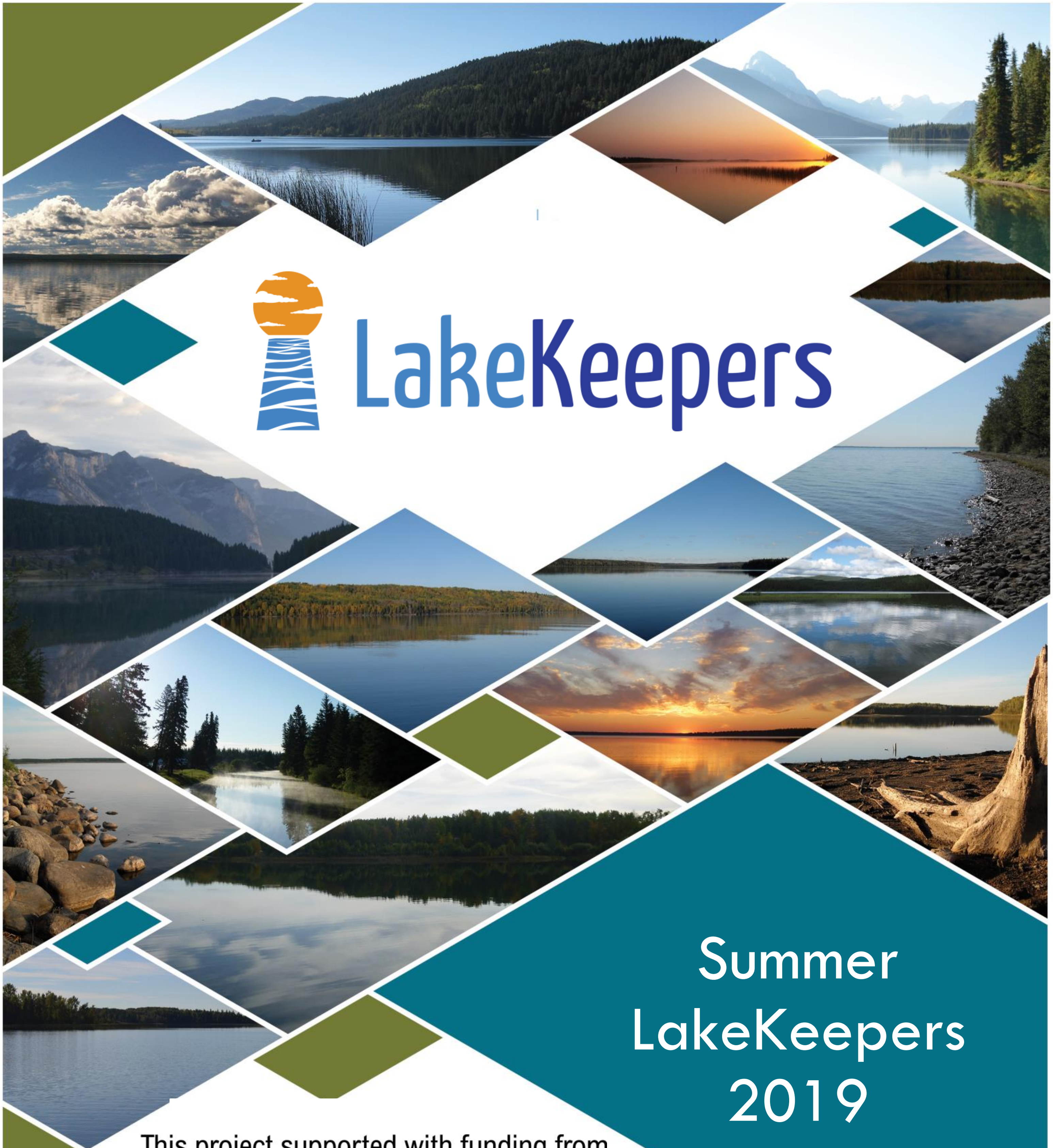

LakeKeepers

Summer LakeKeepers 2019

This project supported with funding from

alberta ecotrust

ALBERTA LAKE MANAGEMENT SOCIETY'S OBJECTIVES

The Alberta Lake Management Society (ALMS) has several 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.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeKeepers program. These leaders in stewardship give us hope that our water resources will not be the limiting factor in the health of our environment.

ACKNOWLEDGEMENTS

The LakeKeepers project was made possible with support from Alberta Ecotrust.

We would like to thank the volunteers from Graham Lake, Haig Lake, Snipe Lake, Swan Lake, Lac La Nonne, Tait Lake, Westover Lake, and Beauvais Lake. We would also like to thank the Mighty Peace Watershed Alliance for their assistance with coordinating volunteers and sample shipment. A special thanks to Cerina Lee for developing the LakeKeeper training videos. This report has been prepared by Bradley Peter and Caleb Sinn.

EXECUTIVE SUMMARY

In 2018, the Alberta Lake Management Society (ALMS), with financial support from Alberta Ecotrust, piloted the LakeKeepers project. This project was designed to enable stewards to conduct lake monitoring by providing them with training and sampling equipment. In the first Summer LakeKeepers season in 2018, five lakes were sampled for a total of 14 monitoring trips. To see the results of the Summer LakeKeepers 2018 sampling program, find the report on our website (https://alms.ca/reports/).

In early 2019, ALMS expanded this program to include winter under-ice sampling, with the cooperation of ice anglers. The addition of winter sampling to ALMS' programs addresses the gap in knowledge of year round processes that affect eutrophication of Alberta lakes. To see the results of the Winter LakeKeepers 2019 sampling program, find the report on our website (https://alms.ca/reports/).

Continuing with the LakeKeepers program in 2019, eight lakes participated in Summer LakeKeepers 2019: Graham Lake, Haig Lake, Snipe Lake, Swan Lake, Lac La Nonne, Tait Lake, Westover Lake, and Beauvais Lake. In total, 21 monitoring trips were completed by 14 volunteers across five different major watersheds throughout the province.

Lakes were monitored for clarity, microcystin, chlorophyll-a, total phosphorus, total nitrogen, and temperature. Some lakes were also monitored for dissolved oxygen. Results indicated that the eight lakes fell into four trophic categories based on average total phosphorus (oligotrophic, mesotrophic, eutrophic, and hypereutrophic) and four categories based on average chlorophyll-*a* (oligotrophic, mesotrophic, eutrophic, and hypereutrophic). Results also indicated that none of the samples collected had harmful levels of the cyanobacteria toxin microcystin. Each lake also displayed unique temperature profiles and water clarity across the open water season, which further highlights the diversity of lakes within Alberta.

More quality control work is required to assess the agreement between volunteer samples and samples collected by ALMS staff. Future work may involve a comparison between LakeKeepers and LakeWatch sampling methods, refinement of the sampling protocol, and the inclusion of additional parameters collected. Future Summer LakeKeeper seasons may also involve transitioning more LakeKeepers kits to include YSI meters in order to increase the quality and frequency of temperature readings, and to expand to collecting more parameters, such as dissolved oxygen. Three of the eight lakes part of Summer LakeKeepers 2019 were sampled with YSI ProODO meters.

This report was updated May 8 2020 to correct the Secchi disk depth from Snipe Lake 2018.

INTRODUCTION

In 2018, the LakeKeepers program was run as a pilot project by ALMS. This program is intended to complement the existing LakeWatch program by bringing a less intensive monitoring program to lakes inaccessible by LakeWatch. The program continued through the winter of 2019 and then to the summer of 2019, where eight lakes which exhibit a wide range in size and depth were selected for the LakeKeeper program based on volunteer availability: Graham Lake, Haig Lake, Snipe Lake, Swan Lake, Lac La Nonne, Tait Lake, Westover Lake, and Beauvais Lake (Table 1, Figure 1). This is three more lakes sampled than the lakes sampled in the Summer LakeKeepers 2018 season. Haig Lake and Snipe Lake are the only two lakes sampled both in the 2018 and 2019 Summer LakeKeepers programs. As of the Summer LakeKeepers 2019 season, no lake has been sampled in both the Summer and Winter LakeKeepers programs.

Education day at Figure Eight Lake, 2018.

Table 1. The major watershed, location, surface area (km^2) and maximum depth (m) of the eight Summer LakeKeepers 2019 lakes.

Lake Data	Major Watershed	Site GPS	Surface Area (km2)	Max Depth*
Graham Lake	Peace River	56.56755, -114.53743	41.10	Unknown
Haig Lake	Peace River	56.89444, -116.10806	9.15	9
Snipe Lake	Peace River	55.13542, -116.77030	41.50	6
Swan Lake	Peace River	55.05989, -117.81322	1.55	Unknown
Lac La Nonne	Athabasca River	53.93938, -114.31990	12.70	20
Tait Lake	Red Deer River	52.54907, -113.27772	0.11	Unknown
Westover Lake	Bow River	51.11152, -114.73708	0.32	Unknown
Beauvais Lake	Oldman River	49.41259, -114.10596	0.89	11

**Max depth based on historical bathymetric surveys.*

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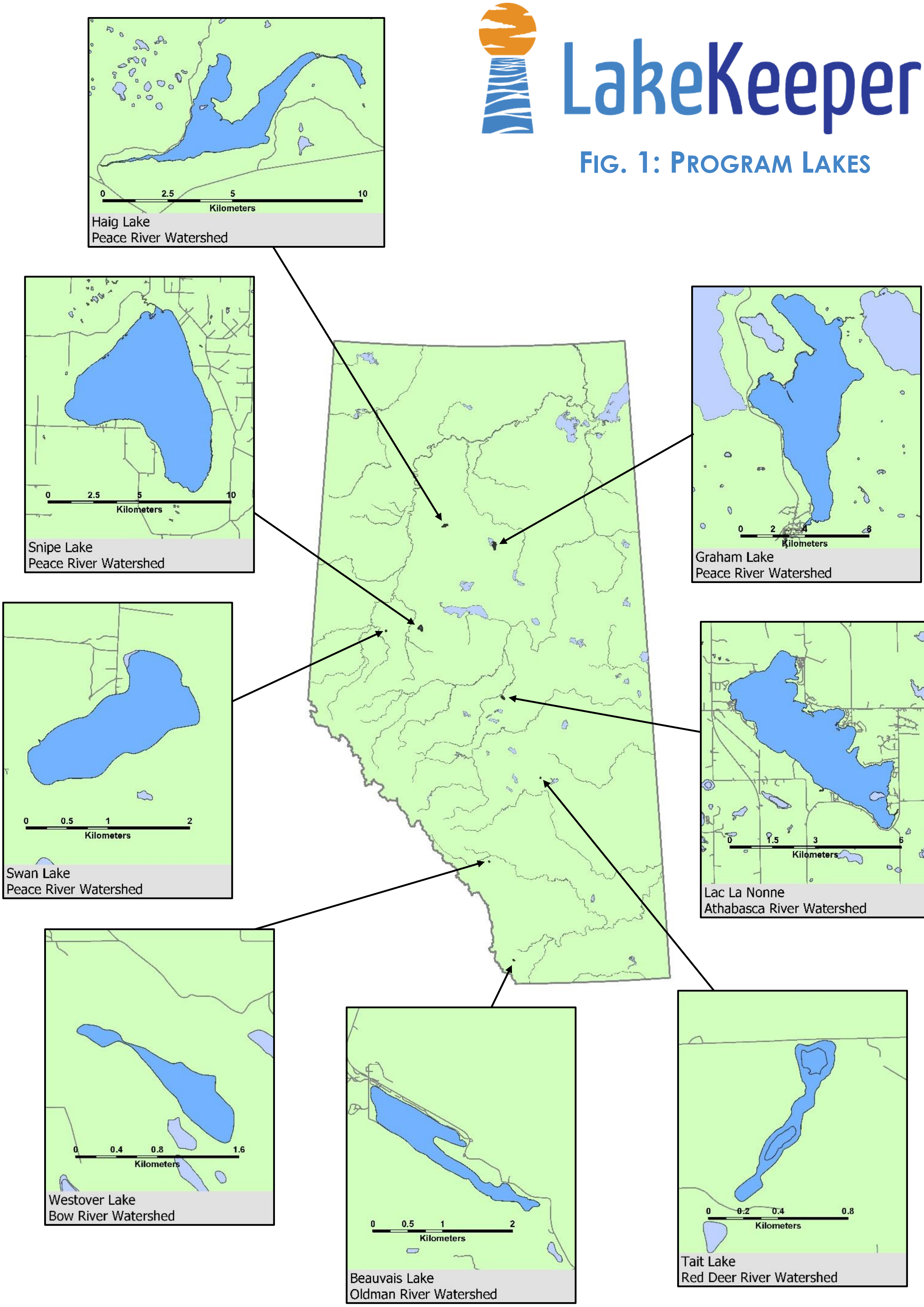
FIG. 1: PROGRAM LAKES



METHODS

Volunteers were provided with a training manual and training videos (available at https://alms.ca/summer-lakekeepers/). Lakes were planned to be sampled three times each: once in June, once in August, and once in September. A single sample site was chosen for each lake, with as close as possible to the deep spot of the main basin as an ideal sample location. Volunteers were provided with field sheets, a lollipop thermometer, a tape and weight, a Secchi disk, a 3.2 L horizontal Van Dorn Beta sampler, a chlorophyll filtering apparatus, and bottle sets. Additional equipment included with some LakeKeepers kits were YSI ProODO temperature and dissolved oxygen meters.

Discrete grabs for total phosphorus, total nitrogen, microcystin, and chlorophyll-*a* were collected at 1 m depths. Discrete grabs for temperature were collected ideally at 1 m, mid-depth, and 1 m off the bottom of the lake. Samples were filtered for chlorophyll-*a* onto Whatman GF-C filter papers. Where YSI meters were used, readings for temperature and dissolved oxygen were obtained every meter of depth until the bottom of the lake was reached. ALMS coordinated delivery of the samples to various analytical laboratories. Total phosphorus and total Kjeldahl nitrogen were submitted to Maxxam Analytics in Edmonton, chlorophyll-*a* was submitted to Innotech in Vegreville, and microcystin samples were submitted to the Alberta Centre for Toxicology in Calgary.

RESULTS

Volunteers successfully completed 20 out of 21 planned sampling trips (Table 2). Lac La Nonne is not included within the completion record, since it was a late addition to the Summer LakeKeepers 2019 program. Trips occurred between June – October 2019. In total, 14 volunteers participated in the program. In addition to measured parameters, volunteers also recorded environmental observations (Appendix Table 1).

Table 2. Sample dates for the 2019 LakeKeeper Lakes.

Trip	Graham	Haig	Snipe	Swan	*Lac La Nonne	Tait	Westover	Beauvais
Trip 1	20-Jul	09-Jun	22-Jun	30-Jun	29-Sep	30-Jun	01-Jun	25-Jun
Trip 2	12-Oct	03-Aug	22-Aug	02-Sep	--	31-Aug	16-Jul	20-Aug
Trip 3	--	10-Oct	31-Oct	09-Oct	--	23-Sep	22-Sep	15-Sep

**Late addition to Summer LakeKeepers 2019 program.*

WATER CLARITY AND 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. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

Secchi disk depth varied greatly between monitored lakes (Figure 2, Appendix Table 2). Beauvais Lake had the highest average water clarity measuring a Secchi depth of 3.68 m, while Westover Lake had the lowest measuring 1.10 m (Figure 2). While that implies Westover had the poorest water clarity, the low value is likely represents the bottom of the lake, as Westover was observed to be only about 1 m deep. Compared to summer 2018, Haig Lake had similarly high water clarity with an average Secchi depth of 2.95 m, while Snipe Lake also had similar water clarity in both years, measuring an average of 1.33 m in 2019. All lakes exhibited various seasonal trends, and some contrary to the anticipated trend of Secchi depth being the smallest in August or early September at the peak of algal growth. For instance, Snipe Lake's Secchi depth was 0.45 m on June 9, then steadily increased through the August sampling and then up to 2.60 m on October 31. Haig Lake and Swan Lake had their highest water clarity in the August and September. Beauvais Lake was also unique in that while it had the greatest average Secchi depth, its clarity decreased throughout the season by 1.75 m from the June 25 to September 15 samplings.

Comparing euphotic depths (Appendix Table 2), which is twice the Secchi depth and represents the depth to which there is enough light for photosynthesis, to the bathymetric maps of the lakes also yielded some interesting results. Haig Lake, whose bathymetry represents that the majority of the lake is about 3 – 6 m deep (Appendix Figure 1), had light penetrating to the bottom of the lake for the majority of the season captured by the LakeKeepers sampling, as the euphotic depth ranged from 4.40 m to 7.70 m across the open water season. Snipe Lake in comparison, where the majority of the lake has a depth of 3 – 4.5 m (Appendix Figure 2), light likely did not penetrate to the bottom of the majority of the lake until October, as the euphotic depth in the June and August samplings were 0.90 m and 1.90 m respectively, and 5.20 m in September. While Beauvais Lake had high water clarity throughout the whole season compared to the other lakes, only at the time of the June 25 sampling, where a euphotic depth of 9.50 m was measured, is it likely that light penetrated to the lake bottom across the majority of the lake. At the later August 20 and September 15 samplings, it is likely that light only penetrated to the bottom of the lake in the shallow southeast portion of the lake, which is no more than 1.5 m deep (Appendix Figure 3), as well as the littoral (shallow, near shoreline) areas of the deeper, northeast section of the lake.

Bathymetry is unavailable for Westover Lake, Swan Lake, Graham Lake and Tait Lake, and there is too little data on Lac La Nonne to comment on seasonal light penetration.

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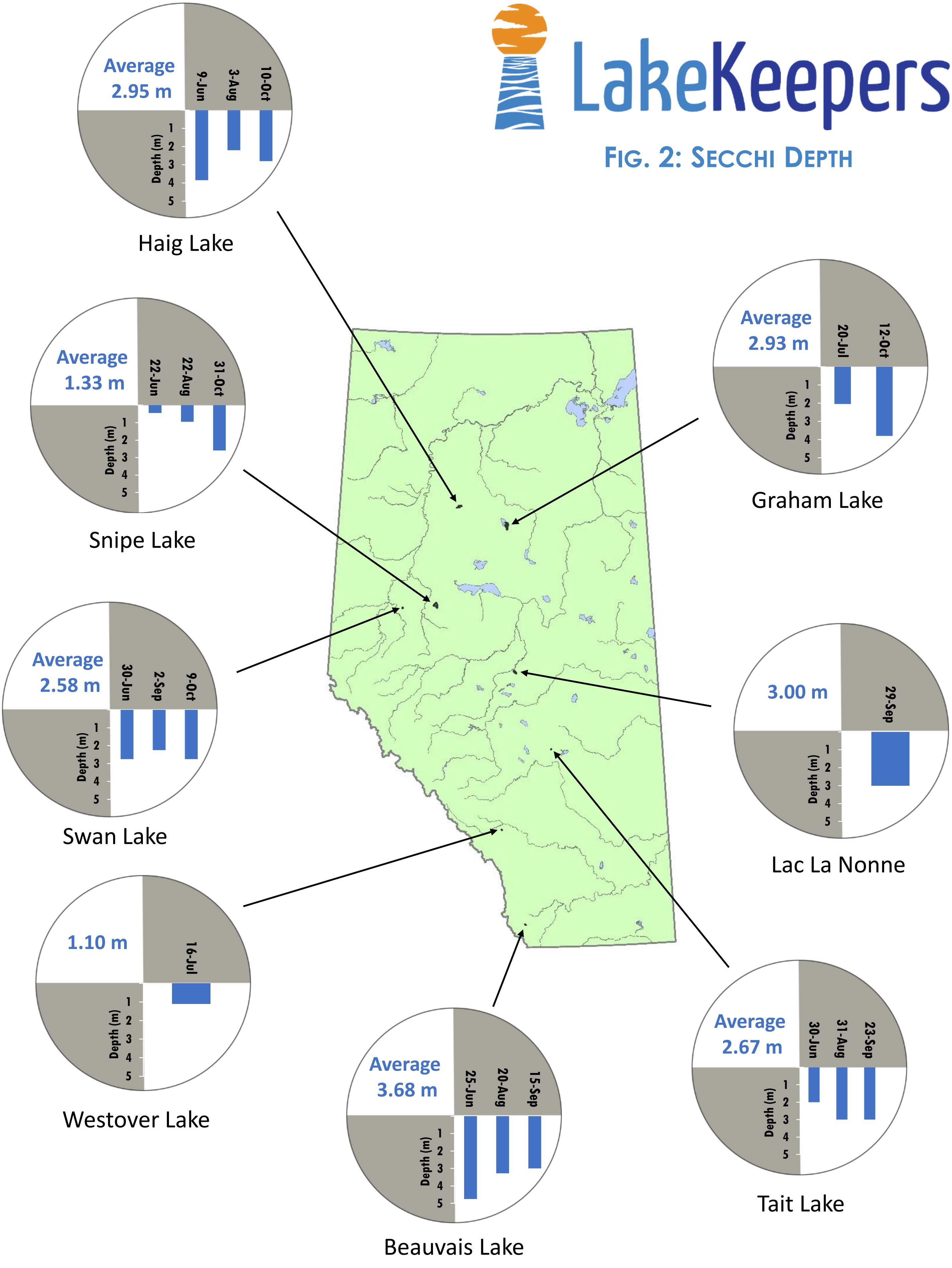


FIG. 2: SECCHI DEPTH

TOTAL PHOSPHORUS AND CHLOROPHYLL-A

ALMS measures a suite of water chemistry parameters. Phosphorus is one of the nutrients that drives algal blooms in Alberta, while chlorophyll-a acts as an indicator of phytoplankton biomass, or how much algae is in the lake. Taking these parameters together, lakes can be classified into oligotrophic (low nutrients), mesotrophic (moderately productive), eutrophic (productive) or hypereutrophic (highly productive). In Alberta, where soil is very fertile, there are many naturally eutrophic lakes, but monitoring lakes for phosphorus and chlorophyll-a overtime can capture the process of lake eutrophication, or the build up of excess nutrients in lakes, likely from nutrient pollution. Where there are excess nutrients, the likelihood and severity of harmful algae/cyanobacteria blooms increases.

Average total phosphorus values ranged from a maximum of 350 µg/L at Lac La Nonne to a minimum of 9 µg/L at Beauvais Lake (Figure 3). Lakes spanned four trophic classifications according to their average total phosphorus values: oligotrophic (Beauvais Lake), mesotrophic (Haig Lake, Westover Lake), eutrophic (Graham Lake, Snipe Lake, Tait Lake), and hypereutrophic (Swan Lake, Lac La Nonne). Total phosphorus levels generally increased throughout the season in half of the lakes (Haig Lake, Graham Lake, Swan Lake, Beauvais) at varying levels, while the other three lakes with seasonal data all had different trends (Appendix Table 2). Lakes that mix regularly due to wind action are likely to display increasing phosphorus concentrations throughout the open water season as phosphorus released from the bottom sediments is incorporated into overlying waters.

Beauvais Lake in the summer.

In most Alberta lakes, phosphorus concentrations are closely correlated with chlorophyll-*a* concentrations. This was true for the majority of Summer LakeKeeper 2019 lakes. Snipe Lake had the highest average chlorophyll-*a* concentration of 42.2 µg/L and Tait Lake had the lowest average chlorophyll-*a* concentration of 1.1 µg/L (Figure 4). The value for Tait Lake is surprising, considering it had eutrophic levels of total phosphorus – such a disparity needs further investigation. The other two lakes with comparably low chlorophyll-*a* values of 2.0 µg/L and 3.8 µg/L for Westover Lake and Beauvais Lake, respectively, are more in line with their average total phosphorus levels. Lakes spanned four trophic classifications according to their average chlorophyll-*a* values: oligotrophic (Tait Lake, Westover Lake), mesotrophic (Beauvais Lake), eutrophic (Haig Lake, Graham Lake, Lac La Nonne, Swan Lake), and hypereutrophic (Snipe Lake).

Some of the disparity between the total phosphorus and chlorophyll-*a* data might be a result of field protocol around filtering collected water in the field needed to analyze lake chlorophyll-*a* levels, and represents an aspect of the LakeKeepers program that requires quality control investigation. Some average values are also likely skewed based on the number of samples taken and time of year they were taken. For instance, Lac La Nonne was only sampled once at the end of September, Graham Lake was only sampled twice, at the end of July and mid-October, and Swan Lake's October 9 sampling had no data for total phosphorus or chlorophyll-*a* (as well as total nitrogen).

Clear day at Haig Lake, Peace River watershed.

Fig.3: Average Total Phosphorus Results

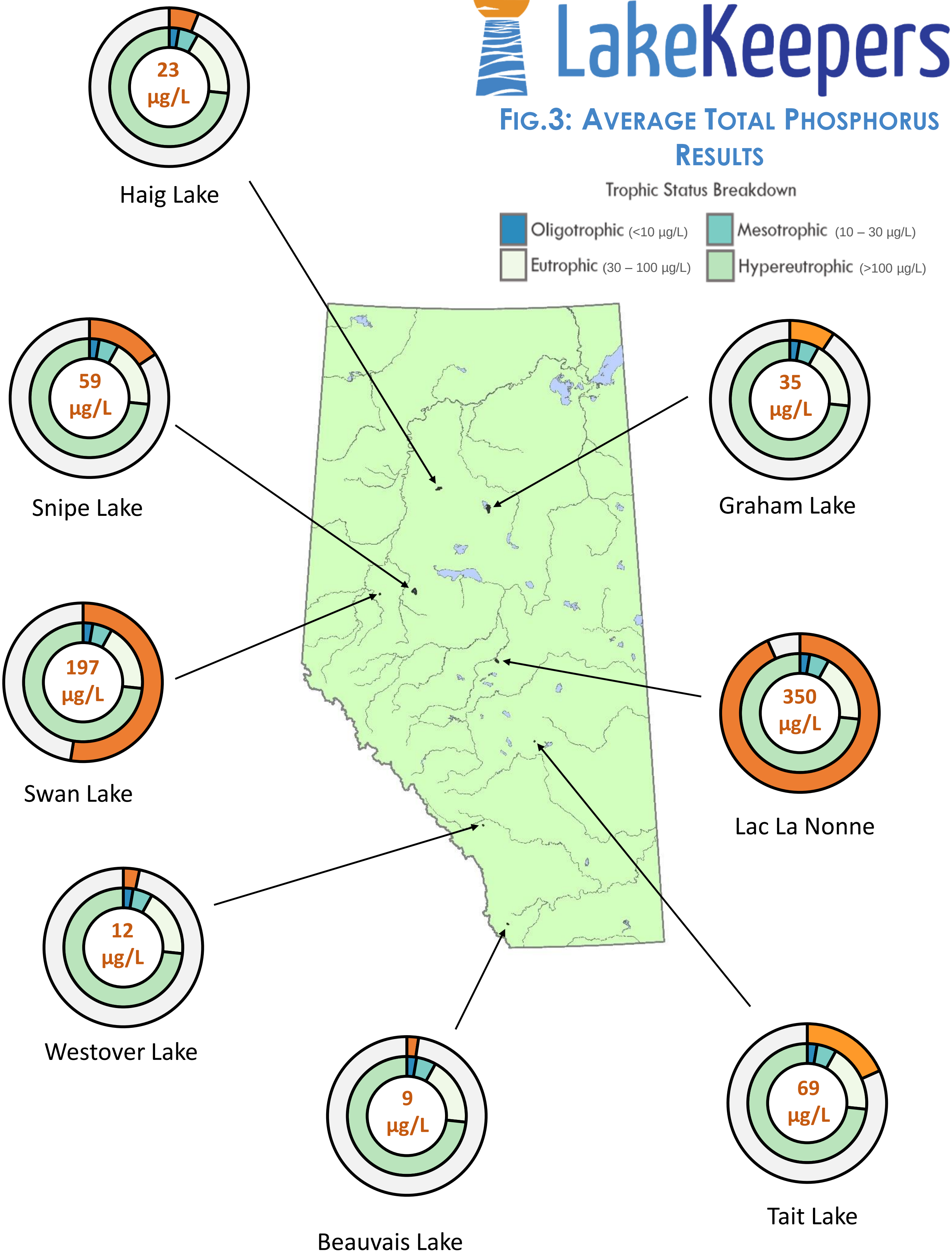
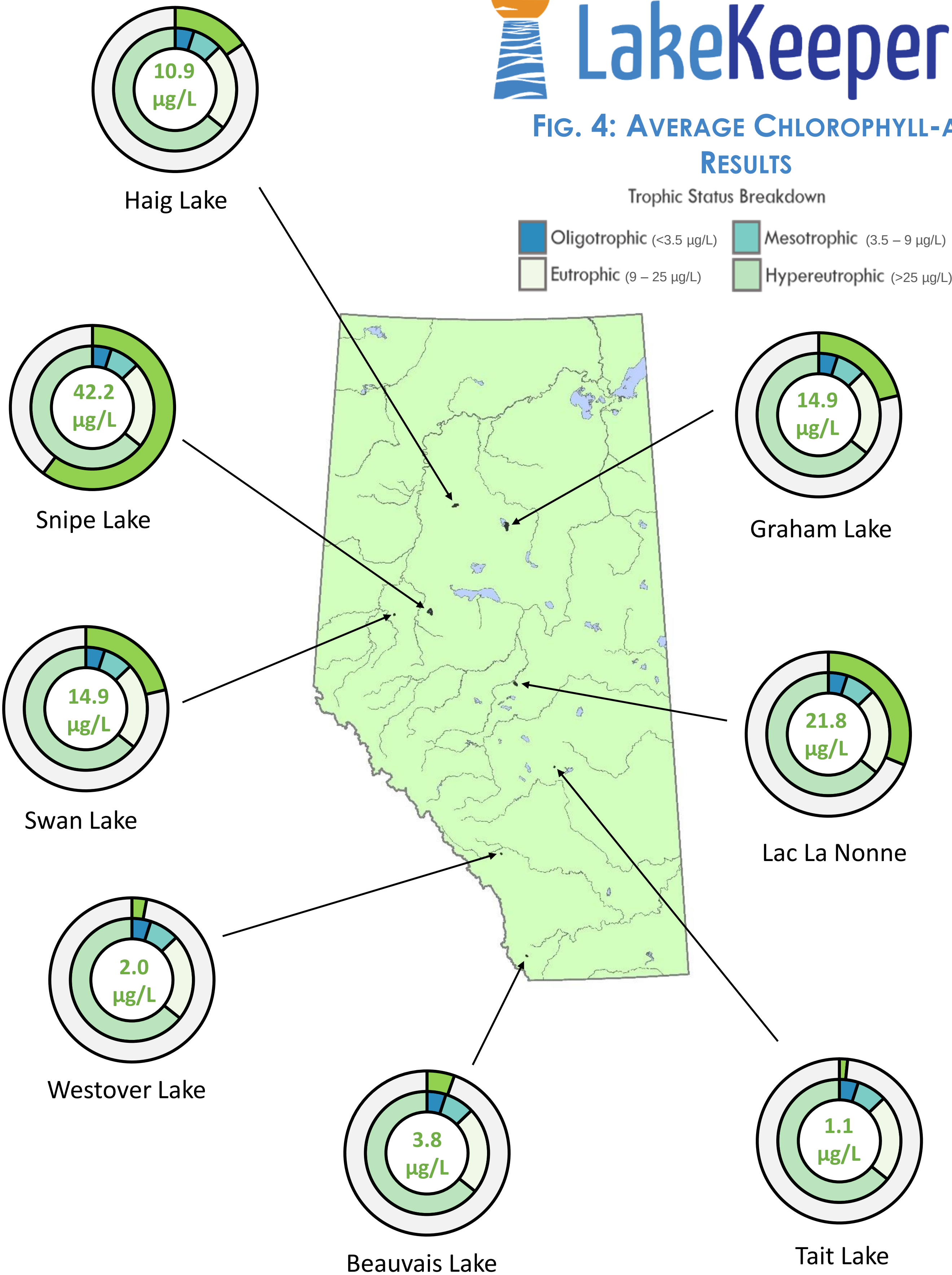


Fig. 4: Average Chlorophyll-a Results



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. Harmful levels of microcystin can be a threat to any humans recreating in or drinking lake water, in addition to livestock and wildlife, including fish. In Alberta, recreational guidelines for maximum safe microcystin levels are set at 20 µg/L.

Average microcystin concentrations ranged from a maximum of 0.40 µg/L at Swan Lake to a minimum of 0.05 µg/L at Tait Lake, Westover Lake and Beauvais Lake (Figure 5). The highest single sampling value for microcystin was 0.68 µg/L at Swan Lake on September 2. Both this value and the averages are all well below the recreational guideline of 20 µg/L. All seasonal and average data is reported in Appendix Table 2.

Despite the low microcystin values recorded at Summer LakeKeepers 2019 lakes, caution should still be observed while recreating near visible cyanobacteria blooms. Microcystin concentrations are also likely to be higher near shore where there are accumulations of cyanobacteria blooms. For example, at Calling Lake in 2018, two samples collected on the southeast shore on July 16th and August 21st had concerning microcystin concentrations of 214.31 µg/L and 331.01 µg/L, respectively.

Southeast shore cyanobacteria accumulation at Calling Lake, 2018.

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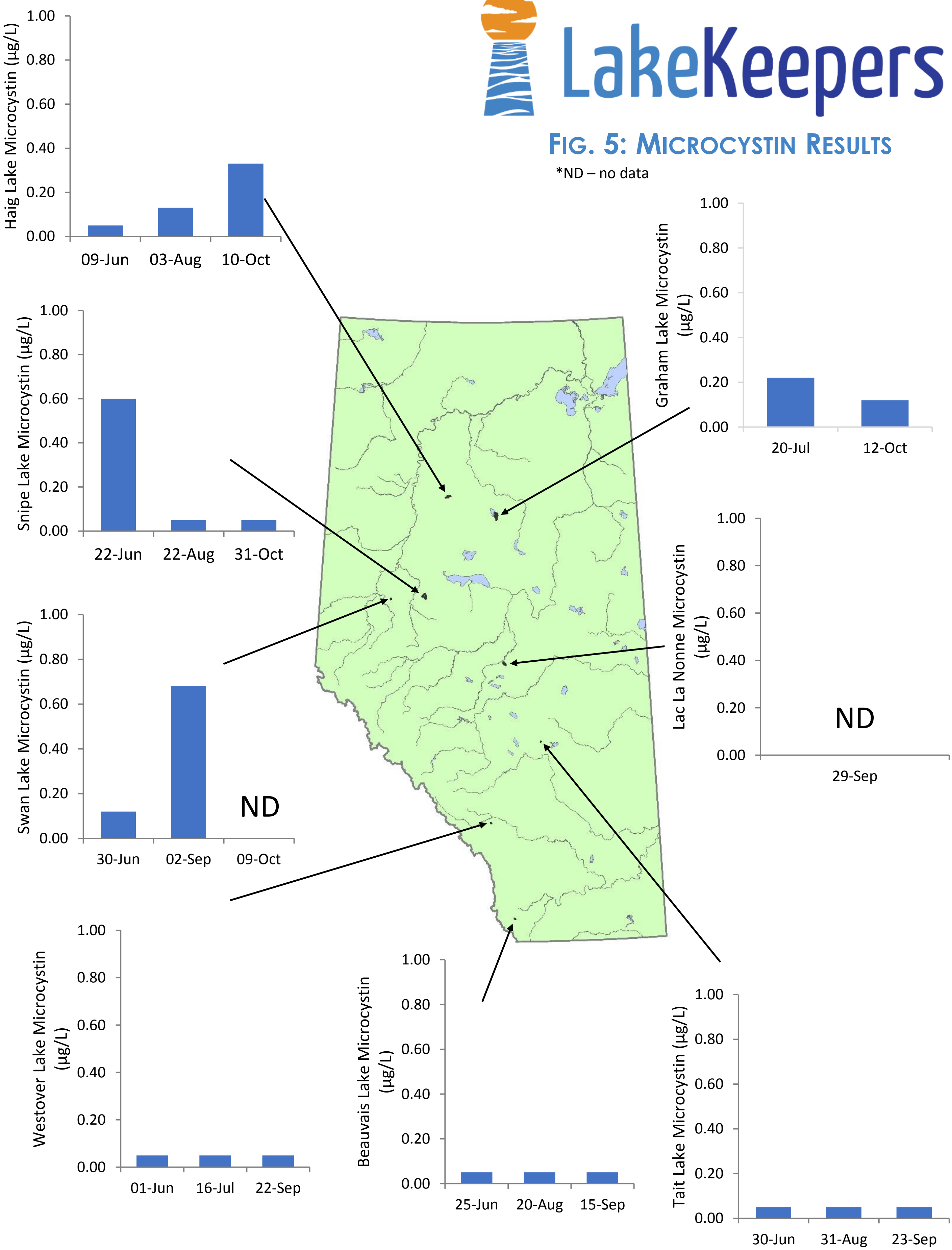
Fig. 5: Microcystin Results

*ND – no data



TEMPERATURE AND DISSOLVED OXYGEN PROFILES

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline (the transition point in layers of the water column, where the water temperature suddenly drops) is important in determining the depth at which dissolved oxygen from the surface can be mixed.

Temperature profiles can indicate the extent to which a water column is mixed. This has important implications for the cycling of nutrients and oxygen throughout a lake. Strong thermal stratification was observed only at Beauvais Lake during the June 25 sampling, and then dissipated throughout the season till the September 15 sampling indicated full water column mixing. Lakes with shallow depths or large surface areas are prone to continuous mixing, and have a lower likelihood of establishing significant stratification – many of the Summer LakeKeepers 2019 lakes were both large in surface area, and/or generally shallow.

Temperature profiles were determined at Haig Lake, Graham Lake, Tait Lake, Swan Lake and Westover Lake with three discrete depth measurements using the Van Dorn Beta sampler protocol. Snipe Lake, Beauvais Lake and Lac La Nonne's temperature profiles were determined with the YSI ProODO meter. Sampling difficulties resulted in missed temperature profiles for Snipe Lake on June 22, and for Swan Lake on October 9. Sampling depths were not recorded at Tait Lake, so the profile depths in Figure are represented as Top, Middle and Bottom, based on how the temperatures were recorded on the field sheet.

At the lakes' surfaces, maximum temperatures fluctuated around 20 °C, and in the fall, most lakes had become isothermal (Figure 6). Lakes within the Peace River watershed were generally around 5 – 10 °C colder than lakes in the more southern watersheds for samples collected from mid-September to the end of October. The coldest values were recorded at Snipe Lake on October 31, where the entire water column was recorded to be about 1 °C.

Dissolved oxygen was recorded at all of the lakes that were sampled with the YSI ProODO meter. Both Snipe Lake and Lac La Nonne measured above the Canadian Council for Ministers of the Environment (CCME) guidelines of 6.5 mg/L dissolved oxygen for all samplings, as well as Beauvais Lake on September 15 (Figure 7). The high average level of 12.4 mg/L dissolved oxygen at Snipe Lake on October 31 is consistent with the cold temperatures recorded that day, along with the observed complete column mixing – the colder the water temperature, the more oxygen can be dissolved. For the June 25 and August 20 sampling at Beauvais Lake, at about 7 m depth the dissolved oxygen levels fell below the CCME guideline. These declining levels of oxygen are typical of a lake that also displays temperature stratification – the lack of water column mixing means oxygen will not be redistributed from the surface to the lower depths.

FIG. 6: TEMPERATURE PROFILES

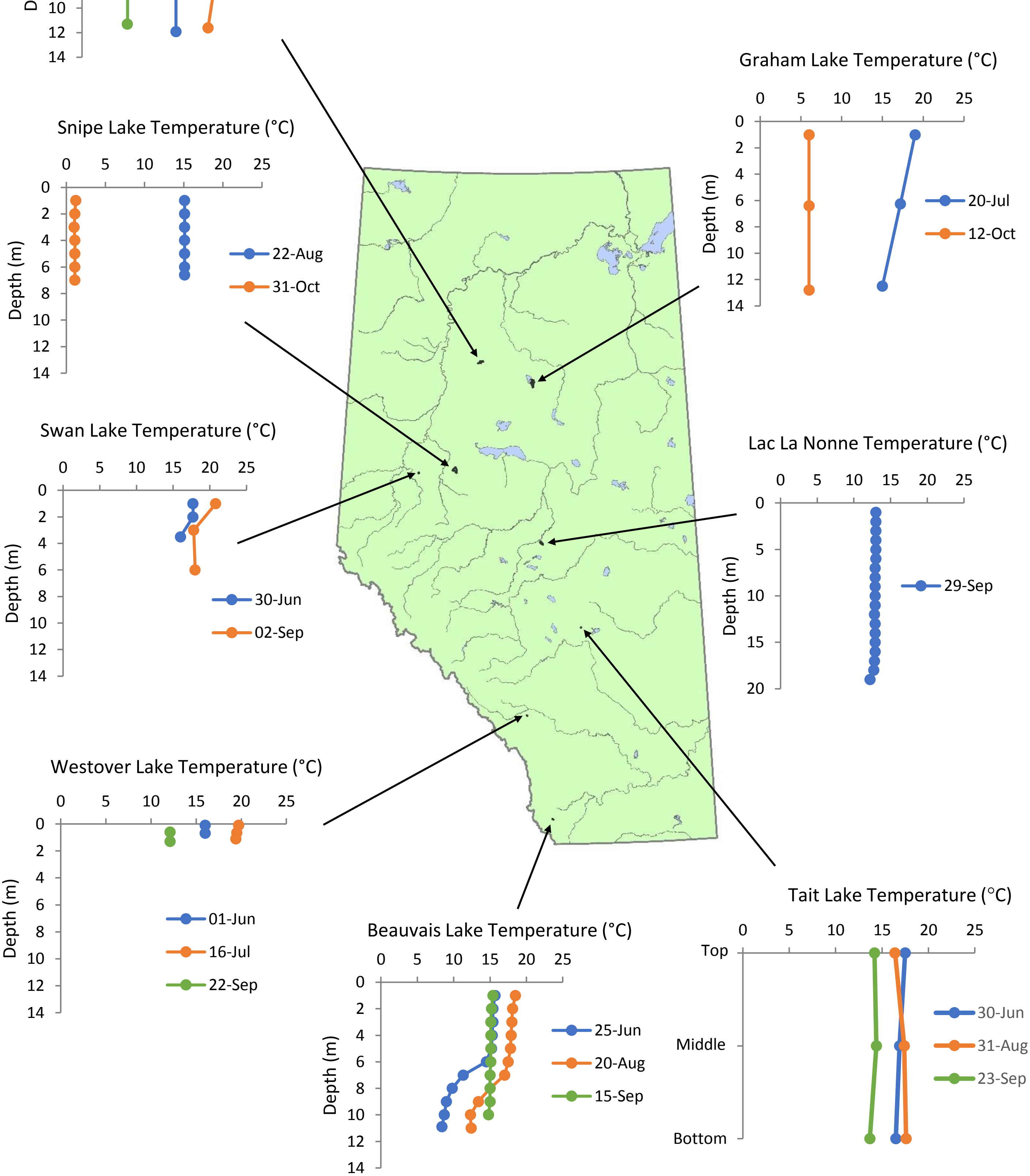


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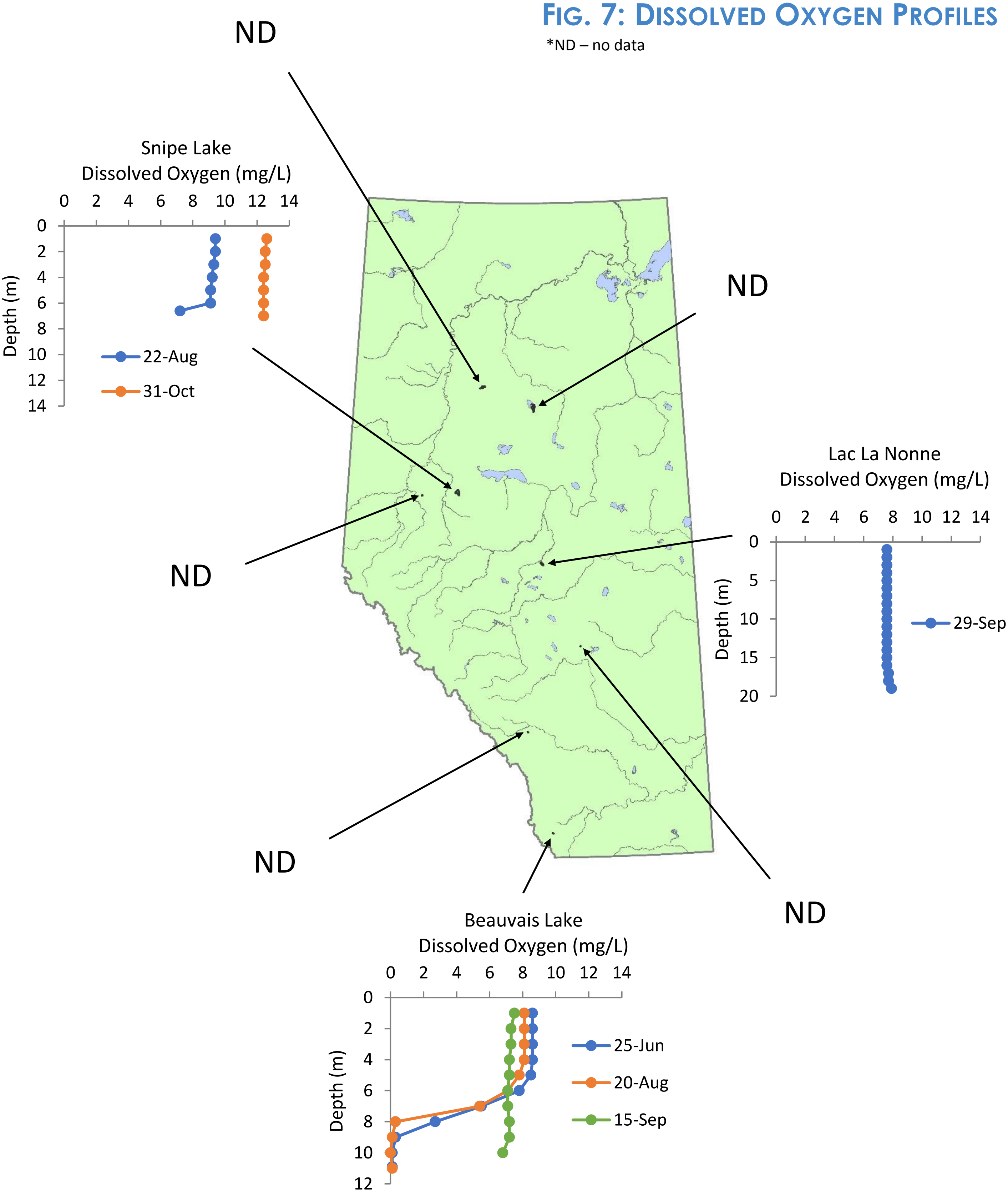
FIG. 7: DISSOLVED OXYGEN PROFILES

*ND – no data



APPENDIX

Appendix Table 1. Observations made during sampling by LakeKeepers at eight lakes in 2019.

Lake	Sample Date	Secchi Disk Colour	Air Temperature (°C)	Cloud Cover (%)	Wind Direction	Wind Speed (km/h)	24 Hour Rainfall (mm)	Evidence of Cyanobacteria Bloom
Graham	20-Jul	Green	23	50	NW	1	0	Particles in Water
	12-Oct	*ND*	4	60	W	15	0	Particles in Water
Haig	09-Jun	Brown	5	0	W	10	0	None
	03-Aug	Brown	18	35	N	20	8	Particles in Water
	10-Oct	Brown	6	25	W	10	0	Particles in Water
Snipe	22-Jun	Green	14	5	*ND*	0	10	None
	22-Aug	Colourless	8	100	SE	12	10	None
	31-Oct	Green	1	100	NW	20	0	None
Swan	30-Jun	Green	4	70	W	15	*ND*	Particles in Water
	02-Sep	Green	22	15	*ND*	0	0	Particles in Water
	09-Oct	Brown	-2	1	*ND*	0	3	Particles in Water
La Nonne	29-Sep	Colourless	3	0	NW	6	0	None
Tait	30-Jun	Green	19	50	W	30	0	None
	31-Aug	Colourless	21	0	NW	5	0	None
	23-Sep	Green	16	25	W	5	0	Particles in Water
Westover	01-Jun	Green	26	30	W	7	*ND*	Scums on Surface
	16-Jul	*ND*	17	50	S	5	5	None
	22-Sep	Brown	16	10	NW	10	0	None
Beauvais	25-Jun	Colourless	19	50	WSW	19	5	None
	20-Aug	Colourless	20	5	NW	16	0	None
	15-Sep	Brown	16	5	SW	5	0	Particles in Water

ND – no data.

Appendix Table 2a. Water chemistry and water clarity data for six of the eight Summer LakeKeeper 2019 lakes.

Lake	Sample Date	Total Phosphorus (µg/L)	Total Kjeldahl Nitrogen (mg/L)	Microcystin (µg/L)	Chlorophyll-*a* (µg/L)	Secchi Disk Depth (m)	Euphotic Depth (m)
Graham	20-Jul	19	0.9	0.22	19.7	2.05	4.10
	12-Oct	51	0.9	0.12	10.0	3.80	7.60
	2019 Average	**35**	**0.9**	**0.17**	**14.9**	**2.93**	**5.85**
Haig	09-Jun	14	0.5	0.05[a]	3.3	3.85	7.70
	03-Aug	26	0.8	0.13	22.4	2.20	4.40
	10-Oct	28	0.6	0.33	7.0	2.80	5.60
	2019 Average	**23**	**0.6**	**0.17**	**10.9**	**2.95**	**5.90**
Snipe	22-Jun	58	1.6	0.60	60.3	0.45	0.90
	22-Aug	90	1.4	0.05[a]	62.4	0.95	1.90
	31-Oct	28	0.9	0.05[a]	3.8	2.60	5.20
	2019 Average	**59**	**1.3**	**0.23**	**42.2**	**1.33**	**2.67**
Swan	30-Jun	64	1.6	0.12	19.7	2.75	5.50
	02-Sep	330	2.0	0.68	10.1	2.25	4.50
	09-Oct	*ND*	*ND*	*ND*	*ND*	2.75	5.50
	2019 Average	**197**	**1.8**	**0.40**	**14.9**	**2.58**	**5.17**
La Nonne	**29-Sep**	**350**	***ND***	***ND***	**21.8**	**3.00**	**6.00**
Tait	30-Jun	81	0.8	0.05[a]	0.4	2.00	4.00
	31-Aug	70	0.8	0.05[a]	1.5	3.00	6.00
	23-Sep	55	0.7	0.05[a]	1.5	3.00	6.00
	2019 Average	**69**	**0.7**	**0.05**	**1.1**	**2.67**	**5.33**

ND – no data.
[a]below detection limit of 0.1 µg/L microscystin; value halved in order to contribute to seasonal averages.

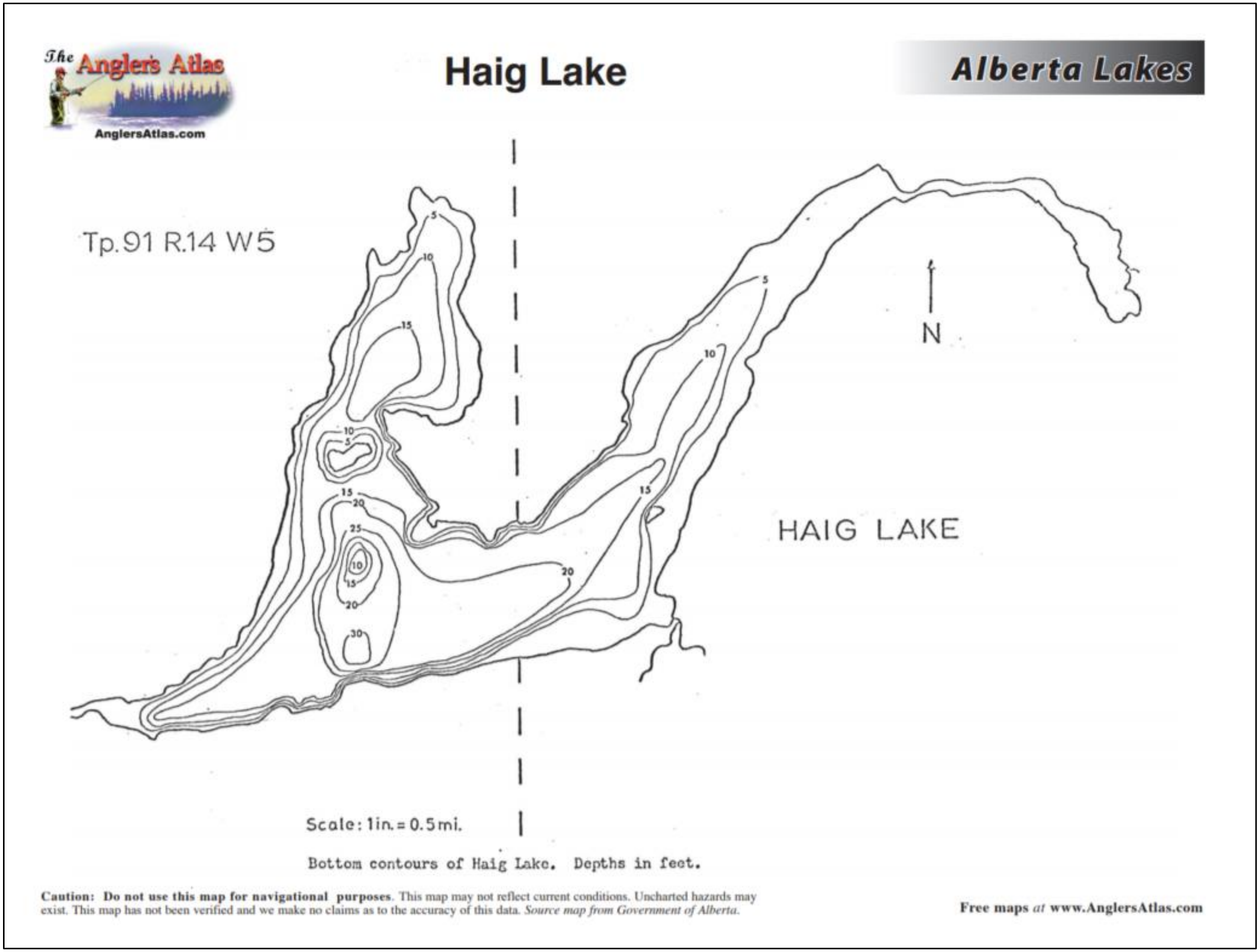
Appendix Table 2b. Water chemistry and water clarity data for two of the eight Summer LakeKeeper 2019 lakes.

Lake	Sample Date	Total Phosphorus (µg/L)	Total Kjeldahl Nitrogen (mg/L)	Microcystin (µg/L)	Chlorophyll-*a* (µg/L)	Secchi Disk Depth (m)	Euphotic Depth (m)
Westover	01-Jun	18	1.4	0.05[a]	2.5	*ND*	*ND*
	16-Jul	10	1.1	0.05[a]	1.3	1.10	1.10
	22-Sep	9	1.1	0.05[a]	2.3	*ND*	*ND*
	2019 Average	**12**	**1.2**	**0.05**	**2.0**	**1.10**	**1.10**
Beauvais	25-Jun	7	0.4	0.05[a]	2.0	4.75	9.50
	20-Aug	10	0.4	0.05[a]	2.1	3.28	6.55
	15-Sep	10	0.4	0.05[a]	7.3	3.00	6.00
	2019 Average	**9**	**0.4**	**0.05**	**3.8**	**3.68**	**7.35**

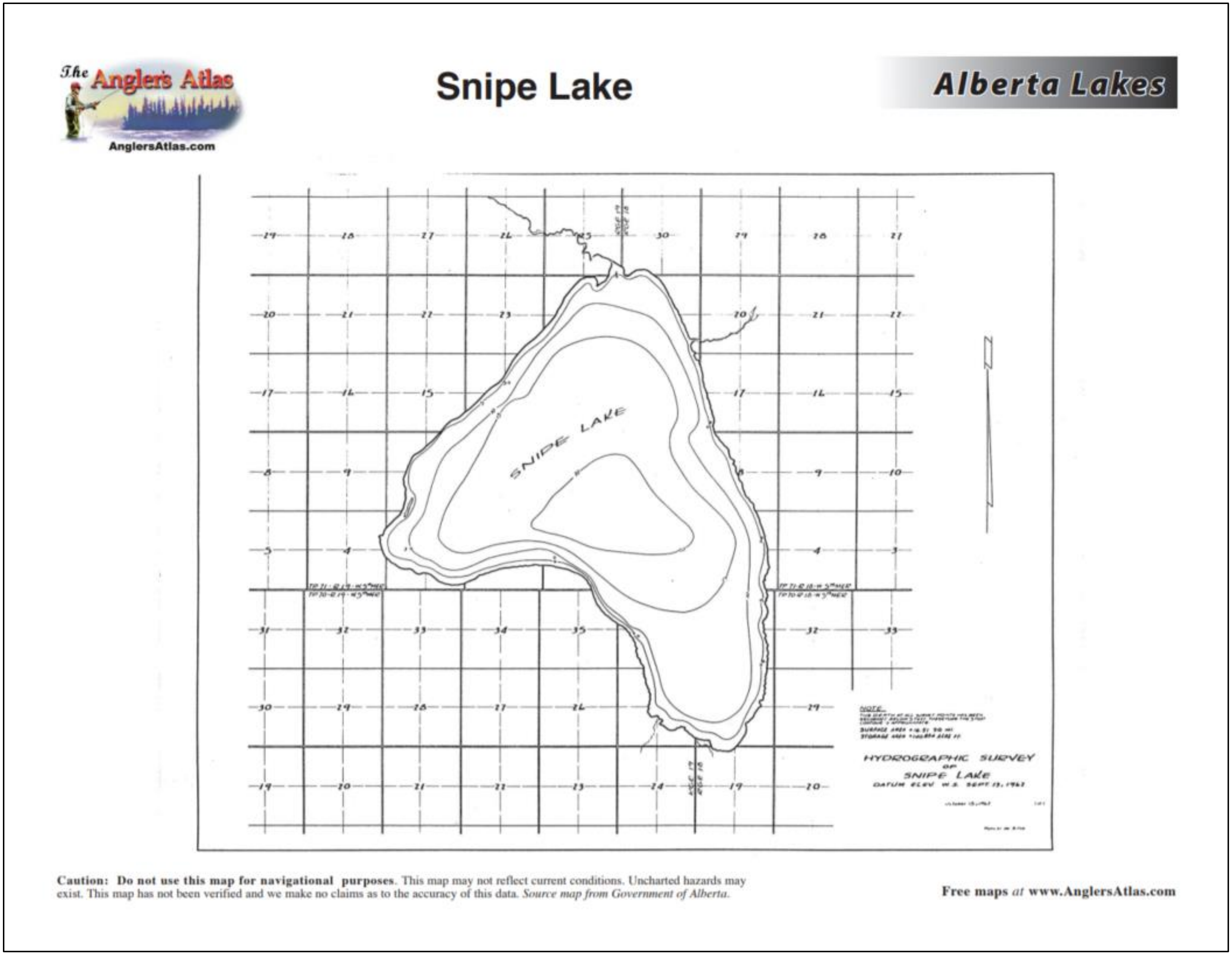
ND – no data.

[a]below detection limit of 0.1 µg/L microscystin; value halved in order to contribute to seasonal averages.

Appendix Figure 1. Bathymetry for Haig Lake. Source: www.anglersatlas.com.



Appendix Figure 2. Bathymetry for Snipe Lake. Source: www.anglersatlas.com.



Appendix Figure 3. Bathymetry for Beauvais Lake. Source: www.albertalakes.ualberta.ca.