

***Big Bear Lake Nutrient TMDL
Annual Water Quality Report 2009***



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**Prepared for:
Big Bear Lake Nutrient TMDL
Task Force**

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Appendix A: Big Bear Lake Nutrient TMDL Compliance Program Watershed-Wide Monitoring Plan

Appendix B: Water Quality Data
1. In-Lake Data
2. Tributary Data

Appendix C: Nuisance Aquatic Plant Eradication Program Results for 2009

1.0 Introduction

Several years ago, the Santa Ana Regional Water Quality Control Board (Regional Board #8) added Big Bear Lake and three of its major tributaries to California's list of impaired water bodies due to elevated levels of nitrogen and phosphorus measured in the lake and tributaries. These chemicals act as fertilizers to stimulate excess algae growth, which can cause fish kills by reducing dissolved oxygen, and aquatic weed infestation, which can out-compete native aquatic plant habitat. The weeds and algae also interfere with recreational uses in and on the water.

Although nitrogen and phosphorus occur naturally in runoff from the surrounding forest to the lake, human development often increases the concentration of these nutrients. Consequently, in April 2006, the Regional Board adopted resolution No. R8-2006-0023 amending the Water Quality Control Plan for the Santa Ana River Basin to incorporate a Total Maximum Daily Load (TMDL) to regulate nutrient concentrations and prevent further impairment of water quality in Big Bear Lake.

Initially, the TMDL sets targets for the total phosphorus loads in Big Bear Lake during relatively dry years. However, as more and better data becomes available, the Regional Board intends to develop a TMDL to control nutrient loads during years of moderate and high precipitation. Thus, monitoring is being conducted both in the lake and in six tributaries that flow into the lake for purposes of evaluating progress toward meeting TMDL targets and to develop a larger body of data regarding nutrients in the lake and watershed. The numerical targets for the dry hydrological conditions are to be achieved by 2015.

Monitoring is being conducted in accordance with approved Monitoring Plans and Quality Assurance Project Plans. In calendar year 2009, the lake was monitored between May and November, and the tributaries were monitored between July and December. Therefore, the data represents only a portion of the year, and averages calculated from these data are partial-year, rather than full annual averages.

1.1 TMDL Monitoring and Reporting Requirement

This document addresses Task 4.1 and Task 4.2 of the adopted TMDL and recently adopted San Bernardino County MS4 Permit (Regional Board Order R8-2010-0036). The program was to include the following:

1. A watershed-wide nutrient monitoring program to determine compliance with interim and/or final phosphorus allocations; compliance with the phosphorus TMDL, and load allocations (LAs), including waste load allocations (WLAs).
2. An In-Lake nutrient monitoring program to determine compliance with interim and final phosphorus and chlorophyll *a* numeric targets.
3. An annual report summarizing the data collected for the year and evaluating compliance with the TMDL, due February 15 of each year.

This report satisfies the obligation of Task Force stakeholders to submit an annual report summarizing the data collected for the year and evaluates progress toward compliance with the TMDL for the Big Bear Lake nutrient TMDLs.

1.2 Monitoring Approach

Over the last few years, with considerable support from state and federal grant funds, local stakeholders developed studies, including comprehensive monitoring programs of the surrounding watershed and the lake itself. Of particular note, the Regional Board required the stakeholders to prepare and submit separate water quality monitoring programs of the two hydrologic areas. Although the two plans share many of the same purposes, they are, in fact, separate documents. Big Bear Municipal Water District (BBMWD) independently developed and implemented the In-Lake Monitoring Program. The other stakeholders (City of Big Bear Lake, Big Bear Municipal Water District, San Bernardino County, Big Bear Mountain Resorts, State of California Department of Transportation and the U.S. Forest Service) took responsibility for developing and implementing the Watershed-Wide Monitoring Plan. Whenever and wherever possible, the stakeholders intend to coordinate and integrate the monitoring efforts to improve data utility and reduce cost.

Included as Appendix A on the attached CD is the *Big Bear Lake Nutrient TMDL Compliance Watershed-Wide Monitoring Plan*, which was approved by the Regional Board in May 2009, and was subsequently implemented by the TMDL Task Force.

1.3 Numeric Targets

A key step in the development of the nutrient TMDL was the identification of the numeric targets to be achieved. The numeric targets do not vary based upon hydrological condition. Like the approved TMDL for dry hydrological conditions, the TMDLs for wet and/or average hydrological conditions that will be developed are expected to assure also that these numeric targets are achieved. Both “causal and response” numeric targets are specified for Big Bear Lake. The targets are shown in Table 5-9a-c of Resolution R8-2006-0023.

The causal target is for total phosphorus in the lake. Phosphorus is the primary limiting nutrient in Big Bear Lake. The annual average of the total Phosphorous concentration is determined by the following methodology: the nutrient data from both the photic composite and discrete bottom samples are averaged by station number and month; a calendar year average is obtained for each sampling location by averaging the average of each month; and finally, the separate annual averages for each location are averaged to determine the lake-wide average.

The response target is the chlorophyll *a* concentration in the lake. Response targets are more direct indicators of impairment and are specified to assess and track water quality improvements in Big Bear Lake. The growing season average of the total chlorophyll *a* concentration is calculated over the period from May 1 through October 31 of each year. The chlorophyll *a* data from the photic samples are averaged by station number and month; a growing season average is obtained for each sampling location by averaging the average of each month; and finally, the separate growing season averages for each location are averaged to determine the lake-wide average.

A weight of evidence approach will be used to assess compliance with the TMDL, which means that data pertaining to all the numeric targets will be evaluated and non-compliance with one target will not automatically imply non-compliance with the TMDL.

2.0 Big Bear Lake: In-Lake Nutrient Monitoring Program

Monitoring in the lake is being conducted in accordance with Water Quality Control Plan (Regional Board Resolution No. R8-2006-0023) for the Santa Ana River Basin.

For the May to December 2009 period, Big Bear Lake TMDL compliance monitoring was conducted by Big Bear Municipal Water District (BBMWD). In-lake samples were analyzed for the following constituents:

Specific Conductance	Dissolved Oxygen
Water temperature	Water Clarity (secchi depth)
Chlorophyll <i>a</i>	Ammonia Nitrogen
Total Nitrogen	Alkalinity
Nitrate +Nitrite Nitrogen	Turbidity
Total Phosphorus	Ortho-phosphate (SRP)
Total Hardness	Total Suspended Solids (TSS)
Total Dissolved Phosphorus	pH
Dissolved Organic Carbon (DOC)	Total Dissolved Solids (TDS)
Total Dissolved Nitrogen	Total Organic Carbon (TOC)

Data were collected and analyzed in order to address: (1) determination of compliance with phosphorus and chlorophyll *a* numeric targets; (2) determination of compliance with the existing total inorganic nitrogen (TIN) objective; and (3) refinement of the in-lake model for the purposes of TMDL review and development. Section 2.1 provides a summary of data collected for the 2009 year toward evaluation of compliance with the TMDL/WLAs/LAs numeric targets.

Sampling Station Locations

To characterize water quality conditions within the Big Bear Lake, four sampling station locations are defined within the lake as shown on Figure 2-1 and listed in Table 2-1. With the exception of hardness, alkalinity, TOC, DOC, and chlorophyll *a*, each sample was collected as a photic zone composite (from the surface to 2 times the secchi depth) and as a bottom discrete (0.5 meters off the surface bottom) sample. Hardness, alkalinity, TOC, DOC, and chlorophyll *a* were collected as photic zone composites. Dissolved oxygen, water temperature, turbidity, specific conductance, and pH were measured at 1-meter intervals from the surface to 0.5 meters from the bottom using a multi-parameter water quality meter. Water clarity was measured with a secchi disk.

Revisions to the Monitoring Plan

There were no revisions made to the Big Bear Lake Nutrient TMDL Monitoring Plan in 2009.

Figure 2-1. Big Bear Lake: In-Lake Monitoring Locations



Table 2-1. Big Bear Lake: In-Lake Monitoring Locations

Station ID	Location Number and Description
MWDL1	Big Bear Lake – Dam
MWDL2	Big Bear Lake – Gilner Point
MWDL6	Big Bear Lake – Mid Lake Middle
MWDL9	Big Bear Lake – Stanfield Middle

Sampling Schedule

The TMDL monitoring plan calls for monthly sampling of all constituents, except TOC and DOC constituents, monthly from March – November; bi-weekly (i.e., every other week) from June 1 through October 31, 2009. The TOC and DOC constituents are to be monitored four times per year (quarterly) from January through December. In 2009, BBMWD collected samples on a total of 13 dates. The exact dates of sampling were dependent upon local weather conditions. Laboratory analysis was performed by GEI Consultants of Denver, Colorado.

2.1 Big Bear Lake Annual Water Quality Summary

Big Bear Lake monitoring results for the period May 1, 2009 through November 30, 2009 are summarized in Table 2-2. The complete set of water quality data for the period is included on CD as Appendix B.

Table 2-2. Summary – Big Bear Lake Water Quality Data (May to November 2009)

Parameter		Water Quality Results per Station			
		Dam	Gilner Point	Mid Lake Middle	Stanfield Middle
Alkalinity as CaCO ₃ (mg/L)	Annual Mean	168.5	168.6	169.5	168.7
	Range of Values	160 – 176	158 – 176	162 – 178	162 – 178
Ammonia N (NH ₄ -N) (µg/L)	Annual Mean	103.0	90.3	59.3	35.0
	Range of Values	11 – 519	8 – 307	7 – 229	7 – 115
Nitrate and Nitrite as N (µg/L)	Annual Mean	6	6.7	3.3	2.3
	Range of Values	ND – 14	ND – 28	ND – 11	ND – 10
Orthophosphate as P (SRP) (µg/L)	Annual Mean	9.3	8.8	6.0	4.3
	Range of Values	2 – 45	ND – 62	ND – 21	ND – 11
pH	Annual Mean	8.3	8.4	8.4	8.5
	Range of Values	7.9 – 8.5	8.1 – 8.6	8.1 – 8.7	8.3 – 8.7
Total Suspended Solids (TSS) (mg/L)	Annual Mean	5.8	6.7	7.0	10.2
	Range of Values	2 – 21.2	2 – 62.8	2 – 19.2	2 – 44
Total Dissolved Nitrogen (TDS) (µg/L)	Annual Mean	941.2	930.8	902.0	885.4
	Range of Values	812 – 1,326	807 – 1,095	802 – 1,021	803 – 977
Total Nitrogen (TN) (µg/L)	Annual Mean	1,087.5	1,086.7	1,071.5	1,132.9
	Range of Values	943 – 1,461	928 – 1,309	918 – 1,298	918 – 2,186
Total Dissolved Phosphorus as P (µg/L)	Annual Mean	19.9	19.7	17.0	16.8
	Range of Values	4 – 60	9 – 79	4 – 32	11 – 24

Table 2-2. cont.. Summary – Big Bear Lake Nutrient TMDL Data (May to November 2009)

Parameter	TMDL Targets	Monthly Mean	Results per Station			
			Dam	Gilner Point	Mid Lake Middle	Stanfield Middle
Chlorophyll <i>a</i> (µg/L)	Lakewide Average during Growing Season no greater than 14 µg/L. To be attained no later than 2015 (dry hydrological conditions), 2020 (all other times).	May	0.95	5.15	6.15	3.20
		June	5.20	5.40	3.40	6.35
		July	5.30	6.95	5.45	7.85
		August	5.00	10.95	17.45	53.05
		September	18.20	17.10	24.60	28.30
		October	9.30	9.40	9.00	6.80
		November ¹	8.15	8.65	9.85	8.80
		Station Average	7.33	9.16	11.01	17.59
		Lakewide Average	11.27 µg/L			
Total Phosphorus as P (µg/L)	Lakewide Average no greater than 35 µg/L. To be attained no later than 2015 (dry hydrological conditions), 2020 (all other times).	May	41.75	38.25	27.88	29.92
		June	36.00	32.50	25.88	23.42
		July	41.50	40.25	29.00	35.58
		August	45.83	57.00	37.80	40.86
		September	56.25	51.00	44.38	65.83
		October	33.00	32.00	28.00	28.50
		November	24.75	32.00	27.42	27.50
		Station Average	39.87	40.43	31.48	35.94
		Lakewide Average	36.93			

¹ Growing Season for Chlorophyll *a* is from May 1st to October 31st; therefore, November data are not included within either the Station or Lakewide average calculations.

3.0 Big Bear Lake Watershed Nutrient Monitoring Program

Monitoring in the tributaries is being conducted in accordance with Water Quality Control Plan (Regional Board Resolution No. R8-2006-0023) for the Santa Ana River Basin as modified by the Regional Board-approved Monitoring Plan (May 2009).

The compliance monitoring program for Big Bear Lake was initiated in July 2009, and samples were collected monthly at tributaries with active flow between July and December, 2009. Field monitoring was directed by Brown and Caldwell and conducted by San Bernardino County Flood Control District staff.

Tributary samples were analyzed for the following constituents:

Total Nitrogen	Ammonia Nitrogen
Nitrate + Nitrite Nitrogen	Nitrogen Kjeldahl
Total Phosphorus	Ortho-phosphate (SRP)
Total Dissolved Phosphorus	Temperature
Total Suspended solids	Turbidity Concentration
pH	Dissolved Oxygen
Conductivity	Total Alkalinity
Hardness	Bicarbonate
BOD	Carbonate
COD	Calcium
DOC	Hydroxide
Total Organic Carbon	Magnesium
Volatile Suspended Solids	Total Dissolved Nitrogen

Section 3.1 provides a summary of data collected for the 2009 year toward evaluation of compliance with the TMDL/WLAs/LAs numeric targets.

Sampling Station Locations

To characterize water quality conditions within the watershed, seven sampling station locations are defined at suitable tributary outfalls surrounding the lake as shown in Figure 3-1 and listed in Table 3-1.

Revisions to the Monitoring Plan

There were no revisions made to the Big Bear Lake Nutrient TMDL Monitoring Plan for 2009.

Figure 3-1 Big Bear Lake Watershed Monitoring Locations

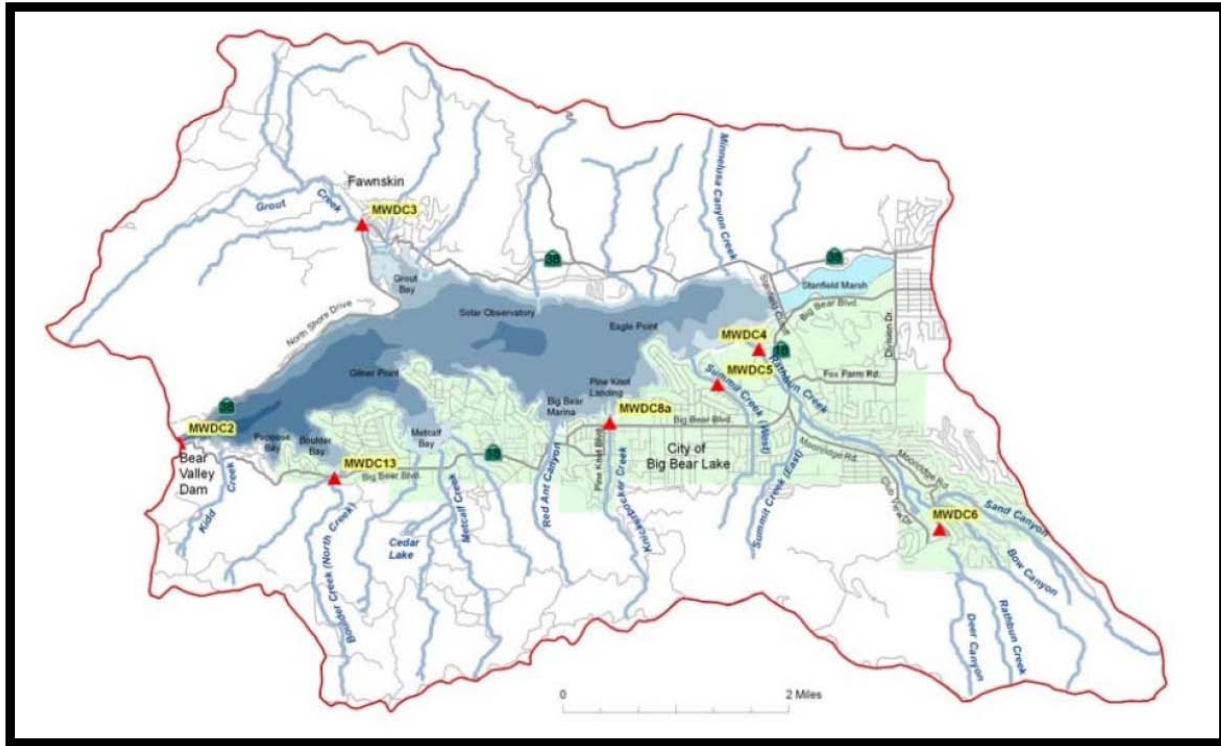


Table 3-1 Big Bear Lake Watershed Monitoring Locations

Station ID	Location Number and Description
MWDC2	Bear Creek Outlet
MWDC3	Grout Creek at Hwy 38
MWDC4	Rathbun Creek at Sandalwood Ave.
MWDC5	Summit Creek at Swan Dr.
MWDC6	Rathbun Creek below the Zoo
MWDC8	Knickerbocker Creek at Hwy 18
MWDC13	Boulder Creek at Hwy 18

Sampling Schedule

The TMDL monitoring plan calls for monthly sampling of all constituents, except chlorophyll *a*, at the Bear Creek Outlet from March through November. For all other stations, the TMDL monitoring plan provides multiple sampling schedules based upon which type of flow discharge is being sampled: Baseflow, Snowmelt and Storm event; as shown in Table 3-2. The sampling team collected samples on a total of 6 dates. Laboratory analysis was performed by E.S. Babcock & Sons Laboratory (Riverside, CA) for all samples collected between July and November 2009. Beginning in December 2009, a subset of samples were sent to GEI Consultants of Denver, Colorado because the laboratory can achieve lower reporting limits. In addition, sampling was eliminated at the Bear Creek outlet beginning in December 2009 due to Caltrans bridge construction at the sampling location.

Table 3-2 Big Bear Lake Watershed Sampling Frequency

Flow Type	Monthly Schedule for Required Monitoring	Frequency
Baseflow	January 1 st – December 31 st	Once per Month when baseflow is present
Snowmelt	January 1 st – May 31 st	Monthly in winter months
Storm Event	January 1 st – December 31 st	Two storms per year

3.1 Big Bear Lake Watershed Annual Water Quality Summary

The monitoring results of the tributary areas draining into Big Bear Lake for the period July through December 2009 are summarized in Table 3-3. The complete set of water quality data for the period is included on CD as Appendix B.

Table 3-3. Summary – Tributary Water Quality Data (July to December 2009)

Parameter		Results per Tributary Area			
		Knickerbocker	Bear Creek	Boulder Creek	Grout Creek
Ammonia N (NH ₄ -N) (µg/L)	Mean	36.9	94	19	46
	Range of Values	8.4 – 84.4	44 – 147	19	46
Bicarbonate (mg/L)	Mean	213.3	208	39	54
	Range of Values	170 – 300	206 – 212	39	54
BOD (mg/L)	Mean	2.04	1.88	0.9	1.4
	Range of Values	0.65 – 3.9	1.15 – 2.60	0.9	1.4
Calcium (mg/L)	Mean	42.22	35.14	8.35	11.85
	Range of Values	29.42 – 64.55	33.14 – 36.91	8.35	11.85
Carbonate (mg/L)	Mean	0.85	0	0	0
	Range of Values	0.85	0	0	0
COD (mg/L)	Mean	10.95	41.5	17	15
	Range of Values	3.15 – 21	28 – 55	17	15
Dissolved Organic Carbon (mg/L)	Mean	2.31	11.54	7	4.5
	Range of Values	1.64 – 3.22	10.22 – 13.21	7	4.5
Hardness as CaCO ₃ (mg/L)	Mean	159.70	161.07	25.42	37.68
	Range of Values	116.28 – 225.41	153.88 – 168.40	25.42	37.68

Parameter		Results per Tributary Area			
		Knickerbocker	Bear Creek	Boulder Creek	Grout Creek
Hydroxide (mg/L)	Mean	0.85	0	0	0
	Range of Values	0.85	0	0	0
Magnesium (mg/L)	Mean	13.01	17.60	1.09	1.94
	Range of Values	10.27 – 15.52	16.83 – 18.30	1.09	1.94
Nitrate as N (µg/L)	Mean	199	42	23	260
	Range of Values	68 – 542	23 – 68	23	248 – 271
Nitrite as N (µg/L)	Mean	49	56	9	9
	Range of Values	9 – 60	40 – 60	9	9
Nitrogen Kjeldahl (µg/L)	Mean	316	1,057	242	194
	Range of Values	176 – 495	911 – 1,181	187 – 298	169 – 218
Total Nitrogen (µg/L)	Mean	524	1,106	245	455
	Range of Values	200 – 750	95 – 1200	190 – 300	440 – 470
Total Dissolved Nitrogen (µg/L)	Mean	749	Not Tested	267	378
	Range of Values	749	Not Tested	267	378
Ortho-phosphate as P (µg/L)	Mean	24	19	14	17
	Range of Values	1 – 40	15 – 31	14	17
Total Phosphorus as P (µg/L)	Mean	59	74	297	22
	Range of Values	32 – 83	41 – 132	270	22
Total Dissolved Phosphorus as P (µg/L)	Mean	48	58	390	16
	Range of Values	7 – 74	32 – 83	390	16

Parameter		Results per Tributary Area			
		Knickerbocker	Bear Creek	Boulder Creek	Grout Creek
Total Alkalinity (mg/L)	Mean	174.8	170.75	32	44
	Range of Values	139 – 246	169 – 174	32	44
Total Organic Carbon (mg/L)	Mean	2.65	12.03	7.02	4.85
	Range of Values	1.81 – 3.52	10.60 – 13.98	7.02	4.85
Total Suspended Solids (mg/L)	Mean	9.25	5.875	0.5	1.5
	Range of Values	1 – 36	3.5 – 10	0.5	1.5
pH	Mean	7.99	8.27	8.5	4.85
	Range of Values	7.52 – 8.27	7.79 – 8.60	8.5	4.85
Dissolved Oxygen (DO) (mg/l)	Mean	6.99	8.13	10.58	9.2
	Range of Values	0.53 – 9.82	6.92 – 10.38	10.58	9.2
Specific Conductivity (EC) (mS μ S/cm)	Mean	0.293	0.357	0.101	0.53
	Range of Values	0.011 – 0.482	0.329 – 0.385	0.101	0.53
Temperature ($^{\circ}$ C)	Mean	10.58	13.38	2.7	2.4
	Range of Values	2.6 – 22.2	7.2 – 18.4	2.7	2.4
Turbidity (ntu)	Mean	9.30	5.93	7.23	0.87
	Range of Values	4.35 – 20.20	2.68 – 10.00	7.23	0.87
Volatile Suspended Solids (mg/L)	Mean	3.3	2.125	0	2.5
	Range of Values	0.5 – 9.0	1 – 3	0	2.5

4.0 Nuisance Aquatic Plant Eradication Program

Eradication of nuisance aquatic plants conducted in accordance with Table 5-9a-c of Regional Board Resolution No. R8-2006-0023 for the Santa Ana River Basin. The results of this program are shown on the maps and charts included as Appendix C on the CD accompanying this report.