THE ALBERTA LAKE MANAGEMENT SOCIETY

VOLUNTEER LAKE MONITORING PROGRAM

2014 Crane Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

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LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch Reports are designed to summarize basic lake data in understandable terms for a lay audience and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeWatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Ron Young for his assistance with sampling Crane Lake in 2014. We would also like to thank Jackson Woren, Brittany Kereliuk, and Kara MacAulay who were summer technicians with ALMS in 2014. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Mike Bilyk was involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Jackson Woren and Bradley Peter. Alberta Environment, the Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), and Environment Canada, were major sponsors of the program.

CRANE LAKE:

Figure 1 - Evening sunset on Crane Lake 2014. Photo taken by Kara MacAulay

Crane Lake was originally named Moore Lake, after Dr. Bromley Moore, a former president of the College of Physicians and Surgeons and a friend of the surveyor Marshall Hopkins[1]. Moore Lake is locally referred to as Crane Lake.

Crane Lake is a medium sized (surface area = 9.28 km^2) and deep (max depth = 26 m, mean depth = 8.3 m) water body located in the Beaver River Watershed (Figure 1, 2). Crane Lake is located in Alberta's Lakeland Region, and is valued for its clear water and natural shoreline. The lake is situated about 280 km northeast of Edmonton in the municipal district of Bonnyville. The town of Bonnyville, south of the lake, and Cold Lake, east of the lake, are the principal urban centers of the area.

Most of Crane Lake's shoreline is Crown Land. Two former Provincial Areas, Crane Lake East and West, have been disestablished and divested to the Municipal District of Bonnyville. There are two commercial resorts on the south shore.

Crane Lake is a headwater lake with a small drainage basin that is only four times the size of the lake. The only inlets are two minor streams: one on the northeast shore and one on the west shore.

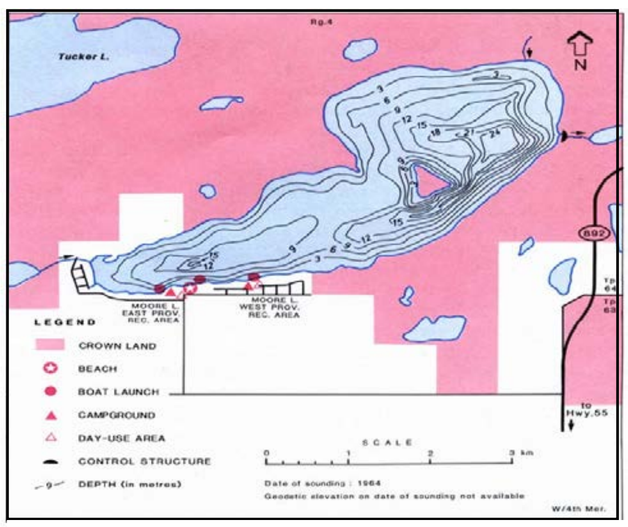

Figure 2 – Bathymetric map of Crane Lake (Mitchell and Prepas 1990).

The outlet flows from the east shore into nearby Hilda and Ethel Lakes and eventually into the Beaver River. Sport fish species in the lake are northern pike (*Esox lucius)*, yellow perch (*Perca flavescens)*, and burbot (*Lota lota)*. Significant growth of aquatic vegetation is limited only to a few areas, such as in the west basin; the lack of extensive vegetation limits fish spawning and feeding habitat in the lake.

[1] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

Crane Lake is located in the rolling morainal plain in the dry-mixedwood natural subregion of the Boreal Forest natural region.[2] The main tree species in the watershed include jack pine on well-drained soils, trembling aspen on moderately drained soils, and black spruce and willows on poorly drained soils. Large wetlands are located along the two inflows at the south end of the lake. Agricultural activity in the drainage basin is limited by undesireable soil structure and a relatively short growing season. Most of the cultivated land is located south of the lake. The main agricultural activity is cattle grazing and a limited number of grazing permits and leases have been issued for Crown land in the drainage basin.

In May 2012 Birchwood Resources Inc. announced plans for an in situ crude bitumen production facility and associated well pad next to Crane Lake[3]. This project is a low pressure Steam Assisted Gravity Drainage ("SAGD") pilot project predicted to process 795 m^3 of bitumen per day. The total footprint of the project is estimated to be ~20 hectares.

Figure 3 - A whitening event captured at Crane Lake in the open water season in 2014. Picture taken by Kara MacAulay.

Crane Lake is known to have a very unique change in water colour during the course of the open water season (Figure 3). This is known as 'whitening events' and occurs when tiny organisms called picoplankton photosynthesize and increase the pH around them, causing calcium to precipitate and create a bright blue/green colour[4]. This event is benign and typically occurs at the height of picoplankton biomass, but may or may not occur every year. Similar events have been observed at Minnie and Marie Lake.

WATER LEVELS:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake. Requests for water quantity monitoring should go through Environment and Sustainable Resource Developments Monitoring and Science division.

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[2] Nat. Regions Committee, 2006. Nat. Regions and Subregions of AB. Compiled by D.J. Downing and WW Pettapiece. GoA Pub. No. T/852

[3] Birchwood Resources Inc. 2012. Proposed Sage Thermal Pilot Project – Public Disclosure May 2012.

[4] Dittrich, M., Obst, M. 2004. Are picoplankton responsible for calcite precipitation in lakes? *Ambio.* Dec; 33(8): 559-564.

Water levels in Crane Lake have shown a general trend towards decline since sampling began in 1980 (Figure 4). However, this decline amounts to only 0.4 m in elevation. Periods of high surface run-off have offered temporary reprieve from declining levels, namely in 1997 when a maximum of 549.7 meters above sea level (m asl) was reached, and in 2007, when the lake was restored to 549.5 m asl. High levels of run-off in the past couple years have likely resulted in the upward trend observed from 2009-2011. Data from Environment Canada was only available until 2011.

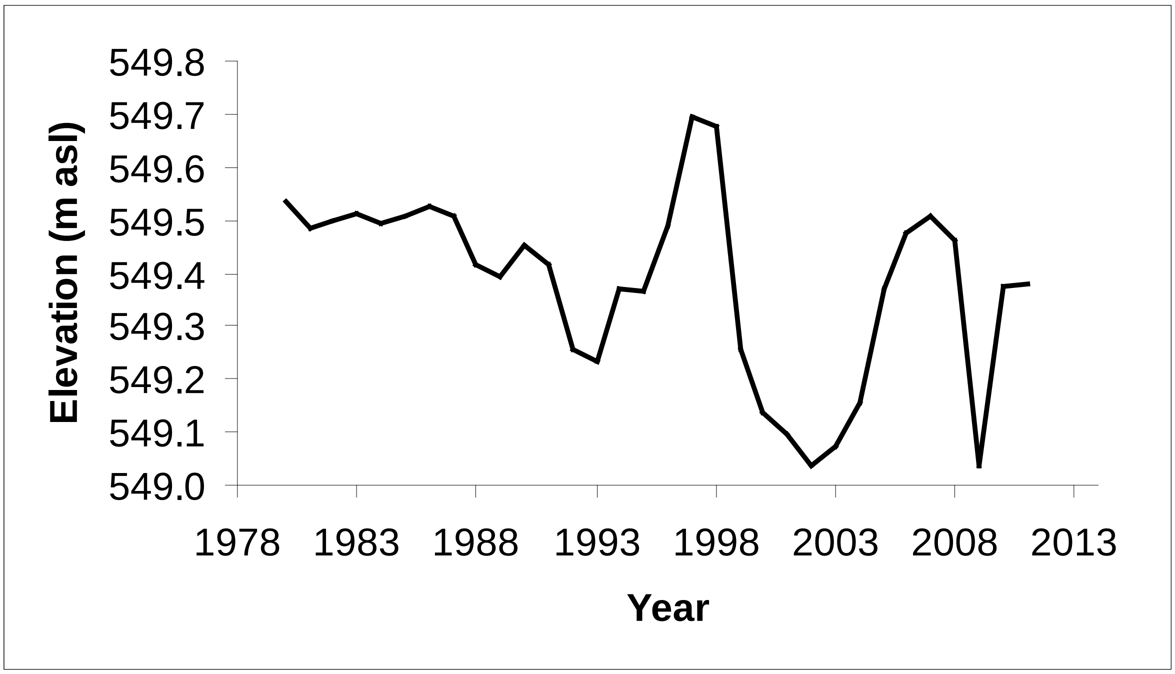


Figure 4 – Water levels measured in meters above sea level (m asl) from 1980-2011. Data retrieved from Environment Canada.

WATER CLARITY & SECCHI DEPTH:

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

Average Secchi depth at Crane Lake measured 3.65 m in the summer of 2014 (Table 1). An average of 3.65 m falls within the historical variation observed at Crane Lake. Secchi disk measurements were taken early in the mornings and ranged from a minimum of 1.5 m on August 25th to a maximum of 5.9 m on July 4th (Figure 5). Crane Lake has low concentrations of chlorophyll-*a* (phytoplankton) and total suspended solids which results in high water clarity measurements.

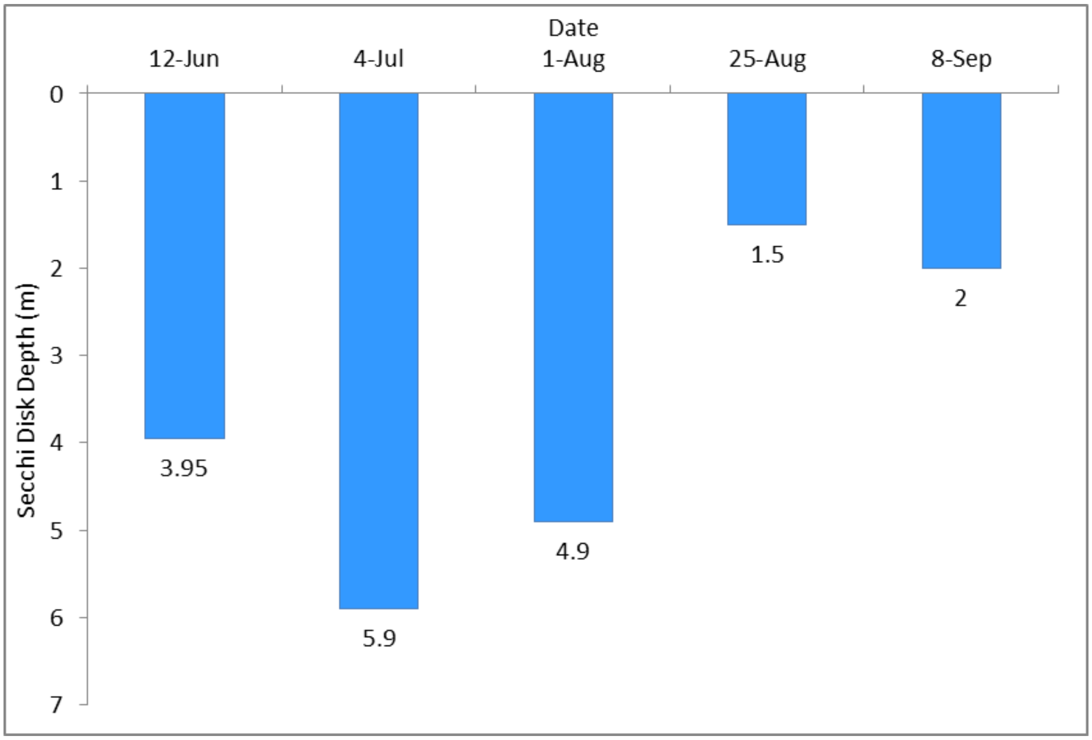


Figure 5 – Secchi disk depth values (m) measured five times at Crane Lake during the summer of 2014.

WATER TEMPERATURE AND DISSOLVED OXYGEN:

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Crane Lake remained strongly stratified throughout the summer of 2014 (Figure 6a). Surface water temperatures measured a maximum of 22.84 °C on August 1st and a minimum of 13.84°C on June 12th. The start of the thermocline in Crane Lake varied, beginning at 5.00 m on both June 12th and July 4th, and 9.00 m on September 8th. On September 8th, the thermocline became reduced, suggesting that by later in the fall the lake likely becomes a uniform temperature, allowing for a turn-over in the water column.

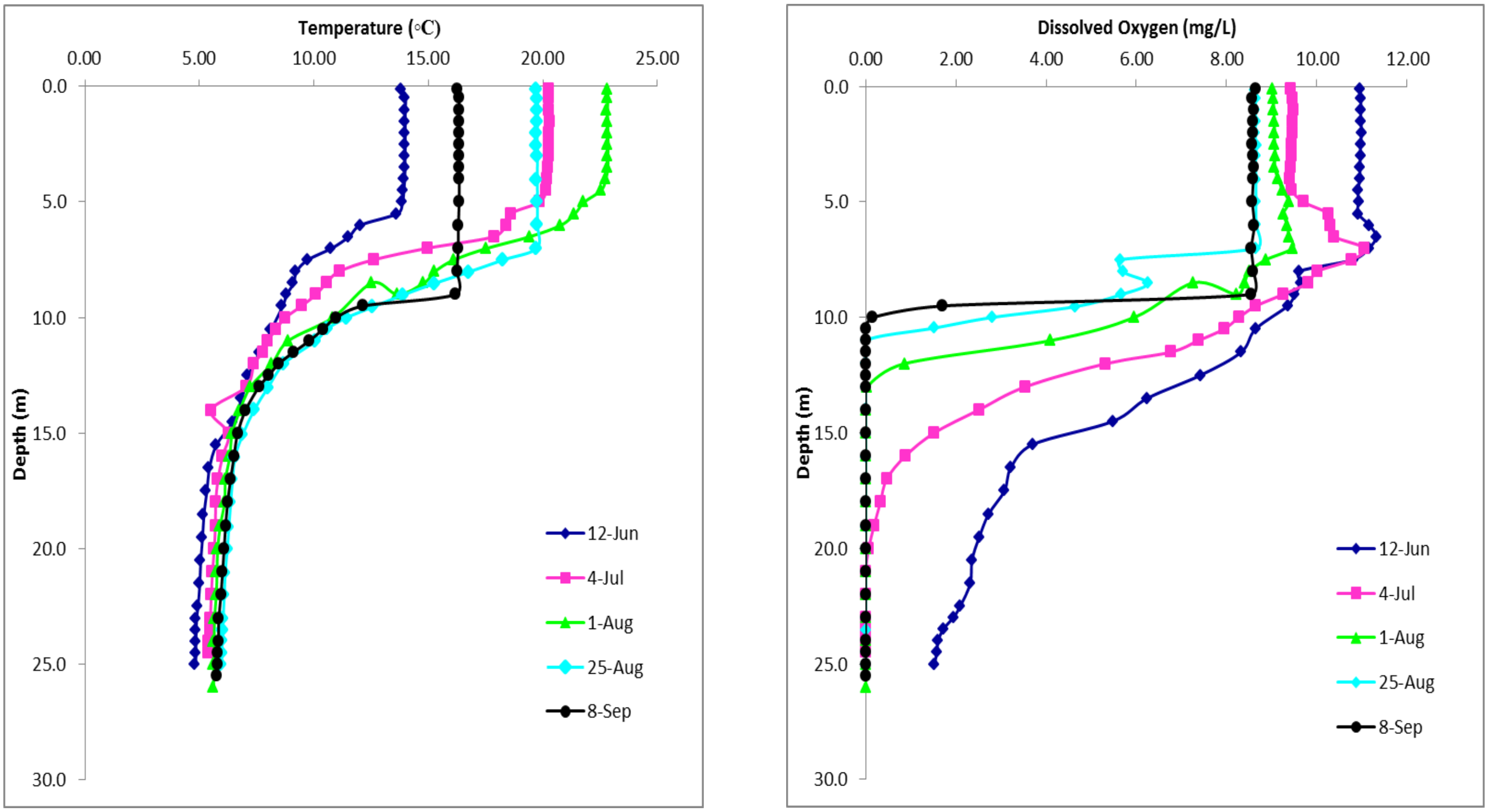


Figure 6 - a) Water temperature (°C) and b) dissolved oxygen concentrations (mg/L) measured five times over the course of the summer at the profile spot at Crane Lake.

Because of the strong thermal stratification observed on each of the sampling trips, dissolved oxygen concentrations are also strongly stratified in Crane Lake (Figure 6b). As is typical of deep lakes, dissolved oxygen concentrations at the surface were high and well above the Canadian Council for Ministers of the Environment (CCME) guideline for the Protection of Aquatic Life (PAL) of 6.5 mg /L. Below the thermocline, dissolved oxygen concentrations dropped dramatically: anoxia occurred as early as 10.00 m on September 8th. Low oxygen levels below the thermocline are a combination of a separation from atmospheric oxygen and the oxygen-consuming decomposition process that occurs at the lake sediments. Increases in dissolved oxygen levels between 5 m and 10 m depths can be explained by a metalimnetic bloom of picoplankton which may be responsible for the whitening event observed in 2014.

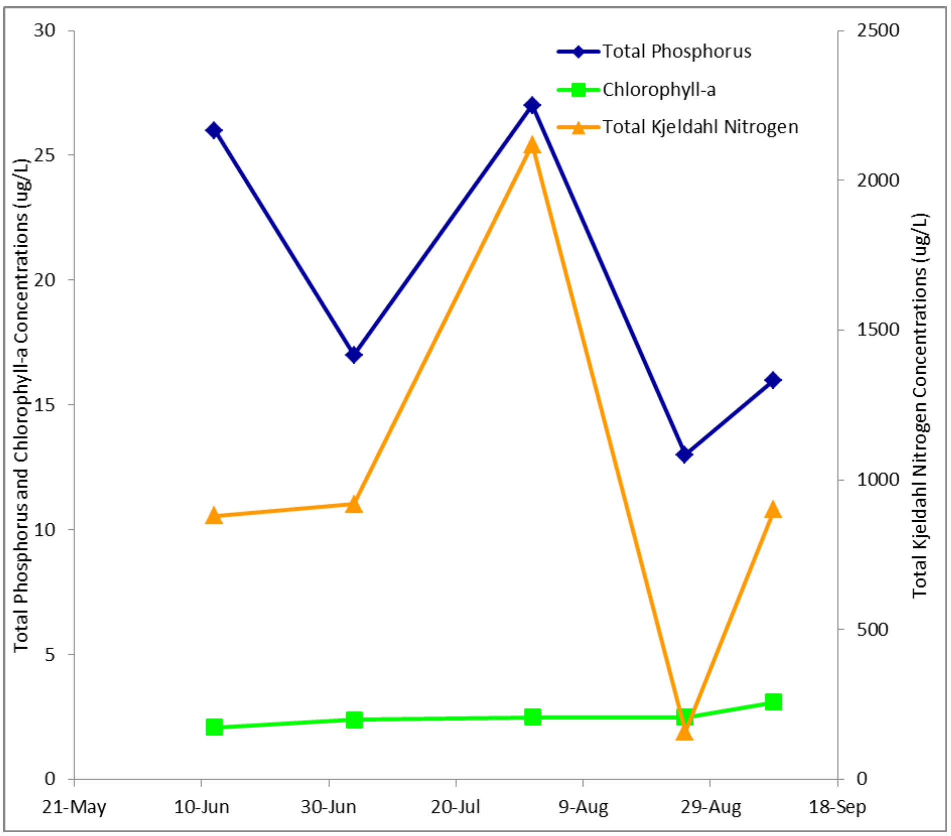
WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorus, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are

Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

Average total phosphorus (TP) concentrations in Crane Lake measured 19.8 µg/L in 2014 (Table 1). This value falls into the mesotrophic, or moderately productive classification, and lies well within the historical variation measured at Crane Lake. Management efforts should try to maintain a mesotrophic TP concentration at Crane Lake, as the current average value nears 30 µg/L, which is the cut-off between a mesotrophic and eutrophic classification. Throughout the summer, TP concentration ranged from a minimum of 13 µg/L on August 25th to a maximum of 26 µg/L on June 12th (Figure 7).

Chlorophyll-*a* concentration remained low throughout the summer of 2014, measuring an average of 2.52 µg/L. An average of 2.52 µg/L falls into the oligotrophic, or low productivity, classification, and on the low side of the historical variation measured at Crane Lake. Throughout the summer, chlorophyll-*a* concentration ranged from a minimum of 2.1 µg/L on June 12th to a maximum of 3.1 µg/L on September 8th.



Finally, total Kjeldahl nitrogen (TKN) concentration measured an average of 900 µg/L in 2014 (Figure 7). This value lies in the middle of the historical variation measured at Crane Lake and falls into the eutrophic classification. However, given the nutrient requirements of algae and cyanobacteria, phytoplankton growth in Crane Lake is likely limited by the amount of phosphorus, not nitrogen, in the water.

Average pH measured 8.804 in 2014 and changed relatively little throughout the open water season. Crane Lake is well buffered, with a high alkalinity (450.4 mg/L $CaCO_3$) and bicarbonate (549.4 mg/L HCO_3) concentration. Conductivity in Crane Lake is also high, measuring 914 µS/cm in 2014. Contributing to the high conductivity are sodium (134.66 mg/L), chloride (30.7 mg/L) and magnesium (40.133 mg/L).

Metals were sampled for twice throughout the summer and all values fell within their respective guidelines except for silver (Table 2). More monitoring should be conducted at Crane Lake to establish if there has been an increase in the concentration of silver in the past year.

MICROCYSTIN:

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 µg/L.

In 2014, concentrations of microcystin reached an observed maximum of 0.08 µg/L on all sampling dates except for August 25th where the concentration was 0.07 µg/L. The seasonal average of microcystin concentration was 0.08 µg/L. It was not determined what species of cyanobacteria is dominant at Crane Lake. Caution should always be taken when recreating in waters experiencing cyanobacteria blooms.

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2014, no zebra or quagga mussels were detected in Crane Lake.

Table 1 – Average Secchi disk depth and water chemistry values for Crane Lake. Previous years averages are provided for comparison.

Parameter	1980	1981	1997	2005	2006	2007	2008	2009	2010	2011	2013	2014
TP (µg/L)	/	26.8	23	24	23.25	22	22.5	19.25	28.7	25	25.6	19.8
TDP (µg/L)	/	11	10	10.6	10.75	10	12.25	11.5	11.3	13.8	12.8	8.8
Chlorophyll-*a* (µg/L)	7.9	8.2	7	7.06	4.77	3.59	2.45	2.28	2.31	6.33	3.18	2.52
Secchi depth (m)	2.7	3.3	3.5	3.22	2.88	3.15	4	3.81	3.75	3.69	3.55	3.65
TKN (µg/L)	1240	940	970	982	980	856	932.5	745	956.7	970	1282	900
NO_2 and NO_3 (µg/L)	5	3	8	5.5	5.88	3.33	2.5	5.1	3.67	5.38	4.1	22
NH_3 (µg/L)	29	22	7	9.6	14	13.4	9.75	15	15.3	11.3	12.8	23.2
DOC (mg/L)	14.5	13.8	/	13.7	13.65	13.87	13.4	13.77	13.17	12.8	20.73	13.7
Ca (mg/L)	16.6	16.7	15.7	13.67	15.15	15.4	15.37	14.73	12.73	14.4	14.17	16.37
Mg (mg/L)	41	39.8	48	41.83	47.65	49.27	50.37	47.2	51.37	50.4	53.53	40.13
Na (mg/L)	89	81	116	125.3	112.2	123.67	124.3	125.3	133.3	121	129	134.67
K (mg/L)	6.6	7.7	7.8	8.13	8.2	8.43	8.13	8.27	7.83	5.67	8.47	8.34
SO_4^{2-} (mg/L)	18	20.5	27.9	24	28	25.7	29.67	34.67	26.67	20.7	22.3	26.33
Cl^- (mg/L)	20.7	21	26.2	29.3	29.65	30.43	30.3	30.6	30.83	30	30.3	30.7
CO_3 (mg/L)	0.22	/	39	41	40.5	43.3	42.67	42.3	37	40.75	41.2	45.44
HCO_3 (mg/L)	/	/	415	457.3	459	460.67	468.67	467.3	480	470.5	412.6	549.4
pH	/	/	8.9	8.92	8.94	8.88	8.89	8.94	8.89	8.95	9.08	8.80
Conductivity (µS/cm)	8.7	8.5	822	842.3	873	862	869.67	867.33	893.33	890	819	914
Hardness (mg/L)	724	704	233	206.67	234	241.3	245.67	231.3	243	243	256	205
TDS (mg/L)	/	/	482	508.67	507	523	531.67	533	536.3	515	543.3	556
Microcystin (µg/L)	/	/	/	0.162	0.39	0.13625	0.0975	0.1275	0.087	0.09	0.07	0.08
Total Alkalinity (mg/L $CaCO_3$)	354	356	400	443.3	444	450.3	455.7	454	456	454	407.4	450.4

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, DOC = dissolves organic carbon, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate TDS = total dissolved solids. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Crane Lake on August 1st and September 8th 2014. Values shown for 2014 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Guidelines**
Aluminum μg/L	2.1	9.07	5.36	8.86	7.95	4.365	9.065	4.75	14.91	5.45	100[a]
Antimony μg/L	0.03	0.03	0.029	0.0423	0.0308	0.0308	0.02675	0.0333	0.0279	0.03	6[e]
Arsenic μg/L	4.27	3.02	3.66	4.48	3.67	3.06	3.075	3.73	2.905	4.155	5
Barium μg/L	13.4	14.4	14.4	13.8	14	13.25	13.35	13.35	13.2	11.21	1000[e]
Beryllium μg/L	0.003	0.003	<0.003	<0.003	<0.003	0.00475	0.0015	0.01195	0.0065	0.004	100[d,f]
Bismuth μg/L	0.0005	0.001	0.002	0.004	0.0019	0.0005	0.0005	0.0005	0.0005	0.01925	/
Boron μg/L	255	327	276	289	310.5	300.5	306.5	324.5	293	307	5000[ef]
Cadmium μg/L	0.01	0.005	0.01	0.0131	0.0117	0.0129	0.0059	0.0088	0.0061	0.006	0.085[b]
Chromium μg/L	0.24	0.359	0.217	0.405	0.472	0.1824	0.197	0.32	0.2815	0.765	/
Cobalt μg/L	0.01	0.025	0.013	0.015	0.0203	0.0089	0.0015	0.00765	0.0118	0.0075	1000[f]
Copper μg/L	0.25	0.38	0.238	1.31	0.294	0.24	0.451	0.4475	0.287	0.195	4[c]
Iron μg/L	6.5	6	6.81	8.8	19.9	5.175	2.6	2.92	14.005	13.8	300
Lead μg/L	0.05	0.066	0.1	0.0345	0.0132	0.01405	0.0208	0.00835	0.0764	0.0065	7[c]
Lithium μg/L	65.7	72.5	61.8	62.1	73.1	66.05	68.35	70.4	66.95	67.7	2500[g]
Manganese μg/L	1.8	1.7	2.45	1.87	1.32	1.36	1.385	1.48	1.265	1.341	200[g]
Molybdenum μg/L	3.19	3.59	3.15	3.23	3	2.9	2.715	2.79	2.655	2.455	73[d]
Nickel μg/L	0.01	0.092	0.064	<0.005	0.132	0.06375	0.0025	0.0025	0.05035	0.009	150[c]
Selenium μg/L	0.19	0.52	0.416	0.721	0.433	0.364	0.5245	0.2945	0.219	0.455	1
Silver μg/L	0.001	0.001	<0.0005	0.0014	0.0038	0.000875	0.00025	0.000375	0.007275	0.1275	0.1
Strontium μg/L	68	75.2	73.8	69	69.9	69.2	67.4	68.45	66.75	56.55	/
Thallium μg/L	0	0.01	0.002	0.0018	0.0031	0.00125	0.00015	0.0004	0.000475	0.00285	0.8
Thorium μg/L	0.004	0.006	0.018	0.0197	0.0008	0.005075	0.00345	0.00015	0.0032	0.047375	/
Tin μg/L	0.02	0.03	<0.03	<0.03	<0.03	0.015	0.015	0.03125	0.015	0.0225	/
Titanium μg/L	0.61	0.79	0.07	0.744	0.574	0.5875	0.5195	0.5035	0.973	0.545	/
Uranium μg/L	0.19	0.21	0.206	0.208	0.179	0.1815	0.176	0.1785	0.172	0.1675	100[e]
Vanadium μg/L	0.15	0.25	0.21	0.235	0.268	0.181	0.1865	0.1845	0.216	0.355	100[f,g]
Zinc μg/L	2.08	2.5	0.751	0.362	0.329	0.66	0.4815	0.468	0.6575	0.5	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5; calcium ion concentrations $[Ca^{+2}] \geq 4$ mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.
[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)
[c] Based on water hardness > 180mg/L (as $CaCO_3$)
[d] CCME interim value.
[e] Based on Canadian Drinking Water Quality guideline values.
[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[g] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.
Red text indicates value that exceeded CCME guidelines.

A BRIEF INTRODUCTION TO LIMNOLOGY

INDICATORS OF WATER QUALITY:

Water samples are collected in LakeWatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in LakeWatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

TEMPERATURE AND MIXING:

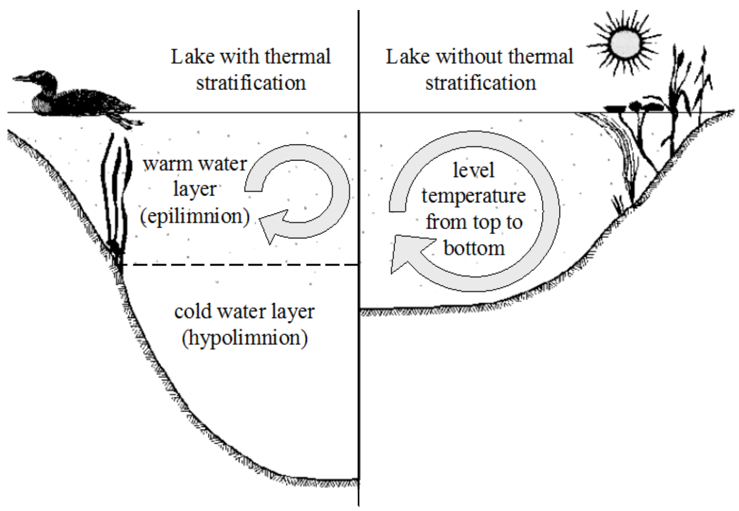


Figure A: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

DISSOLVED OXYGEN:

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

GENERAL WATER CHEMISTRY:

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

PHOSPHORUS AND NITROGEN:

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

CHLOROPHYLL-*A*:

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

SECCHI DISK TRANSPARENCY:

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

TROPHIC STATE:

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic (Table 2)**.

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

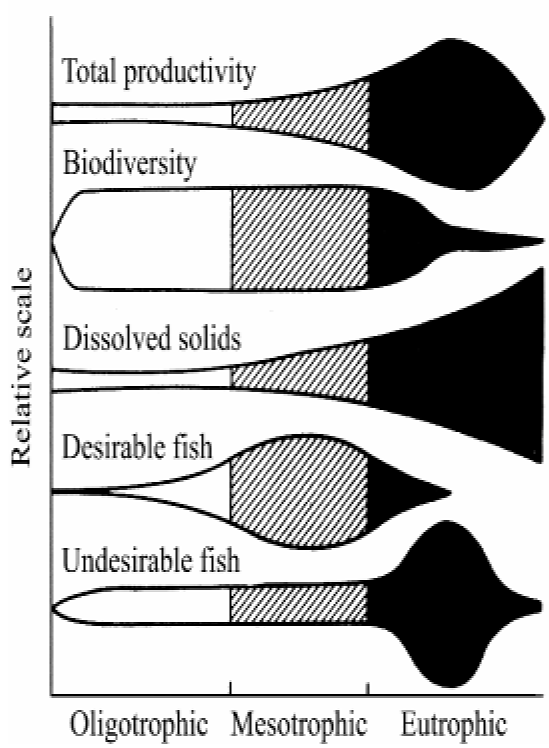


Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll *a* (µg•L^{-1})	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1