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Nutrient Concentrations in Upper and Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes and Associated Outlet Streams, California and Nevada, 2002–03

Open-File Report 2004–1333

Prepared in cooperation with
TAHOE REGIONAL PLANNING AGENCY

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by Michael S. Lico

U.S. GEOLOGICAL SURVEY

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Carson City, Nevada
2004

U.S. DEPARTMENT OF THE INTERIOR
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Multiply	By	To obtain
	Length	
meter (m)	1.094	yard (yd)
	Area	
hectare (ha)	0.003861	square mile (mi^2)
	Volume	
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)

Temperature: Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula °F = [1.8(°C)]+32. Degrees Fahrenheit can be converted to degrees Celsius by using the formula °C = 0.556(°F-32).

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25°C).

Water-quality units and related units used in this report:

mg/L	milligram per liter
μg/L	microgram per liter
μm	micrometer
μS/cm	microsiemens per centimeter

Abbreviations and acronyms:

DOP or SRP	Dissolved orthophosphorus
EWI	Equal-width increment
MDLs	Method detection limits
NH_4	Dissolved ammonia
NO_3	Dissolved nitrate (dissolved nitrate plus nitrite)
NWIS	National Water Information System
TFe or BaFe	Total bioreactive iron
TKN	Total ammonia plus organic nitrogen
TP	Total phosphorus
TRPA	Tahoe Regional Planning Agency
USGS	U.S. Geological Survey

Nutrient Concentrations in Upper and Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes and Associated Outlet Streams, California and Nevada, 2002–03

by Michael S. Lico

ABSTRACT

Five lakes and their outlet streams in the Lake Tahoe Basin were sampled for nutrients during 2002–03. The lakes and streams sampled included Upper Echo, Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes and Echo, Taylor, and Marlette Creeks. Water samples were collected to determine seasonal and spatial concentrations of dissolved nitrite plus nitrate, dissolved ammonia, total Kjeldahl nitrogen, dissolved orthophosphate, total phosphorus, and total bioreactive iron. These data will be used by Tahoe Regional Planning Agency in revising threshold values for waters within the Lake Tahoe Basin. Standard U.S. Geological Survey methods of sample collection and analysis were used and are detailed herein. Data collected during this study and summary statistics are presented in graphical and tabular form.

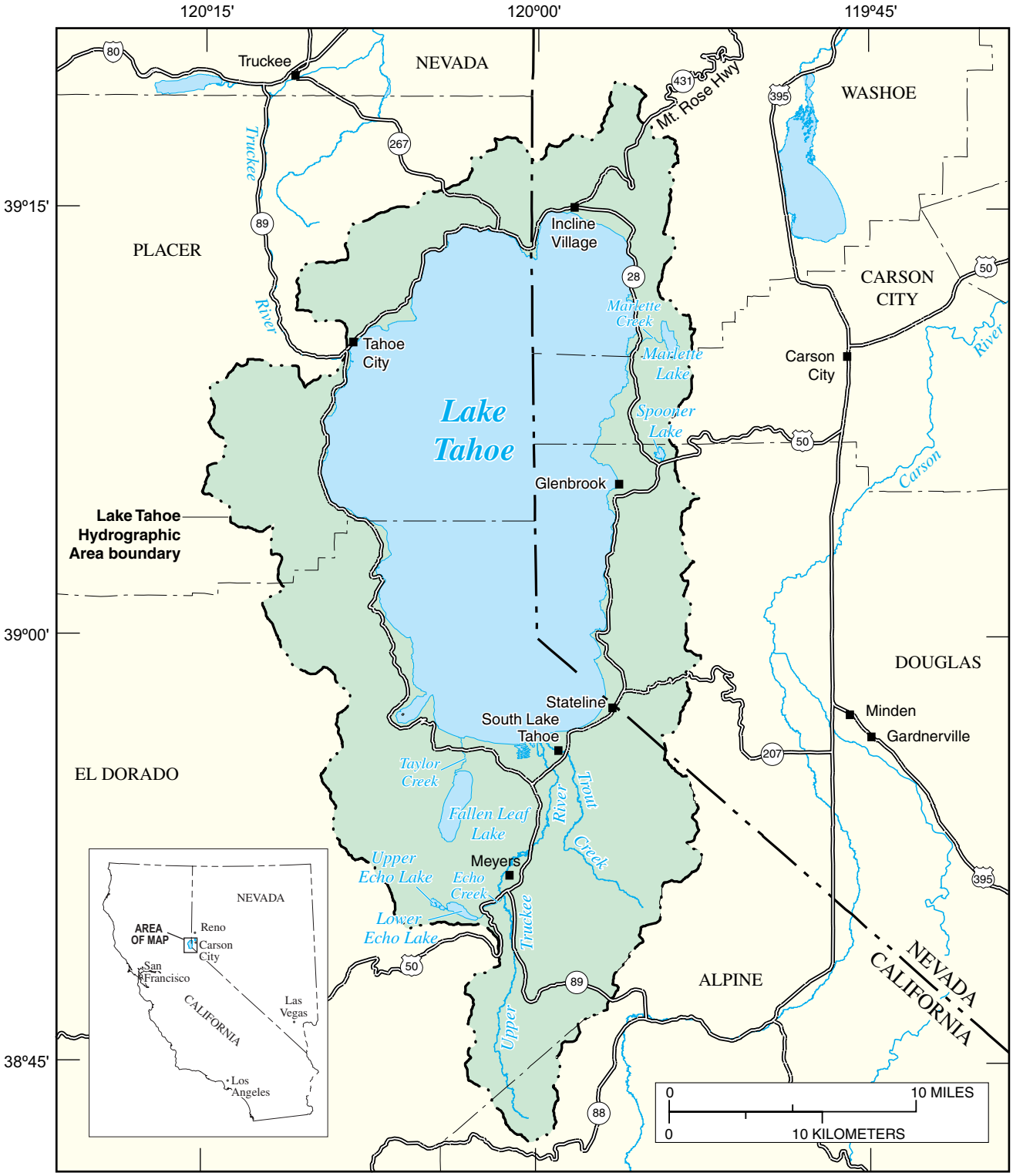
INTRODUCTION

Nutrients have been identified as a key factor in the decline in clarity of Lake Tahoe within the past few decades (Goldman and others, 1998). The control of nutrient input into Lake Tahoe is one of the major issues being addressed by many agencies in the Lake Tahoe Basin. Millions of dollars are being spent on reducing sediment and nutrient input into Lake Tahoe as a result of a Presidential initiative in 1998. In addition to Lake Tahoe, the Lake Tahoe Basin contains more than 170 other lakes and ponds that may suffer the same problems as Lake Tahoe if nutrient input is not kept in check. The total surface area of the other lakes comprises about 3 percent of Lake Tahoe's area (fig. 1; Hill, 1996).

The Tahoe Regional Planning Agency (TRPA) is tasked with the preservation, restoration, and enhancement of the unique environment of the Lake Tahoe region. Among the several areas that receive attention from TRPA is the quality of surface water in the Lake Tahoe Basin. TRPA is responsible for setting threshold values, or water-quality standards, for waters within the Lake Tahoe Basin. Threshold values for several nutrient species are currently set, but TRPA tentatively will update these values during 2005. Many of the other lakes within the Lake Tahoe Basin have very limited information regarding their water quality, including nutrient concentrations. Most of the water from these lakes eventually is discharged into Lake Tahoe via tributary streams. Many of the tributary streams have a large amount of nutrient and sediment data that have been collected during the past few decades (Rowe and others, 2002).

These lakes within the Lake Tahoe Basin have a wide variety of characteristics. They vary greatly in size, the largest being Fallen Leaf Lake (567 ha). Many of the lakes are small, shallow alpine lakes west of Lake Tahoe. Some of the lakes have enhanced storage that is used as drinking and irrigation sources, such as Lower Echo and Marlette Lakes (figs. 2*A* and *D*, respectively). The drainage basins or areas for the lakes have differing physiographic, climatic, and geologic characteristics (Smith and others, 1999). Some of the lakes, such as Upper and Lower Echo Lakes (figs. 2*A* and 3) and Fallen Leaf (fig. 2*B*), have numerous summer homes near their shores that could input nutrients to the lakes. Spooner (fig. 2*C*) and Marlette (fig. 2*D*) Lakes have no developed areas in their drainage basins. Septic systems were replaced at Fallen Leaf Lake in the 1970's with a sewer system that collects septage and exports it out of the Lake Tahoe Basin. At Upper and Lower Echo Lakes, residents are required to dispose of human waste at a central-collection facility near the dam at Lower Echo Lake. Upper and Lower Echo and Fallen Leaf Lakes have motorized-watercraft activity during the summer months, whereas Spooner and Marlette Lakes have none.

The trophic status of the five study area lakes has been described by previous investigators. Upper Echo Lake is oligo-mesotrophic (Reuter and others, 1996) and has a dominance of blue-green algae and a lack of diatoms. Lower Echo Lake is classified as oligotrophic and has minimal amounts of diatoms and much less contribution by blue-green algae (Reuter and others, 1996). Fallen Leaf Lake is described as near ultraoligotrophic by Reuter and others (1996) and has a dominance of diatoms and no blue-green algae. Spooner Lake is classified as meso-oligotrophic by Sater (1994), but she indicates that the lake could be mesoeutrophic at times, especially if the attached macrophyte community is considered. Green algae dominate the phytoplankton community in Spooner Lake with blue-green algae and diatoms present in varying numbers. The trophic level of Marlette Lake is classified as mesotrophic according to Sater (1994). The phytoplankton community is dominated by blue-green algae and diatoms.



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000, 1969–85.
Universal Transverse Mercator projection, Zone 11

Figure 1. Location of study area, Nevada and California.

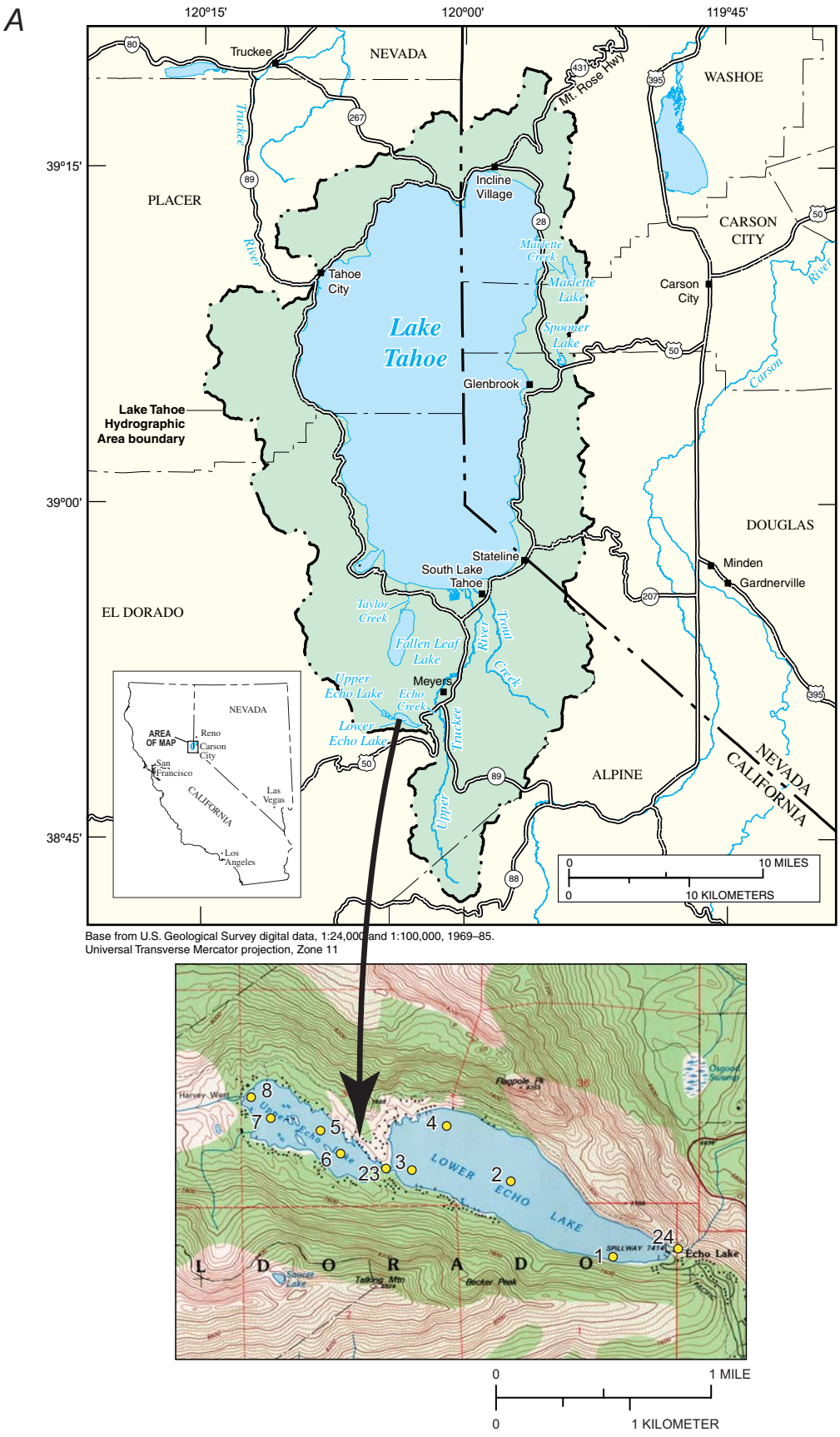


Figure 2. Location of sampling sites in: (*A*) Upper and Lower Echo Lakes, (*B*) Fallen Leaf Lake, (*C*) Spooner Lake, and (*D*) Marlette Lake.

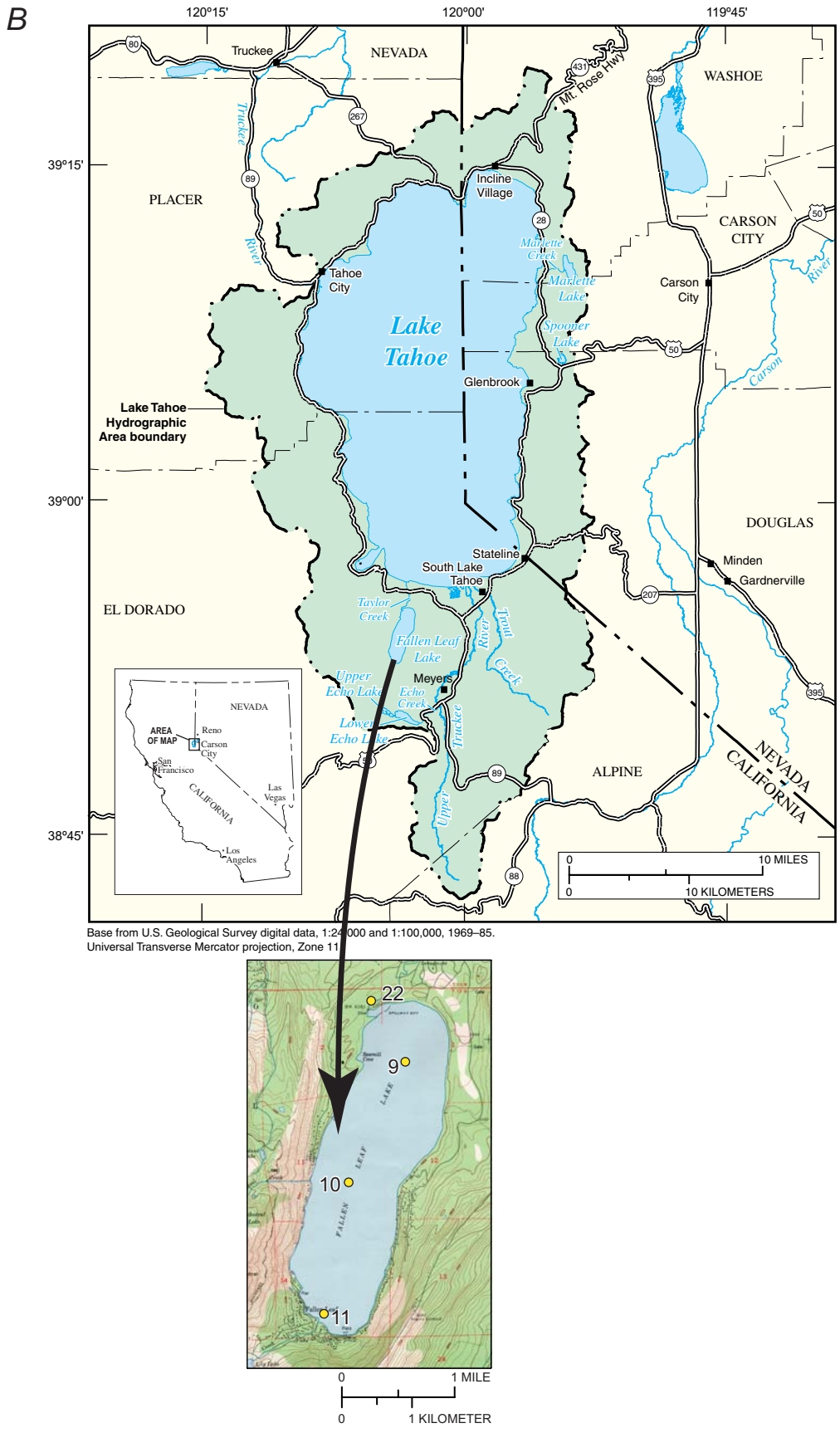


Figure 2. Location of sampling sites in: (*A*) Upper and Lower Echo Lakes, (*B*) Fallen Leaf Lake, (*C*) Spooner Lake, and (*D*) Marlette Lake—Continued.

C

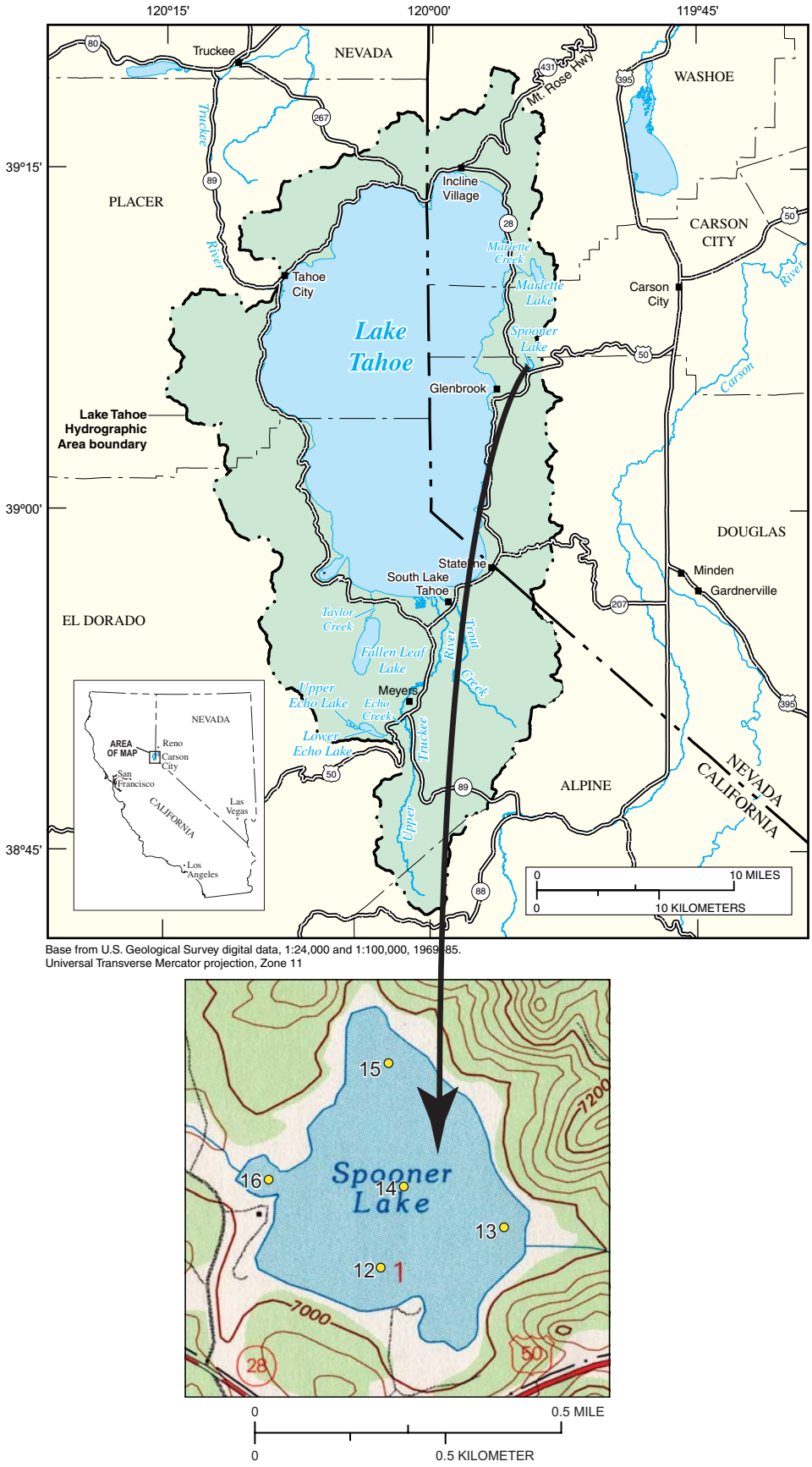


Figure 2. Location of sampling sites in: (*A*) Upper and Lower Echo Lakes, (*B*) Fallen Leaf Lake, (*C*) Spooner Lake, and (*D*) Marlette Lake—Continued.

D

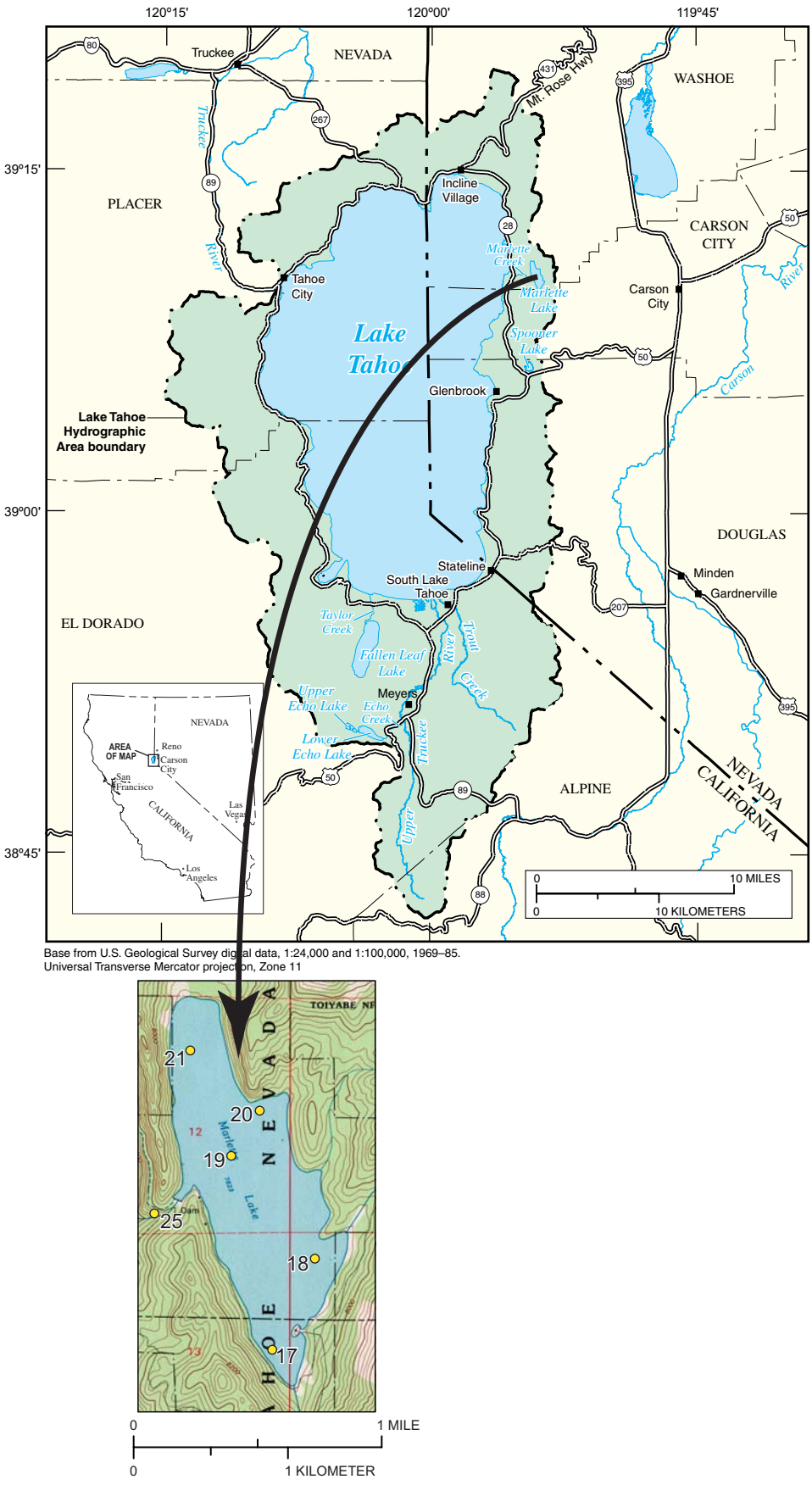


Figure 2. Location of sampling sites in: (*A*) Upper and Lower Echo Lakes, (*B*) Fallen Leaf Lake, (*C*) Spooner Lake, and (*D*) Marlette Lake—Continued.

Figure 3. Summer homes along shore of Lower Echo Lake.

Purpose and Scope

The purpose of this report is to describe water-quality and field data collected during this study. This report includes nutrient concentrations and field data collected during 2002–03 from Upper and Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes within the Lake Tahoe Basin and Echo, Taylor, and Marlette Creeks (fig. 1; table 1) that drain three of these lakes. The following nutrient data were collected: dissolved nitrate plus nitrite (NO_3), dissolved ammonia (NH_4), total ammonia plus organic nitrogen (TKN), dissolved orthophosphorus (DOP or SRP), total phosphorus (TP), and total bioreactive iron (TFe or BaFe). The following field parameters were measured in depth profiles for the lakes and at the centroid of flow in the streams: water temperature, specific conductance, dissolved oxygen, pH, and turbidity. In the lakes, water transparency was measured with a Secchi disc.

Previous Studies of Nutrient Concentrations in Lake Tahoe Basin Lakes

Few sources of nutrient data exist for the waters of Upper and Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes. Available sources include a study on Lake Tahoe Basin water quality by the State of California (1962), a study of Fallen Leaf Lake by the U.S. Geological Survey (USGS; Fuller, 1975), a nationwide study by the U.S. Environmental Protection Agency (Landers and others, 1987) that reported data for many wilderness lakes in California, a report published by University of California, Davis (UCD), one on nutrients in Spooner and Marlette Lakes (Sater, 1994) and the other on water chemistry of Upper and Lower Echo and Fallen Leaf Lakes (Reuter and others, 1996), and data collected by the USGS and published in TRPA annual water-quality reports (Hill, 1992, 1996) and a USGS Annual Data Report (Preissler and others, 1999).

Table 1. Site information for data-collection sites

[Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83)]

Site no. (see fig. 2)	Site name	Site identification no.	Latitude	Longitude
			in degrees, minutes, and seconds	
		Lake sites		
1	Lower Echo Lake, east	385005120025801	38°50′05″	120°02′58″
2	Lower Echo Lake near center	385023120032501	38°50′23″	120°03′25″
3	Lower Echo Lake, southwest	385025120035901	38°50′25″	120°03′59″
4	Lower Echo Lake, northwest	385036120034801	38°50′36″	120°03′48″
5	Upper Echo Lake near center	385035120042301	38°50′35″	120°04′23″
6	Upper Echo Lake, east	385029120042001	38°50′29″	120°04′20″
7	Upper Echo Lake, southwest	385038120044201	38°50′38″	120°04′42″
8	Upper Echo Lake near inlet	385043120044801	38°50′43″	120°04′48″
9	Fallen Leaf Lake, north	385256120040501	38°52′56″	120°04′05″
10	Fallen Leaf Lake near center	385356120035001	38°53′56″	120°03′50″
11	Fallen Leaf Lake, south	385450120032101	38°54′50″	120°03′21″
12	Spooner Lake, south	390621119543201	39°06′21″	119°54′32″
13	Spooner Lake, east	390622119542601	39°06′22″	119°54′26″
14	Spooner Lake near center	390625119542801	39°06′25″	119°54′28″
15	Spooner Lake, north	390628119542501	39°06′28″	119°54′25″
16	Spooner Lake, west	390628119544301	39°06′28″	119°54′43″
17	Marlette Lake, south	390949119535501	39°09′49″	119°53′55″
18	Marlette Lake, southeast	391010119534301	39°10′10″	119°53′43″
19	Marlette Lake near center	391033119540301	39°10′33″	119°54′03″
20	Marlette Lake, east	391043119535501	39°10′43″	119°53′55″
21	Marlette Lake, north	391056119541801	39°10′56″	119°54′18″
		Stream sites		
22	Taylor Creek near Camp Richardson, CA	10336626	38°55′18″	120°03′37″
23	Echo Lakes Channel	385026120040301	38°50′38″	120°04′10″
24	Echo Creek at outlet near Phillips, CA	103366082	38°50′07″	120°02′34″
25	Marlette Creek near Carson City, NV	10336715	39°10′20″	119°54′25″

Acknowledgments

The author thanks the Tahoe Regional Planning Agency for providing funding for this study. Field personnel who assisted in this project were: Rita Whitney (TRPA) and Jim Wood, Carl Thodal, Sienna Sager-Smith, and Dave Berger (USGS).

WATER SAMPLING METHODS

Water samples were collected during three time periods for two consecutive years near the center of each lake (fig. 2). Specifically, water samples were obtained just after ice-out in May or June (Fallen Leaf Lake does not freeze over), during mid-summer when lakes were stratified, and during the fall when the lakes had turned over. Normally, an intermediate layer of maximum temperature gradient, called the thermocline, forms between an upper layer and a lower layer called the epilimnion and hypolimnion, respectively. Samples were obtained from the epilimnion at a depth of 1 or 2 m, and when the lakes were stratified an additional sample was taken from the hypolimnion, which varied at each lake and with the season. During the summer of 2002, several sites in each lake were sampled to determine the spatial variability within the lakes.

At each lake site, field values in a vertical profile of water temperature, specific conductance, dissolved oxygen, and pH were measured with a calibrated Hydrolab multiparameter sonde. Standard USGS protocols (U.S. Geological Survey, 1997) were used in the calibration and measurements of field values in the lake profiles. Water transparency was measured in the lakes with a Secchi disc. Water samples were collected from the lakes using a 1-L all Teflon Kemmerer sampler suspended from a nylon line that was lowered from a boat. The water samples were brought on-board and composited into an 8-L churn splitter (fig. 4). Subsamples were taken from the churn for the determination of turbidity and for the whole-water analyses of nutrients (TKN, TP, and TFe). A subsample from the churn was then filtered through a 0.45-µm mixed cellulose ester membrane for the determination of filtered nutrients (NH_4, NO_3, and DOP).

Figure 4. Sample collection at Lower Echo Lake. An all-Teflon sampler was used to obtain samples from various depths in the lakes.

At each stream site, field values of water temperature, specific conductance, dissolved oxygen, and pH were measured with a calibrated Hydrolab multiparameter sonde. Standard USGS protocols (U.S. Geological Survey, 1997) were used in the calibration and measurements of field values in the streams. Stream-water samples were collected using the equal-width increment (EWI) depth-integrated method described by U.S. Geological Survey (1997) where sample points were determined by dividing the stream into equal segments across the channel. Depth-integrated samples were then taken at the center of these segments with a hand sampler fitted with a Teflon nozzle and bottle and composited into an 8-L polyethylene churn splitter. When streamflow was inadequate to use the EWI method, samples were obtained at the centroid of flow by dipping a 1-L wide-mouthed Teflon bottle into the stream. Subsamples were drawn from the churn splitter in the same manner as those for the lake samples. Turbidity was measured on a subsample drawn from the churn splitter. Field methods for the collection of water samples closely followed those outlined by the USGS (1997).

LABORATORY ANALYSES

Water samples were analyzed at the University of California at Davis, Tahoe Research Group Limnology Laboratory in Davis, California. NH_4 was determined by the indenophenol colorimetric method described by Brzezinski (1987). NO_3 was determined by the Hydrazine method reported by Kempers and Luft (1988) where NO_3 is reduced to nitrite by a hydrazine-copper solution and the subsequent color measured by a spectrophotometer. However, the analysis of NO_3 was changed to a new method in May 2003. The new method consists of a colorimetric determination of NO_3 concentrations by the Hydrazine method with the addition of sodium pyrophosphate to reduce interferences by calcium and magnesium (Kamphake and others, 1967; Strickland and Parsons, 1972). Both analytical methods for NO_3 were used after May 2003, but only the results of the older method are used in the statistical summaries reported in this document. TKN was quantified using a method described by Fishman and Friedman (1985). The colorimetric phosphomolybdate method of Murphy and Riley (1962) and Eaton and others (1995) was used to determine DOP by complexation with an antimony-molybdenum solution. TP was determined by the same method as DOP with the addition of a digestion of the sample with persulfate prior to complexation (Fishman and Friedman, 1985). TFe was determined using a method described by Stookey (1970), which employs the use of colored complex that is measured by a spectrophotometer. Method detection limits (MDLs) for the above described methods are listed in table 2.

Table 2. Method detection limits for analytes listed in this report

[Analyses were performed at the University of California, Davis Limnology Laboratory in Davis, CA. Abbreviation: MDL, method detection limit]

Analyte	MDL[a] (µg/L)
Ammonia nitrogen	3.0 as N
Nitrate plus nitrite nitrogen	2.0 as N
Organic plus ammonia nitrogen (Kjeldahl nitrogen)	35 as N
Orthophosphate (soluble reactive phosphorus)	1.0 as P
Total phosphorus	2.0 as P
Bioreactive iron	3.0 as Fe

[a]Method detection limit: Minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is greater than zero (Childress and others, 1999).

RESULTS

Data collected during this study represent those conditions that existed at the time of sample collection and do not necessarily represent conditions at other times. Profile data collected at each lake site during sample collection are shown at back of report in figure 5 and listed in appendix A. Field data (transparency, turbidity, barometric pressure, and air temperature) are included in appendix B along with the analytical results for nutrients. Appendix C lists all data collected in the field and the nutrient concentrations for samples from the streams. Appendix D reports values for NO_3 determined on samples collected after May 2003 using the newly adopted Hydrazine method with sodium pyrophosphate addition (see Laboratory Analyses section).

Listed in table 3 are the median concentration values for all nutrient analytes, the number of samples, the range of concentrations, and the median values and ranges of concentrations for the epilimnion and hypolimnion of each lake. Also listed in table 3 are median values, number of samples, and ranges for nutrient concentrations in water samples collected from the streams. For comparative purposes, a summary of available data from previous investigations at these lakes is listed in table 4.

Boxplots are a useful way of showing the basic distribution characteristics of data. They display percentiles (typically the 10^{th}, 25^{th}, 50^{th} (median), 75^{th}, and 90^{th}) and allow a graphical method to easily compare two or more sets of data. Boxplots for nutrient concentration data collected during this study are shown in figure 6, at back of report, for lake samples. Samples collected from the streams were not of sufficient numbers to show the basic distribution characteristics of data; thus, the plots for stream nutrient data show the actual values for the three streams (fig. 7 at back of report).

NO_3 concentrations generally were low in lake samples and median values were less than 6 µg/L as N in all lakes. Upper Echo Lake had the highest median NO_3 concentration of all five lakes, but Fallen Leaf Lake had the highest concentration (47.4 µg/L as N) observed during this study (table 3). Concentrations of NO_3 generally were slightly lower in the epilimnion than the hypolimnion, except in Lower Echo Lake. The streams generally had higher concentrations of NO_3 than did the lakes (figs. 6*A* and 7*A*) with median concentrations ranging from 8.9 to 37.7 µg/L as N. The maximum NO_3 concentration was found in a sample from Marlette Creek (71.8 µg/L as N).

Median dissolved NH_4 concentrations in lake samples range from 5.6 to 8.1 µg/L as N (table 3). Marlette Lake had the highest median NH_4 concentration (8.1 µg/L as N) and the highest single observed concentration (28.8 µg/L as N). The epilimnion of Upper and Lower Echo Lakes had a higher median NH_4 concentration than their respective concentrations in the hypolimnion (table 3). Fallen Leaf, Spooner, and Marlette Lakes had higher median NH_4 concentrations in samples from the hypolimnion than those from the epilimnion. Median NH_4 concentrations in streams ranged from 5.2 to 7.8 µg/L as N.

Table 3. Number of samples and median and range of concentrations of nutrient species in Lower and Upper Echo, Fallen Leaf, Spooner, and Marlette Lakes and Echo, Taylor, and Marlette Creeks

[Symbol: <, less than. For each site and constituent, the top number is the median value and the bottom numbers are the ranges of concentrations at that site; concentrations are expressed as micrograms per liter as N, P, or Fe]

Site name (see fig. 2)	Data type	Number of samples	Dissolved nitrate[a]	Dissolved ammonia	Total Kjeldahl nitrogen	Dissolved orthophosphate	Total phosphorus	Total bioreactive iron
Lower Echo Lake	all data	17	4.8	5.6	108	<1.0	4.5	19.3
(sites 1–4)			2.0–16.0	<3.0–18.8	75–202	<1.0–2.6	2.6–5.8	13.4–38.8
	epilimnion	9	5.6	6.6	96	<1.0	4.2	17.0
			3.8–16.0	<3.0–18.8	75–144	<1.0–2.6	2.6–5.8	13.4–33.7
	hypolimnion	8	4.1	3.3	122	<1.0	4.5	29.5
			2.0–10.4	<3.0–8.9	80–202	<1.0–2.1	4.1–5.8	18.7–38.8
Upper Echo Lake	all data	15	5.6	[b]6.1	[b]116	<1.0	5.4	33.4
(sites 5–8)			3.5–39.9	<3.0–9.3	56–359	<1.0–1.7	4.0–7.5	20.5–200.7
	epilimnion	8	5.3	7.5	108	<1.0	5.0	32.6
			3.5–39.9	<3.0–9.3	56–165	<1.0–1.5	4.6–5.7	20.5–63.2
	hypolimnion	7	6.0	[c]5.2	[c]130	<1.0	6.0	42.2
			3.5–34.5	<3.0–9.3	70–359	<1.0–1.7	4.0–7.5	20.9–200.7
Fallen Leaf Lake	all data	16	4.0	6.2	73	<1.0	3.8	[d]8.5
(sites 9–11)			3.1–47.4	<3.0–13.7	<35–254	<1.0–1.4	2.1–7.6	6.1–34.7
	epilimnion	8	3.5	5.2	73	<1.0	3.5	8.9
			3.1–47.4	<3.0–11.7	38–254	<1.0–1.2	2.1–5.4	6.1–31.6
	hypolimnion	8	4.4	6.2	70	<1.0	4.0	[e]7.5
			3.6–7.7	3.2–13.7	<35–170	<1.0–1.4	2.8–7.6	6.1–34.7
Spooner Lake	all data	16	5.0	5.6	[b]548	<1.0	18.5	[d]150
(sites 12–16)			<2.0–24.1	<3.0–14.7	120–892	<1.0–3.0	13.6–60.4	17.9–7,436
	epilimnion	11	4.2	5.2	[f]465	<1.0	18.1	150
			<2.0–8.4	<3.0–14.7	120–816	<1.0–3.0	13.6–60.4	17.9–995.2
	hypolimnion	5	6.2	5.8	618	<1.0	29.4	[g]873
			<2.0–24.1	<3.0–13.5	452–892	<1.0–1.2	17.2–39.5	48.2–7,436
Marlette Lake	all data	17	5.0	8.1	[d]254	<1.0	10.8	56.4
(sites 17–21)			3.3–9.5	<3.0–28.8	87–376	<1.0–1.2	5.5–20.5	42.5–366.6
	epilimnion	11	4.8	7.1	[h]200	<1.0	6.4	49.3
			3.3–7.3	<3.0–16.9	87–376	<1.0–1.0	5.5–14.3	42.5–299.2
	hypolimnion	6	5.9	12.0	[i]280	<1.0	14.6	145

Table 3. Number of samples and median and range of concentrations of nutrient species in Lower and Upper Echo, Fallen Leaf, Spooner, and Marlette Lakes and Echo, Taylor, and Marlette Creeks—Continued

[Symbol: <, less than. For each site and constituent, the top number is the median value and the bottom numbers are the ranges of concentrations at that site; concentrations are expressed as micrograms per liter as N, P, or Fe]

Site name (see fig. 2)	Data type	Number of samples	Dissolved nitrate[a]	Dissolved ammonia	Total Kjeldahl nitrogen	Dissolved orthophosphate	Total phosphorus	Total bioreactive iron
			4.0–9.5	<3.0–28.8	243–373	<1.0–1.2	10.8–20.5	56.4–366.6
Echo Creek (site 23)		8	8.9	5.2	116	1.0	6.9	42.7
			2.3–13.7	<3.0–16.1	86–192	<1.0–2.0	3.1–13.2	17.0–96.4
Taylor Creek (site 22)		7	9.7	7.8	80	<1.0	6.0	27.4
			2.4–29.7	<3.0–98.7	44–264	<1.0–14.1	3.7–29.5	16.4–75.5
Marlette Creek (site 25)		7	37.7	5.4	261	2.9	19.3	284.0
			14.5–71.8	<3.0–13.5	117–1,580	1.9–4.7	8.2–77.8	68.6–2,247
All lake samples		81	4.8	6.1	120	<1.0	5.5	33.7
			<2.0–47.4	<3.0–28.8	<35–892	<1.0–3.0	2.1–60.4	6.1–7,436
All stream samples		22	11.0	5.4	120	1.9	8.6	72.4
			2.3–71.8	<3.0–98.7	44–1,580	<1.0–14.1	3.1–77.8	16.4–2,247

[a]Nitrate results include all oxidized forms of nitrogen (nitrate plus nitrite) as determined by the hydrazine method.

[b]Median values are those of a reduced number of samples: 14 samples.

[c]Median values are those of a reduced number of samples: 6 samples.

[d]Median values are those of a reduced number of samples: 15 samples.

[e]Median values are those of a reduced number of samples: 7 samples.

[f]Median values are those of a reduced number of samples: 9 samples.

[g]Median values are those of a reduced number of samples: 4 samples.

[h]Median values are those of a reduced number of samples: 10 samples.

[i]Median values are those of a reduced number of samples: 5 samples.

Table 4. Median nutrient concentrations for samples collected from Lower and Upper Echo, Fallen Leaf, Spooner, and Marlette Lakes from previous studies and this study

[Abbreviations: e, epilimnion; h, hypolimnion; TRPA, Tahoe Research Planning Agency; USGS, U.S. Geological Survey; --, placeholder; <, less than. Reported nitrate concentrations are the sum of nitrate and nitrite]

Year(s) data collected:	1974–75	1991–92	1991–92	1994	1997–98	2002–03
Reference:	Fuller (1975)	Sater (1994)	USGS[a]	TRPA[b]	USGS[c]	in this report
Lower Echo Lake:						
Nitrate (µg/L as N)	--	--	3	1	2.9	4.8
Ammonia (µg/L as N)	--	--	3.5	5.5	1.5	5.6
Total Kjeldahl nitrogen (µg/L as N)	--	--	118	122	74	108
Orthophosphate (µg/L as P)	--	--	1	1	--	<1
Total phosphorus (µg/L as P)	--	--	6	6	--	4.5
Bioreactive iron (µg/L as Fe)	--	--	26	--	21	19.3
Upper Echo Lake:						
Nitrate (µg/L as N)	--	--	3	1	--	5.6
Ammonia (µg/L as N)	--	--	6.5	5	--	6.1
Total Kjeldahl nitrogen (µg/L as N)	--	--	112	143	--	116
Orthophosphate (µg/L as P)	--	--	1.5	1	--	<1
Total phosphorus (µg/L as P)	--	--	6	9	--	5.4
Bioreactive iron (µg/L as Fe)	--	--	33	--	--	33.4
Fallen Leaf Lake:						
Nitrate (µg/L as N)	1.5	--	2	1	2.9	4
Ammonia (µg/L as N)	5	--	4	5	3.2	6.2
Total Kjeldahl nitrogen (µg/L as N)	530(h), 90(e)	--	76	76	190	73
Orthophosphate (µg/L as P)	2(h), 3(e)	--	2	1	--	<1
Total phosphorus (µg/L as P)	9(h), 9(e)	--	8	5	--	3.8
Bioreactive iron (µg/L as Fe)	[3]20	--	6	--	21	8.5
Spooner Lake:						
Nitrate (µg/L as N)	--	3	3	--	--	5
Ammonia (µg/L as N)	--	6	11.5	--	--	5.6
Total Kjeldahl nitrogen (µg/L as N)	--	644	494	--	--	548
Orthophosphate (µg/L as P)	--	5	2.5	--	--	<1
Total phosphorus (µg/L as P)	--	21	17	--	--	18.5
Bioreactive iron (µg/L as Fe)	--	90	100	--	--	150
Marlette Lake:						
Nitrate (µg/L as N)	--	4	64	--	3.8	5
Ammonia (µg/L as N)	--	16	52	--	11	8.1
Total Kjeldahl nitrogen (µg/L as N)	--	420	344	--	217	254
Orthophosphate (µg/L as P)	--	7	3.5	--	11	<1
Total phosphorus (µg/L as P)	--	14	20	--	27	10.8
Bioreactive iron (µg/L as Fe)	--	190	96	--	155	56.4

[a]Hill (1992).

[b]Reuter and others (1996).

[c]U.S. Geological Survey (2004).

Taylor Creek had the highest median and the highest observed ammonia concentration (98.7 µg/L as N) found during this study. The high concentration of ammonia in the sample from Taylor Creek was taken during the annual die-off of kokanee salmon, which may have contributed to the high concentration.

TKN concentrations generally were low in Upper and Lower Echo and Fallen Leaf Lakes (median concentration ranges from 73 to 116 µg/L as N). Spooner and Marlette Lakes had higher median concentrations of 548 and 254 µg/L as N, respectively. The maximum measured TKN concentration was 892 µg/L as N in a sample from Spooner Lake. The median TKN concentration in the hypolimnion was higher than that in the epilimnion in all lakes except for Fallen Leaf Lake (table 3). Median concentrations of TKN in samples from the streams ranged from 80 to 261 µg/L as N, with Marlette Creek having the highest median.

DOP concentrations were low in all lake samples. Median concentration for all lakes was less than 1.0 µg/L as P, with Spooner Lake having the highest measured concentration of 3.0 µg/L as P (table 3). The median DOP concentrations in the hypolimnion and the epilimnion had no difference. Streams generally had DOP concentrations slightly greater than the lakes with medians ranging from less than 1.0 to 2.9 µg/L as P. The highest measured DOP concentration was in a sample from Taylor Creek (14.1 µg/L as P).

TP concentrations were less than 8 µg/L as P in all samples from Upper and Lower Echo and Fallen Leaf Lakes. Median concentrations at these three lakes were between 3.8 and 5.4 µg/L as P (table 3). Much higher concentrations of TP were found in Spooner and Marlette Lakes, with median values of 18.5 and 10.8 µg/L as P, respectively. Median TP concentrations were slightly higher in the hypolimnion than in the epilimnion for Upper and Lower Echo and Fallen Leaf Lakes. For Spooner and Marlette Lakes, the median concentration of TP in the hypolimnion was about twice that of the epilimnion (table 3). Median concentrations of TP in stream samples were slightly higher than those for the lakes and ranged from 6.0 to 19.3 µg/L as P. Marlette Creek had the highest observed concentration of TP in a stream sample (77.8 µg/L as P).

TFe concentrations generally were low in Upper and Lower Echo and Fallen Leaf Lakes with median concentrations ranging from 8.5 to 33.4 µg/L (table 3; app. B). Spooner and Marlette Lakes had TFe concentrations that generally were higher than those at the other lakes. Median concentrations of TFe in Spooner and Marlette Lakes were 150 and 56.4 µg/L, respectively. Some relatively high concentrations (995.2 and 7,436 µg/L) were found in samples from Spooner Lake. Median concentrations of TFe in the hypolimnion of all lakes, except Fallen Leaf Lake, were greater than those from the epilimnion. TFe concentrations were low in the streams on the west side of Lake Tahoe (Echo and Taylor Creeks) with medians of 42.7 and 27.4 µg/L, respectively. Marlette Creek had the highest median TFe concentration (284 µg/L) of any stream and had a maximum observed concentration of 2,247 µg/L (table 3; app. C).

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Figures 5–7

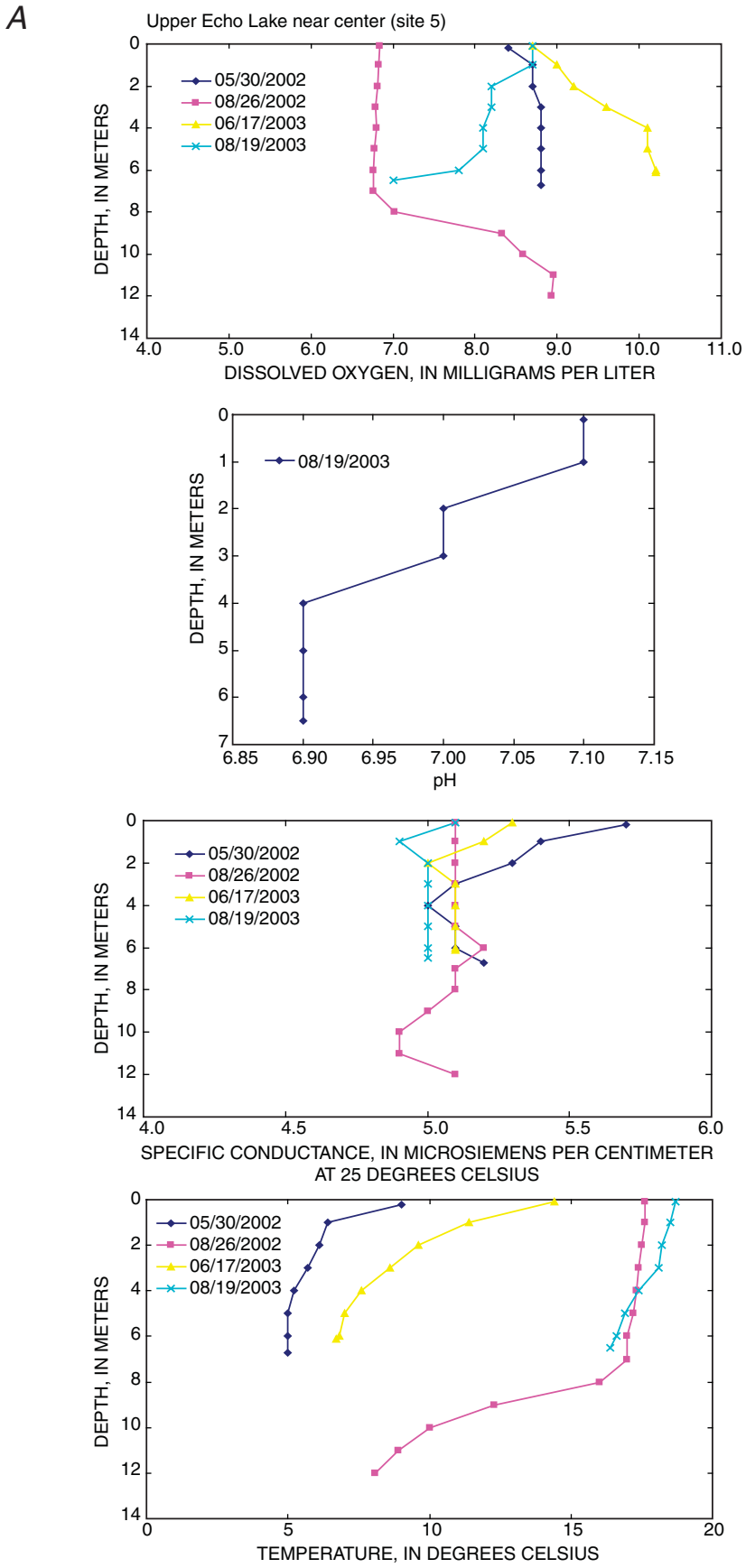
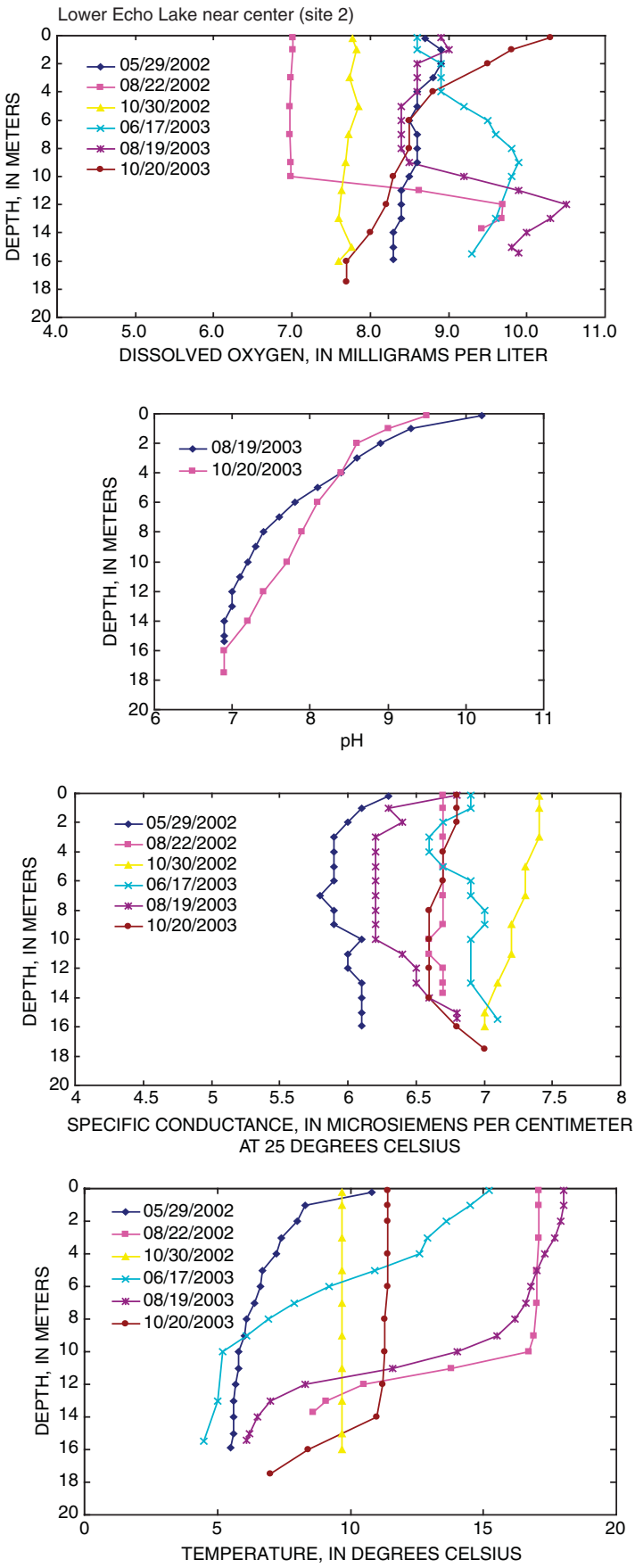


Figure 5. Profiles of field measurements taken in (*A*) Upper Echo Lake near center (site 5), (*B*) Lower Echo Lake near center (site 2), (*C*) Fallen Leaf Lake near center (site 10), (*D*) Spooner Lake near center (site 14), and (*E*) Marlette Lake near center (site 19).

B



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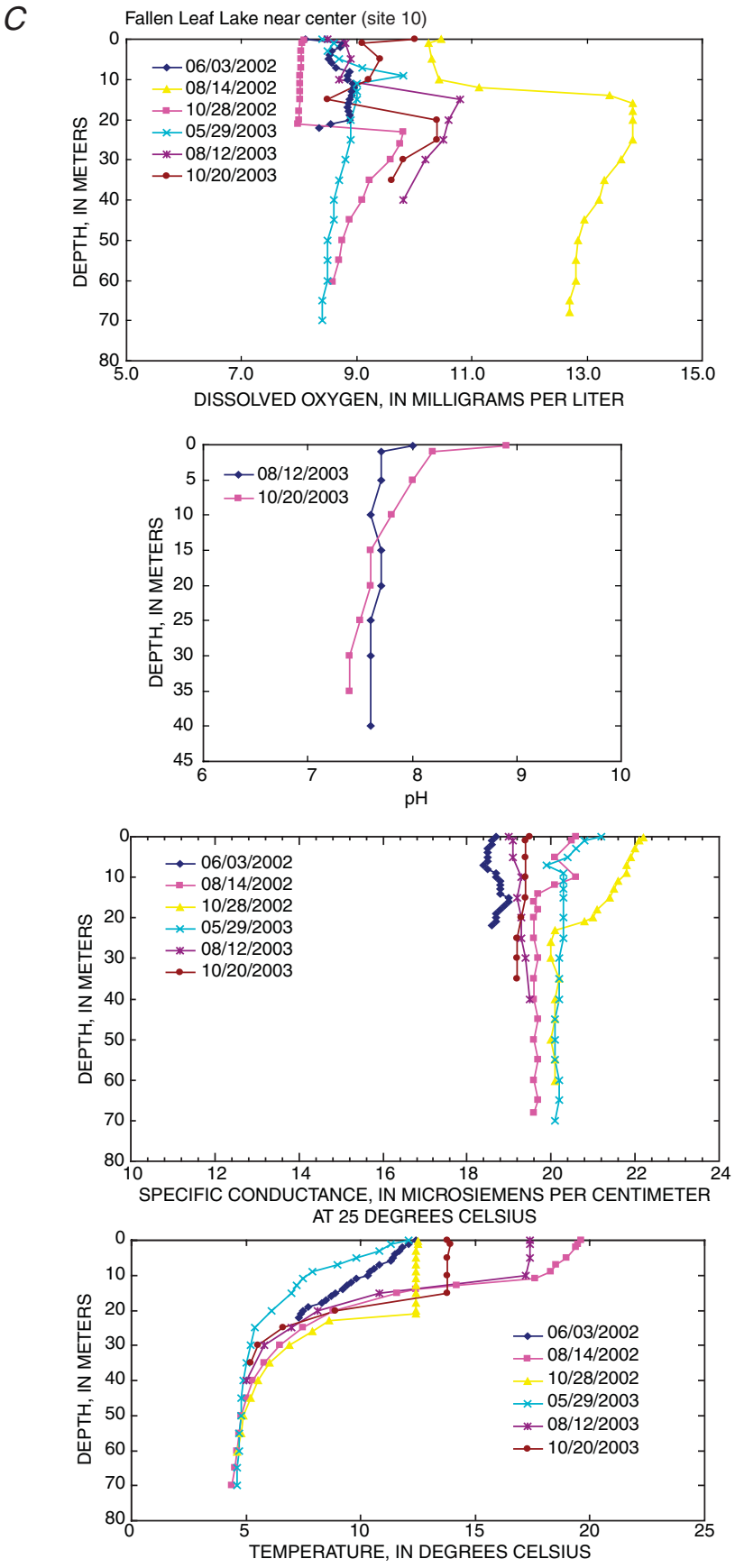

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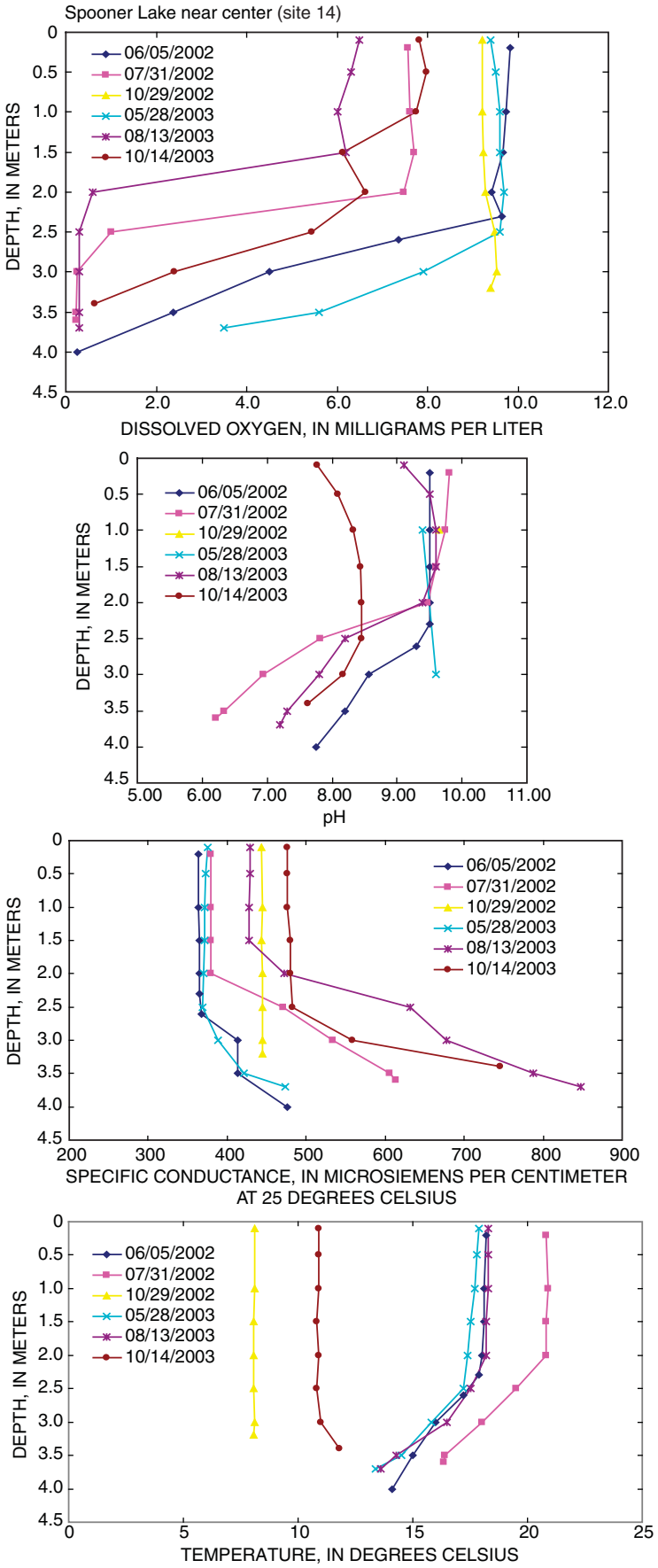
D



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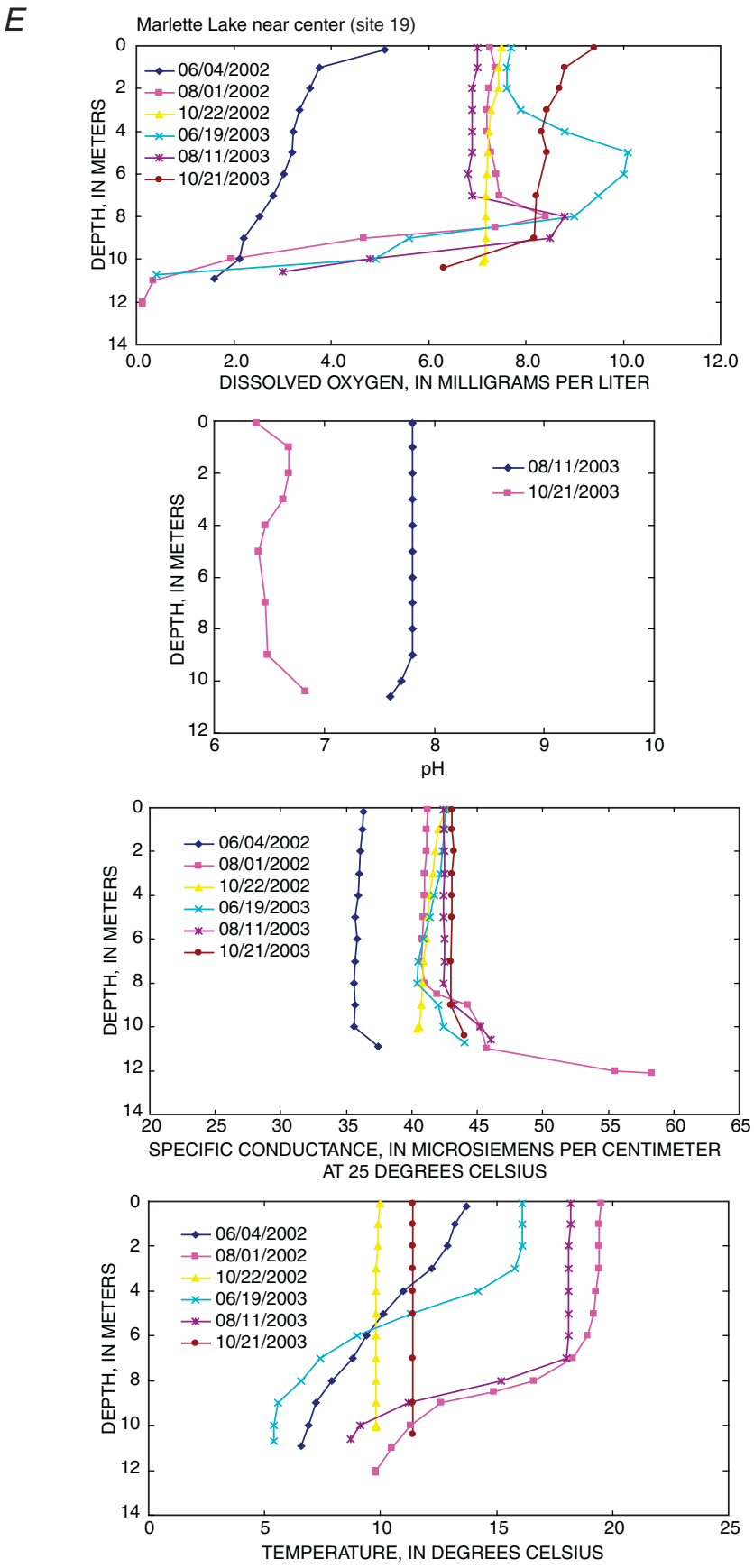

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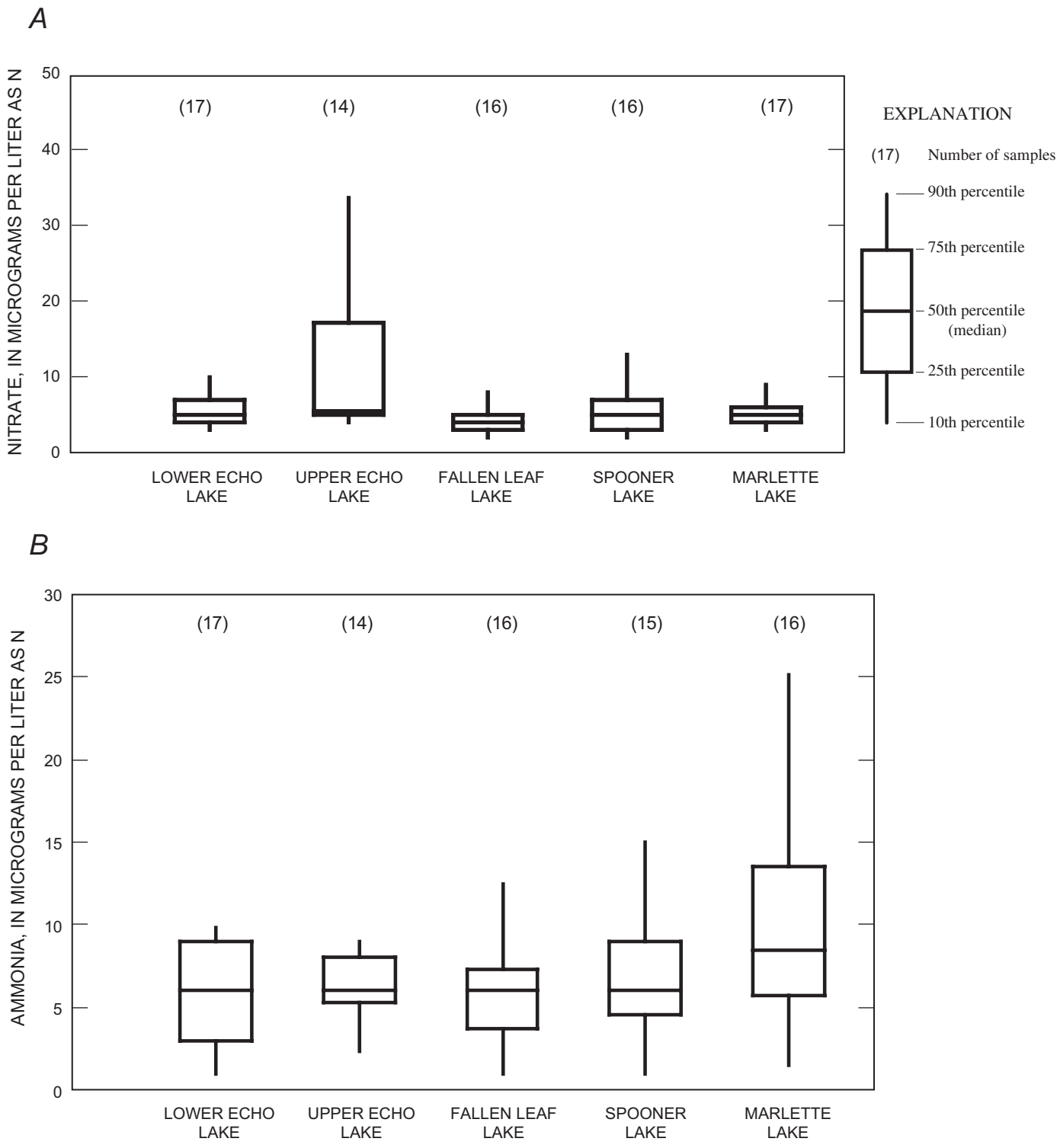
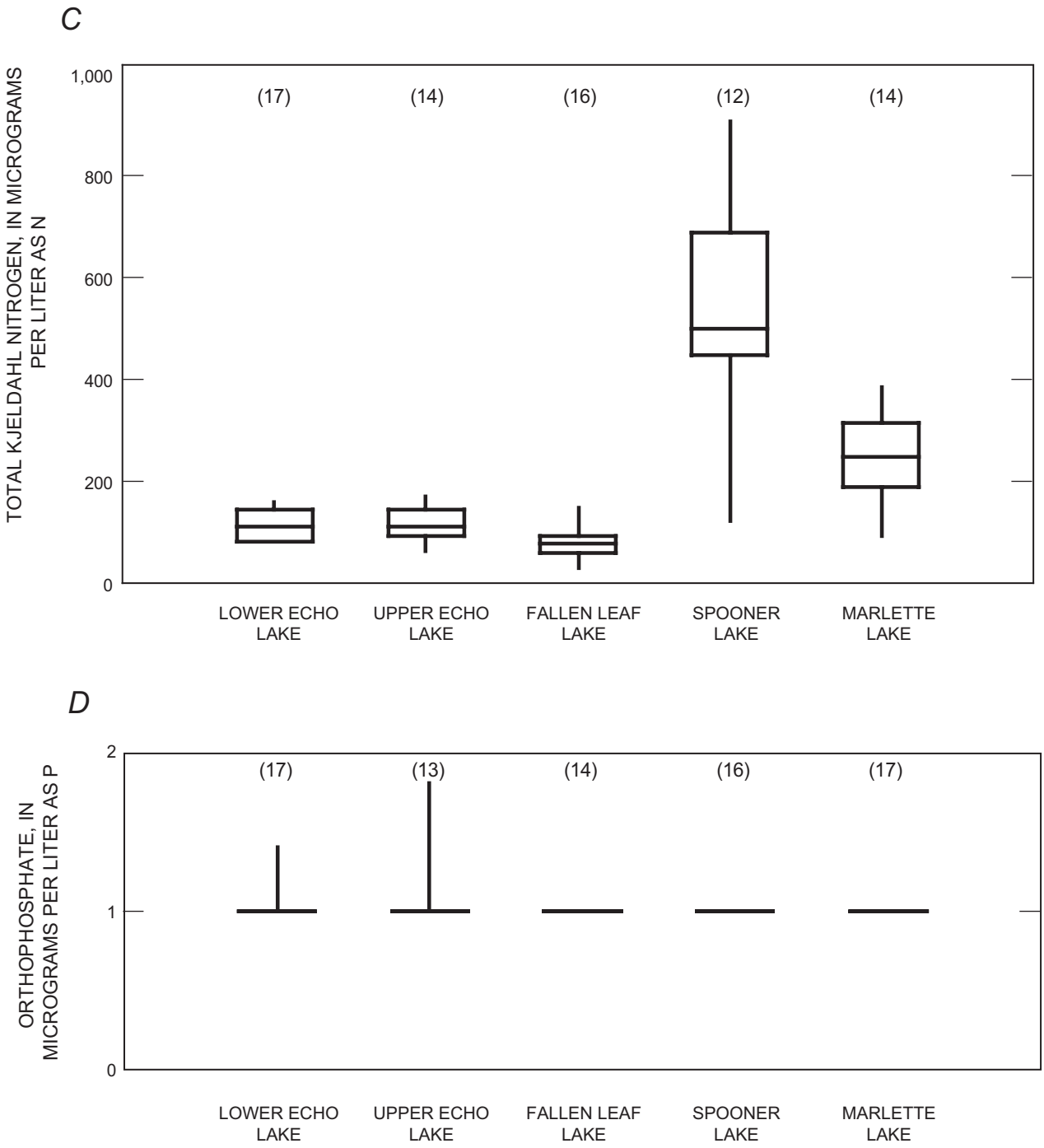


Figure 6. Distribution of nutrient data from Upper and Lower Echo, Fallen Leaf, Spooner, and Marlette Lakes: (*A*) dissolved nitrate (sum of nitrate plus nitrite), (*B*) dissolved ammonia, (*C*) total Kjeldahl nitrogen (ammonia plus organic nitrogen), (*D*) dissolved orthophosphorus (soluble reactive phosphorus), (*E*) total phosphorus, and (*F*) total bioreactive iron.



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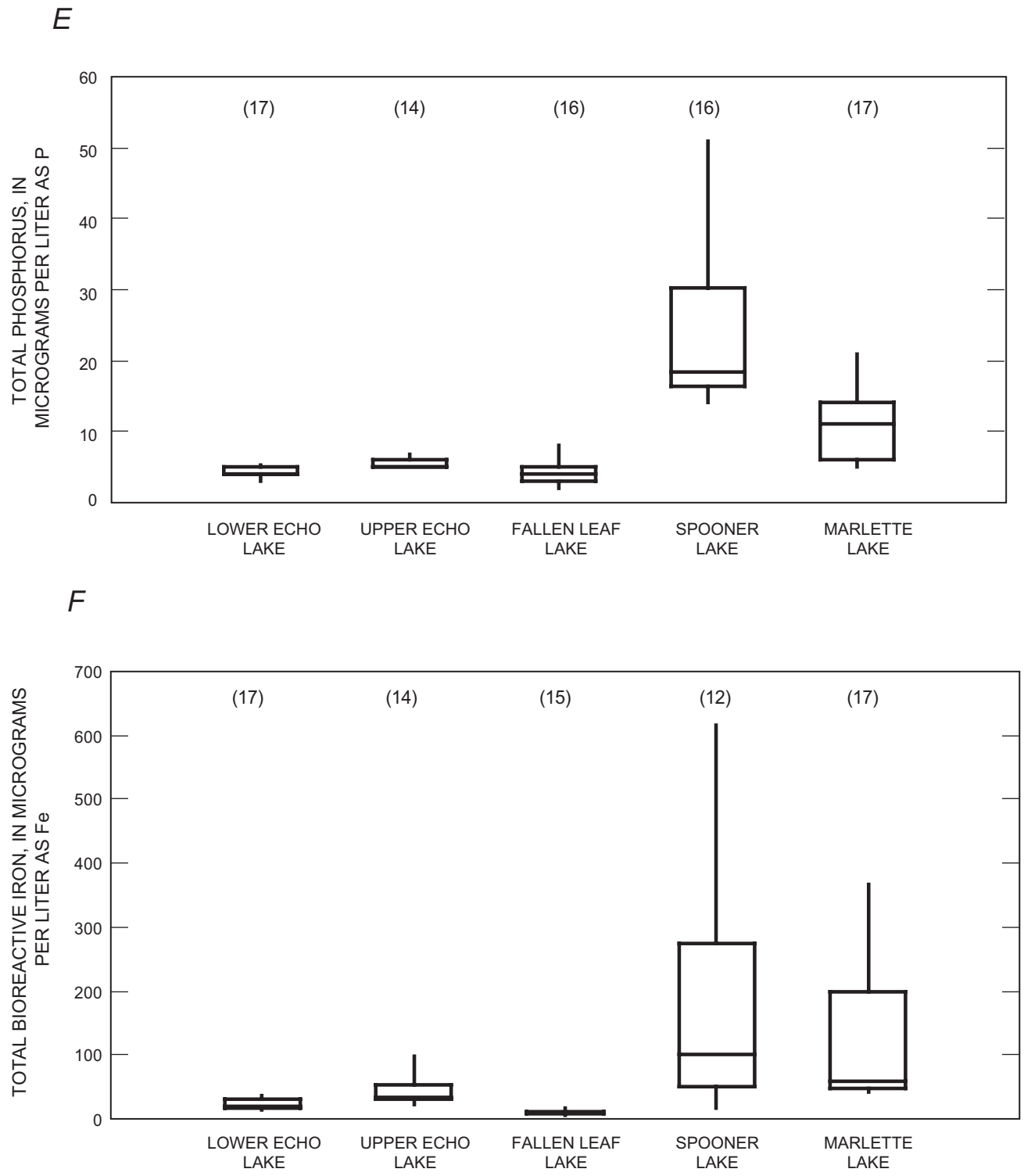

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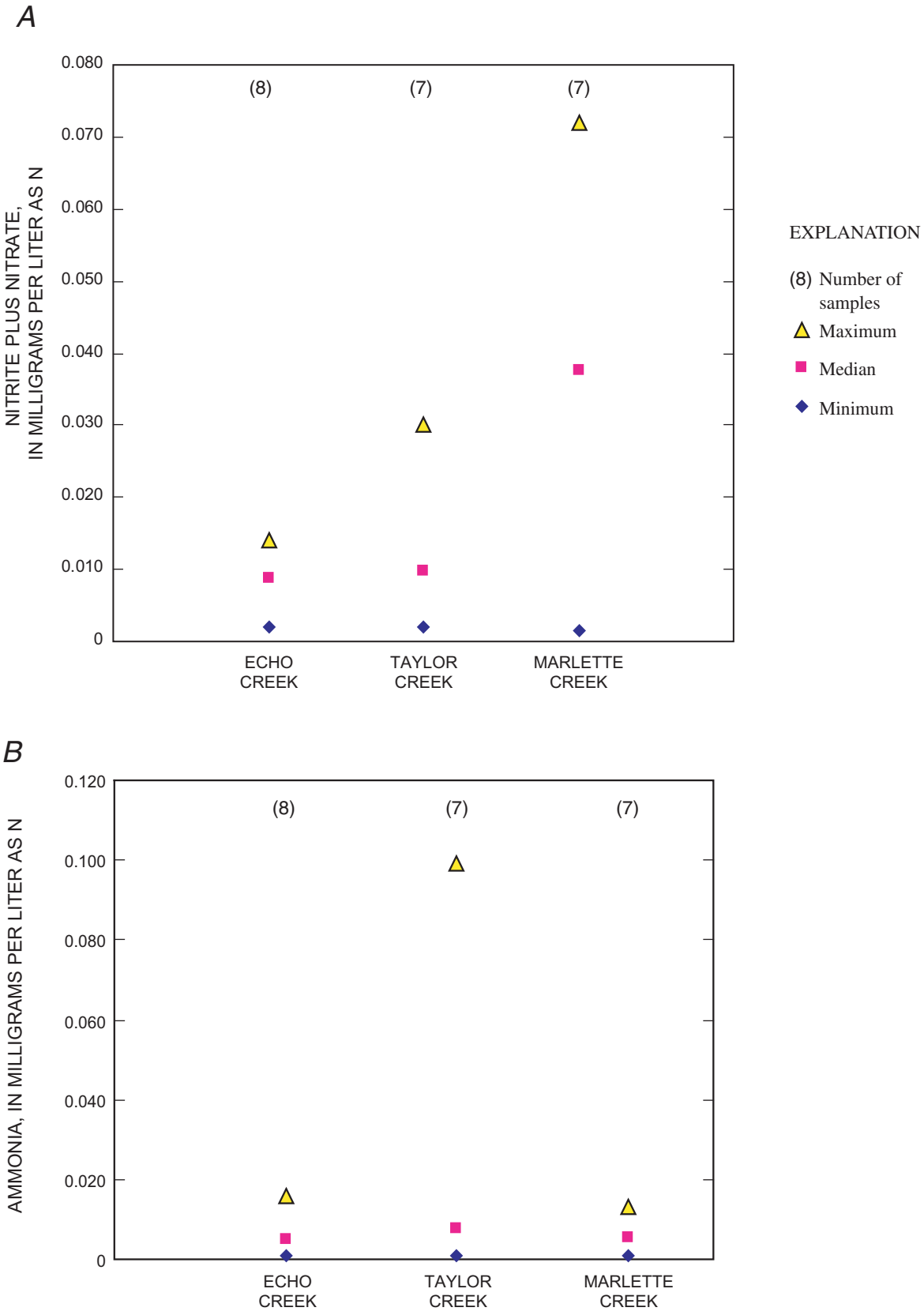
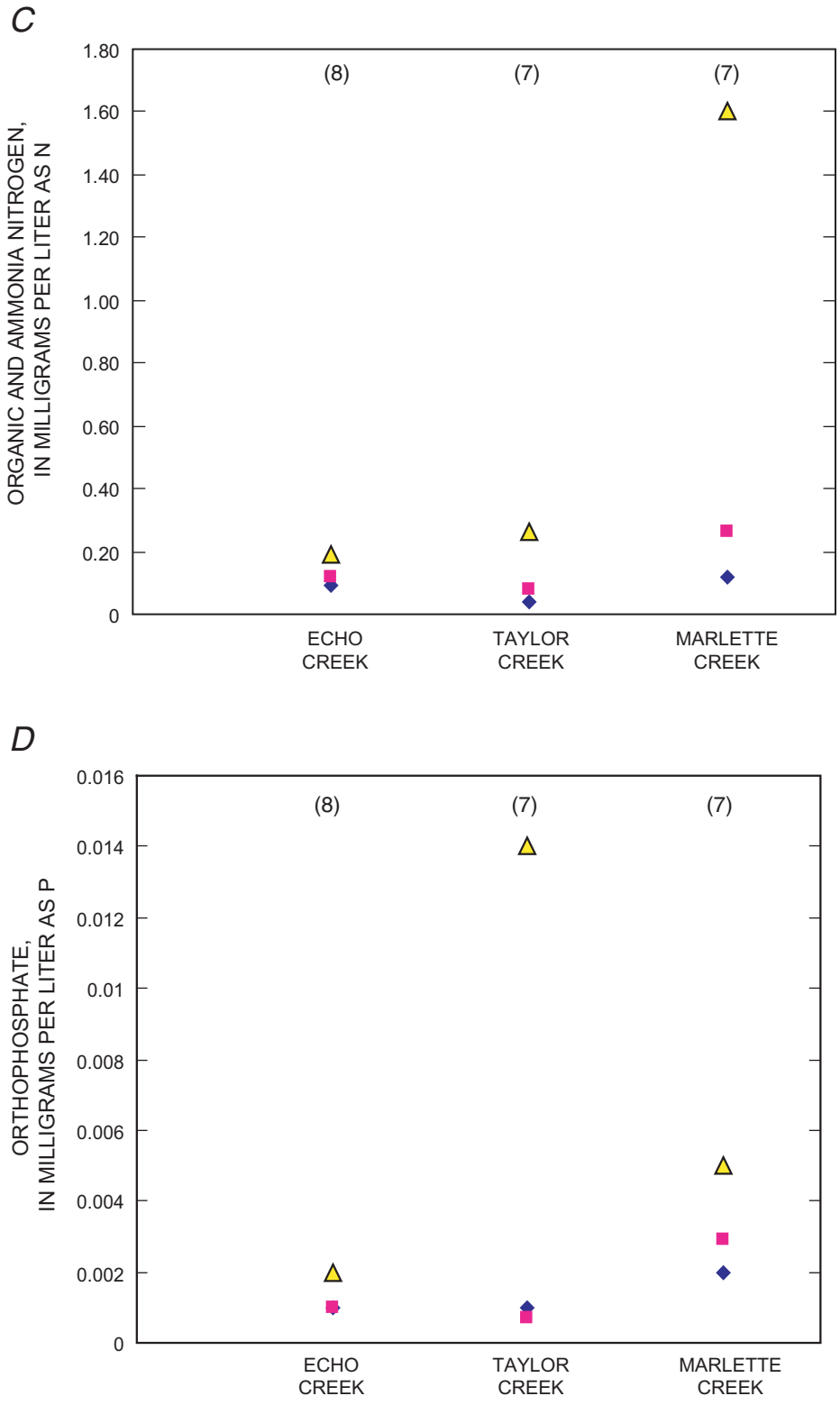


Figure 7. Concentrations of nutrients in samples from Echo, Taylor, and Marlette Creeks: (*A*) dissolved nitrate (sum of nitrate plus nitrite), (*B*) dissolved ammonia, (*C*) total Kjeldahl nitrogen (ammonia plus organic nitrogen), (*D*) dissolved orthophosphorus (soluble reactive phosphorus), (*E*) total phosphorus, and (*F*) total bioreactive iron.



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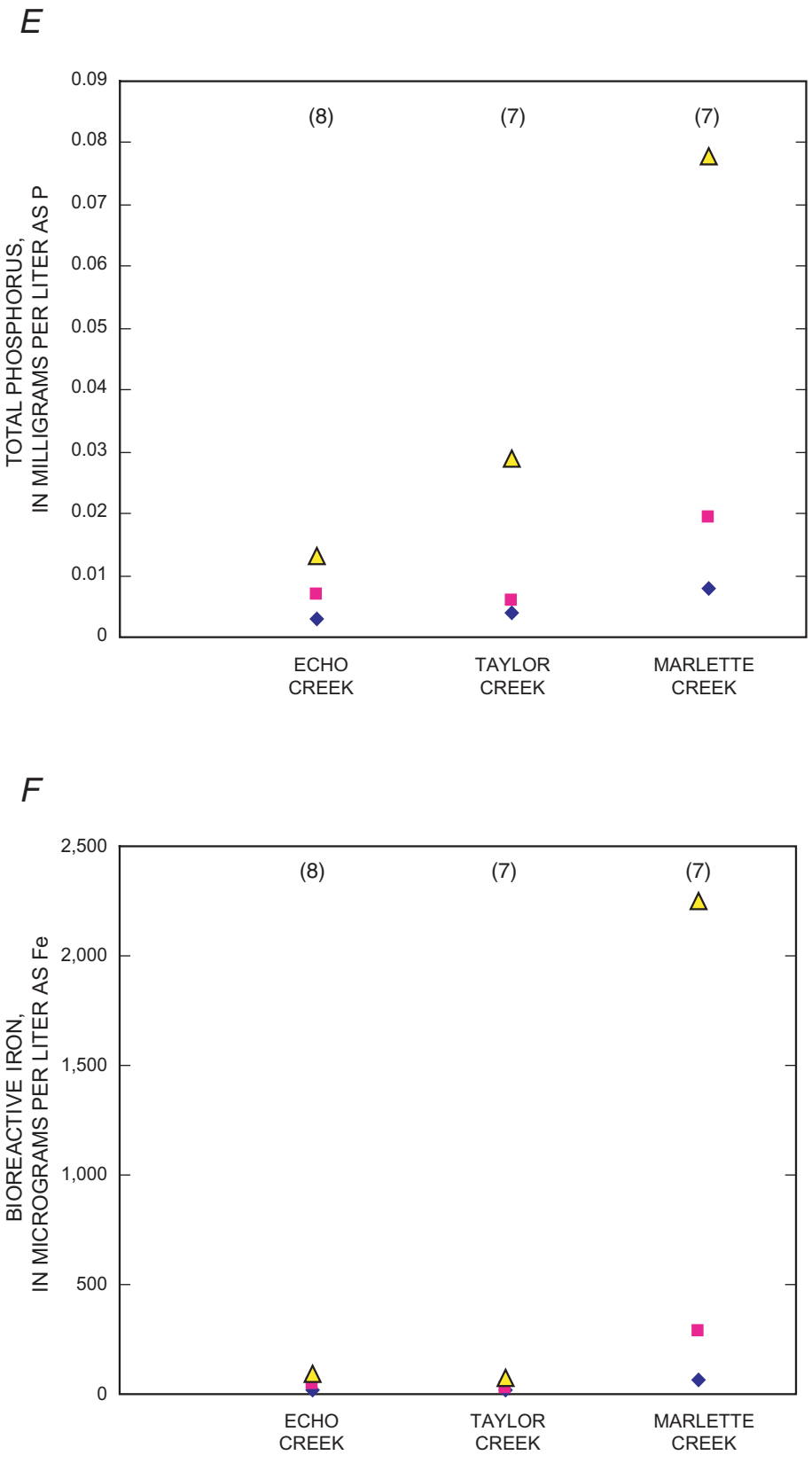

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APPENDIXES

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
1	Lower Echo Lake, east	20020822	1225	0.1	17.6	6.5	7.3		
			1226	1.0	17.6	6.5	7.2		
			1228	2.0	17.6	6.5	7.1		
			1229	4.0	17.5	6.5	7.1		
			1230	6.0	17.1	6.5	7.1		
			1231	8.0	17.0	6.5	7.1		
			1232	10.0	16.9	6.5	7.1		
			1233	11.0	16.2	6.5	7.5		
			1234	12.0	11.3	6.5	9.9		
			1235	13.0	9.1	6.5	10.3		
			1236	14.0	8.3	6.6	10.3		
			1237	14.5	8.5	6.8	10.2		
2	Lower Echo Lake near center	20020529	1257	0.2	10.8	6.3	8.7		
			1258	1.0	8.3	6.1	8.9		
			1259	2.0	8.0	6.0	8.9		
			1301	3.0	7.4	5.9	8.8		
			1303	4.0	7.2	5.9	8.6		
			1304	5.0	6.7	5.9	8.6		
			1306	6.0	6.6	5.9	8.5		
			1308	7.0	6.4	5.8	8.6		
			1309	8.0	6.1	5.9	8.6		
			1310	9.0	6.0	5.9	8.6		
			1312	10.0	5.8	6.1	8.5		
			1313	11.0	5.8	6.0	8.4		
			1314	12.0	5.7	6.0	8.4		
			1315	13.0	5.6	6.1	8.4		
			1317	14.0	5.6	6.1	8.3		
			1318	15.0	5.6	6.1	8.3		
			1320	15.9	5.5	6.1	8.3		
		20020822	0850	0.1	17.1	6.7	7.0		
			0852	1.0	17.1	6.7	7.0		
			0853	3.0	17.1	6.7	7.0		
			0854	5.0	17.0	6.7	7.0		
			0855	7.0	17.0	6.7	7.0		
			0857	9.0	16.9	6.7	7.0		
			0859	10.0	16.7	6.6	7.0		
			0900	11.0	13.8	6.6	8.6		
			0901	12.0	10.5	6.7	9.7		
			0902	13.0	9.1	6.7	9.7		
			0903	13.7	8.6	6.7	9.4		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
2	Lower Echo Lake near center	20021030	0926	0.2	9.7	7.4	7.8		
			0928	1.0	9.7	7.4	7.8	6.6	0.47
			0929	3.0	9.7	7.4	7.7		
			0930	5.0	9.7	7.3	7.9		
			0931	7.0	9.7	7.3	7.7		
			0932	9.0	9.7	7.2	7.7	7.0	0.21
			0933	11.0	9.7	7.2	7.6		
			0934	13.0	9.7	7.1	7.6		
			0935	15.0	9.7	7.0	7.8		
			0936	16.0	9.7	7.0	7.6		
		20030617	0956	0.1	15.2	6.9	8.6		
			0957	1.0	14.5	6.9	8.6	7.6	0.43
			0958	2.0	13.6	6.7	8.9		
			1000	3.0	12.9	6.6	8.9		
			1001	4.0	12.6	6.6	8.9		
			1002	5.0	10.9	6.7	9.2		
			1004	6.0	9.2	6.9	9.5		
			1005	7.0	7.9	6.9	9.6		
			1007	8.0	6.9	7.0	9.8	7.6	0.41
			1009	9.0	6.1	7.0	9.9		
			1010	10.0	5.2	6.9	9.8		
			1012	13.0	5.0	6.9	9.6		
			1013	15.5	4.5	7.1	9.3		
		20030819	0948	0.1	18.0	6.8	8.9	10.2	
			0949	1.0	18.0	6.3	9.0	9.3	0.40
			0950	2.0	17.9	6.4	8.6	8.9	
			0951	3.0	17.7	6.2	8.6	8.6	
			0952	4.0	17.3	6.2	8.6	8.4	
			0954	5.0	17.0	6.2	8.4	8.1	
			0955	6.0	16.8	6.2	8.4	7.8	
			0955	7.0	16.6	6.2	8.4	7.6	
			0956	8.0	16.2	6.2	8.4	7.4	
			0957	9.0	15.5	6.2	8.5	7.3	
			0958	10.0	14.0	6.2	9.2	7.2	
			0959	11.0	11.6	6.4	9.9	7.1	
			1000	12.0	8.3	6.5	10.5	7.0	0.47
			1001	13.0	7.0	6.5	10.3	7.0	
			1002	14.0	6.5	6.6	10.0	6.9	
			1003	15.0	6.2	6.8	9.8	6.9	
			1004	15.4	6.1	6.8	9.9	6.9	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
2	Lower Echo Lake near center	20031020	0900	0.1	11.4	6.8	10.3	9.5	
			0901	1.0	11.4	6.8	9.8	9.0	0.50
			0902	2.0	11.4	6.8	9.5	8.6	
			0903	4.0	11.4	6.7	8.8	8.4	
			0904	6.0	11.4	6.7	8.5	8.1	
			0905	8.0	11.3	6.6	8.5	7.9	
			0907	10.0	11.3	6.6	8.3	7.7	
			0908	12.0	11.2	6.6	8.2	7.4	
			0909	14.0	11.0	6.6	8.0	7.2	
			0910	16.0	8.4	6.8	7.7	6.9	0.40
			0911	17.5	7.0	7.0	7.7	6.9	
3	Lower Echo Lake, southwest	20020822	0956	0.1	17.0	6.8	7.3		
			0957	1.0	17.0	6.8	7.1		
			0958	2.0	16.9	6.8	7.1		
			0959	3.0	16.7	6.8	7.1		
			1000	4.0	16.7	6.8	7.1		
			1001	4.3	16.7	6.8	7.1		
4	Lower Echo Lake, northwest	20020822	1102	0.1	17.4	6.8	7.2		
			1103	1.0	17.2	6.8	7.1		
			1104	2.0	17.1	6.8	7.1		
			1106	3.0	17.1	6.7	7.1		
			1108	4.0	17.0	6.7	7.1		
			1109	5.0	17.0	6.7	7.1		
			1111	6.0	17.0	6.6	7.1		
			1112	7.0	17.0	6.6	7.1		
			1114	8.0	17.0	6.6	7.1		
			1115	9.0	16.9	6.6	7.1		
			1116	10.0	16.7	6.6	7.1		
			1117	11.0	12.5	6.6	9.2		
			1118	12.0	10.0	6.6	9.6		
			1119	13.0	9.4	6.6	9.8		
			1120	14.0	8.3	6.7	9.6		
			1129	15.0	8.0	6.8	9.6		
			1131	16.0	7.5	6.9	8.9		
			1132	17.0	7.4	6.9	8.8		
			1133	18.0	7.2	6.9	8.4		
			1135	19.0	7.2	7.0	8.2		
			1136	19.5	7.2	7.0	8.2		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
5	Upper Echo Lake near center	20020530	1110	0.2	9.0	5.7	8.4		
			1111	1.0	6.4	5.4	8.7		
			1112	2.0	6.1	5.3	8.7		
			1113	3.0	5.7	5.1	8.8		
			1114	4.0	5.2	5.0	8.8		
			1115	5.0	5.0	5.1	8.8		
			1116	6.0	5.0	5.1	8.8		
			1117	6.7	5.0	5.2	8.8		
			1119	0.2	9.0	5.7	8.4		
		20020826	1104	0.1	17.6	5.1	6.8		
			1106	1.0	17.6	5.1	6.8		
			1107	2.0	17.5	5.1	6.8		
			1109	3.0	17.4	5.1	6.8		
			1110	4.0	17.3	5.1	6.8		
			1112	5.0	17.2	5.1	6.8		
			1113	6.0	17.0	5.2	6.8		
			1115	7.0	17.0	5.1	6.8		
			1116	8.0	16.0	5.1	7.0		
			1117	9.0	12.3	5.0	8.3		
			1118	10.0	10.0	4.9	8.6		
			1119	11.0	8.9	4.9	9.0		
			1121	12.0	8.1	5.1	8.9		
		20030617	1131	0.1	14.4	5.3	8.7		
			1133	1.0	11.4	5.2	9.0	8.9	0.21
			1134	2.0	9.6	5.0	9.2		
			1136	3.0	8.6	5.1	9.6		
			1137	4.0	7.6	5.1	10.1	8.9	0.48
			1140	5.0	7.0	5.1	10.1		
			1141	6.0	6.8	5.1	10.2		
			1142	6.1	6.7	5.1	10.2		
		20030819	1047	0.1	18.7	5.1	8.7	7.1	
			1048	1.0	18.5	4.9	8.7	7.1	0.45
			1049	2.0	18.2	5.0	8.2	7.0	
			1050	3.0	18.1	5.0	8.2	7.0	
			1051	4.0	17.4	5.0	8.1	6.9	
			1052	5.0	16.9	5.0	8.1	6.9	
			1053	6.0	16.6	5.0	7.8	6.9	0.48
			1055	6.5	16.4	5.0	7.0	6.9	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
6	Upper Echo Lake, east	20020826	0930	0.1	17.4	5.3	6.9		
			0932	1.0	17.4	5.3	6.9		
			0934	3.0	17.4	5.3	6.9		
			0935	5.0	17.3	5.3	6.8		
			0939	7.0	17.2	5.3	6.7		
			0942	8.0	16.2	5.2	7.0		
			0944	9.0	11.3	5.1	9.8		
			0945	10.0	9.2	5.0	9.9		
			0947	11.0	7.6	5.1	9.9		
			0949	12.0	6.8	5.2	9.7		
			0950	13.0	6.2	5.4	9.5		
			0953	14.0	5.9	5.5	8.7		
			0954	16.0	5.4	6.0	7.1		
			0956	18.0	5.2	6.5	5.7		
			0957	20.0	5.0	7.0	4.5		
			0959	22.0	5.0	7.9	2.8		
			1001	23.6	5.0	8.1	2.6		
7	Upper Echo Lake, southwest	20020826	1225	0.1	17.7	5.1	7.0		
			1227	1.0	17.4	5.1	6.9		
			1229	2.0	17.1	5.1	6.9		
			1231	3.0	17.1	5.1	6.9		
			1232	4.0	17.0	5.1	6.9		
			1233	5.0	17.0	5.1	6.8		
			1234	6.0	16.8	5.1	6.8		
			1236	7.0	16.8	5.1	6.8		
			1238	8.0	13.0	4.8	9.0		
			1239	9.0	10.3	4.9	8.8		
			1240	9.6	9.7	4.9	8.6		
8	Upper Echo Lake near inlet	20020826	1322	0.1	18.2	5.1	7.0		
			1324	0.5	18.2	5.1	7.0		
			1325	1.0	18.1	5.1	7.1		
			1326	1.2	18.0	5.1	7.0		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
9	Fallen Leaf Lake, north	20020814	1240	0.1	21.5	20.0	9.4		
			1243	1.0	20.2	19.8	9.6		
			1245	5.0	18.9	19.6	9.8		
			1247	10.0	18.3	19.5	9.9		
			1249	12.0	17.6	19.5	10.3		
			1251	14.0	14.0	19.3	12.6		
			1253	16.0	11.1	19.2	13.1		
			1255	18.0	9.5	19.2	13.2		
			1257	20.0	8.2	19.2	13.2		
			1300	22.0	7.6	19.3	13.2		
			1302	25.0	6.9	19.3	13.1		
			1304	30.0	6.2	19.3	12.9		
			1306	34.0	5.7	19.4	12.9		
10	Fallen Leaf Lake near center	20020603	1031	0.1	12.4	18.7	8.1		
			1032	1.0	12.1	18.6	8.8		
			1033	2.0	11.8	18.6	8.7		
			1034	3.0	11.7	18.5	8.6		
			1034	4.0	11.5	18.5	8.5		
			1035	5.0	11.4	18.5	8.5		
			1036	6.0	11.3	18.5	8.6		
			1036	7.0	10.8	18.4	8.6		
			1037	8.0	10.6	18.5	8.9		
			1038	9.0	10.4	18.7	8.8		
			1039	10.0	10.3	18.7	8.8		
			1040	11.0	9.8	18.8	8.9		
			1041	12.0	9.6	18.8	9.0		
			1042	13.0	9.4	18.8	8.9		
			1043	14.0	9.2	18.8	8.9		
			1044	15.0	8.9	19.0	8.9		
			1045	16.0	8.7	19.0	8.9		
			1047	17.0	8.5	18.9	8.8		
			1048	18.0	8.3	18.8	8.9		
			1056	19.0	7.7	18.7	8.9		
			1057	20.0	7.5	18.7	8.9		
			1058	21.0	7.4	18.7	8.5		
			1059	22.0	7.3	18.6	8.3		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
10	Fallen Leaf Lake near center	20020814	1111	0.1	20.2	20.6	10.5		
			1128	1.0	19.6	20.5	10.2		
			1129	5.0	19.0	20.1	10.3		
			1131	10.0	18.3	20.6	10.4		
			1133	12.0	17.0	20.1	11.1		
			1135	14.0	12.7	19.7	13.4		
			1137	16.0	10.4	19.6	13.8		
			1138	18.0	9.4	19.7	13.8		
			1140	20.0	8.9	19.6	13.8		
			1142	25.0	7.7	19.6	13.8		
			1144	30.0	6.8	19.7	13.6		
			1146	35.0	5.9	19.6	13.3		
			1148	40.0	5.5	19.6	13.2		
			1150	45.0	5.0	19.7	13.0		
			1152	50.0	4.8	19.6	12.9		
			1154	55.0	4.6	19.7	12.8		
			1155	60.0	4.6	19.6	12.8		
			1157	65.0	4.5	19.7	12.7		
			1159	68.0	4.5	19.6	12.7		
		20021028	1112	0.2	12.5	22.2	8.1		
			1113	1.0	12.5	22.1	8.1	7.9	0.18
			1114	3.0	12.4	22.0	8.0		
			1115	5.0	12.4	21.9	8.0		
			1116	7.0	12.4	21.8	8.0		
			1117	9.0	12.4	21.8	8.0		
			1118	11.0	12.4	21.6	8.0		
			1119	13.0	12.4	21.5	8.0		
			1119	15.0	12.4	21.4	8.0		
			1121	18.0	12.4	21.1	8.0		
			1122	20.0	12.4	21.0	8.0		
			1124	21.0	12.4	20.8	8.0		
			1125	23.0	8.6	20.1	9.8		
			1126	26.0	7.9	20.0	9.8		
			1127	30.0	6.9	20.0	9.6	7.8	0.20
			1128	35.0	6.0	20.2	9.2		
			1129	40.0	5.5	20.1	9.1		
			1131	45.0	5.2	20.1	8.9		
			1132	50.0	4.9	20.0	8.8		
			1132	55.0	4.8	20.1	8.7		
			1133	60.3	4.6	20.1	8.6		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
10	Fallen Leaf Lake near center	20030529	0900	0.1	12.1	21.2	8.4		
			0902	1.0	11.3	20.8	8.6	7.4	0.22
			0903	3.0	10.8	20.6	8.5		
			0904	5.0	9.8	20.4	8.7		
			0906	7.0	9.0	19.9	9.1		
			0907	9.0	7.9	20.3	9.8		
			0909	11.0	7.5	20.3	9.0		
			0910	13.0	7.2	20.3	9.0		
			0911	15.0	7.0	20.3	9.0		
			0913	20.0	6.1	20.3	8.9	7.6	0.29
			0914	25.0	5.4	20.3	8.9		
			0916	30.0	5.2	20.2	8.8		
			0918	35.0	5.0	20.2	8.7		
			0920	40.0	4.9	20.2	8.6		
			0921	45.0	4.8	20.1	8.6		
			0923	50.0	4.8	20.1	8.5		
			0924	55.0	4.7	20.1	8.5		
			0926	60.0	4.7	20.2	8.5		
			0928	65.0	4.6	20.2	8.4		
			0930	70.0	4.6	20.1	8.4		
		20030812	0850	0.1	17.4	19.0	8.5	8.0	
			0851	1.0	17.4	19.1	8.8	7.7	0.82
			0853	5.0	17.4	19.1	8.9	7.7	
			0854	10.0	17.2	19.3	8.7	7.6	
			0856	15.0	10.8	19.2	10.8	7.7	
			0857	20.0	8.1	19.3	10.6	7.7	
			0900	25.0	7.0	19.3	10.5	7.6	0.34
			0859	30.0	5.8	19.4	10.2	7.6	
			0901	40.0	5.0	19.5	9.8	7.6	
		20031020	1135	0.1	13.8	19.5	10.0	8.9	
			1136	1.0	13.9	19.4	9.1	8.2	0.3
			1137	5.0	13.8	19.4	9.4	8.0	
			1138	10.0	13.8	19.4	9.2	7.8	
			1139	15.0	13.8	19.4	8.5	7.6	
			1140	20.0	8.9	19.3	10.4	7.6	
			1141	25.0	6.6	19.2	10.4	7.5	0.2
			1142	30.0	5.5	19.2	9.8	7.4	
			1143	35.0	5.2	19.2	9.6	7.4	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
11	Fallen Leaf Lake, south	20020814	0929	0.1	19.6	20.9	7.5		
			0930	1.0	19.5	20.9	7.4		
			0932	2.0	19.4	20.9	7.4		
			0934	5.0	19.0	20.8	7.3		
			0936	7.0	18.5	20.6	7.3		
			0939	9.0	18.3	20.6	7.3		
			0941	11.0	17.6	20.5	7.5		
			0943	13.0	14.2	20.3	9.1		
			0944	14.0	12.4	19.9	9.5		
			0946	15.0	11.6	19.8	9.5		
			0948	20.0	8.8	19.9	9.6		
			0950	25.0	7.5	20.0	9.6		
			0951	30.0	6.5	20.1	9.4		
			0954	35.0	5.8	20.1	9.2		
			0957	40.0	5.3	20.1	9.1		
			0959	45.0	5.0	20.2	8.9		
			1002	50.0	4.8	20.2	8.9		
			1004	55.0	4.7	20.2	8.8		
			1005	60.0	4.6	20.2	8.7		
			1007	65.0	4.5	20.1	8.6		
			1009	70.0	4.4	20.1	8.5		
12	Spooner Lake, south	20020731	1200	0.2	22.0	385	8.9	10.7	
			1203	0.5	22.0	384	8.9	10.6	
			1204	1.0	21.8	387	9.2	10.7	
			1207	1.5	21.0	380	8.0	10.6	
			1209	2.0	19.9	366	3.2	10.2	
			1211	2.5	18.9	389	0.2	9.1	
			1213	3.2	16.5	563	0.2	8.0	
13	Spooner Lake, east	20020731	1003	0.2	21.8	396	8.6	10.5	
			1005	0.5	21.8	396	8.6	10.4	
			1006	1.0	21.3	392	7.9	10.2	
			1008	1.5	21.2	391	6.3	10.3	
			1010	2.0	20.2	401	0.4	8.8	
			1013	2.5	19.0	447	0.3	8.0	
			1015	3.0	17.6	505	0.2	7.2	
			1016	3.5	16.1	613	0.9	6.8	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
14	Spooner Lake near center	20020605	0925	0.2	18.2	363	9.8	9.5	
			0927	1.0	18.1	364	9.7	9.5	
			0928	1.5	18.1	365	9.7	9.5	
			0929	2.0	18.0	365	9.4	9.5	
			0931	2.3	17.9	365	9.7	9.5	
			0932	2.6	17.2	368	7.4	9.3	
			0937	3.0	16.0	413	4.5	8.6	
			0938	3.5	15.0	413	2.4	8.2	
			0939	4.0	14.1	476	0.2	7.8	
		20020731	0842	0.2	20.8	379	7.6	9.8	
			0844	1.0	20.9	379	7.6	9.7	
			0846	1.5	20.8	379	7.7	9.6	
			0848	2.0	20.8	379	7.5	9.5	
			0850	2.5	19.5	471	1.0	7.8	
			0852	3.0	18.0	534	0.2	6.9	
			0856	3.5	16.4	606	0.2	6.3	
			0857	3.6	16.4	614	0.2	6.2	
		20021029	1013	0.1	8.1	444	9.2		
			1014	1.0	8.1	445	9.2	9.7	
			1014	1.5	8.1	444	9.2		
			1015	2.0	8.1	445	9.3		
			1016	2.5	8.1	445	9.5		
			1016	3.0	8.1	445	9.5		
			1017	3.2	8.1	445	9.4		
		20030528	1000	0.1	17.9	375	9.4		
			1001	0.5	17.8	373	9.5		
			1002	1.0	17.7	372	9.6	9.4	1.2
			1003	1.5	17.5	371	9.6		
			1004	2.0	17.4	370	9.7		
			1005	2.5	17.2	369	9.6		
			1006	3.0	15.8	389	7.9	9.6	1.3
			1007	3.5	14.5	421	5.6		
			1008	3.7	13.4	474	3.5		
		20030813	0820	0.1	18.3	429	6.5	9.1	
			0822	0.5	18.3	429	6.3	9.5	
			0823	1.0	18.3	428	6.0	9.6	4.1
			0824	1.5	18.2	428	6.2	9.6	
			0825	2.0	18.2	472	0.6	9.4	
			0827	2.5	17.5	632	0.3	8.2	
			0828	3.0	16.5	678	0.3	7.8	20.2
			0830	3.5	14.3	788	0.3	7.3	
			0831	3.7	13.6	848	0.3	7.2	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
14	Spooner Lake near center	20031014	1042	0.1	10.9	476	7.8	7.8	
			1043	0.5	10.9	476	8.0	8.1	
			1045	1.0	10.9	476	7.7	8.3	5.5
			1046	1.5	10.8	480	6.1	8.4	
			1048	2.0	10.9	480	6.6	8.5	
			1050	2.5	10.8	482	5.5	8.5	11.8
			1051	3.0	11.0	559	2.4	8.2	
			1052	3.4	11.8	745	0.6	7.6	
15	Spooner Lake, north	20020731	1055	0.2	22.4	394	9.1	10.5	
			1057	0.5	22.3	395	9.2	10.5	
			1059	1.0	21.5	386	7.8	10.2	
			1100	1.5	21.4	385	6.8	10.1	
			1104	2.0	20.0	387	0.3	9.0	
			1106	2.5	18.7	407	0.1	8.6	
			1107	3.0	16.9	518	0.1	7.6	
			1109	3.1	16.5	584	0.2	6.9	
16	Spooner Lake, west	20020731	1253	0.2	22.6	393	9.5	10.7	
			1255	0.5	22.0	394	10.0	10.6	
			1257	1.0	20.7	379	7.0	10.5	
17	Marlette Lake, south	20020801	1204	0.1	20.3	40.7	7.6		
			1206	1.0	20.0	40.7	7.8		
			1207	2.0	19.6	40.6	7.6		
			1208	3.0	19.5	40.6	7.5		
			1209	4.0	19.4	40.6	7.5		
			1210	5.0	19.4	40.6	7.5		
			1212	6.0	19.4	40.6	7.3		
			1213	6.6	19.2	40.8	8.8		
18	Marlette Lake, southeast	20020801	1132	0.1	19.7	40.8	7.3		
			1133	1.0	19.6	40.7	7.3		
			1134	2.0	19.4	40.6	7.3		
			1135	3.0	19.4	40.6	7.2		
			1136	4.0	19.3	40.6	7.2		
			1137	5.0	19.3	40.6	7.1		
			1139	6.0	19.2	40.6	7.1		
			1140	6.7	19.2	40.9	6.2		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
19	Marlette Lake near center	20020604	1044	0.2	13.7	36.3	5.1		
			1045	1.0	13.2	36.2	3.8		
			1046	2.0	12.9	36.1	3.6		
			1047	3.0	12.2	36.0	3.4		
			1048	4.0	11.0	35.9	3.2		
			1049	5.0	10.1	35.7	3.2		
			1050	6.0	9.4	35.8	3.0		
			1051	7.0	8.8	35.7	2.8		
			1052	8.0	7.9	35.6	2.5		
			1053	9.0	7.2	35.7	2.2		
			1054	10.0	6.9	35.6	2.1		
			1101	10.9	6.6	37.4	1.6		
		20020801	0857	0.1	19.5	41.2	7.3		
			0859	1.0	19.4	41.1	7.4		
			0900	2.0	19.4	41.1	7.2		
			0902	3.0	19.4	41.0	7.2		
			0903	4.0	19.3	41.0	7.2		
			0904	5.0	19.2	40.9	7.3		
			0905	6.0	18.9	40.8	7.4		
			0906	7.0	18.3	40.7	7.5		
			0907	8.0	16.6	41.0	8.4		
			0908	8.5	14.9	41.9	7.4		
			0909	9.0	12.6	44.3	4.7		
			0910	10.0	11.3	45.2	2.0		
			0911	11.0	10.5	45.7	0.4		
			0912	12.0	9.8	55.5	0.1		
			0913	12.1	9.8	58.3	0.1		
		20021022	0945	0.1	10.0	42.6	7.5		
			0946	1.0	9.9	42.0	7.4	7.3	3.3
			0947	2.0	9.9	41.8	7.4		
			0948	3.0	9.8	41.6	7.3		
			0951	4.0	9.8	41.4	7.2		
			0952	5.0	9.8	41.2	7.2	7.3	2.8
			0953	6.0	9.8	41.1	7.2		
			0954	7.0	9.8	40.9	7.2		
			0956	8.0	9.8	40.8	7.2		
			0958	9.0	9.8	40.7	7.2		
			0959	10.0	9.8	40.6	7.2		
			1000	10.1	9.8	40.4	7.1		

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
19	Marlette Lake near center	20030619	0910	0.1	16.1	42.6	7.7		
			0911	1.0	16.1	42.5	7.6	7.3	0.7
			0912	2.0	16.1	42.3	7.6		
			0913	3.0	15.8	42.2	7.9		
			0914	4.0	14.2	41.7	8.8		
			0915	5.0	11.3	41.4	10.1		
			0916	6.0	9.0	40.9	10.0		
			0917	7.0	7.4	40.5	9.5		
			0918	8.0	6.6	40.4	9.0		
			0919	9.0	5.6	42.0	5.6	7.3	1.2
			0920	10.0	5.4	42.4	4.9		
			0921	10.7	5.4	44.0	0.4		
		20030811	0941	0.1	18.2	42.4	7.0	7.8	
			0942	1.0	18.2	42.4	7.0	7.8	0.5
			0944	2.0	18.1	42.5	6.9	7.8	
			0945	3.0	18.1	42.5	6.9	7.8	
			0946	4.0	18.1	42.4	6.9	7.8	
			0947	5.0	18.1	42.4	6.9	7.8	
			0948	6.0	18.1	42.5	6.8	7.8	
			0949	7.0	18.0	42.5	6.9	7.8	
			0950	8.0	15.2	42.4	8.8	7.8	
			0952	9.0	11.2	43.2	8.5	7.8	0.8
			0953	10.0	9.1	45.2	4.8	7.7	
			0955	10.6	8.7	46.0	3.0	7.6	
		20031021	0938	0.1	11.4	43.1	9.4	6.4	
			0939	1.0	11.4	43.1	8.8	6.7	3.2
			0941	2.0	11.4	43.2	8.7	6.7	
			0942	3.0	11.4	43.1	8.4	6.6	
			0943	4.0	11.4	43.1	8.3	6.5	
			0944	5.0	11.4	43.1	8.4	6.4	1.8
			0945	7.0	11.4	43.0	8.2	6.5	
			0946	9.0	11.4	43.0	8.2	6.5	
			0948	10.4	11.4	44.0	6.3	6.8	

Appendix A. Physical and chemical profile data collected from study area lakes, 2002-03—Continued

[Abbreviations: m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; std, standard; NTU, nephelometric turbidity units]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Depth (m)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	Dissolved oxygen (mg/L)	pH (std. units)	Turbidity (NTU)
20	Marlette Lake, east	20020801	1056	0.1	19.8	40.6	7.2		
			1057	1.0	19.7	40.7	7.2		
			1058	2.0	19.5	40.6	7.2		
			1059	3.0	19.4	40.6	7.2		
			1100	4.0	19.4	40.6	7.1		
			1101	5.0	19.4	40.6	7.1		
			1102	6.0	18.8	40.6	7.4		
			1103	7.0	18.3	40.5	7.5		
			1105	8.0	16.1	41.5	7.6		
			1106	9.0	13.6	43.4	5.9		
			1107	9.2	13.2	43.6	5.6		
21	Marlette Lake, north	20020801	1012	0.1	19.5	40.7	7.3		
			1013	1.0	19.4	40.7	7.3		
			1014	2.0	19.3	40.7	7.3		
			1015	3.0	19.3	40.7	7.2		
			1016	4.0	19.3	40.7	7.2		
			1018	5.0	19.2	40.6	7.2		
			1019	6.0	19.0	40.7	7.1		
			1020	7.0	17.8	40.8	7.7		
			1021	8.0	16.3	41.1	8.3		
			1022	9.0	14.0	42.2	7.8		
			1024	9.5	12.2	44.2	3.7		
			1025	10.0	11.4	44.8	2.0		
			1026	10.5	10.9	45.2	1.3		
			1027	11.0	10.4	45.1	0.8		
			1028	12.0	9.5	57.0	0.1		
			1030	12.7	9.3	72.0	0.1		

Appendix B. Nutrient concentrations in water samples and field data collected at study area lake sites, 2002–03

[Abbreviations: °C, degrees Celsius; mg/L, milligrams per liter; mm, millimeters; µg/L, micrograms per liter; <, less than; NTU, nephelometric turbidity units; µS/cm, microsiemens per centimeter; Hg, mercury; M, analyte detected but not quantified; na, not analyzed]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Sampling depth	Transparency Secchi disc	Turbidity (NTU)	Barometric pressure	Dissolved oxygen	pH	Specific conductance	Air temperature	Water temperature	Total Kjeldahl nitrogen unfiltered	Ammonia, filtered	Nitrate[a], filtered	Orthophosphate, filtered	Phosphorus, unfiltered	Iron (bioreactive), unfiltered
				(meters)		(NTU)	(mm Hg)	(mg/L)	(units)	(µS/cm at 25°C)	(degrees Celsius)		(µg/L as N)			(µg/L as P)		(µg/L as Fe)
1	Lower Echo Lake, east	20020822	1240	1	9	na	585	7.2	na	6	23.0	17.6	144	6.1	5.6	<1.0	2.9	14.4
		20020822	1300	13	9	na	585	10.3	na	6	23.0	9.1	118	4.0	4.3	<1.0	4.1	28.3
2	Lower Echo Lake near center	20020529	1345	12	7	na	588	8.4	na	6	na	5.7	202	5.6	10.4	<1.0	4.9	38.8
		20020529	1430	5	7	na	588	8.6	na	6	na	6.7	140	18.8	16.0	<1.0	4.6	33.7
		20020822	0920	1	10.3	na	585	7.0	na	7	15.0	17.1	75	8.6	6.0	<1.0	2.6	14.7
		20020822	0940	12	10.3	na	585	9.7	na	7	15.0	10.5	100	8.9	7.5	<1.0	4.1	30.7
		20021030	0930	1	9.5	0.5	580	7.8	6.6	7	6.0	9.7	78	<3.0	4.8	1.4	5.1	19.3
		20021030	1000	9	9.5	0.2	580	7.7	7.0	7	6.0	9.7	166	<3.0	4.0	2.1	5.4	18.9
		20030617	1020	1	7	0.4	583	8.6	7.6	7	21.0	14.5	80	<3.0	10.4	2.6	5.8	30.5
		20030617	1050	8	7	0.4	583	9.8	7.6	7	21.0	6.9	80	<3.0	6.4	1.2	5.8	35.7
		20030819	1015	1	8.3	0.4	586	9.0	9.3	6	22.5	18.0	108	11	4.5	<1.0	4.5	13.4
		20030819	1030	12	8.3	0.5	586	10.5	7.0	6	22.5	8.3	126	5.8	3.3	<1.0	4.5	18.7
		20031020	0930	1	7.5	0.5	588	9.8	9.0	7	14.5	11.4	103	8.5	6.6	<1.0	4.2	16.9
		20031020	0945	16	7.5	0.4	588	7.7	7.0	7	14.5	8.4	110	<3.0	2.0	<1.0	4.5	21.2
3	Lower Echo Lake, southwest	20020822	1010	1	>4.3	na	585	7.1	na	7	22.0	17.0	84	6.6	3.8	<1.0	3.2	17.5
4	Lower Echo Lake, northwest	20020822	1140	1	9.5	na	585	7.1	na	7	20.5	17.2	96	4.5	4.6	<1.0	2.6	17.0
		20020822	1200	13	9.5	na	585	9.8	na	7	20.5	9.4	151	<3.0	3.2	<1.0	4.4	34.7
5	Upper Echo Lake near center	20020530	1145	5	>7	na	585	8.8	na	5	na	5.0	166	<3.0	34.5	<1.0	4.0	55.5
		20020530	1300	2	>7	na	585	8.7	na	5	na	6.1	165	7.7	39.9	<1.0	5.2	63.2
		20020826	1130	1	6.5	na	588	6.8	na	5	21.5	17.6	116	7.5	5.1	<1.0	5.0	33.0
		20020826	1150	10	6.5	na	588	8.6	na	5	21.5	10.1	148	9.3	6.0	<1.0	7.5	110.8
		20030617	1150	1	6.2	0.2	583	9.0	8.8	5	23.0	11.4	56	<3.0	18.0	1.5	4.6	20.5
		20030617	1215	4	6.2	0.5	583	10.1	8.8	5	23.0	7.6	70	<3.0	14.6	1.7	5.5	20.9
		20030819	1110	1	6.5	0.5	586	8.7	7.1	5	22.0	18.5	90	5.8	3.5	<1.0	5.7	25.1
		20030819	1130	6	6.5	0.5	586	7.8	6.9	5	22.0	16.6	102	5.8	3.5	<1.0	6.0	30.9
6	Upper Echo Lake, east	20020826	1010	1	7	na	588	6.9	na	5	18.5	17.4	117	7.7	5.1	<1.0	5.3	32.6
		20020826	1030	10	7	na	588	9.9	na	5	18.5	9.2	359	4.7	3.6	<1.0	6.0	32.3
		20020826	1045	22	7	na	588	2.8	na	8	18.5	5.0	55	9.1	31.0	<1.0	7.5	200.7

Appendix B. Nutrient concentrations in water samples and field data collected at study area lake sites, 2002–03—Continued

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Sampling depth	Transparency Secchi disc	Turbidity (NTU)	Barometric pressure	Dissolved oxygen	pH	Specific conductance	Air temperature	Water temperature	Total Kjeldahl nitrogen unfiltered	Ammonia, filtered	Nitrate[a], filtered	Orthophosphate, filtered	Phosphorus, unfiltered	Iron (bioreactive), unfiltered
				(meters)		(NTU)	(mm Hg)	(mg/L)	(units)	(µS/cm at 25°C)	(degrees Celsius)		(µg/L as N)			(µg/L as P)		(µg/L as Fe)
7	Upper Echo Lake, Southwest	20020826	1245	1	7	na	588	6.9	na	5	21.5	17.4	108	9.3	7.0	<1.0	5.0	32.3
		20020826	1300	8	7	na	588	9.0	na	5	21.5	13.0	112	6.1	5.0	<1.0	6.0	42.2
8	Upper Echo Lake near inlet	20020826	1330	1	>1.2	na	588	7.1	na	5	23.0	18.1	99	6.3	5.3	<1.0	5.0	33.7
9	Fallen Leaf Lake, north	20020814	1250	1	14.6	na	608	9.6	na	20	26.0	20.2	68	5.9	3.6	<1.0	2.5	8.3
		20020814	1320	20	14.6	na	608	13.2	na	19	26.0	8.2	101	6.2	3.6	<1.0	2.8	na
10	Fallen Leaf Lake near center	20020603	1150	20	14.1	na	606	8.9	na	19	16.5	7.5	170	5.8	4.8	<1.0	4.6	34.7
		20020603	1215	2	14.1	na	606	8.7	na	19	16.5	11.8	254	4.2	3.4	<1.0	2.1	31.6
		20020814	1140	20	15.6	na	608	13.8	na	20	22.0	8.9	68	7.8	5.1	<1.0	4.4	7.1
		20020814	1200	25	15.6	na	608	13.8	na	20	22.0	7.7	57	6.2	4.4	<1.0	4.1	8.1
		20021028	1200	1	16.2	0.2	605	8.0	7.9	22	14.0	12.5	40	<3.0	3.1	1.0	5.4	9.4
		20021028	1230	30	16.2	0.2	605	9.6	7.8	20	14.0	6.9	<35	3.3	4.0	1.0	3.9	7.5
		20030529	0945	1	12.2	0.2	606	8.6	7.4	21	18.0	11.3	38	4.6	3.4	1.2	3.7	6.1
		20030529	1000	20	12.2	0.3	606	8.9	7.6	20	18.0	6.1	49	13.7	7.7	1.4	3.4	6.1
		20030812	0905	1	9.5	0.8	606	8.8	7.7	19	19.5	17.4	100	11.7	47.4	<1.0	5.3	14.1
		20030812	0930	25	9.5	0.3	606	10.5	7.6	19	19.5	7.0	61	6.2	7.7	<1.0	5.9	9.6
		20031020	1150	1	14.5	0.3	611	9.1	8.2	19	20.5	13.9	79	3.0	4.0	<1.0	3.3	8.5
		20031020	1210	25	14.5	0.2	611	10.4	7.5	19	20.5	6.6	77	3.2	2.2	<1.0	7.6	7.5
11	Fallen Leaf Lake, south	20020814	1020	1	14.6	na	608	7.4	na	21	22.0	19.5	78	10.0	3.4	<1.0	2.8	11.7
		20020814	1030	25	14.6	na	608	9.6	na	20	22.0	7.5	92	7.1	4.4	<1.0	2.8	6.9
12	Spooner Lake, south	20020731	1215	1	>1.8	na	596	9.2	10.7	387	25.0	21.8	346	12.1	8.4	<1.0	15.0	49.9
13	Spooner Lake, east	20020731	1030	1	>0.6	na	596	7.9	10.2	392	24.5	21.3	816	10.2	4.2	<1.0	30.9	149.8
14	Spooner Lake near center	20020605	0950	3.5	3.5	na	596	2.4	8.2	413	15.0	15.0	452	5.8	3.3	<1.0	17.2	48.2
		20020605	1010	1	3.5	na	596	9.7	9.5	364	15.0	18.1	465	3.5	2.8	<1.0	17.2	42.7
		20020731	0900	1	2.5	na	596	7.6	9.7	379	15.5	20.9	na	14.7	6.0	<1.0	13.8	109.5
		20020731	0920	3	2.5	na	596	0.2	6.9	534	15.5	18.0	785	13.5	11.7	<1.0	29.4	1,654
		20021029	1030	1	3.2	1.4	590	9.2	9.6	445	8.5	8.1	523	<3.0	3.1	3.0	13.6	17.9
		20030528	1020	1	3.5	1.2	596	9.6	9.4	372	24.0	17.7	572	4.8	6.8	1.2	19.9	94.4
		20030528	1030	3	3.5	1.3	596	7.9	9.6	389	24.0	15.8	615	5.5	6.2	1.2	17.8	91.6
		20030813	0830	1	>1	4.1	595	6.0	9.6	428	19.0	18.3	412	<3.0	3.0	<1.0	19.0	413.2
		20030813	0840	1	>1	4.1	595	6.0	9.6	428	19.0	18.3	636	3.2	3.3	<1.0	18.0	415.6
		20030813	0900	3	>1	20	595	0.3	7.8	678	19.0	16.5	892	7.8	24.1	<1.0	29.9	7,436.0
		20031014	1100	1	1.5	5.5	586	7.7	8.3	476	17.0	10.9	446	5.8	<2.0	<1.0	14.6	995.2
		20031014	1120	2.5	1.5	12	586	5.4	8.4	482	17.0	10.8	618	<3.0	<2.0	<1.0	39.5	na

Appendix B. Nutrient concentrations in water samples and field data collected at study area lake sites, 2002–03—Continued

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Sampling depth	Transparency Secchi disc	Turbidity (NTU)	Barometric pressure	Dissolved oxygen	pH	Specific conductance	Air temperature	Water temperature	Total Kjeldahl nitrogen unfiltered	Ammonia, filtered	Nitrate[a], filtered	Orthophosphate, filtered	Phosphorus, unfiltered	Iron (bioreactive), unfiltered
				(meters)		(NTU)	(mm Hg)	(mg/L)	(units)	(µS/cm at 25°C)	(degrees Celsius)		(µg/L as N)			(µg/L as P)		(µg/L as Fe)
15	Spooner Lake, north	20020731	1115	0.5	>0.5	na	596	9.2	10.5	395	24.0	22.3	na	5.2	6.9	<1.0	60.4	304.9
16	Spooner Lake, west	20020731	1310	1	>0.8	na	596	7.0	10.5	379	24.5	20.7	120	6.9	5.8	2.0	49.9	266.4
17	Marlette Lake, south	20020801	1220	1	6.5	na	578	7.8	na	41	27.0	20.0	202	6.4	4.2	<1.0	5.5	46.3
18	Marlette Lake, southeast	20020801	1140	1	6.7	na	578	6.2	na	41	27.0	19.2	198	5.0	3.3	<1.0	5.5	48.7
19	Marlette Lake near center	20020604	1115	8	5	na	578	2.5	na	36	18.5	7.9	254	13.0	9.5	<1.0	20.5	56.4
		20020604	1135	2	5	na	578	3.6	na	36	18.5	12.9	87	11.7	5.0	<1.0	11.9	49.3
		20020801	0940	1	7.5	na	578	7.4	na	41	20.0	19.4	258	7.1	5.1	<1.0	6.4	49.9
		20020801	0955	11	7.5	na	578	0.4	na	46	20.0	10.5	243	28.8	5.1	<1.0	17.1	366.6
		20021022	1000	1	2.4	3.3	570	7.4	na	42	9.0	9.9	na	<3.0	3.3	1.0	10.7	192.2
		20021022	1030	5	2.4	2.8	570	7.2	na	41	9.0	9.8	na	<3.0	4.0	1.2	12.1	200.0
		20030619	0940	1	6.5	0.7	570	7.6	7.7	42	25.0	16.1	376	5.4	4.6	1.0	7.7	59.0
		20030619	1000	9	6.5	1.1	570	5.6	7.3	42	25.0	5.6	373	3.7	4.4	1.0	12.0	81.4
		20030811	1010	1	8.3	0.5	579	7.0	7.8	42	22.5	18.2	168	9.1	4.8	<1.0	6.2	46.0
		20030811	1030	9	8.3	0.8	579	8.5	7.8	43	22.5	11.2	280	11.0	8.4	<1.0	10.8	90.7
		20031021	1000	1	4	3.2	581	8.8	6.7	43	16.0	11.4	367	14.5	7.3	1.0	14.3	296.2
		20031021	1010	1	4	1.6	581	8.8	6.7	43	16.0	11.4	372	16.9	6.5	1.0	14.0	299.2
		20031021	1030	5	4	1.8	581	8.4	6.4	43	16.0	11.4	323	15.6	6.6	1.0	17.4	303.0
20	Marlette Lake, east	20020801	1115	1	7.8	na	578	7.2	na	41	26.0	19.7	176	8.1	5.8	<1.0	5.5	42.5
21	Marlette Lake, north	20020801	1040	1	8.1	na	578	7.3	na	41	22.0	19.4	143	7.1	4.5	<1.0	5.5	46.6

[a]Nitrate results include all oxidized forms of nitrogen (nitrate plus nitrite) as determined by the Hydrazine method.

Appendix C. Nutrient concentrations in water samples and field data collected at study area stream sites, 2002–03

[Abbreviations: --, no data; °C, degrees Celsius; %, percent; mg/L, milligrams per liter; mm, millimeters; µg/L, micrograms per liter; Hg, mercury; <, less than; NTU, nephelometric turbidity units; µS/cm, microsiemens per centimeter]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Barometric pressure (mm Hg)	Dissolved oxygen (mg/L)	pH (units)	Specific conductance (µS/cm at 25°C)	Air temperature (°C)	Water temperature (°C)	Turbidity (NTU)	Suspended sediment finer than 0.063 mm (%)	Suspended sediment concentration (mg/L)	Total Kjeldahl (µg/L as N)	Ammonia, filtered (µg/L as N)	Nitrate[a], filtered (µg/L as N)	Orthophosphate, filtered (µg/L as P)	Phosphosus, unfiltered (µg/L as P)	Iron (bioreactive), unfiltered (µg/L as Fe)
22	Taylor Creek near Camp Richardson, CA	20020603	1440	606	7	--	19	25	15	--	--	--	44	9	3	<1.0	4	76
		20020603	1441	606	7	--	19	25	15	--	--	--	126	5	2	<1.0	4	69
		20020802	1250	605	7	--	22	22	23	--	25	1	96	8	10	<1.0	9	36
		20021023	1410	603	8	7	23	11	11	1	43	1	264	99	30	14	30	27
		20030618	1200	604	8	8	20	25	19	0	--	--	--	--	--	--	--	--
		20030814	1040	610	7	8	22	25	17	0		--	--	--	--	--	--	--
		20031015	1110	606	8	7	20	18	12	1	56	1	80	3	3	<1.0	6	25
23	Echo Lakes Channel between Upper and Lower Lakes, CA[b]	20020822	1040	585	7	--	7	23	16	--	--	--	126	7	6	<1.0	4	26
24	Echo Creek at outlet near Phillips, CA	20020606	0935	585	8	--	6	18	12	--	--	--	185	5	8	<1.0	3	66
		20020802	1010	585	6	--	48	19	19	--	42	2	119	16	14	2	10	96
		20020802	1020	585	6	--	48	19	19	--	--	--	192	15	12	2	10	89
		20021023	1100	582	8	7	8	10	11	0	75	0	91	4	2	1	5	19
		20021023	1105	582	8	7	8	10	11	0	--	--	123	3	5	1	5	17
		20030617	1430	583	9	9	8	23	16	2	58	2	112	<3.0	6	2	13	43
		20030814	0900	587	7	10	31	21	16	0	67	1	101	11	12	1	9	43
		20031015	0930	584	7	8	17	11	9	0	50	0	86	5	10	<1.0	4	39
25	Marlette Creek near Carson City, NV	20020604	1340	578	5	--	37	--	15	--	--	--	593	10	15	3	14	69
		20020801	1320	578	7	--	52	23	11	--	74	14	349	14	65	3	78	2,247
		20021022	1250	570	7	7	53	8	8	3	83	1	1,580	<3.0	36	4	20	134
		20030619	1140	570	7	6	48	15	9	7	73	5	261	5	72	5	39	1,034
		20030811	1120	579	8	8	54	23	9	3	--	--	119	10	64	3	19	572
		20031021	1100	581	7	8	55	23	9	1	50	2	117	<3.0	38	2	8	284
		20031021	1110	581	7	8	55	23	9	1	--	--	165	<3.0	38	3	9	280

[a]Nitrate results include all oxidized forms of nitrogen (nitrate plus nitrite) as determined by the Hydrazine method.

[b]Echo Lakes Channel site was not included in statistical summaries of data for this report.

Appendix D. Nitrate concentrations determined using the Hydrazine method with pyrophosphate for samples collected from study area lake and stream sites after May 2003

[Abbreviation: µg/L, micrograms per liter]

Site no. (see fig. 2)	Station name	Date (yyyymmdd)	Time	Nitrate[a], filtered (µg/L)
2	Lower Echo Lake near center	20030617	1020	10.7
		20030617	1050	6.5
		20030819	1015	3.6
		20030819	1030	2.5
		20031020	0930	8.1
		20031020	0945	2.5
		20031022	1008	3.4
5	Upper Echo Lake near center	20030617	1150	21.5
		20030617	1215	18.6
		20030819	1110	2.3
		20030819	1130	2.5
10	Fallen Leaf Lake near center	20030529	0945	2.6
		20030529	1000	7.5
		20030812	0905	54.8
		20030812	0930	7.4
		20031020	1150	5.1
		20031020	1210	2.5
14	Spooner Lake near center	20030528	1020	6.9
		20030528	1030	6.9
		20030813	0830	2.3
		20030813	0840	2.5
		20030813	0900	6.7
		20031014	1100	1.9
		20031014	1120	1.9
19	Marlette Lake near center	20030619	0940	5.1
		20030619	1000	4.7
		20030811	1010	4.7
		20030811	1030	9.6
		20031021	1000	8.7
		20031021	1010	7.7
		20031021	1030	8.1
22	Taylor Creek	20030618	1200	10.7
		20030814	1040	11.3
		20031015	1110	4.5
24	Echo Creek	20030603	1430	6.5
		20030814	0900	12.2
		20031015	0930	11.3
25	Marlette Creek	20030619	1140	90.6
		20030811	1120	82.9
		20031021	1100	43.2
		20031021	1110	43.2

[a]Nitrate results include all oxidized forms of nitrogen (nitrate plus nitrite).