Water Quality Monitoring Report

Camp Lake
Water Quality Monitoring Report

Prepared for:
Camp Lake Association
Algoma Township Board

Prepared by:
Progressive AE
1811 4 Mile Road, NE
Grand Rapids, MI 49525-2442
616/361-2664

March 2017

Project No: 50750103

progressive|ae

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Introduction

On behalf of the Camp Lake Association and the Algoma Township Board, biologists from Progressive AE have monitored water quality conditions in Camp Lake since 1994 to evaluate baseline water quality conditions. This report contains background information on the various water quality parameters sampled and a discussion of the data collected to date.

Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact of drainage from the surrounding watershed.

Lakes are commonly classified as oligotrophic, mesotrophic, or eutrophic (Figure 1). Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

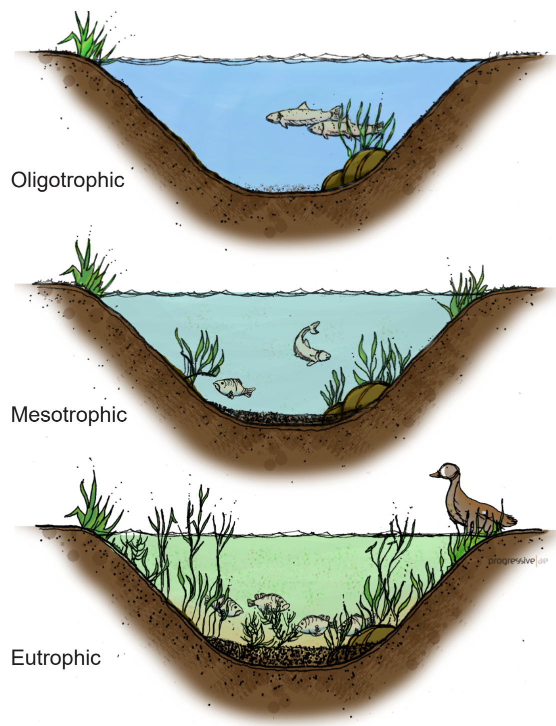

Figure 1. Lake classification.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The aging process in lakes is called "eutrophication" and may take anywhere from a few hundred to several thousand years, generally depending on the size of the lake and its watershed. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as "cultural eutrophication." The problem of cultural eutrophication can be managed by identifying sources of sediment and nutrient loading (i.e., inputs) to the lake and developing strategies to halt or slow the inputs. Thus, in developing a management plan, it is necessary to determine the limnological (i.e., the physical, chemical, and biological) condition of the lake and the physical characteristics of the watershed as well. Key parameters used to evaluate the limnological condition of a lake include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency.

TEMPERATURE

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as "spring turnover" because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the "thermocline." The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as "fall turnover." As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated (Figure 2). Shallow lakes do not stratify. Lakes that are 15 to 30 feet deep may stratify and destratify with storm events several times during the year.

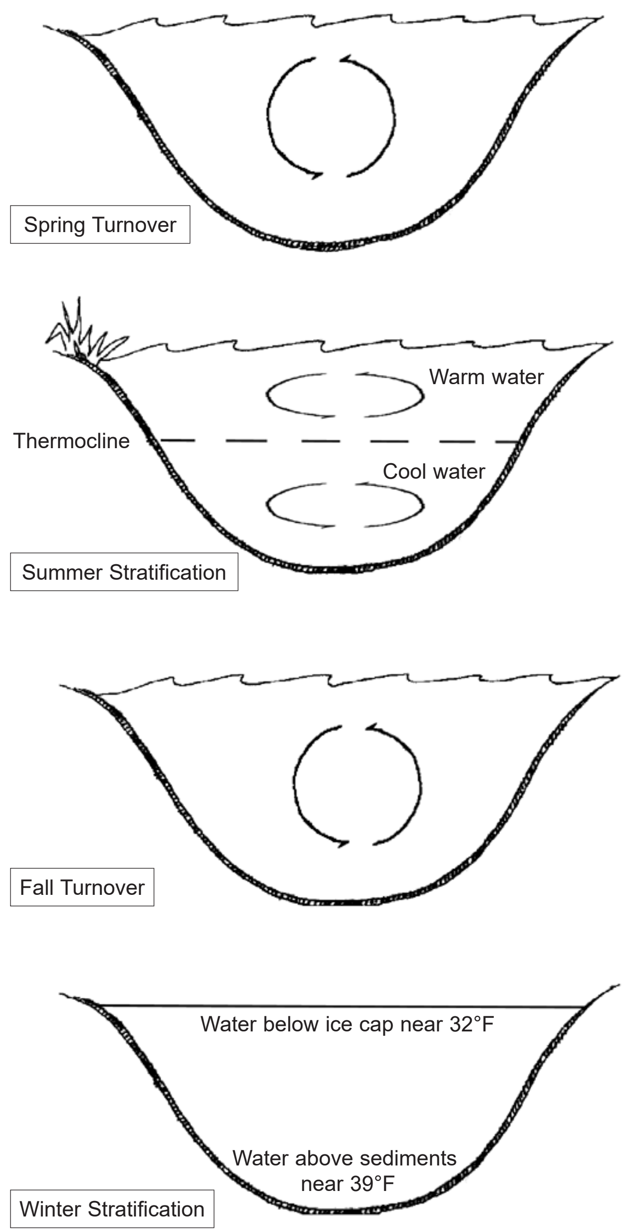

Figure 2. Seasonal thermal stratification cycles.

DISSOLVED OXYGEN

An important factor influencing lake water quality is the quantity of dissolved oxygen in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

PHOSPHORUS

The quantity of phosphorus present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, lake sediments act as a phosphorus trap, retaining phosphorus and, thus, making it unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus will be released from the sediments and may be available to promote aquatic plant growth. In some lakes, the internal release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input).

By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 μg/L (micrograms per liter, or parts per billion) are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.

CHLOROPHYLL-*a*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-*a* concentration greater than 6 μg/L is considered characteristic of a eutrophic condition.

SECCHI TRANSPARENCY

A Secchi disk is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line (Figure 3). The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of approximately twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

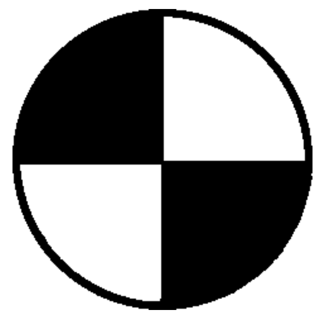

Figure 3. Secchi disk.

Ordinarily, as phosphorus inputs (both internal and external) to a lake increase, the amount of algae the lake can support will also increase. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria developed by the Michigan Department of Environmental Quality is shown in Table 1.

TABLE 1
LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (μg/L)[1]	Chlorophyll-*a* (μg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

1 μg/L = micrograms per liter = parts per billion.

PH AND TOTAL ALKALINITY

pH is a measure of the amount of acid or base in the water. The pH scale ranges from 0 (acidic) to 14 (alkaline or basic) with neutrality at 7. The pH of most lakes in the Upper Midwest ranges from 6.5 to 9.0 (MDEQ 2012; Table 2). In addition, according to MDEQ (2013):

> While there are natural variations in pH, many pH variations are due to human influences. Fossil fuel combustion products, especially automobile and coal-fired power plant emissions, contain nitrogen oxides and sulfur dioxide, which are converted to nitric acid and sulfuric acid in the atmosphere. When these acids combine with moisture in the atmosphere, they fall to earth as acid rain or acid snow. In some parts of the United States, especially the Northeast, acid rain has resulted in lakes and streams becoming acidic, resulting in conditions which are harmful to aquatic life. The problems associated with acid rain are lessened if limestone is present, since it is alkaline and neutralizes the acidity of the water.
>
> Most aquatic plants and animals are adapted to a specific pH range, and natural populations may be harmed by water that is too acidic or alkaline. Immature stages of aquatic insects and young fish are extremely sensitive to pH values below 5. Even microorganisms which live in the bottom sediment and decompose organic debris cannot live in conditions which are too acidic. In very acidic waters, metals which are normally bound to organic matter and sediment are released into the water. Many of these metals can be toxic to fish and humans. Below a pH of about 4.5, all fish die.

The Michigan Water Quality Standard (Part 4 of Act 451) states that pH shall be maintained within the range of 6.5 to 9.0 in all waters of the state.

Alkalinity, also known as acid-neutralizing capacity or ANC, is the measure of the pH-buffering capacity of water in that it is the quantitative capacity of water to neutralize an acid. pH and alkalinity are closely linked and are greatly impacted by the geology and soil types that underlie a lake and its watershed. According to MDEQ (2012):

> Michigan's dominant limestone geology in the Lower Peninsula and the eastern Upper Peninsula contributes to the vast majority of Michigan lakes being carbonate-bicarbonate dominant [which increases alkalinity and moderates pH] and lakes in the western Upper Peninsula having lower alkalinity and thus lesser buffering capacity.

The alkalinity of most lakes in the Upper Midwest is within the range of 23 to 148 milligrams per liter, or parts per million, as calcium carbonate (MDEQ 2012; Table 2).

TABLE 2
pH AND ALKALINITY OF UPPER MIDWEST LAKES

Measurement	Low	Moderate	High
pH (in standard units)	Less than 6.5	6.5 to 9.0	Greater than 9.0
Total Alkalinity or ANC (in mg/L as $CaCO_3$)1	Less than 23	23 to 148	Greater than 148

1 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

SAMPLING METHODS

Water quality sampling was conducted in the spring and summer of 2016 at the deep basin within Camp Lake (Figure 4). Temperature was measured using an AquaCal ClineFinder probe. Samples were collected with a VanDorn bottle at 10-foot intervals from the surface to the bottom at the deep basin sampling site of Camp Lake. Samples were analyzed for dissolved oxygen, and total phosphorus. Dissolved oxygen samples were fixed in the field and then transported to Progressive AE for analysis using the modified Winkler method (Standard Methods procedure 4500-O C). Total phosphorus was analyzed using Standard Methods procedure 4500-P E at Prein and Newhof[1]. In addition to the depth-interval samples at the deep basin, Secchi transparency was measured and a composite chlorophyll-*a* samples were collected from the surface to a depth equal to twice the Secchi transparency. Chlorophyll-*a* samples were analyzed using Standard Methods procedure 10200 H by Prein and Newhof.

1 Prein and Newhof Prein and Newhof, 3260 Evergreen Drive, NE, Grand Rapids, MI 49525.

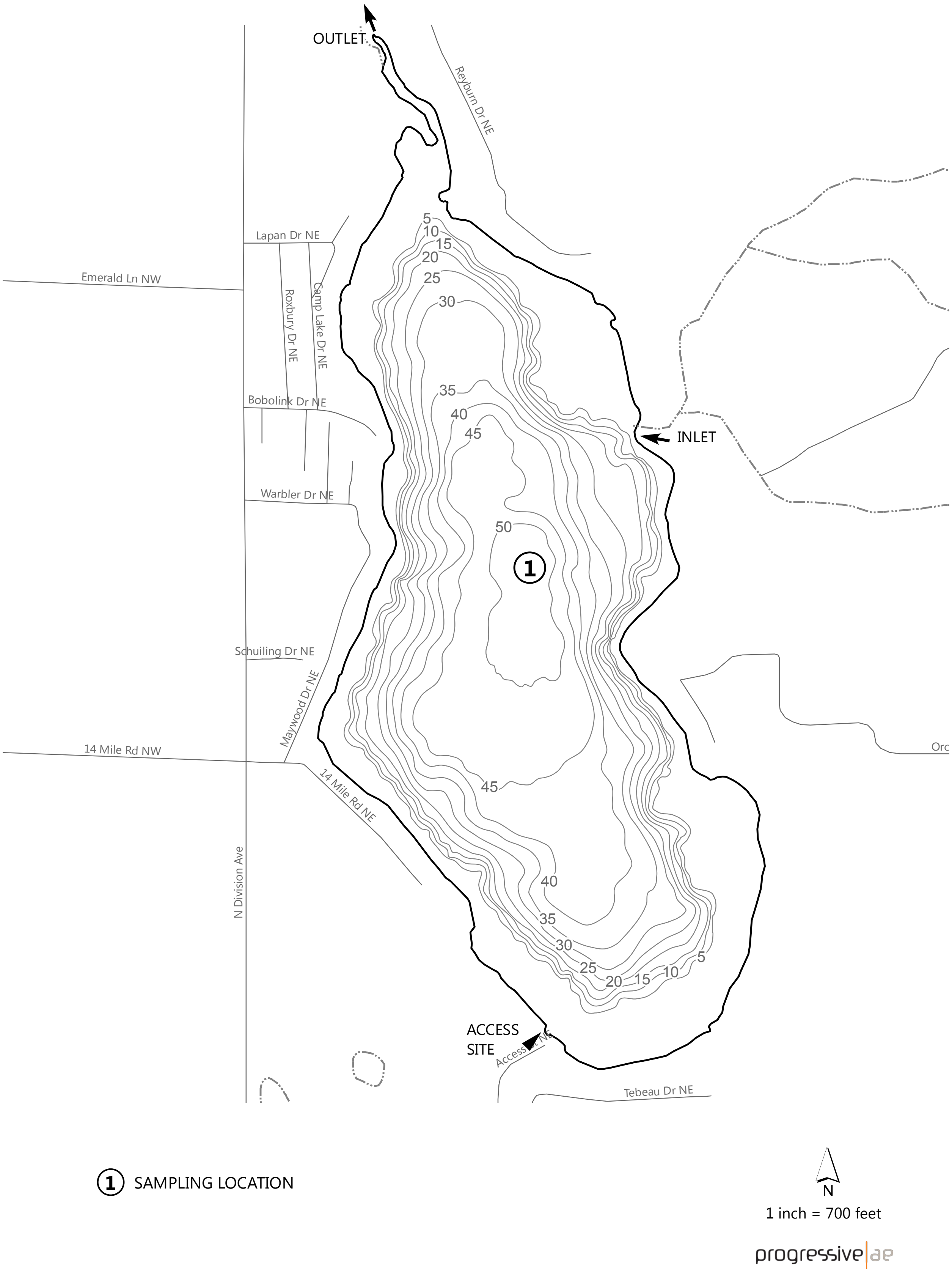

Figure 4. Camp Lake sampling site location map.

Sampling Results and Discussion

Deep-basin water quality data are provided in Table 3. Secchi transparency and chlorophyll-*a* data are included in Table 4. Lake water quality data is summarized in Figures 5 through 7. Lake summary statistics are provided in Table 5. Historical data collected from Camp Lake are included in Appendix A.

TABLE 3
CAMP LAKE
2016 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]
18-Apr-16	1	1	57	14.1	16
18-Apr-16	1	10	49	13.9	22
18-Apr-16	1	20	45	12.6	21
18-Apr-16	1	30	43	11.6	28
18-Apr-16	1	40	43	11.2	31
18-Apr-16	1	50	43	10.0	39
10-Aug-16	1	1	81	9.2	<5
10-Aug-16	1	10	81	9.7	<5
10-Aug-16	1	20	61	3.0	24
10-Aug-16	1	30	47	1.6	23
10-Aug-16	1	40	44	0.6	217
10-Aug-16	1	49	44	0.4	231

TABLE 4
CAMP LAKE
2016 SURFACE WATER QUALITY DATA

Date	Station	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[2]
18-Apr-16	1	12.5	1
10-Aug-16	1	11.5	1

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

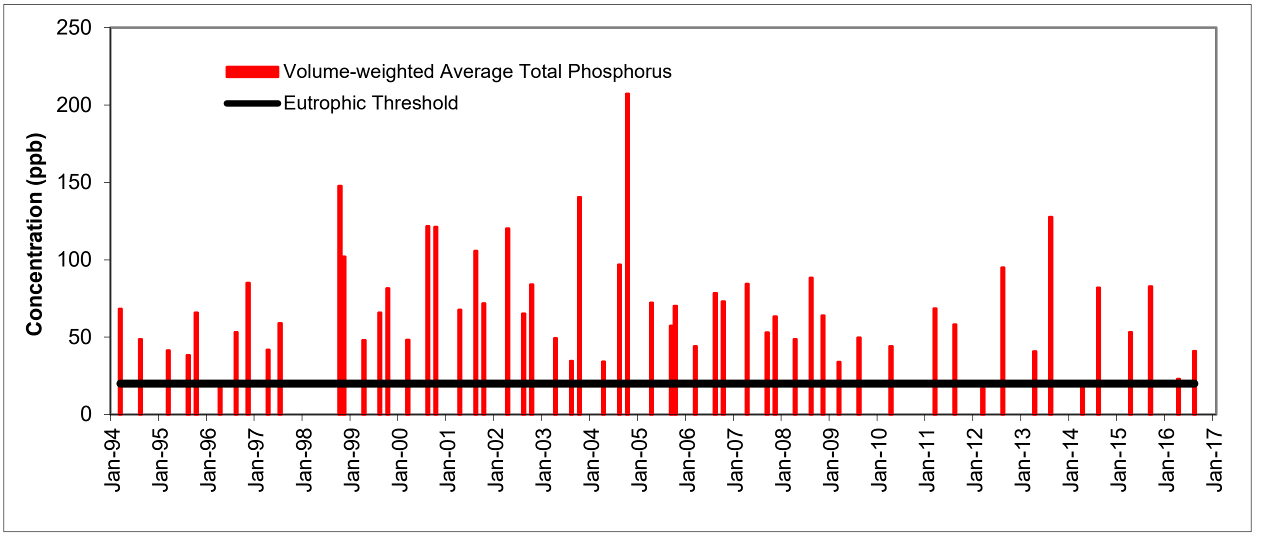

Figure 5. Volume-weighted average total phosphorus concentrations, 1994 - 2016.

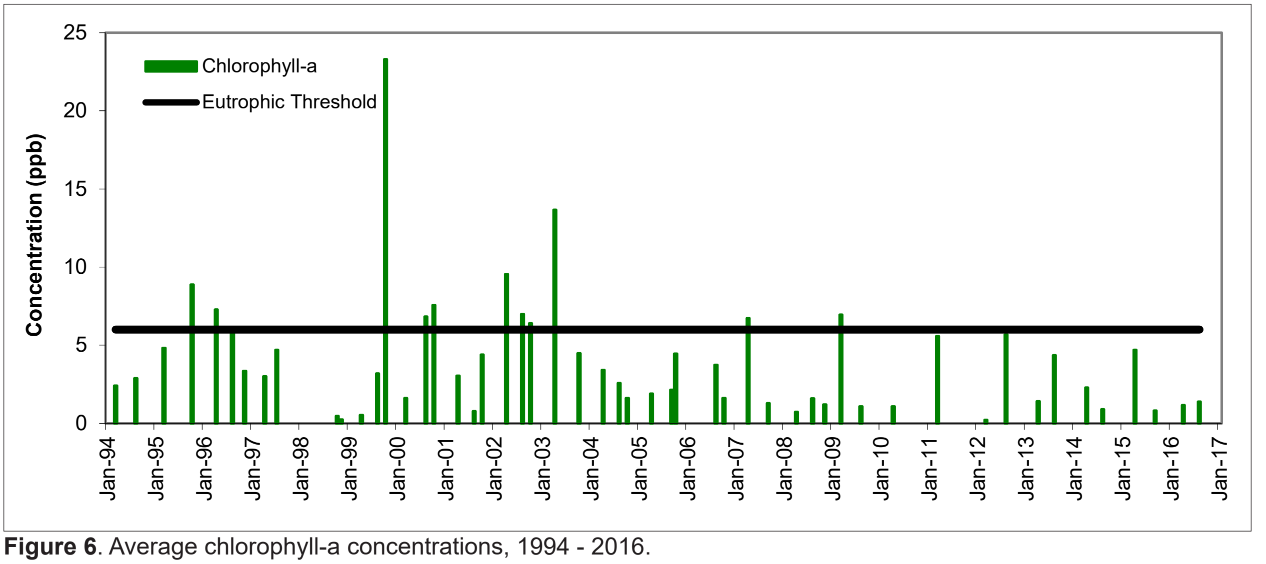

Figure 6. Average chlorophyll-a concentrations, 1994 - 2016.

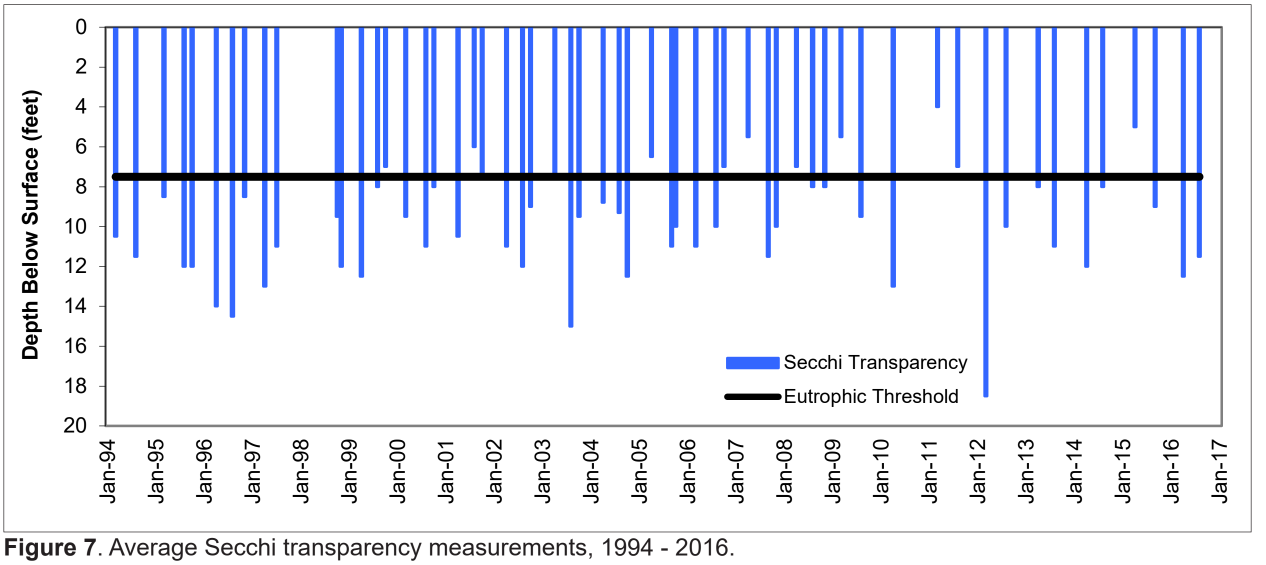

Figure 7. Average Secchi transparency measurements, 1994 - 2016.

TABLE 5
CAMP LAKE
SUMMARY STATISTICS (1994-2016)

	Total Phosphorus (µg/L)[1]	Chlorophyll-*a* (µg/L)[1]	Secchi Transparency (feet)
Mean	120	4	10
Standard Deviation	174	4	3
Median	46	3	10
Minimum	5	0	4
Maximum	1,020	23	19
Number of Samples	340	57	57

The April 2016 sampling occurred during spring turnover when temperature and dissolved oxygen levels were nearly uniform from the surface to the bottom. At 26 parts per billion, the average springtime total phosphorus concentration was above the eutrophic threshold concentration of 20 part per billion. The relatively high spring phosphorus levels indicate nutrient levels in Camp Lake are sufficient to support abundant aquatic plant growth.

The August 2016 sampling period occurred when the lake was thermally stratified. As would be expected, temperatures near the surface were significantly warmer than the deeper waters in the lake. Below a depth of about 20 feet, dissolved oxygen levels were depleted or nearly so. Since warm-water fish species require about 5 parts per million of dissolved oxygen to survive, the deeper waters of Camp Lake were not habitable by fish or many other aquatic organisms. The summertime deep-water oxygen depletion is an indication that Camp Lake is a highly productive and biologically active lake. The substantial build-up of phosphorus in in the deep waters of Camp Lake during summer thermal stratification indicates that internal release of phosphorus from anaerobic sediments is occurring in Camp Lake.

Water clarity in both spring and in late summer was moderate and chlorophyll-*a* values were low indicating minimal algae growth was occurring in the open waters of the lake at the time of sampling. These data are consistent with historical data collected from Camp Lake.

Although pH and alkalinity were not monitored in 2016, historical pH readings in Camp Lake have been within ranges typical for lakes in the Upper Midwest (Appendix A). Total alkalinity in Camp Lake has been in the moderate to high range indicating the lake is a well-buffered system not susceptible to the effects of acid rain.

Based on the data collected to date, Camp Lake would be classified as meso-eutrophic in that it has characteristics of a mesotrophic lake (moderate transparency and moderate to low chlorophyll-*a* levels) and a eutrophic lake (deep-water dissolved oxygen depletion, periodic high phosphorus levels and internal phosphorus release).

1 µg/L = micrograms per liter = parts per billion.

Appendix A
Camp Lake
Historical Water Quality Data

TABLE A1
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
31-Mar-94	1	9	41.0	8.8	42	7.8	147
31-Mar-94	1	12	41.0	8.9	90	7.6	147
31-Mar-94	1	25	41.0	8.7	48	7.4	151
31-Mar-94	1	37	41.0	4.2	83	7.0	150
31-Mar-94	1	50	39.5	1.1	119	6.9	164
18-Aug-94	1	1	74.0	9.1	7	9.2	77
18-Aug-94	1	10	71.5	8.8	9		
18-Aug-94	1	20	67.5	6.6	14		
18-Aug-94	1	30	52.0	0.2	27	8.1	133
18-Aug-94	1	40	47.5	0.0	268		
18-Aug-94	1	50	46.0	0.0	317	7.8	186
24-Mar-95	1	1	41.5	12.8	36		
24-Mar-95	1	10	41.0	12.7	41		
24-Mar-95	1	20	40.5	12.5	46		
24-Mar-95	1	30	40.0	12.5	47		
24-Mar-95	1	40	40.0	11.3	33		
24-Mar-95	1	50	40.0	11.0	43		
9-Aug-95	1	1	76.5	8.6	6		
9-Aug-95	1	10	75.5	8.5	6		
9-Aug-95	1	20	69.0	5.7	13		
9-Aug-95	1	30	56.0	0.5	6		
9-Aug-95	1	40	48.5	0.2	204		
9-Aug-95	1	50	48.0	0.0	349		

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
23-Oct-95	1	1	51.0	9.0	27		
23-Oct-95	1	10	50.0	8.7	27		
23-Oct-95	1	20	50.0	8.7	31		
23-Oct-95	1	30	50.5	8.8	41		
23-Oct-95	1	40	47.5	0.7	230		
23-Oct-95	1	50	45.0	0.0	509		
16-Apr-96	1	1	42.0	11.8	15		
16-Apr-96	1	10	42.0	11.9	25		
16-Apr-96	1	20	41.5	11.5	16		
16-Apr-96	1	30	42.5	11.4	18		
16-Apr-96	1	40	42.5	11.8	18		
16-Apr-96	1	50	42.5	11.5	19		
13-Aug-96	1	1	76.0	9.2	18		
13-Aug-96	1	10	76.5	9.0	9		
13-Aug-96	1	20	63.5	10.3	10		
13-Aug-96	1	30	51.0	0.6	11		
13-Aug-96	1	40	46.5	0.6	298		
13-Aug-96	1	50	45.0	0.4	411		
4-Nov-96	1	1	45.0	7.2	82		
4-Nov-96	1	10	46.0	7.1	79		
4-Nov-96	1	20	46.0	7.9	85		
4-Nov-96	1	30	45.5	7.3	84		
4-Nov-96	1	40	46.0	6.8	94		
4-Nov-96	1	50	44.5	5.6	137		

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3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
4-Apr-97	1	1	46.0	12.2	38		
4-Apr-97	1	10	46.0	12.1	51		
4-Apr-97	1	20	44.0	12.3	32		
4-Apr-97	1	30	43.5	10.4	36		
4-Apr-97	1	40	42.5	8.9	41		
4-Apr-97	1	50	42.5	6.4	86		
28-Jul-97	1	1	81.5	8.6	40		
28-Jul-97	1	10	80.5	8.3	13		
28-Jul-97	1	20	62.5	7.2	6		
28-Jul-97	1	30	51.0	5.9	25		
28-Jul-97	1	40	47.5	1.8	305		
28-Jul-97	1	50	45.0	0.7	356		
14-Oct-98	1	1	59.0	10.4	10		
14-Oct-98	1	10	59.5	9.5	10		
14-Oct-98	1	20	59.5	10.4	28		
14-Oct-98	1	30	53.0	1.8	105		
14-Oct-98	1	40	46.5	0.0	1,000		
14-Oct-98	1	50	45.0	0.0	550		
3-Nov-98	1	1	53.0	10.4	22		
3-Nov-98	1	10	54.0	10.5	35		
3-Nov-98	1	20	53.5	10.5	25		
3-Nov-98	1	30	50.0	9.2	39		
3-Nov-98	1	40	45.5	0.0	500		
3-Nov-98	1	50	45.0	0.0	800		

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TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
5-Apr-99	1	1	48.0	11.3	46		
5-Apr-99	1	10	47.5	11.8	52		
5-Apr-99	1	20	43.5	11.3	43		
5-Apr-99	1	30	42.0	11.0	43		
5-Apr-99	1	40	41.5	10.5	57		
5-Apr-99	1	50	41.5	8.3	57		
16-Aug-99	1	1	75.0	9.5	13		
16-Aug-99	1	10	74.0	9.5	20		
16-Aug-99	1	20	64.0	1.0	36		
16-Aug-99	1	30	48.5	0.6	71		
16-Aug-99	1	40	44.5	0.3	240		
16-Aug-99	1	50	44.0	0.0	419		
25-Oct-99	1	1	50.5	8.2	45		
25-Oct-99	1	10	50.5	8.1	47		
25-Oct-99	1	20	50.5	7.4	98		
25-Oct-99	1	30	50.0	7.5	50		
25-Oct-99	1	40	48.0	5.6	79		
25-Oct-99	1	50	44.5	0.0	676		
29-Mar-00	1	1	46.5	12.7	44		
29-Mar-00	1	10	46.5	12.9	49		
29-Mar-00	1	20	46.0	13.5	59		
29-Mar-00	1	30	44.5	12.0	46		
29-Mar-00	1	40	43.0	12.5	35		
29-Mar-00	1	50	43.0	11.2	46		

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TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
15-Aug-00	1	1	76.8	9.0	34		
15-Aug-00	1	10	76.6	8.9	55		
15-Aug-00	1	20	63.3	1.1	34		
15-Aug-00	1	30	49.1	1.2	165		
15-Aug-00	1	40	46.8	1.0	405		
15-Aug-00	1	50	45.9	1.1	732		
16-Oct-00	1	1	58.0	10.7	16		
16-Oct-00	1	10	58.0	5.8	44		
16-Oct-00	1	20	56.0	3.5	6		
16-Oct-00	1	30	52.5	0.0	180		
16-Oct-00	1	40	47.0	0.0	519		
16-Oct-00	1	50	46.0	0.0	677		
9-Apr-01	1	1	48.5	11.7	28		
9-Apr-01	1	10	47.0	11.1	58		
9-Apr-01	1	20	45.5	10.4	47		
9-Apr-01	1	30	42.5	7.6	111		
9-Apr-01	1	40	39.5	0.6	118		
9-Apr-01	1	50	39.5	0.2	144		
20-Aug-01	1	1	73.5	7.0	23		
20-Aug-01	1	10	73.0	7.0	58		
20-Aug-01	1	20	66.5	1.0	49		
20-Aug-01	1	30	49.5	1.0	127		
20-Aug-01	1	40	44.5	0.0	371		
20-Aug-01	1	50	43.5	0.0	469		

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
29-Oct-01	1	1	50.0	6.4	62		
29-Oct-01	1	10	50.0	6.4	55		
29-Oct-01	1	20	50.0	6.4	68		
29-Oct-01	1	30	49.5	6.3	66		
29-Oct-01	1	40	49.5	4.9	94		
29-Oct-01	1	50	44.5	0.6	271		
2-Apr-02	1	1	39.2	12	410		
2-Apr-02	1	10	39	12	46		
2-Apr-02	1	20	39	12	71		
2-Apr-02	1	30	39	12	48		
2-Apr-02	1	40	39	12	42		
2-Apr-02	1	50	39	12	34		
27-Aug-02	1	1	77.7	7	11		
27-Aug-02	1	10	76.3	7	14		
27-Aug-02	1	20	65.8	0.5	30		
27-Aug-02	1	30	48.6	0.3	105		
27-Aug-02	1	40	44.6	0.3	255		
27-Aug-02	1	50	43.5	0.3	276		
28-Oct-02	1	1	50.4	9.6	32		
28-Oct-02	1	10	50.5	9.3	33		
28-Oct-02	1	20	50.5	9.2	34		
28-Oct-02	1	30	50.5	9	37		
28-Oct-02	1	40	45.3	2	399		
28-Oct-02	1	50	44.1	1.6	454		

1 mg/L = milligrams per liter = parts per million.
2 µg/L = micrograms per liter = parts per billion.
3 S.U. = standard units.
4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
11-Apr-03	1	1	45.1	10.6	47		
11-Apr-03	1	10	40.5	10.0	65		
11-Apr-03	1	20	39.7	9.2	28		
11-Apr-03	1	30	39.6	9.0	54		
11-Apr-03	1	40	39.6	9.0	48		
11-Apr-03	1	50	39.7	8.6	49		
20-Aug-03	1	1	81.1	9.5	13		
20-Aug-03	1	10	77.2	12.6	22		
20-Aug-03	1	20	54.3	0.3	22		
20-Aug-03	1	30	47.1	0.6	42		
20-Aug-03	1	40	44.6	0.2	55		
20-Aug-03	1	45	43.2	0.1	261		
24-Oct-03	1	1	53.8	7.9	45		
24-Oct-03	1	10	53.6	7.5	41		
24-Oct-03	1	20	53.4	7.5	78		
24-Oct-03	1	30	52.2	2.5	146		
24-Oct-03	1	40	44.2	0.5	532		
24-Oct-03	1	50	43.3	1.0	771		
6-Apr-04	1	1	44	10.1	23		
6-Apr-04	1	10	44	10.5	23		
6-Apr-04	1	20	44	10.6	42		
6-Apr-04	1	30	42	9.5	32		
6-Apr-04	1	40	42	9.3	69		
6-Apr-04	1	50	42	8.7	48		

1 mg/L = milligrams per liter = parts per million.

2 μg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
27-Aug-04	1	1	72	8.8	19		
27-Aug-04	1	10	72	9.0	20		
27-Aug-04	1	20	63	0.8	23		
27-Aug-04	1	30	47	1.4	153		
27-Aug-04	1	40	45	1.5	454		
27-Aug-04	1	50	44	1.4	332		
25-Oct-04	1	1	54	9.4	14		
25-Oct-04	1	10	53	9.4	17		
25-Oct-04	1	20	53	9.2	703		
25-Oct-04	1	30	53	6.1	92		
25-Oct-04	1	40	45	2.1	237		
25-Oct-04	1	50	45	2.4	61		
14-Apr-05	1	1	51	14.5	54		
14-Apr-05	1	10	49	11.7	41		
14-Apr-05	1	20	42	11.3	56		
14-Apr-05	1	30	40	5.1	74		
14-Apr-05	1	40	39	1.4	177		
14-Apr-05	1	50	39	0.5	231		
12-Sep-05	1	1	75	9.0	15		
12-Sep-05	1	10	75	8.8	11		
12-Sep-05	1	20	66	1.1	27		
12-Sep-05	1	30	47	1.2	134		
12-Sep-05	1	40	43	1.6	30		
12-Sep-05	1	50	42	1.9	624		

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
31-Oct-05	1	1	54	8.9	43		
31-Oct-05	1	10	54	8.9	39		
31-Oct-05	1	20	54	8.9	25		
31-Oct-05	1	30	51	5.2	43		
31-Oct-05	1	40	44	0.3	246		
31-Oct-05	1	50	43	0.0	422		
23-Mar-06	1	1	40	11.0	39	8.4	149
23-Mar-06	1	10	40	10.4	47	8.0	145
23-Mar-06	1	20	40	10.2	41	7.8	145
23-Mar-06	1	30	40	10.0	57	7.8	146
23-Mar-06	1	40	40	10.0	33	8.0	144
23-Mar-06	1	50	40	9.9	36	7.8	145
17-Aug-06	1	1	77	9.2	25	8.6	146
17-Aug-06	1	10	77	8.8	28	8.5	144
17-Aug-06	1	20	63	3.7	31	8.5	147
17-Aug-06	1	30	48	0.5	58	8.5	145
17-Aug-06	1	40	45	0.2	328	8.4	149
17-Aug-06	1	50	44	0.0	502	8.2	148
30-Oct-06	1	1	49	8.5	56	8.0	132
30-Oct-06	1	10	48	8.2	49	7.9	135
30-Oct-06	1	20	48	8.3	54	8.2	132
30-Oct-06	1	30	48	8.1	56	7.9	137
30-Oct-06	1	40	47	4.3	138	7.6	144
30-Oct-06	1	50	44	0.7	411	7.4	161

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
17-Apr-07	1	1	41	12.1	98		
17-Apr-07	1	10	41	12.2	85		
17-Apr-07	1	20	41	12.1	87		
17-Apr-07	1	30	41	11.8	69		
17-Apr-07	1	40	41	11.7	78		
17-Apr-07	1	50	41	10.1	85		
5-Sep-07	1	1	79	9.5	24		
5-Sep-07	1	10	77	9.6	5		
5-Sep-07	1	20	64	1.2	12		
5-Sep-07	1	30	47	0.5	53		
5-Sep-07	1	40	43	0.5	190		
5-Sep-07	1	50	43	0.0	512		
8-Nov-07	1	1	50	7.6	26		
8-Nov-07	1	10	50	6.7	31		
8-Nov-07	1	20	50	7.8	34		
8-Nov-07	1	30	50	7.2	50		
8-Nov-07	1	40	45	6.1	311		
8-Nov-07	1	50	44	0.5	57		
10-Apr-08	1	1	42	10.4	47		
10-Apr-08	1	10	42	10.2	54		
10-Apr-08	1	20	42	9.8	45		
10-Apr-08	1	30	41	8.5	47		
10-Apr-08	1	40	41	8.5	45		
10-Apr-08	1	50	40	9.2	55		

1 mg/L = milligrams per liter = parts per million.

2 μg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
19-Aug-08	1	1	77	9.1	37	8.8	126
19-Aug-08	1	10	76	9.7	12	8.8	125
19-Aug-08	1	20	59	1.0	19	8.0	151
19-Aug-08	1	30	45	0.4	173	7.7	158
19-Aug-08	1	40	43	0.0	303	7.5	160
19-Aug-08	1	50	43	0.0	435	7.4	176
3-Nov-08	1	1	51	9.1	15		
3-Nov-08	1	10	50	8.7	11		
3-Nov-08	1	20	50	8.5	23		
3-Nov-08	1	30	50	7.8	15		
3-Nov-08	1	40	44	0.0	306		
3-Nov-08	1	50	43	0.0	617		
23-Mar-09	1	1	42	10.2	32		146
23-Mar-09	1	10	41	10.0	35		
23-Mar-09	1	20	41	9.4	30		
23-Mar-09	1	30	41	8.9	30		
23-Mar-09	1	40	40	8.4	43		
23-Mar-09	1	50	40	0.2	59		
25-Aug-09	1	1	74	8.5	5		
25-Aug-09	1	10	73	8.5	5		
25-Aug-09	1	20	60	2.7	12		
25-Aug-09	1	30	48	0.5	57		
25-Aug-09	1	40	45	0.3	224		
25-Aug-09	1	50	44	0.0	388		

1 mg/L = milligrams per liter = parts per million.

2 μg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
6-Apr-10	1	1	54	12.5	18		147
6-Apr-10	1	10	52	12.9	31		
6-Apr-10	1	20	50	12.6	23		
6-Apr-10	1	30	43	9.0	44		
6-Apr-10	1	40	41	4.2	88		
6-Apr-10	1	50	41	1.2	335		
30-Mar-11	1	1	42	18.6	43		
30-Mar-11	1	10	40	15.7	64		
30-Mar-11	1	20	39	6.9	60		
30-Mar-11	1	30	39	6.2	58		
30-Mar-11	1	40	39	2.9	96		
30-Mar-11	1	50	40	0.4	295		
29-Aug-11	1	1	76	6.4	10		
29-Aug-11	1	10	76	4.9	11		
29-Aug-11	1	20	60	0.7	7		
29-Aug-11	1	30	47	0.4	80		
29-Aug-11	1	40	44	0.0	250		
29-Aug-11	1	50	44	0.0	402		
20-Mar-12	1	1	55	13.2	13		
20-Mar-12	1	10	47	11.6	13		
20-Mar-12	1	20	43	11.8	16		
20-Mar-12	1	30	41	11.1	20		
20-Mar-12	1	40	41	11.0	27		
20-Mar-12	1	50	40	10.4	34		

1 mg/L = milligrams per liter = parts per million.
2 µg/L = micrograms per liter = parts per billion.
3 S.U. = standard units.
4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
30-Aug-12	1	1	77	10.3	8		
30-Aug-12	1	10	74	9.9	5		
30-Aug-12	1	20	62	2.9	42		
30-Aug-12	1	30	46	0.7	143		
30-Aug-12	1	40	44	0.0	422		
30-Aug-12	1	50	44	0.0	494		
25-Apr-13	1	1	44	11.2	37		
25-Apr-13	1	10	44	11.1	44		
25-Apr-13	1	20	44	11.5	39		
25-Apr-13	1	30	44	11.1	41		
25-Apr-13	1	40	42	10.1	43		
25-Apr-13	1	50	42	10.0	42		
28-Aug-13	1	1	79	9.8	46		
28-Aug-13	1	10	77	9.6	64		
28-Aug-13	1	20	62	1.6	49		
28-Aug-13	1	30	46	0.2	206		
28-Aug-13	1	40	44	0.0	337		
28-Aug-13	1	50	43	0.0	661		
30-Apr-14	1	1	50	11.7	18		
30-Apr-14	1	10	50	12.3	21		
30-Apr-14	1	20	49	11.3	17		
30-Apr-14	1	30	46	8.7	17		
30-Apr-14	1	40	42	6.6	30		
30-Apr-14	1	50	42	4.3	75		

1 mg/L = milligrams per liter = parts per million.

2 µg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A1 (continued)
CAMP LAKE
1994-2015 DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L $CaCO_3$)[4]
18-Aug-14	1	1	75	8.8	9		
18-Aug-14	1	10	75	8.5	15		
18-Aug-14	1	20	60	0.9	22		
18-Aug-14	1	30	47	0.4	126		
18-Aug-14	1	40	45	0.0	258		
18-Aug-14	1	50	44	0.0	753		
9-Apr-15	1	1	44	13.5	44		
9-Apr-15	1	10	44	13.6	43		
9-Apr-15	1	20	43	13.6	42		
9-Apr-15	1	30	41	8.0	54		
9-Apr-15	1	40	40	3.5	95		
9-Apr-15	1	50	39	0.6	141		
1-Sep-15	1	10	72	9.4	15		
1-Sep-15	1	20	68	4.2	20		
1-Sep-15	1	30	49	1.3	62		
1-Sep-15	1	40	44	0.5	292		
1-Sep-15	1	50	43	0	1,020		

1 mg/L = milligrams per liter = parts per million.

2 μg/L = micrograms per liter = parts per billion.

3 S.U. = standard units.

4 mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE A2
CAMP LAKE
1994-2015 SURFACE WATER QUALITY DATA

Date	Station	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[2]
31-Mar-94	1	10.5	2
18-Aug-94	1	11.5	3
24-Mar-95	1	8.5	5
09-Aug-95	1	12.0	0
23-Oct-95	1	12.0	9
16-Apr-96	1	14.0	7
13-Aug-96	1	14.5	6
04-Nov-96	1	8.5	3
04-Apr-97	1	13.0	3
28-Jul-97	1	11.0	5
14-Oct-98	1	9.5	0
03-Nov-98	1	12.0	0
5-Apr-99	1	12.5	1
16-Aug-99	1	8.0	3
25-Oct-99	1	7.0	23
29-Mar-00	1	9.5	2
15-Aug-00	1	11.0	7
16-Oct-00	1	8.0	8
9-Apr-01	1	10.5	3
20-Aug-01	1	6.0	1
29-Oct-01	1	7.5	4
8-Apr-02	1	11.0	10
27-Aug-02	1	12.0	7
28-Oct-02	1	9.0	6
11-Apr-03	1	7.5	14
20-Aug-03	1	15.0	0
24-Oct-03	1	9.5	4
6-Apr-04	1	8.8	3
27-Aug-04	1	9.3	3
25-Oct-04	1	12.5	2
14-Apr-05	1	6.5	2
12-Sep-05	1	11.0	2

TABLE A2 (continued)
CAMP LAKE
1994-2015 SURFACE WATER QUALITY DATA

Date	Station	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[2]
31-Oct-05	1	10.0	4
23-Mar-06	1	11.0	0
17-Aug-06	1	10.0	4
30-Oct-06	1	7.0	2
17-Apr-07	1	5.5	7
5-Sep-07	1	11.5	1
8-Nov-07	1	10.0	0
10-Apr-08	1	7.0	1
19-Aug-08	1	8.0	2
3-Nov-08	1	8.0	1
23-Mar-09	1	5.5	7
25-Aug-09	1	9.5	1
6-Apr-10	1	13.0	1
30-Mar-11	1	4.0	6
29-Aug-11	1	7.0	0
20-Mar-12	1	18.5	0
30-Aug-12	1	10.0	6
25-Apr-13	1	8.0	1
28-Aug-13	1	11.0	4
30-Apr-14	1	12.0	2
18-Aug-14	1	8.0	1
9-Apr-15	1	5.0	5
1-Sep-15	1	9.0	1

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