Lake Tahoe Water Quality Investigations

Algal Bioassay • Phytoplankton • Atmospheric Nutrient Deposition • Periphyton •

Annual Report:

July 1, 2010– June 30, 2011

Agreement No. 10-031-160

Submitted to:

State Water Resources Control Board
Lahontan Regional Water Quality Control Board

Submitted by:

Tahoe Environmental Research Center
University of California, Davis

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December 1, 2011

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Acknowledgments

We are extremely grateful for the efforts of many individuals with the U.C. Davis Tahoe Environmental Research Center who assisted with this work. In particular, Anne Liston, Tina Hammel, and Veronica Edirveerasingam and their assistants continue to do excellent work in the analytical labs. Thanks to Patty Arneson for assistance with data management. Thanks to Andrea Parra Buxton for assistance with report maps. Dr. Geoff Schladow provided valuable input. Thanks to George Malyj for administrative help. Finally we are very grateful for ongoing support of this monitoring work provided by the State Water Resources Control Board, Lahontan Regional Water Quality Control Board.

Project Overview

The following document is our Annual Report for work completed July 1, 2010 to June 30, 2011 for Agreement No. 10-031-160: 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 contract will accomplish the necessary research, monitoring and data collection for addition to the Lake Tahoe Interagency Monitoring Program (LTIMP), the State Water Board and other governmental entities will be provided with the hard 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:

<u>Algal growth bioassay tests to assess nutrient limitation (Task 3)</u>. 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). It is similar to that published in Goldman et al. (1993) with the exception that14C uptake is not measured. In these bioassays, water is collected and composited from depths of 2,5,8,11,14,17 and 20m at TERC's Lake Tahoe Index Station following TERC standard protocol for sample collection (Hunter et al., 1993). The water sample is returned to the laboratory where three replicate samples are treated as follows: Control – no nutrient additions; N_{20} (add NH_4NO_3 to a final concentration of approximately 20 µg/l N); P_2 (add ortho-P to a final concentration of approximately 2 µg/l P); P_{10} (10 µg/l P); $N_{20}P_{10}$ (20 µg/l N + 10 µg/l P). Flasks of lake water and treatments are incubated under controlled laboratory conditions. Biomass accumulation over the course of the experiment is measured by *in vivo* fluorescence.

<u>Enumeration and identification of phytoplankton and collection of zooplankton samples for archiving (Task 4)</u>. 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. Phytoplankton samples are preserved with an iodine preservative (Lugol's reagent) and counted to the species level when feasible following established TERC protocol (e.g. Hunter et al., 1990; Hunter et al., 1993). Monthly samples of zooplankton will include: a 150m to surface tow at both the Index and Mid-lake stations. Zooplankton samples are preserved with formalin and archived.

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. 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.

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. Thick growths of periphyton coat the rocks in the spring in many areas around the lake and bright green filamentous algae occur along portions of the shoreline in the summer. 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. Nine sites are to be monitored for periphyton biomass a minimum of five times per year. 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 90 samples per year. Biomass is to be reported as chlorophyll *a* and Ash Free Dry Weight (AFDW). Once a year, 39 additional sites will be visited and 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) for the period July 1, 2010 – June 30, 2011) for each task is listed below:

Task	**% Completion in Quarter** (for full 3 yr granting period)
1 – Project Management	33.333%
2 – Quality Assurance	33.333%
3 – Algal Growth Bioassays	33.333%
4 – Phytoplankton and Zooplankton Analysis	33.333%
5 – Atmospheric Deposition of Nutrients	33.333%
6 – Periphyton	33.333%
7 - Reporting	33.333%

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).

A primary objective for the atmospheric deposition quality control samples was to check for potential contamination associated with field monitoring and equipment. Nutrient levels in field blanks were compared with the source blank samples to check for levels of contamination. Table 2 presents the results for analyses of atmospheric deposition field quality control samples collected July 2010 to September 2011. A total of 18 QA/QC samples were collected.

The QA/QC results indicated generally levels of N and P in source and field blanks were generally low, however some elevated levels of N were found in the initial set of samples in July, 2010. The level of NO_3-N in a source blank collected from the deionized water system on 7/15/10 was slightly elevated (NO_3-N = 12 µg/l) while NO_3-N in samples collected from all field blanks which also utilized this water were below the MDL except in the WLL Wet field Blank. In that sample slight contamination with NO3-N was found (NO_3-N= 6 µg/l). Slight contamination with NH4-N or TKN was also found in some of the field blanks for this date. NH_4-N and TKN were elevated in the WLL Dry field blank (NH_4-N = 25.84 µg/l and TKN = 379.75) while NH_4-N for the other field blank values were also slightly elevated ranging from 6-9 µg/l. P was low in the source and field blanks (SRP $\leq$ 2 µg/l, DP $\leq$ 3 µg/l, TP $\leq$ µg/l).

The presence of several elevated N values for either source blanks or field blanks was an indicator of potential contamination either in the sample bottles or collection containers for this date. These quality control samples provided a check of the collection container cleaning done by a new intern. They indicated more thorough cleaning of sample bottles or collectors was needed to be done by the intern. Collectors were cleaned by this intern during the 8/3/10-9/2/10 period. Sample data for this period should be used with caution realizing some samples may have had similar levels of contamination as in these July QA/QC samples.

On subsequent dates, nutrient levels in source and field blank samples were generally very low. Levels of N and P were very low in the majority of deionized water “DIW Blk” source blanks with many samples below the method detection level (MDL). TKN in one source blank collected 11/15/10 was elevated (65.88 µg/l). N and P levels were also very low in the majority of field blank samples with many below or close to the MDL.

Due to typically very low levels of P in atmospheric deposition samples, any sample contamination introduced in the field sampling or bucket cleaning can impact estimates of P loads for individual samples. Many of the container of field blanks were below the MDL but when they did have levels of phosphorus above the MDL, they typically were only slightly elevated (SRP typically elevated by 1-2 µg/l above the MDL and levels of DP, TP typically within 1-3 µg/l of the MDL). It should be stressed these values were very near the lower limits for the P analyses. The source blank water was also occasionally elevated above the MDL and higher at times then container or field blanks using this water. Atmospheric deposition samples using DIW as part of the collection system, i.e. for Dry and Dry-bulk samples, may slightly overestimate P loading when P is present in this DIW water. Overall, the amounts of P introduced to samples as a result of cleaning or field sampling appear to be low.

Table 2. Quality Control samples collected for the atmospheric deposition monitoring July 1, 2010 to September 30, 2011.

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
Source Blk	7/14/10 11:10	Source Blk	-	11.77	5.37	MDL	MDL	MDL	5.62	1
FBWLLD	7/15/10 14:15	Field Blk	4.017	MDL	25.84	379.75	1.59	3.42	4.68	2
FBTB1D	7/15/10 13:50	Field Blk	4.015	MDL	9.0	NA	1.14	MDL	3.12	3
FBTB1ST	7/15/10 13:30	Field Blk	0.5	MDL	5.8	46.39	1.59	3.1	MDL	4
FBWLLW	7/16/10 10:30	Field Blk	0.5	5.8	7.5	MDL	1.59	MDL	4.66	5
Source Blk	11/15/10 15:15	Source Blk	-	MDL	MDL	65.88	MDL	2.19	5.94	1
FBTB1D	11/16/10 15:00	Field Blk	4.0	MDL	MDL	NA	MDL	3.39	4.38	3
FBWLLD	11/16/10 16:10	Field Blk	4.0	2.71	4.29	MDL	MDL	4.07	3.75	2
FBWLLW	11/17/10 10:45	Field Blk	0.5	MDL	3.02	NA	MDL	MDL	3.13	6
Source Blk	11/30/10 15:15	Source Blk	-	MDL	MDL	MDL	MDL	3.44	4.69	1
FBWLLW	11/30/10 15:25	Field Blk	0.5	MDL	4.47	MDL	MDL	3.44	3.44	7
Source Blk	4/13/11 14:25	Source Blk		MDL	MDL	MDL	MDL	MDL	MDL	1
FBWLLD	4/14/11 15:45	Field Blk	4.0	2.89	3.49	NA	1.14	4.66	4.66	2
FBTB1D	4/14/11 16:00	Field Blk	4.0	MDL	MDL	MDL	MDL	3.73	4.97	3
FBTB1ST	4/14/11 15:25	Field Blk	0.5	2.12	3.28	MDL	MDL	3.1	4.04	4
Source Blk	8/18/11 16:15	Source Blk	-	MDL	MDL	MDL	MDL	2.16	3.09	1
FBTB1D	8/19/11 18:15	Field Blk	4.0	MDL	MDL	MDL	MDL	3.09	3.09	2
FBTB1ST	8/19/11 18:30	Field Blk	0.500	3.81	MDL	MDL	MDL	3.39	3.39	3
MDL				2	3	40	1	2	2	12

Notes

1- Deionized water system source blank.
2- Ward Lake Level Dry Field Blank, ~4 liters deionized water to sealed Dry bucket for approx. 24 hours.
3- TB-1 Dry-Bulk Field Blank, ~4 liters deionized water to sealed Dry-Bulk bucket for approx. 24 hours.
4- TB-1 Snow Tube (ST) Field Blank, 0.5 liters deionized water to sealed ST for approx. 24 hours.
5- Ward Lake Level Wet Field Blank, 0.5 liters deionized water to Wet bucket in Aerochem Metrics sampler, overnight during dry period. Note, significant construction ongoing at station. Potential for impact on station results.
6- Ward Lake Level Wet Field Blank, 0.5 liters deionized water to Wet bucket in Aerochem Metrics sampler, for approximately 2 days during dry period.
7- Equipment cleaning blank, new intern cleaned bucket, then added 0.5 liters deionized water and processed.
8- MDL = Method Detection Limit

Task 3. Algal Growth Bioassays

We continued to monitor the growth response of algae to nutrient additions using lake phytoplankton bioassays. 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" in which no nutrients are added and all treatments are replicated in triplicate. 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 $p \leq 0.05$ level of significance. (See Appendix 7 in the 2004-2007 Final Report (Hackley et al., 2007) for a more detailed description of the bioassay method).

The response of Lake Tahoe water to nitrogen (N) and phosphorus (P) enrichment has been tested using algal growth bioassays since the 1960's. The record of bioassays for Lake Tahoe has proven 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 allow us to better understand patterns of nutrient limitation in Lake Tahoe.

Summary of Bioassay Results 2010-2011

In this summary we present the results for standard bioassay experiments done during the period July 1 2010 to July 30, 2011. Five total bioassays were done on a schedule of approximately one bioassay every three months. Table 3 (a-e) presents the results for each of the individual bioassays; Table 4 presents the results for all bioassays done during the period 2002-2011 and Figure 1 summarizes the 2002-2010 results for bioassays for complete years based on 3 periods: Jan.-April, May-Sep. and Oct.-Dec.

In the bioassays done during July 2010 to July 2011, nitrogen was stimulatory more frequently than phosphorus, while the combination of N and P added together increased phytoplankton growth in all five bioassays. Nitrogen added alone was stimulatory in four of five bioassays, which included bioassays done during both summers (8/17/10 and 7/11/11) as well as fall 2010 (11/9/10) and spring 2011 (5/20/11). Phosphorus added alone was stimulatory only in the winter 2011 (1/21/11) bioassay. Nitrogen limitation has been prevalent in the summer the last four years and also frequently occurred in the fall. Phosphorus limitation continues to be prevalent in the winter.

The data for all bioassays done during the period is included in Table 4. The results for complete years 2002-2010 were grouped in Figure 1 based on time of year and typical lake stratification patterns: January to April (no thermal stratification to early onset of stratification); May to September (continued development of stratification to fully stratified); October to December (breakdown of stratification). Patterns reported in the 2010 Summary Report (Hackley et al., 2010) continued in 2011:

1) For 2002-2010 bioassays, during the period January – April, P limitation continues to be prevalent and the combination of N+P was stimulatory over 90 percent of the time.

2) During May to September, N limitation was more frequent (41% of bioassays) than P limitation (12% of bioassays) (N limitation during this period has occurred every year for the last four years). The combination of N+P always increased growth during this period.

3) During October to December, P limitation occurred in 46% of the bioassays, N limitation occurred in 31% of the bioassays and the combination of N+P always increased growth.

P limitation has not been observed in Oct. – Dec. bioassays since 2005. While N limitation was observed in 4 out of the six years during 2005-2010.

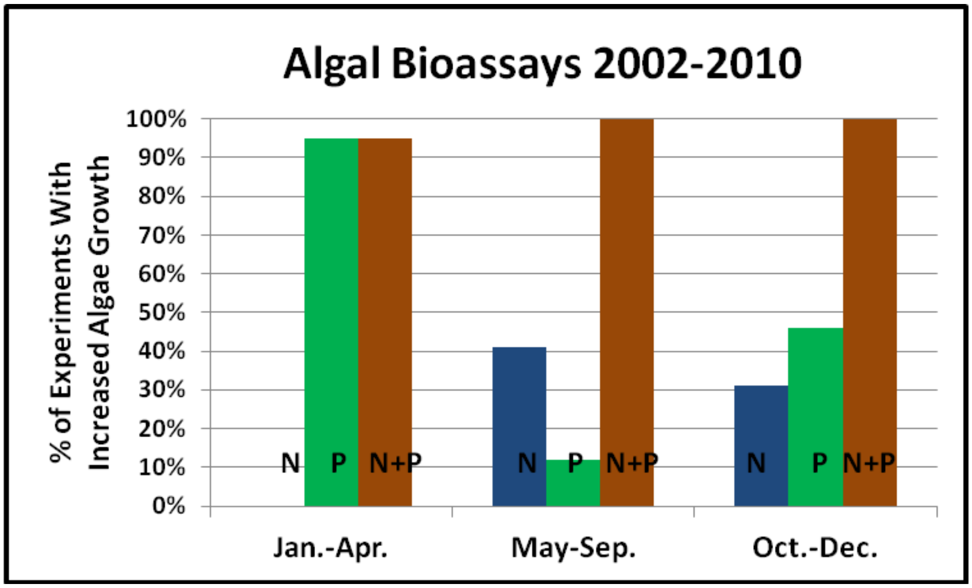

Figure 1. Percentage of bioassays done during three periods: Jan.-April (unstratified – onset of stratification period), May – Sept. (stratified period), and Oct. – Dec. (breakdown of stratification) in which N, P or N+P significantly increased phytoplankton growth.

Decisions on control nutrient inputs to Lake Tahoe should not be made on the basis of these growth bioassays alone. Increased nutrient loading affects the growth of attached algae (periphyton) on hard surfaces in the nearshore. The observation that N+P additions almost always stimulate growth is strong evidence that nutrient load should be controlled as called for as part of the Lake Tahoe TMDL. While any future management action to specifically control N-loading will use this bioassay response data, these actions will require additional supportive information.

Summary Points for Bioassay Monitoring 2010-2011

1. **There was a significant growth response to the combination of N+P in all bioassays (5 of 5 bioassays). The observation that N+P additions almost always stimulate algal growth is strong evidence that nutrient load should be controlled as called for as part of the Lake Tahoe TMDL.**

2. **Nitrogen added alone was stimulatory in the bioassays done during both summers in 2010 and 2011, as well as fall 2010 and spring 2011. Nitrogen limitation has been prevalent in the summer the last four years and also frequent in the fall.**

3. **Phosphorus added alone was stimulatory in the winter 2011 (1/21/11) bioassay. Phosphorus limitation continues to be prevalent in the winter.**

Table 3a. Bioassay done using 2,5,8,11,14,17,20m lake water collected 8/17/10.

Treatment	Day 5 Mean Fluorescence	Std. Dev.	n	Day 5 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response =“*”
Control	0.216	0.008	3	100	
N(20)	0.307	0.020	3	142	*
P(2)	0.231	0.012	3	107	
P(10)	0.234	0.005	3	108	
N(20)P(2)	0.381	0.005	3	176	*
N(20)P(10)	0.388	0.091	3	179	*

Note – used Day 5 fluorescence results

Table 3b. Bioassay done using 2,5,8,11,14,17,20m lake water collected 11/9/10.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response =“*”
Control	0.261	0.010	3	100	
N(20)	0.338	0.006	3	130	*
P(2)	0.268	0.014	3	103	
P(10)	0.268	0.010	3	103	
N(20)P(2)	0.501	0.011	3	192	*
N(20)P(10)	0.646	0.008	3	248	*

Table 3c. Bioassay done using 2,5,8,11,14,17,20m lake water collected 1/21/11.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response =“*”
Control	0.502	0.004	3	100	
N(20)	0.517	0.008	3	103	
P(2)	0.564	0.008	3	112	*
P(10)	0.564	0.007	3	112	*
N(20)P(2)	0.870	0.009	3	173	*
N(20)P(10)	0.965	0.017	3	192	*

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

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.465	0.013	3	100	
N(20)	0.557	0.028	3	120	*
P(2)	0.479	0.034	3	103	
P(10)	0.455	0.015	3	98	
N(20)P(2)	0.784	0.027	3	169	*
N(20)P(10)	0.959	0.040	3	206	*

Table 3e. Bioassay done using 2,5,8,11,14,17,20m lake water collected 7/11/11.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response ="*"
Control	0.290	0.003	3	100	
N(20)	0.502	0.010	3	173	*
P(2)	0.292	0.003	3	101	
P(10)	0.306	0.008	3	106	
N(20)P(2)	0.841	0.009	3	290	*
N(20)P(10)	1.053	0.025	3	364	*

Note – used Day 5 fluorescence results

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, (h) 2009, (i) 2010, (j) 2011. Treatment responses statistically significantly different from the control at the $p \leq .05$ 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

Table 4 cont'd

(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

Table 4 Cont'd.

(g) 2008 Bioassays

	1/30/08	4/24/08	7/24/08	10/27/08
Control	100	100	100	100
N20	102	99	269	99
P2	123	104	109	102
P10	127	102	105	100
N20P2	124	99	293	124
N20P10	127	102	318	171

(h) 2009 Bioassays

	1/30/09	5/1/09	8/17/09	11/13/09
Control	100	100	100	100
N20	98	100	178	124
P2	140	153	105	103
P10	144	166	109	103
N20P2	154	164	285	160
N20P10	159	182	338	207

(i) 2010 Bioassays

	1/28/10	4/15/10	8/17/10*	11/9/10
Control	100	100	100	100
N20	100	100	142	130
P2	141	152	107	103
P10	144	162	108	103
N20P2	147	164	176	192
N20P10	150	171	179	248

(j) 2011 Bioassays

	1/21/10	5/20/11	7/11/11*
Control	100	100	100
N20	103	120	173
P2	112	103	101
P10	112	98	106
N20P2	173	169	290
N20P10	192	206	364

***- Note, for 8/17/10, 7/11/11 bioassays used Day 5 results. For other bioassays typically use Day 6 results.**

Task 4. Enumeration and Identification of Phytoplankton

Phytoplankton form the base of the aquatic food web in Lake Tahoe. The community of unicellular algae is dynamic, with different population abundances rising and falling throughout the year, commonly referred to as seasonal succession. Population trends are similar from year to year, but not so consistent as to be predictable at the species level of classification. This past year, 2010-2011, the phytoplankton community, in terms of biovolume, was very typical (Figure

2). The lowest community biovolume was seen during the late fall and early winter. The highest biovolume was during the summer months, typically June and July. The population abundance also followed similar patterns (Figure 3). Community composition changed throughout the year with diatoms being the dominant algal group in biovolume and abundance during the season of highest phytoplankton growth. In contrast, during the times of lowest abundance and biovolume, the community was often the most diverse.

This routine of annual phytoplankton ecology is deceptive. Without a doubt, the past year was one of the most remarkable years in the recent history of Lake Tahoe. The abundance of diatoms during the summer season (Figure 3) was the highest ever recorded, with over one million cells per liter. Winder et. al. (2009), attributed this recurring summer bloom to climate changes. Indeed, since that paper was written, the trend continues with ever increasing magnitude. The cells are small centric diatoms called *Cyclotella spp*. They have the ability to grow in a wide range of depths but the most abundant populations are located in the upper euphotic, less than 20m. The algal community is dominated by these cells, requiring a shift in the patterns of interaction between taxonomic groups. For example, one taxonomic group, dinoflagellates used to be common in Lake Tahoe during the autumn. In recent years, this group has been appearing with regularity during the late spring. These cells, generally larger than the centric diatoms, occur with relatively smaller abundances. They are flagellated cells with chloroplasts and since they have the cellular ‘equipment’ to photosynthesize, they are considered plants. However, they also have been reported to use other ‘strategies’ for obtaining nutrition, such as phagocytosis. This past year in Lake Tahoe, microscopic observation has captured these cells in the process of consuming centric diatoms by ingestion. The fact that dinoflagellate populations have ‘changed’ season is mostly likely a response to this available food source. Further impacts of the diatom bloom can be seen in the phytoplankton growth rates, as measured by C14 uptake. The *Cyclotella spp*. are small (4 – 6 µm), metabolically active cells. Logarithmic increases of primary production in Lake Tahoe over time can, in large part, be attributed to these cells.

In a broader context, *Cyclotella spp*. are an important food source for protozoans and zooplankton, their small size being a factor that enhances herbivory. *Cyclotella spp*. are tremendously important for all biological processes within the food web. Physically, the additional particulate loading in the water column has a deleterious effect on water visibility. The presence of over one million cells per liter is only a count of the ‘living’ cells. The empty diatom frustules (deceased cells) which co-exist in the water column during the bloom are often 2 or 3 times greater than the living individuals. Taken together, the number of small particles attributed to this one event, the *Cyclotella spp*. bloom, has a significant impact on light absorption and transmission.

While the summer months have important long-term impacts in the phytoplankton, the other seasons are also important. During the fall of 2010, diatoms were still major community members, but the importance of *Cyclotella spp*. diminished after early autumn. Once the lake begins to mix, generally in November, the biovolume dominance shifts to other algal groups. Chlorophytes typically do well in Tahoe’s waters from August through the winter season. During 2010, this same trend was observed. *Ankistrodesmus spiralis* was the dominant green alga but other species were strong performers (*Cosmarium phaseolus, Tetraedron minimum, and Planktonema lauterbornii*). Over the last 12 years, community populations of the green algae has been very interesting. The chlorophyte biovolume and abundance steadily increased over time (Table 5). Additionally, the species richness of chlorophytes since 2003 has been firmly in the double digits. These trends might have some long term implications for the productivity of Tahoe.

The phytoplankton community in January 2011 was remarkably robust. Cell abundance and total bio-volume were high compared with historical records. The euphotic water column was well mixed and all five depth samples had total bio-volumes ranging from 188-197 mm^3/m^3. For comparison, in January 2010, total biovolumes from five individual depth samples ranged from 63-87 mm^3/m^3. The phytoplankton bio-volume doubled in 2011. This increase can be attributed to the diatom population. Diatoms represent 50% of the total bio-volume of the samples. Based on historical records, January is not typically dominated by diatoms. However, in 2011, the centric diatom, *Stephanodiscus alpinus* was the dominant diatom at all sampled depths. Smaller centrics and a couple of pennate species also contributed to the grand total.

The prolonged winter and unsettled spring impacted phytoplankton community dynamics. The growth response within the diatoms seemed to be regional and spotty, with the mid-lake station having almost twice the abundance as the near-shore index station by mid April. Typically, April diatoms dominate the assemblage. This year was not different, but the populations did not hold sustained populations, instead fluctuated. The centric, *Stephanodiscus alpinus* and the pennate, *Synedra acus var. radians* were the dominant biovolume contributors. The most abundant diatom was the small *Cyclotella gordonensis*, with 16,000 – 20,000 cells per liter. As the spring progressed, diatoms continued to gain strength. By mid-May diatoms comprised over 40% of the phytoplankton biovolume. The dominants *Stephanodiscua alpinus* and *Synedra acus var. radians* were still community leaders but populations began to transition to the summer assemblage. The growing abundance (~25000 cells per liter) of the small *Cyclotella spp*. overwhelmed all other species.

By June the long-awaited seasonal succession of diatoms was in full swing. Twelve diatom species comprised 60% of the phytoplankton biovolume and completely overtook the community in abundance. *Cyclotella gordonensis* and *Cyclotella glomerata* (both similar in size ~5µm) had over 300,000 cells per liter in early June, growing to over 700,000 cells per liter by late June. The phytoplankton biovolume and abundance was not as strong as the summer of 2010.

Phytoplankton are in many ways controlled by ambient physical conditions. Seasonal fluctuations and variability due to weather patterns impact the overall performance of the phytoplankton. Nevertheless, despite inter-annual differences, it is still very interesting that changes in the phytoplankton community over time can be discerned without statistical analysis. The changes are sometimes dramatic, as in the *Cyclotella spp*. populations. The changes are also subtle, with seasonal maneuvering within the community composition. It all works together to tell a story and if climate change is a major driving force for this change, the story will continue to unfold as time goes on.

Figure 2: Biovolume

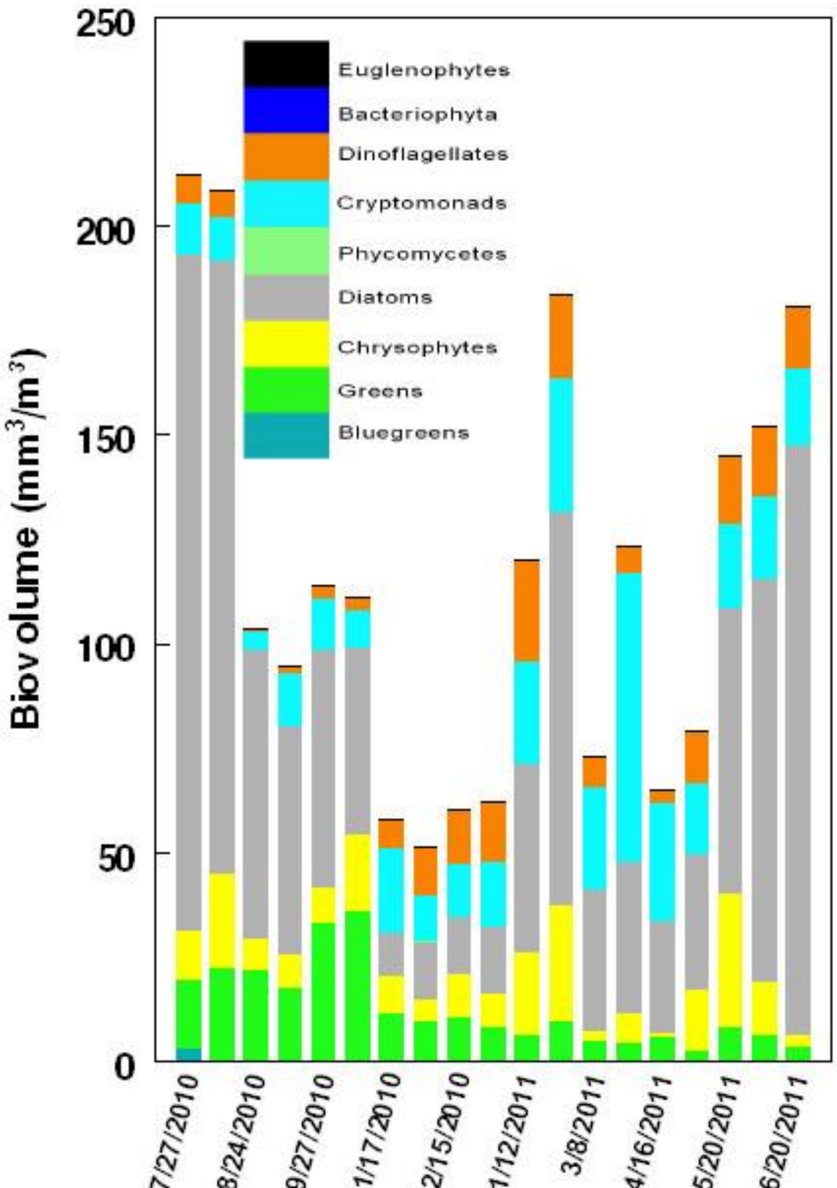

Figure 3: Abundance

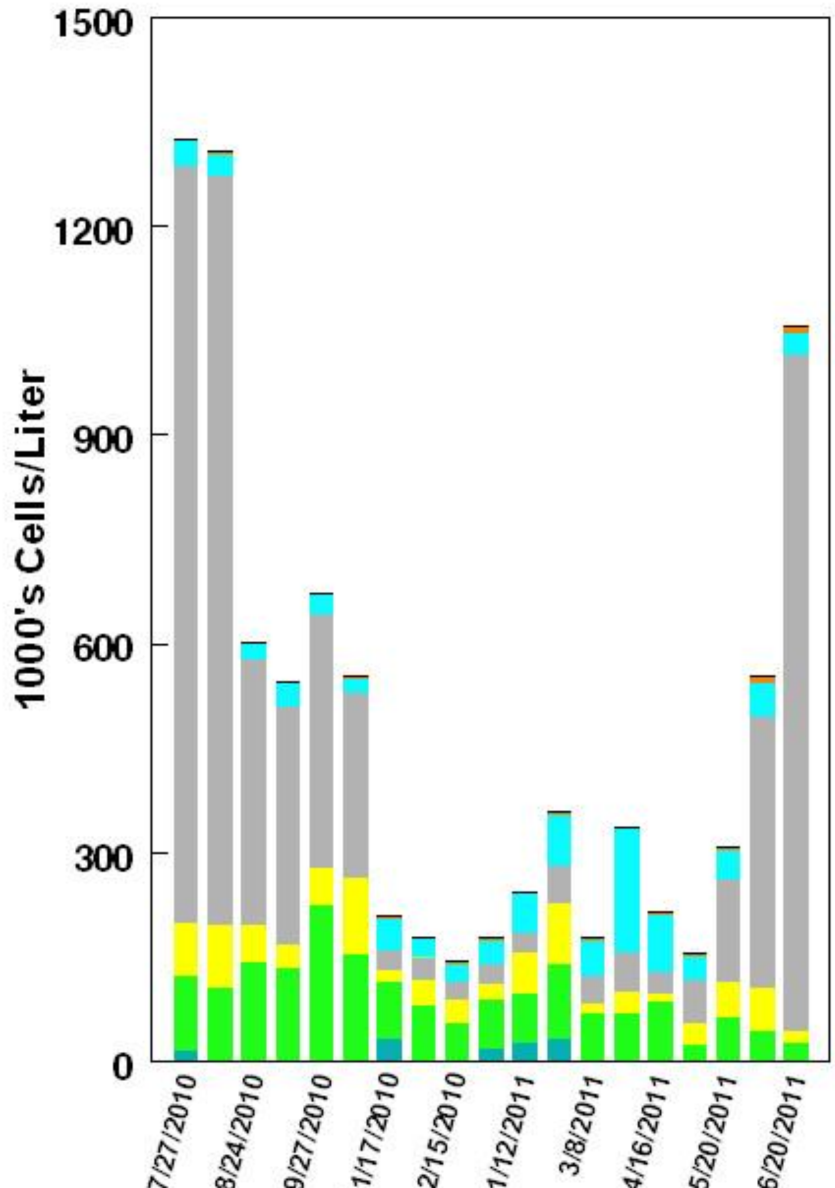

Table 5: Autumn Season Chlorophytes

n = # of sampling events	**1999** n=5	**2000** n=4	**2001** n=11	**2002** n=9	**2003** n=12	**2004** n=11	**2005** n=10	**2006** n=5	**2007** n=5	**2008** n=4	**2009** n=7	**2010** n=7
PHYTOPLANKTON BIOVOLUME (mm^3/m^3)	35	51	51	43	37	49	54	59	54	53	68	95
CHLOROPHYTE BIOVOLUME (mm^3/m^3)	3	3	3	2	6	12	18	3	4	14	7	16
CHLOROPHYTE BIOVOLUME AS PERCENT OF TOTAL	9%	6%	6%	5%	16%	24%	32%	5%	7%	26%	12%	17%
CHLOROPHYTE ABUNDANCE AS PERCENT OF TOTAL	12%	5%	5%	6%	27%	32%	41%	13%	13%	36%	20%	36%
PHYTOPLANKTON TOTAL SPECIES RICHNESS	31	28	33	33	32	35	32	36	36	42	42	37
CHLOROPHYTE SPECIES RICHNESS	10	8	9	9	12	12	9	10	12	16	15	12

Task 4 b. Archiving of Zooplankton samples.

During the period July 1, 2010 to June 30, 2011 18 zooplankton samples were collected and archived for possible later enumeration. These samples included nine 150-0m tows at the Index station and nine 150-0m tows at the Mid-lake station.

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. Atmospheric deposition contributes about 55% of the total nitrogen, 15% of the total phosphorus and 15% of the total fine (<20µm) particles to the lake. A significant portion of the nitrogen, phosphorus and fine 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 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. This station 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. 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. 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 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, precipitation amounts and timing. The nutrient concentration data was used to calculate atmospheric deposition loads and loading rates for Water Years 2010 and 2011. Data from the end of May 2010 (the approximate ending date of data presented in the 2010 Summary Report (Hackley et al., 2010) through the end of September 2011 is presented in this report. The data, sampling period loads and loading rates for Lower Ward Wet, Dry, Buoy TB1 Dry-bulk and Snow Tube and Buoy TB4 Dry-bulk is presented in Appendices 1-5. WY totals are presented in this section.

During July 1, 2010 through September, 2011, 145 samples were collected from the 3 primary stations (30 dry bucket and 50 wet bucket samples from the Ward Lake Level station, 26 dry-bulk samples from each of the lake buoy stations and 13 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 (DP) and total phosphorus (TP).

<u>General Patterns for Precipitation July 1, 2010- September, 2011</u>

The period of study included the end of Water Year 2010 and all of WY 2011. Figure 4 below shows the distribution of precipitation amounts for samples collected at the Lower Ward Valley station during the June 2010- Sept.

Small amounts of precipitation occurred at in the summer 2010 and overall precipitation for WY 2010 was moderate. The summer of 2010 was generally dry, with a few periods in which isolated thunderstorms occurred. A locally heavy thunderstorm occurred in Ward Valley on 8/7/10 which dropped 0.91 inches of precipitation as rain and hail. At the end of August (Aug. 28-29) a small amount of rain also occurred from a cold low pressure system. September was mostly dry. Total WY 2010 precipitation was 38.64 inches which is mid-range among values since 1981.

WY 2011 had significant precipitation (66.92 inches total) which occurred predominantly during two periods: Oct. to Dec. 2010 and mid-February to June 2011. The first three months of WY 2011 (Oct.-Dec.) were extremely “wet” with significant events occurring during each month. Rain events began in early October and a very significant rain event occurred late in October. A total of 7.21 inches of rain occurred at the lower Ward Station 10/23-10/25/10 (much of the precipitation fell on 10/24/10) associated with a low pressure system containing significant tropical moisture. Small amounts of rain occurred again at the end of Oct. with some rain and snow in early November. Then, the first major snow storm of the WY occurred 11/18-11/23/10 associated with a strong arctic low pressure system. This very cold, windy system dropped 3-4 feet of snow at the Lower Ward station. Very cold air remained in the Basin for a period after this storm, with another foot of snow falling on 11/27/10. Warmer temperatures were observed during the first part of December. Periods of rain, snow, mixed precipitation and drizzle occurred at Lake Level during 12/5-12/8/10. Then a moderate storm with 3.39 inches of precipitation as rain and snow at the Lower Ward station and snow at higher elevations occurred 12/13-12/14/10. A major storm occurred in the basin from 12/17-12/20/10 contributing over 8 inches of precipitation as rain/snow mix at the Lower Ward Valley station. This storm was associated with a stationary low pressure system which merged cold air, with tropical moisture from near Hawaii. The elevation at which rain changed to snow was low enough however, to prevent significant rises on the west shore streams. A small amount of additional snow and rain occurred during 12/23-12/27/10. One more significant storm was observed at the end of December leaving approximately 3 more feet of dense wet snow at the Lower Ward Valley station. The series of wet storms in December contributed to a snowpack that was over 200% of average for early January (Sierra Sun, Jan. 10, 2011).

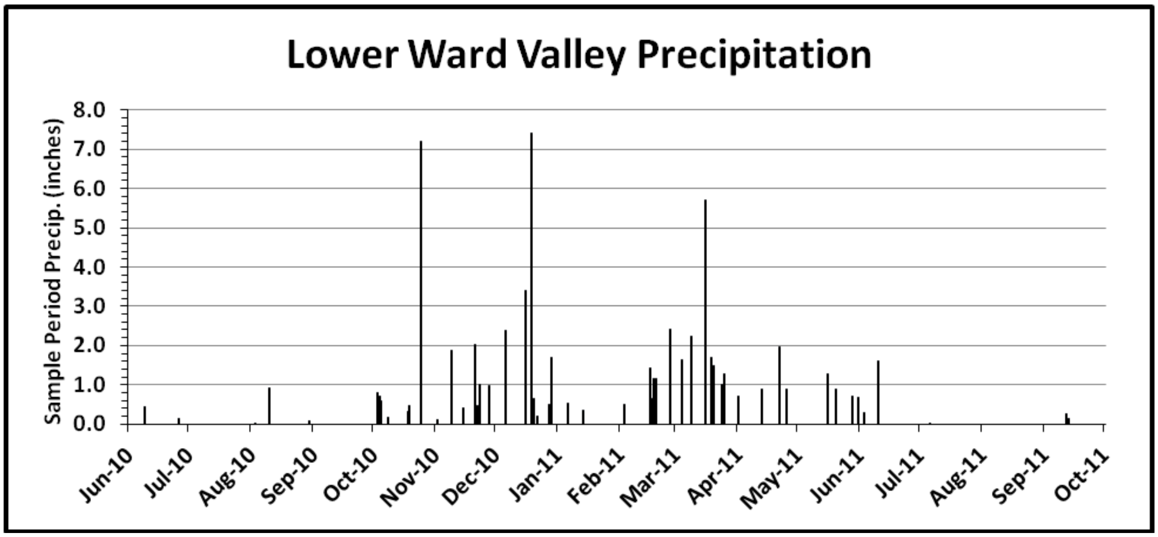

Figure 4. Precipitation amounts occurring at the Lower Ward Valley station. Each vertical bar represents total amount of precipitation during a collection period for a sample – in some cases samples include multiple events, (date under bars are collection dates).

A distinct lull in the wet pattern occurred during January to mid-February 2011. Very little precipitation (0.84 inches) occurred during this period. During the second half of Jan. and the first half of Feb. there were periods of relatively mild day-time temperatures.

A "wet" pattern re-developed in mid-February, with frequent storms and significant precipitation. Approximately 6 feet of new snow accumulated at the Lower Ward station Feb. 16-19, with another 2 feet Feb. 24 and 25 associated with a windy storm. Significant precipitation occurred in March including: nearly 4 inches of rain and snow early in the month, 5.69 inches of precipitation as rain, wet snow, then snow in the middle of March, then frequent snow during most of the second half of March with at least 7-8 feet of additional snow. By the end of March, a very significant snowpack had accumulated. After a brief break in the storms in early April, snow or mixed precipitation storms (several very windy) occurred frequently in the last two weeks of April. In May, periods of milder weather were interspersed with cool, wet weather. Several snow or rain and snow events occurred in the second half of May, with primarily snow falling at the end of May. After rain and snow in the first week of June, a drier, warmer, weather pattern finally developed, which lasted most of the month. One additional rain event occurred at the end of June. The remaining summer portion of 2011 was generally dry and warm with a few periods of isolated thunderstorms. Thunderstorms with some rain were noted along the west shore on July 6, September 10, 11, 12. Particularly heavy thunderstorm-associated rain was observed in the Tahoe Vista and Kings Beach area on 9/11/11.

Overall WY 2011 precipitation (66.92 inches) was the second highest in the last 30 years. WY 1995 was the highest with 73.29 inches. Other WY with nearly similar amounts as WY 2011 included: WY 2006 (65.99 inches), WY 1983 (65.46 inches), WY 1997 (63.54 inches), and WY 1986 (63.26 inches).

There were some significant hydrological impacts associated with the heavy precipitation in 2010-2011. Significant rises occurred on the west shore streams during the Oct. 24, 2010 fall rain event with likely enhanced sediment and nutrient loading. The increased flows on Blackwood Cr. during this event resulted in particularly noticeable erosion of the stream banks in the vicinity of the USGS gage. The winter and spring of 2011 was very wet and cool. As a result, a significant snowpack developed and the major portion of the spring snowmelt was delayed until the second half of June into early July. The rise in lake level elevation was very significant during WY2011 as a consequence of the significant precipitation and runoff. The lake level rose nearly five feet, from a minimum on Oct. 1, 2010 (6223.46 ft.) to a maximum of 6228.42 ft. on July 31, 2011. The bulk of the rise in lake surface elevation (nearly 4 feet) occurred between mid-Feb. through the end of July, 2011.

Annual Loading of Nitrogen and Phosphorus in Atmospheric Deposition

The atmospheric deposition monitoring in the Ward Creek watershed and on the lake at the buoy sampling locations provides data from which N and P deposition loading estimates are calculated. Appendices 1b-5b show the estimated loads (grams/hectare) of N and P associated with samples collected. Table 6 below presents estimated overall WY 2010 and WY2011 N and P loading expressed as a rate (grams/hectare/day) at the Lower Ward Valley, Mid-lake buoy TB-1 and buoy TB4 stations. Values for WY 2006-2009 are shown for comparison. 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 total load for samples analyzed by the proportion of total precipitation analyzed. This annual load was then divided by number of days/year to estimate daily loading rate. To determine dry deposition loading rate, the load for analyzed dry samples was divided by the total number of sampling days for the analyzed samples.

Table 6. Comparisons of loading rates (grams/ hectare/ day) of N and P at the Upper and Lower Ward Valley and buoy stations TB-1 and TB-4 during Water Years 2006 through 2011. Note this data was updated from previous reports to include all available chemistry data.

	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'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	1.93	0.05	0.13	0.25
Lower Ward (Wet) WY'09	37.34	1.11*	1.06*	2.90*	0.10*	0.14*	0.23*
Lower Ward (Wet) WY'10	38.64	1.26	1.65	3.76	0.05	0.11	0.46
Lower Ward (Wet) WY'11	66.92	1.91	2.34	4.39	0.10	0.23	0.34
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	12.23	0.66	0.88	2.10
Lower Ward (Dry) WY'09		1.13*	1.26*	11.73*	0.24*	0.39*	0.92*
Lower Ward (Dry) WY'10		1.03**	1.17**	14.50**	0.21**	0.32**	0.92**
Lower Ward (Dry) WY'11		1.14**	1.06**	12.78**	0.15**	0.25**	0.82**
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	14.16	0.71	1.01	2.35
Lower Ward (Wet+Dry) WY'09		2.24	2.32	14.63	0.34	0.53	1.15
Lower Ward (Wet+Dry) WY'10		2.29**	2.82**	18.26**	0.26**	0.43**	1.38**
Lower Ward (Wet+Dry) WY'11		3.05**	3.40**	17.17**	0.25**	0.48**	1.16**
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	4.29	0.12	0.19	0.35
TB-4 (Dry-Bulk) WY'09		1.92	2.48	4.49	0.04	0.06	0.14
TB-4 (Dry-Bulk) WY'10		2.26	2.08	6.10	0.06	0.11	0.19
TB-4 (Dry-Bulk) WY'11		1.88	1.83	3.28	0.04	0.09	0.19
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	3.93	0.12	0.19	0.35
Mid-lake TB-1 (Dry-Bulk) WY'09		1.90	2.03	3.61	0.05	0.07	0.16
Mid-lake TB-1 (Dry-Bulk) WY'10		2.52	2.67	6.11	0.07	0.11	0.25
Mid-lake TB-1 (Dry-Bulk) WY'11		2.01	1.68	3.09	0.06	0.11	0.23

Notes: "*" – The Wet/Dry sampler malfunctioned in Dec. 2008, resulting in the Dry bucket collecting a portion of the precipitation for several storms, the Wet bucket loading values shown do not account for Wet precipitation in the Dry bucket, the Dry bucket values include some Wet precipitation "**" – during some periods in WY 2010, 2011 there were power interruptions and problems with dust due to construction on property at the Lower Ward Valley station, samples noted to be contaminated with significant amounts of silt or organic material were not used. In early October 2010 the power line to the station was removed during construction activities. The Wet and Dry buckets were continually exposed to deposition for 2-3 weeks. Both Wet and Dry deposition collected in the Wet buckets during storm events was included in the Wet total loading.

<u>Annual N and P Loads in Wet Precipitation in Lower Ward Valley</u>

WY 2011 had the highest Wet precipitation loading rates[1]of NO_3-N (1.91 g/ha/d), NH_4-N (2.34 g/ha/d) and TKN (4.39 g/ha/d) of the last six years. WY 2006 which was the closest to WY2011 in terms of precipitation amount (65.9 inches) had less N loading, i.e. NO_3-N (1.59 g/ha/d), NH_4-N (1.56 g/ha/d).TKN (2.83 g/ha/d). TKN was higher both in WY 2010 and 2011 than the previous 4 years.

Loading rates for phosphorus in Wet precipitation were within the range of values observed for SRP and DP the last six years. TP loading rates in wet precipitation were highest in WY2010 (0.46 g/ha/d) and less in WY 2011 (0.34 g/ha/d).

The elevated TKN in 2010 and 2011 values may reflect to some extent disturbance around the station in these years. In both years, there was construction activity near the station which included grading and tree removal. Silt and organic matter from these activities may have been resuspended and fallen in the Wet bucket during winds associated with storms. (During some dry periods, material resuspended during construction or by winds was captured in the Dry bucket - samples with unusually heavy levels of silt or organic matter which was suspected to be associated with construction, were not used in loading estimates). Contribution of resuspended material from construction activities would have been most likely during periods when snow cover was absent. It is interesting to note, there also had been forest thinning in the Ward Valley watershed during summer 2010. It's also possible some of the small organic debris left after such thinning contributed to the Wet and Dry deposition at the Lower Ward site. Though the local contribution due to construction seems most probable, some contribution also from forest thinning cannot be ruled out.

Two other consequences associated with changes on the property around the station during 2010 and 2011 should be noted. First, in early October 2010 the power line to the station was cut off. During a period of 2-3 weeks, the Aerochem Metrics Wet/Dry collector lid was removed, allowing both the Wet and Dry bucket to capture any deposition (Wet or Dry) for this period. Wet and Dry deposition collected in the Wet buckets during storm events was included in the Wet total loading during this period. A second more general affect during 2010-2011, that should be noted, the construction of new buildings near the station and removal of some trees may have some impact on long-term deposition loading patterns (in addition to any short-term impacts occurring during construction). Current and future data from this site should take into consideration site changes which occurred in 2010 and 2011.

Figures 5 and 6 present the WY 1981- 2011 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 Wet deposition data. DIN load showed a steady increase WY 2009 to WY2011. The most significant increase was

[1] Total Wet loads for the year were divided by #days to obtain a daily rate for comparison with daily rates determined for Dry and Dry-Bulk loading.

in WY 2011 coinciding with the large increase in precipitation this year. The high DIN load in WY 2011 (1534.43 g/ha) was the highest total since WY 1999. The SRP load in WY 2011 (35.97 g/ha) was approximately twice that that occurred in WY 2010 (17.52 g/ha). Much of the increase in SRP loading in WY 2011 may be attributed to overall increased precipitation.

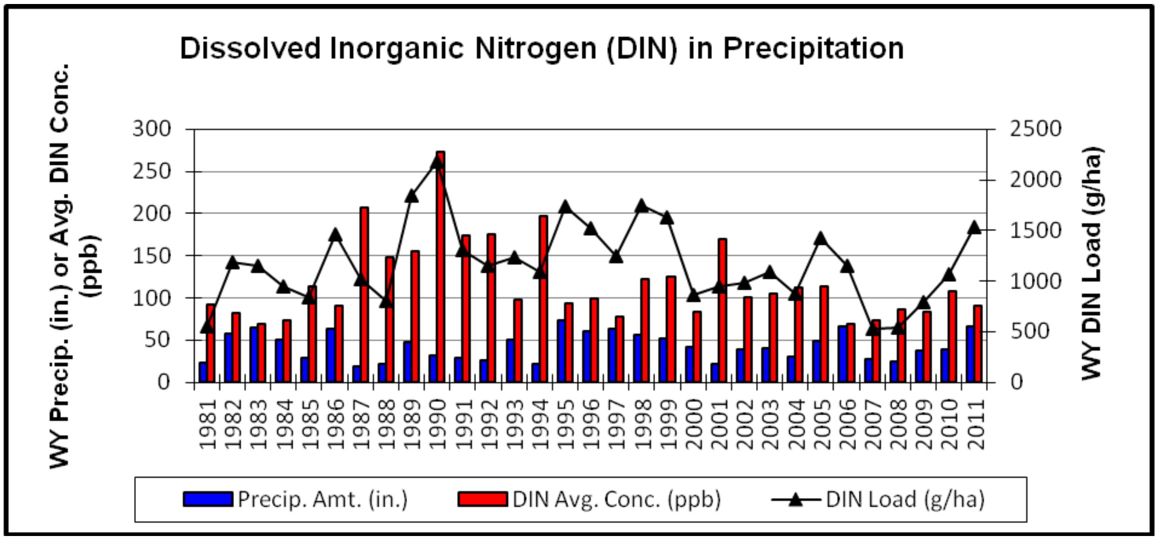

Figure 5. Summary plot of Water Year (WY) total precipitation (inches), average Dissolved Inorganic Nitrogen (DIN) concentration (ppb), and extrapolated annual DIN load (g/ha/yr) in Wet Deposition at the Ward Valley Lake Level station for WY 1981-2011. A Water Year begins Oct. 1 and ends Sept. 30 (i.e. WY 1981 ended 9/30/81).

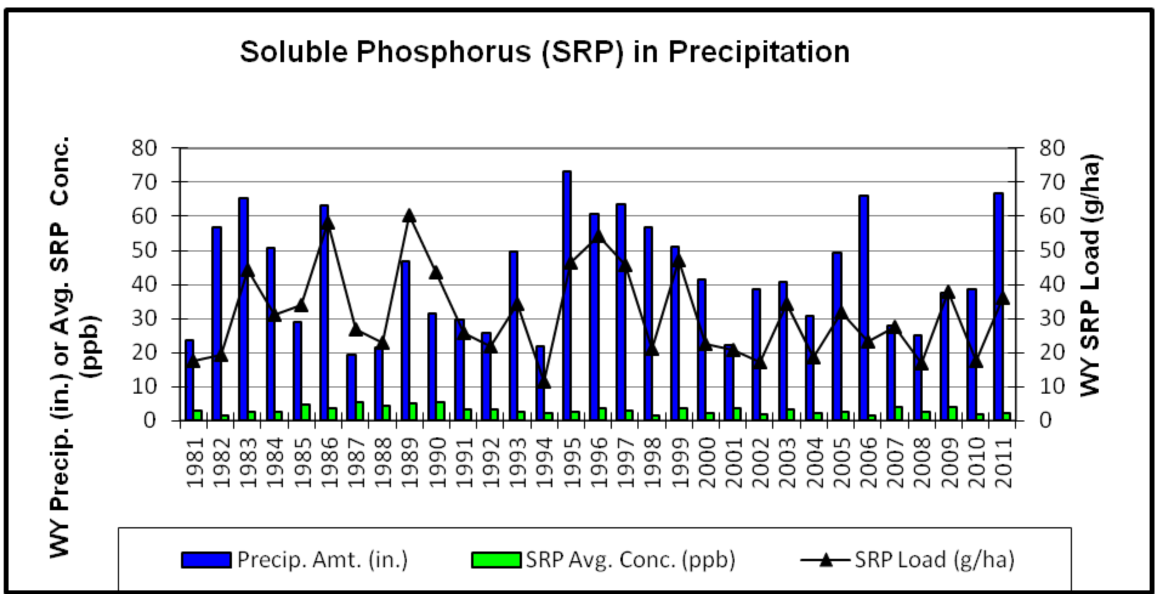

Figure 6. Summary plot of Water Year (WY) total precipitation (inches), average Soluble Reactive Phosphorus (SRP) concentration (ppb), and extrapolated annual SRP load (g/ha/yr) in Wet Deposition at the Ward Valley Lake Level station WY 1981-2011.

Annual N and P Loads in Dry Deposition in Lower Ward Valley

Construction activities near the station in 2010 and 2011 caused apparent contamination of several Dry deposition samples in both years. Samples with heavy silt or organic matter were censored and not used in the loading calculations. Since the Dry buckets are continually exposed during dry periods, they are susceptible to contamination by dust and organic matter during construction activities and through resuspension of settled particles by wind. The field notes and lab results were used to determine which samples had high amounts of silt or organic matter in them during the active construction season and these were censored. Dry deposition loading rate data for the Lower Ward station are shown in Table 6.

The loading rates for WY 2010 and 2011 were relatively similar to WY2009 rates when samples with obvious silt or organic contamination were excluded. Loading rates by nutrient (g/ha/d) during WY 2009, 2010, 2011 respectively were: NO_3-N (1.13, 1.03, 1.14); NH_4-N (1.26, 1.17, 1.06), TKN (11.73, 14.40, 12.78), SRP (0.24, 0.21, 0.15), DP (0.39, 0.32, 0.25) and TP (0.92, 0.92, 0.82). In comparison, rates for NO_3-N and NH_4-N loading were slightly less during WY 2006-2008 (range 0.74-0.98 g/ha/d for NO_3-N and range 1.00-1.01 g/ha/d for NH_4-N). TKN was slightly higher in WY 2010 than WY 2006-2009, 2011 (range 11.73-12.78 g/ha/d). Loading rates for SRP, DP and TP for WY 2006 -2007, 2009-2011 were fairly close, however WY 2008 values were much higher (WY 2008 SRP= 0.66g/ha/d, DP=0.88 g/ha/d, TP=2.35g/ha/d) as a result of an wildfire-associated ash deposition event resulted in noticeably higher loading rates at the Lower Ward station (see Hackley et al., 2010).

Annual N and P Loads in Dry-bulk Deposition at Buoys TB1, TB4

The loading rates at buoy stations TB-1 and TB-4 in WY 2010 and 2011, for most N and P constituents remained close to levels observed the previous 4 years (Table 6). WY 2010-2011 ranges at TB-1 and TB-4 for N and P in grams/hectare/day were: NO_3-N (1.88-2.52), NH_4-N (1.68-2.67), TKN (3.09-6.11), SRP (0.04-0.07), DP (0.09-0.11), TP (0.19-0.25). 2006-2009 ranges for N and P were: NO_3-N (1.66-2.19), NH_4-N (1.61-2.48), TKN (3.14-4.49), SRP (0.04-0.12), DP (0.06-0.21), TP (0.14-0.45). Data from a few extremely long collection periods (6/3-7/2/10, 1/4/11-2/11/11, 4/22/11-6/7/11) was not used in the loading estimates. TKN loading was significantly higher in WY 2010 (6.10 and 6.11 g/ha/d at buoys TB-4 and TB-1 respectively) compared to levels WY2006-2009 and WY 2011).

Summary Points for Atmospheric Deposition Monitoring WY2010, 2011

1. **Precipitation amounts were mid-range among values since 1981 in WY 2010 (38.64 in.) and second highest (66.92 in.) in WY 2011 at the TERC Lower Ward Valley station.**
2. **There were some significant hydrological impacts associated with the heavy precipitation in 2010-2011. Significant rises occurred on the west shore**

streams during the Oct. 24, 2010 fall rain event with likely enhanced sediment and nutrient loading. The increased flows on Blackwood Cr. during this event resulted in particularly noticeable erosion of the stream banks in the vicinity of the USGS gage. The winter and spring of 2011 was very wet and cool. As a result, a significant snowpack developed and the major portion of the spring snowmelt was delayed until the second half of June into early July. The rise in lake surface elevation was very significant during WY2011 as a consequence of the significant precipitation and runoff. The lake level rose nearly five feet, from a minimum on Oct. 1, 2010 (6223.46 ft.) to a maximum of 6228.42 ft. on July 31, 2011.

3. **Atmospheric deposition continues to be a significant source of nitrogen and phosphorus loading for the lake.**

4. **WY 2011 had the highest Wet precipitation loading rates of NO3-N (1.91 g/ha/d), NH4-N (2.34 g/ha/d) of the last six years at the Lower Ward Valley station. WY 2006 which was the closest to WY2011 in terms of precipitation amount (65.9 inches) still had significantly lower N loading, i.e. NO3-N (1.59 g/ha/d), NH4-N (1.56 g/ha/d).**

5. **DIN load in Wet deposition showed an increase WY 2009 to WY2011. The most significant increase was in WY 2011 coinciding with the large increase in precipitation this year. The high DIN load in WY 2011 (1534.43 g/ha) was the highest total since WY 1999. The SRP load in WY 2011 (35.97 g/ha) was approximately twice that that occurred in WY 2010 (17.52 g/ha). Much of the increase in SRP loading in WY 2011 may be attributed to overall increased precipitation.**

6. **The N and P loading rates for WY 2010 and 2011 in dry deposition were relatively similar to WY2009. Construction activities at the site in 2010 and 2011 likely contributed silt and organic matter to deposition samples at times, data from obviously contaminated samples was excluded from the loading estimates.**

7. **The loading rates at buoy stations TB-1 and TB-4 in WY 2010 and 2011, for most N and P constituents remained close to levels observed the previous 4 years.**

Task 6. Periphyton

The purpose of the periphyton monitoring task 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.

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. Substrata within this region desiccate as the lake level declines, and periphyton must recolonize this area when lake level rises. The sublittoral zone extends from the bottom of the eulittoral to the maximum depth of 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 filamentous green algae i.e. *Ulothrix sp, Zygnema sp* and stalked diatom species i.e. *Gomphoneis herculeana*. The attached algae in the eulittoral zone display significant growth allowing for rapid colonization. These algae are able to take advantage of localized soluble nutrients, and can establish a thick coverage over the substrate within a matter of months. Similarly, as nutrient concentrations diminish and shallow nearshore water temperatures warm with the onset of summer, this community rapidly dies back. The algae can slough from the substrate and disperse into the open water, as well as be washed 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. It is the rapid growth ability of the eulittoral periphyton in response to nutrient inputs that lend particular value to monitoring this community as an indicator of localized differences in nutrient loading.

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.

<u>Stations and Methods</u>

Nine routine stations were monitored during Oct. 2010- July, 2011 (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 7) 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 7. Locations of Routine Periphyton Monitoring Stations

SITE NAME	LOCATION
Rubicon	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 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 underwater (as well as above water for a portion of the data) 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 2010- July 2011. Nine routine sites were sampled. All sites were sampled five or more times during the period except Deadman Pt. which was sampled four times. Three of the sampling circuits were made during the spring (March-June), with additional sampling circuits made during Oct. 2010 and early Jan. 2011. Table 8 presents the results for biomass (chlorophyll *a* and Ash Free Dry Weight (AFDW)) and field observations (visual score, average filament length, percent algal coverage, biomass index and basic algal types) at the nine routine periphyton sites for the period July 2010-July 2011. The results for periphyton Chlorophyll *a* biomass are also presented graphically in Figures 7(a-i). In Water Year 2011, lake level played an important role in the levels of periphyton biomass measured. Figure 8 shows fluctuation in lake level during the study period and Figure 9 shows fluctuation in lake level since 2000.

Water Year 2011 Patterns of Periphyton Biomass

In WY 2011 (Oct. 1, 2010 – Sept. 30, 2011) measurements of periphyton biomass were strongly affected by the significant increase in lake surface elevation. The lake rose nearly five feet, (from 6223.46ft minimum surface elevation in October, 2010 to 6228.42 ft in August 2011) (Figs. 8,9) as a result of significant precipitation and runoff. Monitoring was done during very low lake levels early in the WY (Oct. and Jan.) and also during high lake level late in June 2011. During very low lake levels significant biomass associated with the Blue-green algae was present at the 0.5m sampling depth at many sites.[2] As the lake rose very rapidly later in the year, newly submerged substrate

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[2] During years when lake surface elevation is very low, biomass associated with the stable deeper, blue-green algal communities may be located in proximity to the surface. This heavy biomass is not necessarily a consequence of high nutrient availability but rather is a consequence of the lowering lake level. Conversely, during years where lake level rapidly rises and substrate near the surface has been recently submerged, very little biomass may be present, due to the short period of time for colonization.

was typically in proximity to the surface, whereas developing thicker growths of stalked diatoms were submerged to greater and greater depths.

Significant periphyton biomass associated with Blue-green algae growth, was measured at several sites in October, 2010 (Table 8; Figures 7a,b,g,h). Biomass levels were the highest for the WY at several of these sites including: Rubicon Pt. (Chl *a*=133.34mg/m^2), Sugar Pine Pt. (27.85 mg/m^2), Sand Pt. (53.69 mg/m^2) and Deadman Pt. (40.83 mg/m^2).

The lake level rose about a foot between Oct. 1, 2010 and Jan. 1, 2011 associated with significant precipitation (Figure 8). Significant Blue-greens were still noted on the rocks at 0.5m in January at several sites. At Incline West an annual maximum for chlorophyll *a* was measured (62.46 mg/m^2) (Figure 7f) associated with growth of both Blue-green algae and filamentous green algae. At a couple of other sites, stalked diatoms contributed significantly to the biomass. At Pineland (Figure 7c), the highest biomass of the WY was measured (177.15 mg/m^2) attributable to heavy stalked diatom growth over Blue-greens. Zephyr Pt. had moderate amounts of stalked diatoms (34.25 mg/m^2) in January (Figure 7i).

The heavy growth of stalked diatoms (Gomphoneis herculeana) at Pineland in early January was particularly interesting. This early heavy growth may have been caused by a combination of factors. Of particular note during this period, surface runoff and subsurface inputs of nutrients associated with the wet storms in October and Dec. may have contributed to the heavy growth. Upwelling of NO_3-N to surface waters during strong fall and early winter storms may also have contributed to this growth. Other factors may have contributed as well.

During the period January through about mid-February there was a lull in the storm activity, periphyton growing during this period may have been able to take advantage of increased nutrients in the water from earlier storms, increasing solar radiation, calm conditions (which would not subject the periphyton to sloughing), and stable lake level which may have allowed significant colonization of rock submerged since late December.

Lake level held stable through about mid-February, then began to steadily increase. Between mid-February and May 1 the lake rose about 1.5 ft (Figure 8). During this period, significant growth of stalked diatoms occurred at many sites on newly submerged substrate and below. Monitoring done during March to May for routine sites and April-May (see Figure 8) for expanded monitoring sites captured this period of heavy stalked diatom growth.

Highest spring levels of stalked diatom biomass were observed on the westshore including very heavy chlorophyll *a* biomass at Pineland (154.06 mg/m^2) (Figure 7c), moderate levels at Tahoe City (45.35 mg/m^2) (Figure 7d), Dollar Pt. (67.71 mg/m^2) (Figure 7e), and Rubicon Pt. (30.1 mg/$m^2$1) (Figure 7b). The level of stalked diatom biomass was also moderate at Incline West (38.08 mg/m^2) (Figure 7f) in the northern portion of the lake and Zephyr Pt (Figure 7i) along the south east shore (21.93 mg/m^2).

In contrast, sites along the north east shore and Sugar Pine Pt. along the west shore had very little or no periphyton biomass. Maximum chlorophyll *a* levels for these sites during March through early May included: Sand Pt. (4.07 mg/m^2) (Figure 7b), Deadman Pt. (0 mg/m^2) (Figure 7h) and Sugar Pine Pt. (7.35 mg/m^2) (Figure 7b).

From mid-May through the end of June rapid lake level rise (Figure 8), helped preclude the establishment of large biomass of stalked diatoms near the surface at many sites. With a lake level rise of about a foot and a half between mid-May and the end of June, substrate at 0.5 was only submerged for about 1.5 months which was a short time for establishment of significant growth. Sloughing of algae earlier in the spring from deeper substrate at some sites, and perhaps reduced nutrient availability in surface waters and warming temperatures may have also contributed to the low biomasses seen in late June.

Comparisons of visual observation of Periphyton Biomass Index (PBI) at fixed elevations monitored earlier in the year with PBI levels in May often indicated PBI levels either held constant or continued to increase on surfaces as the rocks were submerged to greater and greater depths (Table 8). For instance, filament length was 0.2cm and % coverage 80% (PBI =0.16) at Rubicon Pt. 0.5m at 6223.98 ft elevation on March 28, 2011. On 5/13/11 biomass at approximately the same elevation 6224.02 ft. (0.71m sampling depth) was much greater, (filament length=2.0 cm and % coverage 100% (PBI =2.0)) showing that biomass increased between 3/28/11 and 5/13/11 for this fixed sampling elevation even as the rock was submerged to a greater depth. A similar pattern of increase was observed at Dollar Pt. for a fixed elevation near 6224.00 ft between 3/28/11 (PBI = 0.07) and 5/9/11 (PBI =1.62) and for Incline West (fixed elevation also 6224.0 ft) between 3/31/11 (PBI = 0.27) and 5/6/11 (PBI =1.5). PBI also was compared at fixed elevations for these sites for fixed elevation samples between 1/5/11 and the May sampling dates, and PBI was much increased in May at all three sites after an increase in depth of approximately a half meter. This indicated conditions for growth remained favorable at these sites between January and May, and the stalked diatoms could establish over the Blue-green algae present in January.

In contrast, comparisons of PBI between samples collected in April or May at fixed elevations with values for samples in late June, indicated some samples increased in PBI and some significantly decreased. At Incline West, elevation 6224.38, PBI increased between 5/6/11 (PBI =0.60) and 6/30/11 (PBI =0.90). In contrast, decreases in PBI between April and late June, at fixed elevations, were observed at: Tahoe City (6224.40 ft. elevation) between 4/29/11 (PBI =2.70) and 6/30/11 (PBI =0.25) and Sugar Pine Pt. (6224.40 ft elevation) where PBI declined from (PBI=0.24) on 4/29/11 to PBI=0 on 6/30/11. Conditions may have become less favorable for growth at these sites and/or sloughing of algae occurred. Significant sloughing of periphyton was observed at Tahoe City in late May the day after a strong South wind event associated with a snow storm on 5/25/11.

Significant periphyton stalked diatom growth (PBI=5.0) was still observed at 1.3m at Pineland on 6/30/11. Conditions were still favorable at that depth for sustaining biomass. However, biomass was very low at 0.5m (PBI=0.14) indicating minimal colonization.

Table 8. Summary of eulittoral periphyton Chlorophyll a (Chlor.a), Ash Free Dry Weight (AFDW), visual score from above and below water, average filament length, percent algal coverage, and predominant algal types estimated visually underwater (where SD= stalked diatoms; FG= filamentous greens; CY= blue-green algae) for routine periphyton monitoring sites during July 2010-July 2011. 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. Biomass Index is Filament Length times % Algal Cover. Also,"na" = not available or not collected; "nes" = not enough sample for analysis. Sampling depth and corresponding sampling elevation are also indicated.

Site	Date	Sampling Depth/Elev (m/ ft)	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 Cover. (%)	Biomass Index	Algal Type
Rubicon Pt.	10/13/10	0.5/6221.89	133.34	43.27	89.98	12.88	2	3	1.0	70	0.70	CY
	1/5/11	0.5/6222.91	108.68	25.23	62.89	8.28	3	3.5	0.8	90	0.72	CY,FG
	3/28/11	0.5/6223.98	14.60	3.22	5.99	1.30	3	2.5	0.2	80	0.16	SD
	5/5/11	0.5/6224.51	11.50	1.35(n=3)	6.06	1.56(n=3)	4	3	1.2	50	0.6	SD
	5/13/11	0.59/6224.38	30.11	2.56(n=3)	18.18	4.72(n=3)	4	4	1.8	100	1.8	SD
	5/13/11	0.71/6224.02	-	-	-	-	-	-	2.0	100	2.0	SD
	5/13/11	1.03/6222.97	-	-	-	-	-	-	2.0	80	1.6	FG,SD
Sugar Pine Pt.	10/13/10	0.5/6221.89	27.85	14.58	24.89	11.80		2	0.2	80%	0.16	CY
	1/5/11	0.5/6222.91	10.06	1.18	8.80	0.23	NA	2	0.2	50%	0.10	CY,FG
	3/28/11	0.5/6223.98	7.35	1.15	2.89	1.19	2.5	2.5	0.3	90%	0.27	SD
	4/29/11	0.5/6224.40	6.56	0.88	2.00	1.12	NA	3	0.3	80%	0.24	SD
	6/30/11	0.5/6226.36	BLD	BLD	BLD	BLD	1	1	0.0	0%	0.00	NA
	6/30/11	0.88/6225.11	NES	NES	0.00	0.00	1		0.0	0%	0.00	SD
	6/30/11	1.1/6224.39	-	-	-	-	1	1	0.0	<1%		NA
Pineland	10/13/10	0.5/6221.89	37.41	2.10	33.90	8.68	2	2	0.3	70%	0.21	CY
	1/5/11	0.5/6222.91	177.15	49.00	79.24	24.50	3.5	3	1.5	80%	1.20	CY,SD,FG
	3/28/11	0.5/6223.98	67.43	30.39	56.28	35.80	5	5	3.0	100%	3.00	SD
	4/29/11	0.5/6224.40	154.06*	78.56	91.31*	27.41	4	5	3.5	90%	3.15	SD
	5/13/11	0.59/6224.38	68.22	19.06(n=3)	32.27	5.96 (n=3)		4	2.0	90%	1.80	SD
	6/30/11	0.5/6226.36	1.76	(n=1)	3.81	(n=1)	2	2	0.2	70%	0.14	SD
	6/30/11	0.85/6225.11	16.71	1.16	33.37	2.41		4	2.5	90%	2.25	SD,FG
	6/30/11	1.3/6223.73	-	-	-	-	5	5	5.0	100%	5.00	SD,FG

Site	Date	Sampling Depth/Elev (m/ ft)	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 Cover. (%)	Biomass Index	Algal Type
Tahoe City	10/13/10	0.5/6221.89	18.66	0.19	20.10	2.55	1	2	0.1	50%	0.05	SD
	1/5/11	0.5/6222.91	37.03	4.03	36.17	10.38	2	2.5	0.5	10%	0.05	SD
	3/28/11	0.5/6223.98	24.91	2.85	14.65	0.66	2	3	0.4	90%	0.36	SD
	4/29/11	0.5/6224.40	43.12	20.49	48.78	26.54(n=3)	4	4	3.0	90%	2.70	SD
	5/9/11	0.56/6224.44	45.35	13.58(n=3)	65.15	19.54(n=3)	4	4	2.5	90%	2.25	SD
	5/26/11	0.7/6224.40	-	-	-	-	-	-	0.6	variable	NA	SD
	6/30/11	0.5/6226.36	2.00	0.08	3.23	0.02	2	2	0.2	80%	0.16	SD
	6/30/11	0.85/6225.21	4.59	0.78	7.49	0.15	NA	NA	0.3	50%	0.15	SD
	6/30/11	1.1/6224.39	-	-	-	-	-	-	0.5	50%	0.25	SD
Dollar Pt.	10/13/10	0.5/6221.89	14.77	5.32	17.41	3.54	1	1	0.1	40%	0.04	SD or BG
	1/5/11	0.5/6222.91	34.35(n=1)	NA	35.79	(n=1)	2	2	0.2	60%	0.12	SD,FG
	3/31/11	0.5/6224.00	13.08	1.61	4.98	0.59	2	2	0.1	70%	0.07	SD
	4/29/11	0.5/6224.40	67.71	14.31	67.00	15.70	3	3.5	1.5	80%	1.20	SD
	5/9/11	0.56/6224.44	-	-	-	-	-	3.5	1.0	90%	0.90	SD
	5/9/11	0.69/6224.02	-	-	-	-	-	-	1.8	90%	1.62	SD
	5/9/11	1.0/6223.00	-	-	-	-	-	-	3.0	100%	3.0	SD
	7/1/11	0.5/6226.40	2.49	0.08	3.83	0.51	1.5	2	0.1	90%	0.09	SD
	7/1/11	0.85/6225.25	5.31	2.36	9.46	1.27	-	2	0.3	70%	0.21	SD
	7/1/11	1.15/6224.27	-	-	-	-	-	2.5	0.5	10%	0.05	SD
Incline West	10/13/10	0.5/6221.89	38.69	4.57	43.95	5.13	2	3	0.4	90%	0.36	CY,FG
	1/5/11	0.5/6222.91	62.46	n=1**	66.09	n=1**	2	3	0.7	90%	0.63	CY,FG
	3/31/11	0.5/6224.00	15.42	3.27	7.37	1.01	2	2	0.3	90%	0.27	SD
	5/6/11	0.54/6224.38	38.08	3.80	16.58	1.20	2	3	2.0	30%	0.60	SD
	5/6/11	0.65/6224.02	-	-	-	-	-	4	2.5	60%	1.5	SD
	5/6/11	0.98/6223.06	-	-	-	-	-	3	1.6	90%	1.44	SD
	7/1/11	0.5/6226.40	2.22	0.13	NES	NES	1.5	2	0.1	70%	0.07	SD
	7/1/11	0.85/6225.25	3.49	0.41	5.81	1.41	-		0.5	60%	0.30	SD
	7/1/11	1.1/6224.43	-	-	-	-	-	3	1.5	60%	0.90	CY,FG,SD

Site	Date	Sampling Depth/Elev (m/ ft)	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 Cover. (%)	Biomass Index	Algal Type
Sand Point	10/13/11	0.5/6221.89	53.69	3.76	70.01	0.88	3	3	0.8	80%	0.64	CY,FG
	1/5/11	0.5/6222.91	40.24	5.03	34.81	4.35	2	2	0.4	50%	0.20	CY,FG
	3/31/11	0.5/6224.00	BLD	BLD	BLD	BLD	1	1	0.0	0%	0.00	none
	5/6/11	0.54/6224.38	4.07	1.11	3.68	N=1	3	3	0.8	60%	0.48	SD
	7/1/11	0.5/6226.40	NES	NES	NES	NES	1	1	0.0	0%	0.00	none
	7/1/11	0.85/6225.25	NES	NES	NES	NES	1	1	0.0	0%	0.00	none
Deadman Pt.	10/13/11	0.5/6221.89	40.83	2.63	51.24	0.46	3.5	3	0.6	75%	0.45	CY,FG
	1/5/11	0.5/6222.91	22.28	5.22	26.48	3.84	2	2	0.3	50%	0.15	CY
	3/31/11	0.5/6224.00	BLD	BLD	5.62	5.01	1	1	0.0	0%	0.00	none
	5/6/11	0.54/6224.38	BLD	BLD	1.82	0.90	1	1	0.0	0%	0.00	none
	5/6/11	0.65/6224.02	-	-	-	-	1	1	0.0	0%	0.00	none
	5/6/11	0.98/6223.06	-	-	-	-	-	3	0.5	90%	0.45	CY,FG
Zephyr Point	10/13/10	0.5/6221.89	28.95	11.05	25.86	10.20	3	3	0.6	70%	0.42	CY,FG
	1/5/11	0.5/6222.91	34.25	20.71	28.51	17.59	2	2	1.0	70%	0.70	SD
	3/31/11	0.5/6224.00	21.93	6.03	8.96	5.26	3	3	0.4	100%	0.40	SD
	5/5/11	0.5/6224.51	15.39	2.64	6.98	1.66(n=3)	3	3	0.5	90%	0.45	SD
	5/23/11	0.67/6224.40	12.90	2.22(n=3)	10.16	2.60(N=3)	3	3	0.7	90%	0.63	SD
	7/1/11	0.5/6226.40	BLD	BLD	NES	NES	-	1.5	<0.1	0%	0.00	none
	7/1/11	0.85/6225.25	1.61	0.01	NES	NES	-	-	<0.1	1%	0.00	SD
	7/1/11	1.1/6224.43	-	-	-	-	-	-	0.5	30%	0.15	SD

Notes - * -One Pineland biomass sample replicate had anomalously high chlorophyll *a* = 478.17 mg/m^2 and AFDW= 224.31 g/m^2 and was not included in the Pineland chlorophyll *a* and AFDW means for 4/29/11; one Incline West biomass sample replicate (1/5/11) was anomalously high based on the observations of growth at the site ranking and biomass index, (chlorophyll *a* = 227.41 mg/m2), this sample was not included in totals for chlorophyll *a* and AFDW.

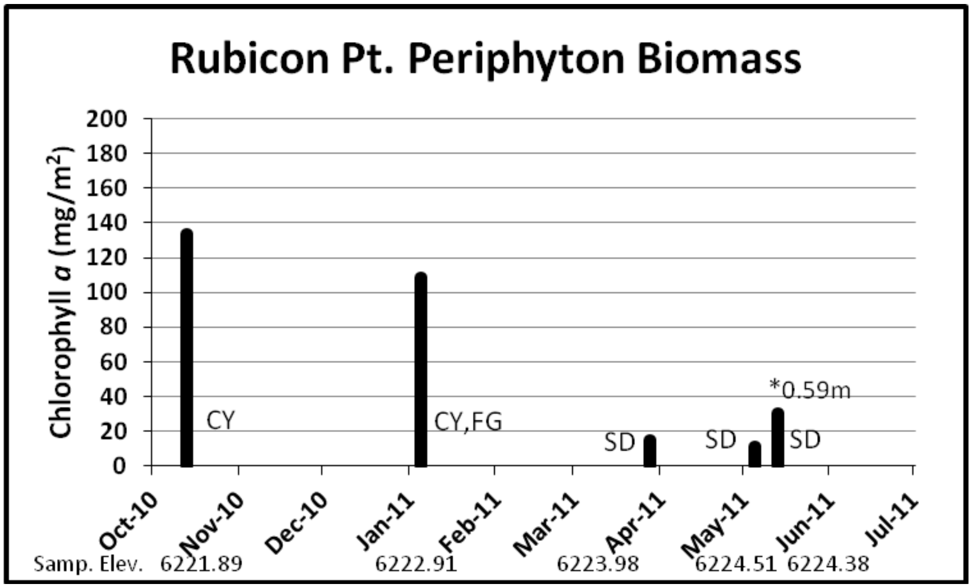

Figure 7 a. Rubicon Pt. periphyton biomass (chlorophyll a) Oct. 2010-July 2011. Predominant algae type(s) observed are indicated for each collection date (CY=Cyanophytes or Blue-green algae; FG= Filamentous green algae; SD=Stalked diatoms). Samples were collected at 0.5m sampling depth except where different depth indicated with "*". Sample collection elevations are indicated along bottom of chart, for reference, the natural rim of the lake is 6223.0 ft.

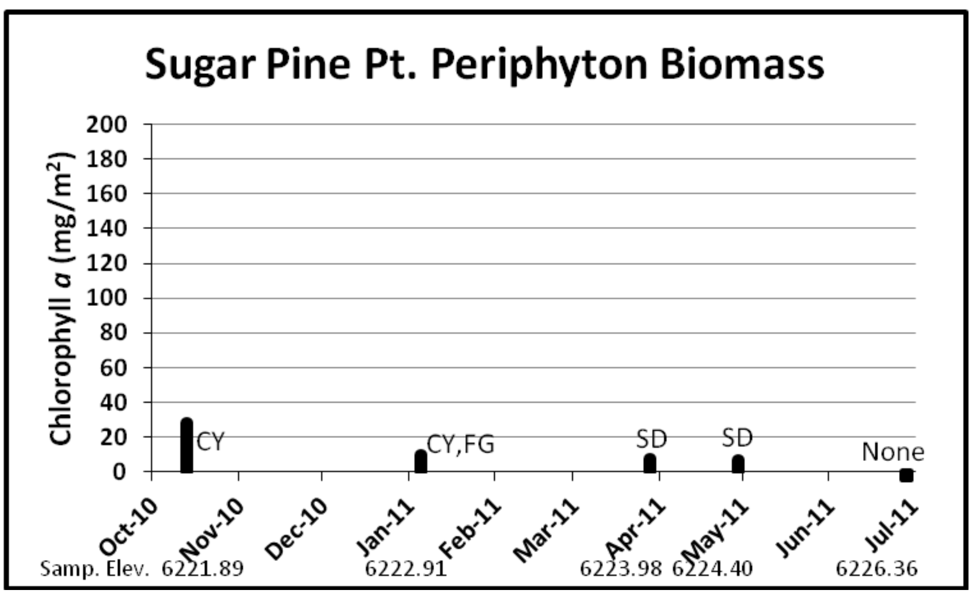

Figure 7 b. Sugar Pine Pt. periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

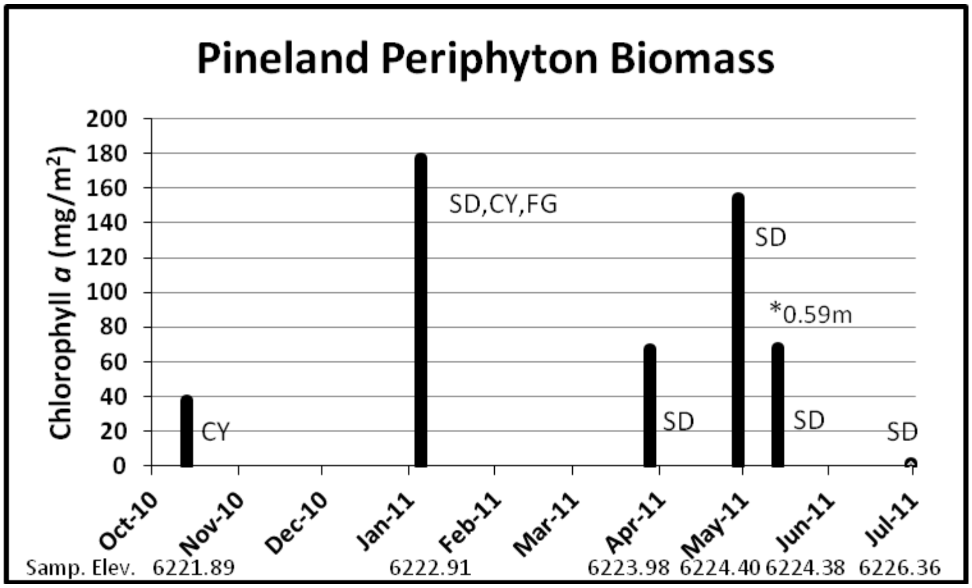

Figure 7 c. Pineland periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

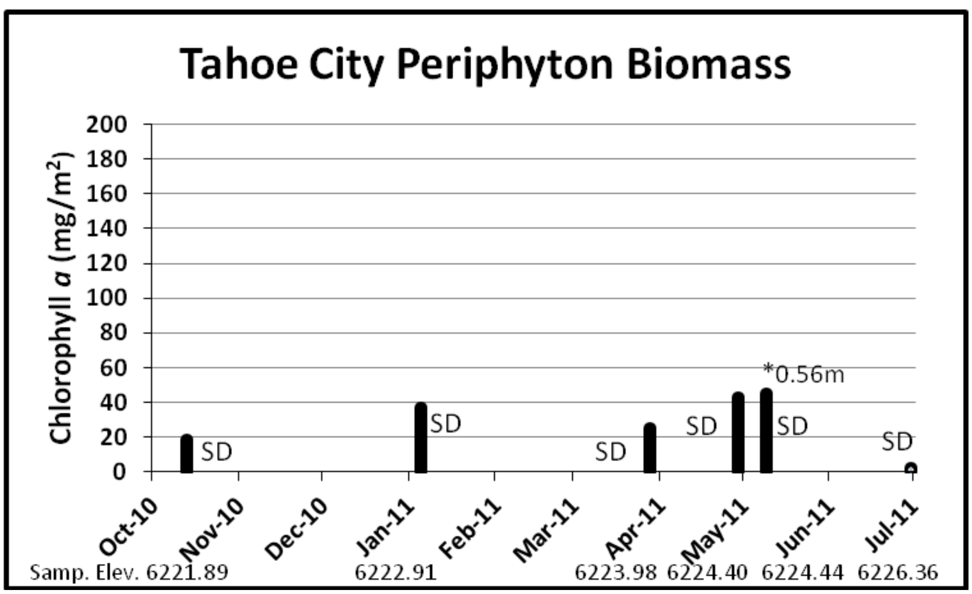

Figure 7 d. Tahoe City periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

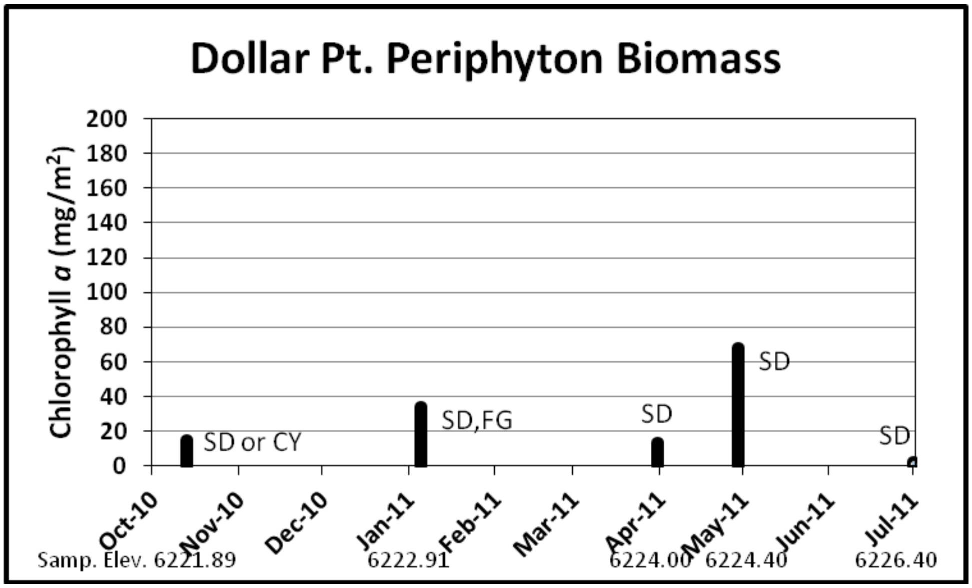

Figure 7 e. Dollar Pt. periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

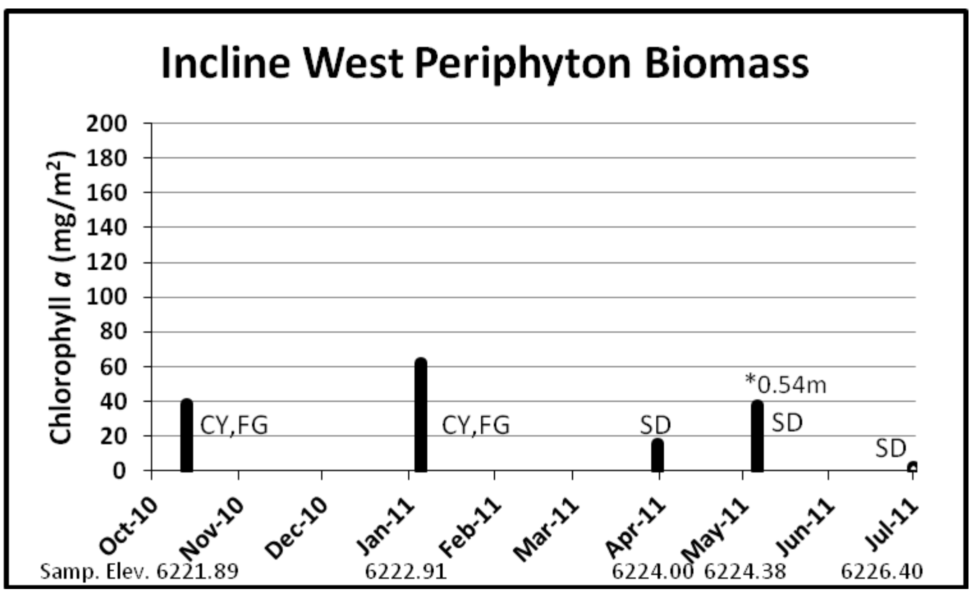

Figure 7 f. Incline West periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

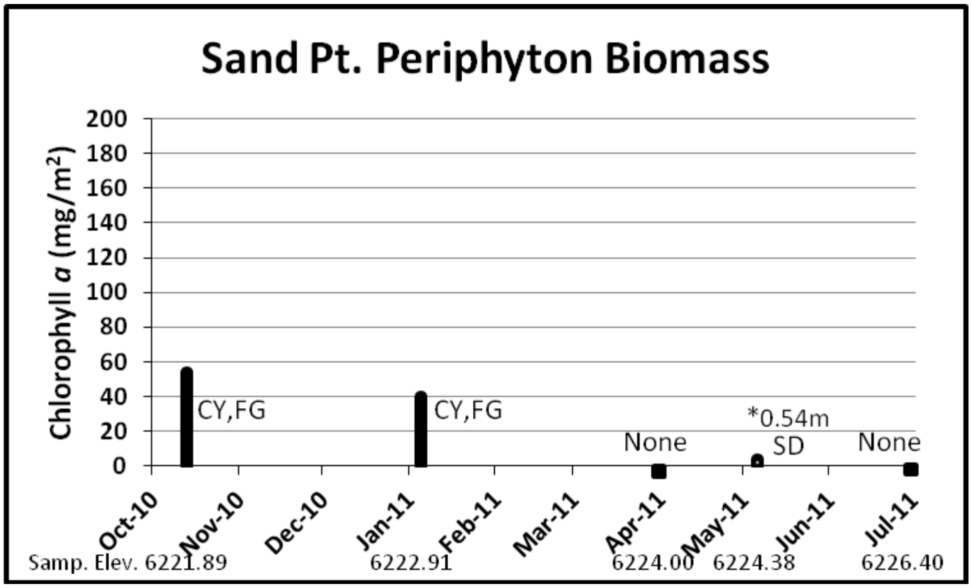

Figure 7 g. Sand Pt. periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

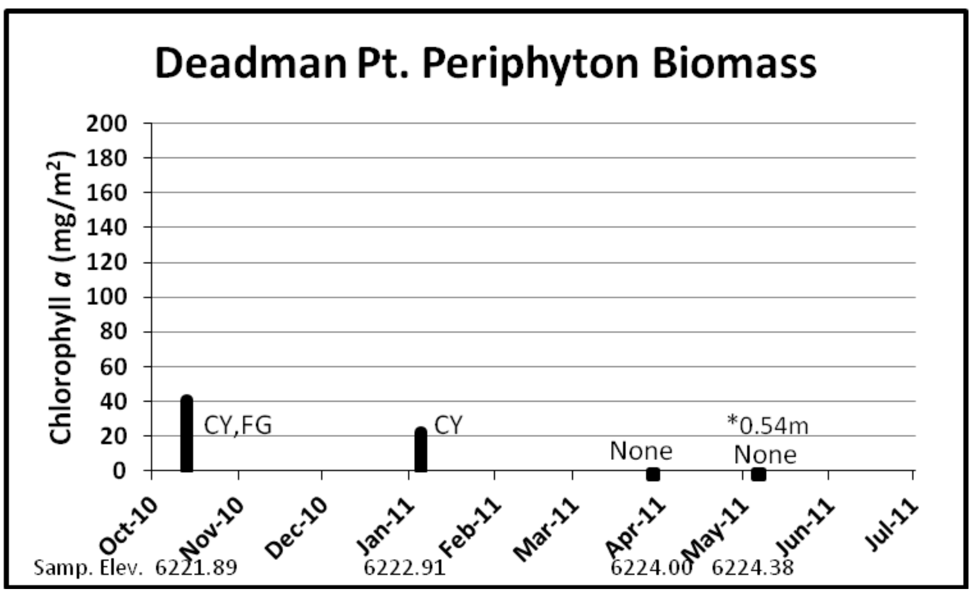

Figure 7 h. Deadman Pt. periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

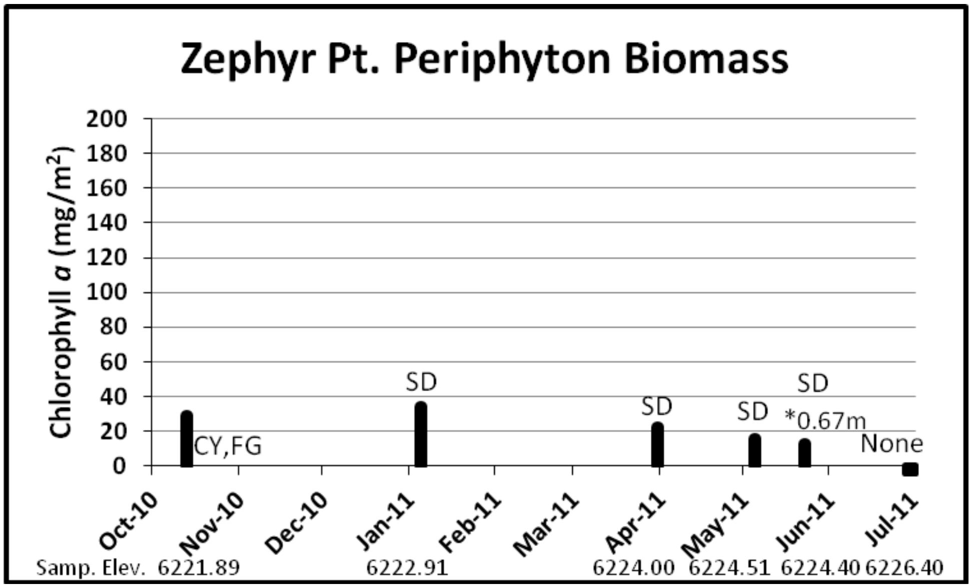

Figure 7 i. Zephyr Pt. periphyton biomass (chlorophyll *a*) Oct. 2010-July 2011.

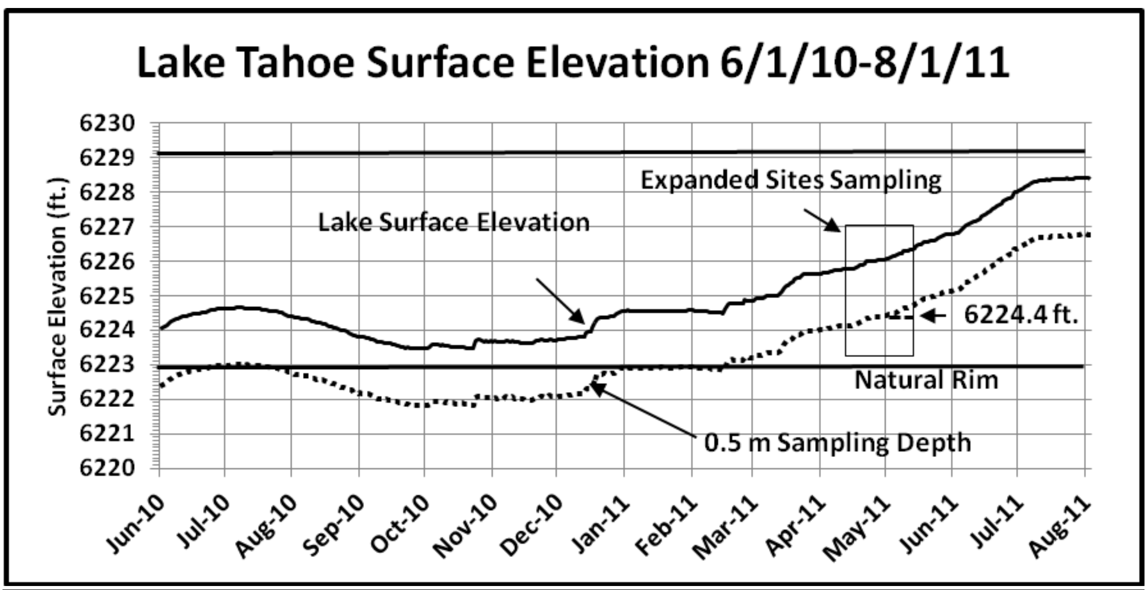

Figure 8. Fluctuation in Lake Tahoe surface elevation 6/1/10-8/1/11. Periphyton samples were typically collected during the period at a depth of 0.5m below the surface on natural rock substrata (dotted line). During the expanded sites monitoring in the spring 2011 (period shown encompassed in small box), the sampling elevation was maintained near 6224.40 ft as the lake began to rise rapidly.

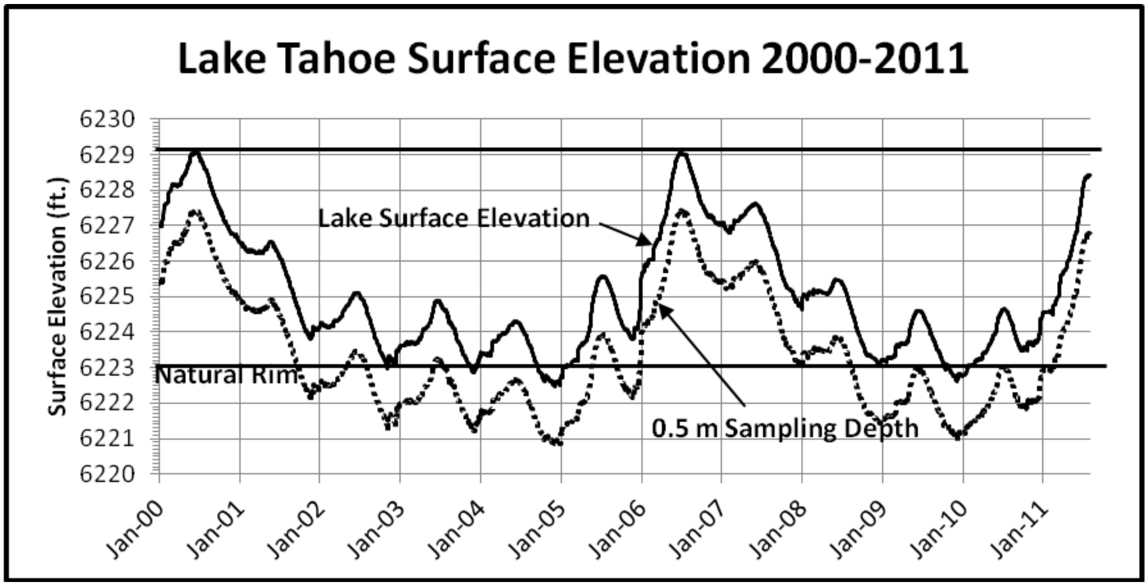

Figure 9. Fluctuation in Lake Tahoe surface elevation 1/1/00-8/1/11. Periphyton samples were typically collected during the period at a depth of 0.5m below the surface on natural rock substrata. The 0.5m sampling depth (shown as a dotted line) fluctuates with the lake surface elevation. The elevation of the natural rim of Lake Tahoe is 6223 ft. The top 6.1 ft. of the lake above the rim are operated as a reservoir.

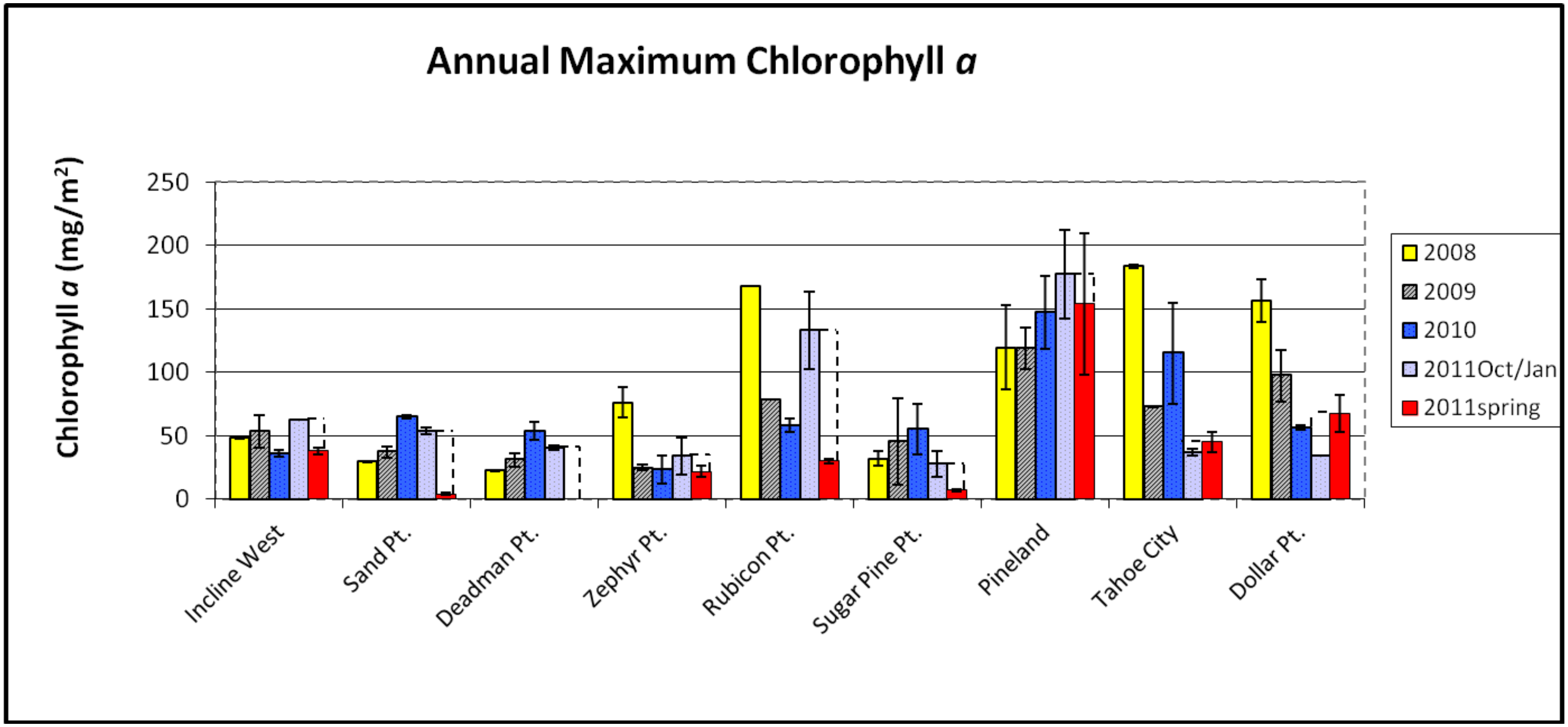

Figure 10. Annual maximum periphyton Chlorophyll *a* Water Years 2008-2011 at the nine routine periphyton monitoring sites at 0.5m. In Water Year 2011, a significant lake level rise of nearly five feet occurred, (from 6223.46ft minimum surface elevation in October, 2010 to 6228.42 ft in August 2011). During low lake level Oct. 2010-Jan. 2011 biomass at many sites was primarily due to Blue-green algae (Cyanophytes) and also filamentous green algae and was quite high, notably at Rubicon Pt. (the maximum biomass for Oct. 2010-Jan. 2011 is shown above as the light blue bar). During the spring, 2011, as lake level rose rapidly, periphyton colonized newly submerged rock, this growth was primarily stalked diatoms (the spring maximum growth for 2011 is shown by the red bar). The maximum for the whole year is the larger of the two maximums, indicated by dashed lines in the figure.

Annual Maximum Biomass

WY 2008-WY2011 maximum biomass values as estimated by chlorophyll *a* for all sites are shown in Figure 10. WY 2011 was a bit unusual in that biomass was high at many sites early in the year associated with low lake levels and significant Blue-green algae biomass. Later in the spring significant biomass associated with stalked diatoms was also present at several sites. So peaks in annual biomass occurred from some sites early in the WY, while for others the peaks occurred in the spring. Pineland actually had peaks in both periods. To reflect the importance of the two periods relative to annual maximum growth in WY2011, data for both Oct./Jan. period and the spring were presented in the summary chart showing annual maximum chlorophyll *a* (Figure 10). The highest of the two bars represents the maximum for the year.

The pattern for maximum annual biomass (when the maximum for both periods combined was used) was slightly different from that typically seen in the long-term monitoring. In past years, three sites in the northwest portion of the lake, (i.e. Pineland, Tahoe City and Dollar Pt.) often had the highest annual maximum chlorophyll *a*. In WY 2011, Pineland continued to have extremely high maximum chlorophyll *a* while, levels at Tahoe City and Dollar were only moderate (not strikingly different from some of the other sites around the lake). These results may be in large part explained by high biomass associated with Blue-greens early in the year at some of the other sites (for instance at several of the east shore sites as well as at Rubicon Pt., levels of biomass early in the year were near maximum). At Tahoe City the Annual Maximum chlorophyll *a* was less than it had been the last three years.

When the data for maximum chlorophyll *a* associated with stalked diatom growth during the spring period is compared, however, the results however do remain consistent with patterns observed in past years. During the spring of 2011 the highest annual periphyton biomass was still observed at these three sites (Pineland, Tahoe City and Dollar Pt. in the northwest portion of the lake). Periphyton biomass in the spring at sites along the east shore was very low in WY 2011 and was moderate at Incline West in the northern part of the lake.

It is interesting to note that at Tahoe City the Annual Maximum chlorophyll *a* was less than it had been the last three years. However, Ash Free Dry Weight (another measure of biomass, which included all the organic material present) at Tahoe City during the peak in 2011 (65.15 g/m2) was close to the peak in 2010 (69.48 g/m2). During peak growth at Tahoe City the growth of stalked diatoms was very heavy and covered the sandy bottom as well as cobble. So a large amount of biomass was present. It’s possible there was less chlorophyll *a* per unit organic material at Tahoe City in 2011.

Expanded Monitoring 2011

While the nine routine sampling sites provide data from many different regions around the lake with differing levels of backshore development and disturbance, the limited number of these sites does not provide enough resolution to determine periphyton biomass on a whole-lake scale. For this reason an "expanded" synoptic sampling was done in the spring in which 43 additional sites along with the nine routine sites were monitored for level of periphyton growth. Table 9 presents the names and locations of these synoptic sites. This synoptic monitoring was timed as much as possible to correspond to peak periphyton growth in each region of the lake.

During spring 2011, the 43 expanded sites were monitored visually while snorkeling. Measurements of filament length, % coverage, above and below water visual ranking, and observations on main algal types present were made. In addition biomass samples (chlorophyll *a* and AFDW were collected at 7 of the sites).

Table 9. Periphyton expanded monitoring locations.

	WEST SHORE	
SITE DESIGNATION	SITE NAME	LOCATION
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
F	N. Meeks Bay	N39 02.475; W120 07.194
G	Tahoma	N39 04.199; W120 07.771
H	S. Fleur Du Lac	N39 05.957; W120 09.774
I	Blackwood Creek	N39 06.411; W120 09.424
J	Ward Creek	N39 07.719; W120 09.304
K	N. Sunnyside	N39 08.385; W120 09.135
L	Tavern Point	N39 08.806; W120 08.628
TCT	Tahoe City Tributary	(adjacent to T.C. Marina)
M	TCPUD Boat Ramp	N39 10.819; W120 07.177
N	S. Dollar Point	N39 11.016; W120 05.888
O	S. Dollar Creek	N39 11.794; W120 05.699
P	Cedar Flat	N39 12.567; W120 05.285
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	
E12	Hidden Beach	N39 13.263; W119 55.832
E13	Burnt Cedar Beach	N39 14.680; W119 58.132
	Incline Condo	N39 14.90; W119 59.63
	Old Incline West	(100 yds No. Incline West)
E14	Stillwater Cove	N39 13.789; W120 00.020
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
	Timber Cove Rocks	Rocks west T. Cove Pier

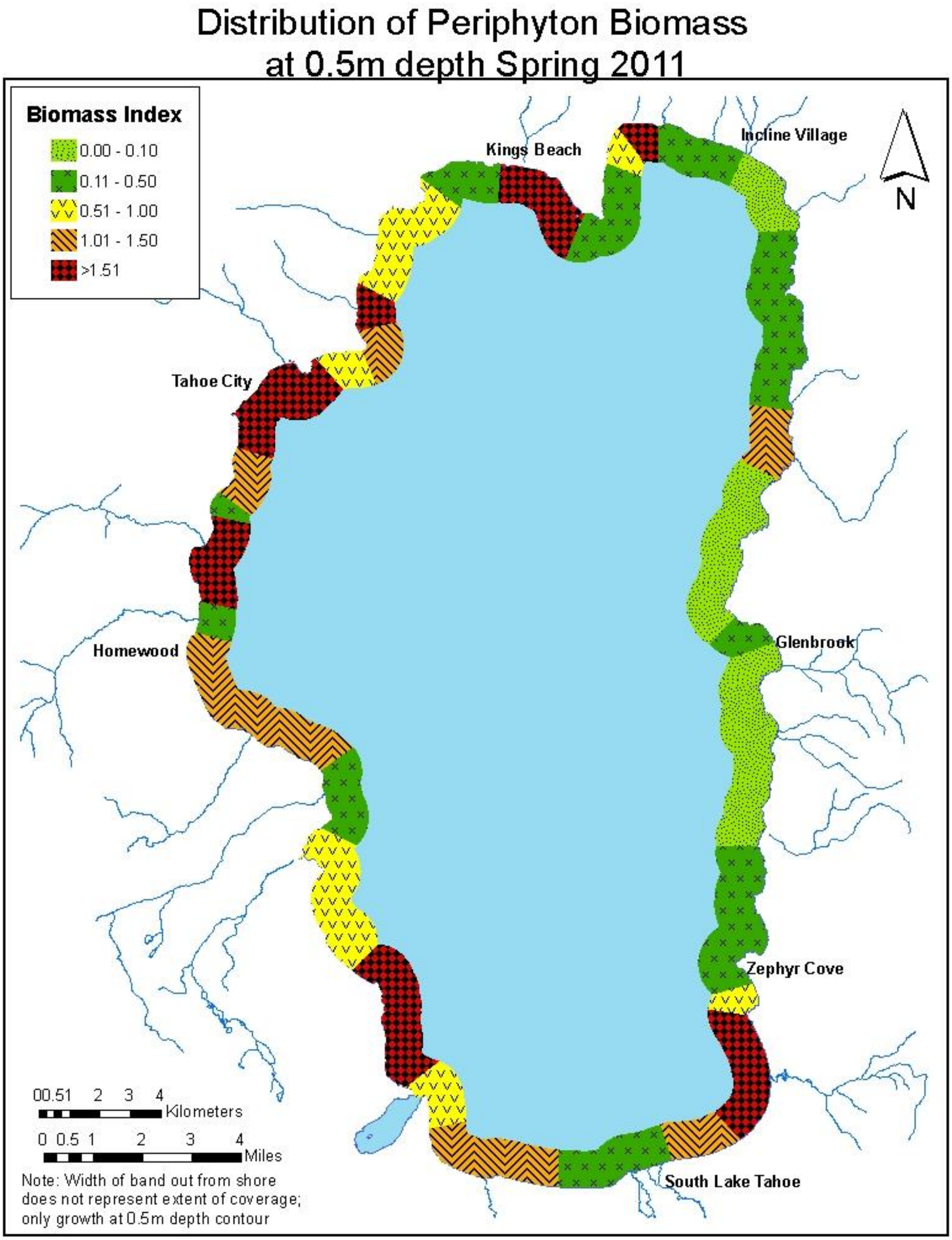

Figure 11. Extrapolated regional distribution of periphyton biomass measured as Biomass Index (Avg. Filament Length x % Area Covered with Algae) April 12 – May 13, 2011.

2011 Expanded Monitoring Results

Data collected for the expanded monitoring 2011 is summarized in Table 10. Figure 11 presents a map showing the general distribution of periphyton biomass (as Biomass Index) around the lake in spring 2011. The 2011 expanded monitoring was done during the spring when lake level was increasing rapidly and significant stalked diatom growth was still present at 0.5m. Sites at South Shore were sampled slightly earlier (on 4/12/11) than other sites (spring biomass often peaks earlier there than at the other sites.) The remaining expanded sites as well as routine sites were sampled during the period 4/29/11 to 5/13/11. Due to rapid lake level rise, after 5/5/11, a fixed sampling elevation of ~6224.40 ft. was used for monitoring to help assure algae had colonized substrate for approximately the same length of time.

Again, 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 and also the rapid lake rise, 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.

Along the southwest shore, from Cascade Creek to Sugar Pine Pt. growth was light to moderate with regions of heavier growth in the E.Bay/Rubicon and Rubicon Pt. areas and near Cascade Cr. E. Bay/Rubicon and Rubicon Pt. areas: U/W visual score was 4 at both sites; Biomass Index values were 1.98 and 1.80 at the sites respectively; chlorophyll *a* was moderately high at both sites (34.62 and 30.11 mg/m2 respectively). Near the mouth of Cascade Cr. U/W visual score was 4 and Biomass Index 1.5 (chlorophyll *a* was not measured).

Along much of the northwest shore from Tahoma to near Dollar Cr. growth was moderate to very heavy (underwater visual scores of 4-5 and Biomass Indexes > 1) with some areas of low-to-moderate growth (Biomass Indexes < 1) interspersed. Areas of heavy biomass were attributable to stalked diatoms. Areas with the heaviest amounts of biomass (U/W visual ranking of 5) included: Tahoma, Kaspian Pt., Ward Cr., Pineland and Tahoe City Tributary. Chlorophyll *a* was measured at two of the sites and was very heavy at Ward Cr. (323.1 mg/m2) and Pineland (154.1 mg/m2). Areas with light growth included the mouth of Blackwood Cr. where substrate is likely unfavorable for growth (sand, gravel, small cobble) and North Sunnyside, where nearshore substrate may also be unfavorable (small cobble prone to tumbling in wave activity).

Further north from Cedar Flat to Stateline Pt. biomass was light to moderate with a region of heavier biomass in the Kings Beach (U/W rank=4, Biomass Index = 1.90) and Brockway Springs (U/W rank = 5, Biomass Index =2.52) areas.

Growth was generally light along the north east and east shore between Stillwater Cove and Zephyr Pt. with a few pockets of heavier growth. One area of heavier growth was in the northeast corner of Crystal Bay at Incline Condominiums (U/W rank=4.5, Biomass Index= 1.82), Incline West adjacent to this site had light-moderate growth (U/W rank = 3, Biomass Index=0.60, chlorophyll *a*= 38.08 mg/m2). Moderate growth was also observed at Chimney Beach (U/W rank = 3.5, Biomass Index=1.5) along the east shore.

Along the south shore growth was moderate both at the south east and south west corners, with light growth near the Tahoe Keys. Moderate growth was observed at So. Elks Pt. (U/W rank=4, Biomass Index=1.60) and Timber Cove boulders (U/W rank=4, Biomass Index = 1.8) at the south east corner of the lake. Moderate growth was also observed at Kiva Beach (U/W rank=4, Biomass Index=1.08).

Overall, during the spring of WY 2011, periphyton biomass was heavier along the west shore, with heaviest growth in the northwest portion of the lake from Tahoma to Dollar Creek. There were also areas of heavier growth in the Kings Beach/Brockway Springs areas, and Incline Condominium site in the northern portion of the lake and at the South west and south east corners of the lake. Growth was lighter along most of the east shore with one area of heavier growth at Chimney Beach. The periphyton appeared to be dominated by the stalked diatom *Gomphoneis herculeana* at most sites in the spring. At a couple sites, Garwood's and Timber Cove there was also some filamentous green algae present.

It is likely a combination of many factors affected patterns of periphyton biomass in WY2011. These factors include nutrient inputs with surface runoff, enhanced inputs from urban/disturbed areas, groundwater, lake mixing/upwelling/currents), lake level, substrate availability and wind/wave events which may affect periphyton loss from the rocks. WY 2011 was a particularly heavy precipitation year. The contribution of nutrients from surface and tributary runoff from the many wet storms may have had more of an impact on nearshore periphyton growth this year compared with years with less precipitation. Several sites with very high biomass this year were in regions that are likely influenced by tributaries and surface runoff (i.e. Ward Cr., Tahoe City Tributary, South Dollar Cr., Pineland may also be influenced by Ward Cr., and the Kings Beach site is near an urban inflow). Upwelling of NO3-N during frequent storms early in this WY may also have contributed to patterns of biomass observed. Finally, the rapid rise in lake elevation as a result of the wet year, resulted in relatively little periphyton right near the surface later in the year. The heavier biomass associated with the spring growth was eventually submerged to depths greater than 0.5m and was not readily apparent right near the surface by early summer.

Table 10. Summary of 0.5m periphyton Chlorophyll *a*, Ash Free Dry Weight (AFDW), visual score, avg. filament length and % algal coverage, predominant algae present based on visual observations while snorkeling (FG=filamentous greens; SD=stalked diatoms; CY= blue green algae), for routine sites (shaded) and expanded periphyton monitoring sites during 2011. Note for chlorophyll *a* and AFDW, n=2 unless otherwise indicated. Visual score is a subjective ranking of the aesthetic appearance of algal growth (viewed underwater) where 1 is the least offensive and 5 is the most offensive. Biomass Index is Filament Length times % Algal Cover. "na" = not available or not collected; "nes" = not enough sample for analysis. Sampling depth and corresponding sampling elevation are also indicated.

Site	Site Name	Date	Sampling Depth/Elev (m/ ft)	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Cover. %	Biomass Index	Algal Type
A	Cascade Creek	5/13/11	0.59/6224.38					3	4	2.5	60%	1.50	SD
B	S. of Eagle Point	5/13/11	0.59/6224.38					2	3	1.2	70%	0.84	SD
C	E.Bay/Rubicon	5/13/11	0.59/6224.38	34.62	8.86	14.55	9.74	4	4	2.2	90%	1.98	SD
	Rubicon Pt.	5/13/11	0.59/6224.38	30.11	2.56(n=3)	18.18	4.72(n=3)	4	4	1.8	100	1.8	SD
D	Gold Coast	5/13/11	0.59/6224.38					2	3	1.0	60%	0.60	SD
E	S. Meeks Point	5/13/11	0.59/6224.38					2.5	3	1.4	60%	0.84	SD
F	N. Meeks Bay	5/13/11	0.59/6224.38					3	3	1.0	70%	0.70	SD
	Sugar Pine Pt.	4/29/11	0.5/6224.40	6.56	0.88	2.00	1.12	NA	3	0.3	80%	0.24	SD
G	Tahoma	4/29/11	0.5/6224.40					NA	5	1.5	80%	1.20	SD
H	S. Fleur Du Lac	4/29/11	0.5/6224.40					NA	4	1.4	90%	1.26	SD
I	Blackwood Creek	4/29/11	0.5/6224.40					NA	2	0.2	60%	0.12	SD
	Kaspian Pt.	4/29/11	0.5/6224.40					NA	5	3.0	90%	2.70	SD
J	Ward Creek	4/29/11	0.5/6224.40	323.10*	92.54	431.81	156.86	NA	5	5.5	100%	5.50	SD
	Pineland	4/29/11	0.5/6224.40	154.06*	78.56	91.31*	27.41	4	5	3.5	90%	3.15	SD
K	N. Sunnyside	4/29/11	0.5/6224.40					NA	4	0.5	90%	0.45	SD
L	Tavern Pt.	4/29/11	0.5/6224.40					4	4	1.5	90%	1.35	SD
	Tahoe City	4/29/11	0.5/6224.40	43.12	20.49	48.78	26.54(n=3)	4	4	3.0	90%	2.70	SD
TCT	Tahoe City Trib.	4/29/11	0.5/6224.40					5	5	3.0	90%	2.70	SD
M	TCPUD Boat Ramp	4/29/11	0.5/6224.40					NA	4	2.0	80%	1.60	SD
N	S. Dollar Pt.	4/29/11	0.5/6224.40					2	3	1.0	90%	0.90	SD
	Dollar Pt.	4/29/11	0.5/6224.40	67.71	14.31	67.00	15.70	3	3.5	1.5	80%	1.20	SD
O	S. Dollar Creek	4/29/11	0.5/6224.40					3	4	2.0	80%	1.60	SD
P	Cedar Flat	4/29/11	0.5/6224.40					3.5	3.5	1.2	80%	0.96	SD
Q	Garwood's	5/9/11	0.56/6224.44					3.5	4	1.0	90%	0.90	SD,FG
R	Flick Point	5/6/11	0.54/6224.38					2	3	1.0	60%	0.60	SD
S	Stag Avenue	5/9/11	0.56/6224.44					3	3	0.5	60%	0.30	SD
T	Agatam Boat R.	5/9/11	0.56/6224.44					3	3.5	1.0	50%	0.50	SD

Site	Site Name	Date	Sampling Depth/Elev (m/ ft)	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Cover. %	Biomass Index	Algal Type
E17	Kings Beach	5/9/11	0.56/6224.44					3.5	4	2.0	95%	1.90	SD
E16	Brockway Springs	5/6/11	0.54/6224.38					4	5	2.8	90%	2.52	SD
E15	No. Stateline Point	5/6/11	0.54/6224.38	3.64	0.53	NES	NES	4	2	0.2	80%	0.16	SD
E14	Stillwater Cove	5/6/11	0.54/6224.38					3	2	1.0	50%	0.50	SD
	Old Incine West	5/6/11	0.54/6224.38					3	3	0.9	60%	0.54	SD
	Incline West	5/6/11	0.54/6224.38	38.08	3.80	16.58	1.20	2	3	2.0	30%	0.60	SD
	Incline Condo	5/6/11	0.54/6224.38					3	4.5	2.6	70%	1.82	SD
E13	Burnt Cedar Beach	5/6/11	0.54/6224.38					2.5	2.5	0.5	70%	0.35	SD
E12	Hidden Beach	5/6/11	0.54/6224.38					1.5	1.5	0.1	40%	0.04	SD
E11	Observation Point	5/9/11	0.56/6224.44					3	3	0.6	70%	0.42	SD
	Sand Pt.	5/6/11	0.54/6224.38	4.07	1.11	3.68	N=1	3	3	0.8	60%	0.48	SD
E10	Chimney Beach	5/6/11	0.54/6224.38					2	3.5	1.5	100%	1.50	SD
E9	Skunk Harbor	5/6/11	0.54/6224.38					1	1	0.0	0%	0.00	none
	Deadman Pt.	5/6/11	0.54/6224.38	BLD	BLD	1.82	0.90	1	1	0.0	0%	0.00	none
E8	So. Deadman Point	5/6/11	0.54/6224.38					3	3	0.7	40%	0.28	SD
E7	So. Glenbrook Bay	5/6/11	0.54/6224.38					1	1.5	0.1	60%	0.06	SD
E6	Cave Rock Ramp	5/5/11	0.5/6224.51					2	2	0.2	50%	0.10	SD
E5	Lincoln Park	5/5/11	0.5/6224.51					2	2	0.2	80%	0.16	SD
E4	No. Zephyr Cove	5/5/11						2	2	0.3	40%	0.12	SD
E3	So. Zephyr Pt.	5/5/11	0.5/6224.51					2	3	1.0	50%	0.50	SD
	Zephyr Pt.	5/5/11	0.5/6224.51	15.39	2.64	6.98	1.66(n=3)	3	3	0.5	90%	0.45	SD
E2	No. Elk Pt.	5/5/11	0.5/6224.51	7.05	1.52(n=3)	4.93	0.13(n=3)	2	3	1.0	80%	0.80	SD
E1	So. Elk Point	5/5/11	0.5/6224.51					3	4	2.0	80%	1.60	SD
	Timber Cove Rock	4/12/11	0.50/6224.12	67.28	18.99(n=3)	38.40	10.02(n=3)	NA	4	1.2	90%	1.08	SD,FG
S1	T. Keys Entrance	4/12/11	0.50/6224.12	28.18	5.91(n=3)	12.72	3.51(n=3)	4.5	3	0.7	60%	0.42	SD
S2	Kiva Point	4/12/11	0.50/6224.12	62.93	22.14(n=3)	40.75	13.46(n=3)	3	4	1.2	90%	1.08	SD

Note - * -One Pineland biomass sample replicate had anomalously high chlorophyll *a* = 478.17 mg/m^2 and AFDW= 224.31 g/m^2 and was not included in the Pineland chlorophyll *a* and AFDW means for 4/29/11.

Summary Points for Periphyton Monitoring

1. **In WY 2011 (Oct. 1, 2010 – Sept. 30, 2011) measurements of periphyton biomass were strongly affected by the significant ~5 ft. rise in lake surface elevation. Biomass was high at many sites early in the year associated with low lake levels and significant Blue-green algae biomass. Annual maximum levels of chlorophyll *a* were measured in October at: Rubicon Pt. (133.34 mg/m^2), Sugar Pine Pt. (27.85 mg/m^2), Sand Pt. (53.69 mg/m^2) and Deadman Pt. (40.83 mg/m^2). An annual maximums was measured in January at Incline West (62.46 mg/m^2) associated with growth of both Blue-green algae and filamentous green algae.**

2. **At two sites, stalked diatoms contributed significantly to the January 2011 chlorophyll *a* biomass and resulted in annual maximum levels. These sites inclued: Pineland (177.15 mg/m^2) which had very heavy stalked diatom growth over Blue-greens and Zephyr Pt. which had moderate amounts of stalked diatoms (34.25 mg/m^2).**

3. **During the spring monitoring of routine sites in 2011, similar to past years, the highest annual periphyton biomass associated with stalked diatom growth was observed at three sites in the northwest portion of the lake: Pineland, Tahoe City and Dollar Pt. Pineland had very high chlorophyll *a* biomass (154.06 mg/m^2) while moderate levels were observed at Tahoe City (45.35 mg/m^2 – which was less than the last three years), Dollar Pt. (67.71 mg/m^2 which was similar annual maximum in 2010 but less than levels in 2008 and 2009), and Rubicon Pt. (30.1 mg/m^2 – which was less than the annual maximums observed the last three years). The level of stalked diatom biomass was also moderate at Incline West (38.08 mg/m^2) in the northern portion of the lake and Zephyr Pt along the south east shore (21.93 mg/m^2). In contrast, 0.5m sites along the north east shore (Sand Pt. and Deadman Pt.) and Sugar Pine Pt. along the west shore had very little or no periphyton biomass in spring 2011.**

4. **The results of the expanded and routine monitoring during the spring of WY 2011, showed that periphyton biomass was heavier along the west shore, with heaviest growth in the northwest portion of the lake from Tahoma to Dollar Creek. Areas with the heaviest amounts of biomass (U/W visual ranking of 5) included: Tahoma, Kaspian Pt., Ward Cr., Pineland and Tahoe City Tributary. There were also areas of heavier growth in the Kings Beach/Brockway Springs areas, and Incline Condominium site in the northern portion of the lake and at the South west and south east corners of the lake. Growth was lighter along most of the east shore with one area of heavier growth at Chimney Beach. The periphyton appeared to be dominated by the stalked diatom *Gomphoneis herculeana* at most sites in the spring.**

5. **Between May 1 and July 1 the lake rose and additional 2 feet. Very little periphyton biomass developed at 0.5m and above during this period due to the rapid lake level increase. Very little periphyton was observed near the surface down to 0.5m in late June. However, at some sites a significant layer of biomass from the spring growth was still present deeper at about 1m.**

6. **It is likely a combination of many factors affected patterns of periphyton biomass in WY2011. These factors include nutrient inputs with surface runoff, enhanced inputs from urban/disturbed areas, groundwater, lake mixing/upwelling/currents), lake level, substrate availability and wind/wave events which may affect periphyton loss from the rocks. WY 2011 was a particularly heavy precipitation year. The contribution of nutrients from surface and tributary runoff from the many wet storms may have had more of an impact on nearshore periphyton growth this year compared with years with less precipitation. Several sites with very high biomass this year were in regions that are likely influenced by tributaries and surface runoff (i.e. Ward Cr., Tahoe City Tributary, South Dollar Cr., Pineland may also be influenced by Ward Cr., and the Kings Beach site is near an urban inflow). Upwelling of NO3-N during frequent storms early in this WY may also have contributed to patterns of biomass observed.**

7. **The heavy growth of stalked diatoms (*Gomphoneis herculeana*) at Pineland in early January was particularly interesting. This early heavy growth may have been caused by a combination of factors. Of particular note during this period, surface runoff and subsurface inputs of nutrients associated with the wet storms in October and Dec. may have contributed to the heavy growth. Upwelling of NO_3-N to surface waters during strong fall and early winter storms may also have contributed to the growth. Other factors may have contributed as well.**

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Appendix Table 1a. Precipitation amounts, N and P concentrations in wet deposition at the Ward Valley Lake Level Station 6/9/10-9/30/11.

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
	6/9/10 17:45	0.43	R	W	0.43	48.89	19.8	185.03	1.14	5.01	5.01	
	6/26/10 20:35	0.14	R	W	0.14	344.13	152.72	283.23	0.46	1.25	188.88	
1	8/3/10 10:25	0.01	R	W	0.01	53.16	5.69	78.18	0.91	2.48	5.28	1
2	8/10/10 16:30	0.91	R+H	W	0.91	209.95	261.99	506.54	4.08	6.62	20.61	2
3	8/30/10 16:50	0.08	R	W	0.08	42.75	48.34	42.97	4.76	8.39	12.42	3
	10/3/10 16:45	NA	R	D	NA							
4	10/4/10 09:20	0.70	R+DF	W+D	0.70	254.37	365.88	459.83	2.71	1.87	3.41	18
5	10/5/10 16:15	0.60	R+S+DF	W+D	0.60	96.75	69.59	110.55	4.06	5.55	13.82	19
6	10/8/10 11:20	0.16	R+DF	W+D	0.16	259.05	353.13	626.79	5.65	9.26	36.44	19
7	10/19/10 14:35	0.46	R+DF	W+D	0.46	68.35	155.25	189.58	3.61	4.03	4.98	20
8	10/25/10 17:20	7.21	RS	W	7.21	16.95	46.34	119.36	2.47	6.78	8.94	21
9	11/2/10 10:25	0.11	R	W	0.11	17.28	22.39	52.23	2.92	6.47	6.47	22
10	11/9/10 10:35	1.87	RS	W	1.87	29.44	36.80	274.61	0.45	3.25	4.00	23
11	11/15/10 16:50	0.40		W	0.40	47.5	77.52	189.56	0.90	4.38	6.57	
12	11/21/10 17:45	2.02+	S	W	2.02	60.44	81.62	105.89	2.04	4.69	7.2	24
13	11/22/10 17:30	0.47+	S	W	0.47	21.25	24.86	51.56	0.68	4.38	5.94	
14	11/23/10 19:10	1.00	S	W	1.00	18.33	18.23	27.57	0.68	4.38	5.01	25
15	11/28/10 13:00	0.97	S	W	0.97	19.69	20.17	28.47	0.45	4.07	5.94	26
16	12/6/10 17:15	2.38	RS	W	2.38	48.15	9.36	28.1	1.57	8.00	8.51	
17	12/16/10 10:50	3.39	RS	W	3.39	24.39	7.28	13.45	1.13	NA	3.7	27
18	12/19/10 15:40	7.40	RS	W	7.40	28.17	8.20	7.55	1.35	3.39	2.77	28
19	12/20/10 13:10	0.66	S+DF	W	0.66	43.43	16.19	53.96	2.25	3.70	6.16	29
20	12/22/10 11:00	0.21	S+DF	W	0.21			157.19				30
21	12/28/10 10:30	0.51	RS	W	0.51	22.56	14.09	127.44	1.13	3.08	6.78	31
22	12/29/10 14:40	1.70	S	W	1.70	10.00	5.88	85.12	0	4.59	5.19	32
23	1/6/11 11:35	0.52	S	W	0.52	19.22	12.24	24.79	2.93	4.01	4.94	

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
24	1/14/11 11:10	0.35	RS	W	0.35	9.68	10.49	79.35	1.36	4.04	16.76	
25	2/3/11 10:30	0.49	S	W	0.49	19.83	9.82	36.34	1.45	4.01	5.86	
26	2/16/11 16:00	1.43	S	W	1.43	46	79.48	164.64	1.81	2.05	8.18	47
27	2/17/11 12:10	0.66	S	W	0.66	21.85	21.84	33.85	0.91	1.43	4.09	48
28	2/18/11 11:40	1.17+	S	W	1.17	11.7	21.43	24.78	0.9	1.11	3.46	49
29	2/19/11 14:30	1.16	S	W	1.17	36.64	13.84	36.34	1.13	1.11	4.09	50
30	2/26/11 11:30	2.40e	S	W	1.13+	28.95	17.22	32.98	.68	.8	5.03	54
31	3/4/11 18:45	1.64	RS	W	1.64	39.68	53.91	116.96	1.82	4.04	4.67	
32	3/9/11 10:00	2.22	RS	W	2.22	22.65	23.30	97.17	1.59	4.67	5.91	
33	3/16/11 13:05	5.69	RS	W	5.69	33.68	33.81	54.26	1.36	4.03	3.41	55
35	3/19/11 11:35	1.71	S	W	1.71	37.44	52.54	95.71	3.4	4.96	7.44	56
36	3/20/11 16:50	1.48	S	W	1.48	11.89	7.59	42.04	2.27	3.72	4.65	57
37	3/24/11 11:00	1.01	S	W	1.01	45.56	44.99	82.63	1	4.34	10.54	58
36	3/25/11 14:15	1.27+	S	W	1.27	15.45	17.12	41.14	0.77	4.65	33.80	59
37	4/1/11 10:35	0.72	S	W	0.72	20.72	34.67	78.12	0.77	2.16	7.73	
38	4/13/11 09:50	0.89	S	W	0.89	131.83	NA	340.3	8.63	13.66	26.08	
39	4/22/11 13:35	1.98	RS	W	1.98	91.53	183.35	246.8	3.86	7.12	12.7	67
40	4/25/11 13:05	0.88	RS	W	0.88	78.3	226.12	204.65	2.72	5.89	7.74	
41	5/16/11 17:10	1.28	RS	W	1.28	81.04	125.1	131.9	4.07	8.92	13.22	
42	5/20/11 11:20	0.88	RSG	W	0.88	55.19	55.10	67.57	4.08	6.26	8.45	
43	5/28/11 11:00	0.70	S	W	0.70	187.22	327.99	344.02	8.19	13.46	21.28	
44	5/31/11 15:45	0.69	S	W	0.69	33.67	52.53	56.29	2.49	3.27	4.2	
45	6/3/11 11:30	0.29	RS	W	0.29	97.1	146.31	118.79	4.55	4.04	5.6	
46	6/10/11 11:30	1.60	RS	W	1.69	23.21	34.34	68.75	2.94	3.42	3.42	
47	7/6/11 17:15	0.02+	R	W	0.02+	19.32	44.07	235.56	8.19	5.52	9.2	68
48	7/6/11 20:20	0.03	R	W	0.03	39.80	44.28	294.22	5.46	6.19	17.94	80
49	9/12/11 08:00	0.26	R	W	0.26	220.04	NA	NA	19.62	25.83	39.98	81
50	9/13/11 11:40	0.15e	R	W	0.15e	201.21	322.59	NA	9.81	14.15	15.38	82
	9/20/11 10:30	T	NA	W	0	NA	NA	NA	NA	NA	NA	83

Appendix Table 1.b. Precipitation loads of N and P in wet deposition at the Ward Valley Lake Level Station 6/9/10-9/30/11.

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
	6/9/10 17:45	0.43	R	W	0.43	5.34	2.16	20.21	0.12	0.55	0.55	
	6/26/10 20:35	0.14	R	W	0.14	12.24	5.43	10.07	0.02	0.04	6.72	
1	8/3/10 10:25	0.01	R	W	0.01	4.14	0.44	6.10	0.07	0.19	0.41	1
2	8/10/10 16:30	0.91	R+H	W	0.91	48.53	60.56	117.08	0.94	1.53	4.76	2
3	8/30/10 16:50	0.08	R	W	0.08	3.33	3.77	3.35	0.37	0.65	0.97	3
	10/3/10 16:45	NA	R	D	NA	NA	NA	NA	NA	NA	NA	
4	10/4/10 09:20	0.70	R+DF	W+D	0.70	45.23	65.05	81.76	0.48	0.33	0.61	18
5	10/5/10 16:15	0.60	R+S+DF	W+D	0.60	14.74	10.61	16.85	0.62	0.85	2.11	19
6	10/8/10 11:20	0.16	R+DF	W+D	0.16	10.53	14.35	25.47	0.23	0.38	1.48	19
7	10/19/10 14:35	0.46	R+DF	W+D	0.46	7.99	18.14	22.15	0.42	0.47	0.58	20
8	10/25/10 17:20	7.21	RS	W	7.21	31.04	84.86	218.59	4.52	12.42	16.37	21
9	11/2/10 10:25	0.11	R	W	0.11	1.36	1.76	4.11	0.23	0.51	0.51	22
10	11/9/10 10:35	1.87	RS	W	1.87	13.98	17.48	130.43	0.21	1.54	1.90	23
11	11/15/10 16:50	0.40		W	0.40	4.83	7.88	19.26	0.09	0.45	0.67	
12	11/21/10 17:45	2.02+	S	W	2.02	31.01	41.88	54.33	1.05	2.41	3.69	24
13	11/22/10 17:30	0.47+	S	W	0.47	2.54	2.97	6.16	0.08	0.52	0.71	
14	11/23/10 19:10	1.00	S	W	1.00	4.66	4.63	7.00	0.17	1.11	1.27	25
15	11/28/10 13:00	0.97	S	W	0.97	4.85	4.97	7.01	0.11	1.00	1.46	26
16	12/6/10 17:15	2.38	RS	W	2.38	29.11	5.66	16.99	0.95	4.84	5.14	
17	12/16/10 10:50	3.39	RS	W	3.39	21.00	6.27	11.58	0.97	NA	3.19	27
18	12/19/10 15:40	7.40	RS	W	7.40	52.95	15.41	14.19	2.54	6.37	5.21	28
19	12/20/10 13:10	0.66	S+DF	W	0.66	7.28	2.71	9.05	0.38	0.62	1.03	29
20	12/22/10 11:00	0.21	S+DF	W	0.21	3.14	1.66	8.38	0.16	0.28	0.35	30
21	12/28/10 10:30	0.51	RS	W	0.51	2.92	1.83	16.51	0.15	0.40	0.88	31
22	12/29/10 14:40	1.70	S	W	1.70	4.32	2.54	36.75	0.00	1.98	2.24	32
23	1/6/11 11:35	0.52	S	W	0.52	2.54	1.62	3.27	0.39	0.53	0.65	

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
24	1/14/11 11:10	0.35	RS	W	0.35	0.86	0.93	7.05	0.12	0.36	1.49	
25	2/3/11 10:30	0.49	S	W	0.49	2.47	1.22	4.52	0.18	0.50	0.73	
26	2/16/11 16:00	1.43	S	W	1.43	16.71	28.87	59.80	0.66	0.74	2.97	47
27	2/17/11 12:10	0.66	S	W	0.66	3.66	3.66	5.67	0.15	0.24	0.69	48
28	2/18/11 11:40	1.17+	S	W	1.17	3.48	6.37	7.36	0.27	0.33	1.03	49
29	2/19/11 14:30	1.16	S	W	1.17	10.80	4.08	10.71	0.33	0.33	1.21	50
30	2/26/11 11:30	2.40e	S	W	1.13+	8.31	4.94	9.47	0.20	0.23	1.44	54
31	3/4/11 18:45	1.64	RS	W	1.64	16.53	22.46	48.72	0.76	1.68	1.95	
32	3/9/11 10:00	2.22	RS	W	2.22	12.77	13.14	54.79	0.90	2.63	3.33	
33	3/16/11 13:05	5.69	RS	W	5.69	48.68	48.86	78.42	1.97	5.82	4.93	55
35	3/19/11 11:35	1.71	S	W	1.71	16.26	22.82	41.57	1.48	2.15	3.23	56
36	3/20/11 16:50	1.48	S	W	1.48	4.47	2.85	15.80	0.85	1.40	1.75	57
37	3/24/11 11:00	1.01	S	W	1.01	11.69	11.54	21.20	0.26	1.11	2.70	58
36	3/25/11 14:15	1.27+	S	W	1.27	4.98	5.52	13.27	0.25	1.50	10.90	59
37	4/1/11 10:35	0.72	S	W	0.72	3.79	6.34	14.29	0.14	0.40	1.41	
38	4/13/11 09:50	0.89	S	W	0.89	29.80	NA	76.93	1.95	3.09	5.90	
39	4/22/11 13:35	1.98	RS	W	1.98	46.03	92.21	124.12	1.94	3.58	6.39	67
40	4/25/11 13:05	0.88	RS	W	0.88	17.50	50.54	45.74	0.61	1.32	1.73	
41	5/16/11 17:10	1.28	RS	W	1.28	26.35	40.67	42.88	1.32	2.90	4.30	
42	5/20/11 11:20	0.88	RSG	W	0.88	12.34	12.32	15.10	0.91	1.40	1.89	
43	5/28/11 11:00	0.70	S	W	0.70	33.29	58.32	61.17	1.46	2.39	3.78	
44	5/31/11 15:45	0.69	S	W	0.69	5.90	9.21	9.87	0.44	0.57	0.74	
45	6/3/11 11:30	0.29	RS	W	0.29	7.15	10.78	8.75	0.34	0.30	0.41	
46	6/10/11 11:30	1.60	RS	W	1.69	9.43	13.96	27.94	1.19	1.39	1.39	
47	7/6/11 17:15	0.02+	R	W	0.02+	1.51	3.44	NA	0.64	0.43	0.72	68
48	7/6/11 20:20	0.03	R	W	0.03	3.10	3.45	22.94	0.43	0.48	1.40	80
49	9/12/11 08:00	0.26	R	W	0.26	14.53	17.94	NA	1.30	1.71	2.64	81
50	9/13/11 11:40	0.15e	R	W	0.15e	7.67	12.29	16.66	0.37	0.54	0.59	82
	9/20/11 10:30	T	NA	W	T	NA	NA	NA	NA	NA	NA	83

Appendix Table 2.a. N and P concentrations in dry deposition at the Ward Valley Lake Level Station 5/15/10-10/4/11.

	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
	5/15/10 17:00	6/1/10 17:10	3.179	DF	DRY	34.08	26.5	120.1	1.83	3.99	13.59	x
	6/1/10 17:10	6/26/10 20:35	0.993	DF	DRY	13.15c	NA	3796.15c	24.98c	53.09c	NA	z
1	6/26/10 20:35	7/2/10 10:40	3.030	DF	DRY	22.20	71.04	1510.26	5.27	7.18	18.82	
2	7/2/10 10:40	7/16/10 10:30	1.918	DF	DRY	13.78c	10.7c	1230.5c	31.81c	46.88c	135.36c	4
3	7/16/10 10:30	7/23/10 13:55	2.664	DF	DRY	10.88	8.07	823.56	5.39	8.07	22.97	5
4	7/23/10 13:55	8/3/10 10:25	2.295	DF	DRY	13.51	8.24	55.88	2.05	5.58	64.95	15
5	7/23/10 13:55	8/12/10 12:00	2.810	DF	DRY	26.38	6.06	287.36	2.26	2.26	24.04	6
6	8/16/10 14:00	9/2/10 16:55	1.576	DF	DRY	14.02c	8.41c	2974.7c	2.95c	7.14c	99.71c	7
7	9/2/10 16:55	9/23/10 10:40	1.755	DF	DRY	4.24c	19.39c	1405.06c	6.57c	13.58c	172.05c	8
8	9/23/10 10:40	10/14/10 14:45	5.342	R+S+DF	DRY	11.06	7.23	804.45	2.93	7.41	31.19	33
9	10/14/10 14:45	10/22/10 14:40	3.626	DF	DRY	25.03	29.91	381.72	4.05	5.89	7.78	34
10	10/22/10 14:40	11/2/10 10:25	3.764	DF	DRY	2.98	5.81	484.61	5.84	6.47	23.12	35
11	11/2/10 10:25	11/17/10 10:45	3.744	DF	DRY	18.06	57.68	345.77	6.78	8.81	10.01	36
12	11/17/10 10:45	12/1/10 16:45	4.025	S+DF	DRY	42.51	62.41	276.55	4.72	4.61	9.53	37
13	12/1/10 16:45	12/22/10 11:00	4.079	R+S+DF	DRY	21.91	17.88	86.82	2.7	4.01	21.88	38
14	12/22/10 11:00	1/6/10 11:35	4.400	S+DF	DRY	12.36	17.75	18.18	2.93	5.55	12.34	39
15	1/6/10 11:35	1/14/11 11:10	3.375+	DF	DRY	21.03	40.86	71.91	1.36	3.72	4.97	60
16	1/14/11 11:10	1/24/11 11:45	2.880	DF	DRY	13.81	26.89	97.89	4.31	5.59	23.28	
17	1/24/11 11:45	2/13/11 10:45	1.968	DF	DRY	27.73	19.3	166.44	6.8	9.86	96.6	61
18	2/13/11 10:45	3/4/11 18:45	2.975	DF	DRY	48.2	8.42	132.7	1.59	4.04	18.67	
19	3/4/11 18:45	3/18/11 16:00	2.877	DF	DRY	34.87	29.33	143.98	5.45	7.44	17.68	
20	3/18/11 16:00	4/13/11 09:50	1.670	DF	DRY	96.17	54.58	190.39	1.36	4.97	48.12	
21	4/13/11 09:50	4/25/11 13:05	2.972	DF	DRY	47.49	57.25	115.62	1.59	5.27	11.15	
22	4/25/11 13:05	5/16/11 17:10	0.500	DF	DRY	NAc	NAc	NAc	NAc	NAc	NAc	69
23	5/16/11 17:10	6/15/11 17:00		DF	DRY	5.47c	8.31c	3312.46c	18.62c	63.81c	411.45c	y
24	6/15/11 17:00	6/30/11 16:10	3.345	DF	DRY	29.27c	7.78c	NAc	2.52c	51.8c	122.3c	70
25	6/30/11 16:10	7/22/11 17:45	0.902	DF	DRY	14.84c	20.72c	3189c	35.36c	102.24c	384.05c	84

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
26	7/22/11 17:45	8/4/11 14:45	2.400	DF	DRY	14.22	10.75	661.8	4.89	9.86	53.9	85
27	8/4/11 14:45	8/22/11 17:45	1.822	DF	DRY	12.38	3.37	828.32	2.72	17.59	54.63	86
28	8/22/11 17:45	9/12/11 08:00	2.288	DF+R	DRY-BULK	63.25	10.14	1202.87	4.56	7.69	42.75	87
29	9/12/11 08:00	9/20/11 10:30	3.550	DF+R	DRY-BULK	28.3	4.58	377.94	1.59	2.39	8.58	88
30	9/20/11 10:30	10/4/11 16:00	2.910	DF+R	DRY-BULK	NA	NA	640.22	NA	NA	NA	89

Appendix Table 2.b. N and P loads in dry deposition at the Ward Valley Lake Level Station 5/15/10-10/4/11.

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	Conc. NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
	5/15/10 17:00	6/1/10 17:10	3.179	DF		21.38	16.63	75.35	1.15	2.50	8.53	x
	6/1/10 17:10	6/26/10 20:35	0.993	DF		C	C	C	C	C	C	z
1	6/26/10 20:35	7/2/10 10:40	3.030	DF	DRY	13.28	42.48	903.10	3.15	4.29	11.25	
2	7/2/10 10:40	7/16/10 10:30	1.918	DF	DRY	C	C	C	C	C	C	4
3	7/16/10 10:30	7/23/10 13:55	2.664	DF	DRY	5.72	4.24	432.98	2.83	4.24	12.08	5
4	7/23/10 13:55	8/3/10 10:25	2.295	DF	DRY	6.12	3.73	25.31	0.93	2.53	29.42	15
5	7/23/10 13:55	8/12/10 12:00	2.810	DF	DRY	14.63	3.36	159.36	1.25	1.25	13.33	6
6	8/16/10 14:00	9/2/10 16:55	1.576	DF	DRY	C	C	C	C	C	C	7
7	9/2/10 16:55	9/23/10 10:40	1.755	DF	DRY	C	C	C	C	C	C	8
8	9/23/10 10:40	10/14/10 14:45	5.342	R+S+DF	DRY	C	C	C	C	C	C	33V
9	10/14/10 14:45	10/22/10 14:40	3.626	DF	DRY	9.93	3.26	251.01	2.48	3.74	4.99	34,w
10	10/22/10 14:40	11/2/10 10:25	3.764	DF	DRY	2.21	4.32	359.99	4.34	4.81	17.17	35
11	11/2/10 10:25	11/17/10 10:45	3.744	DF	DRY	13.34	42.62	255.49	5.01	6.51	7.40	36
12	11/17/10 10:45	12/1/10 16:45	4.025	S+DF	DRY	33.77	49.58	219.68	3.75	3.66	7.57	37
13	12/1/10 16:45	12/22/10 11:00	4.079	R+S+DF	DRY	17.64	14.39	69.89	2.17	3.23	17.61	38
14	12/22/10 11:00	1/6/10 11:35	4.400	S+DF	DRY	10.73	15.41	15.79	2.54	4.82	10.72	39
15	1/6/10 11:35	1/14/11 11:10	3.375+	DF	DRY	14.01	27.22	47.90	0.91	2.48	3.31	60
16	1/14/11 11:10	1/24/11 11:45	2.880	DF	DRY	7.85	15.28	55.64	2.45	3.18	13.23	

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	Conc. NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
17	1/24/11 11:45	2/13/11 10:45	1.968	DF	DRY	10.77	7.50	64.64	2.64	3.83	37.52	61
18	2/13/11 10:45	3/4/11 18:45	2.975	DF	DRY	28.30	4.94	77.91	0.93	2.37	10.96	
19	3/4/11 18:45	3/18/11 16:00	2.877	DF	DRY	19.80	16.65	81.75	3.09	4.22	10.04	
20	3/18/11 16:00	4/13/11 09:50	1.670	DF	DRY	31.70	17.99	62.75	0.45	1.64	15.86	
21	4/13/11 09:50	4/25/11 13:05	2.972	DF	DRY	27.85	33.58	67.81	0.93	3.09	6.54	
22	4/25/11 13:05	5/16/11 17:10	0.500	DF	DRY	C	C	C	C	C	C	69
23	5/16/11 17:10	6/15/11 17:00		DF	DRY	C	C	C	C	C	C	y
24	6/15/11 17:00	6/30/11 16:10	3.345	DF	DRY	C	C	C	C	C	C	70
25	6/30/11 16:10	7/22/11 17:45	0.902	DF	DRY	C	C	C	C	C	C	84
26	7/22/11 17:45	8/4/11 14:45	2.400	DF	DRY	6.74	5.09	313.46	2.32	4.67	25.53	85
27	8/4/11 14:45	8/22/11 17:45	1.822	DF	DRY	4.45	1.21	297.84	0.98	6.32	19.64	86
28	8/22/11 17:45	9/12/11 08:00	2.288	DF+R	DRY-BULK	30.04	4.82	571.36	2.17	3.65	20.31	87
29	9/12/11 08:00	9/20/11 10:30	3.550	DF+R	DRY-BULK	19.83	3.21	264.79	1.11	1.67	6.01	88
30	9/20/11 10:30	10/4/11 16:00	2.910	DF+R	DRY-BULK	NA	NA	386.77	NA	NA	NA	89

Appendix Table 2.c. N and P loading per day in dry deposition at the Ward Valley Lake Level Station 5/15/10-10/4/11.

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
	5/15/10 17:00	6/1/10 17:10	3.179	DF		1.26	0.98	4.43	0.07	0.15	0.50	x
	6/1/10 17:10	6/26/10 20:35	0.993	DF		C	C	C	C	C	C	z
1	6/26/10 20:35	7/2/10 10:40	3.030	DF	DRY	2.38	7.60	161.65	0.56	0.77	2.01	
2	7/2/10 10:40	7/16/10 10:30	1.918	DF	DRY	C	C	C	C	C	C	4
3	7/16/10 10:30	7/23/10 13:55	2.664	DF	DRY	0.80	0.59	60.62	0.40	0.59	1.69	5
4	7/23/10 13:55	8/3/10 10:25	2.295	DF	DRY	0.56	0.34	2.33	0.09	0.23	2.71	15
5	7/23/10 13:55	8/12/10 12:00	2.810	DF	DRY	1.61	0.37	17.58	0.14	0.14	1.47	6
6	8/16/10 14:00	9/2/10 16:55	1.576	DF	DRY	C	C	C	C	C	C	7
7	9/2/10 16:55	9/23/10 10:40	1.755	DF	DRY	C	C	C	C	C	C	8

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
8	9/23/10 10:40	10/14/10 14:45	5.342	R+S+DF	DRY	C	C	C	C	C	C	33,v
9	10/14/10 14:45	10/22/10 14:40	3.626	DF	DRY	1.24	0.41	31.39	0.31	0.47	0.62	34,w
10	10/22/10 14:40	11/2/10 10:25	3.764	DF	DRY	0.20	0.40	33.26	0.40	0.44	1.59	35
11	11/2/10 10:25	11/17/10 10:45	3.744	DF	DRY	0.89	2.84	17.02	0.33	0.43	0.49	36
12	11/17/10 10:45	12/1/10 16:45	4.025	S+DF	DRY	2.37	3.48	15.42	0.26	0.26	0.53	37
13	12/1/10 16:45	12/22/10 11:00	4.079	R+S+DF	DRY	0.85	0.69	3.37	0.10	0.16	0.85	38
14	12/22/10 11:00	1/6/10 11:35	4.400	S+DF	DRY	0.71	1.03	1.05	0.17	0.32	0.71	39
15	1/6/10 11:35	1/14/11 11:10	3.375+	DF	DRY	1.75	3.41	6.00	0.11	0.31	0.41	60
16	1/14/11 11:10	1/24/11 11:45	2.880	DF	DRY	0.78	1.52	5.55	0.24	0.32	1.32	
17	1/24/11 11:45	2/13/11 10:45	1.968	DF	DRY	0.54	0.38	3.24	0.13	0.19	1.88	61
18	2/13/11 10:45	3/4/11 18:45	2.975	DF	DRY	1.46	0.26	4.03	0.05	0.12	0.57	
19	3/4/11 18:45	3/18/11 16:00	2.877	DF	DRY	1.43	1.20	5.89	0.22	0.30	0.72	
20	3/18/11 16:00	4/13/11 09:50	1.670	DF	DRY	1.23	0.70	2.44	0.02	0.06	0.62	
21	4/13/11 09:50	4/25/11 13:05	2.972	DF	DRY	2.30	2.77	5.59	0.08	0.25	0.54	
22	4/25/11 13:05	5/16/11 17:10	0.500	DF	DRY	C	C	C	C	C	C	69
23	5/16/11 17:10	6/15/11 17:00		DF	DRY	C	C	C	C	C	C	y
24	6/15/11 17:00	6/30/11 16:10	3.345	DF	DRY	C	C	C	C	C	C	70
25	6/30/11 16:10	7/22/11 17:45	0.902	DF	DRY	C	C	C	C	C	C	84
26	7/22/11 17:45	8/4/11 14:45	2.400	DF	DRY	0.52	0.40	24.35	0.18	0.36	1.98	85
27	8/4/11 14:45	8/22/11 17:45	1.822	DF	DRY	0.25	0.07	16.43	0.05	0.35	1.08	86
28	8/22/11 17:45	9/12/11 08:00	2.288	DF+R	DRY-BULK	1.46	0.23	27.74	0.11	0.18	0.99	87
29	9/12/11 08:00	9/20/11 10:30	3.550	DF+R	DRY-BULK	2.45	0.40	32.67	0.14	0.21	0.74	88
30	9/20/11 10:30	10/4/11 16:00	2.910	DF+R	DRY-BULK	NA	NA	27.18	NA	NA	NA	89

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 6/3/10-9/30/11.

	Mid-lake (TB-1)	Snow Tube				(Conc.)						
	Start	Collection	Precip.	Precip.	Collector	NO3-N	NH4-N	TKN	SRP	DP	TP	
No.	Date-Time	Date-Time	(in.)	Form	Type	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	Notes
1	6/3/10 09:37	7/2/10 08:05	0.04	R	ST	147.95c	532.83c	2693.31c	96.95c	30.29c	163.1c	10
2	7/2/10 08:05	7/20/10 10:35	0.01	R	ST	32.82c	25.07c	428.97c	45.58c	51.54c	67.06c	11
	7/20/10 10:35	8/3/10 09:30	0		ST							
3	8/3/10 09:30	8/12/10 09:50	0.08	R	ST	183.27	19.63	764.58	4.54	12.53	68.51	12
	8/12/10 09:50	8/31/10 10:30	0		ST							
	8/31/10 10:30	9/9/10 09:40	T	R	ST							
	9/9/10 09:40	9/22/10 09:15	0		ST							
4	9/22/10 09:15	10/13/10 09:40	1.67	R	ST	495.6	527.03	939.81	39.53	47.86	82.75	40
5	10/13/10 09:40	10/20/10 15:24	0.36+	R	ST	127.14	138.78	137	5.85	8.68	12.14	41
6	10/20/10 15:24	11/9/10 09:02	0.07	R+S	ST	21.13	12.85	653.13	0.45	2.79	3.41	42
	11/9/10 09:02	11/17/10 07:25	NA	NA	NA	NA	NA	NA	NA	NA	NA	43
	11/17/10 07:25	12/1/10 10:45	NA	NA	NA	NA	NA	NA	NA	NA	NA	44
	12/1/10 10:45	12/15/10 13:50	NA	NA	NA	NA	NA	NA	NA	NA	NA	45
7	12/15/10 13:50	1/4/11 09:57	2.73+	R+S	ST	44.33	19.66	63.54	2.03	4.01	5.86	46
8	1/4/11 09:57	2/11/11 11:07	0.14	RS	ST	50.44	7.18	164.64	1.13	3.7	6.47	62
	2/11/11 11:07	3/1/11 08:30	NA		ST	NA	NA	NA	NA	NA	NA	63
9	3/1/11 08:30	3/28/11 09:55	2.89	RS	ST	53.81	45.43	153.45	0.55	2.47	4.02	64
	3/28/11 09:55	4/22/11 10:15	NA		ST	NA	NA	NA	NA	NA	NA	71
10	4/22/11 10:15	6/7/11 14:35	2.36+	RS	ST	129.47	160.09	386.83	3.63	4.04	9.64	72
11	6/7/11 14:35	7/2/11 12:25	0.30	RS	ST	NAc	NAc	NAc	NAc	NAc	NAc	73
12	7/2/11 12:25	7/23/11 11:22	0.29	R	ST	99.73c	219.31c	571.95c	10.88c	19.71c	73.61c	90
	7/23/11 11:22	8/4/11 11:10	0		ST	NA	NA	NA	NA	NA	NA	
	8/4/11 11:10	8/26/11 10:30	0		ST	NA	NA	NA	NA	NA	NA	
	8/26/11 10:30	9/8/11 10:02	0		ST	NA	NA	NA	NA	NA	NA	
13	9/8/11 10:02	9/21/11 09:13	0.03	R	ST	147.03	109.16	312.58	7.52	13.23	24.3	91

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 6/3/10-9/30/11.

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Conc.) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	6/3/10 09:37	7/2/10 08:05	0.04	R	ST	C	C	C	C	C	C	10
2	7/2/10 08:05	7/20/10 10:35	0.01	R	ST	C	C	C	C	C	C	11
	7/20/10 10:35	8/3/10 09:30	0		ST							
3	8/3/10 09:30	8/12/10 09:50	0.08	R	ST	28.25	3.03	117.84	0.70	1.93	10.56	12
	8/12/10 09:50	8/31/10 10:30	0		ST							
	8/31/10 10:30	9/9/10 09:40	T	R	ST							
	9/9/10 09:40	9/22/10 09:15	0		ST							
4	9/22/10 09:15	10/13/10 09:40	1.67	R	ST	210.22	223.56	398.65	16.77	20.30	35.10	40
5	10/13/10 09:40	10/20/10 15:24	0.36+	R	ST	24.75+	27.01+	26.67+	1.14+	1.34+	2.36+	41
6	10/20/10 15:24	11/9/10 09:02	0.07	R+S	ST	3.26	1.98	100.66	0.07	0.43	0.53	42
	11/9/10 09:02	11/17/10 07:25	NA	NA	NA							43
	11/17/10 07:25	12/1/10 10:45	NA	NA	NA							44
	12/1/10 10:45	12/15/10 13:50	NA	NA	NA							45
7	12/15/10 13:50	1/4/11 09:57	2.73+	R+S	ST	30.74+	13.63+	44.06+	1.41+	2.78+	4.06+	46
8	1/4/11 09:57	2/11/11 11:07	0.14	RS	ST	7.77	1.11	25.38	0.17	0.57	1.00	62
	2/11/11 11:07	3/1/11 08:30	NA		ST							63
9	3/1/11 08:30	3/28/11 09:55	2.89	RS	ST	39.50	33.35	112.64	0.40	1.81	2.95	64
	3/28/11 09:55	4/22/11 10:15	NA		ST							71
10	4/22/11 10:15	6/7/11 14:35	2.36+	RS	ST	77.61+	95.96+	231.88+	2.18+	2.42+	5.78+	72
11	6/7/11 14:35	7/2/11 12:25	0.30	RS	ST	C	C	C	C	C	C	73
12	7/2/11 12:25	7/23/11 11:22	0.29	R	ST	C	C	C	C	C	C	90
	7/23/11 11:22	8/4/11 11:10	0		ST							
	8/4/11 11:10	8/26/11 10:30	0		ST							
	8/26/11 10:30	9/8/11 10:02	0		ST							
13	9/8/11 10:02	9/21/11 09:13	0.03	R	ST	22.66	16.82	48.18	1.16	2.04	3.75	91

Appendix Table 4.a. N and P concentrations in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 6/3/10-10/12/11.

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	6/3/10 9:37	7/2/10 8:05	0.5	DF+R	DRY-BULK	293.02c	192.92c	2253.81c	21.09c	127.41c	NAc	13
2	7/2/10 8:05	7/20/10 10:35	0.5	DF+R	DRY-BULK	219.05	26.91	869.67	30.99	38.5	154.92	14
3	7/20/10 10:35	8/3/10 9:30	0.5	DF	DRY-BULK	203.42	95.88	234.99	1.82	11.17	45.69	14
4	8/3/10 9:30	8/12/10 9:50	0.365	DF+R	DRY-BULK	736.96	927.72	2198.17	6.81	12.53	30.88	
5	8/12/10 9:50	8/31/10 10:30	0.5	DF	DRY-BULK	243.22	21.01	1155.83	6.58	11.49	40.69	14
6	8/31/10 10:30	9/9/10 9:40	0.5	DF+T	DRY-BULK	321.79	666.73	1591.88	10.02	12.42	23.61	16
7	9/9/10 9:40	9/22/10 9:15	0.5	DF	DRY-BULK	426.56	801.37	1126.41	1.59	5.25	NA	17
8	9/22/10 09:15	10/13/10 09:40	1.895	DF+R	DRY-BULK	387.82	364.87	465.74	11.97	16.67	28.72	
9	10/13/10 9:40	10/20/10 15:24	2.192	DF+R	DRY-BULK	102.5	172.11	296	2.25	3.72	4.05	
10	10/20/10 15:24	11/9/10 9:02	0.47	DF+R+S	DRY-BULK	495.74	385.79	1381.38	4.51	11.55	23.85	
11	11/9/10 9:02	11/17/10 7:25	1.76	DF+S?	DRY-BULK	57.13	29.87	46.34	0.68	4.07	4.07	
12	11/17/10 7:25	12/1/10 10:45	0.735	DF+S	DRY-BULK	219.71	202.11	343.1	3.15	4.6	8.28	
13	12/1/10 10:45	12/15/10 13:50	2.351	DF+R+S	DRY-BULK	80.76	18.53	33.5	1.8	2.78	3.08	
14	12/15/10 13:50	1/4/11 9:57	0.958	DF+R+S	DRY-BULK	89.85	18.6	36.24	1.58	3.39	7.41	
15	1/4/11 9:57	2/11/11 11:07	0.275	DF+R+S	DRY-BULK	46.34*	463.31*	351.98*	16.77*	18.49*	26.81*	
16	2/11/11 11:07	3/1/11 8:30	0.833	S	DRY-BULK	118.59	117.88	178.94	2.27	3	10.07	
17	3/1/11 8:30	3/28/11 9:55	1.77	DF+R+S	DRY-BULK	110.58	98.97	115.56	1.45	4.02	9.28	65
18	3/28/11 9:55	4/22/11 10:15	0.5	DF+R+S	DRY-BULK	488.19	554.75	1029.72	10.22	16.42	26.95	74
19	4/22/11 10:15	6/7/11 14:35	2.14	DF+R+S	DRY-BULK	169.67*	132.53*	243.32*	14.03*	14.62*	22.08*	75
20	6/7/11 14:35	7/2/11 12:25	0.5	DF+R+S	DRY-BULK	188.42	87.14	NA	34.1	61	131.19	76
21	7/2/11 12:25	7/23/11 11:22	0.5	DF+R+S	DRY-BULK	128.64	191.46	579.01	31.74	62.83	149.06	92
22	7/23/11 11:22	8/4/11 11:10	0.5	DF	DRY-BULK	322.9	376.24	885.8	7.39	25.25	93.01	93
23	8/4/11 11:10	8/26/11 10:30	0.5	DF	DRY-BULK	NA	NA	NA	NA	NA	NA	94
24	8/26/11 10:30	9/8/11 10:02	0.5	DF	DRY-BULK	226.94	210.64	288.37	3.42	10.15	19.38	95
25	9/8/11 10:02	9/21/11 9:13	0.433	DF+R	DRY-BULK	641.91	92.99	NA	4.1	9.23	15.07	
26	9/21/11 9:13	10/12/11 15:12	0.5	DF+R+S	DRY-BULK	821.95	580.13	NA	5.3	12.36	NA	

Appendix Table 4.b. N and P loads in dry-bulk deposition (buoy bucket) at the Mid-lake Buoy (TB-1) Station 6/3/10-10/12/11.

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO3-N (g/ha)	NH4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
1	6/3/10 09:37	7/2/10 08:05	0.500	DF+R	DRY-BULK	C	C	C	C	C	C	13
2	7/2/10 08:05	7/20/10 10:35	0.500	DF+R	DRY-BULK	21.62	2.66	85.82	3.06	3.80	15.29	14
3	7/20/10 10:35	8/3/10 09:30	0.500	DF	DRY-BULK	20.07	9.46	23.19	0.18	1.10	4.51	14
4	8/3/10 09:30	8/12/10 09:50	0.365	DF+R	DRY-BULK	53.09	66.83	158.34	0.49	0.90	2.22	
5	8/12/10 09:50	8/31/10 10:30	0.500	DF	DRY-BULK	24.00	2.07	114.05	0.65	1.13	4.02	14
6	8/31/10 10:30	9/9/10 09:40	0.500	DF+T	DRY-BULK	31.75	65.79	157.08	0.99	1.23	2.33	16
7	9/9/10 09:40	9/22/10 09:15	0.500	DF	DRY-BULK	42.09	79.08	111.15	0.16	0.52		17
8	9/22/10 09:15	10/13/10 09:40	1.895	DF+R	DRY-BULK	145.04	136.46	174.18	4.48	6.23	10.74	
9	10/13/10 09:40	10/20/10 15:24	2.192	DF+R	DRY-BULK	44.34	74.45	128.05	0.97	1.61	1.75	
10	10/20/10 15:24	11/9/10 09:02	0.470	DF+R+S	DRY-BULK	45.98	35.78	128.13	0.42	1.07	2.21	
11	11/9/10 09:02	11/17/10 07:25	1.760	DF+S?	DRY-BULK	19.84	10.38	16.10	0.24	1.41	1.41	
12	11/17/10 07:25	12/1/10 10:45	0.735	DF+S	DRY-BULK	31.87	29.32	49.77	0.46	0.67	1.20	
13	12/1/10 10:45	12/15/10 13:50	2.351	DF+R+S	DRY-BULK	37.47	8.60	15.54	0.84	1.29	1.43	
14	12/15/10 13:50	1/4/11 09:57	0.958	DF+R+S	DRY-BULK	16.99	3.52	6.85	0.30	0.64	1.40	
15	1/4/11 09:57	2/11/11 11:07	0.275	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	
16	2/11/11 11:07	3/1/11 08:30	0.833	S	DRY-BULK	19.50	19.38	29.42	0.37	0.49	1.66	
17	3/1/11 08:30	3/28/11 09:55	1.770	DF+R+S	DRY-BULK	38.63	34.57	40.37	0.51	1.40	3.24	65
18	3/28/11 09:55	4/22/11 10:15	0.500	DF+R+S	DRY-BULK	48.17	54.74	101.61	1.01	1.62	2.66	74
19	4/22/11 10:15	6/7/11 14:35	2.140	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	75
20	6/7/11 14:35	7/2/11 12:25	0.500	DF+R+S	DRY-BULK	18.59	8.60	NA	3.36	6.02	12.95	76
21	7/2/11 12:25	7/23/11 11:22	0.500	DF+R+S	DRY-BULK	12.69	18.89	57.13	3.13	6.20	14.71	92
22	7/23/11 11:22	8/4/11 11:10	0.500	DF	DRY-BULK	31.86	37.13	87.41	0.73	2.49	9.18	93
23	8/4/11 11:10	8/26/11 10:30	0.500	DF	DRY-BULK	NA	NA	NA	NA	NA	NA	94
24	8/26/11 10:30	9/8/11 10:02	0.500	DF	DRY-BULK	22.39	20.79	28.46	0.34	1.00	1.91	95
25	9/8/11 10:02	9/21/11 09:13	0.433	DF+R	DRY-BULK	54.85	7.95	NA	0.35	0.79	1.29	
26	9/21/11 9:13	10/12/11 15:12	0.5	DF+R+S	DRY-BULK	81.11	57.25	NA	0.52	1.22	NA	

Appendix Table 4.c. N and P loading per day in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 6/3/10-10/12/11.

	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	6/3/10 09:37	7/2/10 08:05	0.500	DF+R	DRY-BULK	C	C	C	C	C	C	13
2	7/2/10 08:05	7/20/10 10:35	0.500	DF+R	DRY-BULK	1.19	0.15	4.74	0.17	0.21	0.84	14
3	7/20/10 10:35	8/3/10 09:30	0.500	DF	DRY-BULK	1.44	0.68	1.66	0.01	0.08	0.32	14
4	8/3/10 09:30	8/12/10 09:50	0.365	DF+R	DRY-BULK	5.89	7.41	17.57	0.05	0.10	0.25	
5	8/12/10 09:50	8/31/10 10:30	0.500	DF	DRY-BULK	1.26	0.11	5.99	0.03	0.06	0.21	14
6	8/31/10 10:30	9/9/10 09:40	0.500	DF+T	DRY-BULK	3.54	7.34	17.52	0.11	0.14	0.26	16
7	9/9/10 09:40	9/22/10 09:15	0.500	DF	DRY-BULK	3.24	6.09	8.56	0.01	0.04	NA	17
8	9/22/10 09:15	10/13/10 09:40	1.895	DF+R	DRY-BULK	6.90	6.49	8.29	0.21	0.30	0.51	
9	10/13/10 09:40	10/20/10 15:24	2.192	DF+R	DRY-BULK	6.13	10.29	17.69	0.13	0.22	0.24	
10	10/20/10 15:24	11/9/10 09:02	0.470	DF+R+S	DRY-BULK	2.33	1.81	6.49	0.02	0.05	0.11	
11	11/9/10 09:02	11/17/10 07:25	1.760	DF+S?	DRY-BULK	2.50	1.31	2.03	0.03	0.18	0.18	
12	11/17/10 07:25	12/1/10 10:45	0.735	DF+S	DRY-BULK	2.25	2.07	3.52	0.03	0.05	0.08	
13	12/1/10 10:45	12/15/10 13:50	2.351	DF+R+S	DRY-BULK	2.65	0.61	1.10	0.06	0.09	0.10	
14	12/15/10 13:50	1/4/11 09:57	0.958	DF+R+S	DRY-BULK	0.86	0.18	0.35	0.02	0.03	0.07	
15	1/4/11 09:57	2/11/11 11:07	0.275	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	
16	2/11/11 11:07	3/1/11 08:30	0.833	S	DRY-BULK	1.09	1.08	1.64	0.02	0.03	0.09	
17	3/1/11 08:30	3/28/11 09:55	1.770	DF+R+S	DRY-BULK	1.43	1.28	1.49	0.02	0.05	0.12	65
18	3/28/11 09:55	4/22/11 10:15	0.500	DF+R+S	DRY-BULK	1.93	2.19	4.06	0.04	0.06	0.11	74
19	4/22/11 10:15	6/7/11 14:35	2.140	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	75
20	6/7/11 14:35	7/2/11 12:25	0.500	DF+R+S	DRY-BULK	0.75	0.35	NA	0.14	0.24	0.52	76
21	7/2/11 12:25	7/23/11 11:22	0.500	DF+R+S	DRY-BULK	0.61	0.90	2.73	0.15	0.30	0.70	92
22	7/23/11 11:22	8/4/11 11:10	0.500	DF	DRY-BULK	2.66	3.10	7.29	0.06	0.21	0.77	93
23	8/4/11 11:10	8/26/11 10:30	0.500	DF	DRY-BULK	NA	NA	NA	NA	NA	NA	94
24	8/26/11 10:30	9/8/11 10:02	0.500	DF	DRY-BULK	1.73	1.60	2.19	0.03	0.08	0.15	95
25	9/8/11 10:02	9/21/11 09:13	0.433	DF+R	DRY-BULK	4.23	0.61	NA	0.03	0.06	0.10	
26	9/21/11 9:13	10/12/11 15:12	0.5	DF+R+S	DRY-BULK	3.82	2.69	NA	0.02	0.06	NA	

Table 5.a. N and P concentrations in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 6/3/10-10/12/11.

	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	6/3/10 9:18	7/2/10 8:20	0.5	DF+R	DRY-BULK	245.89c	38.92c	1610.6c	48.36c	64.64c	NAc	13
2	7/2/10 8:20	7/20/10 10:16	0.5	DF+R	DRY-BULK	136.72	26.71	544.27	21.78	30.42	69.54	9
3	7/20/10 10:16	8/3/10 9:07	0.5	DF	DRY-BULK	190.85	136.16	226.14	1.82	8.37	25.48	14
4	8/3/10 9:07	8/12/10 10:14	0.485	DF+R	DRY-BULK	688.84	174.85	2741.74	24.05	27.46	44.25	
5	8/12/10 10:14	8/31/10 14:05	0.5	DF	DRY-BULK	232.59	16.74	1179.73	5.67	9.32	32.61	14
6	8/31/10 14:05	9/9/10 9:20	0.685	DF+R	DRY-BULK	252.43	283.28	1024.42	2.96	5.9	10.56	
7	9/9/10 9:20	9/22/10 8:55	0.32	DF	DRY-BULK	577.46	613.45	1464.77	3.4	7.1	14.05	
8	9/22/10 8:55	10/13/10 9:40	1.232	DF+R	DRY-BULK	487.31	530.23	793.13	2.93	10.19	15.75	
9	10/13/10 9:40	10/20/10 15:24	2.374	DF+R	DRY-BULK	112.36	137.71	204	1.8	2.79	1.71	
10	10/20/10 15:24	11/9/10 9:02	0.818	DF+R+S	DRY-BULK	303.4	374.61	736.6	1.35	5.4	20.16	
11	11/9/10 9:02	11/17/10 7:25	1.515	DF+S?	DRY-BULK	70.43	36.2	87.8	0.68	3.39	4.38	
12	11/17/10 7:25	12/1/10 10:45	1.131	DF+S	DRY-BULK	154.37	158.79	264.28	1.35	3.99	14.73	
13	12/1/10 10:45	12/15/10 13:50	2.775	DF+R+S	DRY-BULK	57.29	14.78	13.45	1.35	3.08	3.39	
14	12/15/10 13:50	1/4/11 9:40	1.35	DF+R+S	DRY-BULK	92.98	24.53	134.05	1.35	1.54	3.39	
15	1/4/11 9:40	2/11/11 10:46	0.5	DF+R+S	DRY-BULK	639.33*	282.57*	453.79*	6.57*	8.32*	28.35*	66
16	2/11/11 10:46	3/1/11 8:48	0.627	S	DRY-BULK	142.87	138.84	175.76	2.27	3.31	33.03	
17	3/1/11 8:48	3/28/11 9:25	1.828	DF+R+S	DRY-BULK	113.54	95.91	143.98	1.68	3.71	9.28	
18	3/28/11 9:25	4/22/11 9:19	0.5	DF+R+S	DRY-BULK	501.13	716.5	1012.64	11.35	19.2	50.18	77
19	4/22/11 9:19	6/7/11 15:08	1.869	DF+R+S	DRY-BULK	158.19*	147.37*	182.69*	11.36*	10.88*	14.62*	78
20	6/7/11 15:08	7/2/11 11:45	0.5	DF+R+S	DRY-BULK	169.89	67.6	581.01	16.25	45.67	65.29	79
21	7/2/11 11:45	7/23/11 10:54	0.5	DF+R	DRY-BULK	150.7	94.97	569.51	17.01	38.19	109.95	96
22	7/23/11 10:54	8/4/11 10:25	0.5	DF	DRY-BULK	253.59	314.9	382.03	6.26	16.01	47.74	97
23	8/4/11 10:25	8/26/11 10:05	0.5	DF	DRY-BULK	81.87	79.21	193.49	5.44	9.69	21.9	97
24	8/26/11 10:05	9/8/11 9:19	0.5	DF	DRY-BULK	185.54	206.25	478.46	3.88	9.53	24.91	97
25	9/8/11 9:19	9/21/11 9:33	0.5	DF+R	DRY-BULK	186.62	250.39	NA	3.64	9.23	12.61	98
26	9/21/11 9:33	10/12/11 15:37	0.5	DF+R+S	DRY-BULK	753.99	677.69	NA	2.35	8.03	16.05	

Appendix Table 5.b. N and P loads in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 6/3/10-10/12/11.

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	6/3/10 09:18	7/2/10 08:20	0.500	DF+R	DRY-BULK	C	C	C	C	C	C	13
2	7/2/10 08:20	7/20/10 10:16	0.500	DF+R	DRY-BULK	13.49	2.64	53.71	2.15	3.00	6.86	9
3	7/20/10 10:16	8/3/10 09:07	0.500	DF	DRY-BULK	18.83	13.44	22.31	0.18	0.83	2.51	14
4	8/3/10 09:07	8/12/10 10:14	0.485	DF+R	DRY-BULK	65.93	16.74	262.43	2.30	2.63	4.24	
5	8/12/10 10:14	8/31/10 14:05	0.500	DF	DRY-BULK	22.95	1.65	116.41	0.56	0.92	3.22	14
6	8/31/10 14:05	9/9/10 09:20	0.685	DF+R	DRY-BULK	34.13	38.30	138.49	0.40	0.80	1.43	
7	9/9/10 09:20	9/22/10 08:55	0.320	DF	DRY-BULK	36.47	38.74	92.50	0.21	0.45	0.89	
8	9/22/10 08:55	10/13/10 09:10	1.232	DF+R	DRY-BULK	118.48	128.92	192.84	0.71	2.48	3.83	
9	10/13/10 09:40	10/20/10 15:03	2.374	DF+R	DRY-BULK	52.64	64.52	95.58	0.84	1.31	0.80	
10	10/20/10 15:24	11/9/10 08:44	0.818	DF+R+S	DRY-BULK	48.98	60.47	118.91	0.22	0.87	3.25	
11	11/9/10 09:02	11/17/10 07:45	1.515	DF+S?	DRY-BULK	21.06	10.82	26.25	0.20	1.01	1.31	
12	11/17/10 07:25	12/1/10 10:25	1.131	DF+S	DRY-BULK	34.46	35.44	58.99	0.30	0.89	3.29	
13	12/1/10 10:45	12/15/10 14:25	2.775	DF+R+S	DRY-BULK	31.38	8.09	7.37	0.74	1.69	1.86	
14	12/15/10 13:50	1/4/11 09:40	1.350	DF+R+S	DRY-BULK	24.77	6.54	35.71	0.36	0.41	0.90	
15	1/4/11 09:40	2/11/11 10:46	0.500	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	66
16	2/11/11 10:46	3/1/11 08:48	0.627	S	DRY-BULK	17.68	17.18	21.75	0.28	0.41	4.09	
17	3/1/11 08:48	3/28/11 09:25	1.828	DF+R+S	DRY-BULK	40.96	34.60	51.94	0.61	1.34	3.35	
18	3/28/11 09:25	4/22/11 09:19	0.500	DF+R+S	DRY-BULK	49.45	70.70	99.92	1.12	1.89	4.95	77
19	4/22/11 09:19	6/7/11 15:08	1.869	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	78
20	6/7/11 15:08	7/2/11 11:45	0.500	DF+R+S	DRY-BULK	16.76	6.67	57.33	1.60	4.51	6.44	79
21	7/2/11 11:45	7/23/11 10:54	0.500	DF+R	DRY-BULK	14.87	9.37	56.20	1.68	3.77	10.85	96
22	7/23/11 10:54	8/4/11 10:25	0.500	DF	DRY-BULK	25.02	31.07	37.70	0.62	1.58	4.71	97
23	8/4/11 10:25	8/26/11 10:05	0.500	DF	DRY-BULK	8.08	7.82	19.09	0.54	0.96	2.16	97
24	8/26/11 10:05	9/8/11 09:19	0.500	DF	DRY-BULK	18.31	20.35	47.21	0.38	0.94	2.46	97
25	9/8/11 09:19	9/21/11 09:33	0.500	DF+R	DRY-BULK	18.41	24.71	NA	0.36	0.91	1.24	98
26	9/21/11 9:33	10/12/11 15:37	0.5	DF+R+S	DRY-BULK	74.40	66.87	NA	0.23	0.79	1.58	

Appendix Table 5.c. N and P load per day in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Sta. 6/3/10-10/12/11.

	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	6/3/10 09:18	7/2/10 08:20	0.500	DF+R	DRY-BULK	NA	NA	NA	NA	NA	NA	13
2	7/2/10 08:20	7/20/10 10:16	0.500	DF+R	DRY-BULK	0.75	0.15	2.97	0.12	0.17	0.38	9
3	7/20/10 10:16	8/3/10 09:07	0.500	DF	DRY-BULK	1.35	0.96	1.60	0.01	0.06	0.18	14
4	8/3/10 09:07	8/12/10 10:14	0.485	DF+R	DRY-BULK	7.29	1.85	29.01	0.25	0.29	0.47	
5	8/12/10 10:14	8/31/10 14:05	0.500	DF	DRY-BULK	1.20	0.09	6.08	0.03	0.05	0.17	14
6	8/31/10 14:05	9/9/10 09:20	0.685	DF+R	DRY-BULK	3.88	4.35	15.73	0.05	0.09	0.16	
7	9/9/10 09:20	9/22/10 08:55	0.320	DF	DRY-BULK	2.81	2.98	7.13	0.02	0.03	0.07	
8	9/22/10 08:55	10/13/10 09:10	1.232	DF+R	DRY-BULK	5.64	6.14	9.18	0.03	0.12	0.18	
9	10/13/10 09:40	10/20/10 15:03	2.374	DF+R	DRY-BULK	7.29	8.93	13.23	0.12	0.18	0.11	
10	10/20/10 15:24	11/9/10 08:44	0.818	DF+R+S	DRY-BULK	2.48	3.07	6.03	0.01	0.04	0.17	
11	11/9/10 09:02	11/17/10 07:45	1.515	DF+S?	DRY-BULK	2.65	1.36	3.30	0.03	0.13	0.16	
12	11/17/10 07:25	12/1/10 10:25	1.131	DF+S	DRY-BULK	2.44	2.51	4.18	0.02	0.06	0.23	
13	12/1/10 10:45	12/15/10 14:25	2.775	DF+R+S	DRY-BULK	2.22	0.57	0.52	0.05	0.12	0.13	
14	12/15/10 13:50	1/4/11 09:40	1.350	DF+R+S	DRY-BULK	1.25	0.33	1.80	0.02	0.02	0.05	
15	1/4/11 09:40	2/11/11 10:46	0.500	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	66
16	2/11/11 10:46	3/1/11 08:48	0.627	S	DRY-BULK	0.99	0.96	1.21	0.02	0.02	0.23	
17	3/1/11 08:48	3/28/11 09:25	1.828	DF+R+S	DRY-BULK	1.52	1.28	1.92	0.02	0.05	0.12	
18	3/28/11 09:25	4/22/11 09:19	0.500	DF+R+S	DRY-BULK	1.98	2.83	4.00	0.04	0.08	0.20	77
19	4/22/11 09:19	6/7/11 15:08	1.869	DF+R+S	DRY-BULK	NA	NA	NA	NA	NA	NA	78
20	6/7/11 15:08	7/2/11 11:45	0.500	DF+R+S	DRY-BULK	0.67	0.27	2.31	0.06	0.18	0.26	79
21	7/2/11 11:45	7/23/11 10:54	0.500	DF+R	DRY-BULK	0.71	0.45	2.68	0.08	0.18	0.52	96
22	7/23/11 10:54	8/4/11 10:25	0.500	DF	DRY-BULK	2.09	2.59	3.15	0.05	0.13	0.39	97
23	8/4/11 10:25	8/26/11 10:05	0.500	DF	DRY-BULK	0.37	0.36	0.87	0.02	0.04	0.10	97
24	8/26/11 10:05	9/8/11 09:19	0.500	DF	DRY-BULK	1.41	1.57	3.64	0.03	0.07	0.19	97
25	9/8/11 09:19	9/21/11 09:33	0.500	DF+R	DRY-BULK	1.42	1.90	NA	0.03	0.07	0.10	98
26	9/21/11 9:33	10/12/11 15:37	0.5	DF+R+S	DRY-BULK	3.50	3.15	NA	0.01	0.04	0.07	

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. "*"= prolonged collection period, data not used in loading calculations.

Nutrient Concentrations: (C= sample contamination; NA= Not available or not enough sample for analysis; note units are micrograms/liter; TBA= data not yet available; where concentrations are shown with a "c", sample was considered contaminated and not used in loading calculations).

Table Notes

Small amount of precipitation from thunderstorms, 20ml sample + 480 ml deionized water; (2) localized thunderstorm on 8/7/10 which caused rise on Ward Cr.; (3) 125ml precipitation + 375 ml deionized water; (4) much pollen and large dead crane fly in dry sample, possible contamination, not used for loading; (5) dry bucket had much pollen, small amount of sample spilled in transit; (6) removed Aerochem Metrics sampler on 8/12/10 12:00 to paint tower; (7) thunderstorm this period, Dry bucket had much debris and dust, still construction on property and unpaved road, thunderstorm this period also, construction may have led to unusual silt resuspension, don't use data for loading, also approximate start time when Aerochem Metrics station back up and running; (8) couple aspen leaves, much debris, silt and organic matter in sample, grading and logging on property during period, don't use this sample; (9) much pollen and a few very small bugs in dry bucket; (10) 32ml + 468ml deionized water, much pollen, many dead bugs in ST; (11) added 495ml deionized water to 5ml of sample; (12) 70ml of precipitation from thunderstorms added to 430ml of deionized water; (13) dry bucket out for very long period, 500ml deionized water to process; (14) bucket dry, 500ml deionized water added to process; (15) bucket dry, much pollen, 500 ml deionized water added to process; (16) 220ml sample + 280ml deionized water;(17) 10ml of sample + 490ml deionized water; (18) no power to station, contractor disconnected power cord both Wet and Dry buckets open this period, lid removed; (19)Aerochem Metrics lid removed, Wet + Dry buckets exposed during period; (20) Aerochem Metrics lid over Wet part of period, shifted manually over Dry at 10/18/10 at 0900; (21) 10/22/10 1440 extension cord connected to station, Aerochem Metrics working properly during storm, storm mostly rain from intense rain/ tropical moisture event; (22) 185ml sample + 320ml deionized water; (23) 2 aspen leaves in sample; (24) bucket collected 11/20/10 13:25 with snow 3-4 inches above rim, was combined with bucket collected 11/21/10 17:45 with snow 10-12 inches above rim, snow compacted down for both, melt water added together, lid stuck over dry so bucket collected some dry deposition also, very cold; (25) very cold arctic low pressure system with gusty winds, about 15-18 inches of snow from storm, snow may have blown off over-topped snow, only ½ inch snow above rim of bucket, area more open now due to removal of trees near the lake on the property; (26) snow 3-4 inches above rim, compacted down; (27) very wet storm with much rain at lower elevations, heavy snow, approximately 1 foot at end of storm; (28) much water in bucket, snow also accumulated 1 inch above rim, strong winds had blown snow roof off Aerochem Metrics lid, rain and snow this storm, stationary low pressure system merging cold air and tropical moisture from near Hawaii, power off to station, Wet side open; (29) Wet bucket collected some dry deposition, windy this period; (30) power off, ground-fault interrupter tripped during storm, Wet caught some Dry deposition; (31) Dry bucket may have caught some precipitation; (32) snow 1 ½ feet above rim bucket compacted down, heavy wet snow from strong storm; (33) no power to station, contractor removed disconnected power cord, both Wet and Dry buckets open this period, lid removed 10/3/10, dry bucket caught precipitation during storm 10/2/10; Wet + Dry buckets exposed during period; (34) Dry bucket open during period until10/18/10 0900 when manually shifted lid to cover, Dry closed the rest of the period; (35) many aspen leaves in Dry bucket; (36) Dry bucket had ice in it, no heater in place; (37) snow and ice accumulated on screen over Dry bucket, no heater in place; (38) power was cut to station sometime during period, estimate 12/15/10, ground fault interrupter tripped, likely in heavy snow or rain, lid loose over dry during power outage; (39) Dry bucket frozen with some snow on it, connected heater to timer for next Dry collection; (40) precip rain from thunderstorms; (41) ST leaked, 61 ml caught in another bag, added 268ml deionized water to 232ml sample remaining in ST;(42) 55ml sample + 445 ml deionized H2O; (43) ST bag had leak, re-sealed and placed back out; (44) ST bag leaked, sample lost; (45) no ST in place this period; (46) ST had a leak, some sample lost, amount low, ST cap gone; (47) snow accumulated 6-8 inches above rim, compacted down; (48) snow accumulated ~4 inches above rim; (49) ~2 feet new light snow at station, compacted into bucket; (50) snow accumulated ~4 inches above rim, compacted down; (51-53) no notes; (54) 1 wet bucket spilled, ~2 feet snow accumulated, collected snow by coring down to wet bucket with another wet bucket, precip spilled out of one bucket in transit to the lab, estimated amount by using SNOTEL Ward 3 precipitation accumulated during period 3.6 inches of water divided by 1.5 (approximate factor Ward #3 is greater than Lower Ward Valley station; (55)~15 inches new snow; (56) snow accumulated 1 ft. above rim, used 2nd bucket to core down to bucket in sampler; (57) used clean bucket to core approximately 1 foot to wet bucket in sampler, combined buckets; (58) snow 1 inch above bucket rim; (59) used 2nd bucket to core down to bucket in sampler, strong windy storm with heavy snow, bucket likely did not collect all snow due to strong winds which may have blown snow from top of sample away; (60) Dry bucket frozen on surface portion of the period; (61) much silt in sample; (62) 117ml of precip + 383ml deionized water; (63) no ST cap, bag blew upwards preventing collection of precip; (64) no cap, but ST still collected precip; (65) small pc of green organic matter in TB Dry; (66) bucket dry, added 500ml deionized water to process; (67) last storm very windy; (68) power cut to station, house which had been source of power is being torn down, dry bucket caught most of the precipitation, 29ml of sample + 471ml deionized water; (69) 145 ml of sample + 355 ml deionized water; (70) much pollen and organic matter in sample; (71) no ST or ST cap out this period; (72) ST may have leaked; (73) ST had many dead flies in it, measured volume and discarded water; (74) bucket dry, added 500ml deionized water to process; (75) bucket may have gone dry during portion of the period; (76) dry bucket had trace of precipitation in it, much pollen in dry bucket; (77) 50ml of sample + 450ml deionized water; (78) bucket may have gone dry during portion of the period; (79) 285 ml sample + 215ml deionized sample; (80) 56ml sample + 444ml deionized water, manually switched lid back over wet bucket, had switched over dry bucket at 1715 with onset of precipitation, power to station out, house which was source of power has been torn down; (81) lid on Aerochem Metrics sampler removed 9/11/11 at 1505 prior to thunderstorms (1730-1930) – note there was heavy rain and Tahoe Vista from thunderstorms, a few sprinkles occurred the previous day and were caught in the dry bucket, after changing wet bucket, left lid off sampler; (82) collected precip from wet bucket and left out, collected in new 250 HDPE bottle rinsed 4-5 times with sample; (83) no precipitation or trace, had evaporated; (84) much silt and pollen in sample, roadhouse demolished now, 1 aspen leaf in sample, diluted 60ml of filtered water with 180ml of deionized water due to very slow filtration; raw water was not diluted; (85) bucket very dirty, still much construction on property, may be stirring up dust; (86) many particles on filter; (87) dry bucket lid had been removed from Aerochem sampler the previous day 9/11/11 at 1505, so dry bucket also caught precip 9/11/11 1730-1930; (88) Aerochem Metrics lid removed so Dry bucket caught some precipitation as did Wet bucket; (89) Dry bkt collected after about ½ hour of rain, replaced with Wet bucket, still no power to station; (90) many small black bugs in ST sample, added 242 ml of sample to 258ml deionized water; (91) ST had 22ml or precip to which added 478ml deionized water; (92) bucket dry although precip during period, added 500ml to process, much pollen in sample; (93) 48ml sample + 452ml deionized water; (94) bucket dry, added 500ml deionized water to process, many plastic flakes; (95) bucket dry, added 500ml deionized water to process; (96) bucket dry added 500ml deionized water to process, much pollen; (97) bucket dry, added 500ml deionized water to process; (98) 190 ml sample + 310ml deionized water; (x) additional 2 liters deionized water added, small amount spilled in transit; (z) pine needles, seeds, sprouts in sample, contamination, long collection period, don't use sample; (y) many pieces of organic matter in sample, don't use; (v) bucket out long period, sample caught wet and dry, unable to separate wet contribution from dry in calculations, use Wet bucket estimates of Wet+ Dry during collection periods ending 10/3/10 16:45, 10/4/10 09:20, 10/5/10 16:15; 10/8/10 11:20, do not use 10/14/10 dry sample; (w) in calculation of loading and loading rate, subtracted the contribution from the wet sample collected 10/19/11 to estimate the dry contribution;