	8/9/02 11:45	8/21/02 11:30	1.645	DF	DRY	NA	NA	12.68	11.97	211.48	2.04	4.26	13.44	21,23
12	8/21/02 11:30	8/29/02 14:00	2.620	DF	DRY	NA	NA	17.03	9.68	35.01	0.68	3.38	5.78	21
13	8/29/02 14:00	9/9/02 13:45	2.222	DF	DRY	NA	NA	3.52	3.39	63.97	1.36	3.67	13.38	21
14	9/9/02 13:45	9/25/02 13:30	2.125	DF	DRY	NA	NA	18.42	10.95	300.60	1.37	3.07	11.56	21
15	9/25/02 13:30	10/3/02 17:45	3.190	DF	DRY	NA	NA	21.19	16.27	133.69	7.51	6.44	11.91	21,24
16	10/3/02 17:45	10/11/02 16:10	3.340	DF	DRY	NA	NA	23.97	19.46	151.06	2.96	3.38	5.19	21
17	10/11/02 16:10	10/21/02 14:25	3.280	DF	DRY	NA	NA	10.59	16.95	176.74	1.13	2.44	3.80	21
18	10/21/02 14:25	10/30/02 17:00	3.402	DF	DRY	NA	NA	3.87	3.82	97.43	1.36	3.82	7.63	25
19	10/30/02 17:00	11/6/02 16:55	3.625	DF	DRY	NA	NA	11.29	16.91	158.61	14.12	7.67	16.42	26
20	11/6/02 16:55	11/21/02 10:15	3.112	DF	DRY	NA	NA	4.56	3.09	169.94	30.28	35.59	58.75	27
21	11/21/02 10:15	12/3/02 12:45	2.170	DF	DRY	NA	NA	14.60	14.82	74.77	1.14	2.14	5.20	28
22	12/3/02 12:45	12/12/02 17:40	2.910	DF	DRY	NA	NA	19.41	12.87	89.12	1.82	3.38	6.08	
23	12/12/02 17:40	12/24/02 14:15	2.625	DF	DRY	NA	NA	5.35	3.73	456.73	3.64	6.75	21.59	
24	12/24/02 14:15	1/2/03 17:10	3.580	DF	DRY	NA	NA	12.28	11.17	NA	2.96	3.38	3.98	29
25	1/2/03 17:10	1/10/03 8:45	2.205	DF	DRY	NA	NA	15.52	18.17	229.42	0.45	0.91	13.38	
26	1/10/03 8:45	1/21/03 18:15	2.830	DF	DRY	NA	NA	16.65	21.46	84.24	0.45	1.52	11.86	30
27	1/21/03 18:15	1/29/03 10:35	2.360	DF	DRY	NA	NA	24.60	9.54	132.00	0.45	1.22	6.08	
28	1/29/03 10:35	2/5/03 17:10	3.767	DF	DRY	NA	NA	10.60	1.16	29.55	0.45	2.44	6.11	31
29	2/5/03 17:10	2/13/03 15:20	3.668	DF	DRY	NA	NA	7.76	0.06	29.11	0.23	1.22	4.89	32
30	2/13/03 15:20	2/19/03 13:15	3.355	DF	DRY	NA	NA	10.98	6.01	15.72	1.36	2.44	5.50	
31	2/19/03 13:15	3/5/03 15:40	2.810	DF	DRY	NA	NA	29.96	21.32	61.51	3.63	3.66	7.94	33
32	3/5/03 15:40	3/12/03 14:45	3.354	DF	DRY	NA	NA	5.40	1.89	50.28	2.95	5.18	3.36	
33	3/12/03 14:45	3/19/03 19:00	2.705	DF	DRY	NA	NA	11.73	8.40	77.97	4.53	6.10	11.31	34
34	3/19/03 19:00	3/26/03 20:55	3.294	DF	DRY	NA	NA	12.10	9.98	42.46	0.91	2.44	5.20	34,35
35	3/26/03 20:55	4/2/03 16:45	2.900	DF	DRY	NA	NA	9.68	8.40	52.01	4.53	6.10	5.20	34

Table 3a Cont'd. Ward Lake Level

Samp. No.	Start Date-Time	Collection Date-Time	Dry Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	(Conc.) NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
36	4/2/03 16:45	4/9/03 13:50	3.882	DF	DRY	NA	NA	16.38	9.53	36.76	0.68	2.44	7.34	34
37	4/9/03 13:50	4/16/03 16:50	2.745	DF	DRY	NA	NA	20.47	21.88	67.89	2.27	3.66	7.03	34
38	4/16/03 16:50	4/23/03 16:45	2.655	DF	DRY	NA	NA	31.24	17.86	111.49	0.45	9.95	5.20	34,36
39	4/23/03 16:45	4/30/03 18:00	3.095	DF	DRY	NA	NA	30.86	26.12	181.27	1.63	4.08	9.99	34
40	4/30/03 18:00	5/7/03 15:00	2.757	DF	DRY	NA	NA	13.53	6.03	0.00	1.86	4.39	9.99	
41	5/7/03 15:00	5/14/03 14:40	1.485	DF	DRY	NA	NA	45.34	21.92	148.77	0.23	5.64	15.79	30
42	5/14/03 14:40	5/22/03 18:00	2.140	DF	DRY	NA	NA	19.13	9.41	135.32	1.14	7.24	12.22	37
43	5/22/03 18:00	6/5/03 15:00	2.712	DF	DRY	NA	NA	111.28	27.03	NA	11.59	77.50	158.62	38
44	6/5/03 15:00	6/13/03 16:30	2.005	DF	DRY	NA	NA	6.55	NA	1574.77	NA	25.44	61.21	39
45	6/13/03 16:30	6/24/03 17:25	1.410	DF	DRY	NA	NA	20.96	59.66	2211.48	23.26	79.31	287.67	
46	6/24/03 17:25	7/2/03 18:30	2.462	DF	DRY	NA	NA	6.86	5.02	NA	5.47	14.27	27.38	40
47	7/2/03 18:30	7/8/03 17:30	2.802	DF	DRY	NA	NA	11.43	16.21	286.25	4.79	10.03	41.56	
48	7/8/03 17:30	7/17/03 14:30	2.245	DF	DRY	NA	NA	16.38	13.59	513.84	5.82	10.97	23.20	
49	7/17/03 14:30	7/26/03 13:50	1.938	DF	DRY	4.91	12.30	13.76	6.08	NA	1.36	3.35	8.58	
50	7/26/03 13:50	8/5/03 15:45	3.21	DF	DRY	NA	NA	12.82	11.98	246.86	0.93	4.70	7.41	
51	8/5/03 15:45	8/14/03 12:05	2.322	DF	DRY	5.32	4.79	7.81	6.03	490.02	0.93	10.34	26.42	
52	8/14/03 12:05	8/22/03 17:20	1.339	DF	DRY	NA	NA	8.95	3.07	224.32	0.23	4.70	11.28	
53	8/22/03 17:20	9/3/03 11:55	2.357	DF	DRY	5.20	6.31	19.07	14.23	304.03	0.23	7.52	17.72	92
54	9/3/03 11:55	9/12/03 17:50	2.888	DF	DRY	5.40	3.98	6.74	1.71	330.66	2.53	6.27	17.54	
55	9/12/03 17:50	10/1/03 13:50	1.855	DF	DRY	NA	NA	30.75	109.73	97.61	21.73	29.55	44.94	93
56	10/1/03 13:50	10/6/03 16:00	3.535	DF	DRY	NA	NA	10.19	1.11	91.98	1.15	7.39	7.08	
57	10/6/03 16:00	10/15/03 9:45	3.125	DF	DRY	NA	NA	7.23	1.86	99.48	5.52	6.46	14.77	
58	10/15/03 9:45	10/20/03 11:50	3.292	DF	DRY	NA	NA	8.88	2.72	223.80	0.92	7.69	12.62	
59	10/20/03 11:50	10/28/03 16:50	3.33	DF	DRY	NA	NA	14.66	16.18	93.85	4.41	7.45	8.91	94
60	10/28/03 16:50	11/5/03 12:50	2.87	DF+S	DRY	NA	NA	6.67	9.64	NA	138.07	55.28	233.63	95
61	11/5/03 12:50	11/11/03 13:00	3.38	DF	DRY	NA	NA	10.66	15.10	NA	21.82	26.99	29.82	96
62	11/11/03 13:00	11/25/03 16:30	0.44	DF	DRY	NA	NA	12.43	16.16	NA	61.06	51.60	365.65	97
63	11/25/03 16:30	12/2/03 14:00	2.83	DF	DRY	NA	NA	8.07	18.20	49.79	0.92	8.93	14.16	
64	12/2/03 14:00	12/15/03 12:00	4.63	DF	DRY	NA	NA	13.09	11.87	NA	3.87	13.21	18.73	98
65	12/15/03 12:00	12/26/03 14:40	3.35	DF	DRY	NA	NA	11.35	16.92	NA	0.23	NA	5.40	99
66	12/26/03 14:40	12/30/03 17:05	5.48	DF+S	DRY	5.30	5.01	9.12	4.42	NA	0.46	NA	6.99	100
67	12/30/03 17:05	1/13/04 13:00	5.18	DF+S	DRY	NA	NA	10.53	14.47	NA	0.23	NA	NA	101
68	1/13/04 13:00	1/23/04 15:45	3.71	DF	DRY	NA	NA	18.23	23.83	NA	2.54	NA	NA	
69	1/23/04 15:45	1/29/04 14:40	3.46	DF	DRY	NA	NA	NA	NA	NA	1.38	NA	NA	
70	1/29/04 14:40	2/10/04 17:25	2.61	DF	DRY	NA	NA	NA	NA	NA	2.30	NA	NA	

Table 3b. N and P loads in dry deposition at the Ward Valley lake level station 1 May 2002 to 10 February 2004.

Samp. No.	Table 3b. Start Date-Time	Ward Lake Level Collection Date-Time	Dry Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
								(Load)				
1	4/19/02 13:25	5/2/02 13:40	2.160	DF	NA	18.52	7.94	48.76	1.16	1.43	4.10	
2	5/2/02 13:40	5/17/02 14:00	1.025	DF	NA	1.57	0.86	42.72	0.32	1.05	5.81	19
3	5/17/02 14:00	5/30/02 18:15	1.655	DF	NA	58.14	36.76	NA	1.48	0.80	NA	20
4	5/30/02 18:15	6/11/02 13:20	2.210	DF	NA	7.71	1.20	158.06	1.88	3.46	10.75	21
5	6/11/02 13:20	6/24/02 15:10	1.816	DF	NA	1.64	1.75	34.50	0.57	2.08	13.05	21
6	6/24/02 15:10	7/5/02 9:50	1.945	DF	NA	2.50	1.30	880.05	1.22	7.04	32.93	21,22
7	7/5/02 9:50	7/17/02 10:45	1.678	DF	NA	3.26	1.62	260.98	1.58	1.92	95.74	21
8	7/17/02 10:45	7/24/02 11:30	0.910	DF	NA	2.68	1.82	27.29	0.57	0.93	1.75	21
9	7/24/02 11:30	8/2/02 18:50	1.933	DF	NA	7.00	1.35	57.47	0.26	2.07	3.38	21
10	8/2/02 18:50	8/9/02 11:45	2.920	DF	NA	15.29	5.82	80.67	0.79	1.59	3.86	21
11	8/9/02 11:45	8/21/02 11:30	1.645	DF	NA	4.12	3.89	68.66	0.66	1.38	4.36	21,23
12	8/21/02 11:30	8/29/02 14:00	2.620	DF	NA	8.81	5.01	18.10	0.35	1.75	2.99	21
13	8/29/02 14:00	9/9/02 13:45	2.222	DF	NA	1.54	1.49	28.05	0.60	1.61	5.87	21
14	9/9/02 13:45	9/25/02 13:30	2.125	DF	NA	7.72	4.59	126.06	0.57	1.29	4.85	21
15	9/25/02 13:30	10/3/02 17:45	3.190	DF	NA	13.34	10.24	84.17	4.73	4.05	7.50	21,24
16	10/3/02 17:45	10/11/02 16:10	3.340	DF	NA	15.80	12.83	99.57	1.95	2.23	3.42	21
17	10/11/02 16:10	10/21/02 14:25	3.280	DF	NA	6.86	10.97	114.41	0.73	1.58	2.46	21
18	10/21/02 14:25	10/30/02 17:00	3.402	DF	NA	2.60	2.56	65.41	0.91	2.56	5.12	25
19	10/30/02 17:00	11/6/02 16:55	3.625	DF	NA	8.08	12.10	113.47	10.10	5.49	11.75	26
20	11/6/02 16:55	11/21/02 10:15	3.112	DF	NA	2.80	1.90	104.37	18.60	21.86	36.08	27
21	11/21/02 10:15	12/3/02 12:45	2.170	DF	NA	6.25	6.35	32.02	0.49	0.92	2.23	28
22	12/3/02 12:45	12/12/02 17:40	2.910	DF	NA	11.15	7.39	51.18	1.05	1.94	3.49	
23	12/12/02 17:40	12/24/02 14:15	2.625	DF	NA	2.77	1.93	236.61	1.89	3.50	11.18	
24	12/24/02 14:15	1/2/03 17:10	3.580	DF	NA	8.68	7.89	NA	2.09	2.39	2.81	29
25	1/2/03 17:10	1/10/03 8:45	2.205	DF	NA	6.75	7.91	99.84	0.20	0.40	5.82	
26	1/10/03 8:45	1/21/03 18:15	2.830	DF	NA	9.30	11.99	47.05	0.25	0.85	6.62	30
27	1/21/03 18:15	1/29/03 10:35	2.360	DF	NA	11.46	4.44	61.48	0.21	0.57	2.83	
28	1/29/03 10:35	2/5/03 17:10	3.767	DF	NA	7.88	0.86	21.97	0.33	1.81	4.54	31
29	2/5/03 17:10	2/13/03 15:20	3.668	DF	NA	5.62	0.04	21.07	0.17	0.88	3.54	32
30	2/13/03 15:20	2/19/03 13:15	3.355	DF	NA	7.27	3.98	10.41	0.90	1.62	3.64	
31	2/19/03 13:15	3/5/03 15:40	2.810	DF	NA	16.61	11.82	34.11	2.01	2.03	4.40	33
32	3/5/03 15:40	3/12/03 14:45	3.354	DF	NA	3.57	1.25	33.28	1.95	3.43	2.22	
33	3/12/03 14:45	3/19/03 19:00	2.705	DF	NA	6.26	4.48	41.62	2.42	3.26	6.04	34
34	3/19/03 19:00	3/26/03 20:55	3.294	DF	NA	7.87	6.49	27.60	0.59	1.59	3.38	34,35
35	3/26/03 20:55	4/2/03 16:45	2.900	DF	NA	5.54	4.81	29.77	2.59	3.49	2.98	34

Table 3b Cont'd. Ward Lake Level

Samp. No.	Start Date-Time	Collection Date-Time	Dry Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
36	4/2/03 16:45	4/9/03 13:50	3.882	DF	NA	12.55	7.30	28.16	0.52	1.87	5.62	34
37	4/9/03 13:50	4/16/03 16:50	2.745	DF	NA	11.09	11.85	36.78	1.23	1.98	3.81	34
38	4/16/03 16:50	4/23/03 16:45	2.655	DF	NA	16.37	9.36	58.42	0.24	5.21	2.72	34,36
39	4/23/03 16:45	4/30/03 18:00	3.095	DF	NA	18.85	15.95	110.72	1.00	2.49	6.10	34
40	4/30/03 18:00	5/7/03 15:00	2.757	DF	NA	7.36	3.28	0.00	1.01	2.39	5.44	
41	5/7/03 15:00	5/14/03 14:40	1.485	DF	NA	13.29	6.42	43.60	0.07	1.65	4.63	30
42	5/14/03 14:40	5/22/03 18:00	2.140	DF	NA	8.08	3.97	57.15	0.48	3.06	5.16	37
43	5/22/03 18:00	6/5/03 15:00	2.712	DF	NA	59.56	14.47	NA	6.20	41.48	84.90	38
44	6/5/03 15:00	6/13/03 16:30	2.005	DF	NA	2.59	NA	623.12	NA	10.07	24.22	39
45	6/13/03 16:30	6/24/03 17:25	1.410	DF	NA	5.83	16.60	615.38	6.47	22.07	80.05	
46	6/24/03 17:25	7/2/03 18:30	2.462	DF	NA	3.33	2.44	NA	2.66	6.93	13.30	40
47	7/2/03 18:30	7/8/03 17:30	2.802	DF	NA	6.32	8.96	158.29	2.65	5.55	22.98	
48	7/8/03 17:30	7/17/03 14:30	2.245	DF	NA	7.26	6.02	227.66	2.58	4.86	10.28	
49	7/17/03 14:30	7/26/03 13:50	1.938	DF	4.71	5.26	2.33	NA	0.52	1.28	3.28	
50	7/26/03 13:50	8/5/03 15:45	3.21	DF	NA	8.12	7.59	156.39	0.59	2.98	4.69	
51	8/5/03 15:45	8/14/03 12:05	2.322	DF	2.19	3.58	2.76	224.55	0.43	4.74	12.11	
52	8/14/03 12:05	8/22/03 17:20	1.339	DF	NA	2.37	0.81	59.28	0.06	1.24	2.98	
53	8/22/03 17:20	9/3/03 11:55	2.357	DF	2.93	8.87	6.62	141.42	0.11	3.50	8.24	92
54	9/3/03 11:55	9/12/03 17:50	2.888	DF	2.27	3.84	0.97	188.46	1.44	3.57	10.00	
55	9/12/03 17:50	10/1/03 13:50	1.855	DF	C	C	C	C	C	C	C	93
56	10/1/03 13:50	10/6/03 16:00	3.535	DF	NA	7.11	0.77	64.17	0.80	5.16	4.94	
57	10/6/03 16:00	10/15/03 9:45	3.125	DF	NA	4.46	1.15	61.35	3.40	3.98	9.11	
58	10/15/03 9:45	10/20/03 11:50	3.292	DF	NA	5.77	1.77	145.40	0.60	5.00	8.20	
59	10/20/03 11:50	10/28/03 16:50	3.33	DF	NA	9.62	10.62	61.58	2.89	4.89	5.85	94
60	10/28/03 16:50	11/5/03 12:50	2.87	DF+S	C	C	C	C	C	C	C	95
61	11/5/03 12:50	11/11/03 13:00	3.38	DF	NA	7.11	10.07	NA	14.55	17.99	19.88	96
62	11/11/03 13:00	11/25/03 16:30	0.44	DF	NA	1.07	1.39	NA	5.24	4.43	31.39	97
63	11/25/03 16:30	12/2/03 14:00	2.83	DF	NA	4.51	10.17	27.83	0.51	4.99	7.91	
64	12/2/03 14:00	12/15/03 12:00	4.63	DF	NA	11.95	10.83	NA	3.53	12.06	17.10	98
65	12/15/03 12:00	12/26/03 14:40	3.35	DF	NA	7.49	11.17	NA	0.15	NA	3.56	99
66	12/26/03 14:40	12/30/03 17:05	5.48	DF+S	5.42	9.86	4.78	NA	0.50	NA	7.56	100
67	12/30/03 17:05	1/13/04 13:00	5.18	DF+S	NA	10.75	14.78	NA	0.24	NA	NA	101
68	1/13/04 13:00	1/23/04 15:45	3.71	DF	NA	13.35	17.45	NA	1.86	NA	NA	
69	1/23/04 15:45	1/29/04 14:40	3.46	DF	NA	NA	NA	NA	0.94	NA	NA	
70	1/29/04 14:40	2/10/04 17:25	2.61	DF	NA	NA	NA	NA	1.18	NA	NA	

Table 4a. Precipitation amounts, pH, N and P concentrations in bulk (ST) deposition at the mid-lake station 5/1/02-2/5/04.

Samp. No.	Table 4a. Start Date-Time	Mid-lake Collection Date-Time	ST Precip. (in.)		Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	(Conc.) NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
		Raft (TR-2)													
1	4/22/02 10:50	5/2/02 10:05	0.43		S	ST	4.39	40.74	415.69	214.70	405.01	8.18	12.83	21.37	
-	5/2/02 10:05	5/17/02 9:25	0			ST	-	-	-	-	-	-	-	-	41
2	5/17/02 9:25	5/30/02 13:06	0.11		RS	ST	NA	NA	651.41	572.63	NA	26.64	40.48	NA	
-	5/30/02 13:06	6/11/02 12:31	0			ST	-	-	-	-	-	-	-	-	41
-	6/11/02 12:31	6/24/02 12:40	T			ST	NA	NA	NA	NA	NA	NA	NA	NA	
-	6/24/02 12:40	7/5/02 12:37	0			ST	-	-	-	-	-	-	-	-	41
-	7/5/02 12:37	7/17/02 9:35	0			ST	-	-	-	-	-	-	-	-	41
3	7/17/02 9:35	7/24/02 11:20	0.19		R	ST	NA	NA	586.85	221.07	139.08	10.93	30.67	71.17	
-	7/24/02 11:20	8/2/02 9:35	T			ST	NA	NA	NA	NA	NA	NA	NA	NA	
-	8/2/02 9:35	8/10/02 13:05	0			ST	-	-	-	-	-	-	-	-	41
-	8/10/02 13:05	8/21/02 9:20	0			ST	-	-	-	-	-	-	-	-	41
-	8/21/02 9:20	8/30/02 13:23	0			ST	-	-	-	-	-	-	-	-	41
-	8/30/02 13:23	9/11/02 9:47	0			ST	-	-	-	-	-	-	-	-	41
-	9/11/02 9:47	10/3/02 10:17	0			ST	-	-	-	-	-	-	-	-	41
-	10/3/02 10:17	10/15/02 10:10	0			ST	-	-	-	-	-	-	-	-	41
4	10/15/02 10:10	10/28/02 13:54	0.04		RH	ST	NA	NA	NA	NA	NA	NA	NA	NA	
-	10/28/02 13:54	11/5/02 13:20	0			ST	-	-	-	-	-	-	-	-	41
5	11/5/02 13:20	11/21/02 12:00	0.43	L	RS	ST	5.14	7.24	130.04	24.04	385.20	3.64	9.21	56.27	42
		Buoy (TB-1)													
-	11/21/02 12:00	12/3/02 10:20	0			ST	-	-	-	-	-	-	-	-	
-	12/3/02 10:20	1/2/03 11:24	NA	L	RS	ST	NA	NA	NA	NA	NA	NA	NA	NA	43
6	1/2/03 11:24	1/15/03 13:50	0.21		RS	ST	NA	NA	655.35	198.52	224.93	6.19	18.00	20.07	
7	1/15/03 13:50	1/28/03 10:05	0.41		RS	ST	4.30	50.12	291.82	83.46	118.25	0.68	4.26	13.38	
8	1/28/03 10:05	2/20/03 16:40	0.22		RS	ST	4.80	15.85	648.63	394.45	662.98	11.24	18.00	20.15	
9	2/20/03 16:40	3/11/03 12:55	0.06		RSH	ST	NA	NA	762.90	594.40	NA	3.44	10.55	NA	
10	3/11/03 12:55	3/31/03 10:08	0.02	L	RS	ST	NA	NA	NA	NA	NA	NA	NA	NA	114
11	3/31/03 10:08	4/15/03 12:45	0.6		S	ST	4.80	15.85	164.53	193.90	324.84	18.36	15.25	20.18	
12	4/15/03 12:45	4/30/03 10:10	0.13		S	ST	4.90	12.59	506.29	525.70	NA	2.79	37.62	NA	
13	4/30/03 10:10	5/15/03 10:30	0.16		RS	ST	4.70	19.95	NA	NA	NA	NA	NA	NA	44
14	5/15/03 10:30	6/4/03 10:07	0			ST	-	-	-	-	-	-	-	-	41
-	6/4/03 10:07	6/17/03 12:10	0			ST	-	-	-	-	-	-	-	-	41
15	6/17/03 12:10	6/24/03 12:10	0.07		RHG	ST	NA	NA	1521.24	987.53	NA	80.02	167.71	NA	
-	6/24/03 12:10	7/8/03 9:30	0			ST	-	-	-	-	-	-	-	-	41
-	7/8/03 9:30	7/17/03 12:50	0			ST	-	-	-	-	-	-	-	-	41

Table 4a Cont'd.

Samp. No.	Start Date-Time	Mid-lake Collection Date-Time	ST Precip. (in.)		Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (Conc.) (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
16	7/17/03 12:50	7/26/03 8:55	0.61		R	ST	4.60	25.12	589.66	215.45	1148.94	9.53	20.13	100.52	102
	7/26/03 8:55	8/5/03 9:10	0.24		R	ST	NA	NA	908.92	1023.63	NA	0.93	54.55	114.69	103
-	8/5/03 9:10	8/14/03 11:25	0.00		-	ST	-	-	-	-	-	-	-	-	
17	8/14/03 11:25	8/22/03 10:15	0.53		R	ST	4.40	39.81	650.60	871.55	994.84	7.21	21.32	37.05	
18	8/22/03 10:15	9/2/03 11:50	0.02		R	ST	NA	NA	1437.03	1265.83	NA	NA	NA	NA	
-	9/2/03 11:50	9/11/03 12:35	T		R	ST	NA	NA	NA	NA	NA	NA	NA	NA	
-	9/11/03 12:35	9/21/03 13:00	0.00		-	ST	-	-	-	-	-	-	-	-	
-	9/21/03 13:00	9/30/03 10:45	0.00		-	ST	-	-	-	-	-	-	-	-	
-	9/30/03 10:45	10/6/03 11:50	0.00		-	ST	-	-	-	-	-	-	-	-	
-	10/6/03 11:50	10/20/03 13:50	0.00		-	ST	-	-	-	-	-	-	-	-	
19	10/20/03 13:50	10/28/03 9:45	0.00		DF	ST	NA	NA	8.57	3.42	NA	1.74	9.62	16.28	104
20	10/28/03 9:45	11/11/03 13:01	0.33		RS+DF	ST	4.77	16.98	1192.84	432.73	1368.09	45.55	40.11	92.95	105
21	11/11/03 13:01	11/25/03 11:00	0.06		RS+DF	ST	NA	NA	3654.95	1825.05	NA	61.06	80.95	NA	
22	11/25/03 11:00	12/4/03 10:15	0.07		RS+DF	ST	NA	NA	1287.18	600.37	NA	37.61	8.93	NA	
23	12/4/03 10:15	12/15/03 13:15	0.06	L	RS+DF	ST	NA	NA	148.85	30.87	NA	4.33	29.48	NA	106
24	12/15/03 13:15	12/30/03 15:17	0.28	L	RS+DF	ST	NA	NA	48.62	35.72	NA	NA	NA	12.07	107
25	12/30/03 15:17	1/9/04 9:47	0.08		S+DF	ST	NA	NA	563.21	143.55	NA	0.92	NA	NA	
26	1/9/04 9:47	1/22/04 14:58	0.02		S+DF	ST	NA	NA	137.76	70.49	NA	5.07	NA	NA	
27	1/22/04 14:58	2/5/04 9:55	0.14		S?+DF	ST	NA	NA	NA	NA	NA	13.37	NA	NA	

Table 4b. Precipitation N, P and H loads in bulk (ST) deposition at the mid-lake station 5/1/02-2/5/04.

Samp. No.	Table 4b. Start Date-Time	Mid-lake Collection Date-Time	ST Precip. (in.)		Precip. Form	H+ (g/ha)	NO3-N (g/ha)	(Load) NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
		Raft (TR-2)											
1	4/22/02 10:50	5/2/02 10:05	0.43		S	4.45	45.40	23.45	44.24	0.89	1.40	2.33	
-	5/2/02 10:05	5/17/02 9:25	0			-	-	-	-	-	-	-	41
2	5/17/02 9:25	5/30/02 13:06	0.11		RS	NA	18.20	16.00	NA	0.74	1.13	NA	
-	5/30/02 13:06	6/11/02 12:31	0			-	-	-	-	-	-	-	41
-	6/11/02 12:31	6/24/02 12:40	T			NA	NA	NA	NA	NA	NA	NA	
-	6/24/02 12:40	7/5/02 12:37	0			-	-	-	-	-	-	-	41
-	7/5/02 12:37	7/17/02 9:35	0			-	-	-	-	-	-	-	41
3	7/17/02 9:35	7/24/02 11:20	0.19		R	NA	28.32	10.67	6.71	0.53	1.48	3.43	
-	7/24/02 11:20	8/2/02 9:35	T			NA	NA	NA	NA	NA	NA	NA	
-	8/2/02 9:35	8/10/02 13:05	0			-	-	-	-	-	-	-	41
-	8/10/02 13:05	8/21/02 9:20	0			-	-	-	-	-	-	-	41
-	8/21/02 9:20	8/30/02 13:23	0			-	-	-	-	-	-	-	41
-	8/30/02 13:23	9/11/02 9:47	0			-	-	-	-	-	-	-	41
-	9/11/02 9:47	10/3/02 10:17	0			-	-	-	-	-	-	-	41
-	10/3/02 10:17	10/15/02 10:10	0			-	-	-	-	-	-	-	41
4	10/15/02 10:10	10/28/02 13:54	0.04		RH	NA	NA	NA	NA	NA	NA	NA	
-	10/28/02 13:54	11/5/02 13:20	0			-	-	-	-	-	-	-	41
5	11/5/02 13:20	11/21/02 12:00	0.43	L	RS	0.79	14.20	2.63	42.07	0.40	1.01	6.15	42
		Buoy (TB-1)											
-	11/21/02 12:00	12/3/02 10:20	0			-	-	-	-	-	-	-	
-	12/3/02 10:20	1/2/03 11:24	NA	L	RS	NA	NA	NA	NA	NA	NA	NA	43
6	1/2/03 11:24	1/15/03 13:50	0.21		RS	NA	34.96	10.59	12.00	0.33	0.96	1.07	
7	1/15/03 13:50	1/28/03 10:05	0.41		RS	5.22	30.39	8.69	12.31	0.07	0.44	1.39	
8	1/28/03 10:05	2/20/03 16:40	0.22		RS	0.89	36.25	22.04	37.05	0.63	1.01	1.13	
9	2/20/03 16:40	3/11/03 12:55	0.06		RSH	NA	11.63	9.06	NA	0.05	0.16	NA	
10	3/11/03 12:55	3/31/03 10:08	0.02	L	RS	NA	NA	NA	NA	NA	NA	NA	114
11	3/31/03 10:08	4/15/03 12:45	0.6		S	2.42	25.07	29.55	49.51	2.80	2.32	3.08	
12	4/15/03 12:45	4/30/03 10:10	0.13		S	0.42	16.72	17.36	NA	0.09	1.24	NA	
13	4/30/03 10:10	5/15/03 10:30	0.16		RS	0.81	NA	NA	NA	NA	NA	NA	44
14	5/15/03 10:30	6/4/03 10:07	0			-	-	-	-	-	-	-	41
-	6/4/03 10:07	6/17/03 12:10	0			-	-	-	-	-	-	-	41
15	6/17/03 12:10	6/24/03 12:10	0.07		RHG	NA	27.05	17.56	NA	1.42	2.98	NA	
-	6/24/03 12:10	7/8/03 9:30	0			-	-	-	-	-	-	-	41
-	7/8/03 9:30	7/17/03 12:50	0			-	-	-	-	-	-	-	41

Table 4b Cont'd.

Samp. No.	Start Date-Time	Mid-lake Collection Date-Time	ST Precip. (in.)		Precip. Form	H+ (g/ha)	NO3-N (g/ha)	(Load) NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
16	7/17/03 12:50	7/26/03 8:55	0.61		R	3.89	91.36	33.38	178.02	1.48	3.12	15.57	102
	7/26/03 8:55	8/5/03 9:10	0.24		R	NA	55.41	62.40	NA	0.06	3.33	6.99	103
-	8/5/03 9:10	8/14/03 11:25	0.00		-	-	-	-	-	-	-	-	
17	8/14/03 11:25	8/22/03 10:15	0.53		R	5.36	87.58	117.33	133.93	0.97	2.87	4.99	
18	8/22/03 10:15	9/2/03 11:50	0.02		R	NA	7.30	6.43	NA	NA	NA	NA	
-	9/2/03 11:50	9/11/03 12:35	T		R	NA	NA	NA	NA	NA	NA	NA	
-	9/11/03 12:35	9/21/03 13:00	0.00		-	-	-	-	-	-	-	-	
-	9/21/03 13:00	9/30/03 10:45	0.00		-	-	-	-	-	-	-	-	
-	9/30/03 10:45	10/6/03 11:50	0.00		-	-	-	-	-	-	-	-	
-	10/6/03 11:50	10/20/03 13:50	0.00		-	-	-	-	-	-	-	-	
19	10/20/03 13:50	10/28/03 9:45	0.00		DF	NA	1.32	0.53	NA	0.27	1.48	2.51	104
20	10/28/03 9:45	11/11/03 13:01	0.33		RS+DF	1.42	99.98	36.27	114.67	3.82	3.36	7.79	105
21	11/11/03 13:01	11/25/03 11:00	0.06		RS+DF	NA	55.70	27.81	NA	0.93	1.23	NA	
22	11/25/03 11:00	12/4/03 10:15	0.07		RS+DF	NA	22.89	10.67	NA	0.67	0.16	NA	
23	12/4/03 10:15	12/15/03 13:15	0.06	L	RS+DF	NA	2.27	0.47	NA	0.07	0.45	NA	106
24	12/15/03 13:15	12/30/03 15:17	0.28	L	RS+DF	NA	3.46	2.54	NA	0.07	NA	0.86	107
25	12/30/03 15:17	1/9/04 9:47	0.08		S+DF	NA	11.44	2.92	NA	0.10	NA	NA	
26	1/9/04 9:47	1/22/04 14:58	0.02		S+DF	NA	0.70	0.36	NA	NA	NA	NA	
27	1/22/04 14:58	2/5/04 9:55	0.14		S?+DF	NA	NA	NA	NA	0.48	NA	NA	

Table 5a. N, P and H concentrations in dry-bulk deposition (buoy bucket) at the mid-lake station 5/1/02-2/5/04.

Table 5a. Samp. No.	Mid-lake Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
		Raft (TR-2)												
1	4/22/02 10:50	5/2/02 10:05	2.160	DF+S	DRY-BULK	4.80	15.85	137.38	132.65	248.46	3.86	3.67	10.08	45
2	5/2/02 10:05	5/17/02 9:25	1.000	DF	DRY-BULK	NA	NA	144.77	88.65	195.29	1.36	3.36	14.05	46,47
3	5/17/02 9:25	5/30/02 13:06	0.472	DF+RS	DRY-BULK	4.72	19.05	382.43	689.54	270.07	13.41	7.33	24.79	48
4	5/30/02 13:06	6/11/02 12:31	1.000	DF	DRY-BULK	NA	NA	147.05	50.36	137.27	4.77	8.55	32.54	47,49
5	6/11/02 12:31	6/24/02 12:05	0.361	DF+T	DRY-BULK	4.30	50.12	267.51	320.28	722.59	13.11	54.52	85.50	50
6	6/24/02 12:05	7/5/02 12:37	1.000	DF	DRY-BULK	NA	NA	151.63	78.92	256.50	8.18	14.05	49.88	47
7	7/5/02 12:37	7/17/02 9:35	1.000	DF	DRY-BULK	NA	NA	176.43	35.97	51.75	1.36	4.28	50.80	47,51
8	7/17/02 9:35	7/24/02 11:20	0.910	DF+R	DRY-BULK	4.50	31.62	410.80	247.25	115.55	6.13	9.47	20.68	52
9	7/24/02 11:20	8/2/02 9:35	1.000	DF+T	DRY-BULK	NA	NA	81.09	58.19	78.45	1.14	3.67	10.99	46,47
10	8/2/02 9:35	8/10/02 13:05	1.000	DF	DRY-BULK	NA	NA	206.20	159.27	110.12	3.87	5.83	11.60	47
11	8/10/02 13:05	8/21/02 9:20	1.000	DF	DRY-BULK	NA	NA	207.13	91.23	45.42	4.55	10.74	31.76	47,54
12	8/21/02 9:20	8/30/02 13:23	1.000	DF	DRY-BULK	NA	NA	142.67	135.88	59.90	3.64	5.83	14.29	47
13	8/30/02 13:23	9/11/02 9:47	1.000	DF	DRY-BULK	NA	NA	311.03	187.02	305.89	0.23	3.67	18.93	47,55
14	9/11/02 9:47	10/3/02 17:45	1.000	DF	DRY-BULK	NA	NA	267.38	153.42	337.99	4.10	5.52	19.16	47,56
15	10/3/02 17:45	10/15/02 10:10	1.000	DF	DRY-BULK	NA	NA	238.23	239.13	432.40	10.20	7.62	15.06	47,57
16	10/15/02 10:10	10/28/02 13:54	0.451	DF+RH	DRY-BULK	4.22	60.26	638.12	426.88	NA	10.14	15.34	55.69	58
17	10/28/02 13:54	11/5/02 13:20	0.415	DF	DRY-BULK	4.50	31.62	540.59	285.15	855.36	11.16	15.96	27.98	
18	11/5/02 13:20	11/21/02 12:00	0.428	DF+RS	DRY-BULK	4.50	31.62	664.23	369.77	649.55	28.92	33.14	39.54	59
		Buoy (TB-1)												
19	11/21/02 12:00	12/3/02 10:20	0.562	DF	DRY-BULK	4.50	31.62	415.69	212.53	304.00	4.54	6.42	10.41	54
20	12/3/02 10:20	1/2/03 11:24	0.500	DF+RS	DRY-BULK	4.83	14.79	404.61	66.99	NA	4.78	7.06	11.32	60
21	1/2/03 11:24	1/15/03 13:50	1.460	DF+RS	DRY-BULK	NA	NA	147.62	51.25	121.49	2.50	2.74	9.12	
22	1/15/03 13:50	1/28/03 10:05	2.832	DF+RS	DRY-BULK	4.89	12.88	101.43	29.04	290.60	0.68	1.22	3.95	
23	1/28/03 10:05	2/20/03 16:40	0.695	DF+RS	DRY-BULK	4.80	15.85	342.45	248.91	424.36	7.47	8.83	18.63	
24	2/20/03 16:40	3/11/03 12:55	0.520	DF+RS	DRY-BULK	4.68	20.89	371.86	354.11	NA	12.70	10.98	14.05	
25	3/11/03 12:55	3/31/03 10:08	0.500	DF+RS	DRY-BULK	NA	NA	858.06	467.58	974.69	9.29	7.32	17.43	
26	3/31/03 10:08	4/15/03 12:45	0.930	DF+S	DRY-BULK	4.92	12.02	186.30	284.05	406.91	14.06	11.28	15.26	61
27	4/15/03 12:45	4/30/03 10:10	0.562	DF+S	DRY-BULK	4.90	12.59	388.65	372.82	380.13	2.33	5.64	13.85	
28	4/30/03 10:10	5/15/03 10:30	1.362	DF+RS	DRY-BULK	4.70	19.95	160.60	125.01	342.12	0.23	5.33	6.77	
29	5/15/03 10:30	6/4/03 10:07	1.000	DF	DRY-BULK	NA	NA	187.43	20.25	685.11	4.44	23.52	78.55	47,55
30	6/4/03 10:07	6/17/03 12:10	1.000	DF	DRY-BULK	NA	NA	171.52	180.50	NA	5.00	9.81	46.71	47
31	6/17/03 12:10	6/24/03 18:30	0.850	DF+RHG	DRY-BULK	4.40	39.81	320.06	206.49	1778.70	1.05	11.29	38.66	62
32	6/24/03 18:30	7/8/03 9:30	1.000	DF	DRY-BULK	NA	NA	139.08	107.60	292.67	7.07	15.91	29.64	47
	7/8/03 9:30	7/17/03 12:50	0.408	DF	DRY-BULK	4.30	50.12	313.96	280.70	762.97	4.56	20.18	30.28	

Table 5a Cont'd. Mid-lake Dry-Bulk (Conc.)

Samp. No.	Start Date-Time	Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
34	7/17/03 12:50	7/26/03 8:55	1.86	DF+R	DRY-BULK	4.88	13.18	337.80	222.39	346.81	1.36	3.96	18.69	
35	7/26/03 8:55	8/5/03 9:10	0.96	DF+R	DRY-BULK	4.87	13.49	530.36	537.60	1180.04	3.91	8.78	16.11	108
36	8/5/03 9:10	8/14/03 11:25	1.00	DF	DRY-BULK	NA	NA	93.92	132.14	308.05	0.23	6.58	11.92	47
37	8/14/03 11:25	8/22/03 10:15	2.45	DF+R	DRY-BULK	4.80	15.85	251.10	361.27	504.51	0.47	5.96	7.41	108
	8/22/03 10:15	9/2/03 11:50	1.00	DF+R	DRY-BULK	NA	NA	392.96	487.63	579.39	2.56	8.46	22.87	109
38	9/2/03 11:50	9/11/03 12:35	0.32	DF+R	DRY-BULK	4.30	50.12	1180.66	1192.95	1172.34	5.52	11.29	27.09	
39	9/11/03 12:35	9/21/03 13:00	1.00	DF	DRY-BULK	NA	NA	244.16	228.97	410.64	1.15	6.77	10.46	47
40	9/21/03 13:00	9/30/03 10:45	1.47	DF	DRY-BULK	4.81	15.49	97.99	60.79	368.19	5.06	6.46	11.08	
41	9/30/03 10:45	10/6/03 11:50	1.90	DF	DRY-BULK	4.90	12.59	77.61	83.57	172.30	1.38	5.23	8.93	
42	10/6/03 11:50	10/20/03 13:50	0.50	DF	DRY-BULK	NA	NA	283.62	146.48	220.55	1.61	8.31	32.32	
43	10/20/03 13:50	10/28/03 9:45	1.55	DF	DRY-BULK	4.72	19.05	91.60	90.25	125.33	1.63	5.27	6.76	
44	10/28/03 9:45	11/11/03 13:01	1.20	DF+RS	DRY-BULK	4.51	30.90	323.47	397.66	429.79	11.84	NA	20.31	
45	11/11/03 13:01	11/25/03 11:00	0.33	DF+RS	DRY-BULK	NA	NA	821.71	532.28	NA	13.07	27.09	30.78	
46	11/25/03 11:00	12/4/03 10:15	1.33	DF+RS	DRY-BULK	NA	NA	87.72	56.44	NA	1.15	7.69	135.14	
47	12/4/03 10:15	12/15/03 13:15	1.60	DF+RS	DRY-BULK	4.90	12.59	60.56	13.77	NA	3.87	14.43	28.87	
48	12/15/03 13:15	12/30/03 15:17	2.03	DF+RS	DRY-BULK	NA	NA	54.70	8.66	NA	0.23	NA	1.91	
49	12/30/03 15:17	1/9/04 9:47	0.78	DF+S	DRY-BULK	4.88	13.18	96.84	15.27	NA	0.69	NA	NA	
50	1/9/04 9:47	1/22/04 14:58	1.78	DF+S	DRY-BULK	NA	NA	145.06	51.00	NA	0.46	NA	NA	
51	1/22/04 14:58	2/5/04 9:55	1.465	DF	DRY-BULK	4.91	12.30	NA	NA	NA	1.61	NA	NA	110

Table 5b. N, P and H loads in dry-bulk deposition (buoy bucket) at the mid-lake station 5/1/02-2/5/04.

Table 5b. Samp. No.	Mid-lake Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	(Load) NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
		Raft (TR-2)	1.467						1.67	1.62	2.80	
1	4/22/02 10:50	5/2/02 10:05	~~2.160~~	DF+S	6.76	58.56	56.55	105.91	~~1.65~~	~~1.56~~	~~4.30~~	45
2	5/2/02 10:05	5/17/02 9:25	1.000	DF	NA	28.57	17.50	38.54	0.27	0.66	2.77	46,47
3	5/17/02 9:25	5/30/02 13:06	0.472	DF+RS	1.87	37.47	67.57	26.46	1.31	0.72	2.43	48
4	5/30/02 13:06	6/11/02 12:31	1.000	DF	NA	29.02	9.94	27.09	0.94	1.69	6.42	47,49
5	6/11/02 12:31	6/24/02 12:05	0.361	DF+T	C	C	C	C	C	C	C	50
6	6/24/02 12:05	7/5/02 12:37	1.000	DF	NA	29.92	15.58	50.62	1.61	2.77	9.84	47
7	7/5/02 12:37	7/17/02 9:35	1.000	DF	NA	34.82	7.10	10.21	0.27	0.84	10.03	47,51
8	7/17/02 9:35	7/24/02 11:20	0.910	DF+R	5.68	73.78	44.40	20.75	1.10	1.70	3.71	52
9	7/24/02 11:20	8/2/02 9:35	1.000	DF+T	NA	16.00	11.48	15.48	0.22	0.72	2.17	46,47
10	8/2/02 9:35	8/10/02 13:05	1.000	DF	NA	42.81	33.06	22.86	0.80	1.21	2.41	47
11	8/10/02 13:05	8/21/02 9:20	1.000	DF	NA	40.88	18.00	8.96	0.90	2.12	6.27	47,54
12	8/21/02 9:20	8/30/02 13:23	1.000	DF	NA	28.16	26.82	11.82	0.72	1.15	2.82	47
13	8/30/02 13:23	9/11/02 9:47	1.000	DF	NA	61.38	36.91	60.37	0.05	0.72	3.74	47,55
14	9/11/02 9:47	10/3/02 ~~17:45~~	1.000	DF	NA	55.51	31.85	70.17	0.85	1.15	3.98	47,56
15	10/3/02 ~~17:45~~	10/15/02 10:10	1.000	DF	NA	47.02	47.19	85.34	2.01	1.50	2.97	47,57
16	10/15/02 10:10	10/28/02 13:54	0.451	DF+RH	5.36	56.80	37.99	NA	0.90	1.37	4.96	58
17	10/28/02 13:54	11/5/02 13:20	0.415	DF	2.59	44.28	23.35	70.06	0.91	1.31	2.29	
18	11/5/02 13:20	11/21/02 12:00	0.428	DF+RS	2.67	56.11	31.23	54.87	2.44	2.80	3.34	59
		Buoy (TB-1)										
19	11/21/02 12:00	12/3/02 10:20	0.562	DF	3.51	46.11	23.57	33.72	0.50	0.71	1.15	54
20	12/3/02 10:20	1/2/03 11:24	0.500	DF+RS	1.46	39.93	6.61	NA	0.47	0.70	1.12	60
21	1/2/03 11:24	1/15/03 13:50	1.460	DF+RS	NA	42.53	14.77	35.01	0.72	0.79	2.63	
22	1/15/03 13:50	1/28/03 10:05	2.832	DF+RS	7.20	56.69	16.23	162.42	0.38	0.68	2.21	
23	1/28/03 10:05	2/20/03 16:40	0.695	DF+RS	2.17	46.97	34.14	58.21	1.02	1.21	2.56	
24	2/20/03 16:40	3/11/03 12:55	0.520	DF+RS	2.26	40.14	38.23	NA	1.37	1.19	1.52	
25	3/11/03 12:55	3/31/03 10:08	0.500	DF+RS	NA	84.67	46.14	96.18	0.92	0.72	1.72	
26	3/31/03 10:08	4/15/03 12:45	0.930	DF+S	2.21	34.19	52.13	74.68	2.58	2.07	2.80	61
27	4/15/03 12:45	4/30/03 10:10	0.562	DF+S	1.47	45.34	43.50	44.35	0.27	0.66	1.62	
28	4/30/03 10:10	5/15/03 10:30	1.362	DF+RS	5.36	43.17	33.60	91.96	0.06	1.43	1.82	
29	5/15/03 10:30	6/4/03 10:07	1.000	DF	NA	36.99	4.00	135.21	0.88	4.64	15.50	47,55
30	6/4/03 10:07	6/17/03 12:10	1.000	DF	NA	35.61	37.47	NA	1.04	2.04	9.70	47
31	6/17/03 12:10	6/24/03 18:30	0.850	DF+RHG	6.68	53.69	34.64	298.38	0.18	1.89	6.49	62
32	6/24/03 18:30	7/8/03 9:30	1.000	DF	NA	27.45	21.24	57.76	1.40	3.14	5.85	47
	7/8/03 9:30	7/17/03 12:50	0.408	DF	4.04	25.28	22.60	61.43	0.37	1.62	2.44	

Table 5b Cont'd. Mid-lake Dry-Bulk (Load)

Samp. No.	Start Date-Time	Collection Date-Time	Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
34	7/17/03 12:50	7/26/03 8:55	1.86	DF+R	4.83	123.66	81.41	126.96	0.50	1.45	6.84	
35	7/26/03 8:55	8/5/03 9:10	0.96	DF+R	2.67	105.15	106.58	233.96	0.78	1.74	3.19	108
36	8/5/03 9:10	8/14/03 11:25	1.00	DF	NA	18.54	26.08	60.79	0.05	1.30	2.35	47
37	8/14/03 11:25	8/22/03 10:15	2.45	DF+R	8.05	127.56	183.53	256.29	0.24	3.03	3.76	108
	8/22/03 10:15	9/2/03 11:50	1.00	DF+R	NA	77.55	96.24	114.34	0.51	1.67	4.51	109
38	9/2/03 11:50	9/11/03 12:35	0.32	DF+R	3.33	78.43	79.25	77.88	0.37	0.75	1.80	
39	9/11/03 12:35	9/21/03 13:00	1.00	DF	NA	48.19	45.19	81.04	0.23	1.34	2.06	47
40	9/21/03 13:00	9/30/03 10:45	1.47	DF	4.48	28.33	17.58	106.45	1.46	1.87	3.20	
41	9/30/03 10:45	10/6/03 11:50	1.90	DF	4.97	30.61	32.96	67.96	0.54	2.06	3.52	
42	10/6/03 11:50	10/20/03 13:50	0.50	DF	NA	27.99	14.45	21.76	0.16	0.82	3.19	
43	10/20/03 13:50	10/28/03 9:45	1.55	DF	5.83	28.04	27.62	38.36	0.50	1.61	2.07	
44	10/28/03 9:45	11/11/03 13:01	1.20	DF+RS	7.67	80.25	98.65	106.62	2.94	NA	5.04	
45	11/11/03 13:01	11/25/03 11:00	0.33	DF+RS	NA	53.52	34.67	NA	0.85	1.76	2.00	
46	11/25/03 11:00	12/4/03 10:15	1.33	DF+RS	NA	24.22	15.58	NA	0.32	2.12	37.31	
47	12/4/03 10:15	12/15/03 13:15	1.60	DF+RS	3.96	19.06	4.33	NA	1.22	4.54	9.09	
48	12/15/03 13:15	12/30/03 15:17	2.03	DF+RS	NA	23.00	3.64	NA	0.10	NA	0.80	
49	12/30/03 15:17	1/9/04 9:47	0.78	DF+S	2.02	14.85	2.34	NA	0.11	NA	NA	
50	1/9/04 9:47	1/22/04 14:58	1.78	DF+S	**NA**	50.81	17.87	NA	0.16	NA	NA	
51	1/22/04 14:58	2/5/04 9:55	1.465	DF	3.56	NA	NA	NA	0.47	NA	NA	110

Table 6a. N, P and H concentrations in dry-bulk deposition (buoy bucket) at the (TR-3) raft station 4/22/02-8/30/02 and Northwest (TB-4) buoy station 11/21/02-2/5/04.

Table 6a. Samp. No.	TR3 or TB 4 Lake Start Date-Time	Buoy Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	(Conc.) NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
		Raft (TR-3)												
1	4/22/02 9:55	5/2/02 9:30	~~2.160~~	DF+S	DRY-BULK	4.99	10.23	94.64	78.50	132.62	2.27	2.14	7.65	45
2	5/2/02 9:30	5/17/02 8:45	1.000	DF	DRY-BULK	4.81	15.49	146.17	161.11	417.85	7.04	7.03	15.82	63
3	5/17/02 8:45	5/30/02 12:30	0.330	DF+RS	DRY-BULK	4.65	22.39	611.31	884.85	NA	21.36	25.97	96.41	64
4	5/30/02 12:30	6/11/02 12:05	1.000	DF	DRY-BULK	NA	NA	184.52	149.36	276.57	3.64	4.28	16.49	47,54
5	6/11/02 12:05	6/24/02 12:05	1.000	DF+T	DRY-BULK	4.65	22.39	151.63	134.56	329.36	9.09	5.19	15.58	46,47
6	6/24/02 12:05	7/5/02 11:55	1.000	DF	DRY-BULK	NA	NA	158.31	98.17	62.61	1.36	3.97	18.93	47
7	7/5/02 11:55	7/17/02 9:10	1.000	DF	DRY-BULK	NA	NA	146.88	72.57	64.42	3.41	5.19	16.79	46,47
8	7/17/02 9:10	7/24/02 10:50	1.165	DF+R	DRY-BULK	4.59	25.70	285.60	161.42	123.24	1.59	4.28	16.18	55
9	7/24/02 10:50	8/2/02 9:00	1.000	DF+T	DRY-BULK	NA	NA	136.15	134.34	419.17	2.50	3.36	10.34	46,53
10	8/2/02 9:00	8/10/02 12:25	1.000	DF	DRY-BULK	NA	NA	238.27	173.40	84.33	3.42	4.60	38.17	65
11	8/10/02 12:25	8/21/02 8:50	1.000	DF	DRY-BULK	NA	NA	190.53	66.88	87.05	1.82	3.07	26.16	47
12	8/21/02 8:50	8/30/02 12:37	1.000	DF	DRY-BULK	NA	NA	183.47	161.00	78.00	3.18	4.89	9.43	66
		Buoy (TB-4)												
13	11/21/02 13:00	12/3/02 9:45	0.342	DF	DRY-BULK	4.40	39.81	725.74	379.63	609.89	7.04	3.36	11.94	115
14	12/3/02 9:45	1/2/03 10:35	0.990	DF+RS	DRY-BULK	5.00	10.00	307.45	48.28	NA	3.64	6.14	15.91	55
15	1/2/03 10:35	1/15/03 13:50	1.268	DF+RS	DRY-BULK	NA	NA	170.54	96.92	384.91	1.81	3.35	8.52	
16	1/15/03 13:50	1/28/03 9:37	2.517	DF+RS	DRY-BULK	4.89	12.88	78.54	10.21	229.00	0.23	0.91	4.56	
17	1/28/03 9:37	2/20/03 16:05	0.891	DF+RS	DRY-BULK	4.80	15.85	348.79	193.02	203.89	7.47	2.74	10.38	
18	2/20/03 16:05	3/11/03 12:26	0.310	DF+RS	DRY-BULK	4.50	31.62	881.30	486.67	290.28	9.98	11.59	14.35	
19	3/11/03 12:26	3/31/03 9:10	0.500	DF+RS	DRY-BULK	NA	NA	552.38	494.53	1156.37	11.79	14.64	32.11	67
20	3/31/03 9:10	4/15/03 11:45	1.950	DF+S	DRY-BULK	5.20	6.31	230.78	258.00	588.34	4.08	NA	11.62	
21	4/15/03 11:45	4/30/03 10:50	0.530	DF+S	DRY-BULK	4.91	12.30	419.13	459.28	483.38	2.33	5.64	11.92	55
22	4/30/03 10:50	5/15/03 9:35	1.135	DF+RS	DRY-BULK	4.79	16.22	137.55	83.92	489.36	0.00	5.96	9.34	
23	5/15/03 9:35	6/4/03 9:30	1.000	DF	DRY-BULK	NA	NA	194.26	14.61	NA	2.73	12.97	NA	47,55
24	6/4/03 9:30	6/17/03 9:45	1.000	DF	DRY-BULK	NA	NA	161.70	150.77	633.15	19.98	7.05	42.20	68
25	6/17/03 9:45	6/24/03 18:00	1.275	DF+RHG	DRY-BULK	4.50	31.62	158.51	149.12	309.67	1.86	10.97	27.06	
26	6/24/03 18:00	7/8/03 8:55	1.000	DF	DRY-BULK	NA	NA	107.83	54.74	335.43	6.84	10.97	29.32	47
27	7/8/03 8:55	7/17/03 12:10	0.500	DF+R	DRY-BULK	4.65	22.39	255.67	207.42	700.97	11.17	13.48	67.98	111
28	7/17/03 12:10	7/26/03 8:15	0.44	DF+R?	DRY-BULK	4.61	24.55	863.10	618.37	NA	0.68	2.74	NA	
29	7/26/03 8:15	8/5/03 8:40	1.13	DF+R	DRY-BULK	4.80	15.85	444.15	457.84	752.50	1.17	4.70	91.82	112
30	8/5/03 8:40	8/14/03 10:30	1.00	DF	DRY-BULK	NA	NA	148.22	208.17	402.66	NA	4.08	28.67	47
31	8/14/03 10:30	8/22/03 9:45	1.54	DF	DRY-BULK	5.19	6.46	401.98	426.59	517.39	NA	4.08	20.30	
32	8/22/03 9:45	9/2/03 11:15	1.00	DF	DRY-BULK	NA	NA	288.56	744.49	525.44	0.70	6.27	14.18	47

Table 6a.

Samp. No.	TR3 or TB4 Lake Start Date-Time	Buoy Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	pH	H+ (µg/l)	NO3-N (µg/l)	(Conc.) NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
33	9/2/03 11:15	9/11/03 12:14	1.00	DF	DRY-BULK	5.10	7.94	287.41	297.64	NA	1.15	5.96	9.55	47
34	9/11/03 12:14	9/21/03 12:25	1.00	DF	DRY-BULK	NA	NA	241.29	246.69	644.68	1.15	8.31	11.39	47
35	9/21/03 12:25	9/30/03 9:58	1.62	DF	DRY-BULK	4.97	10.72	96.35	51.79	NA	1.15	6.16	18.78	
36	9/30/03 9:58	10/6/03 10:20	1.98	DF	DRY-BULK	4.90	12.59	75.96	90.70	101.83	1.15	5.23	8.93	
37	10/6/03 10:20	10/20/03 13:15	0.50	DF	DRY-BULK	NA	NA	236.76	150.37	206.48	2.30	9.23	30.78	113
38	10/20/03 13:15	10/28/03 9:05	1.20	DF	DRY-BULK	NA	NA	119.60	122.98	132.33	1.39	5.90	6.15	
39	10/28/03 9:05	11/11/03 12:30	1.36	DF+RS	DRY-BULK	4.79	16.22	209.15	309.98	NA	6.60	NA	11.08	
40	11/11/03 12:30	11/25/03 9:50	1.00	DF+RS	DRY-BULK	NA	NA	291.55	231.55	NA	6.65	9.23	14.16	47
41	11/25/03 9:50	12/4/03 9:30	1.60	DF+RS	DRY-BULK	NA	NA	77.30	61.41	NA	1.15	8.31	11.39	
42	12/4/03 9:30	12/15/03 12:44	2.03	DF+RS	DRY-BULK	5.10	7.94	45.91	23.28	NA	3.65	13.51	18.73	
43	12/15/03 12:44	12/30/03 14:40	1.85	DF+RS	DRY-BULK	NA	NA	66.86	15.27	NA	0.23	NA	2.22	
44	12/30/03 14:40	1/9/04 9:15	1.77	DF+S	DRY-BULK	4.90	12.59	45.79	12.18	NA	0.69	NA	NA	
45	1/9/04 9:15	1/22/04 15:33	1.36	DF+S	DRY-BULK	5.10	7.94	149.92	61.50	NA	0.46	NA	NA	
46	1/22/04 15:33	2/5/04 9:22	1.89	DF	DRY-BULK	4.90	12.59	NA	NA	NA	0.46	NA	NA	

Table 6b. N, P and H loads in dry-bulk deposition (buoy bucket) at the (TR-3) raft station 4/22/02-8/30/02 and Northwest (TB-4) buoy station 11/21/02-2/5/04.

Table 6b. Samp. No.	TR3 or TB4 Lake Start Date-Time	Buoy Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
		Raft (TR-3)	2.432		5.01	46.32	39.42	64.91	1.11	1.05	3.74	
1	4/22/02 9:55	5/2/02 9:30	~~2.160~~	DF+S	~~4.36~~	~~40.34~~	~~33.46~~	~~56.53~~	~~0.97~~	~~0.91~~	~~3.26~~	45
2	5/2/02 9:30	5/17/02 8:45	1.000	DF	3.06	28.85	31.80	82.46	1.39	1.39	3.12	63
3	5/17/02 8:45	5/30/02 12:30	0.330	DF+RS	1.46	39.81	57.63	NA	1.39	1.69	6.28	64
4	5/30/02 12:30	6/11/02 12:05	1.000	DF	NA	36.42	29.48	54.58	0.72	0.84	3.25	47,54
5	6/11/02 12:05	6/24/02 12:05	1.000	DF+T	4.42	29.92	26.56	65.00	1.79	1.02	3.07	46,47
6	6/24/02 12:05	7/5/02 11:55	1.000	DF	NA	31.24	19.37	12.36	0.27	0.78	3.74	47
7	7/5/02 11:55	7/17/02 9:10	1.000	DF	NA	30.49	15.07	13.37	0.71	1.08	3.49	46,47
8	7/17/02 9:10	7/24/02 10:50	1.165	DF+R	5.91	65.66	37.11	28.33	0.37	0.98	3.72	55
9	7/24/02 10:50	8/2/02 9:00	1.000	DF+T	NA	26.87	26.51	82.72	0.49	0.66	2.04	46,53
10	8/2/02 9:00	8/10/02 12:25	1.000	DF	NA	49.47	36.00	17.51	0.71	0.95	7.92	65
11	8/10/02 12:25	8/21/02 8:50	1.000	DF	NA	37.60	13.20	17.18	0.36	0.61	5.16	47
12	8/21/02 8:50	8/30/02 12:37	1.000	DF	NA	38.09	33.42	16.19	0.66	1.02	1.96	66
		Buoy (TB-4)										
13	11/21/02 13:00	12/3/02 9:45	0.342	DF	2.69	48.98	25.62	41.16	0.48	0.23	0.81	115
14	12/3/02 9:45	1/2/03 10:35	0.990	DF+RS	1.95	60.07	9.43	NA	0.71	1.20	3.11	55
15	1/2/03 10:35	1/15/03 13:50	1.268	DF+RS	NA	42.68	24.25	96.32	0.45	0.84	2.13	
16	1/15/03 13:50	1/28/03 9:37	2.517	DF+RS	6.73	41.04	5.34	119.66	0.12	0.48	2.38	
17	1/28/03 9:37	2/20/03 16:05	0.891	DF+RS	2.79	61.33	33.94	35.85	1.31	0.48	1.83	
18	2/20/03 16:05	3/11/03 12:26	0.310	DF+RS	1.93	53.92	29.77	17.76	0.61	0.71	0.88	
19	3/11/03 12:26	3/31/03 9:10	0.500	DF+RS	NA	54.51	48.80	114.11	1.16	1.44	3.17	67
20	3/31/03 9:10	4/15/03 11:45	1.950	DF+S	2.43	88.81	99.29	226.42	1.57	NA	4.47	
21	4/15/03 11:45	4/30/03 10:50	0.530	DF+S	1.29	43.84	48.04	50.56	0.24	0.59	1.25	55
22	4/30/03 10:50	5/15/03 9:35	1.135	DF+RS	3.63	30.81	18.80	109.61	0.00	1.34	2.09	
23	5/15/03 9:35	6/4/03 9:30	1.000	DF	NA	38.34	2.88	NA	0.54	2.56	NA	47,55
24	6/4/03 9:30	6/17/03 9:45	1.000	DF	NA	31.91	29.75	124.95	3.94	1.39	8.33	68
25	6/17/03 9:45	6/24/03 18:00	1.275	DF+RHG	8.37	41.96	39.47	81.97	0.49	2.90	7.16	
26	6/24/03 18:00	7/8/03 8:55	1.000	DF	NA	21.28	10.80	66.20	1.35	2.16	5.79	47
27	7/8/03 8:55	7/17/03 12:10	0.500	DF+R	2.21	25.23	20.47	69.17	1.10	1.33	6.71	111
28	7/17/03 12:10	7/26/03 8:15	0.44	DF+R?	2.11	74.10	53.09	NA	0.06	0.24	NA	
29	7/26/03 8:15	8/5/03 8:40	1.13	DF+R	3.53	99.05	102.10	167.81	0.26	1.05	20.48	112
30	8/5/03 8:40	8/14/03 10:30	1.00	DF	NA	29.25	41.08	79.47	NA	0.81	5.66	47
31	8/14/03 10:30	8/22/03 9:45	1.54	DF	1.96	121.77	129.23	156.74	NA	1.24	6.15	
32	8/22/03 9:45	9/2/03 11:15	1.00	DF	NA	56.95	146.93	103.70	0.14	1.24	2.80	47

Table 6b.

Samp. No.	TR3 or TB4 Lake Start Date-Time	Buoy Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	H+ (g/ha)	NO3-N (g/ha)	NH4-N (g/ha)	(Load) TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
33	9/2/03 11:15	9/11/03 12:14	1.00	DF	1.57	56.72	58.74	NA	0.23	1.18	1.88	47
34	9/11/03 12:14	9/21/03 12:25	1.00	DF	NA	47.62	48.68	127.23	0.23	1.64	2.25	47
35	9/21/03 12:25	9/30/03 9:58	1.62	DF	3.42	30.71	16.51	NA	0.37	1.96	5.99	
36	9/30/03 9:58	10/6/03 10:20	1.98	DF	5.17	31.22	37.28	41.86	0.47	2.15	3.67	
37	10/6/03 10:20	10/20/03 13:15	0.50	DF	NA	23.36	14.84	20.37	0.23	0.91	3.04	113
38	10/20/03 13:15	10/28/03 9:05	1.20	DF	NA	28.30	29.10	31.31	0.33	1.40	1.46	
39	10/28/03 9:05	11/11/03 12:30	1.36	DF+RS	4.58	59.01	87.46	NA	1.86	NA	3.13	
40	11/11/03 12:30	11/25/03 9:50	1.00	DF+RS	NA	57.54	45.70	NA	1.31	1.82	2.79	47
41	11/25/03 9:50	12/4/03 9:30	1.60	DF+RS	NA	25.60	20.33	NA	0.38	2.75	3.77	
42	12/4/03 9:30	12/15/03 12:44	2.03	DF+RS	3.17	18.35	9.30	NA	1.46	5.40	7.49	
43	12/15/03 12:44	12/30/03 14:40	1.85	DF+RS	NA	25.68	5.86	NA	NA	0.09	0.85	
44	12/30/03 14:40	1/9/04 9:15	1.77	DF+S	4.39	15.96	4.25	NA	NA	0.24	NA	
45	1/9/04 9:15	1/22/04 15:33	1.36	DF+S	2.13	40.24	16.51	NA	NA	0.12	NA	
46	1/22/04 15:33	2/5/04 9:22	1.89	DF	4.93	NA	NA	NA	NA	0.18	NA	

Table Legend and Notes:

Table Legend:

Precipitation Form: (S=snow; R=rain; DF= dry fall (Dry deposition); H=hail; G=grauple; NA=information on type not available; T=trace of precip.)

Collector Type: (ST= 8 in. dia. Snow tube; TBG= 8 in. dia. Electrically heated tipping bucket rain and snow gauge; Wet= Aerochem Metrics Wet Bucket; Dry= Dry-Bulk bucket with 4 liter deionized water added, placed in dry-side of Aerochem Metrics sampler; Dry-Bulk= Aerochem Metrics bucket with reduced side height, filled with 4 liters of deionized)

pH: (NES= not enough sample); C= sample contaminated; NA= not measured

Nutrient Concentrations: (C= sample contamination; NA= Not available or not enough sample for analysis; note units are micrograms/liter).

Nutrient Loading: (C= sample contamination; NA= Not available or not enough sample for analysis; note units are grams/ hectare, data reported to 2 decimal points).

Notes:

1	Snow tube (ST) dry, rinsed with 500ml deionized water and processed water
2	Snow tube only had 15 ml of sample, added 500ml of deionized water to process, concentration back-calculated from 0.02 in sample
3	ST sample contaminated with many bugs, discarded
4	Snow tube (ST) dry, rinsed with 1000 ml deionized water and processed water
5	ST sample compromised due to winds; use tipping bucket samples (bulk) for chemistry and logger value for amount
6	Amount needs to be verified with logger records
7	Amount needs to be verified with logger records
8	ST blown off tower by strong winds, use tipping bucket bottles (bulk) for chem and amount
9	ST cap ajar, use tipping bucket samples (bulk) for chem and amount
10	ST bridged with snow, use tipping bucket (bulk) samples for chem and amount
11	Sample contaminated by sprinkler contamination

Notes:

12	Snow several inches above bucket rim, compacted into bucket with lid
13	Approximately 1 foot of snow above rim, compacted into bucket with lid; use the tipping bucket amount 2.14 inches
14	Approximately 5 inches of snow above rim, compacted into bucket with lid
15	Approximately 4-5 inches of snow above rim, compacted into bucket with lid
16	Approximately 1 inch of snow above rim, compacted into bucket with lid
17	Approximately 1 1/2 - 2 feet of snow above rim, compacted into bucket with lid; use the amount from the data logger of 3.05 inches
18	Sample dropped, spilled
19	Removed dry bucket heater part-way through collection period
20	Many small seeds in dry bucket
21	Bucket screened
22	Much pollen in sample; Heavenly Valley "Gondola" forest fire during period;
23	Hazy with smoke from Sequoia Park fire much of period
24	Loose paint removed from tower this period, bucket temporarily placed on car cab during this process to prevent contamination from paint chips
25	Two aspen leaves and 2 pine needles in sample
26	Very smokey in basin on 11/5
27	Many pine needles, leaves and wind-blown dust in dry bucket
28	Dry bucket had ice in it, heater turned off on 12/3
29	Dry bucket frozen
30	Heater partially exposed above water
31	Dry bucket frozen, left sitting out thawing 2/5-2/11/03

32 Heater broken in bucket, also some ice, possible contamination from inside of heater
33 Added 1 liter deionized water to bucket during period
34 Coordinated dry bucket sample collection with ARB minivol filter sample collection
35 Heater not plugged in
36 Wet bucket sample NA this period
37 Sample sat chilled until processed on 5/30
38 Much pollen in sample; slight pink tinge to deposition filter
39 Much pollen and small black particles
40 Pollen and seed sprouting in bucket
41 Snow tube dry, not processed
42 Pieces of plastic and looks like suds in sample
43 Snow tube had pin-hole leak, most sample lost
44 2 small bugs in ST sample
45 slightly milky with plastic flakes
46 a few plastic flakes
47 Bucket dry when collected, added 1l of deionized water to process
48 small amt plastic flakes
49 moderate plastic flakes, also several small black flakes

Notes:

50 Lg. Dead bumblebee in dry bkt.
51 many plastic flakes; bkt sat dry in cold room for week
52 light-moderate plastic flakes; thunderstorms this period
54 moderate plastic flakes
55 many plastic flakes
56 PN filter very dirty
57 I side of bucket dirty
58 thunderstorm, many plastic flakes
59 Dry bkt DI may have splashed out of bkt this storm, 65 mph+ winds
60 93ml of sample in bucket, added 407ml of deionized water to process, sample splash from bucket is possible this period. Some plastic flakes
61 small fly in sample, many plastic flakes
62 Small amt of precip from thunderstorms, much pollen
63 Added 0.850l DI to 0.150 l sample; many plastic flakes
64 Very small pieces of black debris in bkt. Bird poop or other contam?, water milky from plastic
65 not processed until 8/20
66 Added 845ml DI to 155ml sample
67 Added 285ml DI to215 ml sample
68 Added 880ml of DI to 120ml of sample
69 ST had pin-hole leak
70 Added 1 liter deionized water to process
71 ST sample had foul smell, much pollen and other debris, possible contamination?
72 Rinsed ST with 500ml deionized water; rinsed TBG cone with 500 ml of deionized H_2O and discarded H_2O
73 Rinsed ST with 500ml deionized water
74 ST probably bridged with snow, volume low; approximately 2 feet of snow this storm
75 ST cap seal has hole in it sample volume suspect

76 ST probably bridged with snow
77 Estimated amount based on logger record y=.94692302x-.008120881 r^2=.9980
78 High pH, possible sprinkler contamination
79 TBG bottles had very unequal volumes: 570 and 1355 ml; snow approximately 8 inches above wet bucket rim; Aerochem lid froze over dry bucket
80 Aerochem lid froze over wet bucket, dry caught most precipitation
81 TBG bottles had very unequal volumes: 200 and 415 ml
82 High pH due to 2 aspen leaves in wet sample
83 TBG bottles had very unequal volumes: 1860+ and 835 ml
84 Snow 8 inches above wet bucket rim
85 Snow 2 inches above wet bucket rim
86 Snow 4-5 inches above wet bucket rim and leaning to one side, compacted into bucket for collection; uneven amounts in TBG bottles 1135 and 1675 ml
87 Aerochem lid froze over wet bucket, dry caught most precipitation
88 Snow 8 inches above wet bucket rim; uneven amounts in TBG bottles 531 and 1015 ml

Notes:

89 TBG bottles had very unequal volumes: 228 and 39 ml
90 Aerochem Metrics froze over dry bucket, so wet contains some dry deposition
91 Combined wet bucket collected 2/6/04 with bucket collected 2/10/04
92 Dead bee and dead fly in sample, slight foul odor to sample, possible contamination
93 Dead yellow jacket and flying ant in sample, possible contamination
94 Last screened bucket for summer; replaced with bucket with heater
95 Many aspen leaves in sample giving a golden tea color, chemistry may not be representative of dry deposition
96 1 aspen leaf in sample
97 dry bucket heater had been exposed and plastic heater base melted; several aspen leaves and water has organic color; possible contamination
98 small amount of water spilled; dry bucket may have caught some wet precipitation
99 Aerochem Metrics lid froze over dry bucket at end of period, so a portion of dry deposition caught in wet
100 Aerochem Metrics lid froze over wet bucket and dry bucket caught most wet deposition this period (approximately 2 feet of snow)
101 Heater glass broken, possible contamination from inside thermometer
102 Many flakes of plastic from liner in sample
103 1 dead fly and small bugs in sample, possible contamination
104 added 500 ml deionized water to process
105 sample filtration filter very dirty with particulates
106 pin hole leak in ST corner, volume low
107 hole in ST a couple of inches from bottom
108 rain from thunderstorms
108 rain from thunderstorms
109 dry bucket had 50ml of sample added 950 ml DI water to process
110 possible contamination with ash from diesel, boat engine
111 dry bucket had 72ml added 428 ml DI H2O to process
112 thunderstorms this period
113 bucket dry when collected, added 500 ml DI H2O to process
114 snow tube probably leaked, rain gage amt. = 0.80 in.
115 Start time approximate

The data show a range of amounts and concentrations for Wet and Wet/Bulk precipitation at the three stations at which wet precipitation was collected (Upper Ward, Lower Ward, and Mid-lake. (Note only the lower Ward site collects strictly Wet
precipitation separate from Dry. The other two sites collect precipitation predominantly in Snow Tubes, which also can collect some Dry deposition and are considered Wet/Bulk samples. Table 7 presents a very basic summary of sample means and medians for all wet or wet/bulk precipitation samples and includes amount, pH and N and P concentrations. Note, Mid-lake data from sites TR-2, TB-1 was considered together.

Three general observations may be made based on this data. First, the mean and median amount of precipitation associated with each sample collected decreases progressively from the Upper Ward station, to the Lower Ward to Mid-lake. This is a reflection of the trend that greater amounts of precipitation occur at the Upper Ward station and amounts decline as one moves down slope and to the east in Ward Valley. Very little precipitation occurs at the middle of the lake. To the extent that samples represent individual events, the precipitation amounts associated with samples reflect this general trend in precipitation. Second, mean and median pH (pH = 4.67 and 4.77 respectively) in the Mid-lake samples is typically much lower than in Upper Ward (pH = 5.03 and 5.09 respectively) or Lower Ward (pH = 5.12 and 5.10 respectively) precipitation. Third, the mean and median concentrations of NO3-N or NH4-N are typically much higher in the precipitation at mid-lake than at the two sites in Ward. This is significant because although only small amounts of precipitation occur here, the increased concentrations of NO3-N and NH4-N in precipitation can mean wet precipitation in addition to dry deposition can be a significant source of N loading. P is only slightly more concentrated in mid-lake precipitation when compared to Ward Valley precipitation. Therefore, P in wet precipitation may not be as significant a source of loading when the overall amount of precipitation is considered. The relative loading of N and P at the various sites is discussed later in the summary.

Table 7. Mean and median values for amount, pH, N and P concentration for individual samples of (Wet or Wet/Bulk) precipitation collected during the study period (May 2002- Feb. 2004). Note – "amount" was the amount of precipitation represented by individual samples. Since there are some gaps in the data record, these data are presented to show general trends at stations, but should not be used to calculate final loads.

	Amount	pH	NO3-N	NH4-N	TKN	SRP	DP	TP
Sample Means	(in)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
Upper Ward ST or TBG (Wet/Bulk)	2.08	5.03	234	198	730	15	35	26
Lower Ward (Wet)	1.04	5.12	142	103	228	7	18	22
Mid-Lake ST (Wet/Bulk)	0.22	4.67	969	541	705	20	39	54
Sample Medians								
Upper Ward ST or TBG (Wet/Bulk)	1.26	5.09	84	82	181	2	7	7
Lower Ward (Wet)	0.63	5.10	55	39	120	2	4	6
Mid-Lake ST (Wet/Bulk)	0.15	4.77	655	432	663	6	19	20
Sample Number (n)								
Upper Ward ST or TBG (Wet/Bulk)	52	37	50	49	25	48	43	37
Lower Ward (Wet)	62	41	52	53	33	48	45	44
Mid-Lake ST (Wet/Bulk)	22	5	13	13	5	13	12	7

A primary objective of this monitoring was to estimate loads associated with atmospheric deposition both in the watershed and on the lake. The data in Tables 1-6 were first looked at to determine general trends for N and P loading in Dry or Dry-Bulk samples. The N or P load (gram/ hectare) in each sample was divided by the number of days the sample collector sat out to calculate a daily loading rate for each sample. The means and medians of these sample values were then calculated. Table 8 presents the mean and median loading rates for Dry or Dry-Bulk deposition collected during the study period.

Table 8. Preliminary estimates of daily loading rates for Dry or Dry-Bulk deposition at the monitoring stations during the study period (May 2002- Feb. 2004). The load for each individual sample was divided by the number of days the sample collector sat out to calculate the daily loading rate for each sample. The means and medians for all individual sample values for a site were then calculated.

	NO3 g/ha/day	NH4 g/ha/day	TKN g/ha/day	SRP g/ha/day	DP g/ha/day	TP g/ha/day
Sample Means						
Lower Ward (Dry)	1.02 .85	0.74 1.11	12.69 12.72	0.22 .22	0.49 .57	1.22 1.19
TR-3 (Dry-Bulk)	3.81	2.91	3.8	0.07	0.09	0.38
TB-4 (Dry-Bulk)	4 2.89	3.67 3.16	7.95 5.57	0.06 .08	0.12 .17	0.4 .29
Mid-Lake (Dry-Bulk)	4.24 3.01	3.43 2.86	7.49 5.31	0.07 .11	0.15 .22	0.43 .42
Sample Medians						
Lower Ward (Dry)	0.82 .65	0.62 .71	7.14 8.18	0.11 .13	0.29 .41	0.66 .83
TR-3 (Dry-Bulk)	3.04	2.72	4.01	0.07	0.09	0.31
TB-4 (Dry-Bulk)	3.2 2.48	2.26 2.33	7.33 4.66	0.04 .05	0.1 .11	0.22 .26
Mid-Lake (Dry-Bulk)	3.22 2.72	2.4 2.21	4.92 4.39	0.05 .05	0.14 .14	0.28 .29
Sample Number (n)						
Lower Ward (Dry)	66 85	65 76	54 85	67 80	62 76	63 82
TR-3 (Dry-Bulk)	12	12	11	12	12	12
TB-4 (Dry-Bulk)	33 72	33 66	21 72	28 71	32 67	29 66
Mid-Lake (Dry-Bulk)	50 69	50 63	40 68	51 68	46 63	48 65

.35 1 day 12/14/03 MCB

.27

Three general observations were made based on this data. First, these data show that loading rates based on means or medians of individual sample values are generally similar for the three lake stations monitored. This was a valuable finding since it suggests deposition occurring at Mid-lake is also similarly occurring further to the west over the lake. In other words generally similar Dry-Bulk deposition occurs over a region in the Northwest middle portion of the lake. Second, mean and median loading rates for NO3-N and NH4-N in Dry deposition along the west shore at the Lower Ward site are considerably less than for the lake Dry-Bulk samples. Again, the Lower Ward Dry samples do not include wet deposition as the lake Dry-Bulk samples do. The total load in Wet + Dry samples at the Lower Ward is compared against loads later in the summary. Third, the mean and median loading rate for P (SRP, DP, TP) is higher in the Dry

samples from the lower Ward site compared with other sites. This site is forested in the immediate vicinity of the station and is also close to Highway 89. The contribution of particulates from the surrounding forest and resuspension of sand and soil particles by traffic along the nearby highway are potential sources of elevated P at this site.

One of the most important outcomes of this and previous monitoring has been to provide data from which annual loading estimates of N and P at the various sites may be obtained. This data collection period (May 2002 to February 2004) encompassed one complete water year (Water Year 2003) and parts of Water Years 2002 and 2004. This data will be assimilated into the long-term data set to allow comparisons of loading at various stations from Water Year to Water Year. In this summary, we analyzed the data available for Water Year 2003 to estimate loading rates (g/ha/day) at the various stations.

Table 9 presents preliminary estimates of Water Year 2003 loading rates for N and P as well as Water Year total precipitation for the stations monitored in this study. Note, the loading rates from TR-3 and TB-4 were combined to obtain the Water Year value for deposition over the lake west of the Mid-lake station.

Table 9. Preliminary estimates of Water Year 2003 loading rates (grams/ hectare/ day) of N and P at stations monitored. For dry loading rate, total grams/hectare for samples were divided by the total number of sampling days encompassed by sample collection periods during the Water Year. To determine a daily loading rate for Wet or Wet/Bulk precipitation samples, the annual total load for a nutrient was first extrapolated by dividing the load total for samples analyzed (some samples did not have data for all analyses) by the proportion of total precipitation analyzed (amount of precipitation analyzed for a nutrient/ total annual precipitation). This number was divided by 365 days to give the estimate of daily loading rate.

Water Year 2003 Loading	Precip. (in)	NO3-N g/ha/d	NH4-N g/ha/d	TKN g/ha/d	SRP g/ha/d	DP g/ha/d	TP g/ha/d
Upper Ward ST or TBG (Wet/Bulk)	68.49	3.87	3.05*	10.47*	0.15	0.24	0.32
Lower Ward (Wet)	40.92	1.67	1.31	4.11	0.09	0.13	0.24
Lower Ward (Dry)		1.04	0.75	13.05	0.23	0.55	1.26
Lower Ward (Wet+Dry)		2.71	2.06	17.16	0.32	0.68	1.5
TR-3/TB-4 (Dry-Bulk)		3.89	3.42	7.67	0.05	0.09	0.33
Mid-lake (Dry-Bulk)	6.9-7.9**	3.98	3.27	8.02	0.06	0.12	0.27

* - Individual values for Upper Ward loads 4/23/03: [NH4 (133.77 g/ha) and TKN (72.84 g/ha)] are under review and were not included in this estimate. If included the Upper Ward NH4-N loading rate would increase to 3.43 g/ha/d and TKN would increase to 10.62 g/ha/d.

** - Estimated from snow tube amounts and simple rain gage on buoy.

Several observations can be made from this data. First, the trend of decreasing precipitation amounts moving the Upper Ward to the Mid-lake station is readily apparent. Based on data partially from Snow Tubes and partially from a simple rain gage at Mid-lake, the data show that Mid-lake received only a very small amount of precipitation during WY 2003 (an estimated 6.9 – 7.9 inches), which was about a tenth of the amount of precipitation that occurred at the Upper Ward site. Second, interestingly, the loading rate for N (NO3-N, NH4-N and TKN) was fairly similar for wet/bulk deposition at the Upper Ward station and dry-bulk deposition at the lake buoy monitoring sites including Mid-lake. Although the Upper Ward site receives tremendous amounts of precipitation the NO3-N and NH4-N loading at Mid-lake and Upper Ward is nearly similar . The Snow Tubes may not be as effective in collection of dry deposition compared to the Dry-Bulk samplers, which may account for some of the similarity in overall loading. However, the very high concentrations of N in precipitation at the lake deposition sites monitored and possibly higher dry deposition rates could also account for this. Third, the total (Wet + Dry) loading rates for NO3-N and NH4-N for the Lower Ward station were less than for the Upper Ward and lake stations. Fourth, the loading rate for TKN is highest at Ward Lake Level (mostly in the dry deposition fraction), while less occurs at the Upper Ward site but nearly as much occurs at Mid-lake. The P loading rates are also highest at the Ward Lake Level site (again predominantly in Dry deposition), next highest at the Upper Ward site. The lowest amounts of P loading were found in lake deposition samples. The lower Ward site appears to receive more loading of TKN and P than the other sites. This site is more heavily forested in the immediate vicinity of the station than is the Upper Ward site, this may play a role in increased deposition of particulate N and P. This site is also close to Highway 89, and contribution of suspended particulates (sand and soil) from the highway may be important at this site. This site receives less precipitation than upper Ward, which may also play a role in less, wet depositional loading. Fifth, the data also indicate that N and P loading rates at the western lake stations (TR-3, TB-4) are generally similar to the Mid-lake station. Again, this was a valuable finding since it suggests deposition occurring at Mid-lake is also similarly occurring further west over a region of the lake.

Task 6 – Periphyton

INTRODUCTION

Among the first visible evidence of the eutrophication of Lake Tahoe was the increased amount of attached algae, or periphyton growth, along the shoreline in the 1960s. Goldman (1967b) indicated that when he first began studying the lake in 1958, the rocks along shore showed only slight growth of attached algae. However, in the spring of 1967, significant periphyton was found in the shallows and on boat hulls, and waves piled up mats of the detached material along the shore. Increased growth of periphyton was apparent to a largely shore-bound populace providing visual evidence that changes were occurring. This increase in periphyton growth coincided with the period of rapid growth and development within the basin during the 1960s and could be attributed to an increased nutrient loading from the surrounding watershed via stream and ground waters (Goldman 1974, 1981; Loeb and Goldman 1979). Widespread periphyton growth in the near-shore during the spring remains a characteristic of the shoreline today. Many studies have been done that have looked at the biology and distribution of periphyton in Lake Tahoe (Goldman and de Amezaga 1975; Loeb 1980; Loeb and Reuter 1981; Goldman et al. 1982; Reuter 1983; Reuter et al. 1983; Loeb and Reuter 1984; Loeb and Palmer 1985; Loeb 1986; Loeb et al. 1986; Aloi 1986; Reuter et al. 1986a, b; Aloi et al. 1988).

Periphyton grows in the littoral (shore) zone of Lake Tahoe, which may be divided into the eulittoral zone and the sublittoral zone, each with distinct periphyton communities. The eulittoral zone is the shallow area between the low and high lake level (0 to 2 m) and is significantly affected by wave activity. This zone represents only a very small percentage (<1 percent) of the total littoral area. Substrata within this region desiccate as the lake level declines, and periphyton must recolonize this area when lake level rises. The sublittoral zone extends from the bottom of the eulittoral to the maximum depth of photoautotrophic growth. The sublittoral zone remains constantly submerged and represents the largest littoral benthic region of Lake Tahoe.

The eulittoral zone community typically is made up of filamentous green algae and filamentous diatom species. On rock surfaces just beneath the air-water interface (i.e., the uppermost region of the eulittoral), a green filamentous alga, *Ulothrix zonata* is often found. Extending from just below this growth to a depth of approximately 2 m, a brownish or whitish growth of algae covers the bottom of the eulittoral zone. This growth is strongly dominated by one species, the stalked diatom, *Gomphoneis herculeana*. In fact, the growth of this species is so great at times that it resembles a thick shag carpet on the bottom. *Synedra ulna* and various other diatoms are found growing in association with *Gomphoneis*. *Cyanophycean* (blue-green) algae are generally absent from the eulittoral zone.

The attached algae present in the eulittoral zone display significant growth allowing for rapid colonization. These algae are able to take advantage of localized soluble nutrients, and can establish a thick coverage over the substrate with a matter of months. Similarly, as nutrient

concentrations diminish and shallow, nearshore water temperatures warm with the onset of summer, this community rapidly dies back. The algae can slough from the substrate and wash onshore, creating an unsightly mess with a rather foul odor, in those areas where biomass is high. The eulittoral zone periphyton plays an important roll in the aesthetic, beneficial use of the shorezone.

OBJECTIVES

The overall objective of the periphyton monitoring conducted from March of 2000 through November of 2003 was to reinstate this program for the purpose of evaluating nearshore water quality. Specifically we focused on the following tasks:

1. Reinstate the regular monitoring of seasonal and annual periphyton biomass accumulation using methods and analyses that are consistent with historical measures,

2. Determine the spatial distribution of periphyton biomass around the Lake Tahoe shoreline,

3. Summarize the relevant historical periphyton data within the context of the current monitoring program using the most appropriate biomass indicators,

4. Evaluate the change in periphyton biomass indicators by comparing 1982-1985 growth patterns with those of the present study, 2000-2003,

5. Provide preliminary guidance on the potential for establishing numeric water quality standards for littoral zone periphyton growth in Lake Tahoe.

Between 1985 and 2000 periphyton sampling was extremely limited by funding. This represents a significant data gap. The 1982-85 period represents a time where both State of California funding and funding from the National Science Foundation for basic research was dedicated to this project. Research has not been funded since that time. Consequently, our understanding of this algal community, since 1985, has been enhanced only by a 'bare-bones' monitoring program.

HISTORY OF PERIPHYTON MONITORING: 1982-1985

During 1982 to 1985 intensive studies were done by the TRG, which looked at the seasonal and spatial distribution of epilithic periphyton (algae attached to rock surfaces) production in Lake Tahoe and possible factors affecting growth patterns. The primary objectives of this monitoring were to:

1) Document the annual patterns of periphyton production in the littoral zone of Lake Tahoe.

2) Document the spatial distribution patterns of periphyton production and determine if any persistent trends were discernable.
3) Examine the annual rates of sublittoral periphyton primary productivity at Rubicon Pt., California.
4) Collect physical and water quality data associated with the periphyton monitoring to see which factors, if any, might be linked with observed growth patterns.

To determine the annual and spatial distribution patterns of epilithic periphyton production, periphyton biomass was monitored at a total of nine sites around the lake. There were five primary sampling sites, with multiple depths monitored using triplicate samples: Rubicon Pt. (0.5, 2, 8, 16m), Pineland (0.5, 2, 8m), Deadman Pt. (0.5, 2, 8m), Incline West (0.5m), Incline Condo (0.5m). Biomass was sampled on nearly a monthly schedule between February and October 1982-84 and January to April 1985. Four additional "synoptic" sites were monitored (less frequently during the 1982 growth period and regularly during 1983-85) in order to better characterize spatial and seasonal trends. These additional sites included: Sugar Pine Pt., Dollar Pt., Sand Pt. and Zephyr Pt. (all at 0.5m). Three measures of periphyton biomass were collected: chlorophyll a, particulate carbon and particulate nitrogen.

While biomass provided an estimate of the amount of standing crop of periphyton on rock surfaces, the primary productivity of the periphyton was also measured at one site to provide an estimate of the rate of growth (rate of production of new biomass) of the periphyton. Periphyton primary productivity was measured on nearly a monthly basis between February and October 1982-84 and twice during 1985 at Rubicon Pt., at depths of 2, 8, and 16m.

Physical and water quality data were also collected to analyze for possible associations with periphyton growth patterns. Physical measurements taken included: water temperature at each site and depth; light availability (solar radiation) at a single shoreline site near Ward Cr.; and Secchi depth measurements at Rubicon Pt. Samples of water were collected at each location and on each sampling date. Water chemistry analyses included nitrate nitrogen (NO3-N), total phosphorus (TP), and biologically available iron (BAFe). Soluble reactive phosphorus (SRP) and ammonium nitrogen were also collected in 1983-84

Two additional studies were done to better understand factors contributing to differential growth of the periphyton. One study evaluated the methodology of using artificial substrata (glass slides) to track periphyton colonization rates at many sites around the lake. The other study investigated rates and quality of ground water seepage entering the littoral zone its and potential impact on periphyton growth.

MAJOR FINDINGS OF 1982-85 STUDIES

Seasonal Patterns of Periphyton Growth

The periphyton in the eulittoral zone (0.5m) was more seasonally dynamic than that of the sublittoral community. Typically, growth of the eulittoral periphyton began to increase in the late winter, reached maximum growth in the spring, then decreased in the summer. In some years, the eulittoral periphyton showed a secondary increase in growth during the fall. The range between minimum and maximum annual growth was typically greater for the eulittoral than for the sublittoral community. Following peak growth, the algae may slough off the rocks, with growth remaining low throughout the fall and early winter. Aloi et al. (1988) found that at eulittoral sites with high accumulation of biomass (Pineland and Rubicon Pt.), sloughing of the entire algal mat occurred after the spring maximum. At sites with lesser accumulations of biomass (e.g. Deadman Pt. and Sand Pt.), the decrease in algal biomass was a slower process and appeared to be due to a combination of gradual attrition of periphyton biomass, combined with minimal re-growth.

The sublittoral periphyton community generally had less dynamic seasonal biomass fluctuations than the eulittoral community (Loeb et al., 1986). In contrast to the periphyton of the eulittoral zone, this community persists on the rock surfaces remaining viable throughout the year (Reuter et al., 1986a). The seasonal variations of the sublittoral community were generally less predictable than for the eulittoral community (Loeb and Palmer, 1985). It was difficult to distinguish a consistent pattern of seasonal biomass for this community from 1982-85 for the three sublittoral sites monitored (Pineland, Deadman Pt., Rubicon Pt.).

Spatial Variation in Eulittoral Periphyton Biomass

Significant spatial variation in eulittoral chlorophyll a biomass was observed during 1982-1985. Periphyton biomass at Deadman Pt., Sand Pt. and Incline West sites remained consistently low during the study period. While biomass at Pineland, Incline Condo, Rubicon Pt. Dollar Pt. and Sugar Pine Point showed one or more "spikes" in the amount of annual growth and moderate to high maximum levels. Zephyr Pt. also showed some annual fluctuation, but the annual maximum was low to moderately high.

One of the more important findings of these studies was to demonstrate an association between development and disturbance in the watershed with increased periphyton growth near shore. Loeb (1986) compared eulittoral chlorophyll a biomass data for four stations. Two stations (Pineland and Incline Condo) were adjacent to developed areas, and two stations (Incline West and Deadman Pt.) were adjacent to undeveloped areas. Greater amounts of periphyton were found at the developed stations than at the two undeveloped stations. The ratios among the maximum amount of biomass at each location (Deadman Point: Incline West: Incline Condo: Pineland) during each of the three years studied showed a persistent spatial relationship: 1982 (1:3:8:8), 1983 (1:1:6:10), and 1984 (1:2:4:13). Available light energy and water temperature

did not vary significantly enough to explain the spatial differences in periphyton biomass among sites, especially between Incline Condo and Incline West, which were only 200 meters apart. The most likely cause for the differences among stations was nutrient availability. The Incline Condo station, which had higher periphyton biomass, was adjacent to a condominium development, which Loeb estimated used about 0.13 to 0.16 metric tons (MT) of nitrogen and 0.10 to 0.13 MT of phosphorus in fertilizer per year on a lawn upslope of the station. The Incline West site, which had less biomass, is only 200 meters away, adjacent to an undeveloped area. The Pineland site, which had higher biomass, is adjacent to the developed area of Pineland, in the Ward Creek watershed on the west shore. Deadman Point is adjacent to an undisturbed area on the east shore, with the nearest development one kilometer away.

While there was strong evidence of an association between increased periphyton biomass and development or disturbance in the adjacent areas of the watershed, some variations from the pattern did occur. For instance, Rubicon Pt. which is far from significant land-based disturbance, had consistently high biomass was measured at this station from 1983-85 (Aloi et al., 1988). Aloi et al. hypothesize that upwelling of nutrient-rich profundal waters occur here, stimulating algal growth. High chlorophyll a biomass of periphyton also was measured near Sugar Pine Point, a relatively undeveloped area.

Factors Affecting Growth of Periphyton

The increased growth of eulittoral algae in the spring was thought to be largely the result of increased availability of nutrients (Loeb and Reuter, 1984). Both nitrogen and phosphorus inputs to the littoral zone may be increased during the spring. The snowmelt generally occurs from April to June, when much of the annual tributary loading of nutrients occurs. In addition to nutrient inputs from streams, ground water inputs with associated nutrients are thought to be at a maximum during this time (Loeb and Goldman, 1979). Lake mixing also contributes nutrients in late winter, which could affect the growth of periphyton in the spring. A bioassay done using eulittoral periphyton showed that additions of nitrogen significantly stimulated the growth rate of periphyton and that additions of nitrogen plus phosphorus together stimulated growth even more. Reuter et al. (1986b) provided evidence that the eulittoral periphyton, while not having a high physiological affinity for nitrogen, were able to effectively utilize nutrients because breaking waves in the shallow environment enhanced the rate of nutrient diffusion into the cells.

Other physical factors may also impact the growth of periphyton. The period of maximum periphyton growth in the eulittoral zone in the spring coincides with increasing flux of solar radiation and increasing temperature. These factors have more of a general lake-wide impact, rather than a significant local impact on periphyton growth in any one region.

The 1982-85 studies also indicated that increased nutrient availability was likely a cause of the spatial variations in biomass observed during the study. Water temperature differences among sites were not significant enough to contribute to observed biomass differences. Similarly,

differences in light input could not explain biomass differences at sites with similar exposure, for instance Incline West and Incline Condo, which are adjacent to each other. However, increased nutrient availability associated with fertilizer use upslope of the Incline Condo site was thought to be the cause of increased periphyton growth there. Periphyton, being at the boundary between lake and sediments in the near shore zone, may be exposed to elevated nutrient concentrations associated with surface and groundwater as it enters the lake. Preliminary work on groundwater seepage rates and water quality did indicate that groundwater seepage could be important relative to periphyton growth.

CURRENT PERIPHYTON MONITORING PROGRAM: 2000 – 2003

The current funding provided by the California State Water Resources Control Board (SWRCB) through the Lahontan Regional Water Quality Control Board (Lahontan) has allowed us to re-institute the very basic collection and analysis of attached algae in the shore zone of Lake Tahoe. Sampling during the current period has included collection of periphyton from the same nine lake locations that were assessed two decades earlier, with the addition of a tenth site off Tahoe City. Since nutrient availability appears to play a significant role in the amount of periphyton growth, periphyton biomass can serve as a biological indicator of both nutrient inputs and long term environmental change. The comparison of current sampling results to those measured previously, may provide a useful means of assessing near shore perturbations in lake health.

While the comparisons of multi-year data sets can indicate change in ecological communities, environmental assessment is characteristically difficult over short time spans (even years), due to high, natural variability in environmental conditions. This is certainly true within the Lake Tahoe basin where cyclical patterns of drought and heavy precipitation can cause dramatic changes. This has been evidenced in the long-term clarity measurements which demonstrate considerable interannual variability, and which are largely driven by precipitation and depth of mixing (Jassby et al. 2003). While the difference in periphyton growth between locations during a single year appears to be most linked to localized conditions of nutrient loading, changes at a given site over time (e.g. 1982-85 versus 2000-03) are also highly influenced by meteorology and runoff. As discussed below, a significant number of years of data are required to separate the influences of a long-term trend versus changes resulting from wet versus dry years. Only seven years of complete annual data do not allow for this distinction to be made.

METHODS

Sampling Location

Lake Tahoe's 116 km shoreline is characterized by extensive areas of steep gradient boulder separating regions of shallow gradient cobble and sand. Generally, steeply sloped land, upslope of steep shoreline areas, are less developed and often contained within state park or national forest service boundaries. The land above more gently sloping shorelines tends to support urban

centers, a proliferation of roadways, and commercial land use. Neighborhoods surrounding the urban centers often spread to the edge of undeveloped forest lands, creating zones of moderate development. In order to adequately represent the range in shorezone conditions, ten periphyton sampling locations were established around the lake, located on the north, east, and west shores. The south shore consists primarily of sandy substrate and was not included in epilithic substrate monitoring. Four of the sites are considered to represent a low level of shorezone development, while moderately and highly developed areas are represented by three sampling locations each (Table 1).

Table 1

SITE NAME	LOCATION	LEVEL OF DEVELOPMENT
Rubicon	N38 59.52; W120 05.60	Low
Sugar Pine Point	N39 02.88; W120 06.62	Low
Pineland	N39 08.14; W120 09.10	High
Tahoe City	N39 10.24; W120 08.42	High
Dollar Point	N39 11.15; W120 05.52	Moderate
Zephyr Point	N39 00.10; W119 57.66	Moderate
Deadman Point	N39 06.38; W11957.68	Low
Sand Point	N39 10.59; W119 55.70	Low
Incline Condominiums	N39 14.90; W119 59.63	High
Incline West	N39 14.83; W119 59.75	Moderate

For the purposes of this study, a low level of shorezone development was characterized by naturally vegetated landscape, minimal roadways, and no urban structures in the immediate backshore. Moderately developed sites had homes and the necessary supporting infrastructure upslope of the sampling location, while highly impacted sites were immediately lakeward of large landscape manipulations and closely associated with urban centers.

Within each of these development categories, specific sampling locations were selected. With the exception of an additional site at Tahoe City, the other locations were the same as those used in the 1982-85 studies. Global Positioning System (GPS) and photographic data allowed for repeat sampling in the same location, minimizing variation over time. Whenever possible, the sloping face of large lake substrate (boulder) was selected for the collection of periphyton samples. The large substrate was less susceptible to movement by wave action, and the sloping face limited the accumulation of silt and sand, allowing for permanent, clean sampling locations throughout the study period. Non-natural fixtures (bulkheads and pier piles) were avoided since metal and chemical contamination (iron and creosote) may enhance or impede periphyton growth.

Sampling Design

The periphyton sampling schedule was designed to take into account the seasonal growth pattern of the attached algae. Periphyton usually begins to accumulate on the nearshore substrate in January, with peak growth occurring between March and June (Loeb et al. 1986). Algal biomass

decreases during the summer, usually reaching an annual minimum in October. For this reason, sampling for attached algae was concentrated between February and July with monthly monitoring. An additional two to three samples were collected during the remainder of the year to document the annual baseline biomass at each of the sites. While this sampling schedule was adequate to document annual maximum and minimum biomass values, it was not robust enough to describe the duration of these two growth periods.

Sample Collection Methods

During each sampling event, multiple samples were collected from each location to account for within site variation in standing crop biomass. Duplicate samples were collected during periods of lower growth with triplicate samples being collected when overall biomass was near the peak. The number of samples collected from each site on any given sampling event was left to the discretion of the experienced field personnel.

To ensure accuracy within and between sites, periphyton from equivalent areas (5.3 cm^2) of substrate, at a depth of 0.5 meters was collected, using the double syringe periphyton sampler described by Leob and Reuter (1984). Samples were sealed under water to prevent loss of material and stored in a cooler on the boat until processing. This sampling methodology was identical throughout the entire period of record (1982-85 and 2000-03). In addition to algal collections, measurements of percent algal cover, algae height, and descriptions of general species composition were noted in 2000-03. Photographs of the sampling location were taken both underwater and from above to document the visual character of the site, specific to measured biomass levels.

Laboratory Methods

This project's Quality Assurance Project Plan (QAPP) is located at the end of this report.

Periphyton samples were returned to the lab in 2-syringe samplers for processing. Water containing periphyton was removed from the sampler and centrifuged to concentrate the periphyton. The concentrated periphyton was transferred to weighing paper and a "wet weight" determined. Subsamples of this periphyton were transferred to a pre-tared piece of filter paper and weighed, then frozen for later chlorophyll a analysis; the remaining sample was transferred to a precombusted, pre-tared aluminum tin and the weight recorded. This sample was analyzed for dry weight and Ash Free Dry Weight or Loss on Ignition. Below, details are provided for methodologies used to measure periphyton biomass.

Chlorophyll a

Samples for periphyton chlorophyll a biomass determinations were stored in the dark and frozen prior to analysis. The analysis for chlorophyll a involved boiling the periphyton sample in 8-10 ml of 100% methanol for 2-3 minutes while grinding the sample with a glass rod. Samples were then centrifuged to clear particulate material from the chlorophyll solution. The solution was then either decanted and diluted or decanted directly into a 4 cm cuvette and the absorbance read spectrophotometrically (Shimadzu UV160U spectrophotometer) at 666 and 653 nm against a 100% methanol blank. Non-chlorophyll turbidity was determined at 750 nm. The equation of Iwamura et al. (1970) was used to calculate the amount of chlorophyll a in each sample.

This boiling methanol method for chlorophyll a determination has been checked against the cold 90% acetone extraction procedure that uses the trichromatic equations of Strickland and Parsons (1968). No significant differences were found in the chlorophyll a results for epilithic periphyton samples from Lake Tahoe using these two methods.

*Note – A correction was applied to the historical 1983-85 chlorophyll a data to allow direct comparison with 2000-2003 data. During 1983-85 a Beckman DBG dual beam spectrophotometer was used which had a shifted wavelength scale. In order to make correct absorbance readings, this shift had to be taken into account in measurements. This shift was incompletely applied in the 1983-85 measurements however (i.e. to record absorbances at 666 and 653 nm as required in the Iwamura et al (1970) equation, absorbances at 663 and 650 nm were to be measured using the above spectrophotometer, instead absorbances were measured at 663 and 653 nm). In 1990, a large set of periphyton samples was analyzed for chlorophyll a using the same spectrophotometer used in 1983-85 with absorbances measured at wavelengths of 720, 663, 653, 650 nm. Chlorophyll a was then calculated using both the correctly shifted 663, 650 nm absorbance readings as well as the 663 and 653 nm used in the 1983-85 data. A nearly perfect linear relationship was found between the chlorophyll a calculated using 663, 650 nm (correct) versus chlorophyll a calculated using 663, 653. The correct chlorophyll value "Y" (663,650) was related to the uncorrected chlorophyll "X" (663,653) by the following equation: Y = 1.081225X (r^2= 0.9995562). To correct the 1983-85 periphyton chlorophyll a data, chlorophyll a values were multiplied by 1.081225.

Loss On Ignition

Wet samples for Loss On Ignition (LOI) were dried overnight at a temperature of 105^0 C, allowed to cool in a desiccator, and then weighed to give a dry weight. The samples were then combusted at a temperature of 500^0 C for one hour. The loss in weight at this high temperature is assumed to be due primarily to combustion of organic material present in the sample. LOI was calculated as:

$$LOI\ (g/m^2) = (TWW/SWW) * (SDW105 - SCW500) / 0.00053$$

["TWW is Total Wet Weight of periphyton collected; "SWW" is LOI subsample wet weight; "SD105" is weight of subsample after drying overnight at 105^0 C; "SCW500" is weight of subsample after combusting at 500^0 C for 1 hour; all weights in grams; 0.00053 is area sampled in m^2]

Ash Free Dry Weight

Wet samples for Ash Free Dry Weight (AFDW) were dried overnight at a temperature of 60^0 C, allowed to cool in a desiccator, and then weighed to give a dry weight. The samples were then combusted at a temperature of 500^0 C for one hour. The loss in weight at this high temperature is assumed to be due primarily to combustion of organic material present in the sample. AFDW was calculated as:

$$AFDW\ (g/m^2) = (TWW/SWW) * (SDW60 - SCW500) / 0.00053$$

["TWW is Total Wet Weight of periphyton collected; "SWW" is AFDW subsample wet weight; "SD60" is weight of subsample after drying overnight at 60^0 C; "SCW500" is weight of subsample after combusting at 500^0 C for 1 hour; all weights in grams; 0.00053 is area sampled in m^2]

*Note – AFDW was measured in earlier studies in the 1980's. It uses a more gentle drying procedure at 60^0 C to reach dry weight, and is typically used for biological samples. LOI uses a higher temperature to drive off water associated with sediments, and is often used to estimate sediment organic content. The LOI method was used in later studies since one site (Tahoe City) contained periphyton typically mixed with a large amount of sand or silt. Periphyton at other sites also occasionally had high sand or silt content. During the current study we did some cross-comparisons that measured AFDW and LOI sequentially on the same sample. Usually only very slight differences in estimates of organic content were found using the two methods (see Appendix), when large differences were observed the sample typically had much sand or silt, and AFDW gave a higher estimate of organic content. A regression analysis confirmed the close correlation in the two measures of periphyton biomass ($R^2 = 0.9926$).

Selection of Biomass Indicators

Several measures of algal biomass have been used to assess the standing crop in current and past studies. These include Ash Free Dry Weight (AFDW), Loss On Ignition (LOI), and chlorophyll a. AFDW and LOI methods are relatively similar (see description above). A comparison of these two measures of biomass (AFDW vs. LOI) indicated that there was little difference in results (R^2=0.9926). AFDW is typically used for biological samples, and employs drying at a lower temperature than LOI. As described above, LOI was selected to help in analysis of samples with high sediment content. Both methods provide estimates of the amount of total organic material, which may include live and dead periphyton biomass and detritus.

Chlorophyll a concentration, expressed as milligrams of chlorophyll a per square meter is a frequently used method for measuring algal biomass, and was deemed the most appropriate measure for the current data set (1982-85 and 2000-03). This determination was based on several factors. Chlorophyll a is a direct component of the algal material at each site. This eliminates any complications associated with geomorphic material (sand and silt) or other biological material (zoobenthic grazers) altering the biomass measure. Additionally, chlorophyll a has been the most consistent measure of algal biomass in the scientific literature and in the historic periphyton data collected at Lake Tahoe. For these reasons chlorophyll a concentration was used to evaluate the standing crop biomass at each of the sampling sites during the current study and for comparison to the historic biomass measurements.

Several indicators were developed to evaluate annual changes in chlorophyll a biomass within the current study and in comparison to the 1982-85 data set. After careful consideration, we selected (1) annual maximum concentration, (2) annual average concentration, and (3) the annual baseline concentration. Each year was defined as October 1 through September 30, coinciding with the periphyton growing season and the hydrologic "water year". Each of these periphyton indicators gives a slightly different view of the annual biomass at each site. However, we have selected them because each is representative of a different aspect of seasonal growth.

Annual maximum chlorophyll a concentration represents the highest single biomass value recorded at a specific site for the given year. Because this is an actual measured value from field collections it serves as a snapshot of how strong periphyton biomass was during the peak of the growing season. The value also serves as a means of comparing current peak algal accumulations to those measured during the 1980s. However, because this is a single measured point for each year, it does not indicate the duration of the growing season or how long a site may have been at its peak biomass.

The annual average chlorophyll a concentration is an indication of how much algae was present at a given site throughout the year, and is <u>not</u> intended to be a simple snap shot. The value was calculated by integrating the area under the annual growth curves (October 1st – September 30st), (Figures 1a-1t). The benefit to this measure is that it is a time-weighted average rather than an average of the individual biomass values sampled during the year. This provides an indication as to the duration a specific site may have had elevated biomass levels. The drawback to this indicator is that it is an average for the entire year, which is based on connecting individual data points by a straight line, and the accuracy of the measure increases with the number of annual sampling points.

The annual baseline chlorophyll concentration was obtained from the annual growth curves. The lowest values for each of the four-year periods (1982-1985 and 2000-2003) were interpolated from the graphs. These values provide an indication of biomass during the lowest times of the year at each site. The annual baseline concentrations can be compared between sites to assess

where chronic nutrient additions to the nearshore may be problematic. The values can also serve as a measure of how background algal biomass may have changed.

When considering annual measures of biomass accumulation, it was necessary to eliminate some data from the calculations. During 1985, monitoring only persisted through mid-April, and did not fully capture the period of peak biomass accumulation. Maximum chlorophyll a values at Rubicon Point, Sugar Pine Point, and Pineland were well above normal for any of the other years monitored during the 1980s or 2000s. While these maximum values are important in the context of overall periphyton biomass potential, they have been withheld from calculations of annual average biomass and average peak biomass. This decision was made because the sampling year was incomplete; however, it is important to note that even 20 years ago, very high periphyton biomass accumulations were measured.

RESULTS AND DISCUSSION

Presentation of 1982-1985 and 2000-2003 Database

See Appendices A and B

Seasonal and Interannual Distribution of Periphyton Biomass

Generally, all the sampling sites displayed a seasonal growth pattern with the lowest biomass being associated with the late summer or fall months (August – October). Chlorophyll concentrations began to rise around the first of the year, with peak concentrations occurring during the spring (April – June), (Figures 1a-s). The Tahoe City site, which was only sampled during 2000-2003, (Figure 1s) displayed a slightly different pattern. While the annual maximum occurred in the spring, coinciding with the other sites, the annual minimum occurred in June or July and biomass accumulation rapidly rebounding before the end of the summer. This divergence from the other sites suggests that a nutrient source may be available in the nearshore beginning in mid-summer.

The sampling locations representing areas of low human development (Rubicon Point, Sugar pine Point, Deadman Point, and Sand Point) showed relatively little biomass accumulation during the year. Rubicon Point during the early1980s ranged from a baseline biomass of 10 mg/m^2 up to a maximum of about 60 mg/m^2 (Figure 1a). This was similar for the current sampling period where biomass ranged between the baseline of 12 mg/m^2 to near 50 mg/m^2 (Figure 1b). Throughout both sampling periods, periphyton biomass returned to a similar baseline concentration during each annual cycle.

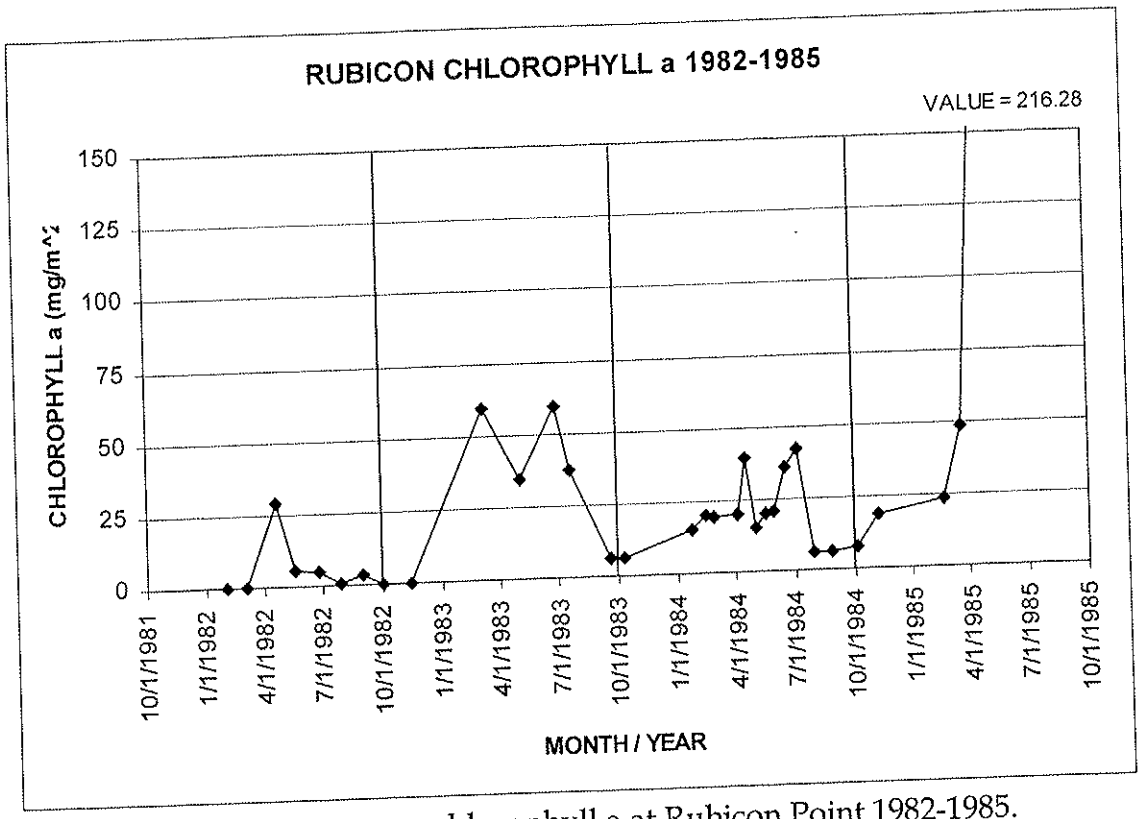

Figure 1a: Measured biomass as chlorophyll a at Rubicon Point 1982-1985.

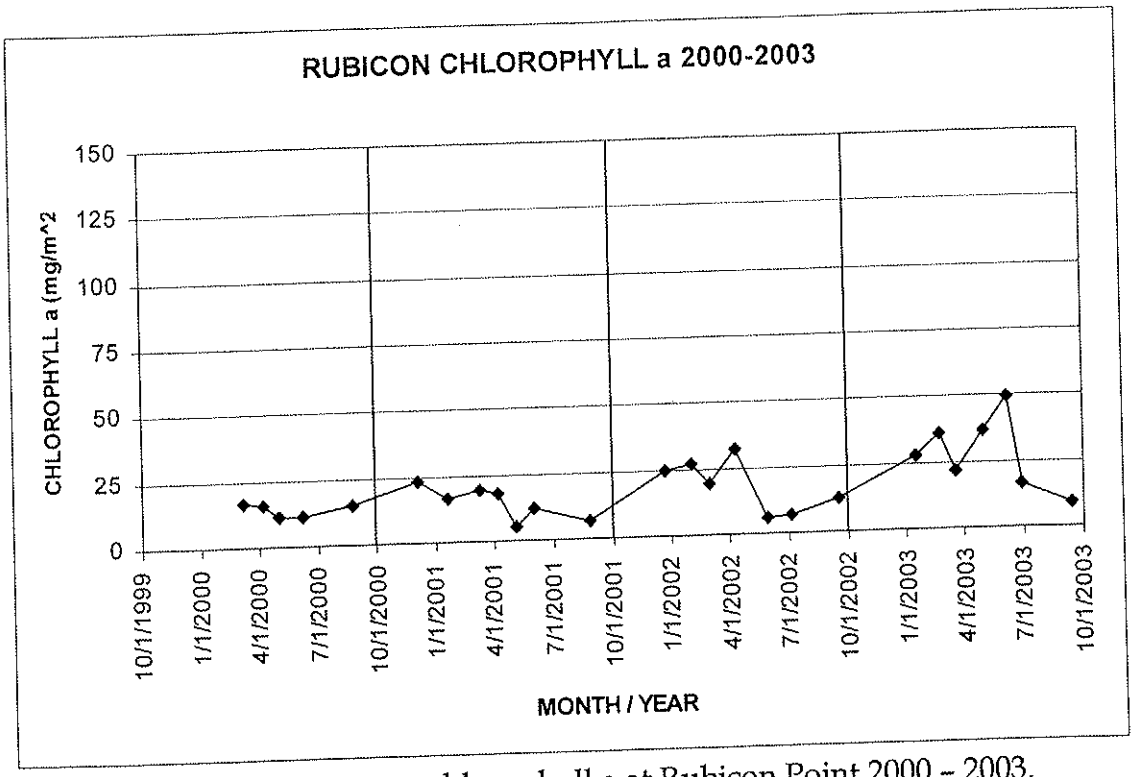

Figure 1b: Measured biomass as chlorophyll a at Rubicon Point 2000 – 2003.

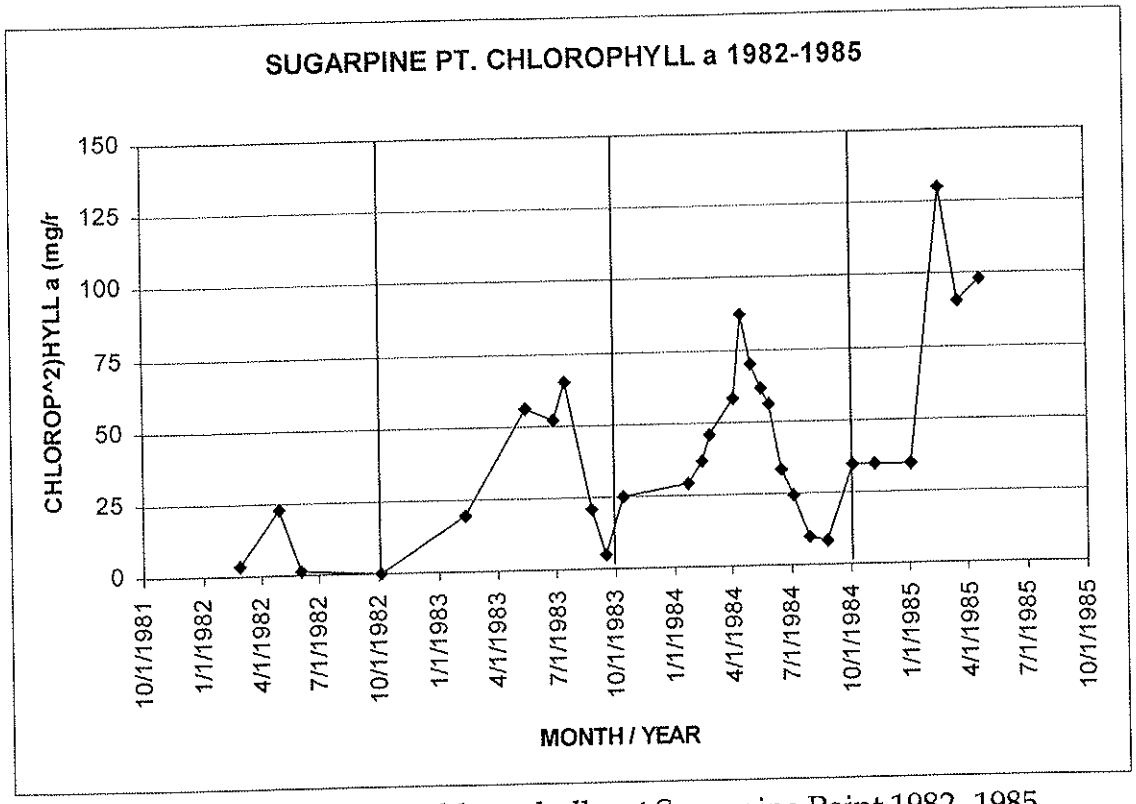

Figure 1c: Measured biomass as chlorophyll a at Sugarpine Point 1982 -1985.

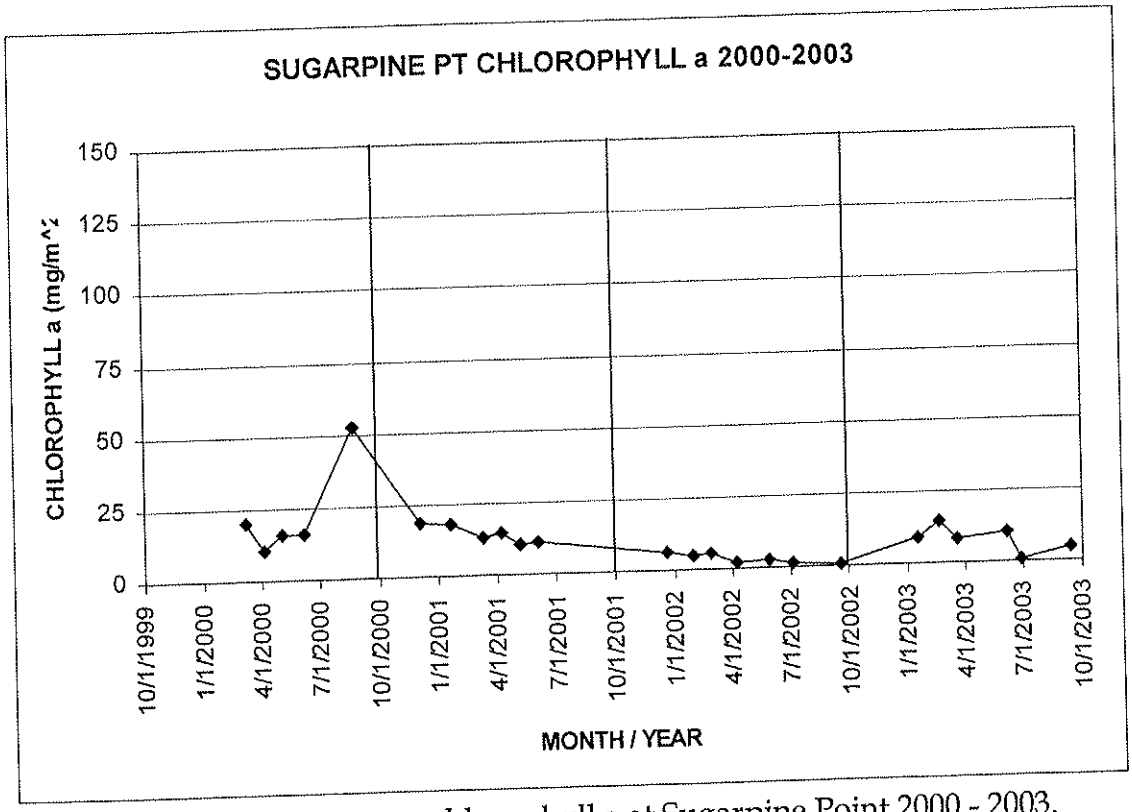

Figure 1d: Measured biomass as chlorophyll a at Sugarpine Point 2000 - 2003.

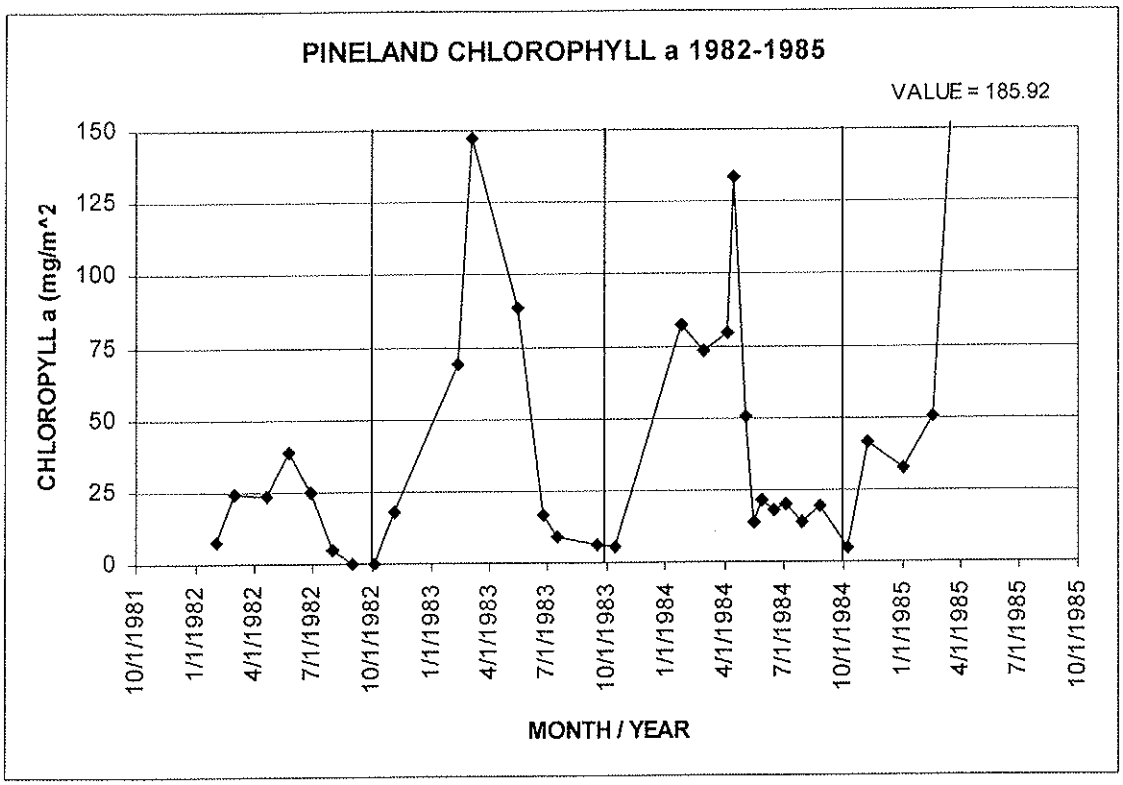

Figure 1e: Measured biomass as chlorophyll a at Pineland 1982 -1985.

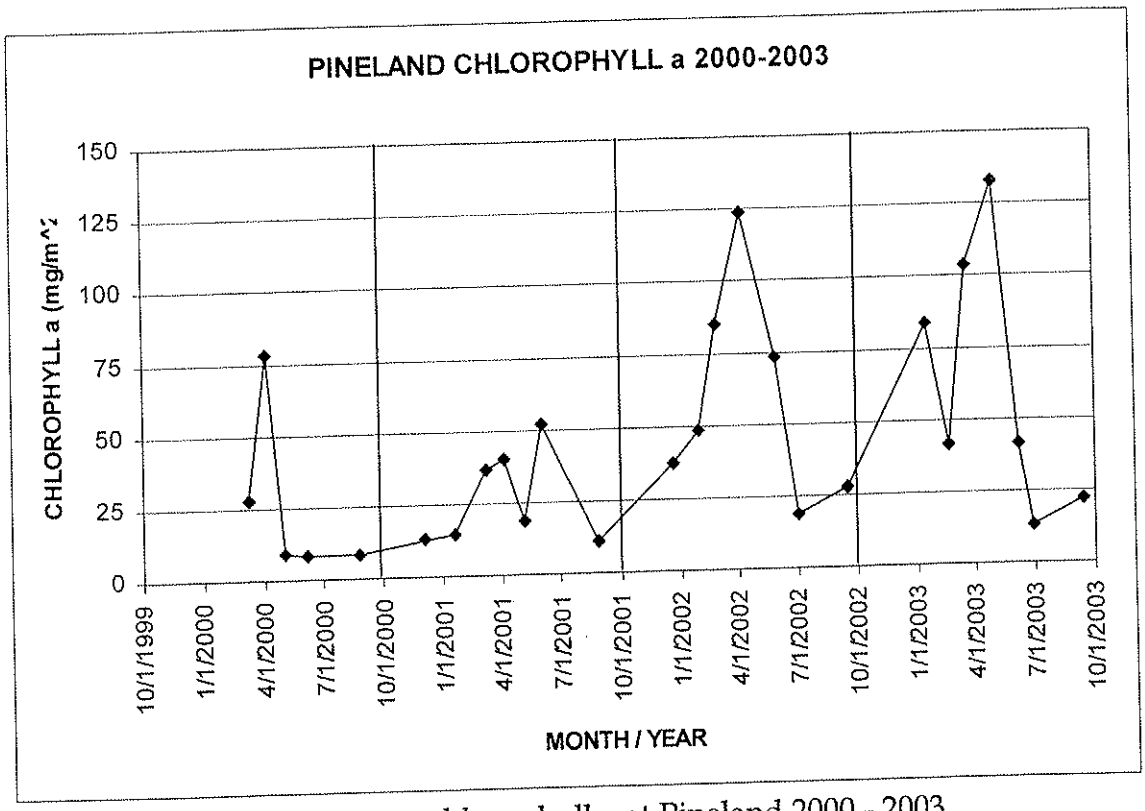

Figure 1f: Measured biomass as chlorophyll a at Pineland 2000 - 2003.

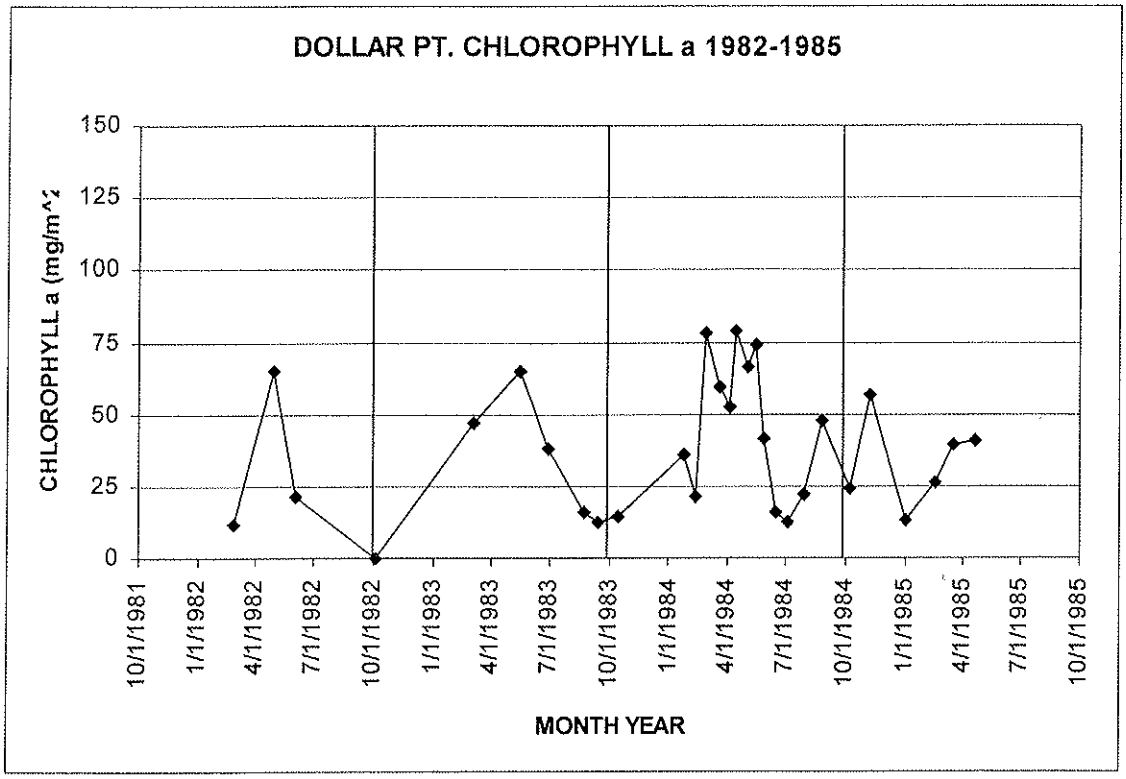

Figure 1g: Measured biomass as chlorophyll a at Dollar Point 1982 - 1985.

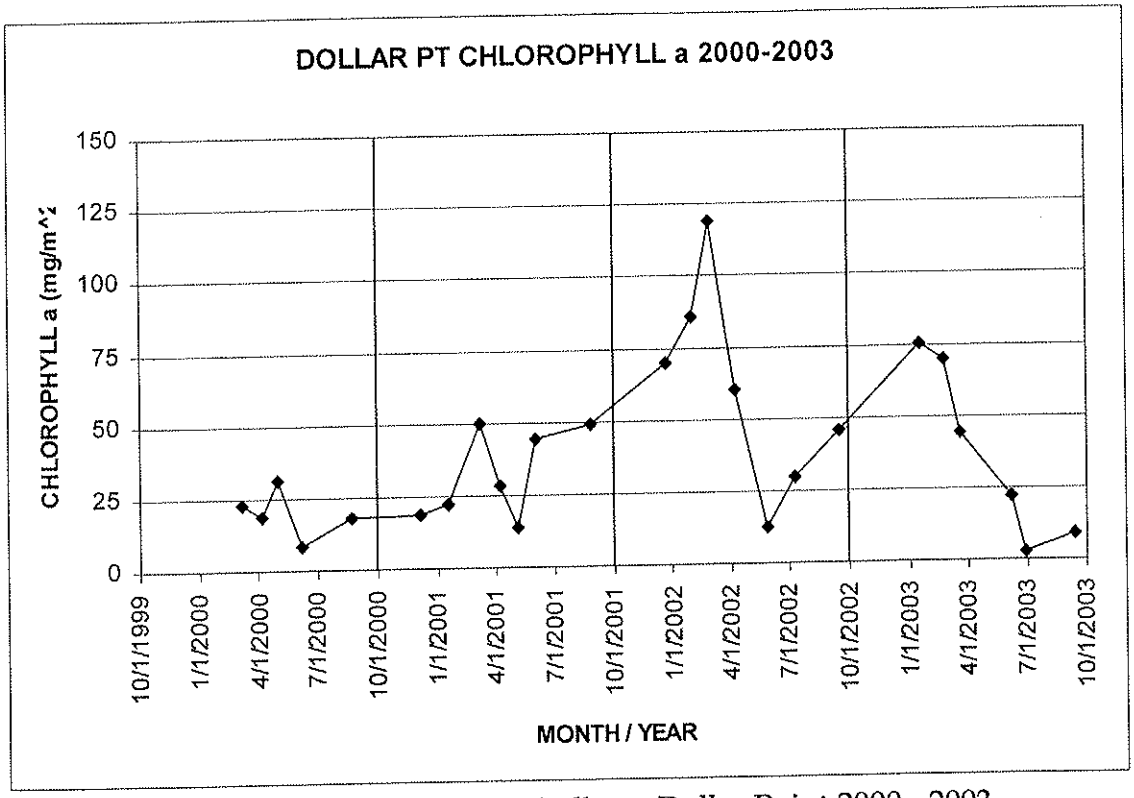

Figure 1h: Measured biomass as chlorophyll a at Dollar Point 2000 - 2003.

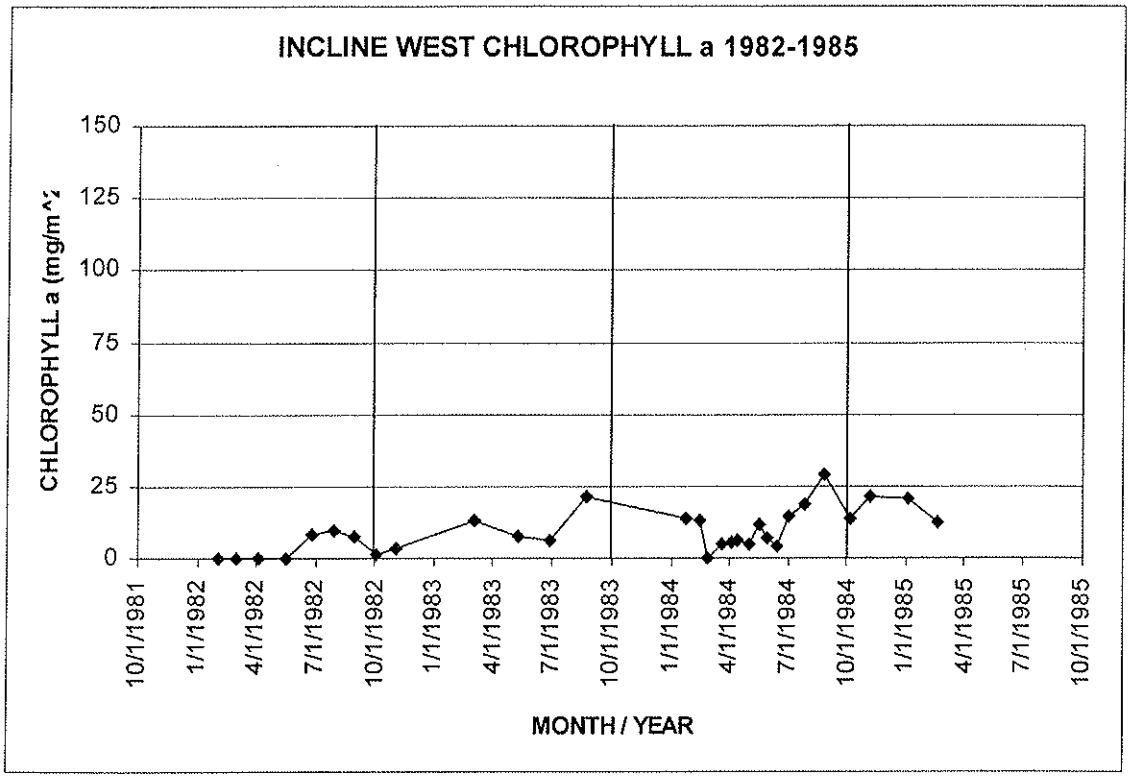

Figure 1i: Measured biomass as chlorophyll a at Incline West 1982 - 1985.

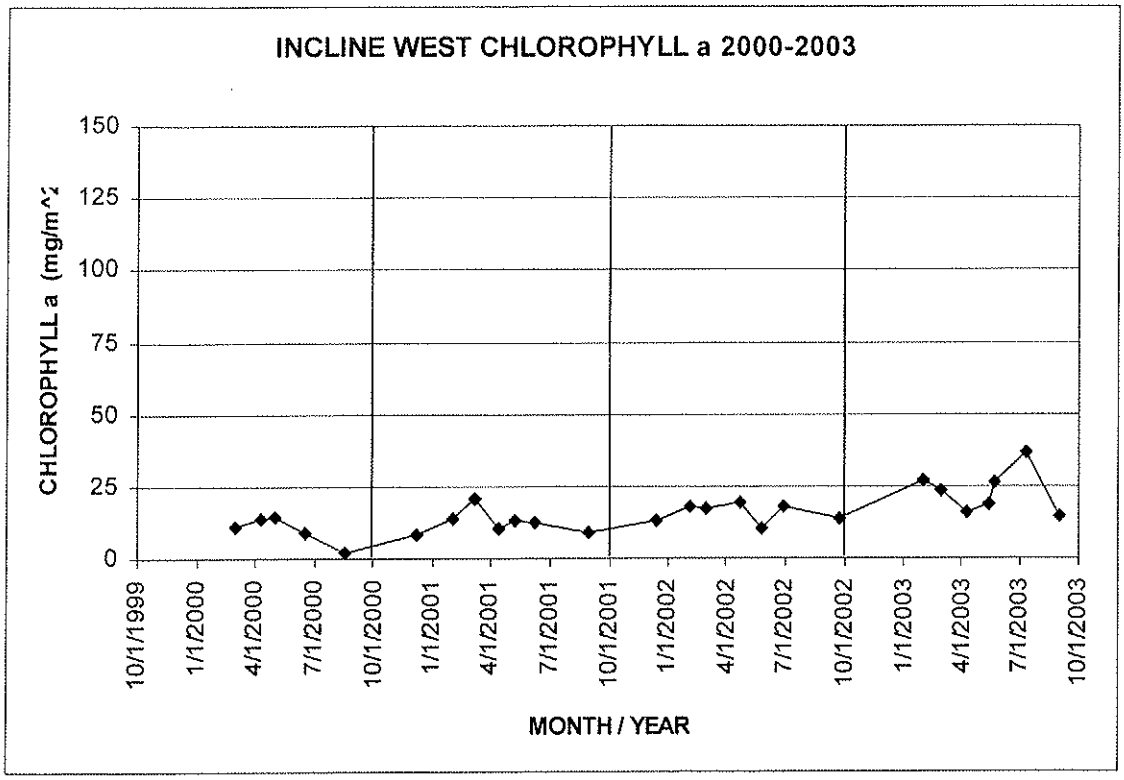

Figure 1j: Measured biomass as chlorophyll a at Incline West 2000 - 2003.

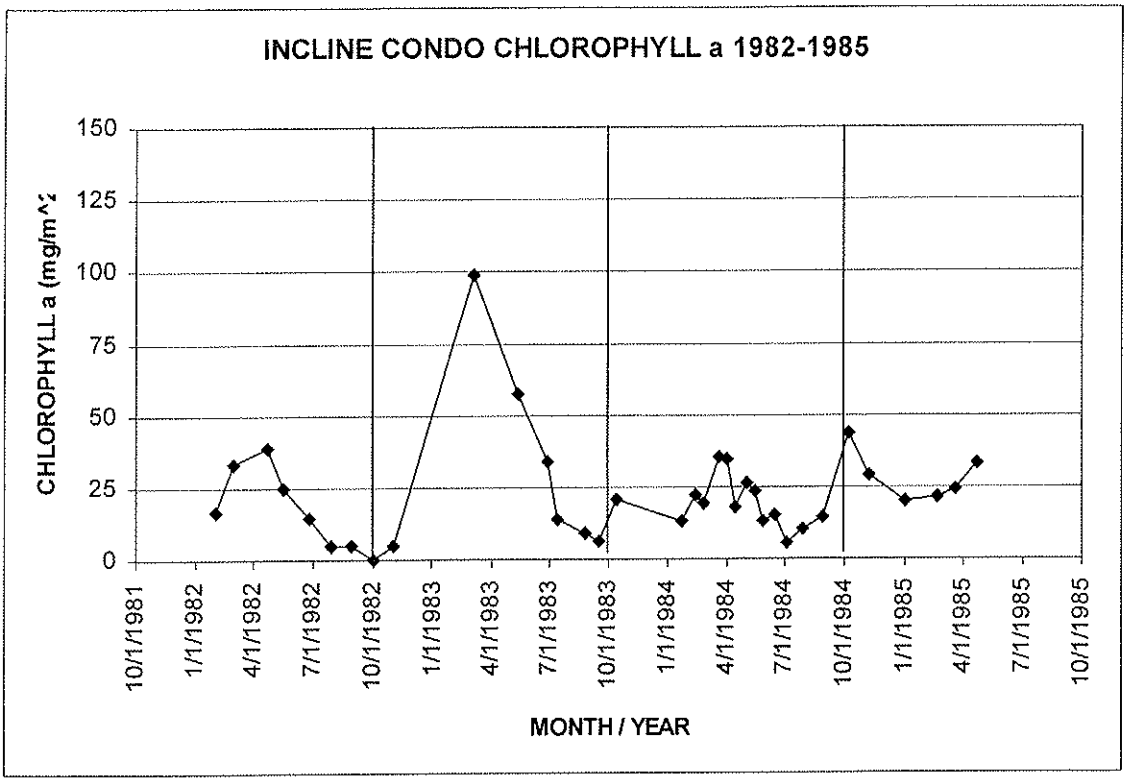

Figure 1k: Measured biomass as chlorophyll a at Incline Condo 1982 - 1985.

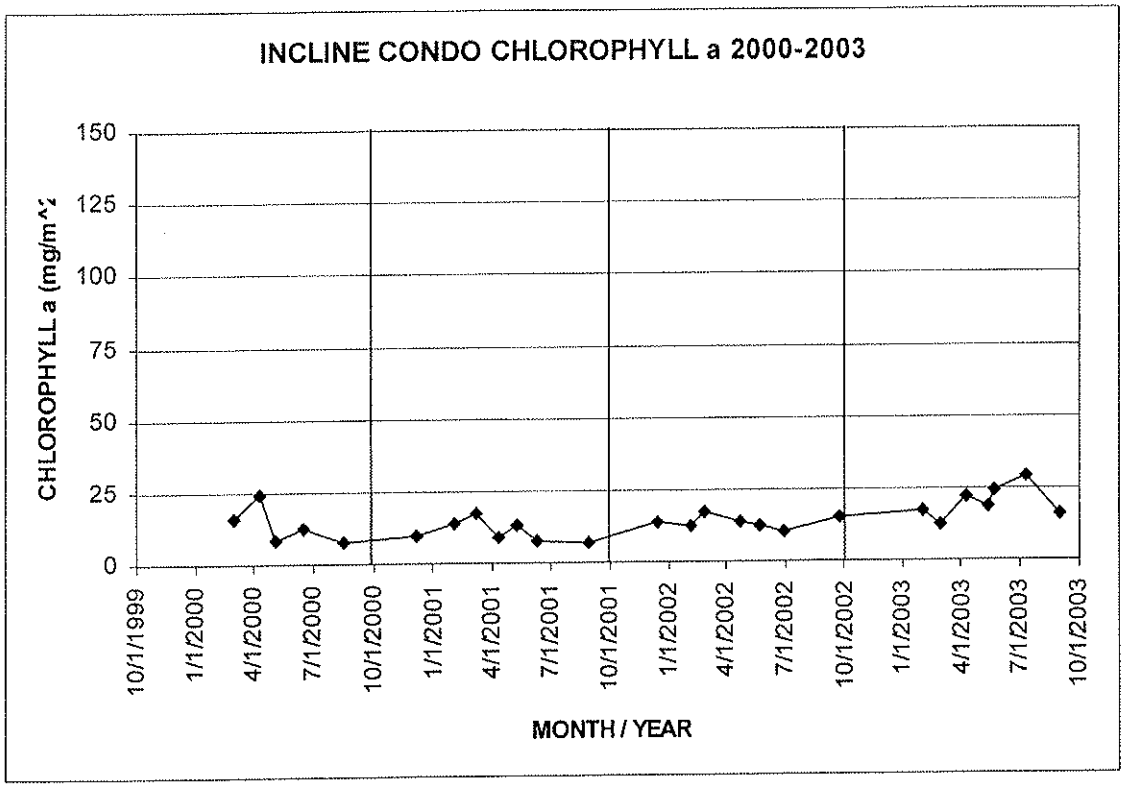

Figure 1l: Measured biomass as chlorophyll a at Incline Condo 2000 - 2003.

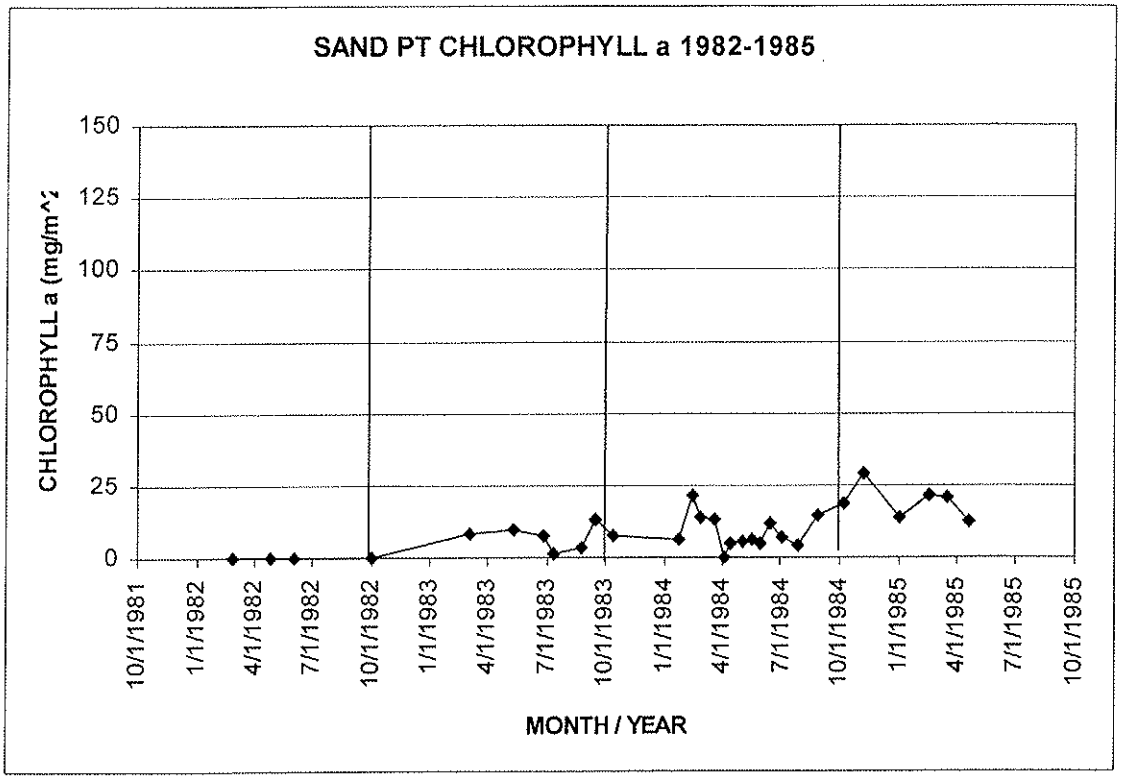

Figure 1m: Measured biomass as chlorophyll a at Sand Point 1982 - 1985.

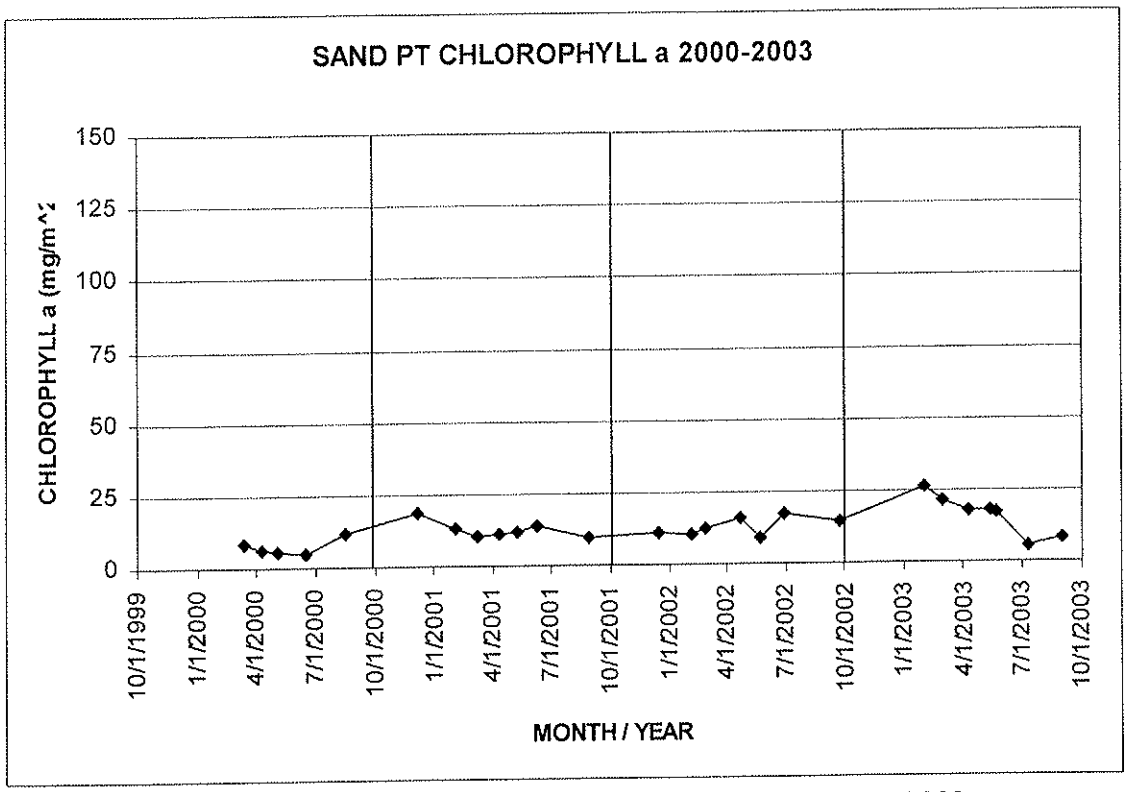

Figure 1n: Measured biomass as chlorophyll a at Sand Point 2000 - 2003.

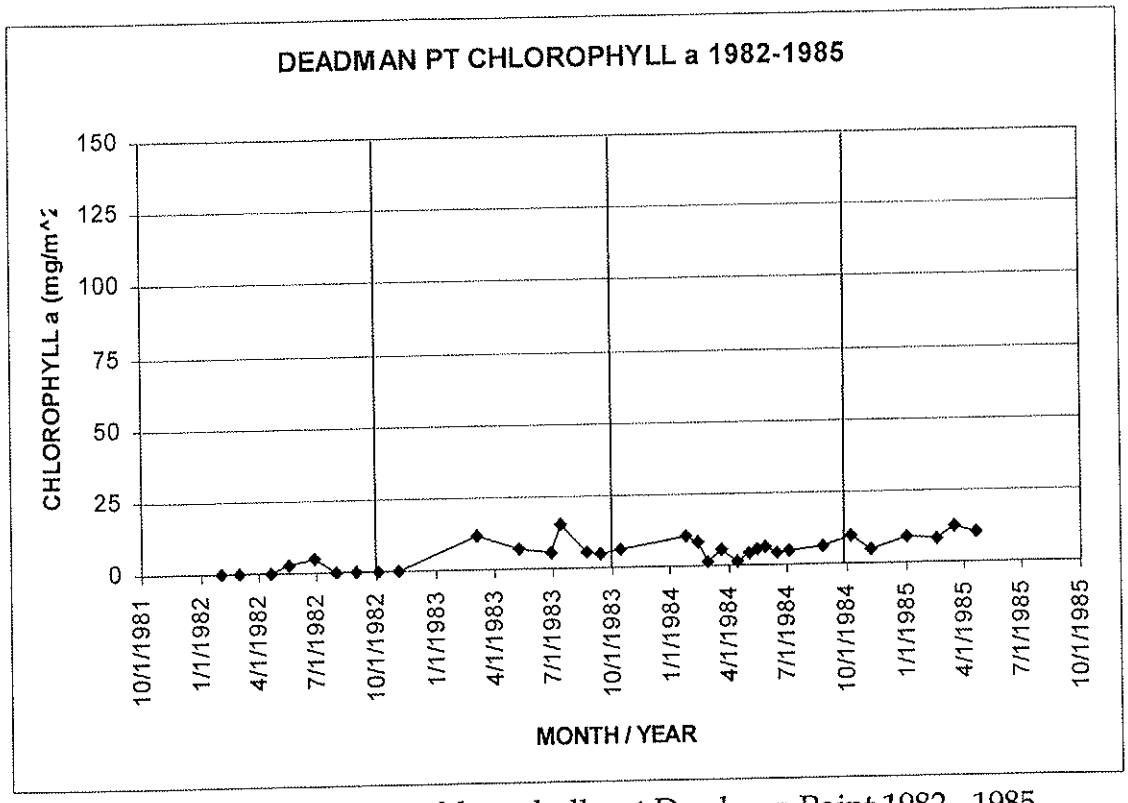

Figure 1o: Measured biomass as chlorophyll a at Deadman Point 1982 - 1985.

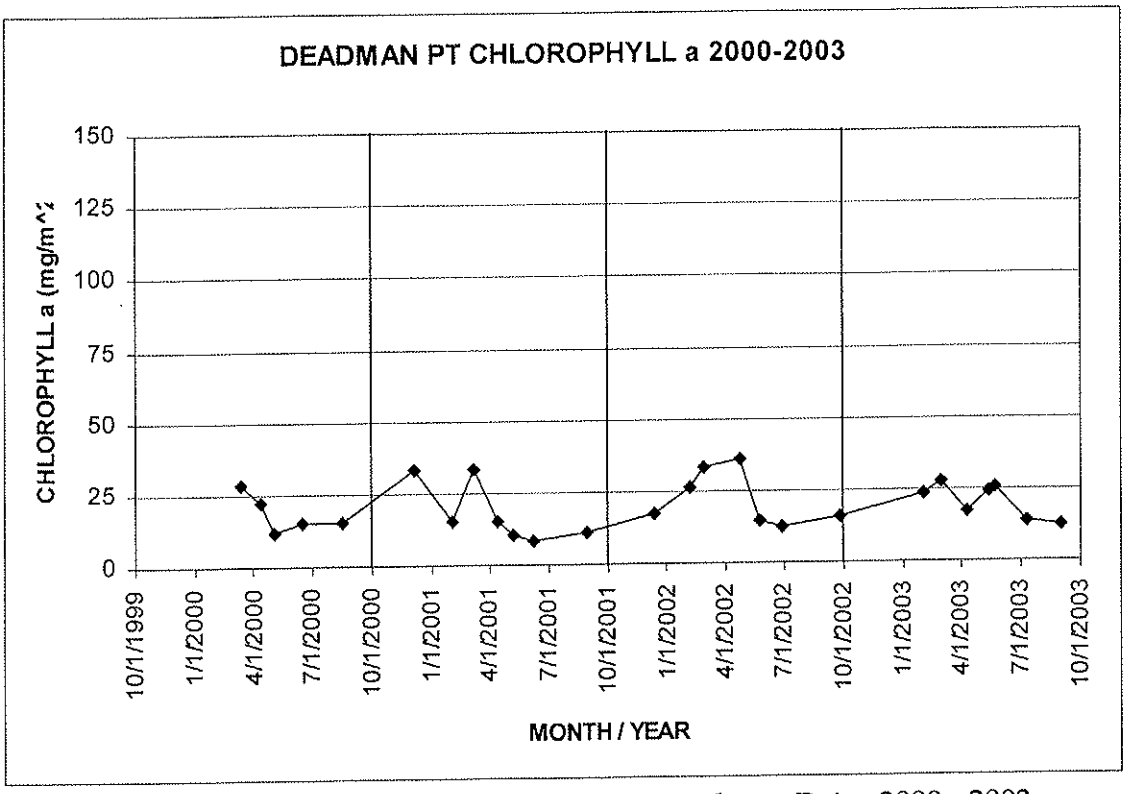

Figure 1p: Measured biomass as chlorophyll a at Deadman Point 2000 - 2003.

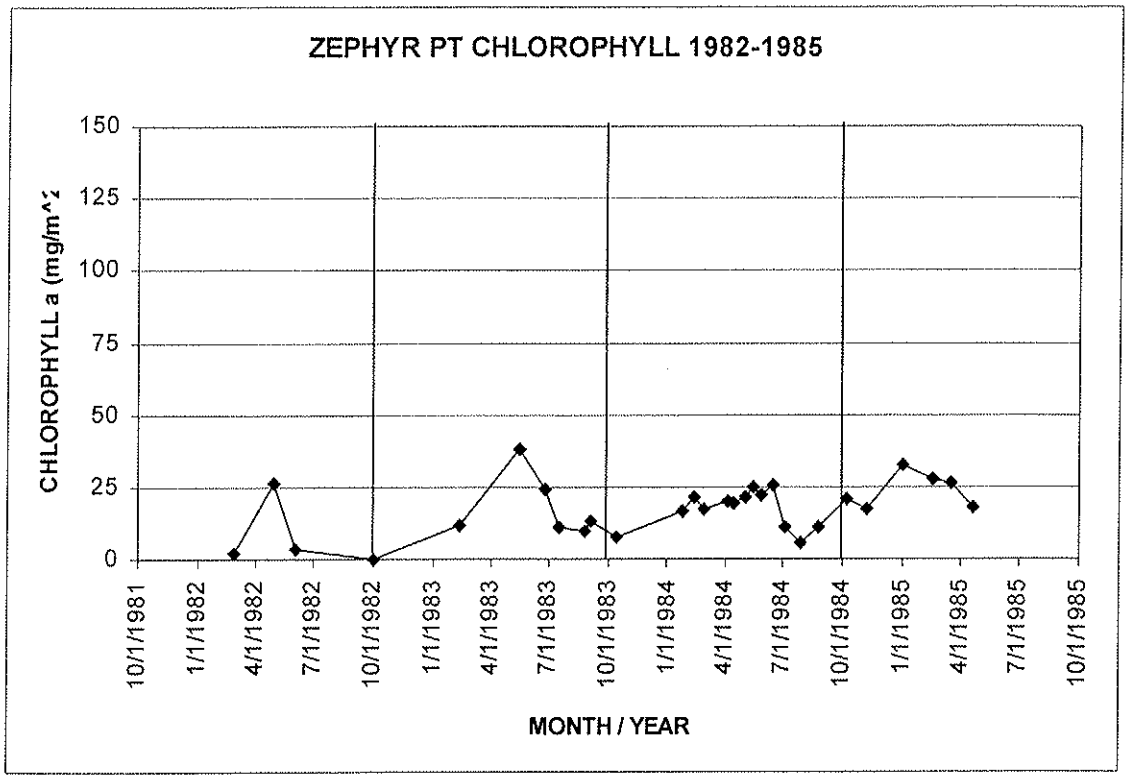

Figure 1q: Measured biomass as chlorophyll a at Zephyr Point 1982 - 1985.

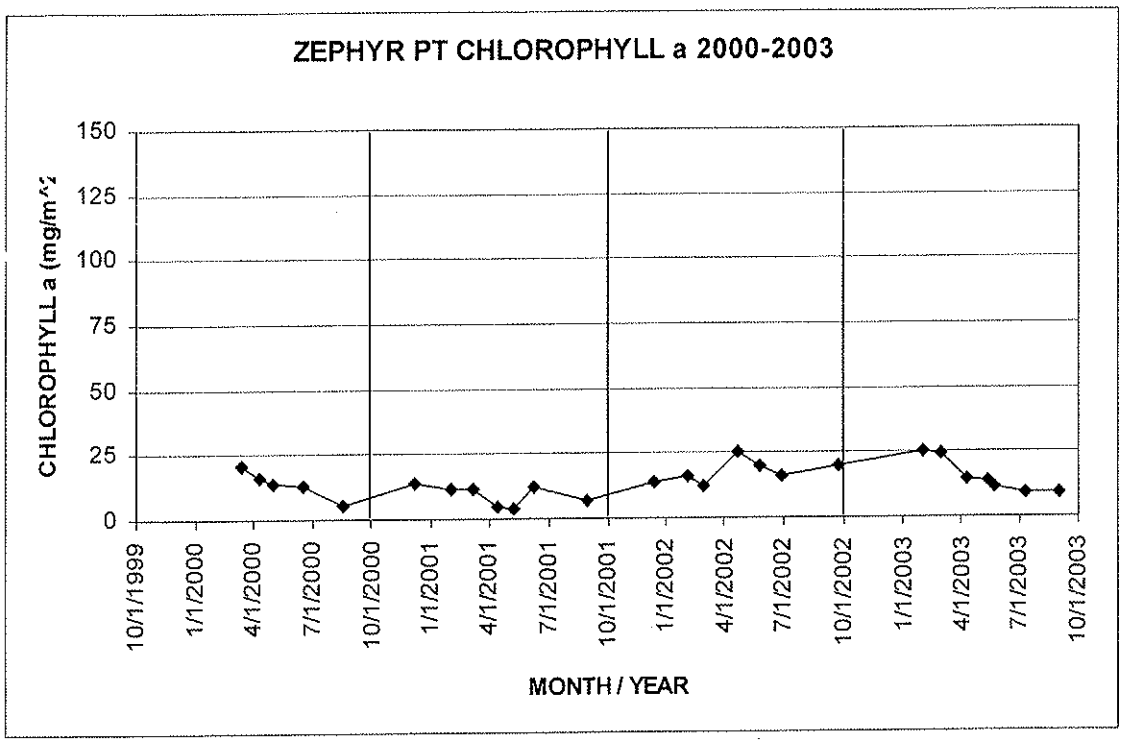

Figure 1r: Measured biomass as chlorophyll a at Zephyr Point 2000 - 2003.

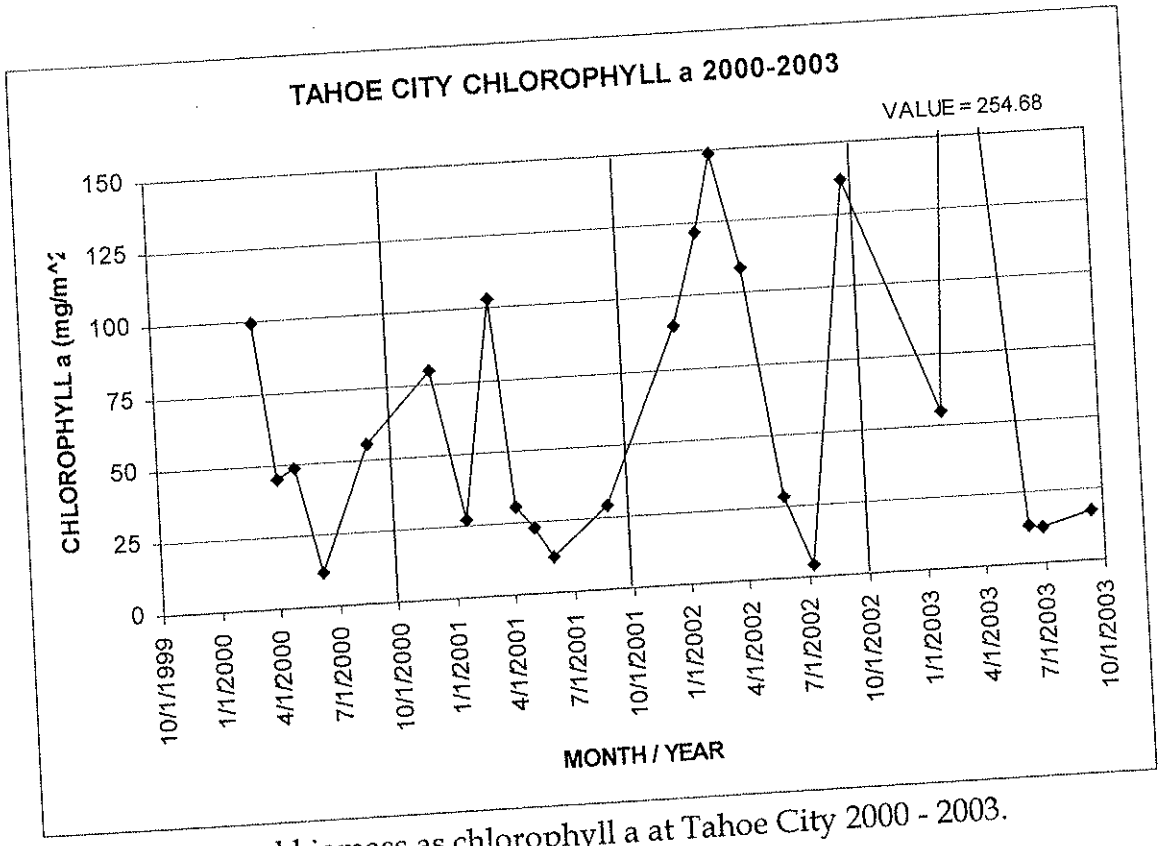

Figure 1s: Measured biomass as chlorophyll a at Tahoe City 2000 - 2003.

At Sugar Pine Point during the early1980s, algal biomass displayed the normal seasonal growth pattern reaching maximum values between 60 and 80 mg/m^2 during the spring and returning to baseline (10 mg/m^2) by the end of the summer (Figure 1c). This pattern changed during the 2000 to 2003 monitoring. Algal biomass reached a high during the fall of 2000 (52.73 mg/m^2) and then remained near baseline conditions (8 mg/m^2) throughout the remainder of the study (Figure 1d). At this location the baseline conditions declined between the historic sampling to the present.

A shift in the baseline biomass condition was noted at Deadman Point and Sand Point as well. While annual peak biomass conditions at both sites remained below 40 mg/m^2 through all the years monitored, there was a more persistent coverage of periphyton after 2000 (Figure 1m-p). This resulted in an increase in the baseline concentration of chlorophyll at both sites. Values at Deadman Point nearly tripled from 6 mg/m^2 to 15 mg/m^2, while those at Sand Point more than doubled, going from 5 mg/m^2 in the 1980s to 12 mg/m^2 during the present study. The consistently low annual maximum algal growth, coupled with an upward shift in the baseline concentration, suggest nutrient levels may have remained low at these sites over the past two decades, with the available nutrients persisting later into the summer.

Another possible cause of increased baseline concentrations of chlorophyll a relates to lake surface elevations. We hope to further evaluate the role that lake level fluctuations have with respect to periphyton biomass in future analyses of the data.

Three periphyton monitoring locations were selected that represented moderate levels of human development. One of these sites was on the west shore (Dollar Point), one on the east shore (Zephyr Point), and one on the north shore (Incline West). The Dollar Point site reflected the elevated level of backshore development with higher periphyton biomass, while the Zephyr Point and Incline West sites behaved similarly to sites with a low level of development. Even though periphyton is a good indicator of available nutrients in the shorezone of the lake, there appears to be different impacts from areas that have approximately the same level of development. However, it should be recognized that the general level of development (low – high) was a subjective measure and did not account for specific measures of land coverage nor did it reflect actual nutrient loading.

Dollar Point maximum algal biomass values exceeded 60 mg/m^2 for all years sampled with the exception of 2000 and 2001. A peak value of over 110 mg/m^2 was recorded during February, 2002 (Figure 1h). These chlorophyll concentrations are much higher than those recorded at Incline West and Zephyr Point over the same period, where annual peak biomass did not exceed 40 mg/m^2 (Figures 1i-j and q-r respectively). Baseline biomass displayed the same discrepancy between sites with the average annual minimum at Dollar Point (20 mg/m^2) being nearly twice that of the other two locations (8-13 mg/m^2).

The monitoring sites associated with a high level of shoreline development (urban centers or developed areas with potentially high nutrient inputs) were Pineland, Tahoe City, and Incline Condo. These sites displayed much higher annual maximum chlorophyll concentrations than any of the other monitoring locations, with peak values often in excess of 120 mg/m^2 (Figures 1e-f, 1t, and 1k-l). The exception to this was the Incline Condo site between 2000 and 2003. Annual peak chlorophyll concentrations reflected the nearby Incline West site with peak values remaining below 30 mg/m^2 (Figure 1l). The reason for this localized change in periphyton biomass is unclear since we are not able to resolve differences between meteorological perturbations and possible improvements in environmental practices within the shorezone development.

Spatial Distribution

The data presented above characterizes periphyton biomass at the monitoring sites as it changed between each individual sampling date. Table 2 condenses the data for each year into an average annual maximum concentrations, average annual concentrations, and average baseline concentrations for the historical and present time periods. These values have been graphically represented in Figures 2-4.

Table 2. Summary values for periphyton biomass indicators. SE denotes standard error.

Biomass Indicator	Annual Maximum Concentration	SE	Average Annual Concentration	SE	Baseline Concentration
Location/Date					
Rubicon Point					
1982	28.72	NA	6.5		
1983	59.52	3.29	30.42		
1984	42.43	7.14	16.59		
1985	216.28	41.3			
Avg for Period	43.56	8.91	17.84	6.93	10
2000	23.58	3.02	13.77		
2001	24.55	1.7	14.75		
2002	32.19	6.51	17.42		
2003	49.15	6.6	24.28		
Avg for Period	32.37	5.92	17.56	2.37	12

Biomass Indicator Location/Date	Annual Maximum Concentration	SE	Average Annual Concentration	SE	Baseline Concentration
Sugar Pine Point					
1982	23.09	2.5	13.81		
1983	64.71	10.7	28.18		
1984	87.43	9.67	34.64		
1985	130.14	26.58			
Avg for Period	58.41	18.84	25.54	6.16	10
2000	52.73	11.25	28.02		
2001	17.87	4.82	15.57		
2002	5.98	1.07	3.76		
2003	14.43	7.86	6.71		
Avg for Period	22.75	10.30	13.52	5.45	8
Pineland					
1982	38.52	4.98	17.69		
1983	147.44	15.06	50.39		
1984	133.62	12.36	42.37		
1985	185.92	59.32			
Avg for Period	106.53	34.24	36.82	9.84	20
2000	78.37	16.34	19.16		
2001	51.5	23.88	24		
2002	123.76	23.58	51.55		
2003	132.63	41.77	57.73		
Avg for Period	96.57	19.15	38.11	9.68	20
Tahoe City					
1982	ND		ND		
1983	ND		ND		
1984	ND		ND		
1985	ND		ND		
Avg for Period	ND		ND		ND
2000	99.88	14.26	45.26		
2001	103.21	20.27	45.01		
2002	148.56	5.31	81.14		
2003	254.68	95.88	85.71		
Avg for Period	151.58	36.11	64.28	11.09	30

Biomass Indicator	Annual Maximum Concentration	SE	Average Annual Concentration	SE	Baseline Concentration
Location/Date					
Dollar Point					
1982	65.15	4.64	27.91		
1983	65.09	6.83	32.08		
1984	78.72	5.27	37.43		
1985	56.62	17.21			
Avg for Period	69.65	4.53	32.47	2.76	20
2000	31.33	5.74	17.89		
2001	49.76	1.11	33.6		
2002	118.66	14.02	56.51		
2003	75.36	6.66	38.9		
Avg for Period	68.78	18.92	36.73	7.96	20
Incline West					
1982	13.31	0.57	5.04		
1983	20.4	2.4	10.05		
1984	22.87	1.57	13.91		
1985	20.24	3.54			
Avg for Period	18.86	2.87	9.67	2.57	8
2000	14.59	1.83	8.54		
2001	20.49	0.19	11.24		
2002	19.57	2.31	15.28		
2003	36.98	1.85	22.33		
Avg for Period	22.91	4.87	14.35	3.00	11
Incline Condo					
1982	38.5	2.3	19.32		
1983	98.93	9.84	41.08		
1984	35.12	2.34	19.02		
1985	43.77	6.87			
Avg for Period	57.52	20.73	26.47	7.30	12
2000	23.97	4.02	12.17		
2001	17.14	0.48	10.17		
2002	17	5.53	13.1		
2003	28.94	2.41	17.94		
Avg for Period	21.76	2.89	13.35	1.65	12

Biomass Indicator	Annual Maximum Concentration	SE	Average Annual Concentration	SE	Baseline Concentration
Location/Date					
Sand Point					
1982	0		0		
1983	12.81	0.93	5.92		
1984	21.28	7.22	9.03		
1985	29.13	0.19			
Avg for Period	21.07	6.19	4.98	2.65	5
2000	12.07	0.97	7.33		
2001	18.72	2.34	13.07		
2002	16.99	1.29	12.82		
2003	26.3	0.41	16.44		
Avg for Period	18.52	2.95	12.42	1.89	12
Deadman Point					
1982	4.6		1.12		
1983	15.39	7.05	6.71		
1984	10.03	1.5	6.16		
1985	12.42	1.35			
Avg for Period	10.01	3.11	4.66	1.78	6
2000	28.21	1.55	17.22		
2001	33.09	7.03	18.27		
2002	35.8	6.18	20.48		
2003	27.37	6.04	19.05		
Avg for Period	31.12	2.01	18.76	0.69	15
Zephyr Point					
1982	26.18	1.97	6.22		
1983	38.23	4.37	15.31		
1984	25.44	2	15.48		
1985	32.24	1.83			
Avg for Period	29.95	4.15	12.34	3.06	12
2000	20.95	1.35	15.83		
2001	13.4	2.09	9.66		
2002	25.63	5.13	16.7		
2003	25.57	1.28	16.81		
Avg for Period	21.39	2.88	14.75	1.71	13

The average annual maximum biomass is clearly higher at locations representing areas of high development (Pineland and Tahoe City), (Figure 2). Dollar Point also displayed an elevated average maximum biomass, indicating the peak growth at this site was high throughout the 1980s and the present study. In contrast to this, the average maximum biomass was consistently low at Incline West, Sand Point, Deadman Point, and Zephyr Point, not exceeding 40 mg/m^2.

While comparing the average peak biomass over each of the four year study periods, at each site, adds insight into the worst case conditions, the values do not include a time-related component as discussed above.

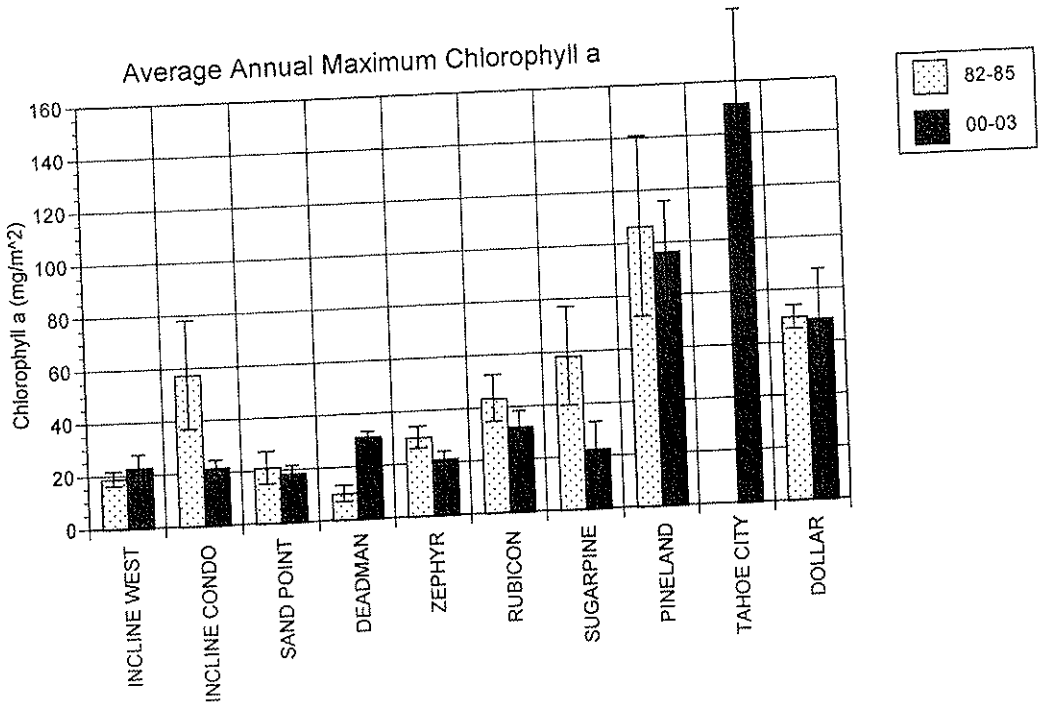

Figure 2. Average annual maximum periphyton biomass (as chlorophyll a) during 1982-85 and 2000-03. Error bars are standard errors for each average.

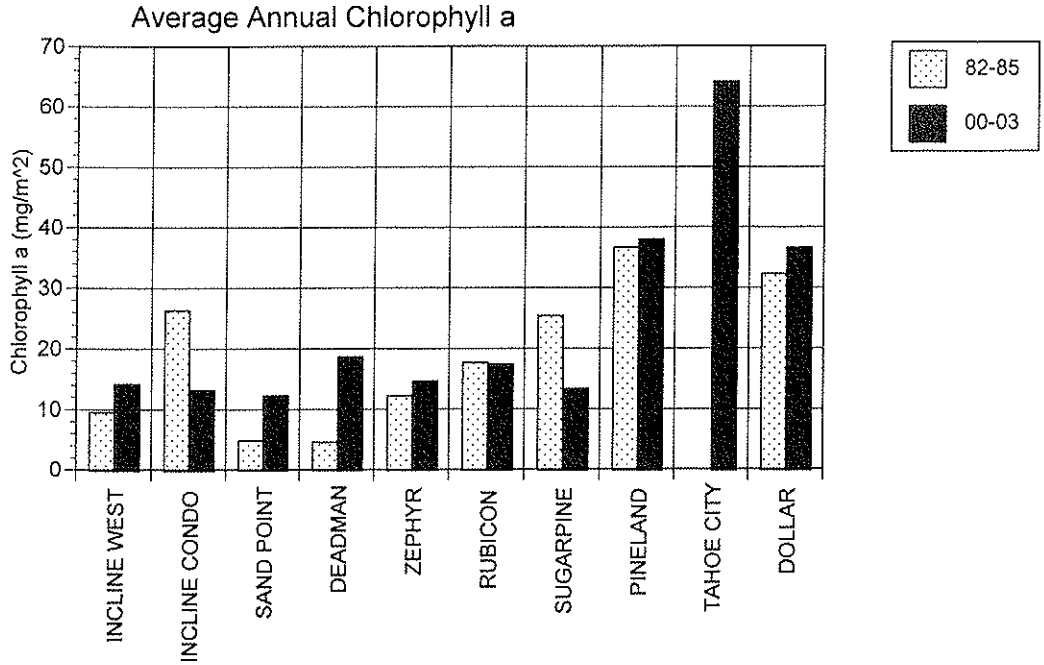

Figure 3. Average annual periphyton biomass (as chlorophyll a) during 1982-85 and 2000-03

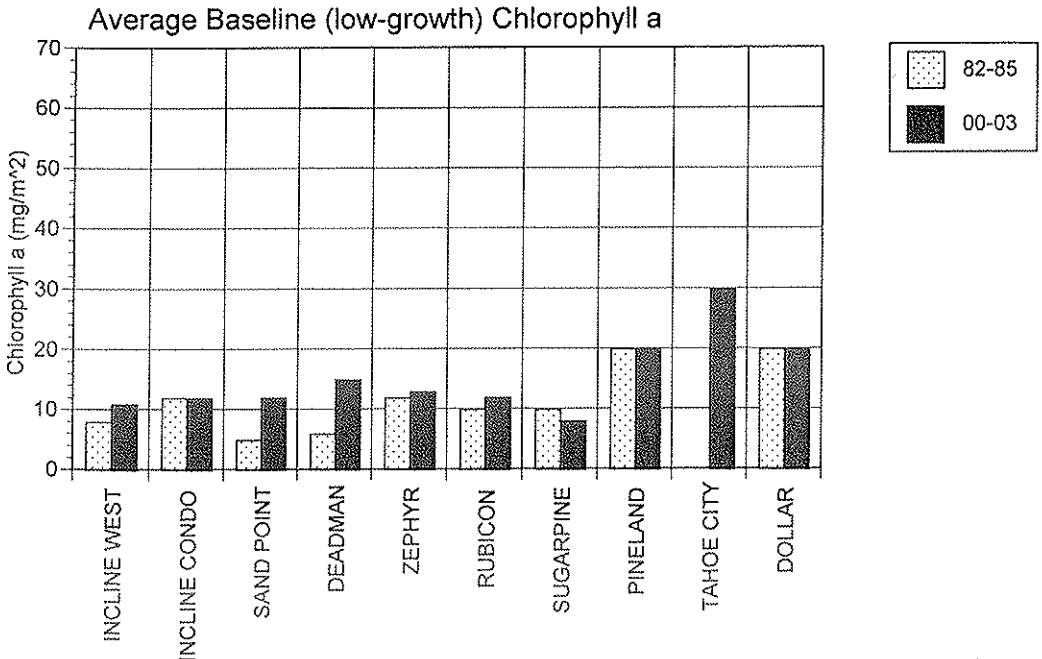

Figure 4. Average baseline (low-growth) periphyton biomass (as chlorophyll a) during 1982-85 and 2000-03.

The average annual biomass provides additional information in that it measures the average biomass present throughout the year. Figure 3 shows that the average annual biomass follows a similar trend as the average annual maximum. This implies that all sites have a similar duration to the growing season. If the sites with very high average maximum biomass concentrations reached their annual maximum biomass over a very short period of time (weeks) and immediately returned to a baseline condition, the average annual concentrations would be greatly reduced.

The annual baseline biomass is an indicator of mean low growth at each of the sites (Figure 4). Again a similar trend is observed. The sites exhibiting the highest average maximum and elevated average annual biomass concentrations, also display elevated baseline biomass conditions. This indicates that some nutrient source is available to these periphyton communities throughout the year that is not available to the other lakeshore locations.

Our biomass indicators are specific to individual monitoring locations and do not provide information about algal growth in the surrounding area, i.e. that area in between the fixed monitoring locations. If lakeshore eutrophication were to increase, it is expected that periphyton might respond with increased biomass in areas currently displaying low levels of growth. With the exception of the ten current monitoring sites, we do not have historical information on the more fine-scale spatial extent of periphyton growth. Consequently, it is not possible to directly address the question whether the range of periphyton growth has expanded over time. In 2003, we conducted preliminary monitoring to begin to determine the feasibility of conducting a whole-lake periphyton biomass analysis. Again, the goal of this specific monitoring was to gain background data to facilitate an informed discussion.

A synoptic survey was designed to coincide with peak biomass conditions in each area of the lake, resulting in multiple sampling events between 19 March and 10 June, 2003. A total of 39 sites were surveyed in addition to the ten routine monitoring locations (Table 3). Of the 49 total survey points, 18 were sampled for chlorophyll. There was a high degree of variation in biomass around the lake with values ranging from 7.8 mg/m^2 at Logan Shoals to 254.7 mg/m^2 at Tahoe City. This variation suggests that there is great potential for increases in maximum periphyton biomass around the lake in the future, if nutrient loading were to continue. Since synoptic surveys were not conducted during the historic period, there is no means to compare spatial changes over time. If synoptic surveys are used in the future to evaluate changes in the spatial distribution of periphyton biomass, it is important to consider the number of samples necessary to characterize the seventy-two miles of Tahoe shoreline.

Table 3. Synoptic sampling locations for periphyton biomass

DESIGNATION	NAME	LOCATION	Chl a (mg/m^2)
	WEST SHORE MARCH 2003		
A	Cascade Creek	N38 57.130; W120 04.615	
B	S. of Eagle Point	N38 57.607; W120 04.660	26.31
C	E.Bay/Rubicon	N38 58.821; W120 05.606	
D	Gold Coast	N39 00.789; W120 06.796	
E	S. Meeks Point	N39 01.980; W120 06.882	43.15
F	N. Meeks Bay	N39 02.475; W120 07.194	
G	Tahoma	N39 04.199; W120 07.771	
H	S. Fleur Du Lac	N39 05.957; W120 09.774	81.44
I	Blackwood Creek	N39 06.411; W120 09.424	
J	Ward Creek	N39 07.719; W120 09.304	
K	N. Sunnyside	N39 08.385; W120 09.135	
L	Tavern Point	N39 08.806; W120 08.628	85.12
M	TCPUD Boat Ramp	N39 10.819; W120 07.177	33.4
N	S. Dollar Point	N39 11.016; W120 05.888	
O	S. Dollar Creek	N39 11.794; W120 05.699	
P	Cedar Flat	N39 12.567; W120 05.285	27.93
Q	Garwoods	N39 13.486; W120 04.974	
R	Flick Point	N39 13.650; W120 04.155	7.99
S	Stag Avenue	N39 14.212; W120 03.710	
T	Agatam Boat Launch	N39 14.250; W120 ~~03.710~~ 02.932	20.84
	EAST SHORE MAY 2003		
E1	South side of Elk Point	N38 58.965; W119 57.399	23.77
E2	North Side of Elk Point	N38 59.284; W119 57.341	
E3	South Side of Zephyr Point	N38 59.956; W119 57.566	
E4	North Zephyr Cove	N39 00.920; W119 57.193	
E5	Logan Shoals	N39 01.525; W119 56.997	7.8
E6	Cave Rock Ramp	N39 02.696; W119 56.935	
E7	South Glenbrook Bay	N39 04.896;W119 56.955	14.02
E8	South Deadman Point	N39 05.998; W119 57.087	
E9	Skunk Harbor	N39 07.856; W119 56.597	
E10	Chimney Beach	N39 09.044; W119 56.008	13.88
E11	Observation Point	N39 12.580; W119 55.861	8.84
	NORTH SHORE MAY 2003		
E12	Hidden Beach	N39 13.263; W119 55.832	
E13	Burnt Cedar Beach	N39 14.680; W119 58.132	10.37
E14	Stillwater Cove	N39 13.789; W120 00.020	
E15	North Stateline Point	N39 13.237; W120 00.193	17.59
E16	Brockway Springs	N39 13.560; W120 00.829	
E17	Kings Beach Ramp Area	N39 14.009; W120 01.401	26.47
	SOUTH SHORE MAY 2003		
S1	Tahoe Keys Entrance	N38 56.398; W120 00.390	24.95
S2	Kiva Point	N38 56.555; W120 03.203	31.17

Trends

By viewing biomass indicators over a larger time scale (twenty years), trend comparisons can begin to be made between the historic and present data. An evaluation of the average peak biomass at a given lake location during the 1980s could be compared to the worst case measured at that location in the early 2000s. This might indicate how shorezone eutrophication has degraded or improved over time. Similarly the average annual concentration of chlorophyll could be used to compare site-specific changes in the annual aesthetic quality of the shorezone. Shifts in the annual baseline biomass might be used as an indicator of how chronic periphyton growth has changed during the past two decades, providing additional insight into shorezone eutrophication during non-peak growing seasons.

However, the use of this data as a measure of absolute change in periphyton biomass over the past twenty years must be done with caution. The frequency of sampling directly affects the average annual calculations and four-year time spans are relatively short and, runoff to the lake was not equal during the periods 1982-85 and 2000-03. In fact, taking the Ward Creek total annual discharge (October 1-September 31) for each year, the mean flow for 1982-85 (400×10^8 liters) was approximately 130% above or 2.3 times the 2000-03 flow (172×10^8 liters). If discharge with its associated nutrient load is an important regulator of periphyton growth, changes between 1982-85 and 2000-03 could be due to differences in runoff and not indicative of a significant trend in periphyton growth. Presently there is insufficient information on the factors controlling periphyton in Lake Tahoe to allow us to apply a numeric factor to account for the impact of flow/nutrient load on this algal community.

For many years the Tahoe Research Group has worked to separate out the individual impacts of a long-term trend from interannual variability with regard to evaluating 1969-2003 annual Secchi depth data. Numerous scientific papers have been dedicated to this issue, summarizing a significant body of knowledge gained through focused research. Given that (1) we only have seven years of data on periphyton biomass over a 23 years period (not every year as with Secchi depth) (2) the number of sampling dates in any given year for periphyton has never been more than one-third to one-half the number for Secchi depth, and (3) the Secchi depth measurements are taken on a large scale that integrate lake processes, where periphyton is highly subject to local hydrology and nutrient loads, (4) and that we know that 2000-03 was very dry in comparison to 1982-85, any direct comparison of these two periods for the purpose of trend identification can not be justified. If periphyton is to be used to assess long-term trends in water quality an expanded design is required.

Despite our inability at this time to statistically analyze this data with respect to temporal trends, some general observations may be meaningful for future discussions:

1) Annual baseline chlorophyll a (which should not be influenced by wet versus dry years to the degree that annual maximum or annual cumulative biomass would be) suggests that while values

at Deadman Pt. and Sand Pt. on the undeveloped east shore, increased, all other locations appeared unchanged.

2) The relative relationships between the sampling locations appeared generally consistent over the 20-year period. Locations that were low in 1982-85 were generally low in 2000-03 and sites with elevated chlorophyll a in 1982-85 also showed elevated chlorophyll in 2000-03.

3) If (and we present this with extreme caution) periphyton growth is related directly to flow and nutrient load, it may be noteworthy that many of the sites in 2000-03 were comparable to 1982-85. Based on this reasoning, one could hypothesize that locations such as Pineland and Dollar Point will have much higher periphyton during subsequent years when flow is comparable to 1982-85. Only additional monitoring will help to evaluate this. As noted previously, both monitoring and research are need for us to more fully understand the details of periphyton growth in Lake Tahoe.

Water Quality Standards for Periphyton

Factors to Consider

The accumulation of attached algae on rocks, piers, boats and other hard bottom substrates is arguably the most obvious indicator of Lake Tahoe's declining water quality for the largely shore-bound population. Thick, carpet-like, expanses of periphyton biomass carpets the shoreline in places, creating a sharp contrast to the blue hue of the open waters. Beaches can be fouled when this material dies and breaks free, and slippage by humans walking on the rocks/cement areas also poses a safety concern.

The current Lahontan RWQCB water quality standard (WQS) for periphyton in Lake Tahoe, as stated on page 3-9 of the Water Quality Control Plan [Biological Indicators], states, "for Lake Tahoe, algal productivity and the biomass of phytoplankton, zooplankton, and periphyton shall not be increased beyond the levels recorded in 1967-71, based on statistical comparison of seasonal and annual means." We believe that it would be beneficial to re-consider this definition since periphyton biomass during the period 1967-71 was measured by allowing biomass to grow on artificial substrates that do not mimic actual ambient conditions. Work by the TRG in the early 1980s clearly demonstrated this limitation, which is why we chose to sample the natural rock substrates. Currently, the TRPA has no environmental threshold/indictor for periphyton. The anticipated reduction of nutrients that will come about as a result of the Lake Tahoe TMDL and EIP should reduce the growth of this algae. As with other key indicators of water quality, we need realistic targets in order to measure success.

Recommendations for and final adoption of a numeric WQS by States or Tribes, under the Federal Clean Water Act, requires a number of steps and is part of both a scientific and required administrative process. Our goal in this section of the report is not to make a final recommendation to the Lahontan RWQCB as to the most appropriate numeric WQS for

periphyton growth. Rather, we wish to initiate a discussion focusing on some of the more important scientific aspects of this topic that need to be considered. Should Lahontan choose to pursue the adoption of revised numeric WQS for periphyton further, we strongly suggest this be done under a separate scope of work.

Water quality standards can be developed by many means. For example, (1) numeric value(s) can be based on replicating conditions some time in the past when water quality was in a desirable condition (e.g. Lake Tahoe transparency [Secchi depth]), (2) there may be a scientific literature which suggests that exceedence of a certain value would be harmful to aquatic biota (e.g. toxics or dissolved oxygen), (3) values can be determined by examination of current reference conditions (i.e. what are the numeric values in those portions of the water body not affected by pollutants), (4) values can be based on the desire not to exceed a given value over a certain percent of time (e.g. values can not exceed the 90^{th} percentile of the existing data base), (5) models can also be used to guide selection of values, and (6) in the case of aesthetic beneficial uses, the selection of values can be based on the public/agency perception of acceptable conditions. At this time there is no evidence to suggest that periphyton growth is having a significant impact on lake biota. Consequently, a numeric WQS for periphyton at Lake Tahoe would most likely be based on aesthetic concerns and/or the desire to replicate previous conditions.

Numeric WQS exist in many forms – the most common are adoption of a single value concentration for a selected parameter can not exceed a stated value and the annual average (or some other indicator of average condition) can not exceed a stated value. Often, both are adopted. In the case of open-water clarity at Lake Tahoe, this is fairly straight forward; an average annual value, measured at the long-term monitoring site is evaluated. For attached algae there are many factors to consider.

As discussed above, the accumulation/growth of periphyton biomass occurs on a number of spatial and time scales. First, biomass can be evaluated as the amount/concentration of material within a prescribed area (i.e. how much is present on a square meter of substrate – the ability of a bottom surface to support biomass). Second, an indication of worsening conditions could be that biomass is found during seasons when it historically did not occur. Third, growth can increase based on the spatial extent of its distribution, i.e. if growth was historically observed in a 100 m^2 area but now it extends into a 300 m^2 area or beyond, this denotes an increase, even though the amount in an given square meter may not of changed. The data collected to date primarily focus on the first scenario, i.e. the absolute amount of growth on a given area of substrate. We also have some data on the second scale, temporal extent of growth. The spatial growth of periphyton on a lake-wide has been confined to the 10 sites sampled. As presented above, during 2003 we conducted a true synoptic survey. However, any revision of the WQS can not be based on this limited data set; an expanded monitoring program is required and recommended.

Approaches

Based on the available data, we suggest that future discussions regarding a revised WQS for periphyton (if desired) need to consider at least the following categories:

- Literature definitions for nuisance levels of attached algae,
- Single annual maximum chlorophyll *a* concentration that can not be exceeded,
- Average annual chlorophyll *a* concentration that can not be exceeded,
- Annual baseline concentration that can not be exceeded (note: more data is needed to define the length of time the baseline concentration should be achieved),
- Statistical value based on the distribution of data and how often it exceeds a certain value under reference and all conditions, and
- Level of acceptable growth based on public perception.

Again, it is important to note that we are not making a recommendation for final specific numeric values at this time. All values referred to below require additional discussion.

Application to Lake Tahoe

• *Literature Definitions* – The most widely cited reference for defining nuisance levels of attached algae are those of Gene Welch, Richard Horner and associates at the University of Washington (Horner et al. 1983; Welch et al. 1988). Using chlorophyll *a* as an measure of biomass there authors suggested values of 150 mg m^{-2} for a maximum value and 100 mg m^{-2} for a mean value. This was developed primarily for stream periphyton and to our knowledge comparable values have not been published for lake periphyton. Based on the Lake Tahoe, eulittoral (splash zone) community, both these values would be exceedingly high and not very appropriate (refer to data presented above). Even at its highest (Tahoe City), average annual chlorophyll *a* did not exceed 70 mg m^{-2} despite the fact that this was an unacceptable condition.

The reason for this lack of consistency lies in the fact that the Tahoe community is dominated by the stalked diatom *Gomphoneis herculeana*. Since most of its biomass is in the form or its non-chlorophyllous, carbonaceous stalk, its mass to chlorophyll ratio is very high, i.e. nuisance biomass conditions occur long before the literature chlorophyll thresholds are met. Consequently, values specific to Lake Tahoe are required and literature values are not recommended.

• *Annual Maximum, Average Annual and Baseline Chlorophyll a Concentration* – Figures 2-4 show that there are a number of sampling locations that can serve as reference conditions. These are located in non-urbanized areas and typically have lower biomass. Examples include, Incline West, Sand Point, Deadman Point, Zephyr Point and to a less extent Rubicon Point. If we were use to annual maximum biomass as a water quality standard and base our selection on desire to achieve reference station levels around the lake, a value of not to exceed 25-30 mg chl a/m^2

would be a good starting point for discussion. Similarly, a corresponding value can be derived for average annual chlorophyll a. For baseline concentration, a value of 10 mg chl a/m^2 would be a reasonable initial value for consideration. In this discussion, the reference conditions demonstrate that low levels of periphyton are achievable in Lake Tahoe and the management goal would be to reduce nutrient loads to sufficient levels to reach these levels. Clearly, there will be locations around the lake that may not be able to achieve these lower values because of stream flow or other un-controllable sources of nutrients. Taking this approach, the merit of exceptions would need to be considered.

• *Statistically Based Values* – In their desire to establish national water quality standards for nutrients, the US EPA made an initial suggestion that numeric values could perhaps be expressed as the 75th percentile of values from reference waterbodies and/or the 25th percentile from all waterbodies in a given area (Nutrient Criteria Development Workshop, March 14-15, 2002, San Diego, CA).

Based on the data summary in Table 4 and using these criteria, a value of 9 mg/m^2 represents the 25th percentile for all data. This value is lower than the annual maximum since it accounts for all data and is not overly influenced by single high values. It is important to keep in mind that these US EPA criteria are very much under debate and they may not be suitable for Lake Tahoe periphyton. The goal here was to present an alternative process. If, for example, we define the 25th percentile for the developed sites of Pineland, Tahoe City and Dollar Point, the value is 15-20 mg/m^2. The 75th percentile for the remaining eight sites is 20-25 mg/m^2. Again, these values are presented for discussion only, but as can see seen, a number of approaches yield similar values.

Table 4. Values represent periphyton biomass (mg chl a/m^2) corresponding to the stated percentile. Based on the cumulative distribution of each data point over the entire 1982-85, 2000-2004 period of record. For example, at Rubicon Point, 10% of the samples had a biomass value of less than or equal to 4 mg chl a/m^2, 50% of the samples had a chl a concentration ≤15 mg/m^2, etc.

	10%	25%	50%	75%	90%
Rubicon Pt.	4	7	15	23	38
Sugar Pine Pt.	1	5	14	35	61
Pineland	3	10	22	49	93
Tahoe City (2000-03)	12	25	47	104	137
Dollar Pt.	9	15	28	50	71
Incline West	2	8	11	17	20
Incline Condo	6	9	15	22	34
Sand Pt.	0	6	11	15	19
Deadman Pt.	0	5	10	16	25
Zephyr Pt.	6	11	16	23	28
Total Combined	3	9	15	26	50

• *Public Perception* – Yet another approach for developing a water quality standard for periphyton based on aesthetic perception would be to survey the public on what levels they find undesirable. If combined with quantitative sampling, a water quality standard could be developed. This could be done by showing photographs of shoreline conditions (periphyton growth), from different locations, over the course of a season. We took some initial steps towards this goal, but quickly realized it was outside our scope of work and that it would require a much more significant effort.

Use of Models and Suggestions for Further Research and Monitoring

Modeling periphyton growth around Lake Tahoe in response to nutrient inputs will require a significant amount of new research. We simply do not have the understanding at this time to even attempt such a task. As noted above, research on periphyton and the factors controlling its growth in Lake Tahoe only got underway during the period 1979-1984, with no new research funded since. While there are a few generic models for algal growth in streams, a similar model in lakes is lacking. As with many other process, the oligotrophic nature of Lake Tahoe almost requires that a customized model be developed.

Depending on the emphasis that the Basin agencies wish to place on periphyton in the future, we strongly recommend that the Lake Tahoe Science Advisory Group establish a subcommittee to investigate this further and develop a science plan for the research and monitoring steps that would be required to construct a periphyton model.

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Periphyton Quality Assurance Project Plan (QAPP)

1) Title and Approval Page

Attached Algae (Periphyton) in the Littoral Zone of Lake Tahoe

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2. Table of Contents:

3. Distribution List

Dr. John Reuter, Brant Allen, Scott Hackley, Patty Bucknell (of UC Davis-Tahoe Research Group); Bruce Warden (of Lahontan Regional Water Quality Control Board) will receive copies of this Quality Assurance (QA) plan, and any approved revisions of this plan. Once approved, this plan will be available to any interested party by requesting a copy from Dr. John Reuter (see address on title page).

4. Project Organization

- Project Management (Dr. John Reuter) - Provides scientific guidance and general oversight to the project team at Tahoe. Assures all tasks are addressed effectively.
- Together with Brant Allen and Scott Hackley prepares the results of work completed for each task in Annual and Final Reports.
- Quarterly, Annual and Final Report Preparation (Reuter, Allen, Hackley) - prepares the results of work done for each task in Quarterly, Annual and Final Reports
- Field Studies Coordination (Brant Allen, Scott Hackley) - Responsible for coordinating field work to assure all tasks are carried out.
- Field Data Collection (Allen, Hackley) - Responsible for periphyton sample collection during regular monitoring and synoptics. Also documenting growth through site photographs and recording field observations in notes.
- Laboratory Analyses (Hackley, Allen) - Responsible for processing of periphyton samples in the lab, includes: initial sample processing and weighing, analyses for dry weight and ash free dry weight, chlorophyll a analyses.
- Historical Data Compilation (Reuter, Allen, Hackley) - Compile a database which presents relevant data from historical periphyton studies done by the Tahoe Research Group.
- Data Management (Allen, Hackley) - Prepare and update frequently a database which contains data collected from field and lab studies.
- Archiving of Data (Arneson) - Archives data collected into TRG data files.
- Literature Review (Reuter, Allen, Hackley) - Compile literature relevant to all tasks.
- Quality Assurance Management (Patty Bucknell) - Over sees quality assurance program for laboratory analyses.
- Principle Data Users (John Reuter, U.C. Davis Tahoe Research Group; Bruce Warden, LRWQCB)
- Primary Decision Makers and Implementers (LRWQCB)

5. Problem Definition/Background

Thick growths of attached algae now coat the shoreline rocks of Lake Tahoe in the spring. This growth is a major impediment toward achieving an aesthetic beneficial use for the largely shore-bound populace. While the TRG database on this growth was quite extensive in the 1980's, only intermittent sampling has been done since. Given that these algae serve as biological indicators of (a) nutrient inputs and (b) long-term environmental changes, the absence of this data from the

monitoring program has been significant. There is a distinct need not only to provide ongoing monitoring of growth, but also to thoroughly analyze information that has been gathered to date. Such analysis would provide information on: (1) trends in biomass over time, (2) spatial changes in biomass, and (3) trends in the timing of biomass accumulation. With information available from studies of nutrient source inputs being concomitantly conducted as part of the Lake Tahoe TMDL Research Program e.g., (1) LTIMP stream loading; (2) storm water loading and monitoring; (3) regional groundwater loading estimates, it may be possible to identify the most likely nutrient sources which fuel periphyton growth. Of potential interest to regulatory agencies and the public is whether remedial actions might be taken to help reduce periphyton growth. If (an) appropriate numeric target(s) for this attached algae can be established, areas exceeding this target around the lake could then be identified. Currently there are no numeric water quality standards for attached algal growth. Based upon the likely nutrient sources fueling periphyton growth in such areas, recommendations for remedial action in areas exceeding target levels, could focus on specific source reduction. This work is a companion to studies being conducted on nearshore turbidity by Ken Taylor (DRI) under contract to the Lahontan RWQCB. Combined, it is intended that these projects will form the basis for reassessing existing water quality standards as they apply to the nearshore zone of Lake Tahoe.

Note: for the purpose of this work the terms periphyton and attached algae are used synonymously and defined as the predominantly algal community that grows attached to rock surfaces. This natural community also includes bacteria, and other organisms that inhabit this area [benthic invertebrates are very occasional and do not significantly contribute to biomass]. Since the Lake Tahoe periphyton community that is being sampled in this study (0.5 m) has an annual cycle with little to no interannual accumulation of biomass, each year's accumulation represents only growth during that year. Consequently, samples also include non-living periphyton (detritus), but again, only 'new' material.

6. Project/ Task Description and Schedule

Task 6.1. Sample Collection.
(Scheduled Start 5/1/02/ Finish 2/1/04)
Samples of periphyton will be collected at the following shoreline locations around the lake at a minimum of eight times per year: Pineland (Sunnyside), Sugar Pine Pt., Rubicon Pt., Zephyr Pt., Deadman Pt., Sand Harbor, Incline Village, Stateline Pt. (north), Tahoe City and Dollar Pt. Six of the samplings will be done between January and August, when periphyton growth in the eulittoral zone (0-0.5m) is the greatest; the remaining two samplings will be done between September and December. Previous studies have shown that the eulittoral zone serves as the best indicator of site to site differences in the levels of growth (Loeb and Reuter, 1984). 2-syringe samplers described by Loeb (1981) will be used to remove and collect periphyton from a known surface area of rock at 0.5m below the water surface. Boulders or large rocks selected for sampling will be generally representative of the level of growth at the 0.5m depth (note that samples are collected only from naturally occurring rock surfaces and not other substrata such as boat piers, boat hulls, break water structures, cement wall/boat ramps, etc.). Usually slightly

sloping surfaces are sampled, however vertical surfaces may be sampled when horizontal surfaces have accumulated sand, or there are not sufficient horizontal surfaces available. This monitoring will update information on current levels of periphyton growth around the lake

Task 6.2. Laboratory Analysis
(Scheduled Start 5/1/02/ Finish 2/1/04)
Periphyton will be returned to the lab in 2-syringe samplers, then processed. Water and periphyton are removed from the sampler, centrifuged to concentrate the periphyton, then the concentrated periphyton transferred to weighing paper and a wet weight determined. Subsamples of this periphyton are then transferred to a pre-tared piece of filter paper and weighed, then frozen for later chlorophyll a analysis; the remaining sample is transferred to a precombusted, pre-tared aluminum tin and the weight recorded. This sample is analyzed for dry weight and Ash Free Dry Weight or Loss on Ignition. Processing methods and analytical methods are described in Loeb and Reuter (1984). These laboratory analyses provide periphyton biomass data.

Task 6.3. Statistical Review of All Relevant Historic Periphyton Data
(Scheduled Start 5/1/02/ Finish 2/1/04)
A database of all relevant historic periphyton data and current data will be created. This data will be statistically analyzed (summary statistics and statistical analyses to discern trends) to determine: (1) trends in biomass over time, (2) spatial changes in biomass and (3) trends in the timing of biomass accumulation.

Task 6.4. Synoptic Surveys
(Scheduled Spring 2003 and Date for Second Synoptic to be Determined)
Conduct synoptic surveys of periphyton growth around the lakeshore to obtain a more complete assessment of spatial variation in periphyton growth. These will be done once per year during the period of biomass accumulation and maximum biomass standing crop (typically associated with spring snowmelt). Since the period of maximum growth may vary depending on region, we will attempt to do "regional" synoptic sampling around areas showing peak growth. For instance if the west shore were found to be peaking in mid-March but the north and east shores have yet to peak, we would do a synoptic focusing on intensive monitoring on the west shore in March. Then other "regional" synoptics focusing on east or north shore would be done later depending on observed peak levels of growth. The purpose of these synoptics is to get a better understanding of the distribution of periphyton growth on a finer scale than we have had in the past or as part of the current 10 station sampling design (i.e. determination of the levels of growth between our standard monitoring sites).

During each regional synoptic, samples from the routine monitoring sites in the region will be collected for biomass, the sites will also be assigned an overall level of growth score ranging from 1-5 (where 1 is least amount of growth, 5 highest growth) based on visual observation. These scores are subjective and provide an aesthetic gauge of levels of growth. Both field

personnel have done extensive periphyton monitoring (since the 1980's) and thus have a good understanding of the general range of growth that is found in the lake. Visual observations will be made both above water (characterizing level of algae growth visible from above the water) and below water (at 0.5m depth). Photographs will also be taken both above and below water for documentation.

We will then make above and below the water visual observations only of the levels of growth at stations *between* sites. We will locate in the area between each 2 adjacent routine sites one to several more sampling points that are taken at approximately equal intervals between sites. GPS locations of additional sites will be recorded, above and below water numeric scores assigned, and pictures taken. In addition, we will sample biomass at least one of the additional sites.

Products from this synoptic sampling will be: (1) maps of visual scoring of levels of growth between sites during peak growth periods (an aesthetic gauge of levels of growth); (2) maps of actual biomass levels at the routine monitoring stations along with 10 additional sites (provides physical measurements that have historically been done; which will be compared with visual scores); (3) photos above and below water at each site (provides documentation and may later be used to provide examples of periphyton levels to go along with each visual score - these might be useful for future studies characterizing the level of periphyton growth visually around the lake).

Task 6.5. Determination of Numeric Targets for Algal Growth
(Scheduled Start 6/1/02/ Finish 2/1/04)
Based on current and historic data for periphyton in Lake Tahoe, determine appropriate numeric target(s) for this attached algae which, if achieved, will protect the designated beneficial uses of the lake. Avenues to be explored in determining these numeric targets include, but are not limited to: (1) reconstruction of periphyton levels during period 1967-1971; (2) analysis of biomass levels in undisturbed regions of the lake; (3) literature review for quantitative definition of nuisance condition. The data base containing historic and current biomass values should be quite useful in determining levels of growth which might be considered low or very high. Data from the synoptics should be useful in determining whether numeric target values might be applied to the lake as a whole, or whether such target values might require adjustment in certain regions based on high natural availability or input of nutrients.

Task 6.6. Identify Regions Which Exceed Numeric Targets
(Scheduled Start 6/1/02/ Finish 2/1/04)
Based on the results obtained above, identify those regions of the lakeshore which currently exceed the recommended numeric target for beneficial use.

Task 6.7. Discuss Primary Sources Which Fuel Periphyton Growth
(Scheduled Start 6/1/02/ Finish 2/1/04)
Combine the results of surveys from Tasks 6.1-6.4 above, with results of nutrient sources studies being concomitantly conducted by the LRWQCB to discuss the most likely sources of nutrients which fuel periphyton growth. Timing and magnitude of nutrient load will be considered. The following sources should be available for this analysis: (1) LTIMP stream loading data; (2) storm water loading and modeling, and (3) regional groundwater loading estimates.
In addition, discussion of influence of upwelling and circulation patterns may be possible based on LTIMP lake nutrient data and based also on input from Geoff Schladow and Simon Hook who are looking at physical processes in the lake such as mixing and circulation patterns.

Task 6.8. Recommendations for Remedial Actions to Reduce Periphyton Growth
(Scheduled Start 6/1/02/ Finish 2/1/04)
Based on the results from Task 6.7 above, provide recommendations for possible remedial actions to reduce the level of periphyton growth in regions identified to exceed the recommended numeric target (Task 6.5).

Task 6.9. Potential Use of a Model to Relate Periphyton Growth to Nutrient Loading
(Scheduled Start 6/1/02/ Finish 2/1/04)
Conduct a literature review to determine applicability of existing models which would allow quantitatively linking nutrient loading and or concentration to Lake Tahoe periphyton growth. This review will include a list of parameters/data which must be available for use in the model. If no current model is acceptable, the contractor will provide suggestions for construction of such a tool.

7. Quality Objectives and Criteria for Measurement Data

7.1 Type of Data Needed to Support the Project -
The following data are needed to meet project goals: periphyton biomass data as: chlorophyll a, dry weight and Ash Free Dry Weight or Loss on Ignition. During synoptics visual scores of the relative level of periphyton growth will be needed.

7.2 Intended Use of Data -
The biomass data will be used to provide information on current and historical levels of periphyton growth. It will be used to discern temporal and spatial patterns in biomass. Based on current and historical values it will be used in establishing periphyton "target levels" of growth which, if achieved, will protect the designated beneficial uses of the lake. It may be used to test suitability of certain models linking periphyton growth with nutrient input or availability. The visual score data will be used to provide an aesthetic gauge of levels of growth around the lake during peak growth periods.

7.3 Conditions Under Which Data Should Be Collected -
Personnel sampling periphyton in the field should be trained in proper use of the 2-syringe samplers and skilled at taking samples with good replication (i.e. minimal loss of sample or pulling of extraneous material into the sampler). Sampling should be done on natural rock substrata at 0.5m which have levels of growth, generally representative of growth at the sampling location. If possible a single boulder may be used repeatedly for measurements, since the lake surface elevation typically fluctuates up or down and previous sampling marks remain visible for long periods. Samples should be taken on previously unsampled portions of the rock. If rocks have large accumulations of sand, samples should be collected from vertical portions of rocks or boulder where accumulated sand is less. Samples should be collected under relatively calm conditions to be able to accurately locate the 0.5m depth and facilitate accurate collection of samples. Visual scores for the relative level of periphyton growth should be made under relatively calm conditions to promote viewing of periphyton from above the water surface.

7.4 Acceptable Limits on Decision Errors -
There can be quite significant variability seasonally and year to year in the biomass parameters. There also can be significant variation within a site, and on a single rock. A challenge in sampling is to select sampling locations which are representative of the overall growth. Tolerable limits on precision therefore must reflect significant natural variability in samples. Analysis of recent data for chlorophyll a, dry weight, Loss On Ignition (LOI) was done with the intent to compare coefficient of variances for these analyses at different percentiles. The 90th percentile coefficient of variation (CV) values for these analyses appears to be a good demarcation point for triplicates to identify samples which may need censoring. The initial 90th percentile CV expressed as % for triplicate samples are as follows: chlorophyll a (50%); dry weight (50%); LOI (60%); AFDW (to be determined). When the CV is greater than the values above, data will be considered for possible outliers. Field and lab notes for the samples will also be analyzed to see if there is supportive information to justify censoring individual data points. For duplicate samples we determine relative percent difference (RPD) values for the various analyses, for recent samples. Note that the variation between samples does not reflect the researchers ability to obtain 'replicate ' samples, i.e. it is not an indicator of sampling error. Rather the distribution of periphyton biomass *in situ* is somewhat heterogeneous. Biomass differences reflect this natural variability. As discussed below, when the researcher determines a higher degree of heterogeneity (based on experience and best professional judgment) triplicate samples are taken.

As indicated above the variation seasonally in various parameters can be quite large. For instance chlorophyll a varied by a factor of 6 fold in 2002 at the Pineland site from a low of 18.94 mg/m^{-2} in July to 123.76 mg/m^{-2} in April. Of particular interest to decision makers are representative values indicating acceptable levels of growth and unacceptable (very high) levels of growth. Given the magnitude of variation seen during a year at a site, and variability in subsampling, at the present time, we consider a reasonable tolerable limit on decision errors to be in the range of +/- 33 %.

8. Special Training Requirements/Certifications

SCUBA may be occasionally needed to collect periphyton samples that are deeper than 0.5 m (for instance when studying the amount of growth along a transect extending into deeper water). Brant Allen is currently certified for research diving with UC Davis, Certification #0923, issued 1985.

A university certification in boat handling is likely to be required in 2003. Documentation of the completion of a U.S. Coast Guard training course will most likely suffice.

9. Documentation and Records

All field measurements and observations will be recorded at the time of completion using a standard field form and/or field notebook. Chlorophyll a and biomass data will be entered on standard periphyton laboratory data sheets. All data will be entered into a database developed specifically for the periphyton program.

10. Experimental Design

In order to monitor growth of periphyton, natural periphyton growing on rocky substrate (epilithic periphyton) is monitored. Ten sampling stations have been selected which provide continuity with historical periphyton monitoring sites. Periphyton biomass data is available for nine of the sites back in the 1980's, the Tahoe City site was added in year 2000 to provide monitoring off this urbanized area. The sites are widely dispersed to provide samples from many broad regional areas of the lake (along the east, west and north shores). The southern-most shore is mostly sand with sparse rocky substrate in the shallow areas and therefore epilithic periphyton has not been monitored long-term

Replicate (duplicate or triplicate samples) of epilithic periphyton are sampled from 0.5m depth using a 2-syringe sampling device. The periphyton collected is then analyzed in the lab for Chlorophyll a, Dry Weight, and Ash Free Dry Weight as indicators of biomass. These measurements are critical for the study.

During the regional synoptic sampling, the relative level of periphyton growth based on visual observation above and below water will be assigned a subjective score from 1 (lowest)-5 (highest). Although this is a subjective measurement it begins to address the subjective side of the aesthetic beneficial uses impacted by periphyton in the shorezone. These scores provide an aesthetic gauge of levels of growth. Both field personnel have done extensive periphyton monitoring (since the 1980's) and thus have a good understanding of and familiarity with the general range of growth that is found in the lake. The scores will be compared with actual

physical biomass measurements at 10-20 sites. We will also document levels of growth above and below water photographically.

11. Scheduled Project Activities

Six sampling rounds of ten sites will be done between January and August, and two sampling rounds will be done during September to December. The synoptic sampling will be done during the period of peak periphyton growth in the spring.

12. Sampling Method Requirements

Details of sampling methods used may be found in Loeb and Reuter (1984). Briefly, two-syringe samplers described by Loeb (1981) will be used to remove and collect periphyton from a known surface area of rock at 0.5m below the water surface. The syringe containing the brush is affixed over a portion of rock containing periphyton and the brush turned several times to remove periphyton from the rock surface. Loosened periphyton in the brushing syringe is then collected by withdrawing the plunger of the second attached syringe. The brush end of the sampler is then corked, the sampler brought to the surface and placed into an ice chest and returned to the lab for processing the same day.

Epilithic periphyton typically shows quite a bit of natural variation in distribution and amount of growth over rock surfaces. Therefore boulders or rocks selected for sampling should be generally representative of the level of growth at the 0.5m depth. Areas sampled on the rock also should also be visually determined to be representative of growth at the 0.5m depth on the rock. Usually slightly sloping surfaces are sampled, however vertical surfaces may be sampled when horizontal surfaces have accumulated sand, or there is not sufficient horizontal surface area available. Once analyzed, sample values may be censored (see Section 7.4 above) and/or if there is information in the field or lab notes to suggest a particular sample appears anomalous or may have been compromised (i.e. sampler leaked or spilled, etc.). Otherwise, values from a particular site and date will be averaged to obtain a mean value.

13. Sample Handling and Custody Requirements

Samples are collected in numbered two-syringe samplers. The sampler numbers and corresponding samples are recorded on the field data sheets or in the field notebook. Brant Allen and Scott Hackley perform the field sampling and are custodians of periphyton samples in the field and the lab. They also perform the lab processing and analysis of periphyton samples. Samples are initially split into subsamples for chlorophyll a and dry weight. The subsamples for chlorophyll a are stored frozen in a freezer at the TRG in aluminum tins (labeled with site, replicate number and sampling date) until analysis. The subsamples for dry weight are placed in a drying oven in labeled tins the same day of collection.

14. Analytical Methods/ Requirements

Methods for processing of periphyton samples are given in Loeb and Reuter, (1984). Briefly, the samplers containing periphyton are returned to the lab where the sample is centrifuged to concentrate the periphyton + solids and water is decanted. The periphyton sample is then transferred to weighing paper, dried to damp consistency, weighed, and subsampled (weighing each) rapidly for chlorophyll a, Loss on Ignition (LOI) or Ash Free Dry Weight (AFDW).

Chlorophyll a is analyzed using a hot methanol extraction. Samples (which are stored frozen until analyzed) are mixed and ground with a glass rod in boiling methanol (under a fume hood) for about 3 minutes. The solution is allowed to cool then is centrifuged to remove turbidity. Absorbances of the supernatant are then measured using a spectrophotomer at 750, 666 and 653 nm. The chlorophyll a content is determined using the equation of Iwamura et al. (1970) (with additional factors to account for subsampling and units):

Chlorophyll a (mg/m^2) = (17.12* ABS 666 - 8.68* ABS 653) * (Volume Methanol (ml) * Total Sample Wet Weight (g))/(4 (cm)* Chlorophyll a subsample wet weight (g)*$5.3*10^{-4}$ (m^2))/1000

Loss on Ignition (LOI) is determined by placing a sub-sample in a tared, precombusted aluminum tin at 105 °C overnight, determining a 105C Dry Weight, then combusting the dried material at 500 °C for 1 hr, and determining the weight of the remaining material. The weight loss of material after 500 °C combustion from the 105 °C Dry Weight, then corrected for subsample amount, and sampling area is representative of volatile organic matter and reported in g/m^{-2} LOI (APHA, 1971).

Ash Free Dry Weight (AFDW) is determined by placing a sub-sample in a tared, precombusted aluminum tin at 60 °C overnight, determining a 60C Dry Weight, then combusting the dried material at 500 °C for 1 hr, and determining the weight of the remaining material. The weight loss of material after 500 °C combustion from the 60 °C Dry Weight, (corrected for subsample amount, and sampling area) is representative of volatile organic matter and reported in g/m^{-2}AFDW.

Both LOI and AFDW have been used to estimate volatile organic matter of periphyton in Tahoe studies over several years. AFDW is more typically used for biomass estimation in periphyton studies. The initial drying at 60 °C is less extreme than at 105 °C. LOI is typically used for analysis of volatile organic matter in sediments. At several Tahoe sites we have often encountered significant silt and sand in the periphyton samples. Such samples will often give different "Dry Weights" depending upon whether dried at 60 °C or 105 °C, due to water associated with the sediments which does not evaporate at 60 °C but is driven off at 105 °C. A comparison of the AFDW and LOI methods typically showed that the AFDW value was often slightly higher for sandy or silty samples than the LOI value, presumably due primarily to water associated with sediments which is counted as part of the volatile material (although it is also possible there is some volatile organic material that is driven off at 105 °C with the LOI method,

a greater proportion of the weight loss in the AFDW method with silty sediments is likely due to water associated with sediments). Comparisons of both methods have shown dry weights and AFDW and LOI values to be nearly similar for samples which are primarily periphyton with little or no sediment.

The primary waste product of concern in the analyses above is waste methanol generated by the chlorophyll a method. This waste methanol is disposed of by the U.C. Davis Dept. of Environmental Health and Safety.

15. Quality Control Requirements

The periphyton monitoring is designed to reflect the amount of attached algal growth present in specific lake locations. There is no standard growth pattern that the collected samples can be compared to. Therefore it is assumed that the collected biomass is representative of the area in which it was collected. Assurances that collected samples are representative rely on replicate samples and the expertise of the sampling personnel to place sampling tubes over section of the substrate that reflect the area's growth pattern. During periods of high standing crop biomass, when within site variability can be high, researchers may collect triplicate samples. The additional sample increases the statistical power of the analysis and can account for the presence of higher variability. Collection of the triplicate sample is left up to the discretion of the researchers.

Laboratory quality control will be administered by the overall laboratory quality control person (currently Patty Bucknell).

16. Instrument/Equipment Calibration, Inspection and Maintenance Requirements

The quality control procedure for the measurement of periphyton biomass is regular calibration of the analytical balance. Service is preformed on a bi-annual basis (or as needed) to ensure the proper precision and accuracy of the balance.
Measurements of chlorophyll a are conducted using a Shimadzu UV160U Spectrophotometer. Performance of the spectrophotometer and analyses are checked through the ongoing UCD-TRG Quality Assurance Program.
Specifically designed 2-syringe sampling devices (Loeb 1981) are repaired as needed to ensure proper function.

17. Data Acquisition Requirements

Historical periphyton data collected by the Tahoe Research Group will be used to determine changes in ambient periphyton growth. Some of this data has gone through peer review and is contained in published papers. Other data remains unpublished but was collected using the same methods, often by the same researchers as the peer reviewed material.

Lake surface elevation data may be used during the study. Data collected by the U.S. Geological Survey will be gathered from a web based data information system and from archived files.

18. Data Management

Field and laboratory data is written on preformatted data sheets and in field notebooks at the time of sample collection and analysis. These data are stored at the TRG laboratory in Tahoe City. Data is transferred into electronic format (Excel spreadsheet, and Word documents) and backed up on disk at the TRG and in Davis. A review of data entry for accuracy and completeness is conducted prior to release in quarterly reports.

19. Assessment and Oversight

Overall project assessment takes place, at minimum, on a quarterly basis through the process of data analysis and reporting. Monthly meetings between project researchers discuss periphyton growth patterns and whether monitoring is sufficiently describing field observations. Any proposed changes to the monitoring schedule or sampling protocols are written and discussed with the project supervisor (Reuter).

20. References

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Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Deadman Pt.	2/2/1982	0.5	BLD	NA	NA
Deadman Pt.	2/28/1982	0.5	BLD	NA	NA
Deadman Pt.	4/21/1982	0.5	BLD	NA	NA
Deadman Pt.	5/17/1982	0.5	3.04	NA	1
Deadman Pt.	6/26/1982	0.5	4.60	NA	1
Deadman Pt.	7/30/1982	0.5	BLD	NA	NA
Deadman Pt.	8/30/1982	0.5	BLD	NA	NA
Deadman Pt.	10/3/1982	0.5	BLD	NA	NA
Deadman Pt.	11/3/1982	0.5	BLD	NA	NA
Deadman Pt.	3/4/1983	0.5	11.71	3.60	3
Deadman Pt.	5/10/1983	0.5	7.09	0.58	3
Deadman Pt.	6/27/1983	0.5	5.75	0.61	3
Deadman Pt.	7/12/1983	0.5	15.39	7.05	3
Deadman Pt.	8/23/1983	0.5	5.34	0.24	3
Deadman Pt.	9/14/1983	0.5	5.10	0.64	3
Deadman Pt.	10/13/1983	0.5	6.12	0.59	3
Deadman Pt.	1/23/1984	0.5	10.03	1.50	3
Deadman Pt.	2/13/1984	0.5	8.01	0.81	3
Deadman Pt.	2/26/1984	0.5	1.31	NA	1
Deadman Pt.	3/20/1984	0.5	5.87	0.25	3
Deadman Pt.	4/3/1984	0.5	NA	NA	NA
Deadman Pt.	4/14/1984	0.5	1.52	0.10	2
Deadman Pt.	5/1/1984	0.5	3.92	0.46	2
Deadman Pt.	5/16/1984	0.5	5.29	0.13	2
Deadman Pt.	5/28/1984	0.5	6.15	0.81	2
Deadman Pt.	6/15/1984	0.5	3.86	0.78	2
Deadman Pt.	7/3/1984	0.5	4.90	0.64	3
Deadman Pt.	7/28/1984	0.5	NA	NA	NA
Deadman Pt.	8/26/1984	0.5	6.09	0.48	2
Deadman Pt.	10/6/1984	0.5	9.96	1.87	3
Deadman Pt.	11/7/1984	0.5	5.07	0.44	3
Deadman Pt.	1/2/1985	0.5	8.84	2.54	3
Deadman Pt.	2/18/1985	0.5	8.54	1.59	3
Deadman Pt.	3/17/1985	0.5	12.42	1.35	3
Deadman Pt.	4/20/1985	0.5	10.38	1.36	3
Dollar Pt.	2/25/1982	0.5	11.61	0.51	3
Dollar Pt.	4/28/1982	0.5	65.15	4.64	3
Dollar Pt.	6/2/1982	0.5	21.32	1.25	3
Dollar Pt.	10/3/1982	0.5	BLD	NA	NA
Dollar Pt.	3/4/1983	0.5	47.09	2.59	3
Dollar Pt.	5/15/1983	0.5	65.09	6.83	3
Dollar Pt.	6/27/1983	0.5	38.36	4.01	3
Dollar Pt.	7/12/1983	0.5	NA	NA	NA
Dollar Pt.	8/23/1983	0.5	16.09	6.27	3
Dollar Pt.	9/14/1983	0.5	12.59	6.66	3
Dollar Pt.	10/13/1983	0.5	14.73	2.50	3
Dollar Pt.	1/23/1984	0.5	36.07	8.01	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Dollar Pt.	2/13/1984	0.5	21.74	3.58	3
Dollar Pt.	2/26/1984	0.5	77.83	12.02	3
Dollar Pt.	3/20/1984	0.5	59.73	10.94	3
Dollar Pt.	4/3/1984	0.5	52.30	7.76	3
Dollar Pt.	4/14/1984	0.5	78.72	5.27	3
Dollar Pt.	5/1/1984	0.5	66.66	3.64	3
Dollar Pt.	5/16/1984	0.5	73.92	9.37	3
Dollar Pt.	5/28/1984	0.5	41.69	1.69	3
Dollar Pt.	6/15/1984	0.5	15.74	3.33	2
Dollar Pt.	7/3/1984	0.5	12.61	1.72	3
Dollar Pt.	7/28/1984	0.5	22.20	3.76	3
Dollar Pt.	8/26/1984	0.5	47.48	5.22	3
Dollar Pt.	10/6/1984	0.5	24.07	5.03	3
Dollar Pt.	11/7/1984	0.5	56.62	17.21	2
Dollar Pt.	1/2/1985	0.5	12.92	4.09	3
Dollar Pt.	2/18/1985	0.5	26.30	1.94	3
Dollar Pt.	3/17/1985	0.5	39.74	14.30	2
Dollar Pt.	4/20/1985	0.5	40.92	5.67	3
Incline Condo.	2/2/1982	0.5	16.31	3.17	3
Incline Condo.	2/28/1982	0.5	33.16	2.93	3
Incline Condo.	4/21/1982	0.5	38.50	2.70	3
Incline Condo.	5/17/1982	0.5	24.85	5.40	3
Incline Condo.	6/26/1982	0.5	14.20	1.31	3
Incline Condo.	7/30/1982	0.5	4.98	1.42	3
Incline Condo.	8/29/1982	0.5	5.18	NA	1
Incline Condo.	10/3/1982	0.5	BLD	NA	NA
Incline Condo.	11/3/1982	0.5	4.91	NA	1
Incline Condo.	3/4/1983	0.5	98.93	9.84	3
Incline Condo.	5/10/1983	0.5	57.65	16.24	3
Incline Condo.	6/27/1983	0.5	33.93	3.08	3
Incline Condo.	7/12/1983	0.5	13.89	2.80	3
Incline Condo.	8/23/1983	0.5	9.22	1.83	3
Incline Condo.	9/14/1983	0.5	6.11	NA	1
Incline Condo.	10/13/1983	0.5	21.07	5.06	3
Incline Condo.	1/23/1984	0.5	13.10	2.05	3
Incline Condo.	2/13/1984	0.5	22.31	2.61	3
Incline Condo.	2/26/1984	0.5	19.12	2.17	3
Incline Condo.	3/20/1984	0.5	35.12	2.34	3
Incline Condo.	4/3/1984	0.5	34.23	2.02	3
Incline Condo.	4/14/1984	0.5	18.07	3.36	3
Incline Condo.	5/1/1984	0.5	26.19	2.32	3
Incline Condo.	5/16/1984	0.5	23.71	1.68	3
Incline Condo.	5/28/1984	0.5	13.31	NA	1
Incline Condo.	6/15/1984	0.5	15.31	2.98	3
Incline Condo.	7/3/1984	0.5	5.73	0.41	3
Incline Condo.	7/28/1984	0.5	10.37	1.11	3
Incline Condo.	8/26/1984	0.5	14.25	2.29	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Incline Condo.	10/6/1984	0.5	43.77	6.87	3
Incline Condo.	11/7/1984	0.5	28.94	2.34	3
Incline Condo.	1/2/1985	0.5	19.97	0.64	3
Incline Condo.	2/18/1985	0.5	21.67	2.10	3
Incline Condo.	3/17/1985	0.5	23.87	2.69	3
Incline Condo.	4/20/1985	0.5	33.34	9.27	2
Incline West	2/2/1982	0.5	2.15	0.36	3
Incline West	2/28/1982	0.5	3.06	0.76	3
Incline West	4/4/1982	0.5	4.46	0.25	3
Incline West	5/17/1982	0.5	10.42	2.32	3
Incline West	6/26/1982	0.5	13.31	0.57	3
Incline West	7/30/1982	0.5	BLD	NA	NA
Incline West	8/29/1982	0.5	BLD	NA	NA
Incline West	10/3/1982	0.5	BLD	NA	NA
Incline West	11/3/1982	0.5	BLD	NA	NA
Incline West	3/4/1983	0.5	20.40	2.40	3
Incline West	5/10/1983	0.5	15.45	4.20	3
Incline West	6/27/1983	0.5	5.71	0.67	3
Incline West	7/12/1983	0.5	NA	NA	NA
Incline West	8/23/1983	0.5	3.82	0.08	3
Incline West	9/14/1983	0.5	NA	NA	NA
Incline West	10/13/1983	0.5	NA	NA	NA
Incline West	1/23/1984	0.5	17.51	2.09	3
Incline West	2/13/1984	0.5	8.26	1.81	3
Incline West	2/26/1984	0.5	9.05	0.48	3
Incline West	3/20/1984	0.5	10.78	1.51	3
Incline West	4/3/1984	0.5	7.97	1.05	3
Incline West	4/14/1984	0.5	16.51	1.11	3
Incline West	5/1/1984	0.5	16.56	3.36	3
Incline West	5/16/1984	0.5	22.87	1.57	2
Incline West	5/28/1984	0.5	20.40	6.62	3
Incline West	6/15/1984	0.5	8.14	1.18	3
Incline West	7/3/1984	0.5	6.45	1.32	3
Incline West	7/28/1984	0.5	6.97	0.62	3
Incline West	8/26/1984	0.5	9.82	0.13	3
Incline West	10/6/1984	0.5	11.02	1.15	3
Incline West	11/7/1984	0.5	7.18	0.82	3
Incline West	1/2/1985	0.5	8.96	2.26	2
Incline West	2/18/1985	0.5	12.39	0.17	3
Incline West	3/17/1985	0.5	20.24	3.54	3
Incline West	4/20/1985	0.5	11.17	1.70	3
Pineland	2/2/1982	0.5	7.54	5.14	3
Pineland	2/28/1982	0.5	23.90	3.24	3
Pineland	4/21/1982	0.5	23.70	2.32	3
Pineland	5/24/1982	0.5	38.52	4.98	3
Pineland	6/26/1982	0.5	24.67	5.35	3
Pineland	7/30/1982	0.5	4.50	0.01	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Pineland	8/30/1982	0.5	BLD	NA	NA
Pineland	10/3/1982	0.5	BLD	NA	NA
Pineland	11/3/1982	0.5	18.10	NA	1
Pineland	2/11/1983	0.5	69.10	6.60	3
Pineland	3/4/1983	0.5	147.44	15.06	3
Pineland	5/15/1983	0.5	88.52	39.37	3
Pineland	6/25/1983	0.5	16.93	3.38	3
Pineland	7/16/1983	0.5	8.65	1.39	3
Pineland	8/18/1983	0.5	NA	NA	NA
Pineland	9/15/1983	0.5	6.24	0.85	3
Pineland	10/13/1983	0.5	5.49	1.18	3
Pineland	1/23/1984	0.5	82.19	14.16	3
Pineland	2/13/1984	0.5	NA	NA	NA
Pineland	2/26/1984	0.5	73.56	6.85	3
Pineland	4/3/1984	0.5	79.28	1.22	2
Pineland	4/14/1984	0.5	133.62	12.36	3
Pineland	5/1/1984	0.5	50.58	NA	1
Pineland	5/16/1984	0.5	13.89	1.09	3
Pineland	5/28/1984	0.5	21.30	2.37	3
Pineland	6/15/1984	0.5	18.23	2.22	3
Pineland	7/3/1984	0.5	19.91	5.62	3
Pineland	7/28/1984	0.5	13.60	0.15	3
Pineland	8/26/1984	0.5	19.45	3.99	3
Pineland	10/6/1984	0.5	4.50	0.74	2
Pineland	11/7/1984	0.5	41.18	3.64	2
Pineland	1/2/1985	0.5	32.58	7.51	3
Pineland	2/18/1985	0.5	50.36	15.96	3
Pineland	3/17/1985	0.5	153.20	35.01	3
Pineland	4/20/1985	0.5	185.92	59.32	3
Rubicon Pt.	2/1/1982	0.5	BLD	NA	NA
Rubicon Pt.	3/4/1982	0.5	BLD	NA	NA
Rubicon Pt.	4/18/1982	0.5	28.72	NA	1
Rubicon Pt.	5/18/1982	0.5	5.39	0.83	3
Rubicon Pt.	6/24/1982	0.5	5.16	1.29	3
Rubicon Pt.	7/28/1982	0.5	0.93	0.93	3
Rubicon Pt.	8/31/1982	0.5	3.14	0.69	3
Rubicon Pt.	10/1/1982	0.5	BLD	NA	NA
Rubicon Pt.	11/12/1982	0.5	BLD	NA	NA
Rubicon Pt.	3/6/1983	0.5	59.16	23.87	3
Rubicon Pt.	5/3/1983	0.5	34.60	4.74	3
Rubicon Pt.	6/27/1983	0.5	59.52	3.29	3
Rubicon Pt.	7/18/1983	0.5	37.43	9.48	4
Rubicon Pt.	8/24/1983	0.5	NA	NA	NA
Rubicon Pt.	9/17/1983	0.5	5.97	2.83	3
Rubicon Pt.	10/8/1983	0.5	5.97	0.83	3
Rubicon Pt.	1/23/1984	0.5	15.07	2.50	4
Rubicon Pt.	2/13/1984	0.5	19.74	2.64	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Rubicon Pt.	2/26/1984	0.5	19.32	2.05	4
Rubicon Pt.	4/3/1984	0.5	19.87	3.95	4
Rubicon Pt.	4/14/1984	0.5	39.59	10.30	3
Rubicon Pt.	5/1/1984	0.5	15.00	3.21	4
Rubicon Pt.	5/16/1984	0.5	19.96	0.64	3
Rubicon Pt.	5/28/1984	0.5	21.05	2.69	4
Rubicon Pt.	6/15/1984	0.5	36.29	9.66	3
Rubicon Pt.	7/3/1984	0.5	42.43	7.14	4
Rubicon Pt.	7/28/1984	0.5	6.22	1.27	4
Rubicon Pt.	8/26/1984	0.5	5.99	0.85	4
Rubicon Pt.	10/6/1984	0.5	7.49	1.50	2
Rubicon Pt.	11/7/1984	0.5	18.37	5.35	3
Rubicon Pt.	2/18/1985	0.5	23.69	1.23	3
Rubicon Pt.	3/17/1985	0.5	48.17	11.84	4
Rubicon Pt.	4/20/1985	0.5	216.28	41.30	4
Sand Pt.	2/25/1982	0.5	BLD	NA	NA
Sand Pt.	4/28/1982	0.5	BLD	NA	NA
Sand Pt.	6/2/1982	0.5	BLD	NA	NA
Sand Pt.	10/3/1982	0.5	BLD	NA	NA
Sand Pt.	3/4/1983	0.5	8.07	2.96	3
Sand Pt.	5/10/1983	0.5	9.58	2.15	3
Sand Pt.	6/27/1983	0.5	7.80	1.15	3
Sand Pt.	7/12/1983	0.5	1.23	0.23	3
Sand Pt.	8/23/1983	0.5	3.59	0.25	3
Sand Pt.	9/14/1983	0.5	12.81	0.93	3
Sand Pt.	10/13/1983	0.5	7.63	0.37	3
Sand Pt.	1/23/1984	0.5	5.96	1.39	3
Sand Pt.	2/13/1984	0.5	21.28	7.22	3
Sand Pt.	2/26/1984	0.5	13.90	1.82	3
Sand Pt.	3/20/1984	0.5	13.34	2.59	3
Sand Pt.	4/3/1984	0.5	BLD	NA	NA
Sand Pt.	4/14/1984	0.5	4.68	0.99	3
Sand Pt.	5/1/1984	0.5	5.64	0.58	3
Sand Pt.	5/16/1984	0.5	5.96	NA	1
Sand Pt.	5/28/1984	0.5	5.11	0.30	3
Sand Pt.	6/15/1984	0.5	11.76	1.49	3
Sand Pt.	7/3/1984	0.5	6.83	0.70	3
Sand Pt.	7/28/1984	0.5	4.37	NA	1
Sand Pt.	8/26/1984	0.5	14.25	2.62	3
Sand Pt.	10/6/1984	0.5	18.92	2.48	3
Sand Pt.	11/7/1984	0.5	29.13	0.19	3
Sand Pt.	1/2/1985	0.5	13.93	1.07	3
Sand Pt.	2/18/1985	0.5	21.46	1.37	3
Sand Pt.	3/17/1985	0.5	20.56	2.61	3
Sand Pt.	4/20/1985	0.5	12.19	0.26	3
Sugar Pine Pt.	2/25/1982	0.5	3.36	0.95	3
Sugar Pine Pt.	4/28/1982	0.5	23.09	2.50	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Sugar Pine Pt.	6/2/1982	0.5	1.66	0.38	3
Sugar Pine Pt.	10/2/1982	0.5	BLD	NA	NA
Sugar Pine Pt.	2/11/1983	0.5	19.46	2.53	3
Sugar Pine Pt.	5/15/1983	0.5	55.79	21.15	3
Sugar Pine Pt.	6/25/1983	0.5	52.12	4.14	3
Sugar Pine Pt.	7/16/1983	0.5	64.71	10.70	3
Sugar Pine Pt.	8/25/1983	0.5	20.59	1.94	3
Sugar Pine Pt.	9/15/1983	0.5	5.02	0.48	3
Sugar Pine Pt.	10/13/1983	0.5	24.55	3.40	3
Sugar Pine Pt.	1/23/1984	0.5	28.91	4.27	3
Sugar Pine Pt.	2/13/1984	0.5	36.91	6.39	2
Sugar Pine Pt.	2/26/1984	0.5	45.56	8.02	3
Sugar Pine Pt.	4/3/1984	0.5	57.90	13.36	3
Sugar Pine Pt.	4/14/1984	0.5	87.43	9.67	3
Sugar Pine Pt.	5/1/1984	0.5	70.11	7.76	3
Sugar Pine Pt.	5/16/1984	0.5	61.48	2.85	3
Sugar Pine Pt.	5/28/1984	0.5	55.66	7.31	3
Sugar Pine Pt.	6/15/1984	0.5	33.03	13.25	2
Sugar Pine Pt.	7/3/1984	0.5	24.46	6.34	3
Sugar Pine Pt.	7/28/1984	0.5	9.68	4.44	2
Sugar Pine Pt.	8/26/1984	0.5	8.33	0.78	3
Sugar Pine Pt.	10/6/1984	0.5	34.35	8.55	3
Sugar Pine Pt.	11/7/1984	0.5	34.58	8.42	3
Sugar Pine Pt.	1/2/1985	0.5	34.53	2.55	3
Sugar Pine Pt.	2/18/1985	0.5	130.14	26.58	3
Sugar Pine Pt.	3/17/1985	0.5	90.47	19.96	3
Sugar Pine Pt.	4/20/1985	0.5	98.15	16.27	3
Zephyr Pt.	2/25/1982	0.5	2.09	0.35	3
Zephyr Pt.	4/28/1982	0.5	26.18	1.97	3
Zephyr Pt.	6/2/1982	0.5	3.17	0.47	3
Zephyr Pt.	10/2/1982	0.5	BLD	NA	NA
Zephyr Pt.	2/11/1983	0.5	11.55	1.08	3
Zephyr Pt.	5/15/1983	0.5	38.23	4.37	3
Zephyr Pt.	6/25/1983	0.5	24.45	6.20	3
Zephyr Pt.	7/16/1983	0.5	11.23	2.25	3
Zephyr Pt.	8/25/1983	0.5	9.89	2.13	3
Zephyr Pt.	9/5/1983	0.5	13.23	1.38	3
Zephyr Pt.	10/13/1983	0.5	7.31	0.71	3
Zephyr Pt.	1/23/1984	0.5	16.77	3.10	2
Zephyr Pt.	2/13/1984	0.5	21.39	1.46	3
Zephyr Pt.	2/26/1984	0.5	17.26	3.50	3
Zephyr Pt.	4/3/1984	0.5	19.78	0.21	3
Zephyr Pt.	4/14/1984	0.5	19.62	2.13	2
Zephyr Pt.	5/1/1984	0.5	21.51	4.05	3
Zephyr Pt.	5/16/1984	0.5	24.90	2.64	3
Zephyr Pt.	5/28/1984	0.5	22.11	3.81	3
Zephyr Pt.	6/15/1984	0.5	25.44	2.00	3

Appendix A. Summary of 1982-1985 periphyton mean chlorophyll a (mg/m^2), standard error (S.E.) and sample size (n) data.

Station	Date	Depth (m)	Mean Chl a (mg/m^2)	S.E. (mg/m^2)	n
Zephyr Pt.	7/3/1984	0.5	11.20	1.38	3
Zephyr Pt.	7/28/1984	0.5	5.83	0.44	3
Zephyr Pt.	8/26/1984	0.5	11.36	1.25	2
Zephyr Pt.	10/6/1984	0.5	20.65	3.74	3
Zephyr Pt.	11/7/1984	0.5	17.03	2.83	3
Zephyr Pt.	1/2/1985	0.5	32.24	1.83	3
Zephyr Pt.	2/18/1985	0.5	27.66	2.28	3
Zephyr Pt.	3/17/1985	0.5	26.58	2.48	3
Zephyr Pt.	4/20/1985	0.5	18.10	2.63	2

*Note – A correction was applied to the historical 1983-85 chlorophyll a data to allow direct comparison with 2000-2003 data. To correct the 1983-85 periphyton chlorophyll a data, all 1983-1985 chlorophyll a values were multiplied by 1.081225 (see main report for further explanation).

Appendix B. Summary of periphyton mean chlorophyll a, LOI, AFDW, standard deviation (S.D.), standard error (S.E.), and number of samples analyzed for data collected 2000-2003. Visual rankings (1 best -5 worst) of level of periphyton observed from shore above water and beneath the water at 0.5m, and average algal filament lengths (cm) and percent algal coverage at 0.5m are also shown.

Station	Date	Mean Chl a (mg/m²)	Chl a S.D. (mg/m²)	Chl a S.E. (mg/m²)	n	Mean LOI (g/m²)	LOI S.D. (g/m²)	LOI S.E. (g/m²)	n	Mean AFDW (g/m²)	AFDW S.D. (g/m²)	AFDW S.E. (g/m²)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Deadman Pt.	3/13/2000	28.21	2.68	1.55	3												
Deadman Pt.	4/10/2000	22.42	5.00	2.88	3												
Deadman Pt.	5/2/2000	11.50	1.71	0.98	3												
Deadman Pt.	6/15/2000	15.48	4.16	2.40	3												
Deadman Pt.	8/17/2000	14.88	2.75	1.59	3												
Deadman Pt.	12/5/2000	32.94	7.54	4.36	3												
Deadman Pt.	2/1/2001	15.47	7.33	4.23	3												
Deadman Pt.	3/7/2001	33.09	12.17	7.03	3												
Deadman Pt.	4/12/2001	15.45	4.90	2.83	3												
Deadman Pt.	5/7/2001	10.08	2.64	1.52	3												
Deadman Pt.	6/7/2001	8.16	3.42	1.98	3												
Deadman Pt.	8/29/2001	10.78	2.74	1.58	3												
Deadman Pt.	12/12/2001	17.28	0.84	0.48	3												
Deadman Pt.	2/4/2002	26.33	2.45	1.42	3												
Deadman Pt.	2/26/2002	33.35	4.77	2.76	3	34.18	4.51	2.61	3								
Deadman Pt.	4/22/2002	35.80	10.70	6.18	3	39.68	6.73	3.89	3							0.25	40%
Deadman Pt.	5/24/2002	14.80	3.25	1.87	3	28.49	7.00	4.04	3								
Deadman Pt.	6/28/2002	12.74	0.30	0.17	3	24.70	6.00	3.46	3								
Deadman Pt.	9/24/2002	15.63	5.28	3.05	3	28.83	8.53	4.93	3								
Deadman Pt.	1/30/2003	23.42	8.66	6.13	2	NA	NA	NA	NA	49.97	14.52	10.27	2			0.2	60%
Deadman Pt.	2/28/2003	27.37	8.54	6.04	2	50.61	10.34	7.31	2	50.59	10.75	7.60	2				
Deadman Pt.	4/8/2003	17.32	2.51	1.45	3	35.01	3.55	2.05	3					2	3	0.33	70%
Deadman Pt.	5/12/2003	24.12	13.52	7.80	3	42.41	2.46	1.42	3	45.61	2.00	1.16	3	2	3	0.4	90%
Deadman Pt.	5/21/2003	25.29	0.98	0.57	3	50.48	5.85	3.38	3	49.94	5.95	3.44	3	2	3	0.8	80%
Deadman Pt.	7/10/2003	13.51	3.04	1.75	3	32.22	2.59	1.49	3	33.13	2.77	1.60	3	2	3	0.27	50%
Deadman Pt.	9/2/2003	12.13	6.04	4.27	2	27.76	8.03	5.68	2	28.28	8.77	6.20	2	2	2	0.13	40%
Deadman Pt.	11/18/2003	15.06	9.40	6.65	2	27.45	13.78	9.75	2	29.13	13.70	9.69	2	2	2	0.27	60%
Dollar Pt.	3/6/2000	22.72	7.25	4.19	3												
Dollar Pt.	4/5/2000	18.55	1.87	1.08	3												
Dollar Pt.	5/1/2000	31.33	9.94	5.74	3												
Dollar Pt.	6/6/2000	8.41	1.21	0.70	3												
Dollar Pt.	8/22/2000	18.03	6.07	3.51	3												
Dollar Pt.	12/4/2000	18.66	6.85	3.96	3												
Dollar Pt.	1/18/2001	21.86	15.13	8.74	3												
Dollar Pt.	3/8/2001	49.76	1.92	1.11	3												
Dollar Pt.	4/5/2001	28.01	1.69	0.97	3												
Dollar Pt.	5/4/2001	13.94	7.65	4.42	3												

Appendix B. Summary of periphyton mean chlorophyll a, LOI, AFDW, standard deviation (S.D.), standard error (S.E.), and number of samples analyzed for data collected 2000-2003. Visual rankings (1 best -5 worst) of level of periphyton observed from shore above water and beneath the water at 0.5m, and average algal filament lengths (cm) and percent algal coverage at 0.5m are also shown.

Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Dollar Pt.	5/31/2001	44.20	19.86	11.46	3												
Dollar Pt.	8/27/2001	49.12	18.93	10.93	3												
Dollar Pt.	12/21/2001	69.58	15.42	8.90	3												
Dollar Pt.	1/31/2002	85.46	34.89	20.14	3												
Dollar Pt.	2/28/2002	118.66	24.29	14.02	3	109.20	14.80	8.55	3								
Dollar Pt. (algae)	4/8/2002	57.98	17.21	9.94	3	36.08	1.02	0.72	2								
Dollar Pt. (sand)	4/8/2002	2.32	1.37	0.79	3	5.00	0.75	0.53	2								
Dollar Pt. (total)	4/8/2002	60.30	18.37	10.61	3	41.08	0.27	0.19	2							0.6	67%
Dollar Pt.	5/28/2002	12.57	3.66	2.12	3	12.90	2.98	1.72	3								
Dollar Pt.	7/8/2002	29.84	7.42	4.28	3	29.68	11.32	6.54	3								
Dollar Pt.	9/16/2002	45.38	7.53	4.35	3	15.90	2.05	1.18	3								
Dollar Pt.	1/16/2003	75.36	9.42	6.66	2	26.50	6.78	4.79	2								
Dollar Pt.	2/21/2003	69.89	23.57	16.67	2	35.92	14.89	10.53	2	35.49	14.72	10.41	2				
Dollar Pt.	3/18/2003	44.05	9.89	7.00	2	33.99	6.91	4.89	2					2	3	0.3	80%
Dollar Pt.	4/30/2003	NA	NA	NA	NA	21.19	7.40	4.27	3	21.44	7.93	4.58	3	3	3	0.77	50%
Dollar Pt.	6/6/2003	22.36	11.29	6.52	3	32.91	17.20	9.93	3	34.85	18.07	10.43	3	2	3	1.2	70%
Dollar Pt.	6/27/2003	2.76	0.93	0.54	3	3.05	1.26	0.73	3					1	2	0.27	40%
Dollar Pt.	9/12/2003	9.33	0.02	0.02	2	16.28	1.29	0.91	2					4	2	0.1	50%
Dollar Pt.	12/3/2003	8.63	2.18	1.54	2	7.73	1.96	1.39	2	8.44	2.07	1.47	2	2	2	0.1	70%
Incline Condo	3/1/2000	15.69	2.91	1.68	3												
Incline Condo	4/10/2000	23.97	6.96	4.02	3												
Incline Condo	5/2/2000	8.43	1.10	0.63	3												
Incline Condo	6/15/2000	12.41	3.05	1.76	3												
Incline Condo	8/17/2000	7.80	2.44	1.41	3												
Incline Condo	12/5/2000	9.46	2.98	1.72	3												
Incline Condo	2/1/2001	13.95	3.52	2.03	3												
Incline Condo	3/7/2001	17.14	0.83	0.48	3												
Incline Condo	4/12/2001	8.89	2.71	1.56	3												
Incline Condo	5/7/2001	13.02	3.96	2.29	3												
Incline Condo	6/7/2001	7.52	2.29	1.32	3												
Incline Condo	8/29/2001	7.07	2.33	1.35	3												
Incline Condo	12/12/2001	14.00	1.16	0.67	3												
Incline Condo	2/4/2002	12.38	6.86	3.96	3												
Incline Condo	2/26/2002	17.00	9.57	5.53	3	19.38	12.51	7.22	3								
Incline Condo	4/22/2002	13.66	7.38	4.26	3	23.18	13.51	7.80	3								
Incline Condo	5/24/2002	12.36	9.89	5.71	3	24.36	14.73	8.50	3								
Incline Condo	6/28/2002	10.69	7.47	4.31	3	22.77	9.18	6.49	2								

Appendix B. Summary of periphyton mean chlorophyll a, LOI, AFDW, standard deviation (S.D.), standard error (S.E.), and number of samples analyzed for data collected 2000-2003. Visual rankings (1 best -5 worst) of level of periphyton observed from shore above water and beneath the water at 0.5m, and average algal filament lengths (cm) and percent algal coverage at 0.5m are also shown.

Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Incline Condo	9/24/2002	15.32	2.61	1.51	3	33.00	7.03	4.06	3								
Incline Condo	1/30/2003	17.37	4.22	2.98	2	NA	NA	NA	NA	35.87	11.43	8.08	2				
Incline Condo	2/28/2003	12.48	0.75	0.53	2	25.13	1.98	1.40	2	25.72	2.82	2.00	2			0.27	70%
Incline Condo	4/8/2003	21.97	1.41	0.81	3	41.23	2.18	1.26	3					2	2	0.27	70%
Incline Condo	5/12/2003	18.77	4.12	2.38	3	38.84	9.87	5.70	3	41.37	11.07	6.39	3	2	3	0.7	50%
Incline Condo	5/21/2003	24.49	8.01	4.63	3	31.15	5.15	2.97	3	30.51	4.97	2.87	3	2.5	3	1.07	60%
Incline Condo	7/10/2003	28.94	3.41	2.41	2	48.53	2.52	1.78	2	50.22	2.18	1.54	2	3	3	0.3	80%
Incline Condo	9/2/2003	15.83	1.16	0.82	2	33.66	11.56	8.17	2	34.26	11.97	8.46	2	2	2	0.13	70%
Incline Condo	11/18/2003	3.64	1.19	0.84	2	NA	NA	NA	NA	NA	NA	NA	NA	2	2	0.2	60%
Incline West	3/1/2000	11.06	0.98	0.56	3												
Incline West	4/10/2000	14.09	7.04	4.98	2												
Incline West	5/2/2000	14.59	3.18	1.83	3												
Incline West	6/15/2000	8.85	1.80	1.04	3												
Incline West	8/17/2000	1.97	0.68	0.39	3												
Incline West	12/5/2000	8.56	0.80	0.46	3												
Incline West	2/1/2001	13.72	4.80	2.77	3												
Incline West	3/7/2001	20.49	0.33	0.19	3												
Incline West	4/12/2001	10.46	1.46	0.84	3												
Incline West	5/7/2001	13.13	0.42	0.24	3												
Incline West	6/7/2001	12.26	1.85	1.07	3												
Incline West	8/29/2001	8.83	0.34	0.20	3												
Incline West	12/12/2001	13.30	1.20	0.69	3												
Incline West	2/4/2002	17.96	6.18	3.57	3												
Incline West	2/26/2002	17.38	3.32	1.92	3	18.72	6.26	3.62	3								
Incline West	4/22/2002	19.57	3.99	2.31	3	28.36	5.64	3.26	3								
Incline West	5/24/2002	10.24	5.00	3.54	2	23.73	9.54	6.75	2								
Incline West	6/28/2002	17.96	3.57	2.06	3	26.02	8.11	4.68	3								
Incline West	9/24/2002	13.86	1.01	0.58	3	30.29	4.50	2.60	3								
Incline West	1/30/2003	27.06	6.75	4.77	2	NA	NA	NA	NA	45.34	12.54	8.87	2				
Incline West	2/28/2003	23.34			1	42.82	12.88	9.10	2	44.00	14.54	10.28	2			0.53	80%
Incline West	4/8/2003	15.74	0.43	0.25	3	35.65	8.75	5.05	3					2	3	0.4	60%
Incline West	5/12/2003	18.97	5.99	3.46	3	32.64	8.79	5.08	3	36.05	8.96	5.17	3	3	3	0.6	65%
Incline West	5/21/2003	26.32	6.33	3.65	3	42.54	4.82	2.78	3	42.17	4.69	2.71	3	3	3	0.73	80%
Incline West	7/10/2003	36.98	2.62	1.85	2	61.40	12.59	7.27	3	63.43	12.93	7.46	3	3	3	0.4	80%
Incline West	9/2/2003	14.42	1.92	1.36	2	33.91	3.84	2.72	2	34.51	3.89	2.75	2	3	2	0.17	60%
Incline West	11/18/2003	8.97	4.55	3.22	2	14.83	9.51	6.72	2	16.02	10.73	7.59	2	2	2	0.27	60%
Pineland	3/7/2000	27.57	6.03	3.48	3												

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Pineland	4/5/2000	78.37	28.30	16.34	3												
Pineland	5/1/2000	8.73	2.39	1.38	3												
Pineland	6/6/2000	8.16	2.65	1.53	3												
Pineland	8/22/2000	8.54	4.18	2.41	3												
Pineland	12/4/2000	13.01	4.90	2.83	3												
Pineland	1/18/2001	14.65	11.52	6.65	3												
Pineland	3/8/2001	36.83	8.28	4.78	3												
Pineland	4/5/2001	39.92	41.06	23.71	3												
Pineland	5/4/2001	18.79	4.02	2.32	3												
Pineland	5/31/2001	51.50	41.36	23.88	3												
Pineland	8/27/2001	10.78	3.86	2.23	3												
Pineland	12/21/2001	37.66	2.39	1.38	3												
Pineland	1/31/2002	48.11	17.20	9.93	3												
Pineland	2/27/2002	84.96	40.46	23.36	3	50.11	18.58	10.73	3								
Pineland	4/8/2002	123.76	40.84	23.58	3	62.24	9.48	5.47	3								
Pineland	5/28/2002	73.13	9.23	5.33	3	39.81	5.66	3.27	3							2	25%
Pineland	7/3/2002	18.94	8.97	5.18	3	18.68	6.58	3.80	3								
Pineland	9/16/2002	27.35	7.59	4.38	3	37.70	7.57	4.37	3								
Pineland	1/16/2003	83.59	6.55	4.63	2	60.61	5.16	3.65	2								
Pineland	2/21/2003	41.54	18.68	13.21	2	44.24	25.54	18.06	2	43.73	24.38	17.24	2				
Pineland	3/18/2003	103.55	12.86	7.42	3	68.89	2.79	1.61	3					3	4	1.9	80%
Pineland	4/30/2003	132.63	72.35	41.77	3	58.92	30.20	17.44	3	61.85	32.57	18.80	3	4	5	3.27	80%
Pineland	6/6/2003	41.52	6.33	3.66	3	41.49	5.22	3.01	3	43.63	5.66	3.27	3	2	3	0.9	50%
Pineland	6/27/2003	13.36	1.98	1.14	3	16.12	7.98	4.61	3					2	2	0.37	50%
Pineland	9/12/2003	22.37	7.24	5.12	2	27.91	3.72	2.63	2					2	2	0.2	40%
Pineland	12/3/2003	24.68	4.84	3.42	2	23.27	0.82	0.58	2	24.03	0.83	0.58	2	2	3	0.57	70%
Rubicon Pt.	3/7/2000	16.29	2.98	1.72	3												
Rubicon Pt.	4/5/2000	15.46	2.90	1.67	3												
Rubicon Pt.	5/1/2000	11.20	2.60	1.50	3												
Rubicon Pt.	6/6/2000	11.12	2.16	1.24	3												
Rubicon Pt.	8/22/2000	14.84	3.83	2.21	3												
Rubicon Pt.	12/4/2000	23.58	5.24	3.02	3												
Rubicon Pt.	1/18/2001	16.84	1.27	0.73	3												
Rubicon Pt.	3/8/2001	19.22	2.54	1.47	3												
Rubicon Pt.	4/5/2001	18.17	9.78	5.64	3												
Rubicon Pt.	5/4/2001	5.49	0.57	0.33	3												
Rubicon Pt.	5/31/2001	12.00	3.77	2.18	3												

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Rubicon Pt.	8/27/2001	6.76	1.91	1.10	3												
Rubicon Pt.	12/21/2001	24.55	2.95	1.70	3												
Rubicon Pt.	1/31/2002	27.10	4.07	2.35	3												
Rubicon Pt.	2/28/2002	19.27	2.51	1.45	3	16.85	4.93	2.85	3								
Rubicon Pt.	4/8/2002	32.19	11.28	6.51	3	23.58	8.31	4.80	3							0.3	50%
Rubicon Pt.	5/28/2002	6.31	0.65	0.46	2	12.77	2.57	1.48	3								
Rubicon Pt.	7/3/2002	7.09	1.73	1.00	3	10.85	3.54	2.04	3								
Rubicon Pt.	9/16/2002	12.78	0.32	0.19	3	18.37	1.00	0.58	3								
Rubicon Pt.	1/16/2003	28.08	4.56	3.23	2	25.49	4.80	3.39	2								
Rubicon Pt.	2/21/2003	36.05	7.19	5.08	2	30.93	5.68	4.02	2	30.28	6.60	4.67	2				
Rubicon Pt.	3/18/2003	21.98	1.42	0.82	3	26.66	2.37	1.37	3					3	4	0.73	90%
Rubicon Pt.	4/30/2003	36.63	9.56	5.52	3	34.35	7.96	4.59	3	34.61	8.04	4.64	3	4	4	1.47	90%
Rubicon Pt.	6/6/2003	49.15	11.44	6.60	3	61.04	5.94	3.43	3	63.97	6.16	3.55	3	4	4	1.4	90%
Rubicon Pt.	6/27/2003	16.17	6.77	3.91	3	22.27	3.45	1.99	3					2	2	0.63	70%
Rubicon Pt.	9/12/2003	8.82	2.66	1.54	3	15.56	2.71	1.91	2					2	3	0.23	50%
Rubicon Pt.	12/3/2003	11.76	2.54	1.80	2	15.20	3.65	2.58	2	15.41	3.95	2.79	2	2	3	0.73	70%
Sand Pt.	3/13/2000	8.32	2.41	1.39	3												
Sand Pt.	4/10/2000	5.88	1.79	1.03	3												
Sand Pt.	5/2/2000	5.31	1.34	0.77	3												
Sand Pt.	6/15/2000	4.90	1.77	1.02	3												
Sand Pt.	8/17/2000	12.07	1.67	0.97	3												
Sand Pt.	12/5/2000	18.72	4.06	2.34	3												
Sand Pt.	2/1/2001	12.98	1.24	0.72	3												
Sand Pt.	3/7/2001	10.52	0.95	0.55	3												
Sand Pt.	4/12/2001	11.02	0.48	0.28	3												
Sand Pt.	5/7/2001	11.72	1.42	0.82	3												
Sand Pt.	6/7/2001	13.80	3.66	2.11	3												
Sand Pt.	8/29/2001	9.77	1.63	0.94	3												
Sand Pt.	12/12/2001	10.90	1.88	1.09	3												
Sand Pt.	2/4/2002	10.13	2.44	1.41	3												
Sand Pt.	2/26/2002	12.37	3.48	2.01	3	20.00	7.79	4.50	3								
Sand Pt.	4/22/2002	15.91	3.82	2.20	3	30.93	7.12	4.11	3								
Sand Pt.	5/24/2002	8.77	3.09	1.78	3	18.99	4.19	2.42	3								
Sand Pt.	6/28/2002	16.99	2.24	1.29	3	28.85	5.06	2.92	3								
Sand Pt.	9/24/2002	14.45	3.01	1.74	3	28.86	5.47	3.16	3								
Sand Pt.	1/30/2003	26.30	0.58	0.41	2	NA	NA	NA	NA	30.56	10.44	7.38	2				
Sand Pt.	2/28/2003	21.30	1.43	1.01	2	42.16	4.49	3.18	2	42.16	4.49	3.18	2			0.3	50%

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Sand Pt.	4/8/2003	17.63	2.35	1.36	3	31.87	6.92	4.00	3					3	3	0.3	70%
Sand Pt.	5/12/2003	18.25	7.09	4.09	3	30.37	4.27	2.46	3	32.83	3.93	2.27	3	3	3	0.37	60%
Sand Pt.	5/21/2003	17.44	3.87	2.23	3	40.51	4.68	2.70	3	39.01	3.79	2.19	3	3	3	0.53	60%
Sand Pt.	7/10/2003	5.44	0.60	0.43	2	13.90	4.47	3.16	2	13.90	4.47	3.16	2	2	2	0.37	50%
Sand Pt.	9/2/2003	8.45	1.38	0.98	2	22.02	9.62	6.80	2	22.97	9.86	6.97	2	2	2	0.17	40%
Sand Pt.	11/18/2003	18.56			1	25.61	2.14	1.51	2	26.74	2.55	1.80	2	2	2	0.2	50%
Sugar Pine Pt.	3/7/2000	20.39	6.02	3.47	3												
Sugar Pine Pt.	4/5/2000	10.03	0.93	0.66	2												
Sugar Pine Pt.	5/1/2000	15.57	3.40	1.96	3												
Sugar Pine Pt.	6/6/2000	15.72	3.91	2.26	3												
Sugar Pine Pt.	8/22/2000	52.73	19.49	11.25	3												
Sugar Pine Pt.	12/4/2000	18.46	6.06	3.50	3												
Sugar Pine Pt.	1/18/2001	17.87	8.35	4.82	3												
Sugar Pine Pt.	3/8/2001	13.45	1.80	1.28	2												
Sugar Pine Pt.	4/5/2001	14.79	3.57	2.06	3												
Sugar Pine Pt.	5/4/2001	10.03	1.15	0.66	3												
Sugar Pine Pt.	5/31/2001	11.22	2.66	1.53	3												
Sugar Pine Pt.	8/27/2001	NA	NA	NA	NA												
Sugar Pine Pt.	12/21/2001	5.98	1.85	1.07	3												
Sugar Pine Pt.	1/31/2002	4.68	2.29	1.32	3												
Sugar Pine Pt.	2/28/2002	5.50	2.58	1.49	3	11.18			1								
Sugar Pine Pt.	4/8/2002	1.93			1	NA	NA	NA		NA							
Sugar Pine Pt.	5/28/2002	3.08	0.47	0.27	3	NA	NA	NA		NA						0.3	10%
Sugar Pine Pt.	7/3/2002	1.25	0.60	0.35	3	NA	NA	NA		NA							
Sugar Pine Pt.	9/16/2002	0.91	1.20	0.70	3	NA	NA	NA		NA							
Sugar Pine Pt.	1/16/2003	8.78	4.08	2.88	2	NA	NA	NA		NA							
Sugar Pine Pt.	2/21/2003	14.43	11.12	7.86	2	23.08			1	23.08			1				
Sugar Pine Pt.	3/18/2003	8.33	5.94	3.43	3	3.41			1					1	2	0.17	60%
Sugar Pine Pt.	4/30/2003	NA	NA	NA	NA	10.29	NA	NA	1	10.86			1	2	2	0.43	30%
Sugar Pine Pt.	6/6/2003	10.49	0.85	0.49	3	9.38	0.77	0.45	3	9.86	1.22	0.70	3	2	3	0.77	67%
Sugar Pine Pt.	6/27/2003	0.83	0.41	0.24	3									1	1	0	<5%
Sugar Pine Pt.	9/12/2003	4.56	1.12	0.65	3	5.68			1					1	1	<0.1	30%
Sugar Pine Pt.	12/3/2003	11.17	0.90	0.64	2	13.19	0.45	0.32	2	13.63	0.49	0.34	2		2	0.13	50%
Tahoe City	3/6/2000	99.88	24.69	14.26	3												
Tahoe City	4/4/2000	44.79	16.05	9.27	3												
Tahoe City	5/1/2000	48.51	5.28	3.05	3												
Tahoe City	6/6/2000	12.07	3.20	1.85	3												

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Tahoe City	8/22/2000	55.09	11.90	6.87	3												
Tahoe City	12/4/2000	79.61	11.91	6.88	3												
Tahoe City	1/18/2001	26.81	7.79	4.50	3												
Tahoe City	3/8/2001	103.21	35.12	20.27	3												
Tahoe City	4/5/2001	30.61	9.02	5.21	3												
Tahoe City	5/4/2001	23.13	10.84	6.26	3												
Tahoe City	5/31/2001	12.10	3.97	2.29	3												
Tahoe City	8/27/2001	29.34	18.56	10.72	3												
Tahoe City	12/21/2001	89.71	31.46	18.17	3												
Tahoe City	1/31/2002	121.98	61.97	35.78	3												
Tahoe City	2/28/2002	18.50			1	17.37			1								
Tahoe City	2/28/2002	148.56	7.51	5.31	2	141.53	92.55	65.44	2								
Tahoe City (algae)	4/8/2002	127.10			1	102.83			1								
Tahoe City (algae)	4/8/2002	66.76	16.02	11.35	2	30.78			1								
Tahoe City (sand)	4/8/2002	198.34			1												
Tahoe City (sand)	4/8/2002	42.05	7.85	5.55	2	38.05			1								
Tahoe City (Total)	4/8/2002	325.45			1												
Tahoe City (Total)	4/8/2002	108.81	23.87	16.88	2				1							0.25	10%
Tahoe City	5/28/2002	28.30	22.14	12.78	3	23.79	17.95	10.36	3								
Tahoe City	7/8/2002	4.37	2.26	1.30	3	6.55			1								
Tahoe City	9/16/2002	136.71	24.84	14.34	3	47.45	6.23	3.60	3								
Tahoe City	1/30/2003	54.75	10.00	7.07	2	NA	NA	NA	NA	50.33	0.02	0.02	2				
Tahoe City	2/21/2003	171.01	128.52	90.88	2	118.49	79.29	56.06	2	121.52	80.64	57.02	2				
Tahoe City	3/18/2003	254.68	166.06	95.88	3	146.48	112.95	65.21	3					3	4	1.73	70%
Tahoe City	4/30/2003	NA	NA	NA	NA	92.19	19.74	11.40	3	105.55	25.07	14.47	3	3	4	1.83	40%
Tahoe City	6/6/2003	13.12	9.22	5.32	3	16.68	11.27	6.51	3	18.18	12.57	7.26	3	2	2	1.27	50%
Tahoe City	6/27/2003	12.71	8.84	5.11	3	19.01	14.98	8.65	3					2	2	0.33	60%
Tahoe City	9/12/2003	16.95			1	46.28			1					3	3	<0.1	70%
Tahoe City	12/3/2003	24.46	0.52	0.37	2	31.96	1.38	0.98	2	34.50	0.46	0.32	2	2	2	0.1	80%
Zephyr Pt.	3/13/2000	20.95	2.34	1.35	3												
Zephyr Pt.	4/10/2000	16.17	4.66	2.69	3												
Zephyr Pt.	5/2/2000	14.14	2.99	1.73	3												
Zephyr Pt.	6/15/2000	13.01	6.87	3.97	3												
Zephyr Pt.	8/17/2000	5.31	1.61	0.93	3												
Zephyr Pt.	12/5/2000	13.40	3.62	2.09	3												
Zephyr Pt.	2/1/2001	11.52	0.86	0.50	3												
Zephyr Pt.	3/7/2001	11.20	0.93	0.54	3												

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Zephyr Pt.	4/12/2001	4.28	2.20	1.56	2												
Zephyr Pt.	5/7/2001	3.91	0.66	0.38	3												
Zephyr Pt.	6/7/2001	11.88	2.66	1.54	3												
Zephyr Pt.	8/29/2001	7.13	0.42	0.25	3												
Zephyr Pt.	12/12/2001	14.00	5.91	3.41	3												
Zephyr Pt.	2/4/2002	16.11	3.08	1.78	3												
Zephyr Pt.	2/26/2002	12.20	0.56	0.32	3	11.60	2.10	1.21	3								
Zephyr Pt.	4/22/2002	25.63	8.89	5.13	3	19.79	10.32	5.96	3								
Zephyr Pt.	5/24/2002	19.67	5.81	3.35	3	23.92	6.23	3.60	3							0.5	NA
Zephyr Pt.	6/28/2002	16.29	6.05	3.49	3	18.29	1.04	0.74	2								
Zephyr Pt.	9/24/2002	19.86	7.37	4.25	3	29.73	9.82	5.67	3								
Zephyr Pt.	1/30/2003	25.57	1.81	1.28	2	NA	NA	NA	NA	25.20	1.53	1.08	2				
Zephyr Pt.	2/28/2003	24.43	8.83	6.24	2	36.38	3.91	2.77	2	37.07	4.07	2.88	2			0.37	60%
Zephyr Pt.	4/8/2003	14.22	2.86	1.65	3	16.11	9.10	5.26	3					2	2	0.63	40%
Zephyr Pt.	5/12/2003	13.63	3.62	2.56	2	23.48	1.17	0.83	2	26.08	1.66	1.66	2	3	3	1.3	30%
Zephyr Pt.	5/21/2003	11.11	0.87	0.50	3	19.17	2.38	1.37	3	18.51	2.48	1.43	3	2	2.5	0.33	80%
Zephyr Pt.	7/10/2003	9.27	0.89	0.63	2	20.51	3.32	2.35	2	20.88	3.85	2.72	2	2	2	0.2	40%
Zephyr Pt.	9/2/2003	9.21	4.92	2.84	3	12.57	1.09	0.63	3	11.72	1.11	0.64	3	2	2	0.93	70%
Zephyr Pt.	11/18/2003	14.57	3.17	2.24	2	16.06	3.31	2.34	2	18.35	3.86	2.73	2	3	2	0.23	60%
Synoptic Sampling																	
Synoptic Site A	3/19/2003													2	3	0.63	40%
Synoptic Site B	3/19/2003	26.31	0.98	0.69	2	23.52	0.04	0.03	2					3	3	1.1	70%
Synoptic Site C	3/19/2003													3	4	1.17	90%
Rubicon Pt.	3/18/2003	21.98	1.42	0.82	3	26.66	2.37	1.37	3					3	4	0.73	90%
Synoptic Site D	3/19/2003													2	3	1.03	80%
Synoptic Site E	3/19/2003	43.15	10.36	7.33	2	49.02	7.54	5.33	2					3	3	0.47	90%
Synoptic Site F	3/19/2003													2	3	0.43	60%
Sugar Pine Pt.	3/18/2003	8.33	5.94	3.43	3	3.41			1					1	2	0.17	60%
Synoptic Site G	3/19/2003													2	2	0.23	60%
Synoptic Site H	3/19/2003	81.44	20.93	14.80	2	52.94	1.33	0.94	2					2	3	0.93	80%
Synoptic Site I	3/19/2003													3	4	1.83	30%
Synoptic Site J	3/19/2003													3	4	0.77	50%
Pineland	3/18/2003	103.55	12.86	7.42	3	68.89	2.79	1.61	3					3	4	1.9	80%
Synoptic Site K	3/19/2003													2	3	0.43	NA
Synoptic Site L	3/19/2003	85.12			1	73.68	NA	NA	1					3	4	1.77	NA
Tahoe City	3/18/2003	254.68	166.06	95.88	3	146.48	112.95	65.21	3					3	4	1.73	70%

Appendix B. Summary of periphyton mean chlorophyll a, LOI, AFDW, standard deviation (S.D.), standard error (S.E.), and number of samples analyzed for data collected 2000-2003. Visual rankings (1 best -5 worst) of level of periphyton observed from shore above water and beneath the water at 0.5m, and average algal filament lengths (cm) and percent algal coverage at 0.5m are also shown.

Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Synoptic Site M	3/25/2003	33.40	0.74	0.53	2	34.43	3.54	2.50	2					4	4	1.93	80%
Synoptic Site N	3/25/2003													3	3	0.4	60%
Dollar Pt.	3/18/2003	44.05	9.89	7.00	2	33.99	6.91	4.89	2					2	3	0.3	80%
Synoptic Site O	3/25/2003													3	3	1.13	80%
Synoptic Site P	3/25/2003	27.93	4.04	2.86	2	32.32	3.76	2.66	2					1	2	0.43	90%
Synoptic Site Q	3/25/2003													3	3	1.4	60%
Synoptic Site R	3/25/2003	7.99	0.26	0.18	2	9.43	0.13	0.09	2					1	2	NA	50%
Synoptic Site S	3/25/2003													1	1	0.23	30%
Synoptic Site T	3/25/2003	20.84	0.26	0.18	2	15.46	2.81	1.99	2					NA	2	0.2	30%
Synoptic Site E1	5/22/2003	23.77	6.09	4.31	2	21.27	8.94	6.32	2	21.15	9.46	6.69	2	2.5	4	1.7	60%
Synoptic Site E2	5/22/2003													3	3	1.36	60%
Synoptic Site E3	5/22/2003													2	3	0.97	50%
Zephyr Pt.	5/21/2003	11.11	0.87	0.50	3	19.17	2.38	1.37	3	18.51	2.48	1.43	3	2	2.5	0.33	80%
Synoptic Site E4	5/22/2003													2	2	0.07	20%
Synoptic Site E5	5/22/2003	7.80			1	6.90	NA	NA	1	6.90			1	2	2.5	0.83	80%
Synoptic Site E6	5/22/2003													3	3	0.6	60%
Synoptic Site E7	5/22/2003	14.02	7.25	5.12	2	28.06	13.41	9.49	2	27.29	13.32	9.42	2	3	3	0.53	50%
Synoptic Site E8	5/22/2003													2	2	1.1	30%
Deadman Pt.	5/21/2003	25.29	0.98	0.57	3	50.48	5.85	3.38	3	49.94	5.95	3.44	3	2	3	0.8	80%
Synoptic Site E9	5/22/2003													2	3	1.27	70%
Synoptic Site E10	5/22/2003	13.88	2.43	1.72	2	26.22	6.88	4.86	2	25.61	7.35	5.19	2	2.5	2.5	0.47	40%
Sand Pt.	5/21/2003	17.44	3.87	2.23	3	40.51	4.68	2.70	3	39.01	3.79	2.19	3	3	3	0.53	60%
Synoptic Site E11	5/22/2003	8.84	1.67	1.18	2	14.82	1.68	1.19	2	14.31	1.98	1.40	2	3	3	1	70%
Synoptic Site E12	5/28/2003													2	2	0.37	70%
Synoptic Site E13	5/28/2003	10.37	0.37	0.26	2	7.95	0.60	0.43	2	7.93	1.13	0.80	2	2	3	0.43	90%
Incline Condo	5/21/2003	24.49	8.01	4.63	3	31.15	5.15	2.97	3	30.51	4.97	2.87	3	2.5	3	1.07	60%
Incline West	5/21/2003	26.32	6.33	3.65	3	42.54	4.82	2.78	3	42.17	4.69	2.71	3	3	3	0.73	80%
Synoptic Site E14	5/28/2003													2	2	0.83	30%
Synoptic Site E15	5/28/2003	17.59	4.59	3.24	2	32.64	11.01	7.79	2	33.99	12.42	8.78	2	2	2	0.57	60%
Synoptic Site E16	5/28/2003													2	3	0.97	90%
Synoptic Site E17	5/28/2003	26.47	10.94	7.74	2	29.93	1.01	0.72	2	31.72	0.84	0.59	2	2	3	1.23	90%
Synoptic Site S1	6/10/2003	24.95	6.59	4.66	2	16.99	4.87	3.44	2	16.81	5.46	3.86	2	2	3	0.97	90%
Synoptic Site S2	6/10/2003	31.17	11.49	8.12	2	26.19	3.00	2.12	2	25.62	3.13	2.21	2	2	3	0.83	40%
Transect 2/27/02																	
Pineland 0.1m	2/27/2002	2.56	0.49	0.29	3	NA	NA	NA		NA							
Pineland 0.25m	2/27/2002	87.46	14.40	8.31	3	57.43	13.50	7.79	3								
Pineland 0.5m	2/27/2002	84.96	40.46	23.36	3	50.11	18.58	10.73	3								

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Station	Date	Mean Chl a (mg/m^2)	Chl a S.D. (mg/m^2)	Chl a S.E. (mg/m^2)	n	Mean LOI (g/m^2)	LOI S.D. (g/m^2)	LOI S.E. (g/m^2)	n	Mean AFDW (g/m^2)	AFDW S.D. (g/m^2)	AFDW S.E. (g/m^2)	n	From Shore Rank	U/W 0.5m Rank	Algal Fil. Lnth (cm)	Algal Coverage %
Pineland 0.75m	2/27/2002	71.28	32.38	18.69	3	40.42	5.61	3.24	3								
Pineland 1m	2/27/2002	74.08	11.68	6.75	3	41.22	11.39	6.58	3								
Pineland 1.5m	2/27/2002	62.82	13.44	7.76	3	47.64	8.12	4.69	3								
Misc.																	
Dollar Pt. 0.1m	9/16/2002	9.46	5.16	2.98	3	15.77			1								
Pineland 0.1m	9/16/2002	53.44	20.53	11.85	3	27.85	3.76	2.17	3								
TC near Trib 0.25m	2/28/2003	50.20	30.86	21.82	2	39.70	21.49	15.20	2	42.13	25.35	17.93	2				