Lake Tahoe Water Quality Investigations

Algal Bioassay • Phytoplankton • Atmospheric Nutrient Deposition • Periphyton

Annual Report

July 1, 2007 – June 30, 2008

Agreement No. 07-024-160-0

Submitted to:

State Water Resources Control Board
Lahontan Regional Water Quality Control Board

Submitted by:

Tahoe Environmental Research Center
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Project Overview

The following document is our annual report for work completed during the first year (July 1, 2007 to June 30, 2008) of Agreement No. 07-024-160-0: Lake Tahoe Water Quality Investigations by the U.C. Davis – Tahoe Environmental Research Center (TERC).

Under terms of this contract TERC is to provide the SWRCB with water quality research and monitoring at Lake Tahoe to assess the progressive deterioration of the lake. This research and data will support the Lake Tahoe Interagency Monitoring Program (LTIMP). The State Water Board will be provided with scientific data needed to develop planning, management and enforcement strategies which will prevent future degradation of the lake's famous clarity and protect the surrounding watershed and streams.

The objective of this project is to continue monitoring critical ongoing long-term water quality parameters in Lake Tahoe. The primary research and monitoring tasks addressed in this project include:

Algal growth bioassay tests to assess nutrient limitation (Task 3). The purpose of this task is to determine the nutrient or nutrients which limit phytoplankton growth. These findings have been very important in current efforts toward lake restoration. They have highlighted the need for an expanded erosion control strategy. Bioassays are to be done four times per year using Lake Tahoe water containing natural phytoplankton, collected at the TERC's Index station along the west shore. The bioassay method to be used is described in detail in Hackley et al. (2007).

Enumeration and identification of phytoplankton and zooplankton species (Task 4). The purpose of this task is to provide ongoing information on phytoplankton and zooplankton species present in the water column. This task is particularly critical since changes in the biodiversity of the phytoplankton are both indicators of pollution and affect food-chain structure. Implementation of this task allows TERC to determine if new and undesirable species are colonizing the lake. In addition, the size and composition of particles, including phytoplankton cells in the water, have a significant effect on light transmittance, and hence affect the famed clarity of Lake Tahoe. Characterization of phytoplankton dynamics in Lake Tahoe fills a critical knowledge gap, allowing for more informed management decisions. Zooplankton are significant in the food chain structure of the lake. The zooplankton community is composed of both herbivorous species (which feed on phytoplankton) and predatory species (which feed on other zooplankton.)

Samples of both phytoplankton and zooplankton will be collected monthly from the Index and Mid-lake stations. At the Index station monthly phytoplankton samples will include: a 0-105m composite and discreet samples from depths of 5, 20, 40, 60, 75, 90m. At the Mid-lake station monthly phytoplankton samples will include: a 0-100m composite sample and a 150-450m composite. Monthly samples of zooplankton will include: a 150m to surface tow at both the Index and Mid-lake stations. Phytoplankton analysis is to include species present, cell numbers and biovolume measurements. Zooplankton analysis will include species present and numbers.

Atmospheric deposition of nitrogen and phosphorus (Task 5). The purpose of this task is to provide ongoing information on nutrient loading to the lake via atmospheric deposition. The historical TERC data shows that atmospheric deposition of nitrogen, and to a lesser extent phosphorus, is an important source of nutrients to the lake. Atmospheric deposition also contributes fine particles directly to the lake surface. Atmospheric deposition data from TERC monitoring was utilized in the Tahoe TMDL to help determine estimates of wet deposition loads and to provide additional information on dry loading of nutrients to the lake. Data collected from collectors located on buoys on the lake has proved valuable in providing estimates of N and P loading directly to the lake. Continued collection of atmospheric deposition data is important for updating and applying the Tahoe lake clarity model. In addition more information is needed on particle deposition to the lake. In Task 5, Atmospheric deposition monitoring will be continued at TERC's Lower Ward Valley station and on buoys on the lake. Approximately 35 dry bucket samples and 30 wet samples are to be collected over the year at Ward Lake level, 30 dry-bulk samples and approximately 15 snow tube samples are to be collected at the mid-lake station, and approximately 30 dry-bulk samples are to be collected at an additional lake buoy station i.e. TB-4. Samples are to be analyzed for NO_3-N, NH_4-N, TKN, DP and TP. In addition, a pilot program for determining the feasibility of collecting atmospheric deposition particles in collectors on the lake will be initiated. A literature search investigating feasibility of using simple buckets as collectors will be done by TERC. If determined to be feasible by the State Water Board's Contract Manager, initial tests of the method will be done at the TERC lab.

Monitoring of attached algae or periphyton along the shoreline (Task 6). The purpose of this monitoring is to assess levels of nearshore attached algae (periphyton) growth around the lake. The rate of periphyton growth is an indicator of local nutrient loading and long-term environmental changes. Monitoring trends in periphyton growth is important in assessing local and lake-wide nutrient loading trends. The near shore periphyton can significantly impact the aesthetic, beneficial use of the shore zone in areas where thick growth develops. Seven sites are to be monitored for periphyton biomass a minimum of five times per year in this project. Three of the samplings are to be done between January and June when attached algae growth in the eulittoral zone (0.5m) is greatest; the remaining two samplings are to be done between July – December. Duplicate biomass samples will be taken from natural substrate at each site for a total of 70 samples per year. Biomass is to be reported as chlorophyll *a* and Ash Free Dry Weight (AFDW). Twice a year, 39 additional sites will be visited and an above water visual assessment of the level of growth visible near shore (ranking 1-5) will be done.

The additional tasks associated with this project include: Project management (Task 1), quality assurance (Task 2), and reporting of data. The summary of % work completed based on a three-year granting period is shown in Table 1.

Table 1. The summary of % work completed (based on a 3 year granting period) during the 5th quarterly reporting period (July 1 – Sept. 30, 2008) for each task is listed below, % of total project completion is also shown to the right:

Task	**% Completion in Quarter** (for full 3 yr granting period)
1 – Project Management	33%
2 – Quality Assurance	33%
3 – Algal Growth Bioassays	33%
4 – Phytoplankton and Zooplankton Analysis	33%
5 – Atmospheric Deposition of Nutrients	33%
6 – Periphyton	33%
7 - Reporting	33%

Task 1. Project Management and Administration

1.1. Project oversight – Entailed sampling coordination, overall project coordination, discussions with staff, assist in data evaluation, interfacing with agency staff, and incorporation of data into other Basin research/monitoring projects.
1.2. Quarterly invoicing – Entails ensuring that contract requirements were met through completion of this quarterly status report and the report was submitted to the SWRCB Project Representative on schedule. Ensure that invoicing is properly carried out.

Task 2. Project Quality Assurance

Standardized QA/QC practices for components were followed as specified in the TRG QA/QC Manual (Janik et al., 1990). For QA/QC applied to periphyton monitoring see "Periphyton Quality Assurance Project Plan" in Hackley et al. (2004). QA/QC procedures for algal bioassays are described in Appendix 7 of Hackley et al. (2007).

For the atmospheric deposition monitoring, a total of 18 quality control samples were collected. A primary objective for these quality control samples was to check for levels of background nutrients in the various sample collectors and identify potential problematic levels of contamination, then to take corrective measures if needed. Table 2 presents the results of the analyses for the atmospheric deposition quality control samples. Levels of all nutrient species were very low in the deionized water "DIW Blk" (source blanks). Values for nutrient levels in field blank and carboys deionized water samples were compared with the source blank samples to check for levels of contamination. Levels of contamination present in the atmospheric sampling equipment were very low overall. NH4-N was slightly elevated 1-3 µg/l above background in some of the field blanks. TKN and TP also showed slight elevation in some samples. There did not appear to be any consistent contamination problems in the equipment or deionized water sources.

Table 2. Quality Control samples collected for the atmospheric deposition monitoring July 1, 2007 to June 30, 2008.

QC Sample	Date	Type	Vol. liters	NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
DIW Blanks										
DIW Blk	7/25/2007 19:35	Source Blk	-	4.28	<MDL	10.12	NA	NA	3.19	1
DIW Blk	9/21/2007 11:00	Source Blk	-	2.22	<MDL	8.11	4.75	6.70	3.83	1
DIW Blk	9/27/2007 11:40	Source Blk	-	1.13	NA	11.90	1.38	4.32	7.41	1
DIW Blk	12/28/07 12:50	Source Blk		0.67	3.72	1.36	NA	3.39	3.36	
DIW Blk	3/5/08 12:35	Source Blk		0.70	4.09	21.54	2.37	3.40	3.09	
DIW Carboy										
Carboy Blk	7/25/2007 20:15	Source Blk	-	2.74	<MDL	11.88	NA	NA	27.43	2
Carboy Blk	3/5/08 14:25	Source Blk		1.39	5.55	29.15	1.80	4.17	3.40	
Equipment										
Grad. Cyl.	7/26/2007 10:18	Equip. Blk	-	1.88	<MDL	45.33/21.57	NA	NA	3.19	3
Collectors										
Ward Wet										
FBWLLW	9/28/2007 10:10	Field Blk	0.5	1.61	7.48	0.96	1.62	5.86	4.62	6
FBWLLW	3/6/08 17:20	Field Blk	0.5	3.40	NA	47.67	2.71	5.82	3.09	
Ward Dry										
FBWLLD	9/21/2007 10:15	Field Blk	4.000	4.28	1.26	42.83	3.62	6.06	4.78	4
FBWLLD	12/27/07 12:05	Field Blk	3.990	1.18	4.96	23.45	0.46	4.93	3.66	
FBWLLD	3/26/08 14:15	Field Blk	3.977	1.06	4.45	35.95	0.68	4.59	5.51	
TB-1 Dry										
FBTB1D	12/27/07 11:40	Field Blk	3.997	NA	NA	NA	NA	NA	NA	
FBTB1D	3/26/08 14:35	Field Blk	4.000	0.89	5.77	49.94	0.09	4.59	4.90	
TB-1 ST										
FBTB1ST	9/21/2007 10:40	Field Blk	0.5	2.74	6.30	11.04	4.08	5.10	5.42	5
FBTB1ST	12/28/07 11:50	Field Blk	0.500	1.18	6.74	NA	0.58	4.97	12.43	
FBTB1ST	3/26/08 15:05	Field Blk	0.500	0.89	4.67	23.56	0.45	3.06	3.67	

Notes

1- Deionized water system source blank.
2- Deionized water system water from storage carboy in lab.
3- Equipment check, deionized water ran through graduated cylinder on boat.
4- Ward Lake Level Dry Field Blank, 4 liters deionized water to sealed Dry bucket for at least 24 hours.
5- TB-1 Snow Tube (ST) Field Blank, 0.5 liters deionized water to sealed ST for at least 24 hours.
6- Ward Lake Level Wet Field Blank, 0.5 liters deionized water to Wet bucket in Aerochem Metrics sampler, overnight during dry period.

Task 3. Algal Growth Bioassays

The response of Lake Tahoe water to nitrogen and phosphorus enrichment has been tested using algal bioassays since the 1960s. 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.

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 (at two different levels: 2 µg P/L and 10 µg P/L) or the combination of both N and P 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 of six 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 2007-2008

In this annual data summary we present the results for four routine bioassay experiments – two were conducted in 2007 (September, November) and two were conducted in 2008 (January, April). The results of each of the bioassays are presented in Table 3(a-d). The results for all bioassays done during the period 2002-2008 are summarized in Table 4.

Some seasonal differences in bioassay response were seen. In the bioassays done in September, and November 2007, phytoplankton growth was stimulated by nitrogen (N) and the combination of nitrogen (N) plus phosphorus (P) "N+P" caused the greatest amount of growth. The phosphorus alone treatments were not significantly stimulatory in either bioassay during September and November. In the bioassay done at the end of January 2008, phytoplankton growth was primarily stimulated by phosphorus and the combination of N+P in treatments did not cause greater growth than P alone. The bioassay results for April 2008 were different than past bioassays done at this time of year - all treatments including the control (where no nutrient addition is made) showed an uniform increase in biomass (there were no statistically different treatment responses). In recent past bioassays (2002-2008) at that time of the year, P was usually found to be limiting to algal growth (Table 4).

The phytoplankton in the April bioassay showed a uniform growth response (as measured by *in vivo* fluorescence) to all treatments including the controls (i.e. all treatments including the controls increased in biomass uniformly). This seems to indicate the algae used in the bioassay had sufficient N and P for growth and that conditions in the bioassay were favorable to promote growth. The lake water used in this bioassay was collected after an apparent wind-driven upwelling event along the west shore. Very strong south to southwest winds occurred the previous day (April 23) with significant south to southwest winds also occurring April 19-22. With the movement of surface water, pushed north and east away from the west shore, this can result in upwelling of deep water along portions of the west shore. It is likely this occurred at the Index Station (where the bioassay samples were collected). The secchi depth at the Index Station was very deep (37.5m) on April 24 and phytoplankton abundance and biovolume were very low in the lake water (see figures 1, 2 in the phytoplankton enumeration section of this report) which is consistent with upwelling of deep water. Upwelling of deep water can bring up water enriched in nutrients and viable phytoplankton. The algae used in the bioassay may have been viable algae which possibly had sufficient N and P for growth, but were previously light-limited while in deeper water. With sufficient light provided to the algae during the bioassay, light limitation may have been removed resulting in the uniform growth response of the algae.

The significant growth response to the combination of N+P in 38 of 39 bioassays done 2002-2008, continues to support the fact that Tahoe phytoplankton are still N and P co-deficient and that nutrient reduction is important for the management of excessive algal growth. The results for the April 2008 bioassay described above were somewhat unique. They were likely a consequence of collection of algae after a Spring 2008 upwelling event along the west shore.

Table 3.a. Bioassay done using 2,5,8,11,14,17,20m lake water collected 9/27/07.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.158	0.007	3		
N(20)	0.226	0.019	3	143	*
P(2)	0.144	0.006	3	91	
P(10)	0.141	0.005	3	89	
N(20)P(2)	0.320	0.023	3	202	*
N(20)P(10)	0.449	0.028	3	284	*

Table 3.b. Bioassay done using 2,5,8,11,14,17,20m lake water collected 11/9/07.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.260	0.020	3		
N(20)	0.297	0.020	3	114	*
P(2)	0.271	0.005	3	104	
P(10)	0.282	0.024	3	108	
N(20)P(2)	0.392	0.016	3	150	*
N(20)P(10)	0.469	0.028	3	180	*

Table 3.c. Bioassay done using 2,5,8,11,14,17,20m lake water collected 1/30/08.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. (p≤.05) Response =“*”
Control	0.278	0.015	3		
N(20)	0.284	0.006	3	102	
P(2)	0.342	0.016	3	123	*
P(10)	0.354	0.026	3	127	*
N(20)P(2)	0.346	0.023	3	124	*
N(20)P(10)	0.352	0.016	3	127	*

Table 3.d. Bioassay done using 2,5,8,11,14,17,20m lake water collected 4/24/08.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. (p≤.05) Response =“*”
Control	0.312	0.027	3		
N(20)	0.309	0.010	3	99	
P(2)	0.323	0.012	3	104	
P(10)	0.316	0.016	3	102	
N(20)P(2)	0.309	0.008	3	99	
N(20)P(10)	0.318	0.023	3	102	

Table 4. Summary of N and P bioassay treatment responses as % of control done in: (a) 2002, (b) 2003, (c) 2004, (d) 2005, (e) 2006, (f) 2007, (g) 2008. 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	4/23/04	8/20/04	10/28/04	12/11/04
Control	100	100	100	100	100
N20	100	97	112	104	99
P2	133	112	101	103	134
P10	135	122	112	114	150
N20P2	132	153	210	127	161
N20P10	134	202	248	185	173

(d) 2005 Bioassays

	2/16/05	4/15/05	6/10/05	8/15/05	10/20/05	12/15/05
Control	100	100	100	100	100	100
N20	99	97	109	105	109	113
P2	121	193	99	109	110	102
P10	122	233	105	105	121	108
N20P2	123	214	176	177	143	162
N20P10	127	241	239	258	193	190

(e) 2006 Bioassays

	2/21/06	4/12/06	6/19/06	8/9/06	10/31/06
Control	100	100	100	100	100
N20	98	98	84	117	98
P2	181	155	85	113	100
P10	214	162	91	141	113
N20P2	195	155	153	120	135
N20P10	200	161	253	173	273

(f) 2007 Bioassays

	1/9/07	3/2/07	4/13/07	6/12/07	9/27/07	11/9/07
Control	100	100	100	100	100	100
N20	99	100	97	100	143	114
P2	142	112	131	113	91	104
P10	143	112	136	93	89	108
N20P2	143	120	138	145	202	150
N20P10	146	118	136	176	284	180

(g) 2008 Bioassays

	1/30/08	4/24/08
Control	100	100
N20	102	99
P2	123	104
P10	127	102
N20P2	124	99
N20P10	127	102

Task 4.a. Phytoplankton Enumeration and Analysis

Lake Tahoe phytoplankton, the microscopic autotrophic plants of the limnetic zone, continues to have dynamic community change. This reporting period, from July 2007-June 2008 has several noteworthy events which signal short-term responses to environmental conditions and may have future implications for the phytoplankton community.

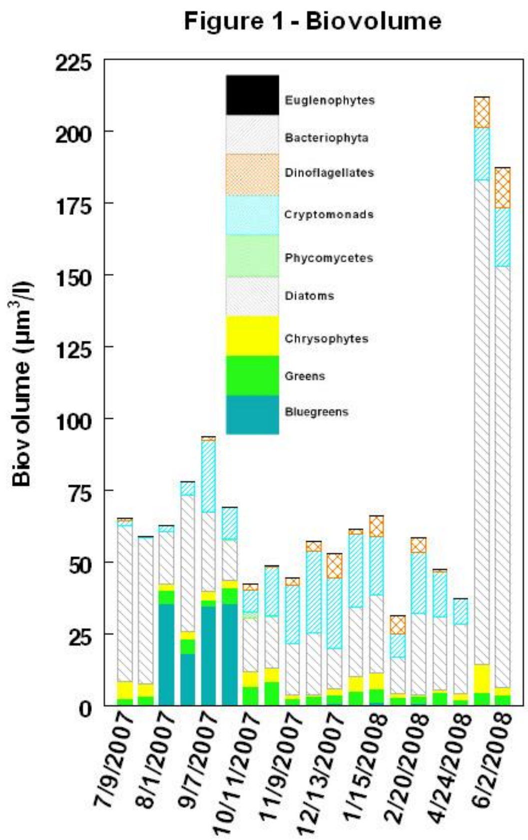
Seasonal changes continue to dominate the annual algal succession. Within the phytoplankton community, physical and chemical parameters control resource availability. Seasons and the transitions between seasons have very characteristic changes in the water column. Upwelling events as well as the lack of mixing, temperature, and light availability will impact phytoplankton at all depths. Seasonal changes in Tahoe phytoplankton communities are predictable at the dominant group level. Spring diatoms, summer greens, winter cryptophytes are seen from year to year. However, the predictability of the subdominant assemblages fluctuates inter-annually.

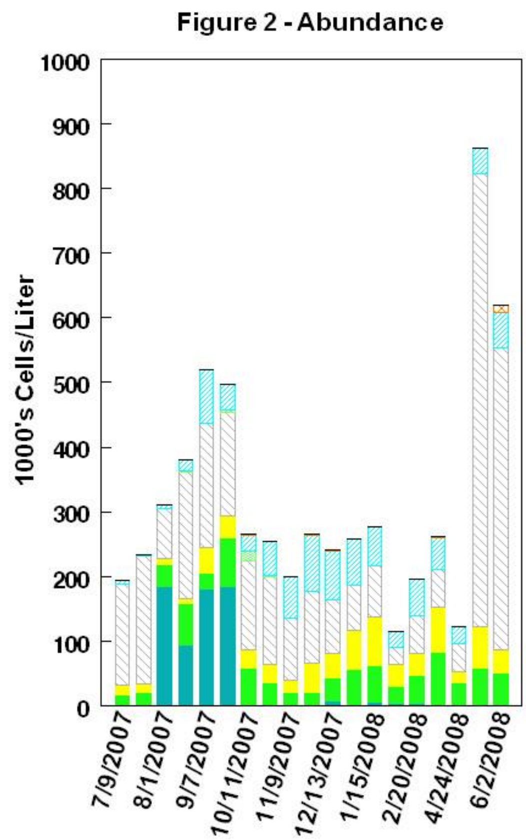
I have made some corrections to the summer 2007 quarterly report. In samples from this time period I saw small cells which I initially identified as a green alga. I referred to this identification difficulty in the progress report. After examining photographs and viewing the cells with a more powerful microscope I have changed that identification to a colonial blue-green alga. With these data corrections the total bio-volume of the samples changed only slightly. However, the phytoplankton community interaction grew more complex.

The phytoplankton group interaction for the last year is summarized in *Figure 1 and 2*. Both graphs appear similar at first glance. *Figure 1* represents the relative bio-volume of phytoplankton for each sampling date. Diatoms have been well represented throughout the year, especially during the phytoplankton bloom in late spring 2008. Cryptophytes (Figure 3 -lower photo shows *Cryptomonas sp.* a Cryptophyte) have vied for the dominant role during winter months when low light and relatively high nutrient conditions prevail.

The unusual increase in blue-green algae during the summer of 2007 is noteworthy. The environmental conditions at this time of year; high light, relatively low nutrients, and a stable, stratified water column; are perfect for blue-green algae. In past years we have seen blue-green algae appear at this time of year, but not to this extent. The population of blue-greens were present at all depths throughout the euphotic zone (<100m).

Figure 2 represents the relative abundance (cells/l) of phytoplankton for each sampling date. Notice that the colored bars for chrysophyte and green algae represent a larger percentage of the total than seen in the bio-volume graph. This indicates that these cell groups, while numerous, were small and did not contribute large amounts to the overall biomass. On the other hand, dinoflagellates were not numerous. However, they were large cells and they made significant contributions to the total phytoplankton.





Figures 1 and 2. Biovolume (Fig. 1) and abundance (Fig. 2) of phytoplankton in the upper water column (0-100m) of Lake Tahoe, July 1, 2007 – June 30, 2008.

Much emphasis is placed on community level interaction between groups for limited resources. Indeed, taxonomic groups of algae often have similar growth requirements and respond in similar ways to environmental conditions. The diatoms have been the dominant algal group in Tahoe. Some aspects of diatom population growth are predictable. The group nearly always has a spring-time population bloom. The timing of this bloom is **not** predictable. It can occur anytime between March and July. In the last decade the blooms have been occurring later in the spring. In some years there is a double bloom, one earlier in the spring and one later. In 2007-2008, the single bloom occurred in late May and extended past June, into July 2008 (*Fig 1*). The magnitude of the bloom, both in abundance and bio-volume was remarkable. The last recording of a diatom bloom with a sample total bio-volume over 200 $\mu m^3/l$, was in May 2001.

The bloom is usually attributed to one or two species of diatoms which have a sterling performance. All diatoms present in the spring community do well at this time, but usually only one or two species excel. It is very difficult to predict which species will be the successful competitor for biomass dominant. This year, it was the centric diatom genus of *Cyclotella*, which includes three species, *Cyclotella ocellata, Cyclotella stelligera, and Cyclotella glomerata*

(Figure 3 upper photo - shows photo of *Cyclotella sp*.). These cells do not exceed 15 µm in diameter and it takes many thousands of cells to produce the bio-volume numbers seen in the May-June 2008 bloom. Indeed, in the past five years, we have seen the gradual decline of pennate diatoms and the emergence of centric diatoms as group dominants. In addition, the sometimes rare and numerically low centric diatoms *Aulacoseria italica, Cyclotella bodanica,* and *Stephanodiscus alpinus* have all had population revivals. On the flip side, the pennate diatoms *Synedra sp*., *Achnanthes sp.* and *Asterionella sp.* have struggled to compete. Each of these groups has been major dominants in the diatom community in the past. The environmental parameters which aid centric populations need to be deciphered. One reason might be climate changes which have some control over the timing of the spring bloom. The later the spring bloom, the more likely that the centric diatoms will become the population dominant.

These population changes impact the ecological balance in several ways. Phytoplankton community structure is altered. Grazers have to respond to the fluctuating food resources, both in terms of quantity and quality. Certainly these changes have implications further up the food web and within the microbial community.

Visually, the impact of less light penetration through cubic meters of many small cells (*Cyclotella sp.*) versus a population of larger, but few cells (*Synedra sp*.) is significant. Visibility is decreased. There is less total light to reach the deeper depths. During the stratified periods, most of the phytoplankton are below 60m, but can survive there only because there is adequate light. With less light at these depths, populations may struggle to survive if they do not have the flexibility to adapt.

Within the phytoplankton community, resource competition continues to define the species that are present and dominant. The timing and the availability of these resources are not always consistent. Water column stability, seasonality and climate changes have a collective impact on nutrient distribution. Phytoplankton, being primary producers, are sensitive to these physical and chemical changes. The community is responsive and the impacts of external alterations are quickly reflected within the phytoplankton. The comparison of planktonic algae to the 'yellow canary' of the water environment, is not an exaggeration. Scientist need to have a better understanding of the phytoplankton populations so that changes can be interpreted in a meaningful manner.

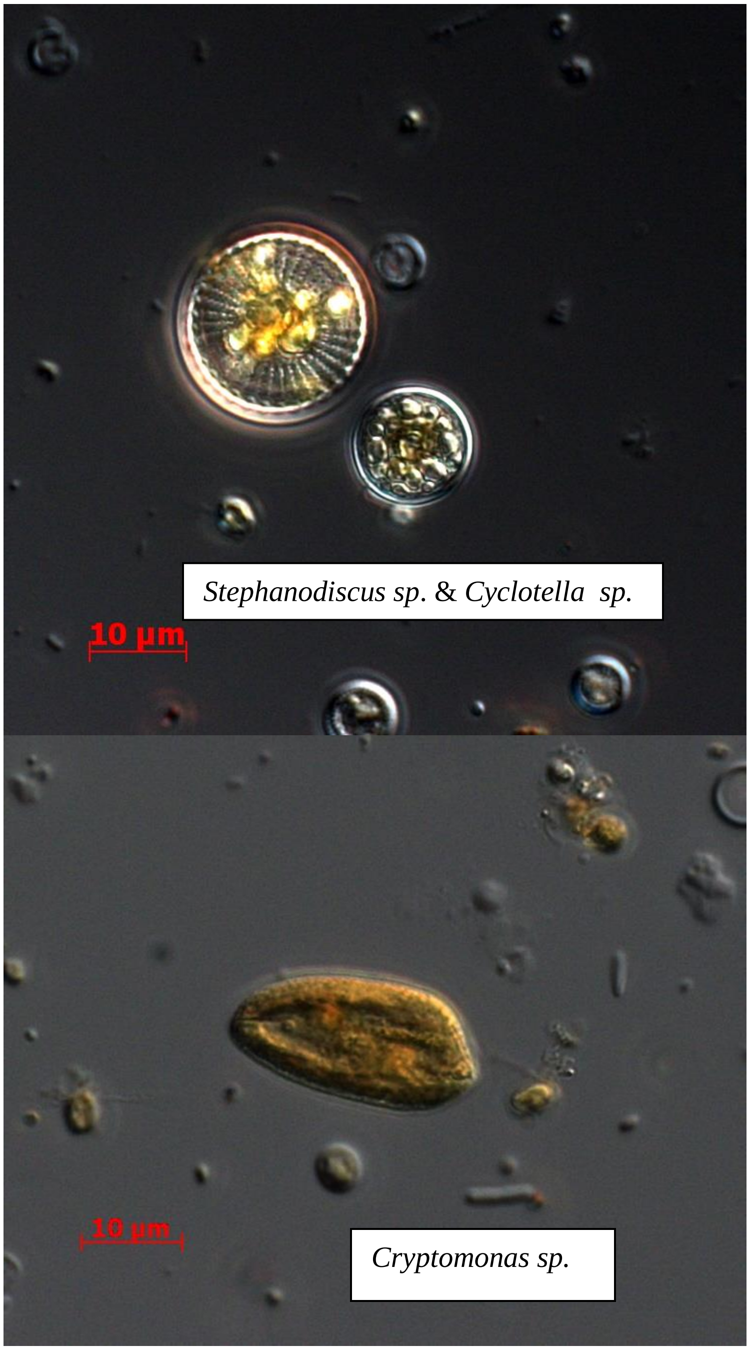


Figure 3. Pictures taken through microscope of : (a-upper photo) the centric diatoms *Stepanodiscus sp.* and *Cyclotella sp.* (*Cyclotella* species were a primary contributor to the 2008 spring diatom bloom). (b-lower photo) *Cryptomonas sp.* a Cryptophyte. (Photos by Debbie Hunter, UC Davis TERC).

Task 4.b. Zooplankton Enumeration and Analysis

The zooplankton community of Lake Tahoe has been relatively consistent since the 1980s, dominated by the copepod species *Diaptomus tyrelli* and *Epischura nevadensis*, and the rotifers Kellicottia spp, *Keratella spp.* and *Polyarthra spp*. (Winder et al., 2008). Zooplankton are significant in the food web structure of the lake. The zooplankton community is composed of herbivorous members (which feed on phytoplankton), omnivorous members (which may feed on phytoplankton, other zooplankton, bacteria, and detritus), and predatory species (which feed on other zooplankton). Different life stages of some of the species can have different primary food sources. The zooplankton are a food source for fish and the invertebrate *Mysis relicta*.

During July 1, 2007 to June 30, 2008 eight 150-0m tows for zooplankton were collected at the mid-lake station and nine 150-0m tows were collected at TERC's Index station off of the west shore. Some difficulties were encountered with rough lake conditions on certain dates which reduced the total number of samples collected. Additional sampling was done however during several cruises to obtain information on zooplankton distribution at discreet depths in the water column.

Figures 4 and 5 present the results for the 150-0m zooplankton monitoring July 1, 2007 to June 30, 2008. Overall abundances for *Epischura*, *Diaptomus* and rotifers were relatively low over the year. At the Index station, peaks in rotifers were observed in July, 2007 and June 2008. *Epischura*, and nauplii (larval stages of *Epischura* and *Diaptomus*) peaked in August 2007. *Diaptomus* populations were low throughout most of the year. At the mid-lake station (for data available through February 2008), rotifers peaked in July 2007and again in January, 2008, *and Epischura* density was low with a slight peak in October 2007. *Diaptomus* numbers were very low throughout most of the year. Nauplii numbers were highest in July 2007. Typically, *Epischura* peaks in Fall and *Diaptomus* in early spring/summer. Rotifers are very variable but usually abundant from fall until late spring and decline during the summer (Monika Winder, personal communication).

Monitoring of zooplankton is important for understanding current food web structure and ecosystem interactions in Lake Tahoe. This data will be incorporated into the long-term dataset for zooplankton. The data will be used to better understand current as well as historical interactions between zooplankton, phytoplankton, invertebrates, fishery and other aspects of the lake ecosystem.

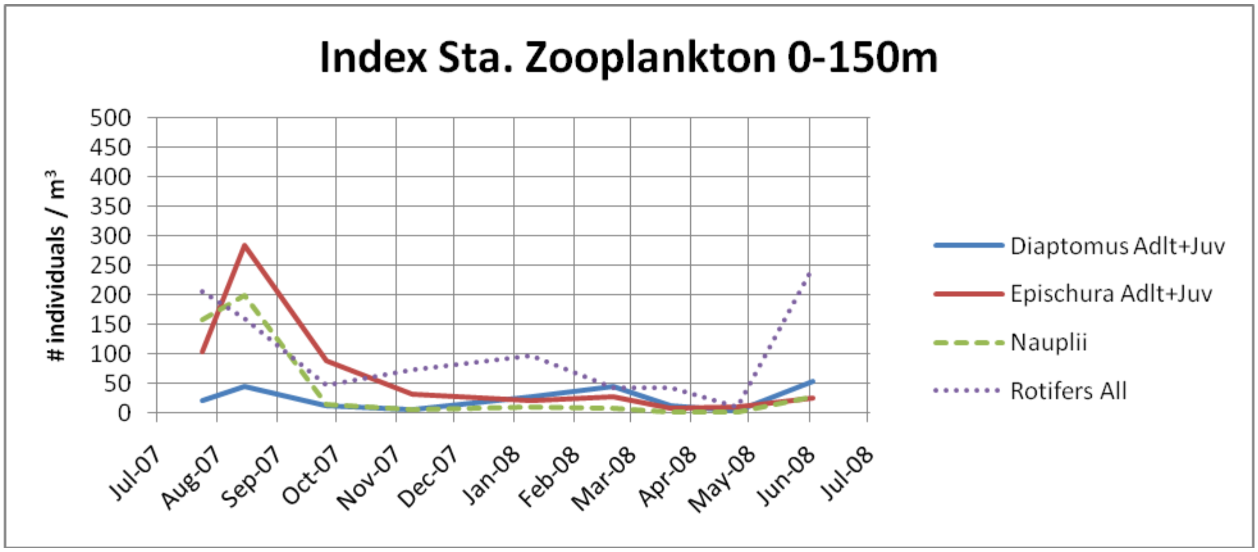


Figure 4. Zooplankton densities (individuals per cubic meter) at the Index station during July 1, 2007 to June 30, 2008.

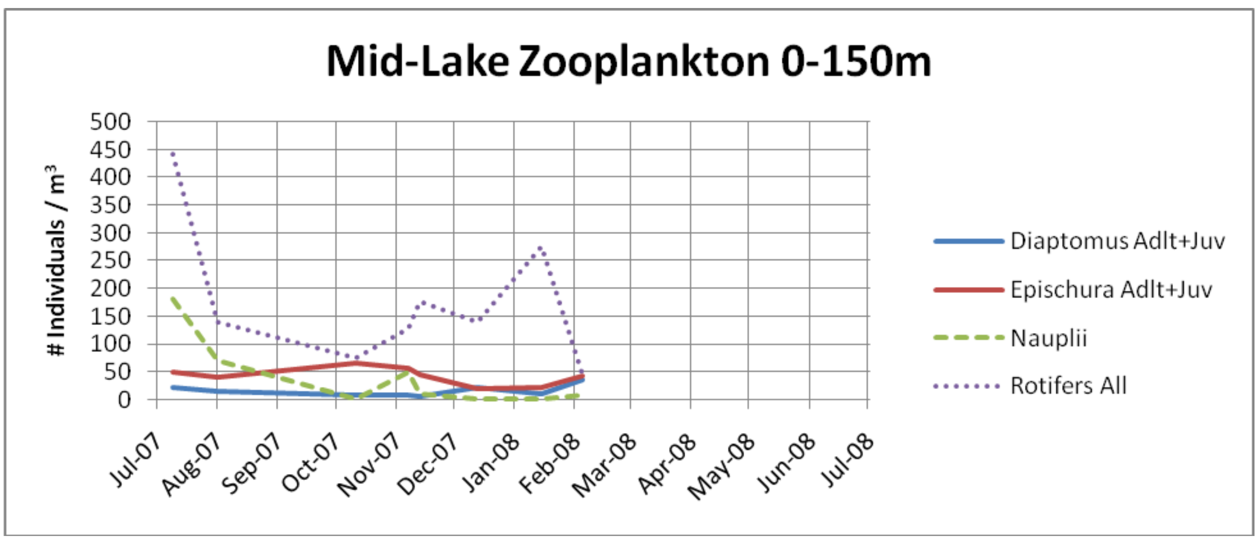


Figure 5. Zooplankton densities (individuals per cubic meter) at the Mid-lake station during July 1, 2007 through February, 2008 (data after February not ready for reporting).

Task 5. Atmospheric Deposition of Nitrogen and Phosphorus

Monitoring of atmospheric deposition is crucial to an understanding of its role in degradation of the lake and for use in watershed management. Atmospheric deposition contributes nitrogen, phosphorus and fine particles which all impact lake clarity. Estimates in the nutrient and sediment budget for Lake Tahoe produced as part of the Tahoe TMDL project indicate that atmospheric deposition contributes about 55% of the Total Nitrogen, 15% of the Total Phosphorus and 15% of the Total Fine Sediment (<20μm) particles to the lake. A significant portion of the nitrogen, phosphorus and fine sediment particles in the atmospheric deposition is thought to originate in the basin. Control of air pollutants generated within the basin is therefore potentially a tool for watershed managers to reduce pollutants which impact the clarity of the lake. The atmospheric deposition monitoring program of TERC provides basic information on nutrient loading from this source (atmospheric deposition both in the watershed on land and directly to the lake surface), as well as on precipitation timing and amounts. The data also provides information on past and current trends in atmospheric deposition.

The current contract provides for atmospheric monitoring at 3 primary stations: the lower Ward Lake Level station, and two stations located on the lake: the Mid-lake buoy station (TB-1) and an additional lake buoy (buoy station TB-4).

Stations and Methods

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. 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 bucket 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 collection is 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 on a large buoy (TB-1) in the north central portion of the lake (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.

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. 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 TERC's Standard Operating Procedures for precipitation monitoring).

Results

Data collected for this task include information on atmospheric deposition concentrations, nutrient loading, precipitation amounts and timing. Appendices 1-5 present summary tables for precipitation amounts, concentrations and nutrient loading from July 1 2007 through summer 2008. From July 1, 2007-October 8, 2008 147 atmospheric deposition samples were collected from the 3 primary stations: 40 dry bucket and 36 wet bucket samples from the Ward Lake Level station, 30 dry-bulk samples from each of the lake buoy stations and 11 Mid-lake snow tube samples. Samples were analyzed for ammonium (NH_4-N), nitrate (NO_3-N), total Kjeldahl nitrogen (TKN), soluble reactive phosphorus (SRP), total dissolved phosphorus and total phosphorus (TP).

Overall precipitation during the reporting period was relatively low. Figure 6 presents amounts of precipitation collected in Wet deposition buckets at the Lower Ward Valley precipitation station July 1, 2007 to October 2008 (Appendix 1 presents the data summary for this site). The majority of precipitation occurred between late September 2007 and late March 2008. However there was an absence of very large rain events which can significantly influence precipitation totals in some years. There were also several dry periods during winter 2008 (portions of January, February and March). Precipitation was low in April and May 2008, and the summers of both 2007 and 2008 were very dry. Total precipitation at the Lower Ward station was 27.92 inches in Water Year 2007 (a Water Year "WY" is the period October 1 to September 30 of the following year) and 24.98 inches in WY 2008. These amounts are relatively low when contrasted with WY 2006 which was very "wet" and had a total of 65.99 inches of precipitation and WY 2005 with 49.40 inches.

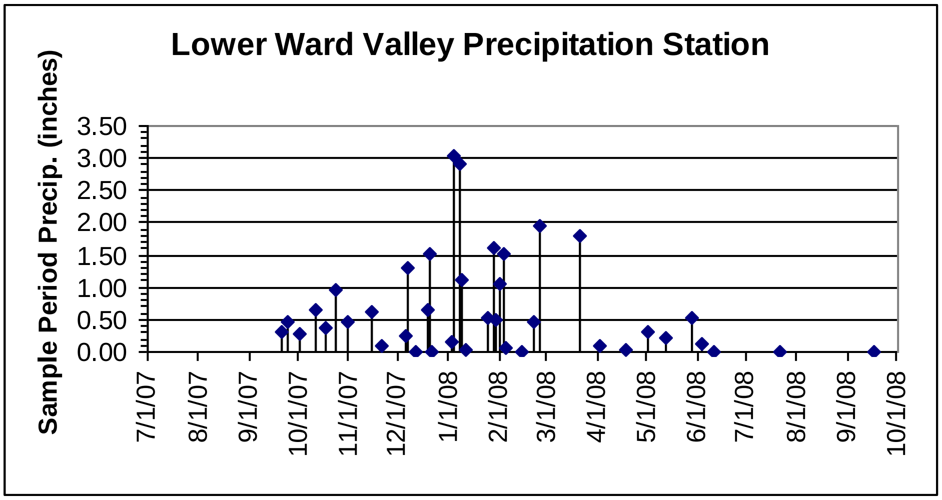


Figure 6. Chart showing precipitation amounts occurring at the Ward Valley Lake Level station during sample "Wet Bucket" collection periods 7/1/07-10/1/08. Each vertical bar corresponds to the total amount of precipitation which occurred during a particular collection period, in some cases two or more Wet buckets were combined in a collection period, (the date under each bar is the final collection date of the sample(s)).

A characterization of precipitation, along with potentially significant weather or atmospheric-deposition-related events occurring during the period are summarized by quarter below:

(July – September 2007)

- The period July 1 to September 30, 2007 was mostly dry. Precipitation began in the latter portion of September which helped to dissipate fire danger in the basin. 0.31 inches of precipitation fell as rain and snow at the Ward Valley lake level station on September 19th and 20th. Another small storm occurred September 22 and 23 which left 0.46 inches of rain at the Lower Ward station, precipitation was much greater at the Upper Ward Valley station where 1.37 inches fell mostly as rain. At the end of September another small storm dropped 0.28 inches of rain and snow at the lower Ward station.
- Summer 2007 appeared to be somewhat windier than normal based on anecdotal field observations; however, the data on wind needs to be analyzed to verify if this was indeed the case.

(October 2007 – January 3, 2008)

- The period October 1 to January 3, 2008 was characterized by generally small storms and low total precipitation for the period. Several of these relatively small storms occurred during each of the three months during the period. Storms worthy of mention during the period include: a rain storm in evening on October 19th which resulted in very small rises in west shore streams; on October 29 a brief period of rain from thunderstorms occurred (this was just after the severe wildfires in Southern Calif.); on November 10 and 11 a storm which included rain then snow resulted in a slight increase in flow in Ward Creek along the west shore; a snow storm on December 6th and 7th dropped about a foot of snow at the Lower Ward station; and an event ending December 20 dropped about 14 inches of additional snow at the Lower Ward station.

- During the week of October 22nd major wildfires occurred in Southern California associated with strong Santa Ana winds. These winds blew most of the smoke offshore over the Pacific Ocean. Very little smoke from these fires was observed in the Tahoe basin due to the predominant offshore direction of the winds. However by October 29th the weather pattern had changed and allowed a weather system from the Eastern Pacific to move into the Tahoe basin as thunderstorms. This system appeared to move over the same section of the Pacific that also had also received smoke from the fires in Southern California.

(January 4 – March, 2008)

- The period January through March was characterized by 3 primary periods of storms. The first period was during January 4-8. A very strong storm (memorable for the heavy snow and winds - blizzard warnings were issued prior to it) began with rain and strong winds during the day on January 4. The rain changed to heavy snow and ultimately 2-4 feet of snow fell at lake level from the storm (January 4-6). Nearly 6 inches of precipitation was collected at the Lower Ward station from this storm. Another snowstorm on January 8 dropped over an inch additional precipitation as snow. After a relative dry spell, precipitation picked up again in the later part of January with over half an inch of precipitation as snow falling during January 20-24. A second significant period of storms occurred from about January 27 to February 3 when a series of storms dropped over 4.68 inches of precipitation as snow at the Lower Ward station. A third significant storm period was from about February 20-24 when 2.42 inches of precipitation occurred as snow. Very little additional precipitation occurred after the February storms. Much of March was dry with a small amount of rain and snow occurring in the middle of the month.

(April – June, 2008)

- The period April 1 through June 30, 2008 was relatively dry with limited precipitation. The most significant precipitation occurred later in May including the Memorial Day weekend when weather cooled significantly and produced rain and some hail (total precipitation during the period May 13-28 was still small with 0.52 inches collected at the lower Ward Valley station).
- Likely the most significant event during the period was a consequence of a storm system that moved across parts of California with frequent lightning on June 21, 2008. Approximately 8000 lightning strikes resulted from this storm and started about 800 fires in California. The number of fires eventually grew significantly. This turned out to be the single largest wildfire “event” in California’s history (since since record-keeping began in 1936) (Associated Press, 2008). Smoke from some of these fires began filling the Tahoe basin soon after they started and varying levels of smoke were present in the basin for more than three consecutive weeks, through mid- July.

- There was frequent wind during the spring of 2008. John Juskie of National Weather Service in Sacramento, (Capital Public Radio, 2008) reported that spring 2008 was unusually windy in Northern California. The Pacific band of the jet stream sagged further south than normal during the spring, bringing winds to the area as weather disturbances passed through the northwest.
- There were very warm, near record temperatures in mid-May (May 16-18), followed by a significant cool-down with wet weather over the Memorial Day (May 24-26) weekend.
- During late May the National Weather Service in Reno noted that dust from the Nevada desert was being blown over Lake Tahoe.

(July – September, 2008)

- Smoke from fires in California continued to fill the Tahoe basin to varying degrees in through mid-July. A significant ash fall event was noted along parts of the northwest shore of Lake Tahoe on July 9, 2008. Pieces of ash including small pine needle ashes were carried by the air currents over the lake. This ash was likely from the American River Complex fires over 35 miles to the west of the basin. Strong up-canyon afternoon winds on July 9 were noted at the fire which caused "a significant run of the Westville fire to the east and north" (KCRA.com, 2008). It is possible the air currents carried ash from this fire to the Lake Tahoe Basin. Ash was deposited on the lake (at least as far east as mid-lake at buoy TB-1) as well as on land down the west shore at TERC's Ward Valley Lake Level precipitation station south of Pineland/Sunnyside. In Tahoe City a thin coating of ash was deposited on boats at the Tahoe City Marina and along the shoreline. Very light ash fall was observed also at TERC in Incline Village.
- The heaviest ash was likely closer to northwest shore, as there was a noticeable drop-off in the level of ash in buoy deposition collectors from the west shore out to the mid-lake buoy. Significant ash was collected in TERC's Dry deposition sampler at the Lower Ward Valley station, ash was also collected in TERC's Dry-bulk atmospheric deposition collectors at buoy TB-4 and buoy TB-1 at mid-lake.
- Smoke also decreased visibility in the basin again around July 26-28, a portion of this smoke was from fire near the Yosemite park entrance.
- The period July 1 through September 30 2008 was very dry with minimal precipitation along the northwest shore. At the Lower Ward Precipitation station, only 0.01 inches of precipitation was collected from storms during the week of July 15-21. A trace of precipitation also fell at the Lower Ward station on September 16th associated with thunderstorms. The first significant rain along the west shore did not occur until October 3-4.

One of the most important results of the atmospheric deposition monitoring has been to provide estimates of annual N and P loading by Water Year from atmospheric deposition in the Ward Creek watershed and on the lake at the sampling locations. Table 5 presents preliminary estimates for WY 2007 and WY 2008 atmospheric deposition loading rates at the UC Davis TERC Lower Ward Valley, buoy TB-4 and Mid-lake buoy TB-1 stations, as well as precipitation amounts at the Lower Ward station. Loading rates from 2005 and 2006 are shown for comparison. Note for TKN, a portion of the data for WY2008 is not ready for reporting so these numbers will change substantially. Data for all other nutrients should be subject to very minor changes as the result of data still outstanding.

Table 5. Comparisons of loading rates (grams/ hectare/ day) of N and P at the Lower Ward Valley and buoy stations TB-1 and TB-4 during Water Years 2005 to 2008. To determine dry deposition loading rate, the load for analyzed dry samples was divided by the total number of sampling days represented by analyzed samples. This method was used for all samples except the WY2008 Dry and Dry-Bulk P deposition samples. Since some of these samples had very high P levels which might contribute to overestimates of annual averages, we first calculated an annual load for all samples excluding high P samples associated with ash fall event (7/10, 7/15/08), then if any data was missing during the non-smoke period, loads for these periods were estimated based on the average loading rate for the non-ash impacted samples. The loads for the non-ash impacted samples and ash impacted samples then were summed and divided by 366 days to determine loading rate. 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 the number of days in the year to give the estimate of daily loading rate.

	Precip. (in)	NO_3-N g/ha/d	NH_4-N g/ha/d	TKN g/ha/d	SRP g/ha/d	DP g/ha/d	TP g/ha/d
Lower Ward (Wet) WY'05	49.40	1.92	1.89	3.95	0.10	0.21	0.36
Lower Ward (Wet) WY'06	65.99	1.59	1.56	2.83	0.06	0.24	0.42
Lower Ward (Wet) WY'07	27.92	0.71	0.79	2.16	0.08	0.12	0.20
Lower Ward (Wet) WY'08	24.98	0.75	0.73	1.90	0.05	0.13	0.25
Lower Ward (Dry) WY'05		0.84	1.39	12.73	0.23	0.64	1.16
Lower Ward (Dry) WY'06		0.89	1.00	11.94	0.17	0.51	1.31
Lower Ward (Dry) WY'07		0.74	1.01	12.55	0.26	0.44	1.03
Lower Ward (Dry) WY'08		0.98	1.01	9.17*	056	0.80	2.00
Lower Ward (Wet+Dry) WY'05		2.76	3.28	16.68	0.33	0.85	1.52
Lower Ward (Wet+Dry) WY'06		2.48	2.57	14.78	0.23	0.75	1.73
Lower Ward (Wet+Dry) WY'07		1.45	1.80	14.71	0.34	0.56	1.23
Lower Ward (Wet+Dry) WY'08		1.73	1.74	11.07*	0.61	0.93	2.25
TB-4 (Dry-Bulk) WY'05		3.26	3.30	5.54	0.08	0.16	0.29
TB-4 (Dry-Bulk) WY'06		1.81	2.10	3.51	0.05	0.14	0.24
TB-4 (Dry-Bulk) WY'07		2.18	1.61	3.93	0.04	0.09	0.24
TB-4 (Dry-Bulk) WY'08		1.66	2.43	3.88*	0.12	0.19	0.34
Mid-lake TB-1 (Dry-Bulk) WY'05		3.23	3.03	5.96	0.13	0.22	0.36
Mid-lake TB-1 (Dry-Bulk) WY'06		2.05	1.88	4.06	0.09	0.21	0.45
Mid-lake TB-1 (Dry-Bulk) WY'07		2.19	1.63	3.14	0.06	0.13	0.27
Mid-lake TB-1 (Dry-Bulk) WY'08		1.78	1.87	3.02*	0.12	0.19	0.35

Notes: "*" – a substantial portion of the data is not yet ready for reporting for TKN values for TB-1, TB-4 Dry-bulk samples, so TKN numbers could change substantially.

Loading of nitrogen in Wet deposition at the Lower Ward Valley station was decreased in Water Years 2007 and 2008 relative to WY 2005 and 2006 for all N fractions. The decrease was most dramatic for the dissolved N-fractions when NO_3-N and NH_4-N loading rates in WY2007 and WY2008 were about one half the loading rates in WY 2005 and 2006. For TKN, WY 2007 and 2008 loading rates were about 70% of those in WY 2006 and about 50% of the WY 2005 value. Precipitation was much lower in WY 2007 and 2008 compared to WY 2005 and 2006 and this likely contributed to the lower N-loading associated with wet precipitation at the Lower Ward site.

Loading rates for phosphorus in Wet precipitation also showed declines for most fractions in WY 2007 and 2008 relative to WY 2005 and 2006. Loading rates for DP in precipitation at Lower Ward were fairly similar in WY 2007 (0.12 g/ha/d) and WY 2008 (0.13 g/ha/d) and less than observed in WY 2005 (0.21 g/ha/d) and 2006 (0.24 g/ha/d). TP loading rates also were similar to each other and reduced in WY 2007 and 2008 relative to the previous two years. Loading of SRP was more variable between years. Loading rates for SRP in precipitation at Lower Ward were lowest in WY 2008 (0.05 g/ha/d) and WY 2006 (0.06 g/ha/d) and somewhat higher in WY 2007 (0.08 g/ha/d) and WY 2005 (0.10 g/ha/d).

Dry deposition loading of nitrogen at the Lower Ward station also showed patterns. NH_4-N loading in dry deposition was very consistent ranging from 1.00-1.01 g/ha/d for WY 06- WY08. NH_4-N loading was slightly higher in WY 2005 at 1.39 g/ha/d. TKN loading in dry deposition was fairly similar in WY 2005-2007, (the 2008 TKN data was not ready for reporting as of the time of this report). Loading of NO_3-N was somewhat variable between years, ranging from 0.74 g/ha/d in WY 2007 to 0.98 g/ha/d in WY 2008; however, the sharp decline in loading seen for Wet deposition between WY 2005-2006 and WY 2007-2008 was not seen for Dry deposition.

Of particular interest, the Dry deposition data at the Lower Ward site, showed a significant increase in the deposition of phosphorus in WY 2008. This is in contrast to data for phosphorus in Wet deposition for WY 2008. Levels of SRP, DP and TP loading in Dry deposition were all significantly greater in WY 2008 compared with WY 2005-2007 values. SRP loading ranged from 0.17-0.26 g/ha/d for WY 2005-2007 then increased to 0.56 g/ha/d in WY 2008. DP loading ranged from 0.44-0.64 g/ha/d for WY 2005-2007 and was 0.80 in WY 2008. TP ranged from 1.03-1.31 g/ha/d in WY 2005-2007 and was 2.00 g/ha/d in WY2008. This increase in Dry deposition of phosphorus at the Lower Ward station appears to largely have been the result of phosphorus associated with ash deposition on July 9th contributed by wildfires to the west of the Tahoe basin. This will be discussed below.

The overall loading rates for combined Wet + Dry deposition loading at the Lower Ward indicated less inorganic N deposition and more phosphorous loading in WY 2008 than the past several years. Overall NO_3-N and NH_4-N loading was substantially less in WY 2007 and 2008 than in WY 2005 and 2006. Phosphorus loads increased in WY 2008, substantially for SRP and less dramatically for DP, TP compared with loading rates in WY 2005-2007.

Atmospheric Dry-bulk deposition measured at buoys on the lake also showed some interannual patterns. First, the deposition loading rates obtained from the two buoys continues to give similar results for loading. Dry-bulk N and P loading rates were very close to each other in WY 2008 at Buoys TB-1 and TB-4. Dry-bulk loading rates in WY 2008 for TB-1 and TB-4 respectively by nutrient were: NO_3-N (TB-1 1.78 g/ha/d; TB-4 1.66 g/ha/d); NH_4-N (1.87; 2.43); SRP (0.12; 0.12); DP (0.19; 0.19); and TP (0.35; 0.34).

Loading rates for NO_3-N and NH_4-N in Dry-bulk deposition at TB-1 and TB-4 were highest in WY 2005, when comparing the last four WY. At buoys TB-1 and TB-4, SRP, DP, and TP loading was higher in WY 2008 than WY2007 although precipitation as measured at the lower Ward site was slightly less in WY 2008 (24.98 in.) than WY 2007 (27.92 in.). Phosphorus deposition associated with an ash event in July may have been largely responsible for elevated phosphorus deposition at the mid-lake stations in the north portion of the lake in WY 2008 compared to WY 2007.

In the near future data for both dry and bulk loading will be compiled into the long-term data set to allow comparisons of loading at the stations from WY to WY and assessment of trends. Figures 7 and 8 present the WY 1981- 2008 data for Dissolved Inorganic Nitrogen (DIN) and Soluble Reactive Phosphorus respectively in Wet deposition at the Lower Ward station. A couple of patterns are apparent for the most recent WY 2007 and 2008 “Wet” DIN and SRP data. DIN average concentrations and total precipitation were low in WY 2007 and 2008 and overall DIN loads were very low in these two WY. Indeed, these low DIN loads (~500 g/ha) during WY 2007 and WY 2008 were the lowest since the record began in 1981. SRP average concentrations were in the mid-range for values in precipitation. With relatively low precipitation, total loads of SRP were also low in WY 2007 and 2008.

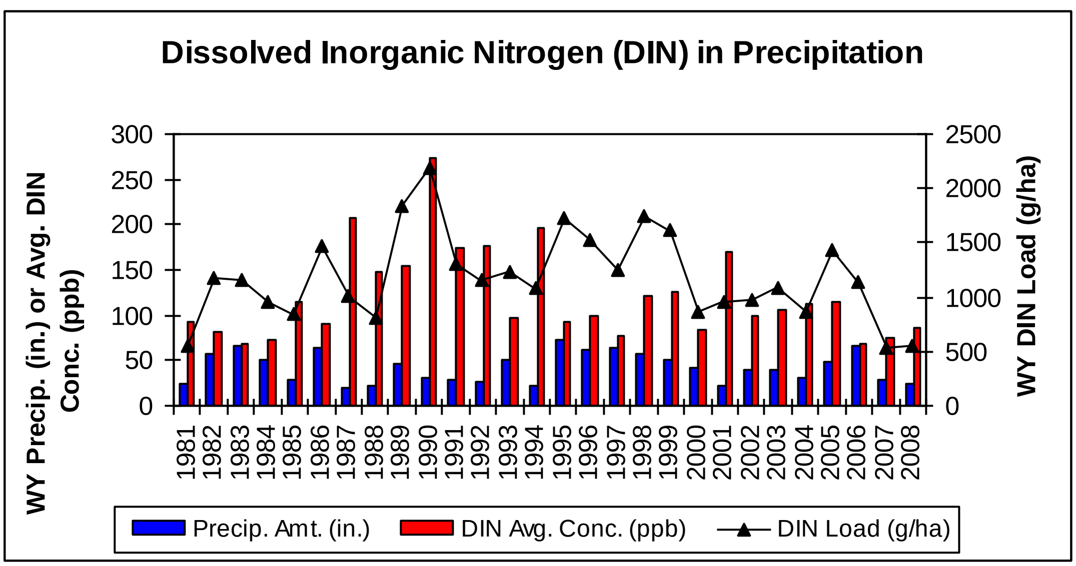


Figure 7. Summary plot of Water Year (WY) total precipitation (inches), average Dissolved Inorganic Nitrogen (DIN) concentration (ppb), and extrapolated annual DIN load (g/ha/yr) in

Wet Deposition at the Ward Valley Lake Level station for WY 1981-2008. A Water Year begins October 1 and ends September 30 (i.e. WY 1981 ended September 30, 1981).

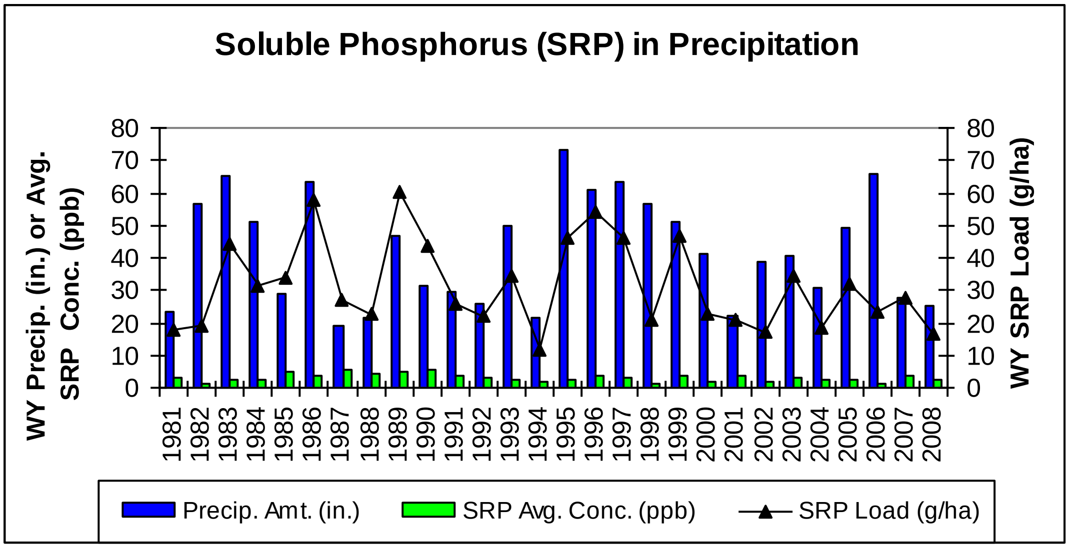


Figure 8. Summary plot of Water Year (WY) total precipitation (inches), average Soluble Reactive Phosphorus (SRP) concentration (ppb), and extrapolated annual SRP load (g/ha/yr) in Wet Deposition at the Ward Valley Lake Level station for WY 1981-2008.

Preliminary Information on Atmospheric Deposition Monitoring during the Heavy Smoke Period with emphasis on Ash Fall event July 9, 2008

Summer 2008 was particularly interesting, as Lake Tahoe experienced a prolonged period of smoke resulting from fires burning outside the Basin - to the west in California. As mentioned above, a storm system with frequent lightning started at least 800 fires in parts of California on June 21, 2008. The number of fires eventually grew significantly. This turned out to be the single largest wildfire “event” in California’s history (since since record-keeping began in 1936). Smoke from some of these fires began filling the Tahoe basin soon after they started June 21 and varying levels of smoke were present in the basin for several weeks, through mid- July.

The presence of smoke for such a prolonged period is unusual for the basin. During past summers, significant smoke has occasionally filled the basin for periods of many days but rarely for periods of several weeks. During the recent Angora fire in 2007, a distinct plume of smoke covered parts of the basin for about 5 days with smoke (light smoke was observed after it was controlled). Goldman et al. (1990) noted smoke from large fires in Southern California in 1985 to impact visibility in the Tahoe basin beginning July 3, 1985 with the entire basin shrouded in smoke by July 11.

Smoke from wildfires can impact Lake Tahoe. Goldman et al (1990) found smoke in the Basin from the Southern California fires to have impacted solar radiation reaching the lake surface and also to have impacted algal primary production, likely as a consequence of nutrients contributed by dry fallout from the smoke. Observations by TERC during the Angora fire in 2007 documented increases in atmospheric deposition of N and P associated with the smoke from the fire and associated brief increases in algal growth in the South Shore area. While we are in initial stages of analyzing all the data from the summer of 2008, it is instructive to present some initial observations on one ash fall event which occurred during this period of heavy smoke.

During the period of heavy smoke an unusual ash fall event was observed on July 9 in the northwest portion of the basin. In the afternoon on July 9, 2008, pieces of ash including small pine needle ashes were carried by the air currents over the lake. Ash was deposited out on the lake at least as far as mid-lake buoy TB-1 (where light ash was observed in the Dry-bulk deposition bucket). Significant ash fell at TERC's Ward Valley precipitation station near the lake. Figure 9 shows a photo of charred remnants of pine needles and coarser ash on a screen situated over deionized water in the collection bucket. Finer particles of ash were found in that deionized water. In Tahoe City, a thin coating of ash was deposited on boats at the Tahoe City Marina and along the shoreline (some charred remains of possibly bay leaves were also observed floating in the lake). Very light ash fall was observed also at TERC in Incline Village, NV on this date. Anecdotal observations suggest that this ash fall event may have been localized to a region in the northwest portion of the lake. Heaviest ash may have been along the shore near Tahoe City (significant ash was observed at sites in Lower Ward Valley and in Tahoe City) with less ash deposited at mid-lake, and very little in Incline at TERC.

This ash was likely derived from the American River Complex fires over 35 miles to the west of the Tahoe basin. "Strong up-canyon afternoon winds" occurred at the fire on July 9 and were noted "to cause a significant run of the Westville fire to the east and north" (news story from KCRA.com, July 10, 2008). It is possible these air currents and topography played a role in carrying ash from this fire to the Tahoe basin. Deposition from wildfire smoke can have impacts quite a distance from the fire. In a summary of general wildfire impacts on the northernfirerockies.org website (Cilimburg and Short, 2005) it was indicated that although much of the ash and charred material in wildfires is usually deposited in nearby forests, during massive conflagrations, fire-generated convection currents may transport ash in towering smoke columns and deposit it hundreds of miles from its origin (McNabb and Cromack, 1990). Goldman et al. (1990) provided evidence for impacts of smoke from fires in Southern California, hundreds of miles away.

During the heavy smoke period, Dry and Dry-bulk deposition was collected about weekly from the Lower Ward Valley station and Buoys TB-1 and TB-4 near the middle portion of the lake. The N and P concentration, loads and loading data from this period is included with data in Appendix Tables 2, 4 and 5.

The data does appear to show an impact possibly associated with the ash deposition event July 9th, 2008. Phosphorus loading appears to have been quite high in samples collected during this ash fall event. SRP load and loading rates collected at the Lower Ward Valley site (collection period July 7th (17:55) – July 10th (13:10)) were extremely high (load =105.94 g/ha; loading rate = 37.81 g/ha/d). SRP loads and loading at Buoys TB-1 and TB-4 were also quite elevated relative to typical levels at these sites. SRP load and loading rate at Buoy TB-4 (collection period July 3rd (10:22) – July 10th (07:50)) were 19.62 g/ha and 2.85 g/ha/d respectively and at Buoy TB-1 (collection period collection period July 3rd (10:50) – July 10th (08:12)) were 18.87

g/ha and 2.74 g/ha/d, respectively. For the Lower Ward and the open-water buoys stations respectively, these daily deposition rates for phosphorus were approximately 60 and 25 times the daily average values respectively (see Table 5). DP loads and loading were generally only slightly higher than SRP loading at these sites, indicating most of the dissolved fraction was SRP. Total phosphorus was also high for samples collected on this date. There did not appear to be a similar spike in dissolved inorganic nitrogen (NO_3-N, NH_4-N) during this period.

Figure 9. Ash deposited on "bug screen" over Dry Deposition bucket in Lower Ward Valley (note charred remnants of pine needles on the screen and surrounding equipment). Finer particles of ash accumulated in the deionized water underneath the bug screen. Photo taken on July 10, 2008 after significant ash fall event on July 9.

Preliminary analysis of the data also indicates that deposition loads for samples collected July 10 (which included the ash fall) comprised a significant portion of the total Wet + Dry deposition of SRP for WY 2008 (Figure 10). At Lower Ward, SRP in Dry deposition collected July 10 (105.94 g/ha) was 48% of total Wet + Dry SRP deposition for the year, at TB-1 deposition of 18.87 g/ha was 44% of the total Dry-bulk (Wet + Dry) SRP load for the WY, at TB-4 deposition of 19.62 g/ha was 44% of the WY SRP total. Based on anecdotal evidence, this ash fall may not have impacted the whole lake. The value from the lake buoys of 44% therefore might be considered an upper limit estimate of percent of annual atmospheric SRP loading contributed to the whole lake during the ash fall event.

The portions of Total P in July 10 samples contributed with ash fall relative to the whole WY were somewhat less than for SRP (figure 11). At Lower Ward, TP in Dry deposition collected July 10 (153.49 g/ha) was 19% of total Wet + Dry TP deposition for the year, at TB-1 deposition of 34.21 g/ha was 27% of the total Dry-bulk TP load for the WY, at TB-4 deposition of 29.60 g/ha was 24% of the WY TP total. Again, since this ash deposition event may not have impacted the whole lake, the values from the lake buoys of 24-27% may be considered an upper limit for % annual atmospheric loading of TP contributed to the whole lake during the ash fall event. For comparison we estimated that 6-11 percent of the total annual P-loading from atmospheric deposition was contributed by the Angora fire in 2007 (data presented by TERC, 2008 at the 4th Biennial Lake Tahoe Science Symposium). Based on NASA remote imagining photos, the Basin was not completely filled in by smoke during the entire period of the Angora Fire. The relative ability of phosphorus to leach from the fine particles transported into the Basin in WY 2008 may have also contributed to these observations. We hope to gain further information on possible extent of the plume associated with the July 9th, 2008 ash fall event (including possibly NASA photos) which may help further refine our estimates.

Phosphorus as well as other relatively heat tolerant nutrients (potassium, magnesium and calcium) tend to be concentrated in ash (Cilimburg and Short, 2005). It is possible the high phosphorus in the samples collected July 10 was attributable to the ash. The July 9th ash fall event initially appears to have been localized over part of the northwest portion of the Tahoe basin. Deposition of P was highest on shore (as measured at the Lower Ward station and was much less, about 20% at the mid-lake buoy). It would be desirable to have additional corroborative data on P deposition associated with the ash fall over the lake, and information on areal extent of the ash fall area. It is of particular interest because the SRP contributed with such deposition would have been a readily available form of phosphorus for algal growth.

Much more analysis of all the data will be done to better understand the potential significance of the heavy smoke during the California wildfires in June and July 2008 on the lake as a whole. The calculations presented above – and specifically related to the WY 2008 fire/smoke/ash event should be viewed as preliminary until these additional analyses are complete. They are included to keep the Basin's resource agencies up-to-date with our current ideas. These findings should not be used at this time to support policy decisions.

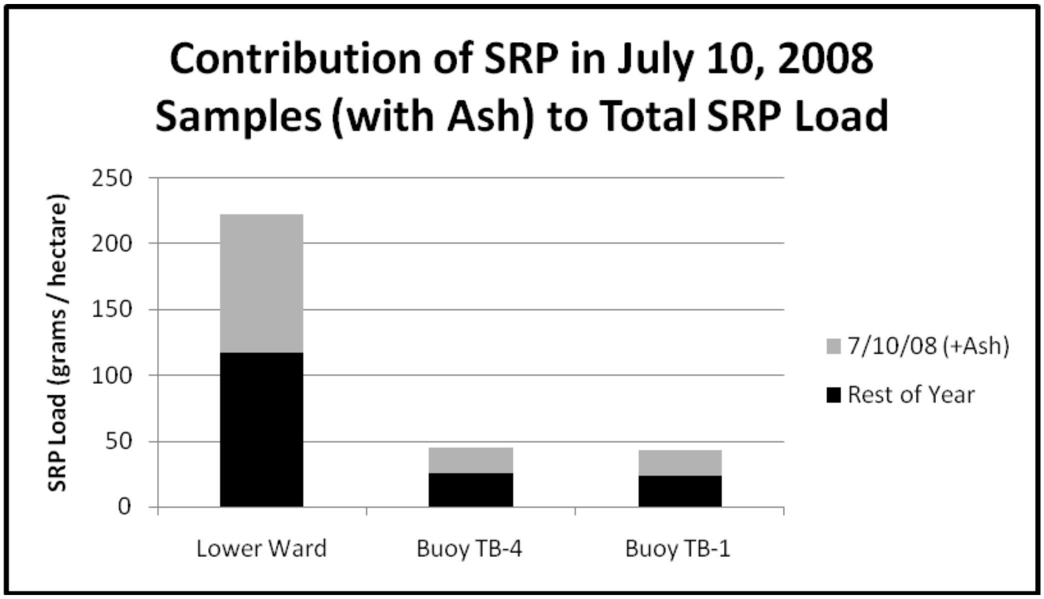


Figure 10. Estimate of contribution of dry deposition SRP collected including 7/9/08 ash fall deposition relative to total water year (Wet + Dry) SRP deposition at the Lower Ward, Buoy TB-4 and Buoy TB-1 stations (note Dry-bulk deposition collected at the buoys is combination of Wet + Dry deposition). The collection periods for buckets which caught the 7/9/08 ash fall were slightly different for the Lower Ward and two buoy stations: i.e. the Dry bucket at Lower Ward sat out for 3 days (7/7/08 17:55 – 7/10/08 13:10), the Dry-bulk bucket at Buoy TB-4 sat out for 7 days (7/3/08 10:22 – 7/10/08 07:50), and the Dry-bulk bucket at Buoy TB-1 also sat out for 7 days (7/3/08 10:50 – 7/10/08 08:12). Important note – these loading estimates are specific to each station and may not necessarily represent deposition to the whole lake area.

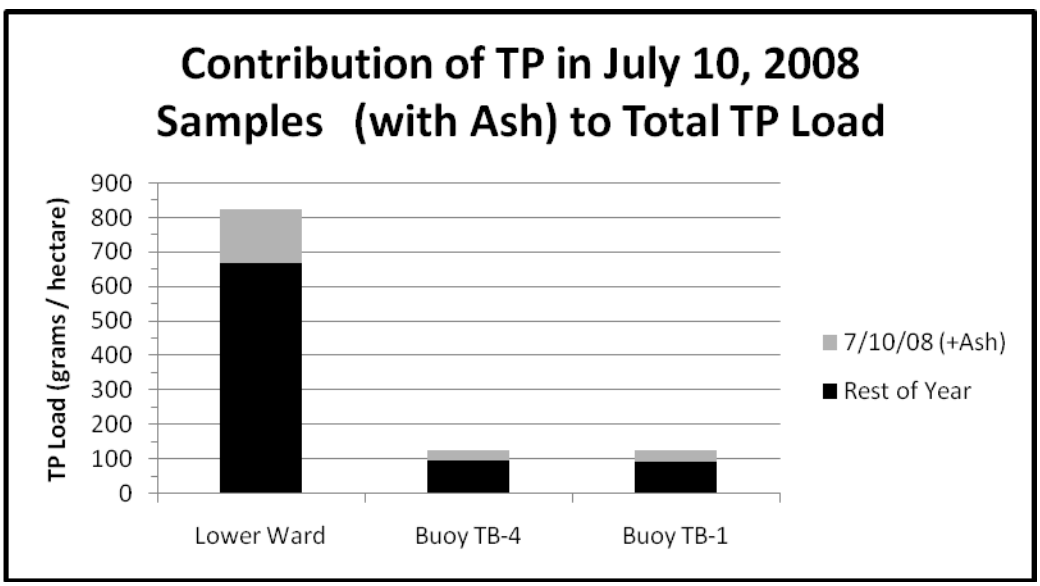


Figure 11. Estimate of contribution of dry deposition TP collected including 7/9/08 ash fall deposition relative to total water year (Wet + Dry) TP.

Task 6. Periphyton

The purpose of periphyton monitoring is to assess the levels of nearshore attached algae (periphyton) growth around the lake. As for phytoplankton, nutrient availability plays a large role in promoting periphyton growth. The amount of periphyton growth can be an indicator of local nutrient loading and long-term environmental changes in lake condition.

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 and is significantly affected by wave activity. It represents only a very small (<1%) of the total littoral area, but it is the most visible to the general land-bound population. Substrata within this region dries out 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 the photoautotrophic growth. The sublittoral zone remains constantly submerged and represents the largest littoral benthic region of Lake Tahoe.

The eulittoral zone community is typically made up of a stalked diatom species *Gomphoneis herculeana* and filamentous green algae species such as *Mougeotia, Zygnema, Ulothrix* and others. The attached algae in the eulittoral zone display significant growth resulting in rapid colonization. These algae are able to take advantage of localized soluble nutrients, and can establish a thick coverage over the substrate within a matter of months. As nutrient concentrations diminish, and shallow nearshore water temperatures warm, with the onset of summer, periphyton in the eulittoral zone typically die back. When this occurs, the algae can slough from the substrate and disperse into the open water, as well as wash ashore. In areas where biomass is high, the slimy coating over rocks and sloughed material accumulated along shore can be a nuisance. The eulittoral zone periphyton plays an important role in the aesthetic, beneficial use of the shorezone.

The sublittoral zone is made up of different algal communities down through the euphotic zone. Cyanophycean (blue-green) algal communities make up a significant portion of the uppermost sublittoral zone. These communities are slower growing and more stable than the filamentous and diatom species in the eulittoral zone.

Ongoing monitoring has shown that lake level fluctuations associated with operation of the upper six feet of the lake as a reservoir, can have an important impact on algal assemblages and biomass near the surface in the eulittoral zone. During years when lake surface elevation drops to unusually low levels (near or below the natural rim), biomass associated with the stable blue-green algal communities may be located in proximity to the surface (i.e. algae that typically resides in the sublittoral now inhabits the eulittoral only because of the drop in lake level). This can result in heavy biomass near the surface. This heavy biomass is not necessarily a consequence of high nutrient availability but rather is a consequence of the lowered lake level and persistent presence of blue green algae. During years of relatively stable lake levels, blue green algae may also establish on rocks which in the past were exposed by lower lake levels.

The period from July 1, 2007 through the summer of 2008 was an interesting one for periphyton growth. During the late-spring of 2008, the routine monitoring showed some relatively high levels of periphyton growth at some sites. As the lake lowered during the summer of 2008, blue green algae became exposed at the surface in some areas, appearing as patchy, dark organic material on the surfaces of rocks. In some areas, some bright green algae were also exposed above the water line, often associated with the blue green algae. The following section summarizes the results of routine periphyton monitoring during July 1, 2007 – June 30, 2008 along with the results of an expanded monitoring survey done May-June, 2008 and an additional survey for surface periphyton done August-September, 2008.

Stations and Methods

Nine routine stations were monitored during July 2007-June 2008 (Rubicon Pt., Sugar Pine Pt., Pineland, Tahoe City, Dollar Pt., Zephyr Pt., Deadman Pt., Sand Pt., Incline West). These nine sites are located around the lake (Table 6) and represent a range of backshore disturbance levels from relatively undisturbed land (Rubicon Point and Deadman Point) to a developed urban center (Tahoe City).

Table 6. Locations of Routine Periphyton Monitoring Stations

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

A detailed description of the sample collection and analysis procedures is given in Hackley et al. (2004). Briefly, the method entails collection while snorkeling of duplicate samples of attached algae from a known area of natural rock substrate at a depth usually of 0.5m, using a syringe and toothbrush sampler. These samples are transported to the laboratory where the samples are processed and split, with one portion of the sample analyzed for Ash Free Dry Weight (AFDW) and the other portion frozen for later analysis of Chlorophyll *a* concentration (both AFDW and chlorophyll *a* are used as measures of algal biomass). We also measure average filament length, % algal coverage, and estimate the visual score in field observations. The visual score is a subjective ranking (1-5) of the level of algal growth viewed above or below water where 1 is least offensive appearing (usually natural rock surface with little or no growth) and 5 is the most offensive condition with very heavy growth.

Results

Monitoring at Routine Sites

In this report we summarize the data collected from July 2007-June 2008. The nine routine sampling sites were sampled five times: once in early winter (November-December) 2007, three times during the typical period of peak growth - late winter-early spring (February, March, April), and again in late Spring (May-June) when periphyton growth typically declines. This monitoring schedule focused on the peak growth period, while also providing information on levels during traditionally lower growth periods.

Table 7 presents the results for chlorophyll *a*, AFDW and field observations of visual score, average filament length and percent algal coverage at the nine routine periphyton sites for the period July 2007-June 2008. Figures 12a-12k present the results for chlorophyll *a* biomass at each site for the current sampling year.

<u>Routine Monitoring Results July 1, 2007 to June 30, 2008</u>

The typical seasonal pattern with a peak in periphyton growth in the spring was observed in 2008 at the four sites along the west and northwest shores when significant peaks in biomass were observed in April at Rubicon Pt., Pineland, Tahoe City, Dollar Pt. . Levels of Chlorophyll *a* (Chl) and AFDW for these sites on April 10, 2008 were: Rubicon Pt. (Chl = 168.17 mg/m^2; AFDW = 113.79 mg/m^2), Pineland (Chl = 119.68 mg/m^2; AFDW = 57.91 mg/m^2), Tahoe City (Chl = 183.72 mg/m^2; AFDW = 87.52 mg/m^2); Dollar Pt. (Chl = 156.52 mg/m^2; AFDW = 134.25 mg/m^2). The peak chlorophyll levels at all these sites were quite high and over 100 mg/m^2. The spring peaks for biomass at these sites appeared to be largely the result of increased growth of the stalked diatom *Gomphoneis herculeana*.[1]

One site along the south east shore (Zephyr Pt.) also had a significant spring peak, but later in the season than for the west shore sites above. Peak biomass at Zephyr Pt. was measured on June 2 (Chl = 76.45 mg/m^2; AFDW = 31.91 mg/m^2). *Gomphoneis* appeared to be largely responsible for the peak on that date.

At the four remaining sites, biomass peaks were lower than the above. At Incline West in the north east portion of the lake, biomass was highest in February (Chl = 48.19 mg/m^2; AFDW = 35.90 mg/m^2), however we were unable to sample this site in March. Both *Gomphoneis* and green filamentous algae appeared to contribute to the biomass peak here. At Deadman Pt. and Sand Pt. along the east shore, very little change in biomass occurred and levels were moderately low. At Deadman Pt. peak biomass was observed in March (Chl = 22.58 mg/m^2; AFDW = 15.44 mg/m^2), and the algae were a mix of *Gomphoneis*, green filamentous algae and blue green algae. At Sand Pt. peak biomass was also observed in March (Chl = 29.70 mg/m^2; AFDW = 29.69 mg/m^2) with similar mix of algae. At Sugar Pine Pt. along the west shore two peaks in biomass were observed, one in February (Chl = 31.18 mg/m^2; AFDW = 18.35 mg/m^2) and one in April (Chl = 32.15 mg/m^2; AFDW = 13.33 mg/m^2). These peaks were relatively small compared with biomass at the other sites. Both *Gomphoneis* and green filamentous algal species appeared to contribute to the biomass peak there in April.

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[1] Note that this stalked diatom contains relatively less chl *a* per unit biomass (weight) because the stalks – which comprise most of the biomass – do not contain chlorophyll.

Table 7. Summary of eulittoral periphyton chlorophyll a (Chlor.*a*), Ash Free Dry Weight (AFDW), visual score, average filament length and percent algal coverage for routine periphyton monitoring sites during July 2007-June 2008. Note for chlorophyll *a* and AFDW, n=2 unless otherwise indicated (i.e. two replicate samples were taken). Visual score is a subjective ranking of the aesthetic appearance of algal growth ("above" viewed above water; "below" viewed underwater) where 1 is the least offensive and 5 is the most offensive. "na" = not available or not collected; "nes" = not enough sample for analysis.

Site	Date	Depth (m)	Chlor. *a* (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (g/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage (%)
Rubicon Pt.	12/12/07	0.5	NA	NA	NA	NA	NA	NA	NA	NA
	2/11/08	0.5	70.82	6.11	27.82	0.54	NA	3	0.5	90%
	3/12/08	0.5	63.69	10.29	20.20	0.98	3	4	2.0	90%
	4/10/08	0.5	168.17*	NA*	113.79	18.94	4	4	3.0	90%
	5/23/08	0.5	13.79	1.28	15.46	2.61	5	3	0.5	70%
Sugar Pine Pt.	12/12/07	0.5	10.52	0.81	7.92	1.57	2	2	<0.1	30%
	2/11/08	0.5	31.18	0.98	18.35	0.89	NA	2	0.4	80%
	3/12/08	0.5	17.44	0.75	8.59	1.41	NA	2	0.3	70%
	4/10/08	0.5	32.15	8.18	13.33	3.54	NA	2	0.5	60%
	5/23/08	0.5	13.77	1.50	8.38	2.41	2	2	0.6	90%
Pineland	12/12/07	0.5	52.32		24.85	4.24	2	2	0.2	40%
	2/11/08	0.5	68.47	23.66	24.25	1.04	NA	3	0.8	100%
	3/12/08	0.5	75.47	10.22	44.29	11.71	NA	5	3.2	100%
	4/10/08	0.5	119.68	47.18	57.91	15.69	4	4	2.2	90%
	5/19/08	0.5	76.20	60.86	44.09	32.64	4	4	2.0	70%
Tahoe City	12/12/07	0.5	26.15	5.39	12.61	1.45	2	2	0.3	50%
	2/7/08	0.5	64.18	27.37	36.16	14.86	3	3	0.7	70%
	3/12/08	0.5	72.71	13.76(n=3)	52.33	20.05(n=3)	2	4	2.8	70%
	4/10/08	0.5	183.72	1.89	87.52	4.02	4	4	3.2	80%
	5/19/08	0.5	21.78	7.97	21.02	11.08	3	3	1.7	40%

Site	Date	Depth (m)	Chlor. *a* (mg/m²)	Std Dev (mg/m²)	AFDW (g/m²)	Std Dev (g/m²)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage (%)
Dollar Pt.	11/27/07	0.5	21.27	5.02	12.41	2.36	2	2	0.1	80%
	2/11/08	0.5	43.14	8.11	19.51	3.35	NA	3	0.8	100%
	3/12/08	0.5	99.32	8.80	58.58	8.01	2	3	0.6	80%
	4/10/08	0.5	156.52	23.91	134.25	3.92	4	4	2.5	90%
	5/19/08	0.5	17.36	5.47	12.31	1.75	3	3	0.1	60%
Incline West	11/26/07	0.55	24.67	1.84	31.49	4.13	3	3	0.4	90%
	2/12/08	0.5	48.19	0.84	35.90	2.74	2	2	0.4	90%
	3/12/08	0.5	NA	NA	NA	NA	NA	NA	NA	NA
	4/10/08	0.5	35.94	1.98	31.81	3.23	4	4	1.5	100%
	6/4/08	0.5	34.93	10.18	43.05	6.99	4	4	2.5	90%
Sand Point	11/26/07	0.34	12.03	0.19	20.97	2.49	2	3	0.5	70%
	2/12/08	0.5	26.80	3.21	25.76	2.49	2	2	0.2	90%
	3/12/08	0.5	29.70	0.79	29.69	1.03	3	3	0.3	90%
	4/10/08	0.5	24.96	2.23	29.71	2.00	3	3	0.4	80%
	6/5/08	0.5	20.24	7.45	24.47	10.04	3	3	0.5	50%
Deadman Pt.	11/26/07	0.5	NA	NA	NA	NA	NA	NA	NA	NA
	2/12/08	0.5	20.56	1.10	15.40	0.25	2	2	0.2	90%
	3/12/08	0.5	22.58	0.12	15.44	1.64	3	3	0.2	80%
	4/10/08	0.5	16.49	1.45	15.44	5.15	3	2	0.1	70%
	6/5/08	0.5	15.75	1.66	15.28	1.51	3	3	0.4	40%
Zephyr Point	11/26/07	0.5	20.49	3.58	18.00	2.07	3	3	0.1	80%
	2/12/08	0.5	44.39	3.15	25.72	0.42	2	2	0.3	60%
	3/12/08	0.5	37.20	5.73	22.06	10.01	2	3	0.5	80%
	4/10/08	0.5	46.96	2.23	23.82	0.49	3	3	1.5	60%
	6/2/08		76.45	16.43	31.91	4.87	3	3	1.2	90%

Notes - * One Rubicon Pt. Chlorophyll a for 4/10/08 was anomalously high (319.36 mg/m²) and not included (n=1).

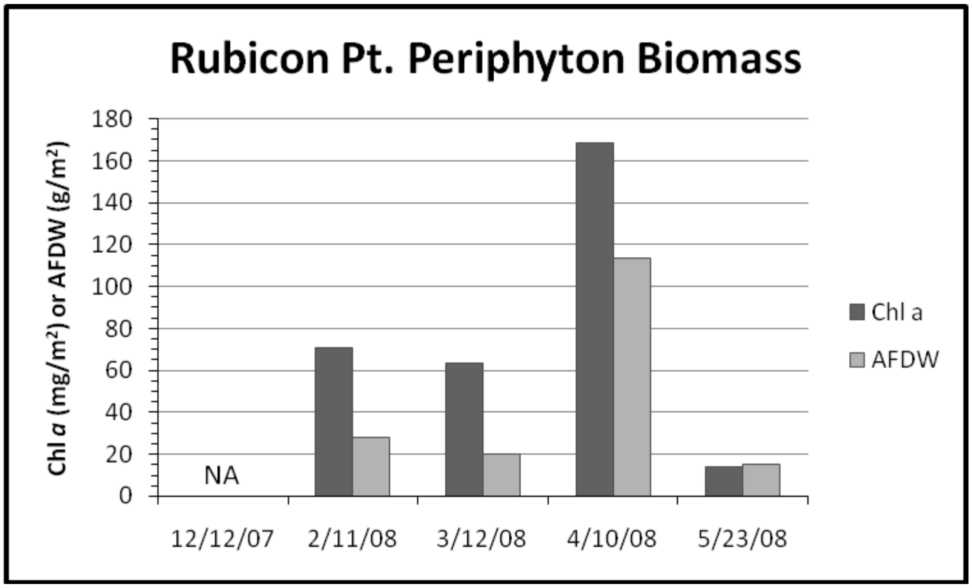

Figure 12.a. Rubicon Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

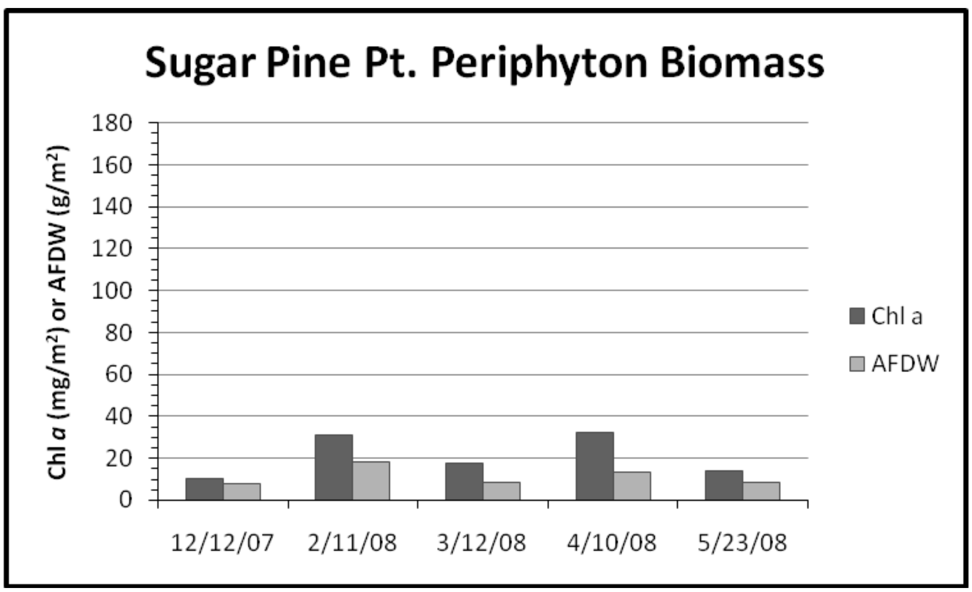

Figure 12.b. Sugar Pine Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

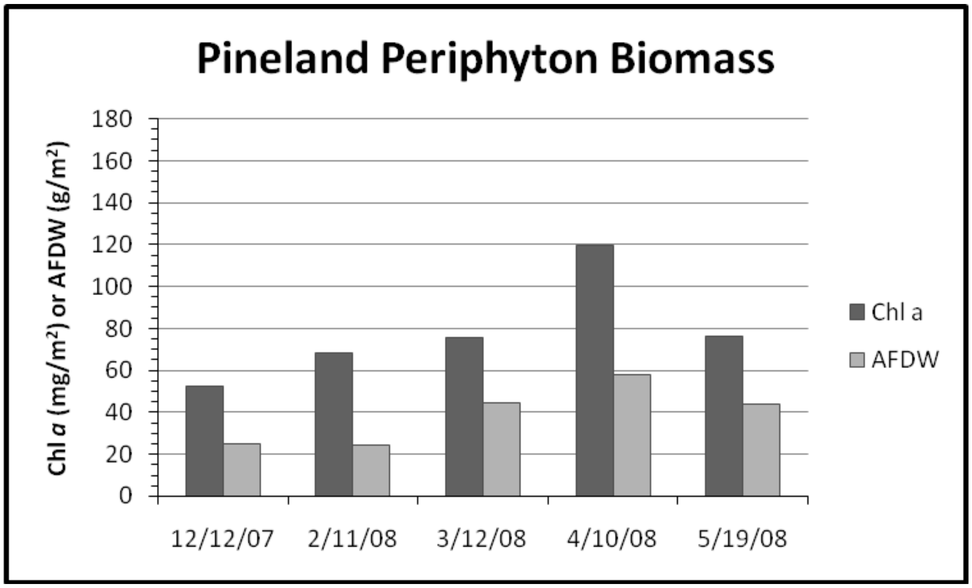

Figure 12.c. Pineland periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

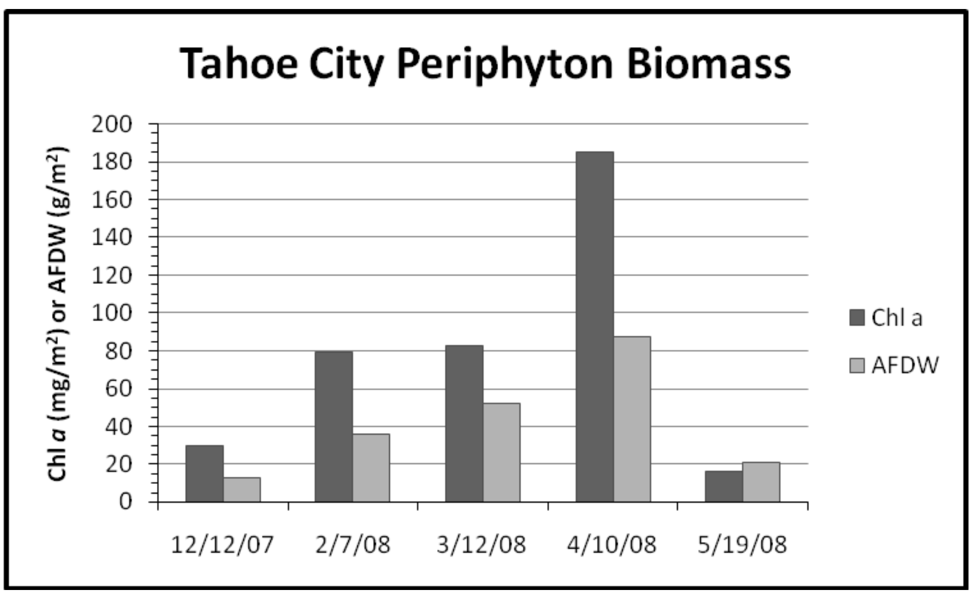

Figure 12.d. Tahoe City periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

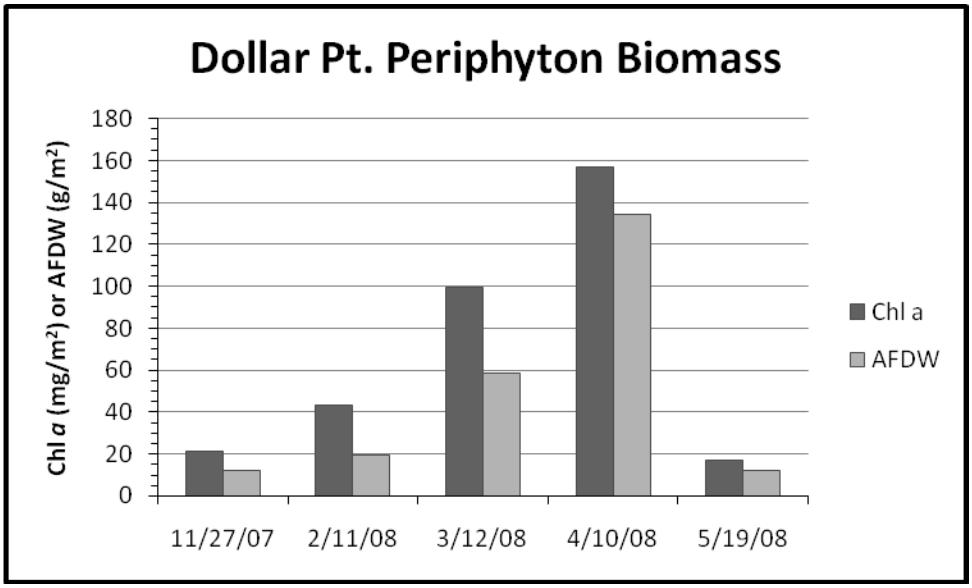

Figure 12.e. Dollar Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

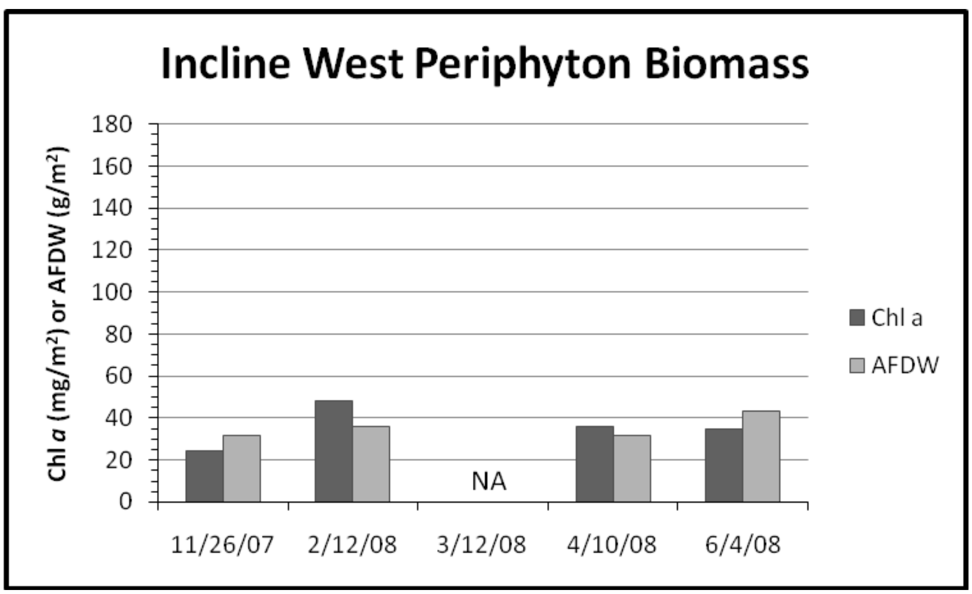

Figure 12.f. Incline West periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

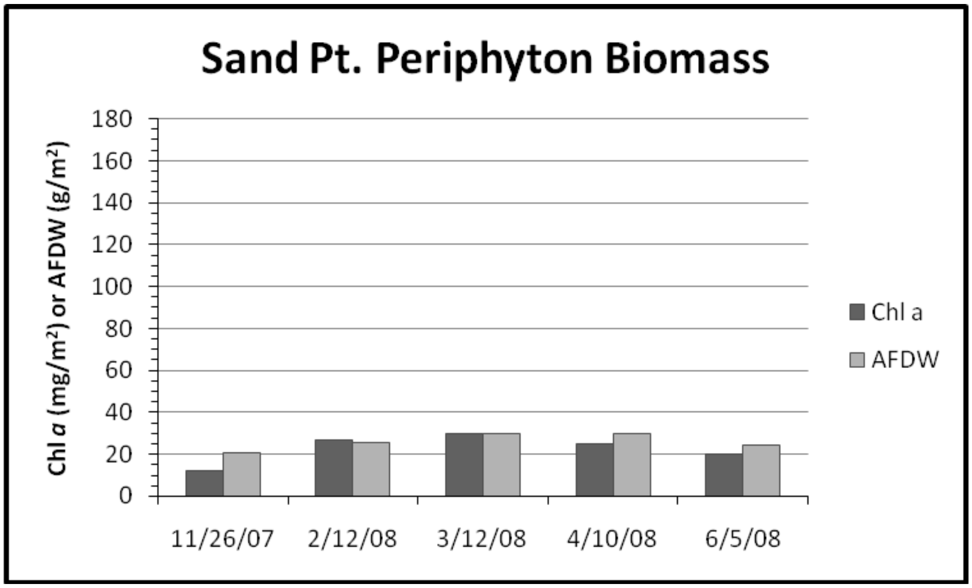

Figure 12.g. Sand Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

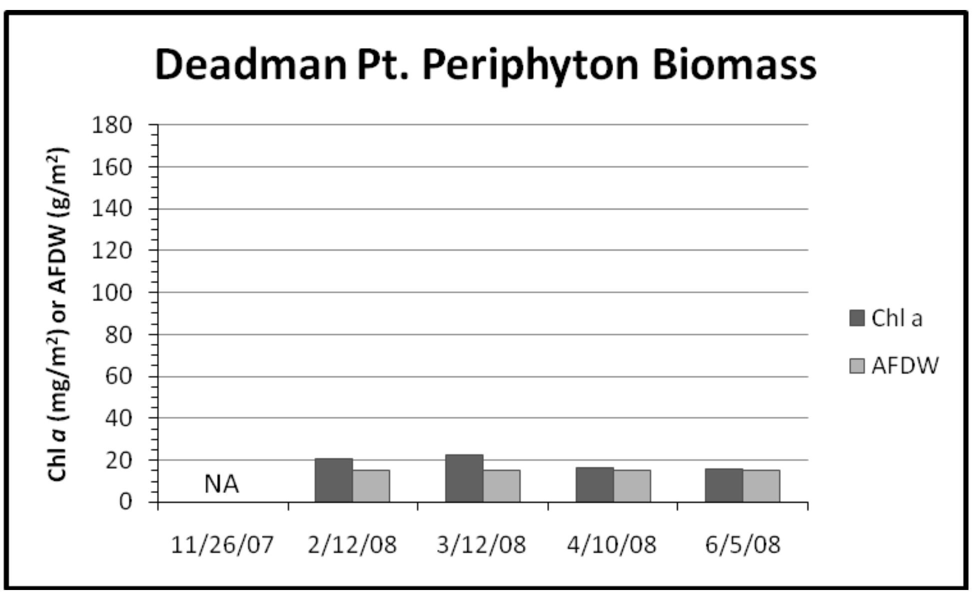

Figure 12.h. Deadman Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008.

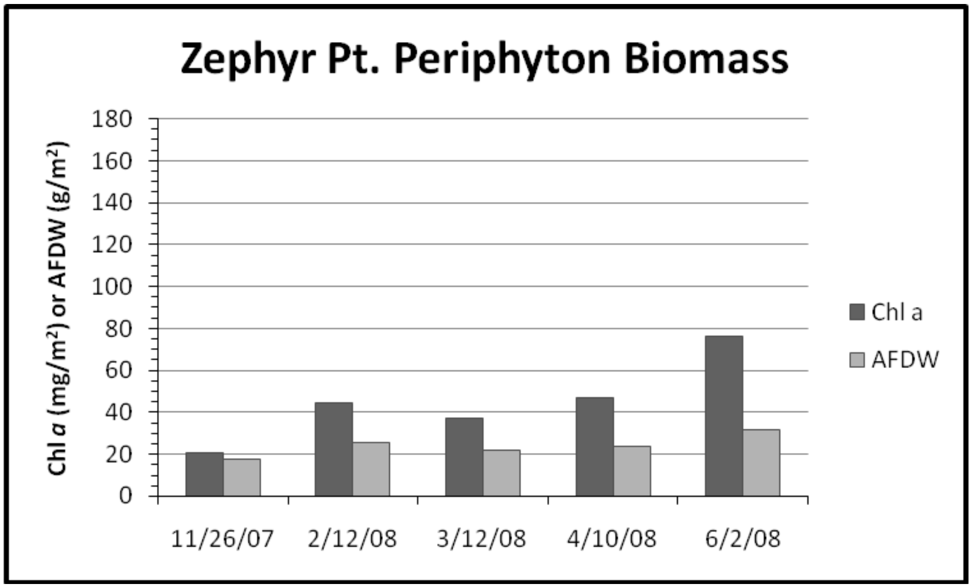

Figure 12.i. Zephyr Pt. periphyton chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2008

Annual Maximum Biomass

WY 2008 maximum biomass values as estimated by chlorophyll *a* for all sites are shown in Figure 13. Annual biomass values for WY 2005-2007 are also shown for comparison. Again, maximum annual biomass levels were high in the northwest portion of the lake (Pineland, Tahoe City and Dollar Pt.), similar to recent years. WY 2008 maximum annual biomass levels at Pineland and Tahoe City were fairly close to levels observed in WY 2007, while the maximum level observed at Dollar Pt. in WY2008 (maximum chl a = 156.52 mg/m^2) was significantly higher compared with levels in WY2005-2007 (range for maximum chl a = 43.65 – 101.79 mg/m^2).

Similar to Dollar Pt., annual maximum biomass at Rubicon Pt. (southwest) and Zephyr pt. (southeast) was also significantly higher than the last three years. At Rubicon Pt. the annual maximum in WY 2008 (168.17 mg/m^2) was markedly higher than values in WY2005-2007 (range for maximum chl a = 19.11 – 64.18 mg/m^2). At Zephyr Pt. the annual maximum (WY 2008 chl a= 76.45 mg/m^2) was also significantly higher than maximums in WY 2005-2007 (range for maximum chl a= 19.63 – 35.22 mg/m^2).

Annual maximum chlorophyll a at Incline West , Sand Pt., Deadman Pt. and Sugar Pine Pt. were relatively close to levels observed in WY 2005-2008 and less than maximums for the sites above.

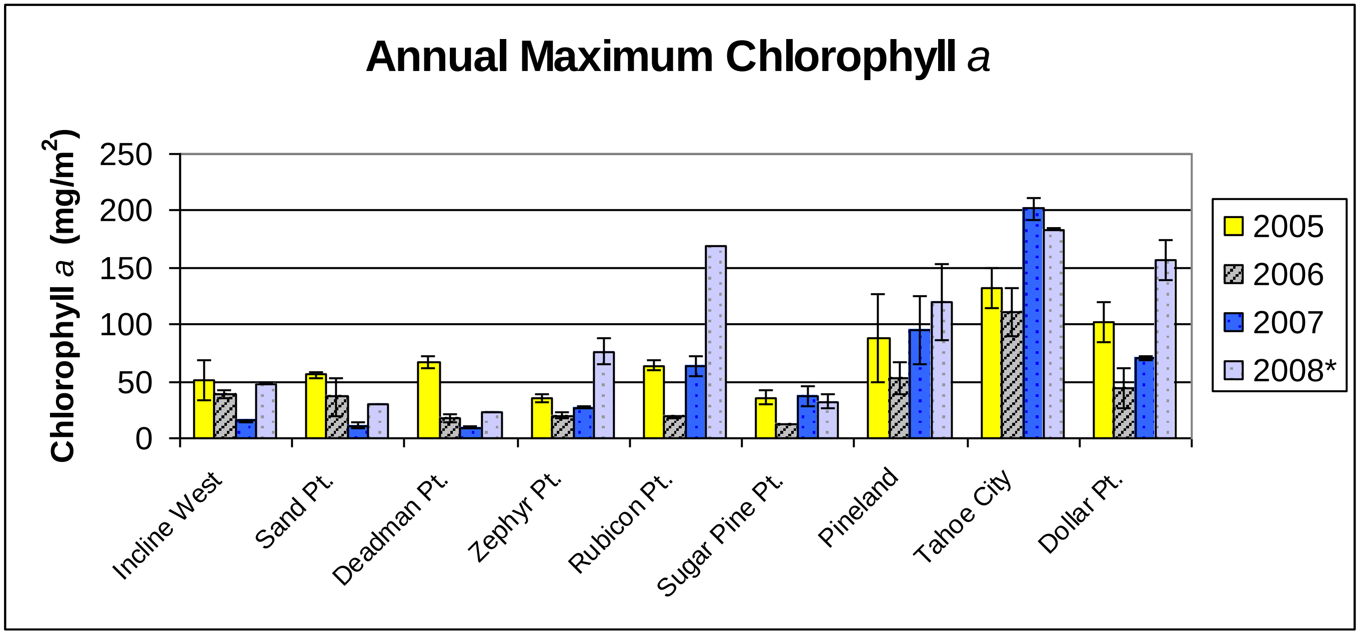

Figure 13. Annual maximum chlorophyll *a* during Water Year 2008 compared with WY 2005-2007 at the nine routine periphyton monitoring sites at 0.5m. (*- Note, WY 2008 periphyton data was for partial year, i.e. through June 2008). An anomalously high replicate for Rubicon Pt. was not used (there was extremely heavy growth which made sampling very difficult).

A combination of factors may have contributed to observed patterns in periphyton biomass and annual maximum biomass levels observed during 2008. WY 2008 was characterized by: overall low precipitation and only a few notable periods of storms which included a very strong storm early in January with significant wind, rain and snow, a second notably stormy period at the end of January and beginning of February. The strong storm in early January however, may have provided lake mixing upwards of nutrients to "kick-off" algal growth early in 2008. The lake surface elevation was relatively stable from early winter 2007 through spring. Therefore most of the substrate below the surface had been submerged for a long time (approximately two years – see figure 14) and likely had some amount of algal and bacterial growth already established when the growing season started. Also, there were significant stretches of time during February, March and April when there were no significant storms. Frequent sunny days during these periods may have been favorable for promoting periphyton growth. The absence of severe storms and associated violent wave activity (which can remove periphyton from rocks) may have been favorable for maintaining the growing algal community on the rocks in the spring. Some early season snow melt may also have helped fuel periphyton growth particularly along the west shore. Spring was relatively windy with possible upwelling of water and nutrients likely at times, particularly along west shore which may have added nutrients and further favored growth there. It is possible the wave activity along the west shore, which is more protected from southwest winds, was also not extreme enough to promote sloughing and allowed development of significant biomass.

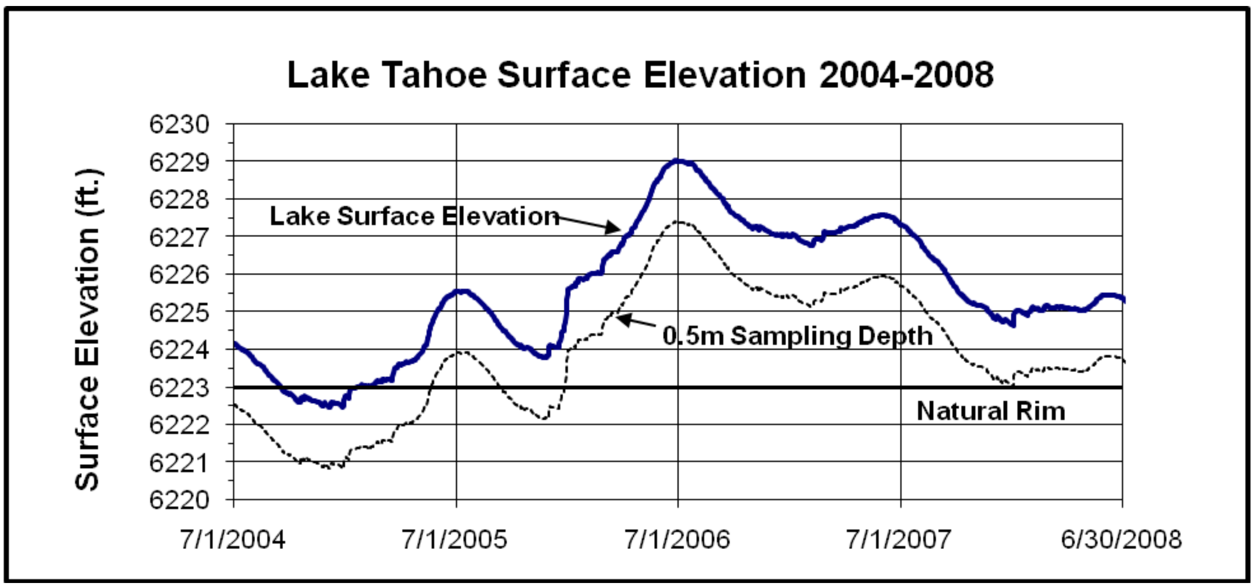

Figure 14. Fluctuation in Lake Tahoe surface elevation 7/1/04-6/30/08 (Lake level data from USGS web site). Periphyton samples were collected during the period usually at a depth of 0.5m below the surface on natural rock substrata. The 0.5m sampling depth (shown as a dotted line) fluctuates with the lake surface elevation. The depth of the natural rim of Lake Tahoe is 6223 ft.

Expanded Monitoring Spring and Summer 2008

The expanded monitoring done in 2008 was designed to provide information on relative levels of periphyton growth at many more sites around the lake than included in the routine monitoring. Similar surveys were done in past years; however, this was the first year in which algal biomass samples were not collected. The goal of the expanded survey this year was to do a rapid visual assessment of levels of growth in those areas located between routine sites. Sites used in the expanded monitoring in WY 2008 were many of the same ones as used in WY 2004-2007 expanded monitoring (Table 8).

The first expanded monitoring run was done May 19 – June 5, 2008. Information on above and below water visual score (where visual score is a subjective ranking of the aesthetic appearance of algal growth where a value of one is the least offensive and five is the most offensive), measurement of average periphyton filament length, estimation of % periphyton coverage over the bottom at 0.5m was collected while snorkeling. Information on predominant algal type was also collected and photographs taken. Since measurements were made by snorkeling at all sites, this survey took several days to complete.

Expanded Monitoring May – June 2008 Results

Results for the expanded monitoring done May 19 – June 5, 2008 are presented in Table 9. This synoptic monitoring was done somewhat after the peak growth at many sites along the west shore. At many sites along the west shore, the *Gomphoneis* was apparently in different states of sloughing from the rocks. In some areas however, very thick *Gomphoneis* was still growing near the surface (i.e. Rubicon Pt. near the surface, Gold Coast, South Meeks Pt., Ward Cr. Mouth, Pineland, Tahoe City Tributary, So. Dollar Pt.). These sites generally had higher visual scores reflecting poor aesthetic appearance of algae nearshore. A few sites had very little periphyton and sloughing of the algae may have already occurred at these (Blackwood Cr., Tahoma, North Sunnyside). It is important to note that due to the issue of variable timing of growth and subsequent die-off of periphyton at various locations around the lake, this synoptic data is best considered as supplemental to the routine seasonal monitoring. Conclusions related to the ability of a specific site to support periphyton should be tempered by these considerations.

While *Gomphoneis* growth appeared to dominate the algal assemblage at many sites along the west shore, blue green algae and some green filamentous algae were also noted as part of the algal assemblage. Blue green algae were noted at sites from Cascade Cr. to Rubicon Pt., and at Sugar Pine Pt. Blue green algae may have been more prevalent then noted, potentially hidden under the overlying *Gomphoneis* growth. Green filamentous algae were noted in the algal assemblage at the E. Bay/ Rubicon area, Gold Coast, Rubicon Pt., Sugar Pine Pt, and So. Fleur Du Lac sites.

Along the northwest and north shores generally moderate levels of periphyton growth were observed. Visual scores generally were in moderate range (about 3). Much of the growth along this stretch was also attributable to *Gomphoneis*. Growth of *Gomphoneis* was particularly heavy at South Dollar, Brockway springs and Incline West, which all had underwater visual scores of 4. Blue green algae were noted at Agatam boat launch, Burnt Cedar Beach, North Stateline Pt.

Table 8. Periphyton expanded monitoring locations.

SITE DESIGNATION	SITE NAME	LOCATION
	WEST SHORE	
A	Cascade Creek	N38 57.130; W120 04.615
B	S. of Eagle Point	N38 57.607; W120 04.660
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
G	Tahoma	N39 04.199; W120 07.771
H	S. Fleur Du Lac	N39 05.957; W120 09.774
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
TCT	Tahoe City Tributary	(adjacent to T.C. Marina)
M	TCPUD Boat Ramp	N39 10.819; W120 07.177
O	S. Dollar Creek	N39 11.794; W120 05.699
P	Cedar Flat	N39 12.567; W120 05.285
Q	Garwood's	N39 13.486; W120 04.974
R	Flick Point	N39 13.650; W120 04.155
S	Stag Avenue	N39 14.212; W120 03.710
T	Agatam Boat Launch	N39 14.250; W120 02.932
	EAST SHORE	
E1	South side of Elk Point	N38 58.965; W119 57.399
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
E6	Cave Rock Ramp	N39 02.696; W119 56.935
E7	South Glenbrook Bay	N39 04.896;W119 56.955
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
E11	Observation Point	N39 12.580; W119 55.861
	NORTH SHORE	
E13	Burnt Cedar Beach	N39 14.680; W119 58.132
E15	North Stateline Point	N39 13.237; W120 00.193
E16	Brockway Springs	N39 13.560; W120 00.829
E17	Kings Beach Ramp Area	N39 14.009; W120 01.401
	SOUTH SHORE	
S1	Tahoe Keys Entrance	N38 56.398; W120 00.390
S2	Kiva Point	N38 56.555; W120 03.203

Table 9. Summary of visual survey of relative levels of periphyton growth at 0.5m. Survey was performed by snorkeling, data collected included above water “Above” and below water “Below” visual score, avg. filament length and % algal coverage May 19 – June 5, 2008. Visual score is a subjective ranking of the aesthetic appearance of algal growth (where 1 is the least offensive and 5 is the most offensive).

Site	Site Name	Date	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage %
A	Cascade Creek	5/23/08	2	2	0.6	50%
B	S. of Eagle Point	5/23/08	2	3	1.2	80%
C	E.Bay/Rubicon	5/23/08	3	3	0.5	80%
D	Gold Coast	5/23/08	3	4	1.5	70%
E	S. Meeks Point	5/23/08	4	4	2.2	40%
G	Tahoma	5/23/08	1	2	0.4	70%
H	S. Fleur Du Lac	5/19/08	3.5	3.5	1.5	70%
I	Blackwood Creek	5/23/08	1	1	0.0	5%
J	Ward Creek	5/23/08	4	5	6.0	50%
K	N. Sunnyside	5/19/08	2	2	0.5	40%
TCT	Tahoe City Tributary	5/19/08	4	4	1.8	60%
M	TCPUD Boat Ramp	5/19/08	3	3	0.2	20%
O	S. Dollar Creek	5/28/08	3	4	2.0	70%
P	Cedar Flat	5/28/08	2	3	1.0	50%
Q	Garwood’s	5/28/08	2	2	0.5	60%
R	Flick Point	5/28/08	2	3	1.2	70%
S	Stag Avenue	5/28/08	1	2	0.7	50%
T	Agatam Boat Launch	6/4/08	2	2	<0.1	30%
E1	South side of Elk Point	6/2/08	3	3	0.3	70%
E2	North Side of Elk Point	6/5/08	-	2	0.2	40%
E3	South Side of Zephyr Pt	6/5/08	3	3	1.4	70%
E4	North Zephyr Cove	6/5/08	3	3	1.5	60%
E5	Logan Shoals	6/5/08	1	1	0.3	5%
E6	Cave Rock Ramp	6/2/08	2	3	0.5	50%
E7	South Glenbrook Bay	6/5/08	2	2	0.6	80%
E8	South Deadman Point	6/5/08	3	3	0.7	80%
E9	Skunk Harbor	6/5/08	3	3	0.4	50%
E10	Chimney Beach	6/2/08	3	4	1.2	90%
E11	Observation Point	6/5/08	3	3	0.5	40%
E13	Burnt Cedar Beach	6/5/08	3	3	0.5	50%
E15	North Stateline Point	6/5/08	3	3	0.6	50%
E16	Brockway Springs	6/4/08	3	4	1.5	90%
E17	Kings Beach	6/4/08	3	3	0.2	50%
S1	Tahoe Keys Entrance	5/27/08	1	2	0.1	30%
S2	Kiva Point	5/27/08	2	2	0.3	40%

Green filamentous algae were also noted to be part of the assemblage at several locations including North Stateline Pt., Brockway Springs and Incline West.

Along the east shore, levels of periphyton growth were light to moderate. Visual scores were generally 2's and 3's. At almost half the sites much of the growth was again due to *Gomphoneis*. However, at many sites blue green algae and green filamentous algae also made a significant contribution to the algal assemblage: Such was the case for South Deadman Pt., and Skunk Harbor. At Deadman Pt. and Observation Pt. the whole assemblage appeared to be blue green algae and green filamentous algae.

Growth of periphyton was low at the two south shore sites monitored. At the Tahoe Keys and Kiva sites algal growth apparently had already peaked. Visual scores were low 1-2. Only a small amount of *Gomphoneis* was observed.

Overall, growth of periphyton during late May and early June lake wide was generally moderate, with some areas still having quite significant growth. There were some areas of noticeably higher growth than in recent years (i.e. Rubicon Pt., and Zephyr Pt). The stalked diatom *Gomphoneis* appeared to dominate the biomass in many areas around the lake. However, the *Gomphoneis* appeared to be in process of sloughing at many sites. Green filamentous algae and blue green algae also were a significant part of the periphyton at some sites from the west, north and east regions of the lake. At some east shore sites the blue green algae and filamentous green algae appeared to predominate in the algal assemblage.

Algal Blooms in the Southeast Portion of the Lake During Summer 2008

It should be noted that the summer of 2008 was also extremely interesting as a bloom of masses of bright green filamentous algae *Zygnema* occurred in Marla Bay just above the bottom. This algae was not strictly attached to rocks or other substrate as periphyton, nor strictly free-floating, but was found as large clumps or masses hovering just above the bottom. (Such algae which is neither strictly attached as periphyton nor strictly planktonic as phytoplankton is called metaphyton.) TERC was involved with much work related to this bloom. For more information specifically related to this bloom the reader is directed to Wittmann et al. (2008).

Visual Observations of Green filamentous Algae Growth During Summer 2008

During August 2008, bright green algal growth had been reported to be present along some areas of the east shore. Our inspection of the rocky shoreline at Sand Harbor showed some bright green filamentous algae growing near or just above the surface of the water on some areas of boulders impacted by waves. The bright green filamentous algae was an attached form of *Zygnema*. Typically, the level of periphyton growth is relatively low around much of the lake during the summer. So it was of interest to provide more documentation on the presence of green filamentous algae which was very noticeable on rocks in some areas of the lake.

To learn more about the overall distribution of the filamentous green algae in around the lake during August and September we did a very basic lake-wide visual survey for presence of bright green attached algae at or above the surface on rocks. Observations were made on presence or absence of bright green filamentous algae near or above the surface on rocks from boat or from shore. At several sites, samples of periphyton at the were also collected for species identification. We present here some initial observations from this work done late in the summer 2008.

The results of this survey showed that during August and September 2008, bright green attached algae were present to some degree on rocks at or just above waterline in many areas of the lake (Table 10). This bright green algae often covered only a portion of the exposed rock surfaces, yet still was visually quite noticeable. There was also significant blue green algae at or above the surface in many areas due to a rapidly lowering lake level. This algae appeared as dark-colored organic material above the water line. The blue-greens and green filamentous algae were found together at many sites. It is interesting to note that green filamentous algae had been observed earlier in the year during the expanded monitoring in May and June submerged at many but not all sites where it was found later in the summer.

The filamentous algae and blue green algae was sampled at several sites for species identification during the late summer survey. The bright green algae was found to be the attached form of *Zygnema* at many of these sites. The blue green algae appeared to include *Dichothrix* and other species.

The survey also showed interesting presence of some other green filamentous algae in certain areas of the lake. Near Garwoods a darker green *Cladophora*-like filamentous algae was found growing over a thick covering of diatoms (*Cymbella*). At South Shore, off El Dorado Beach, some similar thick growth of a green *Cladophora*-like filamentous algae was also found on some rocks. Definitive identification of this *Cladophora*-like filamentous algae still must be made. In addition *Sprirogyra* was found on rocks near the Timber Cove pier. Significant algal metaphyton was found in the south east portion of the lake during this survey and during the bloom-related work (see Wittmann et al. 2008).

We also sampled our routine periphyton monitoring sites for algal biomass during August and early September 2008. The results of that monitoring were not ready for reporting with this report, but will be included with the next annual report.

We are continuing to analyze the most recent periphyton data to understand patterns and significance of periphyton growth during summer 2008. The above observations were included to keep the Basin's resource agencies up-to-date with our recent observations of growth around the lake. Again, these findings should <u>not</u> be used at this time to support policy decisions.

Table 10. Visual survey of presence of bright green attached filamentous algae on rocks at the surface around the lake August-September 2008.

Site	Site Name	Date	Bright Green Attached Algae on rocks At Surface?
C	E.Bay/Rubicon	9/16/08	yes
	Rubicon Pt.	9/16/08	yes
E	S. Meeks Point	9/16/08	yes
	Sugar Pine Pt.	9/16/08	yes*
	Kaspian Campground	9/17/08	no
	Kaspian Pt.	9/17/08	yes*
	Pineland	9/16/08	yes*
TCT	Tahoe City Tributary	9/8/08	no**
M	TCPUD Boat Ramp	9/8/08	no
	Dollar Pt.	9/8/08	yes
Q	Garwood's	9/5/08	no**
R	Flick Point	9/5/08	yes
S	Stag Avenue	9/5/08	yes
E17	Kings Beach	9/8/08	yes*
E16	Brockway Springs	9/5/08	yes
E15	North Stateline Point	9/5/08	yes
E14	Stillwater Cove	9/5/08	yes
	Incline West	9/5/08	yes
E13	Burnt Cedar Beach	9/5/08	yes
E12	Hidden Beach	9/5/08	yes
E11	Observation Point	9/5/08	yes
	Sand Harbor	8/14/08	yes
	Sand Point	8/15/08	yes
E9	Skunk Harbor	8/22/08	yes
	Deadman Point	8/15/08	yes
E8	South Deadman Point	8/22/08	yes
E7	South Glenbrook Bay	8/22/08	yes
E6	Cave Rock Ramp	8/22/08	yes
E5	Logan Shoals	8/22/08	yes
E4	North Zephyr Cove	8/22/08	yes
E1	Elk Pt	8/15/08	no
	Timber Cove Pier	10/1/08	no**
	El Dorado Beach	10/1/08	no**

*- very small amount of bright green algae on rocks at surface
** - other attached green filamentous algae present just below surface

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Appendix Table 1.a. Precipitation amounts, N and P concentrations in wet deposition at the Ward Valley Lake Level Station 7/1/07-9/17/08.

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
1	9/21/2007 14:00	0.31	RS	WET	0.31	NA	298.16	238.50	3.85	15.31	25.52	
2	9/24/2007 17:10	0.46	R	WET	0.46	71.05	76.04	266.74	10.84	10.79	36.13	
3	10/2/2007 10:45	0.28	RS	WET	0.28	397.55	673.44	706.53	14.54	23.74	36.68	
4	10/11/07 10:20	0.65	S	WET	0.65	61.39	57.73	79.30	4.85	8.94	18.50	
5	10/17/07 15:25	0.37	RS	WET	0.37	16.81	23.89	99.33	9.61	C	19.45	9
6	10/23/07 10:45	0.97	R	WET	0.97	47.35	33.87	62.42	2.98	5.87	9.26	10
7	10/31/07 10:30	0.47	R	WET	0.46+	282.30	10.57	554.06	7.11	9.57	12.35	11
8	11/14/07 14:10	0.61	R	WET	0.61	32.31	21.94	39.60	1.60	4.02	6.49	12
9	11/21/07 09:55	0.08	R	WET	0.08	31.54	5.00	10.40	1.62	5.19	18.17	13
10	12/6/07 11:20	0.25	R	WET	0.25	16.61	22.17	NA	1.39	6.11	16.63	
11	12/7/07 17:50	1.30	S	WET	1.30	17.07	14.26	78.81	0.69	2.47	4.27	14
	12/12/07 14:50	Trace		WET	Trace	NA	NA	NA	NA	NA	NA	15
12	12/19/07 09:50	0.66		WET	0.66	15.32	19.17	112.20	0.93	3.09	6.87	16
13	12/20/07 11:15	1.51	S	WET	1.51	50.85	55.47	54.04	1.16	15.40	32.03	17
	12/21/07 11:15	Trace	S	WET	Trace	NA	NA	NA	NA	NA	NA	18
14	1/3/08 11:00	0.16	S	WET	0.16	106.42	118.19	NA	3.01	7.32	11.59	
15	1/4/08 16:20	3.02	RS	WET	3.02	10.94	9.62	110.32	6.02	C	14.64	
16	1/7/08 10:30(a)	See "b"	S	WET	1.08	32.83	12.29	38.36	0.69	3.40	5.80	34
17	1/7/08 10:30(b)	2.92	S	WET	1.40	19.70	22.50	91.82	1.16	13.55	17.39	35
18	1/9/08 11:10	1.12	S	WET	1.12	26.06	7.46	37.95	1.81	5.80	6.87	
19	1/11/08 10:10	0.04	R	WET	0.04	4.44	7.67	176.03	1.82	3.96	5.19	36
20	1/24/08 10:00	0.53		WET	0.53	167.70	211.22	251.55	2.26	6.10	12.32	
21	1/28/08 11:00	1.62	S	WET	1.62	23.32	17.76	63.11	2.04	0.91	8.63	37
22	1/30/08 10:30	0.49	S	WET	0.49	41.50	34.38	97.94	1.81	4.88	11.40	
23	2/1/08 10:40	1.06	S	WET	1.06	15.99	20.58	62.35	1.13	1.83	12.94	
24	2/3/08 15:00	1.51+	S	WET	1.21	13.81	24.56	55.65	1.13	4.88	6.78	38
25	2/5/08 10:00	0.07	S	WET	0.07	7.27	14.51	50.79	0.68	4.27	5.85	39

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
26	2/14/08 17:25	T	RS	WET	.0025	2.87	1.73	35.10	1.81	5.55	7.39	40
27	2/22/08 10:30	0.46	S	WET	0.46	29.25	31.05	39.93	1.58	6.78	9.24	
28	2/25/08 18:30	1.96	S	WET	1.96	20.07	20.37	46.78	1.13	5.85	7.81	41
29	3/21/08 13:40	1.80	RS	WET	1.80	70.11	68.41	123.67	2.95	7.35	9.49	
30	4/2/08 10:15	0.08	S	WET	0.08	15.50	7.11	43.14	1.84	4.66	6.21	48
31	4/18/08 09:40	0.02		WET	0.02	27.18	20.05	108.74	0.90	3.43	4.21	49
32	5/2/08 10:00	0.31		WET	0.31	169.03	86.90	381.33	0.90	6.45	19.35	
33	5/13/08 15:10	0.23	R	WET	0.23	34.78	506.26	609.66	3.61	8.15	44.53	
34	5/28/08 11:45	0.52	RH	WET	0.52	155.39	167.31	268.84	2.93	NA	16.36	
35	6/4/08 10:10	0.11	R	WET	0.11	53.93	11.30	NA	1.13	12.06	59.37	50
	6/11/08 15:05	T		WET	T	NA	NA	NA	NA	NA	NA	
36	7/21/08 12:15	0.01	R	WET	0.01	45.77	75.51	NA	3.17	6.42	8.85	63
	9/17/08 10:15	T	R	WET	T	NA	NA	NA	NA	NA	NA	71

Appendix Table 1.b. Precipitation loads of N and P in wet deposition at the Ward Valley Lake Level Station 7/1/07-9/17/08.

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Load) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	9/21/2007 14:00	0.31	RS	WET	0.31	NA	23.48	18.78	0.31	1.21	2.01	
2	9/24/2007 17:10	0.46	R	WET	0.46	8.30	8.88	31.17	1.27	1.26	4.22	
3	10/2/2007 10:45	0.28	RS	WET	0.28	28.27	47.90	50.25	1.03	1.69	2.61	
4	10/11/07 10:20	0.65	S	WET	0.65	10.14	9.53	13.09	0.80	1.48	3.05	
5	10/17/07 15:25	0.37	RS	WET	0.37	1.58	2.25	9.34	0.90	C	1.83	9
6	10/23/07 10:45	0.97	R	WET	0.97	11.67	8.34	15.38	0.73	1.45	2.28	10
7	10/31/07 10:30	0.47	R	WET	0.46+	33.70	1.26	66.14	0.85	1.14	1.47	11
8	11/14/07 14:10	0.61	R	WET	0.61	5.01	3.40	6.14	0.25	0.62	1.01	12
9	11/21/07 09:55	0.08	R	WET	0.08	2.46	0.39	0.81	0.13	0.40	1.42	13
10	12/6/07 11:20	0.25	R	WET	0.25	1.05	1.41	NA	0.09	0.39	1.06	
11	12/7/07 17:50	1.30	S	WET	1.30	5.64	4.71	26.02	0.23	0.82	1.41	14
	12/12/07 14:50	Trace		WET	Trace	NA	NA	NA	NA	NA	NA	15
12	12/19/07 09:50	0.66		WET	0.66	2.57	3.21	18.81	0.16	0.52	1.15	16
13	12/20/07 11:15	1.51	S	WET	1.51	19.50	21.27	20.73	0.44	5.91	12.28	17
	12/21/07 11:15	Trace	S	WET	Trace	NA	NA	NA	NA	NA	NA	18
14	1/3/08 11:00	0.16	S	WET	0.16	4.32	4.80	NA	0.12	0.30	0.47	
15	1/4/08 16:20	3.02	RS	WET	3.02	8.39	7.38	84.62	4.62	C	11.23	
16	1/7/08 10:30(a)	See "b"	S	WET	1.08							34
17	1/7/08 10:30(b)	2.92	S	WET	1.40	14.61	16.69	68.10	0.86	10.05	12.90	35
18	1/9/08 11:10	1.12	S	WET	1.12	7.41	2.12	10.80	0.51	1.65	1.95	
19	1/11/08 10:10	0.04	R	WET	0.04	0.35	0.60	13.72	0.14	0.31	0.40	36
20	1/24/08 10:00	0.53		WET	0.53	22.58	28.43	33.86	0.30	0.82	1.66	
21	1/28/08 11:00	1.62	S	WET	1.62	9.60	7.31	25.97	0.84	0.37	3.55	37
22	1/30/08 10:30	0.49	S	WET	0.49	5.17	4.28	12.19	0.23	0.61	1.42	
23	2/1/08 10:40	1.06	S	WET	1.06	4.31	5.54	16.79	0.30	0.49	3.48	
24	2/3/08 15:00	1.51+	S	WET	1.21	5.30	9.42	21.34	0.43	1.87	2.60	38
25	2/5/08 10:00	0.07	S	WET	0.07	0.57	1.13	3.96	0.05	0.33	0.46	39

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Load) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
26	2/14/08 17:25	T	RS	WET	.0025	0.23	0.14	2.76	0.14	0.44	0.58	40
27	2/22/08 10:30	0.46	S	WET	0.46	3.42	3.63	4.67	0.18	0.79	1.08	
28	2/25/08 18:30	1.96	S	WET	1.96	9.99	10.14	23.29	0.56	2.91	3.89	41
29	3/21/08 13:40	1.80	RS	WET	1.80	32.05	31.28	56.54	1.35	3.36	4.34	
30	4/2/08 10:15	0.08	S	WET	0.08	1.21	0.55	3.36	0.14	0.36	0.48	48
31	4/18/08 09:40	0.02		WET	0.02	2.12	1.56	8.48	0.07	0.27	0.33	49
32	5/2/08 10:00	0.31		WET	0.31	13.31	6.84	30.03	0.07	0.51	1.52	
33	5/13/08 15:10	0.23	R	WET	0.23	2.03	29.58	35.62	0.21	0.48	2.60	
34	5/28/08 11:45	0.52	RH	WET	0.52	20.52	22.10	35.51	0.39	NA	2.16	
35	6/4/08 10:10	0.11	R	WET	0.11	4.20	0.88	NA	0.09	0.94	4.63	50
	6/11/08 15:05	T		WET	T	NA	NA	NA	NA	NA	NA	
36	7/21/08 12:15	0.01	R	WET	0.01	3.57	5.89	NA	0.25	0.50	0.69	63
	9/17/08 10:15	T	R	WET	T	NA	NA	NA	NA	NA	NA	71

Appendix Table 2.a. N and P concentrations in dry deposition at the Ward Valley Lake Level Station 7/1/07-10/8/08.

	Ward Valley Dry	Lake Level				(Conc.)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	Notes
1	6/28/2007 13:59	7/13/2007 17:20	1.203	DF	DRY	C	C	C	C	C	C	1
2	7/13/2007 17:20	8/9/2007 10:15	0.5	DF	DRY	63.41	53.33	NA	15.65	16.16	NA	2
3	8/9/2007 10:15	8/20/2007 15:30	1.86	DF	DRY	C	C	C	C	C	C	3
4	8/20/2007 15:30	8/28/2007 10:00	2.707	DF	DRY	8.90	17.21	177.35	0.91	C	8.93	
5	8/28/2007 10:00	9/11/2007 10:10	2.191	DF	DRY	10.78	0.63	278.04	0.45	11.66	13.40	
6	9/11/2007 10:10	9/21/2007 14:00	2.85	DF	DRY	25.16	7.55	140.80	8.83	10.21	14.35	
7	9/21/2007 14:00	10/2/2007 15:45	3.288	DF	DRY	45.54	50.93	303.70	4.61	9.56	19.11	
8	10/2/2007 15:45	10/11/07 10:20	3.426	DF	DRY	18.42	4.72	235.71	13.61	20.81	29.60	
9	10/11/07 10:20	10/23/07 10:45	3.748	DF	DRY	27.43	6.14	299.55	2.07	5.87	8.95	19
10	10/23/07 10:45	11/5/07 09:00	3.620	DF	DRY	19.47	2.81	155.44	6.20	8.96	9.58	20
11	11/5/07 09:00	11/7/07 17:10	3.878	DF	DRY	15.48	59.23	102.30	1.61	3.71	4.95	21
12	11/7/07 17:10	11/14/07 14:10	3.394	DF	DRY	15.74	61.37	NA	1.14	4.33	4.95	22
13	11/14/07 14:10	11/21/07 09:55	3.532	DF	DRY	2.94	10.29	NA	1.62	5.49	16.01	23
14	11/21/07 09:55	11/30/07 14:15	2.786	DF	DRY	5.57	23.30	491.31	C	6.18	7.93	
15	11/30/07 14:15	12/12/07 14:50	NA	DF	DRY	8.61	15.84	115.60	2.32	5.49	13.73	24
16	12/12/07 14:50	12/21/07 11:15	3.558	DF	DRY	17.51	5.41	76.32	3.24	8.01	10.68	25
17	12/21/07 11:15	1/3/08 11:00	3.642	DF	DRY	7.75	18.06	51.94	3.01	7.70	18.31	
18	1/3/08 11:00	1/11/08 10:10	3.483	DF	DRY	12.25	7.05	230.31	3.86	6.10	13.73	
19	1/11/08 10:10	1/24/08 10:00	4.069	DF	DRY	25.21	27.94	62.35	3.62	3.66	23.41	42
20	1/24/08 10:00	2/5/08 10:00	4.590	DF	DRY	13.08	12.00	57.85	1.81	4.94	9.58	43
21	2/5/08 10:00	2/14/08 17:25	2.947	DF	DRY	11.28	11.16	60.99	5.88	8.32	32.04	
22	2/14/08 17:25	2/25/08 18:30	3.106	DF	DRY	22.56	30.63	76.86	2.26	7.39	24.49	44
23	2/25/08 18:30	3/6/08 17:20	2.567	DF	DRY	19.15	7.97	115.73	5.53	6.79	20.70	
24	3/6/08 17:20	3/19/08 17:15	1.935	DF	DRY	37.94	37.36	149.00	0.91	4.29	28.47	
25	3/19/08 17:15	4/2/08 10:15	1.751	DF	DRY	22.72	7.81	102.51	4.37	6.83	25.78	
26	4/2/08 10:15	4/18/08 09:40	2.133	DF	DRY	28.91	17.52	204.15	1.58	6.54	20.57	
27	4/18/08 09:40	5/2/08 10:00	2.200	DF	DRY	54.36	52.09	437.86	3.84	7.37	25.19	
28	5/2/08 10:00	5/13/08 15:10	2.278	DF	DRY	16.09	20.50	NA	7.66	11.07	151.21	
29	5/13/08 15:10	5/28/08 11:45	2.030	DF	DRY	3.46	4.78	NA	14.20	5.20	181.17	
30	5/28/08 11:45	6/11/08 15:05	1.615	DF	DRY	C	C	C	C	C	C	51

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
31	6/11/08 15:05	6/23/08 13:35	2.164	DF	DRY	12.93	9.04	NA	7.0	34.01	67.71	52
32	6/23/08 13:35	7/7/08 17:55	1.852	DF	DRY	14.04	2.41	NA	12.64	43.60	124.16	53
33	7/7/08 17:55	7/10/08 13:10	3.462	DF	DRY	26.23	27.20	NA	155.05	157.54	224.65	64
34	7/10/08 13:10	7/15/08 13:20	3.236	DF	DRY	15.08	5.95	NA	28.55	32.73	58.43	65
35	7/15/08 13:20	7/21/08 12:15	3.055	DF	DRY	13.68	5.22	NA	3.62	7.65	13.42	66
36	7/21/08 12:15	7/29/08 10:10	2.613	DF	DRY	9.20	5.23	NA	NA	12.24	23.49	67
37	7/29/08 10:10	8/20/08 20:15	0.730	DF	DRY	C	C	C	C	C	C	68
38	8/20/08 20:15	9/5/08 17:45	1.655	DF	DRY	C	C	C	C	C	C	69
39	9/5/08 17:45	9/17/08 10:15	2.627	DF	DRY	15.97	9.54	NA	1.35	3.40	11.14	70
40	9/17/08 10:15	10/8/08 11:40	2.637	DF	DRY	3.69	5.14	NA	3.93	3.10	10.54	72

Appendix Table 2.b. N and P loads in dry deposition at the Ward Valley Lake Level Station 7/1/07-10/8/08.

	Ward Valley Dry	Lake Level				(Load)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(g/ha)	(g/ha)	(g/ha)	(g/ha)	(g/ha)	(g/ha)	Notes
1	6/28/2007 13:59	7/13/2007 17:20	1.203	DF	DRY	C	C	C	C	C	C	1
2	7/13/2007 17:20	8/9/2007 10:15	0.5	DF	DRY	6.26	5.26	NA	1.54	1.59	NA	2
3	8/9/2007 10:15	8/20/2007 15:30	1.86	DF	DRY	C	C	C	C	C	C	3
4	8/20/2007 15:30	8/28/2007 10:00	2.707	DF	DRY	4.75	9.19	94.75	0.49	C	4.77	
5	8/28/2007 10:00	9/11/2007 10:10	2.191	DF	DRY	4.66	0.27	120.22	0.19	5.04	5.79	
6	9/11/2007 10:10	9/21/2007 14:00	2.85	DF	DRY	14.15	4.25	79.19	4.97	5.74	8.07	
7	9/21/2007 14:00	10/2/2007 15:45	3.288	DF	DRY	29.55	33.05	197.07	2.99	6.20	12.40	
8	10/2/2007 15:45	10/11/07 10:20	3.426	DF	DRY	12.45	3.19	159.37	9.20	14.07	20.01	
9	10/11/07 10:20	10/23/07 10:45	3.748	DF	DRY	20.29	4.54	221.57	1.53	4.34	6.62	19
10	10/23/07 10:45	11/5/07 09:00	3.620	DF	DRY	13.91	2.01	111.05	4.43	6.40	6.84	20
11	11/5/07 09:00	11/7/07 17:10	3.878	DF	DRY	11.85	45.33	78.29	1.23	2.84	3.79	21
12	11/7/07 17:10	11/14/07 14:10	3.394	DF	DRY	10.54	41.11	C	0.76	2.90	3.32	22
13	11/14/07 14:10	11/21/07 09:55	3.532	DF	DRY	2.05	7.17	C	1.13	3.83	11.16	23
14	11/21/07 09:55	11/30/07 14:15	2.786	DF	DRY	3.06	12.81	270.13	C	3.40	4.36	
15	11/30/07 14:15	12/12/07 14:50	NA	DF	DRY	NA	NA	NA	NA	NA	NA	24
16	12/12/07 14:50	12/21/07 11:15	3.558	DF	DRY	12.30	3.80	53.59	2.28	5.62	7.50	25
17	12/21/07 11:15	1/3/08 11:00	3.642	DF	DRY	5.57	12.98	37.33	2.16	5.53	13.16	
18	1/3/08 11:00	1/11/08 10:10	3.483	DF	DRY	8.42	4.85	158.31	2.65	4.19	9.44	
19	1/11/08 10:10	1/24/08 10:00	4.069	DF	DRY	20.24	22.44	50.07	2.91	2.94	18.80	42
20	1/24/08 10:00	2/5/08 10:00	4.590	DF	DRY	11.85	10.87	52.40	1.64	4.47	8.68	43
21	2/5/08 10:00	2/14/08 17:25	2.947	DF	DRY	6.56	6.49	35.47	3.42	4.84	18.63	
22	2/14/08 17:25	2/25/08 18:30	3.106	DF	DRY	13.83	18.78	47.11	1.39	4.53	15.01	44
23	2/25/08 18:30	3/6/08 17:20	2.567	DF	DRY	9.70	4.04	58.63	2.80	3.44	10.49	
24	3/6/08 17:20	3/19/08 17:15	1.935	DF	DRY	14.49	14.27	56.90	0.35	1.64	10.87	
25	3/19/08 17:15	4/2/08 10:15	1.751	DF	DRY	7.85	2.70	35.42	1.51	2.36	8.91	
26	4/2/08 10:15	4/18/08 09:40	2.133	DF	DRY	12.17	7.38	85.94	0.67	2.75	8.66	
27	4/18/08 09:40	5/2/08 10:00	2.200	DF	DRY	23.60	22.62	190.11	1.67	3.20	10.94	
28	5/2/08 10:00	5/13/08 15:10	2.278	DF	DRY	7.23	9.22	NA	3.44	4.98	67.98	
29	5/13/08 15:10	5/28/08 11:45	2.030	DF	DRY	1.39	1.91	NA	5.69	2.08	72.58	
30	5/28/08 11:45	6/11/08 15:05	1.615	DF	DRY	C	C	C	C	C	C	51

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
31	6/11/08 15:05	6/23/08 13:35	2.164	DF	DRY	5.52	3.86	NA	2.99	14.52	28.92	52
32	6/23/08 13:35	7/7/08 17:55	1.852	DF	DRY	5.13	0.88	NA	4.62	15.94	45.38	53
33	7/7/08 17:55	7/10/08 13:10	3.462	DF	DRY	17.92	18.58	NA	105.94	107.64	153.49	64
34	7/10/08 13:10	7/15/08 13:20	3.236	DF	DRY	9.63	3.80	NA	18.23	20.90	37.32	65
35	7/15/08 13:20	7/21/08 12:15	3.055	DF	DRY	8.25	3.15	NA	2.18	4.61	8.09	66
36	7/21/08 12:15	7/29/08 10:10	2.613	DF	DRY	4.74	2.70	NA	NA	6.31	12.11	67
37	7/29/08 10:10	8/20/08 20:15	0.730	DF	DRY	C	C	NA	C	C	C	68
38	8/20/08 20:15	9/5/08 17:45	1.655	DF	DRY	C	C	NA	C	C	C	69
39	9/5/08 17:45	9/17/08 10:15	2.627	DF	DRY	8.28	4.95	NA	0.70	1.76	5.78	70
40	9/17/08 10:15	10/8/08 11:40	2.637	DF	DRY	1.92	2.67	NA	2.05	1.61	5.49	72

Appendix Table 2.c. N and P loading per day in dry deposition at the Ward Valley Lake Level Station 7/1/07-10/8/08.

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) 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)	Notes
1	6/28/2007 13:59	7/13/2007 17:20	1.203	DF	DRY	C	C	C	C	C	C	1
2	7/13/2007 17:20	8/9/2007 10:15	0.5	DF	DRY	0.23	0.20	NA	0.06	0.06	NA	2
3	8/9/2007 10:15	8/20/2007 15:30	1.86	DF	DRY	C	C	C	C	C	C	3
4	8/20/2007 15:30	8/28/2007 10:00	2.707	DF	DRY	0.61	1.18	12.19	0.06	C	0.61	
5	8/28/2007 10:00	9/11/2007 10:10	2.191	DF	DRY	0.33	0.02	8.58	0.01	0.36	0.41	
6	9/11/2007 10:10	9/21/2007 14:00	2.85	DF	DRY	1.39	0.42	7.79	0.49	0.57	0.79	
7	9/21/2007 14:00	10/2/2007 15:45	3.288	DF	DRY	2.67	2.98	17.80	0.27	0.56	1.12	
8	10/2/2007 15:45	10/11/07 10:20	3.426	DF	DRY	1.42	0.36	18.16	1.05	1.60	2.28	
9	10/11/07 10:20	10/23/07 10:45	3.748	DF	DRY	1.69	0.38	18.44	0.13	0.36	0.55	19
10	10/23/07 10:45	11/5/07 09:00	3.620	DF	DRY	1.08	0.16	8.59	0.34	0.50	0.53	20
11	11/5/07 09:00	11/7/07 17:10	3.878	DF	DRY	5.06	19.37	33.45	0.53	1.21	1.62	21
12	11/7/07 17:10	11/14/07 14:10	3.394	DF	DRY	1.53	5.98	NA	0.11	0.42	0.48	22
13	11/14/07 14:10	11/21/07 09:55	3.532	DF	DRY	0.30	1.05	NA	0.17	0.56	1.64	23
14	11/21/07 09:55	11/30/07 14:15	2.786	DF	DRY	0.33	1.40	29.42	C	0.37	0.47	
15	11/30/07 14:15	12/12/07 14:50	NA	DF	DRY	NA	NA	NA	NA	NA	NA	24
16	12/12/07 14:50	12/21/07 11:15	3.558	DF	DRY	1.39	0.43	6.05	0.26	0.64	0.85	25
17	12/21/07 11:15	1/3/08 11:00	3.642	DF	DRY	0.43	1.00	2.87	0.17	0.43	1.01	
18	1/3/08 11:00	1/11/08 10:10	3.483	DF	DRY	1.06	0.61	19.88	0.33	0.53	1.18	
19	1/11/08 10:10	1/24/08 10:00	4.069	DF	DRY	1.56	1.73	3.85	0.22	0.23	1.45	42
20	1/24/08 10:00	2/5/08 10:00	4.590	DF	DRY	0.99	0.91	4.37	0.14	0.37	0.72	43
21	2/5/08 10:00	2/14/08 17:25	2.947	DF	DRY	0.70	0.70	3.81	0.37	0.52	2.00	
22	2/14/08 17:25	2/25/08 18:30	3.106	DF	DRY	1.25	1.70	4.27	0.13	0.41	1.36	44
23	2/25/08 18:30	3/6/08 17:20	2.567	DF	DRY	0.97	0.41	5.89	0.28	0.35	1.05	
24	3/6/08 17:20	3/19/08 17:15	1.935	DF	DRY	1.11	1.10	4.38	0.03	0.13	0.84	
25	3/19/08 17:15	4/2/08 10:15	1.751	DF	DRY	0.57	0.20	2.58	0.11	0.17	0.65	
26	4/2/08 10:15	4/18/08 09:40	2.133	DF	DRY	0.76	0.46	5.38	0.04	0.17	0.54	
27	4/18/08 09:40	5/2/08 10:00	2.200	DF	DRY	1.68	1.61	13.57	0.12	0.23	0.78	
28	5/2/08 10:00	5/13/08 15:10	2.278	DF	DRY	0.64	0.82	NA	0.31	0.44	6.06	
29	5/13/08 15:10	5/28/08 11:45	2.030	DF	DRY	0.09	0.13	NA	0.38	0.14	4.89	
30	5/28/08 11:45	6/11/08 15:05	1.615	DF	DRY	C	C	C	C	C	C	51

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) 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)	Notes
31	6/11/08 15:05	6/23/08 13:35	2.164	DF	DRY	0.46	0.32	NA	0.25	1.22	2.42	52
32	6/23/08 13:35	7/7/08 17:55	1.852	DF	DRY	0.36	0.06	NA	0.33	1.12	3.20	53
33	7/7/08 17:55	7/10/08 13:10	3.462	DF	DRY	6.40	6.63	NA	37.81	38.41	54.78	64
34	7/10/08 13:10	7/15/08 13:20	3.236	DF	DRY	1.92	0.76	NA	3.64	4.17	7.45	65
35	7/15/08 13:20	7/21/08 12:15	3.055	DF	DRY	1.39	0.53	NA	0.37	0.77	1.36	66
36	7/21/08 12:15	7/29/08 10:10	2.613	DF	DRY	0.60	0.34	NA	NA	0.80	1.53	67
37	7/29/08 10:10	8/20/08 20:15	0.730	DF	DRY	C	C	C	C	C	C	68
38	8/20/08 20:15	9/5/08 17:45	1.655	DF	DRY	C	C	C	C	C	C	69
39	9/5/08 17:45	9/17/08 10:15	2.627	DF	DRY	0.71	0.42	NA	0.06	0.15	0.49	70
40	9/17/08 10:15	10/8/08 11:40	2.637	DF	DRY	0.09	0.13	NA	0.10	0.08	0.26	72

Appendix Table 3.a. Precipitation amounts, N and P concentrations in bulk deposition collected in Snow Tube collector at the Mid-lake Buoy (TB-1) Station 7/1/07-8/15/08.

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
	6/27/2007 8:15	7/26/2007 10:18	0.01	DF	ST	NA	NA	NA	NA	NA	NA	4
	7/26/2007 10:18	8/15/2007 9:32	0	DF	ST	NA	NA	NA	NA	NA	NA	
	8/15/2007 9:32	8/28/2007 14:57	0	DF	ST	NA	NA	NA	NA	NA	NA	
	8/28/2007 14:57	9/11/2007 8:42	0.01	DF	ST	NA	NA	NA	NA	NA	NA	5
1	9/11/2007 8:42	10/2/2007 14:15	0.21	R+S+DF	ST	848.85	333.50	945.74	25.15	37.30	105.43	6
2	10/2/2007 14:15	10/11/07 14:40	0.29	S+DF	ST	929.20	380.00	1088.32	42.22	62.67	117.72	
3	10/11/07 14:40	10/23/07 12:35	0.10	R+S+DF	ST	64.60	58.28	117.45	5.05	10.19	11.73	26
4	10/23/07 12:35	11/5/07 09:42	0.13	R+DF	ST	173.45	159.23	311.59	25.47	36.74	38.59	27
5	11/5/07 09:42	11/13/07 14:05	0.38	R+DF	ST	363.37	205.12	3438.44	19.46	25.32	40.14	
6	11/13/07 14:05	12/13/07 12:36	0.61+	R+S+DF	ST	18.52	157.70	328.44	12.05	29.57	31.42	28
	12/13/07 12:36	1/11/08 11:40	NA	R+S+DF		NA	NA	NA	NA	NA	NA	45
7	1/11/08 11:40	2/5/08 14:47	0.64+	R+S+DF	ST	144.60	94.93	283.66	3.39	7.01	15.10	46
	2/5/08 14:47	2/15/08 13:58	T	R+S+DF	ST	NA	NA	NA	NA	NA	NA	
8	2/15/08 13:58	2/26/08 11:26	0.46	S+DF	ST	302.05	230.05	401.18	4.52	10.78	11.33	
	2/26/08 11:26	3/12/08 10:00	0	DF	ST	NA	NA	NA	NA	NA	NA	
9	3/12/08 10:00	3/24/08 09:38	0.20	S+DF	ST	69.67	212.37	349.38	4.53	7.65	12.86	47
10	3/24/08 09:38	4/3/08 11:27	0.01	S+DF	ST	43.84	38.95	1479.65	2.49	4.67	4.99	54
	4/3/08 11:27	4/26/08 12:15	0	DF	ST	NA	NA	NA	NA	NA	NA	
11	4/26/08 12:15	5/29/08 14:14	0.40	R+DF	ST	88.94	424.31	1276.09	32.67	68.03	170.50	
	5/29/08 14:14	6/25/08 10:20	0	DF	ST	NA	NA	NA	NA	NA	NA	
	6/25/08 10:20	7/3/08 10:50	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/3/08 10:50	7/10/08 08:12	0	DF	ST	NA	NA	NA	NA	NA	NA	73
	7/10/08 08:12	7/15/08 10:25	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/15/08 10:25	7/29/08 09:28	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/29/08 09:28	8/15/08 09:50	0	DF	ST	NA	NA	NA	NA	NA	NA	74

Appendix Table 3.b. Precipitation amounts, N and P loads in bulk deposition collected in Snow Tube collector at the Mid-lake Buoy (TB-1) Station 7/1/07-8/15/08.

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Load) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
	6/27/2007 8:15	7/26/2007 10:18	0.01	DF	ST	C	C	C	C	C	C	4
	7/26/2007 10:18	8/15/2007 9:32	0	DF	ST	NA	NA	NA	NA	NA	NA	
	8/15/2007 9:32	8/28/2007 14:57	0	DF	ST	NA	NA	NA	NA	NA	NA	
	8/28/2007 14:57	9/11/2007 8:42	0.01	DF	ST	C	C	C	C	C	C	5
1	9/11/2007 8:42	10/2/2007 14:15	0.21	R+S+DF	ST	130.83	51.40	145.76	3.88	5.75	16.25	6
2	10/2/2007 14:15	10/11/07 14:40	0.29	S+DF	ST	68.44	27.99	80.17	3.11	4.62	8.67	
3	10/11/07 14:40	10/23/07 12:35	0.10	R+S+DF	ST	9.96	8.98	18.10	0.78	1.57	1.81	26
4	10/23/07 12:35	11/5/07 09:42	0.13	R+DF	ST	26.73	24.54	48.02	3.93	5.66	5.95	27
5	11/5/07 09:42	11/13/07 14:05	0.38	R+DF	ST	35.07	19.80	331.88	1.88	2.44	3.87	
6	11/13/07 14:05	12/13/07 12:36	0.61+	R+S+DF	ST	2.87	24.43	50.89	1.87	4.58	4.87	28
	12/13/07 12:36	1/11/08 11:40	NA	R+S+DF		NA	NA	NA	NA	NA	NA	45
7	1/11/08 11:40	2/5/08 14:47	0.64+	R+S+DF	ST	23.51	15.43	46.11	0.55	1.14	2.45	46
	2/5/08 14:47	2/15/08 13:58	T	R+S+DF	ST	NA	NA	NA	NA	NA	NA	
8	2/15/08 13:58	2/26/08 11:26	0.46	S+DF	ST	35.29	26.88	46.87	0.53	1.26	1.32	
	2/26/08 11:26	3/12/08 10:00	0	DF	ST	NA	NA	NA	NA	NA	NA	
9	3/12/08 10:00	3/24/08 09:38	0.20	S+DF	ST	10.74	32.73	53.85	0.70	1.18	1.98	47
10	3/24/08 09:38	4/3/08 11:27	0.01	S+DF	ST	6.76	6.00	228.05	0.38	0.72	0.77	54
	4/3/08 11:27	4/26/08 12:15	0	DF	ST	NA	NA	NA	NA	NA	NA	
11	4/26/08 12:15	5/29/08 14:14	0.40	R+DF	ST	9.04	43.11	129.65	3.32	6.91	17.32	
	5/29/08 14:14	6/25/08 10:20	0	DF	ST	NA	NA	NA	NA	NA	NA	
	6/25/08 10:20	7/3/08 10:50	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/3/08 10:50	7/10/08 08:12	0	DF	ST	NA	NA	NA	NA	NA	NA	73
	7/10/08 08:12	7/15/08 10:25	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/15/08 10:25	7/29/08 09:28	0	DF	ST	NA	NA	NA	NA	NA	NA	
	7/29/08 09:28	8/15/08 09:50	0	DF	ST	NA	NA	NA	NA	NA	NA	74

Appendix Table 4.a. N and P concentrations in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 7/1/07-10/8/08.

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO3-N (µg/l)	NH4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
1	6/28/2007 7:35	7/26/2007 10:18	0.500	DF	DRY-BULK	C	C	C	C	C	C	83
2	7/26/2007 10:18	7/27/2007 9:57	3.283	DF	DRY-BULK	NA	NA	28.61	NA	NA	4.47	
3	7/27/2007 9:57	8/15/2007 9:32	0.500	DF	DRY-BULK	236.18	65.08	317.63	14.60	24.55	68.26	7
4	8/15/2007 9:32	8/28/2007 14:57	0.500	DF	DRY-BULK	255.86	533.36	1031.87	17.92	33.87	81.66	7
5	8/28/2007 14:57	9/11/2007 8:42	0.500	DF	DRY-BULK	533.12	419.96	759.01	4.54	19.27	24.72	7
6	9/11/2007 8:42	10/2/2007 14:15	0.500	DF	DRY-BULK	789.58	348.04	680.79	13.38	21.89	56.41	7
7	10/2/2007 14:15	10/11/07 14:40	0.500	DF+S	DRY-BULK	226.55	275.72	399.08	1.15	7.41	10.28	29
8	10/11/07 14:40	10/23/07 12:35	0.772	DF+R	DRY-BULK	289.38	13.90	696.63	6.65	12.66	16.67	
9	10/23/07 12:35	11/5/07 09:42	1.564	DF+R	DRY-BULK	197.35	253.53	344.81	4.82	11.11	25.01	30
10	11/5/07 09:42	11/13/07 14:05	2.678	DF+R	DRY-BULK	43.18	79.60	51.80	1.14	5.85	4.27	
11	11/13/07 14:05	12/13/07 12:36	0.722	DF+R+S	DRY-BULK	288.96	25.82	416.89	2.78	6.71	21.96	
12	12/13/07 12:36	1/11/08 11:40	0.646	DF+R+S	DRY-BULK	331.91	186.90	338.79	7.71	6.40	18.91	
13	1/11/08 11:40	2/5/08 14:47	0.600	DF+S	DRY-BULK	197.27	139.12	180.50	1.81	5.49	12.01	
14	2/5/08 14:47	2/15/08 13:58	1.680	DF+R+S	DRY-BULK	61.94	41.11	73.91	2.26	7.39	8.93	
15	2/15/08 13:58	2/26/08 11:26	3.260	DF+S	DRY-BULK	49.51	49.90	70.38	0.90	5.90	6.52	
16	2/26/08 11:26	3/12/08 10:00	0.320	DF	DRY-BULK	405.01	453.32	464.33	8.35	8.26	10.71	
17	3/12/08 10:00	3/24/08 09:38	0.745	DF+R+S	DRY-BULK	149.37	136.83	178.49	2.95	6.43	7.96	
18	3/24/08 09:38	4/3/08 11:27	0.765	DF+S	DRY-BULK	134.38	110.19	338.64	1.58	4.67	9.97	
19	4/3/08 11:27	4/26/08 12:15	0.500	DF+R	DRY-BULK	165.01	119.41	310.47	7.00	11.07	35.53	55
20	4/26/08 12:15	5/29/08 14:14	0.595	DF+R	DRY-BULK	70.08	38.21	NA	15.85	49.35	126.47	56
21	5/29/08 14:14	6/25/08 10:20	0.500	DF	DRY-BULK	199.11	95.67	NA	33.41	45.76	69.82	57
22	6/25/08 10:20	7/3/08 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/08 10:50	7/10/08 08:12	0.939	DF	DRY-BULK	158.48	277.85	NA	101.81	110.39	184.60	75
24	7/10/08 08:12	7/15/08 10:25	2.040	DF	DRY-BULK	64.62	130.54	NA	10.57	11.93	19.43	76
25	7/15/08 10:25	7/22/08 07:38	0.822	DF+R?	DRY-BULK	147.29	347.93	NA	7.46	10.71	13.12	77
26	7/22/08 07:38	7/29/08 09:28	0.676	DF	DRY-BULK	268.32	634.22	NA	6.07	10.40	20.44	78
27	7/29/08 09:28	8/15/08 09:50	0.500	DF	DRY-BULK	169.41	101.17	NA	11.46	24.77	56.97	79
28	8/15/08 09:50	9/5/08 13:50	0.500	DF	DRY-BULK	38.75	149.34	NA	12.61	25.39	89.32	79
29	9/5/08 13:50	9/16/08 10:00	0.690	DF	DRY-BULK	227.35	231.76	NA	5.41	8.66	38.99	
30	9/16/08 10:00	10/8/08 10:40	0.535	DF+R	DRY-BULK	488.38	354.86	NA	2.70	7.13	28.22	80

Appendix Table 4.b. N and P loads in dry-bulk deposition (buoy bucket) at the Mid-lake Buoy (TB-1) Station 7/1/07-10/8/08.

	Mid-lake (TB-1)	Dry-Bulk				(Load)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(g/ha)	(g/ha)	(g/ha)	(g/ha)	(g/ha)	(g/ha)	Notes
1	6/28/2007 7:35	7/26/2007 10:18	0.500	DF	DRY-BULK	C	C	C	C	C	C	7
2	7/26/2007 10:18	7/27/2007 9:57	3.283	DF	DRY-BULK	NA	NA	18.54	NA	NA	2.90	
3	7/27/2007 9:57	8/15/2007 9:32	0.500	DF	DRY-BULK	23.31	6.42	31.34	NA	2.42	6.74	7
4	8/15/2007 9:32	8/28/2007 14:57	0.500	DF	DRY-BULK	25.25	52.63	101.82	1.77	3.34	8.06	7
5	8/28/2007 14:57	9/11/2007 8:42	0.500	DF	DRY-BULK	52.61	41.44	74.90	0.45	1.90	2.44	7
6	9/11/2007 8:42	10/2/2007 14:15	0.500	DF	DRY-BULK	77.91	34.34	67.18	1.32	2.16	5.57	7
7	10/2/2007 14:15	10/11/07 14:40	0.500	DF+S	DRY-BULK	30.40	37.00	53.56	0.15	0.99	1.38	29
8	10/11/07 14:40	10/23/07 12:35	0.772	DF+R	DRY-BULK	44.09	2.12	106.14	1.38	1.93	2.54	
9	10/23/07 12:35	11/5/07 09:42	1.564	DF+R	DRY-BULK	60.91	78.25	106.43	1.49	3.43	7.72	30
10	11/5/07 09:42	11/13/07 14:05	2.678	DF+R	DRY-BULK	22.82	42.07	27.38	0.60	3.09	2.26	
11	11/13/07 14:05	12/13/07 12:36	0.722	DF+R+S	DRY-BULK	41.17	3.68	59.40	0.40	0.96	3.13	
12	12/13/07 12:36	1/11/08 11:40	0.646	DF+R+S	DRY-BULK	42.32	23.83	43.19	0.98	0.82	2.41	
13	1/11/08 11:40	2/5/08 14:47	0.600	DF+S	DRY-BULK	23.36	16.47	21.37	0.21	0.65	1.42	
14	2/5/08 14:47	2/15/08 13:58	1.680	DF+R+S	DRY-BULK	20.54	13.63	24.51	0.75	2.45	2.96	
15	2/15/08 13:58	2/26/08 11:26	3.260	DF+S	DRY-BULK	31.85	32.10	45.28	0.58	3.80	4.19	
16	2/26/08 11:26	3/12/08 10:00	0.320	DF	DRY-BULK	25.58	28.63	29.32	0.53	0.52	0.68	
17	3/12/08 10:00	3/24/08 09:38	0.745	DF+R+S	DRY-BULK	21.96	20.12	26.24	0.43	0.95	1.17	
18	3/24/08 09:38	4/3/08 11:27	0.765	DF+S	DRY-BULK	20.29	16.64	51.13	0.24	0.71	1.51	
19	4/3/08 11:27	4/26/08 12:15	0.500	DF+R	DRY-BULK	16.28	11.78	30.64	0.69	1.09	3.51	55
20	4/26/08 12:15	5/29/08 14:14	0.595	DF+R	DRY-BULK	8.23	4.49	NA	1.86	5.79	14.85	56
21	5/29/08 14:14	6/25/08 10:20	0.500	DF	DRY-BULK	19.65	9.44	NA	3.30	4.52	6.89	57
22	6/25/08 10:20	7/3/08 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/08 10:50	7/10/08 08:12	0.939	DF	DRY-BULK	29.37	51.49	NA	18.87	20.46	34.21	75
24	7/10/08 08:12	7/15/08 10:25	2.040	DF	DRY-BULK	26.02	52.56	NA	4.26	4.80	7.82	76
25	7/15/08 10:25	7/22/08 07:38	0.822	DF+R?	DRY-BULK	23.89	56.44	NA	1.21	1.74	2.13	77
26	7/22/08 07:38	7/29/08 09:28	0.676	DF	DRY-BULK	35.80	84.61	NA	0.81	1.39	2.73	78
27	7/29/08 09:28	8/15/08 09:50	0.500	DF	DRY-BULK	16.72	9.98	NA	1.13	2.44	5.62	79
28	8/15/08 09:50	9/5/08 13:50	0.500	DF	DRY-BULK	3.82	14.74	NA	1.24	2.51	8.81	79
29	9/5/08 13:50	9/16/08 10:00	0.690	DF	DRY-BULK	30.96	31.56	NA	0.74	1.18	5.31	
30	9/16/08 10:00	10/8/08 10:40	0.535	DF+R	DRY-BULK	51.56	37.47	NA	0.29	0.75	2.98	80

Appendix Table 4.c. N and P loading per day in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 7/1/07-10/8/08.

	Mid-lake (TB-1)	Dry-Bulk				(Load/day)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	Notes
1	6/28/2007 7:35	7/26/2007 10:18	0.500	DF	DRY-BULK	C	C	C	C	C	C	7
2	7/26/2007 10:18	7/27/2007 9:57	3.283	DF	DRY-BULK	NA	NA	18.81	NA	NA	2.94	
3	7/27/2007 9:57	8/15/2007 9:32	0.500	DF	DRY-BULK	1.23	0.34	1.65	NA	0.13	0.35	7
4	8/15/2007 9:32	8/28/2007 14:57	0.500	DF	DRY-BULK	1.91	3.98	7.70	0.13	0.25	0.61	7
5	8/28/2007 14:57	9/11/2007 8:42	0.500	DF	DRY-BULK	3.83	3.02	5.45	0.03	0.14	0.18	7
6	9/11/2007 8:42	10/2/2007 14:15	0.500	DF	DRY-BULK	3.67	1.62	3.16	0.06	0.10	0.26	7
7	10/2/2007 14:15	10/11/07 14:40	0.500	DF+S	DRY-BULK	3.37	4.10	5.94	0.02	0.11	0.15	29
8	10/11/07 14:40	10/23/07 12:35	0.772	DF+R	DRY-BULK	3.70	0.18	8.91	0.12	0.16	0.21	
9	10/23/07 12:35	11/5/07 09:42	1.564	DF+R	DRY-BULK	4.73	6.08	8.26	0.12	0.27	0.60	30
10	11/5/07 09:42	11/13/07 14:05	2.678	DF+R	DRY-BULK	2.79	5.14	3.35	0.07	0.38	0.28	
11	11/13/07 14:05	12/13/07 12:36	0.722	DF+R+S	DRY-BULK	1.38	0.12	1.98	0.01	0.03	0.10	
12	12/13/07 12:36	1/11/08 11:40	0.646	DF+R+S	DRY-BULK	1.46	0.82	1.49	0.03	0.03	0.08	
13	1/11/08 11:40	2/5/08 14:47	0.600	DF+S	DRY-BULK	0.93	0.66	0.85	0.01	0.03	0.06	
14	2/5/08 14:47	2/15/08 13:58	1.680	DF+R+S	DRY-BULK	2.06	1.37	2.46	0.08	0.25	0.30	
15	2/15/08 13:58	2/26/08 11:26	3.260	DF+S	DRY-BULK	2.92	2.95	4.16	0.05	0.35	0.39	
16	2/26/08 11:26	3/12/08 10:00	0.320	DF	DRY-BULK	1.71	1.92	1.96	0.04	0.03	0.05	
17	3/12/08 10:00	3/24/08 09:38	0.745	DF+R+S	DRY-BULK	1.83	1.68	2.19	0.04	0.08	0.10	
18	3/24/08 09:38	4/3/08 11:27	0.765	DF+S	DRY-BULK	2.01	1.65	5.07	0.02	0.07	0.15	
19	4/3/08 11:27	4/26/08 12:15	0.500	DF+R	DRY-BULK	0.71	0.51	1.33	0.03	0.05	0.15	55
20	4/26/08 12:15	5/29/08 14:14	0.595	DF+R	DRY-BULK	0.25	0.14	NA	0.06	0.18	0.45	56
21	5/29/08 14:14	6/25/08 10:20	0.500	DF	DRY-BULK	0.73	0.35	NA	0.12	0.17	0.26	57
22	6/25/08 10:20	7/3/08 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/08 10:50	7/10/08 08:12	0.939	DF	DRY-BULK	4.26	7.47	NA	2.74	2.97	4.96	75
24	7/10/08 08:12	7/15/08 10:25	2.040	DF	DRY-BULK	5.11	10.32	NA	0.84	0.94	1.54	76
25	7/15/08 10:25	7/22/08 07:38	0.822	DF+R?	DRY-BULK	3.47	8.20	NA	0.18	0.25	0.31	77
26	7/22/08 07:38	7/29/08 09:28	0.676	DF	DRY-BULK	5.06	11.96	NA	0.11	0.20	0.39	78
27	7/29/08 09:28	8/15/08 09:50	0.500	DF	DRY-BULK	0.98	0.59	NA	0.07	0.14	0.33	79
28	8/15/08 09:50	9/5/08 13:50	0.500	DF	DRY-BULK	0.18	0.70	NA	0.06	0.12	0.42	79
29	9/5/08 13:50	9/16/08 10:00	0.690	DF	DRY-BULK	2.86	2.91	NA	0.07	0.11	0.49	
30	9/16/08 10:00	10/8/08 10:40	0.535	DF+R	DRY-BULK	2.34	1.70	NA	0.01	0.03	0.14	80

Table 5.a. N and P concentrations in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 7/1/07-10/8/08.

	Buoy TB-4	Dry-Bulk				(Conc.)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(μg/l)	(μg/l)	(μg/l)	(μg/l)	(μg/l)	(μg/l)	Notes
1	6/28/2007 6:46	7/26/2007 9:37	0.500	DF	DRY-BULK	295.23	122.83	416.37	28.07	23.92	105.26	7
2	7/26/2007 9:37	7/27/2007 9:20	2.885	DF	DRY-BULK	NA	NA	22.01	NA	NA	3.51	
3	7/27/2007 9:20	8/15/2007 9:02	0.500	DF	DRY-BULK	211.36	76.63	186.03	NA	13.05	33.81	7
4	8/15/2007 9:02	8/28/2007 15:40	0.500	DF	DRY-BULK	236.18	169.56	635.75	6.58	17.71	40.51	7
5	8/28/2007 15:40	9/11/2007 8:20	0.500	DF	DRY-BULK	440.70	338.06	721.37	5.90	17.40	30.30	7
6	9/11/2007 8:20	10/2/2007 13:45	0.500	DF	DRY-BULK	785.14	411.57	710.50	11.31	17.57	61.96	7
7	10/2/2007 13:45	10/11/07 13:13	0.528	DF+S	DRY-BULK	354.87	550.84	581.78	7.00	14.82	21.18	31
8	10/11/07 13:13	10/23/07 12:00	0.658	DF+R	DRY-BULK	299.12	720.58	787.72	5.74	10.19	12.97	
9	10/23/07 12:00	11/5/07 09:04	1.792	DF+R	DRY-BULK	146.02	246.87	359.35	3.21	10.50	11.42	32
10	11/5/07 09:04	11/13/07 14:45	2.235	DF+R	DRY-BULK	41.55	71.02	62.10	1.14	4.02	4.33	
11	11/13/07 14:45	12/13/07 13:20	0.616	DF+R+S	DRY-BULK	11.62	223.43	327.08	2.78	5.56	10.07	
12	12/13/07 13:20	1/11/08 10:33	0.818	DF+R+S	DRY-BULK	277.09	170.49	322.17	5.90	7.39	17.08	
13	1/11/08 10:33	2/5/08 15:32	1.028	DF+S	DRY-BULK	108.67	87.18	104.00	2.49	7.62	15.10	
14	2/5/08 15:32	2/15/08 14:41	1.673	DF+R+S	DRY-BULK	57.54	30.34	60.99	2.26	6.47	8.01	
15	2/15/08 14:41	2/26/08 10:52	3.320	DF+S	DRY-BULK	49.70	73.57	78.38	0.90	6.16	8.88	
16	2/26/08 10:52	3/12/08 09:44	0.444	DF	DRY-BULK	340.94	346.44	376.02	7.44	7.35	13.17	
17	3/12/08 09:44	3/24/08 10:02	1.031	DF+R+S	DRY-BULK	116.65	91.30	127.45	2.27	6.43	11.33	
18	3/24/08 10:02	4/3/07 11:09	0.511	DF+S	DRY-BULK	178.41	151.22	739.82	1.36	3.74	12.15	
19	4/3/07 11:09	4/26/08 11:57	0.500	DF+R	DRY-BULK	201	206.82	752.95	5.20	8.10	35.21	59
20	4/26/08 11:57	5/29/08 14:55	0.500	DF+R	DRY-BULK	60.04	35.60	NA	31.77	37.01	174.79	60
21	5/29/08 14:55	6/25/08 09:40	0.500	DF	DRY-BULK	197.27	194.93	NA	18.06	30.30	45.23	61
22	6/25/08 09:40	7/3/08 10:22	0.962	DF	DRY-BULK	122.28	228.41	660.90	18.28	31.54	NA	62
23	7/3/08 10:22	7/10/08 07:50	0.910	DF	DRY-BULK	144.07	326.00	NA	109.26	118.74	164.81	81
24	7/10/08 07:50	7/15/08 10:55	1.837	DF	DRY-BULK	72.77	151.10	NA	4.83	7.65	29.45	
25	7/15/08 10:55	7/22/08 07:20	0.615	DF	DRY-BULK	317.78	423.81	NA	4.98	7.04	13.27	
26	7/22/08 07:20	7/29/08 08:50	0.545	DF	DRY-BULK	278.12	850.82	NA	6.07	10.71	38.39	78
27	7/29/08 08:50	8/15/08 09:50	0.500	DF	DRY-BULK	152.20	195.75	NA	11.88	43.03	22.60	
28	8/15/08 09:50	9/5/08 13:25	0.500	DF	DRY-BULK	46.26	92.52	NA	28.03	42.83	149.28	
29	9/5/08 13:25	9/16/08 09:35	0.248	DF	DRY-BULK	568.38	590.87	NA	4.28	9.59	80.45	
30	9/16/08 09:35	10/8/08 10:15	0.500	DF+R	DRY-BULK	453.21	342.86	NA	7.19	10.85	22.02	82

Appendix Table 5.b. N and P loads in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 7/1/07-10/8/08.

Samp. No.	Buoy TB-4 Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	6/28/2007 6:46	7/26/2007 9:37	0.500	DF	DRY-BULK	29.13	12.12	41.09	NA	2.36	10.39	7
2	7/26/2007 9:37	7/27/2007 9:20	2.885	DF	DRY-BULK	NA	NA	12.53	NA	NA	2.00	
3	7/27/2007 9:20	8/15/2007 9:02	0.500	DF	DRY-BULK	20.86	7.56	18.36	NA	1.29	3.34	7
4	8/15/2007 9:02	8/28/2007 15:40	0.500	DF	DRY-BULK	23.31	16.73	62.73	0.65	1.75	4.00	7
5	8/28/2007 15:40	9/11/2007 8:20	0.500	DF	DRY-BULK	43.49	33.36	71.18	0.58	1.72	2.99	7
6	9/11/2007 8:20	10/2/2007 13:45	0.500	DF	DRY-BULK	77.47	40.61	70.11	1.12	1.73	6.11	7
7	10/2/2007 13:45	10/11/07 13:13	0.528	DF+S	DRY-BULK	57.40	57.40	60.62	0.73	1.54	2.21	31
8	10/11/07 13:13	10/23/07 12:00	0.658	DF+R	DRY-BULK	93.57	93.57	102.29	0.75	1.32	1.68	
9	10/23/07 12:00	11/5/07 09:04	1.792	DF+R	DRY-BULK	87.31	87.31	127.09	1.14	3.71	4.04	32
10	11/5/07 09:04	11/13/07 14:45	2.235	DF+R	DRY-BULK	31.33	31.33	27.39	0.50	1.77	1.91	
11	11/13/07 14:45	12/13/07 13:20	0.616	DF+R+S	DRY-BULK	27.16	27.16	39.76	0.34	0.68	1.22	
12	12/13/07 13:20	1/11/08 10:33	0.818	DF+R+S	DRY-BULK	27.52	27.52	52.01	0.95	1.19	2.76	
13	1/11/08 10:33	2/5/08 15:32	1.028	DF+S	DRY-BULK	17.69	17.69	21.10	0.51	1.55	3.06	
14	2/5/08 15:32	2/15/08 14:41	1.673	DF+R+S	DRY-BULK	10.02	10.02	20.14	0.75	2.14	2.64	
15	2/15/08 14:41	2/26/08 10:52	3.320	DF+S	DRY-BULK	48.20	48.20	51.36	0.59	4.04	5.82	
16	2/26/08 10:52	3/12/08 09:44	0.444	DF	DRY-BULK	30.36	30.36	32.95	0.65	0.64	1.15	
17	3/12/08 09:44	3/24/08 10:02	1.031	DF+R+S	DRY-BULK	18.58	18.58	25.93	0.46	1.31	2.31	
18	3/24/08 10:02	4/3/07 11:09	0.511	DF+S	DRY-BULK	15.25	15.25	74.61	0.14	0.38	1.23	
19	4/3/07 11:09	4/26/08 11:57	0.500	DF+R	DRY-BULK	20.41	20.41	74.30	0.51	0.80	3.47	59
20	4/26/08 11:57	5/29/08 14:55	0.500	DF+R	DRY-BULK	3.51	3.51	NA	3.13	3.65	17.25	60
21	5/29/08 14:55	6/25/08 09:40	0.500	DF	DRY-BULK	19.23	19.23	NA	1.78	2.99	4.46	61
22	6/25/08 09:40	7/3/08 10:22	0.962	DF	DRY-BULK	43.36	43.36	125.47	3.47	5.99	NA	62
23	7/3/08 10:22	7/10/08 07:50	0.910	DF	DRY-BULK	58.55	58.55	NA	19.62	21.32	29.60	81
24	7/10/08 07:50	7/15/08 10:55	1.837	DF	DRY-BULK	54.78	54.78	NA	1.75	2.77	10.68	
25	7/15/08 10:55	7/22/08 07:20	0.615	DF	DRY-BULK	51.44	51.44	NA	0.60	0.85	1.61	
26	7/22/08 07:20	7/29/08 08:50	0.545	DF	DRY-BULK	91.51	91.51	NA	0.65	1.15	4.13	78
27	7/29/08 08:50	8/15/08 09:50	0.500	DF	DRY-BULK	19.32	19.32	NA	1.17	4.25	2.23	
28	8/15/08 09:50	9/5/08 13:25	0.500	DF	DRY-BULK	9.13	9.13	NA	2.77	4.23	14.73	
29	9/5/08 13:25	9/16/08 09:35	0.248	DF	DRY-BULK	28.92	28.92	NA	0.21	0.47	3.94	
30	9/16/08 09:35	10/8/08 10:15	0.500	DF+R	DRY-BULK	44.72	33.83	NA	0.71	1.07	2.17	82

Appendix Table 5.c. N and P load per day in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Sta. 7/1/07-10/8/08.

	Buoy TB-4	Dry-Bulk				(Load/day)						
Samp.	Start	Collection	Vol.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	Liters	Form	Type	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	(g/ha/d)	Notes
1	6/28/2007 6:46	7/26/2007 9:37	0.500	DF	DRY-BULK	1.04	0.43	1.46	NA	0.08	0.37	7
2	7/26/2007 9:37	7/27/2007 9:20	2.885	DF	DRY-BULK	NA	NA	12.68	NA	NA	2.02	
3	7/27/2007 9:20	8/15/2007 9:02	0.500	DF	DRY-BULK	1.10	0.40	0.97	NA	0.07	0.18	7
4	8/15/2007 9:02	8/28/2007 15:40	0.500	DF	DRY-BULK	1.76	1.26	4.73	0.05	0.13	0.30	7
5	8/28/2007 15:40	9/11/2007 8:20	0.500	DF	DRY-BULK	3.18	2.44	5.20	0.04	0.13	0.22	7
6	9/11/2007 8:20	10/2/2007 13:45	0.500	DF	DRY-BULK	3.65	1.91	3.30	0.05	0.08	0.29	7
7	10/2/2007 13:45	10/11/07 13:13	0.528	DF+S	DRY-BULK	4.12	6.39	6.75	0.08	0.17	0.25	31
8	10/11/07 13:13	10/23/07 12:00	0.658	DF+R	DRY-BULK	3.25	7.83	8.56	0.06	0.11	0.14	
9	10/23/07 12:00	11/5/07 09:04	1.792	DF+R	DRY-BULK	4.01	6.78	9.87	0.09	0.29	0.31	32
10	11/5/07 09:04	11/13/07 14:45	2.235	DF+R	DRY-BULK	2.23	3.80	3.33	0.06	0.22	0.23	
11	11/13/07 14:45	12/13/07 13:20	0.616	DF+R+S	DRY-BULK	0.05	0.91	1.33	0.01	0.02	0.04	
12	12/13/07 13:20	1/11/08 10:33	0.818	DF+R+S	DRY-BULK	1.55	0.95	1.80	0.03	0.04	0.10	
13	1/11/08 10:33	2/5/08 15:32	1.028	DF+S	DRY-BULK	0.87	0.70	0.84	0.02	0.06	0.12	
14	2/5/08 15:32	2/15/08 14:41	1.673	DF+R+S	DRY-BULK	1.91	1.01	2.02	0.07	0.21	0.27	
15	2/15/08 14:41	2/26/08 10:52	3.320	DF+S	DRY-BULK	3.00	4.45	4.74	0.05	0.37	0.54	
16	2/26/08 10:52	3/12/08 09:44	0.444	DF	DRY-BULK	2.00	2.03	2.20	0.04	0.04	0.08	
17	3/12/08 09:44	3/24/08 10:02	1.031	DF+R+S	DRY-BULK	1.98	1.55	2.16	0.04	0.11	0.19	
18	3/24/08 10:02	4/3/07 11:09	0.511	DF+S	DRY-BULK	1.79	1.52	7.43	0.01	0.04	0.12	
19	4/3/07 11:09	4/26/08 11:57	0.500	DF+R	DRY-BULK	0.86	0.89	3.23	0.02	0.03	0.15	59
20	4/26/08 11:57	5/29/08 14:55	0.500	DF+R	DRY-BULK	0.18	0.11	NA	0.09	0.11	0.52	60
21	5/29/08 14:55	6/25/08 09:40	0.500	DF	DRY-BULK	0.73	0.72	NA	0.07	0.11	0.17	61
22	6/25/08 09:40	7/3/08 10:22	0.962	DF	DRY-BULK	2.89	5.40	15.63	0.43	0.75	NA	62
23	7/3/08 10:22	7/10/08 07:50	0.910	DF	DRY-BULK	3.75	8.49	NA	2.85	3.09	4.29	81
24	7/10/08 07:50	7/15/08 10:55	1.837	DF	DRY-BULK	5.14	10.68	NA	0.34	0.54	2.08	
25	7/15/08 10:55	7/22/08 07:20	0.615	DF	DRY-BULK	5.63	7.51	NA	0.09	0.12	0.24	
26	7/22/08 07:20	7/29/08 08:50	0.545	DF	DRY-BULK	4.24	12.96	NA	0.09	0.16	0.58	78
27	7/29/08 08:50	8/15/08 09:50	0.500	DF	DRY-BULK	0.88	1.13	NA	0.07	0.25	0.13	
28	8/15/08 09:50	9/5/08 13:25	0.500	DF	DRY-BULK	0.22	0.43	NA	0.13	0.20	0.70	
29	9/5/08 13:25	9/16/08 09:35	0.248	DF	DRY-BULK	2.57	2.67	NA	0.02	0.04	0.36	
30	9/16/08 09:35	10/8/08 10:15	0.500	DF+R	DRY-BULK	2.03	1.54	NA	0.03	0.05	0.10	82

Table Legend:
Precipitation Form: (S=snow; R=rain; DF= dry fall (Dry deposition); H=hail; G=graupel; 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 H2O)
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; TBA= data not yet available).

Table Notes
(1) Small dead moth in sample, possible contamination; (2) bucket had gone dry, added 0.5 liters deionized water to process; (3) looked like screen and bucket had bird droppings on it, likely contamination; (4) 2 spiders in ST sample likely contamination; (5) likely contamination, discarded; (6) added 330ml deionized water to 170ml of sample to process; (7) bucket dry, added 500ml deionized water to process; (8) ST sat out for long period, likely partial sample evaporation; (9) 2 aspen leaves in sample; (10) major fires in So. Calif. from Santa Ana winds, no smoke in basin, 1 aspen leaf in sample; (11) rain from thunderstorms, filter has dark gray color, ash from So. Calif. fires?; (12) Aerochem Metrics sampler replaced, had been malfunctioning; (13) brought wet bkt volume to 500ml for processing; (14) Aerochem Metrics lid may have knocked some snow from bucket when closed; (15) small amt of precip was discarded; (16) some ice on bkt rim, Aerochem Metrics lid may not have sealed completely; (17) snow 3 inches above bkt rim, compacted with lid; (18) 3 ml of precip (trace) added to 12/20/07 sample and processed; (19) major fires in So. Calif. from Santa Ana winds, no smoke in basin, 1 aspen leaf in sample; (20) 3 aspen leaves in dry sample; (21) replaced Aerochem Metrics sampler, had been malfunctioning, placed out dry bkt with heater for first time this season; (22) 200 ml of dry sample had spilled; (23) small amt of ice on surface of dry bkt; (24) dry bkt vol not available; (25) dry bkt partially frozen; (26) 61ml of sample + 439 ml deionized water to process; (27) 110 ml sample + 390ml deionized water to process, filter brownish-gray; (28) pin-hole leak in ST volume underestimated; (29) 204ml of sample, took 150ml of this and added to 350ml deionized water; (30) many plastic flakes, filter has slight gray color; (31) portion of sample spilled and caught enroute from boat; (32) slight dark color on filter; (33) filtered 150 ml ST sample and filter was grayish; (34) snow accumulated 1.5 ft. above bucket rim, “a” bucket = snow accumulated in original Aerochem Metrics wet bucket to rim, plus some compacted down with another bucket “b”; (35) “b” bucket, snow overlying bucket “a”; (36) 68 ml of sample, added 432ml of deionized water to process; (37) snow accumulated 4-5 inches above bucket rim, compacted down; (38) not all precip collected in wet bucket, Aerochem Metrics lid had shifted and knocked part of overlying snow off bucket, approximately 2 feet of dry snow from storm, TBG didn’t collect all snow; (39) 113 ml sample + 387 ml deionized water, dry bucket caught portion of storm; (40) 4ml of sample + 501 ml deionized water; (41) snow compacted down into bucket during storm, approximately 2 feet total snow and wet snow from storm; (42) thin layer of ice in dry bucket, had added 1 liter additional of deionized water during period, sample filter very dirty; (43) dry bucket frozen with 1 inch of snow on surface; (44) small amt (20-30ml) spilled in transit and water contacted outer bag; (45) ST had pin-hole leak, no sample; (46) ST had pin-hole leak, partial sample; (47) ST had 168ml sample + 332 ml deionized water; (48) 132 ml sample + 368 ml deionized water; (49) 30ml sample + 470ml deionized water; (50) 178 ml sample + 322 ml deionized water; (51) dead bug and much pollen in sample, possible contamination; (52) much pollen some dark debris in dry bucket; (53) much pollen in sample, intermittent periods of smoke from fires in CAwhich were caused by lightning storms 6/21/08, some very smokey days; (54) 6 ml sample + 494ml deionized water; (55) bucket dry, added 500ml deionized water; (56) thunderstorms with rain this period; (57) bucket dry, added 500ml deionized water, moderate to heavy smoke when collected from CA fires; (58) many small black bugs and white plastic flakes; (59) bucket dry, added 500ml deionized water; (60) 45 ml sample + 455ml deionized water, filter dark-brown-green, National Weather Service noted dust from Nevada desert blown south over Lake Tahoe this period; (61) bucket dry, added 500ml deionized water to process, moderate-to-heavy smoke when collected; (62) much smoke past week from CA fires, often variable during the day; (63) 10 ml of precip + 490 ml of deionized water to process; (64) very heavy ash on screen in bucket and in sample, pieces of small charred pine needles, some suds upon mixing, significant ash fall event along at least northwest portion of the basin from American River Complex fire to the west, charred bay leaves actually found near Tahoe City marina; (65) some ash in sample, probably residual from surrounding surfaces; (66) not as much smoke this pd.; (67) some smoke during pd., one day of heavy smoke from fire near Yosemite, filter has some organic wind-blown debris, filtered first through non-precombusted GF/C filter then through precombusted GF/F filter; (68) dead moth in sample, possible contamination; (69) small dead bee in sample, possible contamination, very difficult to filter; (70) windy previous day associated with thunderstorms:; (71) trace of precip associated with thunderstorms and wind previous day, no precip in bucket, left out; (72) some aspen leaves in dry bucket; (73) obvious ash in ST sample; (74) ST dry, left out; (75) obvious ash in dry-bulk bucket from ash fall event 7/9/08, 6-7 small midge flys in dry-bulk sample too; (76) no obvious ash, much pollen in sample; (77) small amount of precip and pollen this period; (78) periods of smoke during period, one day of heavy smoke from fire near Yosemite entrance; (79) bucket dry, added 500ml deionized water; (80) 85ml of sample +450ml deionized water, small spider in sample, possible contamination; (81) obvious ash in sample, more than bucket at TB-1; (82) 10ml of precip + 490 ml deionized water to process; (83) bucket dry, added 500ml deionized water to process, much particulate debris in sample, likely bird feces;