Enos Lake Protection and Monitoring Program: Review of 2017 Water Quality Data

from PGL 2016

For: **BC Conservation Foundation, Lantzville Office**
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Summary

A water quality monitoring program was carried out in 2017 by the staff of the BC Conservation Foundation. This report summarizes the results of that sampling and provides some interpretation of these data in comparison to data collected previously and to water quality guidelines. Overall few issues were identified for Enos Lake. Biologically the lake is fairly productive with some indicators (water clarity, phosphorus and chlorophyll concentrations and well as hypolimnetic oxygen deficits) indicating some concern that the lake may be more productive than might be desirable. Concentrations of phosphorus and hypolimnetic dissolved oxygen may not meet guidelines set for the lake.

No issues were identified with potential contaminants such as Polyaromatic Hydrocarbons (PAHs) or with metals.

There were some problems identified with data quality that should be addressed.

Presently the major risks (in addition to watershed development) to the present ecology and stability of the lake ecosystem appear to be posed by climate change and species introductions.

1.0 Background

Enos Lake is a small lake in a mostly undeveloped area of the Fairwinds Community located in Nanoose Bay, BC. Enos Lake has a surface area of 18 ha, with a watershed area of approximately 235ha. Within the watershed, 12 ha has been previously developed with predominantly low-density residential housing (PGL 2016).

Enos Lake is of interest by biologists who have been sampling the lake for some decades. Enos Lake was home to an endangered stickleback species pair: the Enos Lake Benthic and Limnetic Threespine Stickleback pair (Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2012). Previously two distinct species, this pair now exists as an inter-breeding hybrid population. Recovery of two distinct populations does not appear possible and there are no habitat protection provisions in the most recent COSEWIC report (COSEWIC, 2012)[3]. The species pair previously had scientific value but was not commercially or culturally significant.

Aside from the stickleback pair, there are no other fish species confirmed to be present in Enos Lake[4]. (PGL 2016).

Water quality sampling has been carried out since 2006, but it appears that prior to 2016 there was no standardized sampling program. The PGL report of 2016 used the prior Aquaterra report 2014, compiling the 2013 sampling and the MESL report of 2014 as the basis of the proposed a program for 2017, which this report summarizes.

The purpose of the sampling is to provide a monitor of the overall health of Enos Lake in the context of the development in the watershed over the next 10 to 20 years. The lake water chemistry and biology are indicators of watershed health and of change.

There were a series of samplings commissioned by Fairwinds between 2006 and 2010 that provide reference points for the 2017 data:

Keystone (2006) sampled the lake in September 2006 at five sites. They collected water profile data at the deep site (SWMP 3) and general water chemistry and dissolved metals at all sites.

In 2007 Keystone carried out a more extensive program. Keystone (2007a) measured profiles, sampled general water chemistry and dissolved metals but also sampled and measured PAHs and chlorinated phenols in lake sediments in April 2007. The sampling was repeated in November (Keystone 2007b).

In 2008 the lake was sampled in April (Aquaterra 2008a) and October (Aquaterra 2008b) for profiles, general chemistry and dissolved metals in water. Similarly in April 2009 (Aquaterra 2009a) and November 2009 (Aquaterra 2009b).

Other references with data are:
Vancouver Island University monitored the lake in 2007 and 2008. Water level, surface temperature, temperature, dissolved oxygen and conductivity data were collected.

Data are also provided for water chemistry taken at the deep station (Ministry EMS site E275383) on March 11 2009 (MoE 2009).

All of the above data were provided in a three ring binder ("The Blue Binder") by the Friends of Enos Lake. The custodian is Ross Peterson.

The PGL (2016) report provide the following suggestions for reporting, some of which are outside the terms of reference of this report.

Data should be reviewed against targets as soon as possible after each sampling event; however, formal reporting is only required once per year. From the onset of construction through to one year beyond build-out, analysis and reporting will be led by the developer's QEP. If monitoring continues beyond that temporal scope, reporting requirements will be at the discretion of the RDN or whoever assumes responsibility for the monitoring.

Annual reports will be submitted by December 31 for each calendar year in which work was performed. Reports will include, at minimum:

- A summary of work performed, including dates, individuals, weather conditions, methods, QA/QC protocols, and any challenges encountered during the work.

- A presentation of the water quality results, including but not limited to data summaries (graphical or tabular) compared against the targets listed in this document (where relevant).

- Any anecdotal observations related to Enos Lake ecology, including but not limited to aquatic invasive species.
- A summary of preventative actions taken with respect to aquatic invasive species undertaken in the past year (e.g. signage, educational materials for residents or visitors, etc.)
- A discussion interpreting the results of the program for the past year, including but not limited to input provided for storm water management practices or new phases of construction.
- Recommendations for augmentation to the program, if relevant.
- Laboratory certificates and raw data for the year, as appendices.

2.0 Water Quality Results

From the PGL 2016 report, Table 3.1 summarizes the water quality monitoring program and will be used as the structure for interpreting the water quality results for each individual parameter.

Table 3-1. Summary of Water Quality Monitoring Program for Enos Lake

Parameter (units)		Water Quality Target	Future Monitoring[a]
Field Parameters (profiles at 1m increments)	Secchi Depth (m)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Dissolved Oxygen (mg/L and % saturation)	• ≥5 mg/L epilimnion • ≥2 mg/L hypolimnion	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Conductivity (µS/cm)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Temperature (°C)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	pH	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Redox (mV)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
Laboratory Parameters	*E. coli* (# per mL)	BC Water Quality Guidelines (recreation – secondary contact)[c]	August 2017: 5 times in 30 days. Surface sample from SWMP-03 and any two shoreline locations. Repeat on 5 year increment.
	PAHs (µg/mg)	BC Water Quality Guidelines (freshwater sediments)	August 2017: surface sediment from three locations: SWMP-06, SWMP-04 and SWMP-03.
	Metals (various)	BC Water Quality Guidelines (total metals, freshwater aquatic life). Both average and short-term maximum guidelines apply, where applicable.	February 2017 and August 2017: five samples in a 30 day period. Each sample to occur at three depths from SWMP-03. Sampling to be repeated on five year increments.
	Chlorophyll *a* (µg/L)	Avoid any increase	Quarterly sampling at site SWMP-03, starting in 2017, and repeated annually. Samples to be taken from three depths (surface, mid, deep water)
	Hardness (as $CaCO_3$)	None – required to interpret metals data	February 2017 and August 2017: five samples in a 30 day period. Each sample to occur at three depths from SWMP-03. Sampling to be repeated on five year increments. Data required to interpret metals concentrations.
	Phosphorous (mg/L)	12 µg/L	Quarterly sampling at site SWMP-03, starting in 2017. Samples to be taken from three depths (surface, mid, deep water)

[a]Future monitoring is limited to the scope being taken on by the Developer and will continue until at least one year post build-out within the Enos Lake watershed. It is anticipated that some form of longer term monitoring will be undertaken by RDN in support of long term operation of stormwater infrastructure.
[b]Quarterly sampling is defined as February, May, August, and November.
[c]It is assumed that swimming will not be a recreational use of Enos Lake. If that assumption is incorrect, primary contact guidelines should apply.

2.1 Secchi depth

Secchi depth is a measure of water clarity and an important characteristic of lake water for both aesthetic and ecological perspectives. Secchi depth has a direct relationship with chlorophyll a (a measure of the amount of algae in the water) and phosphorus concentration. No summary for Secchi was made in the 2016 PGL report and no Secchi data could be found in any other reports that had been prepared over the past 10 years.

In the 2017 data, 11 data points were provided (all at station 03):
2 March 1.45 m
2 June 2.8
27 June 4.0
4 July 4.5
12 July 4.0
fire closure mid July to late August
24 August 4.8 m
29 August 3.0
5 September 3.0
11 Sept 2.7
14 Sept 2.8
20 November 2.8 m

From these data it can be inferred that there is significant variation over the sampling period with a range from 1.4 to 4.8 m with an average of 3 m. Because of the changes over a relatively short time, Secchi data should (if possible) to be collected at a frequent interval (monthly – as was done here) to be of more value – although quarterly sampling was recommended in the PGL report.

Using Secchi depths to characterize lake productivity is routinely used. Average summer Secchi depths of less than three meters are typical of eutrophic (biologically productive) lakes. Mesotrophy (moderately productive lakes) is indicated by depths of 3-6 m and oligotrophic (unproductive) lakes have annual average Secchi depth of greater than 6 meters. (British Columbia 2017a). By this criterion, Enos Lake is at the boundary between mesotrophy and eutrophy. Movement into a eutrophic state would be undesirable.

2.2 Dissolved Oxygen

2017 dissolved oxygen profiles were taken at the same time as temperature, conductivity and redox potential. Summary tables (measured concentrations and calculated percent saturation) are compiled below as Tables 2.1 and 2.2. Enos Lake is generally considered to be a monomictic lake (thermally stratified in the summer but isothermal in the winter) but during the cold winter of 2016-2017, the lake has ice cover January and February which would make it a dimictic lake with thermal stratification under the ice that year. The first sampling occurred a week after the ice had melted.

Table 2.1 Enos Lake dissolved oxygen profiles 2017 (concentrations)

	02-Mar-17	02-Jun-17	24-Aug-17	20-Nov-17
Depth (m)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)
0.5	12.55			
1	12.63	6.47	7.53	9.3
2	12.65	6.63	7.5	9.2
3	12.66	6.84	7.7	9.3
4	12.67	7.89	7.55	9.3
5	12.68	9.41	7.27	9.3
6	12.68	10.10	5.17	9.15
7	12.67	9.99	2.25	9.18
8	12.68	8.32	1.4	9.26
9	12.67	7.30	1.25	8.85
10	12.65	1.63	1.16	8.83
11	12.56	1.64		

Table 2.2 Enos Lake dissolved oxygen profiles 2017 (percent saturation)

	02-Mar-17	02-Jun-17	24-Aug-17	20-Nov-17
Depth (m)	D.O. (% sat)	D.O. (% sat)	D.O. (% sat)	D.O. (% sat)
0.5	98			
1	98	70	87	77
2	98	70	87	76
3	98	70	89	77
4	98	80	86	77
5	98	88	74	77
6	98	88	49	76
7	98	85	20	76
8	98	70	12	76
9	98	61	11	73
10	98	14	10	73
11	98	14		

It should be noted that the March sampling was done when the lake was thermally mixed with temperatures 4.6 - 4.8 C the water column after the lake had been mixed by the wind after the ice melted and the dissolved oxygen was essentially at 100% saturation.

The June sampling shows the lake stratified with a thermocline between 3 and 5 meters deep and the water below 8 meters beginning to show an oxygen depletion and notable loss of oxygen deeper than 10 meters.

The August 2017 temperature profile shows a deeper thermocline between 4 and 7 meters and low oxygen concentrations below 7 meters. The depth of stratification varies by time of year and from year to year depending on weather conditions in spring and summer. Results from previous years show considerable variation.

The November sampling shows that the lake had been de-stratified thermally with only a slight temperature gradient but the lake had only begun to mix and replenish the oxygen deficit that had been present in the hypolimnion.

The water quality target for dissolved oxygen is for greater than 5 mg/L in the epilimnion. This target was met. The target for dissolved oxygen in the hypolimnion is for greater than 2 mg/L. This target was not met for the deep waters in the summer (June through August)

2.3 Conductivity

Conductivity is a measure of dissolved ions in the water and is a general indicator of lake processes and of watershed disturbance. The profiles shown in Table 2.3 reflect the temperature stratification.

Table 2.3 Enos Lake conductivity profiles 2017

	02-Mar-17	02-Jun-17	24-Aug-17	20-Nov-17
Depth (m)	Conduc. (µS/cm)	Conduc. (µS/cm)	Conduc. (µS/cm)	Conduc. (µS/cm)
0.5	140.2			
1	139.7	12.5	143.2	138.2
2	140.0	42.7	143.2	138.4
3	139.8	40.1	42.6	138.6
4	139.9	132.8	141.6	138.7
5	139.8	117.6	126	138.8
6	139.7	63.3	126.3	138.7
7	139.7	108.7	127.9	138.8
8	139.7	157.7	133.2	138.7
9	139.8	89.7	134.4	138.7
10	139.6	91.5	134.1	138.7
11	141.0	63.1		

The profiles for March and November when the lake was unstratified, are as expected with similar measurements to bottom at about 140 µS/cm. The two profiles in June (especially) and August show some anomalies. In June, values vary widely and there appears to be some issues with the equipment. Variation such as is reported is outside the limits of what might be expected and has been reported in previous sampling. The data for August show only one anomalous value at 3 m depth.

Conductivity is probably reflective of precipitation and watershed runoff. In previous sampling the conductivity range at station 03 has a relatively wide range.

Table 2.4 Enos Lake conductivity ranges (from Keystone and Aquaterra reports)

September 2006	134-141 µS/cm
April 2008	137-145
October 2008	115-123
April 2009	104-119
May 2010	92-104

2.4 Temperature

Thermal stratification of the lake is important for understanding the lake ecology and the processes in the lake. Table 2.5 below summarizes the lake temperature profiles for the for seasons. The March and November profiles show the lake to be unstratified and mixing. The June and August profiles show a strongly stratified lake with an upper warm layer (the epilimnion) and a deeper cool layer (the hyplimnion) separated by a zone of rapidly changing temperature (the thermocline – defined as a change of more than 1 degree C for each depth of water).

The June sampling shows the lake stratified with a thermocline between 3 and 5 meters deep and an 11.8 degree difference between the surface and deepest water. The August temperature profile shows a deeper thermocline between 4 and 7 meters and a top to bottom temperature difference of 13 degrees.

Table 2.5 Enos Lake temperature profiles 2017

	02-Mar-17	02-Jun-17	24-Aug-17	20-Nov-17
Depth (m)	Temp. (°C)	Temp. (°C)	Temp. (°C)	Temp. (°C)
0.5	4.8			
1	4.7	19.2	22.6	7.4
2	4.7	19.2	22.5	7.3
3	4.7	19.2	22.3	7.3
4	4.7	15.9	21.7	7.3
5	4.7	12.3	16.1	7.3
6	4.7	9.4	13	7.3
7	4.6	8.6	10.2	7.2
8	4.6	8.0	9.6	7.2
9	4.6	7.8	9.6	7.2
10	4.6	7.5	9.6	7.2
11	4.6	7.4		

2.5 pH

Profiles for pH for the four sampling periods are provided in Table 2.6 below.

Table 2.6 Enos Lake pH profiles 2017

	02-Mar-17	02-Jun-17	24-Aug-17	20-Nov-17
Depth (m)	pH	pH	pH	pH
0.5	2.6			
1	6.0	8.01	8.13	6.82
2	6.0	8.41	8.22	6.94
3	6.0	8.50	8.2	6.99
4	6.1	8.42	8.05	7.03
5	6.15	8.44	7.52	7.1
6	6.45	8.55	6.99	7.12
7	6.75	8.51	6.83	7.14
8	7.1	8.40	6.76	7.15
9	7.41	8.34	6.75	7.17
10	7.59	8.23	6.75	7.17
11	7.0	8.11		

As with the conductivity measurements, there are some problems with these data that are measured as part of a multi-parameter meter system. For example the value of pH 2.6 for the surface sample for March is clearly an error and the data for that depth should be discounted – and likely the others for that date should also be deleted. It may be a problem with the instrument or with calibration, but readings like this (out of what might reasonably be expected) should be cause to check both the instrument and / or the sampling and calibration procedures. The differences in pH values between dates are implausible. It would seem unlikely that pH would vary as widely (2 pH units) as the data indicate.

Previous data is also highly variable. For site 03, Sept 2006, 7.5-7.9; April 2007, 6.4-6.8; November 2007 6.7; April 2008 7.2-8.0; October 2008, 6.6-7.4 and April 2009 4.7-6.4 (the latter seems suspicious). These examples cover a wide range – wider than might be expected for a moderately buffered lake. Some extra attention and QA should be considered if the pH data are to be considered credible.

2.6 Redox

Redox potential is another measurement that is collected using the multi parameter probe used for temperature, dissolved oxygen, conductivity and pH. Only two profiles were taken – in August and November – and are shown in the table below. Redox values often reflect dissolved oxygen concentrations.

Table 2.7 Enos Lake redox profiles 2017

	24-Aug-17	20-Nov-17
Depth (m)	Redox (mV)	Redox (mV)
1	56.6	75.5
2	56.6	81
3	65.2	84.7
4	71.6	88.7
5	87.4	90.5
6	91.2	92.6
7	83.1	93.8
8	68.2	94.9
9	59	97.9
10	52.9	98.9

Previous data for redox in 2007 are 113 and 183 mV in April and November 2008 (surface samples at station 03). Representative profile data at station 03 for April 2008 show 135 at the surface and -80 at the bottom. At deeper than 11 m the negative values may be because the sensor was in the anoxic sediment boundary layer. In October 2008, the redox profile ranged from +94 to +103 in the surface waters but -38 to -96 in the near bottom waters. Similarly in April 2009, surface waters were in the range 93-139 mV but -85 to -94 within 1 meter of the bottom.

2.7 Microbiological Parameters: *E. coli*

Escherishia coli is a species of bacteria in the coliform group of indicators of fecal contamination in water. It indicates the presence of warm-blooded organisms (birds, mammals and humans).

Sampling for *E. coli* in the PGL report is stated as: August 2017; 5 times in 30 days. Surface samples from SWMP-3 and any two shoreline locations. Repeat on 5 year increment.

Samples were taken in a 30 day period in August and September and are summarized in Table 2.8 below. All are surface water samples.

Table 2.8 Enos Lake *E.coli* samples 2017

Date		MDL	24-Aug-17			29-Aug-17			05-Sep-17			11-Sep-17			14-Sep-17		
Site (prefixed by SWMP)			3	4	6	3	6	4	3	4	6	3	6	4	3	6	4
E. coli	CFU/100mL	1	1	5	9	1	7	7	1	3	21	6	31	6	9	5	7
	Mean values																
	site 3	**3.6**															
	site 4	**5.6**															
	Site 6	**15**															

The BC Water Quality Guidelines (recreation – secondary contact) specifies that *E. coli* numbers should be less than or equal to 385/100 mL geometric mean so present conditions are well within that guideline.

2.8 PAHs in sediments

The sampling program specified samples from three locations (sites 3, 4 and 6) to be taken in August. Results are tabulated below (Table 2.9). PAHs are indicators of hydrocarbon presence or contamination and of combustion products of fires.

For many of the individual PAHs, concentrations are near the detection limits of the chemical. Some do show detectable results: for example Phenanthrene (RDL 0.010 mg/kg, mean of three samples was 0.036 mg/kg). Similar results for Pyrene, Chrysene, Benzo(b) fluoranthene, Indento (1,2,3-cd)pyrene, and Benzo (g,h,i) perlene show values well above detection limits.

BC water quality guidelines exist for some PAHs. The guideline for Phenanthene in freshwater sediments is 0.040 µg/g – close to the value reported. Other PAHs that have higher concentrations do not have existing guidelines.

Table 2.9 Sediment PAHs

Sediment PAH samples 29 August 2017					
			SWMP-3	SWMP-6	SWMP-4
			Sediment	Sediment	Sediment
CCME PAH IN SEDIMENTS BY GC-MS (SOIL)					
Calculated Parameters					
Index of Additive Cancer Risk(IARC)	N/A	0.1	1.1	0.25	0.59
Polycyclic Aromatics		RDL			
Naphthalene	mg/kg	0.01	<0.017 (1)	<0.012 (1)	<0.010 (1)
2-Methylnaphthalene	mg/kg	0.01	<0.017 (1)	<0.012 (1)	<0.010 (1)
Acenaphthylene	mg/kg	0.0051	<0.0084 (1)	<0.0058 (1)	<0.0051 (1)
Acenaphthene	mg/kg	0.0051	<0.0084 (1)	<0.0058 (1)	0.0055 (1)
Fluorene	mg/kg	0.01	<0.017 (1)	0.021 (2)	0.011 (1)
Phenanthrene	mg/kg	0.01	0.041 (2)	0.030 (2)	0.037 (2)
Anthracene	mg/kg	0.01	0.039 (1)	<0.012 (1)	0.012 (1)
Fluoranthene	mg/kg	0.01	0.11 (1)	0.051 (1)	0.067 (1)
Pyrene	mg/kg	0.01	0.098 (1)	0.035 (1)	0.045 (1)
Benzo(a)anthracene	mg/kg	0.01	0.022 (1)	<0.012 (1)	<0.010 (1)
Chrysene	mg/kg	0.01	0.041 (1)	0.030 (1)	0.015 (1)
Benzo(b)fluoranthene	mg/kg	0.01	0.076 (1)	0.023 (2)	0.044 (1)
Benzo(k)fluoranthene	mg/kg	0.01	0.028 (1)	<0.012 (1)	0.014 (1)
Benzo(a)pyrene	mg/kg	0.01	0.031 (2)	<0.012 (1)	0.012 (2)
Indeno(1,2,3-cd)pyrene	mg/kg	0.02	0.067 (1)	<0.023 (1)	0.033 (1)
Dibenz(a,h)anthracene	mg/kg	0.0051	<0.0084 (1)	<0.0058 (1)	0.0055 (2)
Benzo(g,h,i)perylene	mg/kg	0.02	0.091 (1)	<0.023 (1)	0.046 (1)
Low Molecular Weight PAH`s	mg/kg	0.51	<0.84	<0.58	<0.51
High Molecular Weight PAH`s	mg/kg	0.02	0.61	0.14	0.3
Total PAH	mg/kg	0.51	<0.84	<0.58	<0.51
Surrogate Recovery (%)					
D10-ANTHRACENE (sur.)	%	N/A	91	95	95
D8-ACENAPHTHYLENE (sur.)	%	N/A	85	86	89
D8-NAPHTHALENE (sur.)	%	N/A	78	88	80
TERPHENYL-D14 (sur.)	%	N/A	95	99	102

2.9 Metals in lake water and sediments

Three sets of samples were taken of Enos Lake water. The first was for dissolved calcium and manganese on March 2nd at site 3. Those results are tabulated below (Table 2.10). The concentrations are as expected and consistent with what might be expected for the lake and what has been reported in previous sampling.

Table 2.10 Dissolved Calcium and Magnesium

ENOS LAKE 2017 WATER QUALITY MONITORING PROGRAM LAB RESULTS					
Sampling Date			**02-Mar-17**		
Site			**SWMP-03**		
Depth			**1 m**	**5 m**	**10 m**
Additional Dissolved Metals by ICPMS					
Dissolved Calcium (Ca)	ug/L	50	14200	14400	14300
Dissolved Magnesium (Mg)	ug/L	50	1550	1530	1540
Total Metals by ICPMS					
Total Calcium (Ca)	ug/L	50	16800	15300	14700
Total Magnesium (Mg)	ug/L	50	1760	1600	1580

Calcium and magnesium are the most plentiful cations in lake water. The concentrations are typical and are in agreement with the values reported in the dissolved metals table below. They are also the principal components of the measure of water Hardness – see section 2.11 below.

The PGL (2016) report summarizes the water quality guidelines and results of previous sampling.

Table 2-4. Metals Baseline Results for Enos Lake Monitoring.

Metal	BC Water Quality Guideline (Aquatic Life - Maximum)	Baseline Maximum Value (2006 – 2013)[e]
Aluminum	0.1[a]mg/L	0.04mg/L (MOE, 2011)
Arsenic	5.0µg/L	0.2µg/L (AquaTerra, 2010)
Boron	1.2mg/L	<0.1mg/L (AquaTerra, all years)
Cobalt	110µg/L	<0.5µg/L (AquaTerra, all years)
Copper	[0.094(hardness)+2][b]µg/L	<0.1µg/L (AquaTerra, all years)
Iron	0.35 mg/L	<0.05mg/L (AquaTerra, all years)
Lead	3µg/L[c]	<0.5µg/L (AquaTerra, all years)
Manganese	1.6[d]mg/L	0.051mg/L (AquaTerra, 2009)
Molybdenum	2mg/L	0.00014mg/L (MOE, 2011)
Selenium	2µg/L	0.07µg/L (MOE, 2011)
Silver	0.1[d]µg/L	<0.0002µg/L (AquaTerra, all years)
Zinc	33[d]µg/L	1.5µg/L (MOE, 2009)

[a]Presumes pH > 6.5, which has always been the case for Enos Lake.
[b]Hardness as mg/L $CaCO_3$. Given typical values of hardness for Enos Lake (~55mg/L), this threshold is approximately 5 µg/L.
[c]Presumes hardness as mg/L $CaCO_3$ greater than 8mg/L. Baseline hardness data for Enos Lake are extensive and very consistently were measured at approximately 55 mg/L.
[d]Values are highly dependent on hardness. Criteria reported here is based on the background values reported to date.
[e]Baseline values are presented mostly for dissolved metals, with the exception of the MOE data which were total metals.

A detailed set of samples were taken March 8 to 23 and include a range of dissolved metals. The table of results is listed below.

Table 2.11 Dissolved metals in Enos Lake March 2017

Site SWMP-3			24-Aug-17			29-Aug-17			5-Sep-17			11-Sep-17			14-Sep-17		
Depth			1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5m	10m
Dissolved Metals by ICPMS																	
Aluminum (Al)	ug/L	3.0	29.4	9.8	12.9	26.3	8.3	12.7	27.7	7.3	9.90	26.1	14.3	11.7	20.6	17.9	12.9
Antimony (Sb)	ug/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic (As)	ug/L	0.10	0.19	0.14	0.18	0.17	0.14	0.16	0.18	0.14	0.19	0.17	0.15	0.15	0.18	0.18	0.18
Barium (Ba)	ug/L	1.0	18.9	17.6	15.5	19	17.8	16.4	19.1	18.6	15.50	19.4	21.9	18	19.8	19.9	17.7
Beryllium (Be)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Boron (B)	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	ug/L	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium (Cr)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt (Co)	ug/L	0.20	<0.20	<0.20	0.27	<0.20	<0.20	0.23	<0.20	<0.20	0.22	<0.20	<0.20	0.23	<0.20	<0.20	0.29
Copper (Cu)	ug/L	0.20	0.54	0.66	0.35	0.97	0.65	0.24	0.56	0.67	0.40	0.73	1.10	0.39	0.47	0.63	0.22
Iron (Fe)	ug/L	5	16.1	26	1160	12	27.9	1420	11.6	120	325.00	14.1	37.8	576	15.6	20.2	1420
Lead (Pb)	ug/L	0.20	<0.20	0.28	0.29	<0.20	<0.20	<0.20	<0.20	0.22	<0.20	<0.20	0.25	<0.20	<0.20	<0.20	<0.20
Lithium (Li)	ug/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Manganese (Mn)	ug/L	1.0	<1.0	2.8	537	<1.0	2.3	489	<1.0	57.8	552.00	<1.0	2.1	558	<1.0	<1.0	726
Molybdenum (Mo)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel (Ni)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silicon (Si)	ug/L	100	2140	2740	4180	1980	2600	3890	1930	2740	3580	1980	2520	3900	1960	2030	4010
Silver (Ag)	ug/L	0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Strontium (Sr)	ug/L	1.0	55.1	47.2	48.8	53.1	46.7	47.6	54.6	45.8	52.70	53.4	47.8	47.1	56.5	56.4	52.3
Thallium (Tl)	ug/L	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Tungsten (W)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Uranium (U)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Vanadium (V)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Zinc (Zn)	ug/L	5.0	<5.0	15	6.6	<5.0	<5.0	<5.0	<5.0	6.9	<5.0	<5.0	15.2	5.4	<5.0	<5.0	<5.0
Zirconium (Zr)	ug/L	0.50	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (Ca)	mg/L	0.05	18.6	16.7	17.2	16.6	15.4	15.7	17.2	15.5	15.60	16.6	15.7	15.3	17.8	18	17.1
Magnesium (Mg)	mg/L	0.05	1.92	1.7	1.67	1.86	1.69	1.57	1.81	1.61	1.82	1.88	1.73	1.67	1.89	1.86	1.71
Potassium (K)	mg/L	0.050	1.93	0.31	0.364	0.34	0.289	0.312	0.325	0.282	0.34	0.346	0.29	0.32	0.36	0.324	0.358
Sodium (Na)	mg/L	0.05	1.94	7.73	7.38	8.42	7.39	7.05	7.81	7.14	7.86	8.35	7.61	7.29	8.4	8.19	7.54
Sulphur (S)	mg/L	3.0	1.95	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Noted from the March 2017 sampling:
Many (20 of 34) dissolved metal parameter results are below the minimum detection limits (MDL) for the parameter for all depths and dates. These include antimony, beryllium, bismuth, boron, cadmium, chromium, cobalt, lithium, molybdenum, nickel, selenium, silver, thallium, tin, titanium, tungsten, uranium, vanadium, sulphur and zirconium.

None of the parameters measured exceed the BC Water Quality Guidelines.

Parameters which show detectable concentrations and deserve some comment are:
Dissolved aluminum. Aluminum is plentiful in soils and its range in Enos Lake (18.2 and 24 µg/L) is not of concern.
Dissolved arsenic. Concentrations are slightly above the detection limit but arsenic is common in surface and groundwater in many coastal areas and of no particular concern. It is a potential indicator of watershed disturbance.
Dissolved barium. Moderately high concentrations but of no particular ecological significance.
Dissolved copper. Moderately concentrations but of no particular ecological significance.
Dissolved iron. Iron is a natural component of surface waters and soil and the concentrations here are of no particular concern.
Dissolved lead. Moderately concentrations but of no particular ecological significance.
Dissolved manganese. A common element in water and the concentrations are of no concern.
Dissolved silicon. A common element in water. The concentrations are typical of coastal lakes.
Dissolved strontium. Moderately concentrations but of no particular ecological significance.
Dissolved zinc. Concentrations are slightly above the detection limit but zinc is common in surface and groundwater in many coastal areas and of no particular concern.

The final four parameters on the chart (calcium, magnesium, potassium and sodium) are the four major cations typically found in lake water and the concentrations are typical of small coastal lakes and of no ecological concern.

A second set of samples for metals were taken 24 August to 14 September to satisfy the specified 5 samples in 30 days schedule specified in the PGL Table 3.1 monitoring program. A summary table is below.

Table 2.12 Dissolved metals in August and September 2017

As with the samples taken in March, no obvious problems or concerns are apparent.

Site SWMP-3			24-Aug-17			29-Aug-17			5-Sep-17			11-Sep-17			14-Sep-17		
Depth			1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5m	10m
Dissolved Metals by ICPMS																	
Aluminum (Al)	ug/L	3.0	29.4	9.8	12.9	26.3	8.3	12.7	27.7	7.3	9.90	26.1	14.3	11.7	20.6	17.9	12.9
Antimony (Sb)	ug/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic (As)	ug/L	0.10	0.19	0.14	0.18	0.17	0.14	0.16	0.18	0.14	0.19	0.17	0.15	0.15	0.18	0.18	0.18
Barium (Ba)	ug/L	1.0	18.9	17.6	15.5	19	17.8	16.4	19.1	18.6	15.50	19.4	21.9	18	19.8	19.9	17.7
Beryllium (Be)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Boron (B)	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	ug/L	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium (Cr)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt (Co)	ug/L	0.20	<0.20	<0.20	0.27	<0.20	<0.20	0.23	<0.20	<0.20	0.22	<0.20	<0.20	0.23	<0.20	<0.20	0.29
Copper (Cu)	ug/L	0.20	0.54	0.66	0.35	0.97	0.65	0.24	0.56	0.67	0.40	0.73	1.10	0.39	0.47	0.63	0.22
Iron (Fe)	ug/L	5	16.1	26	1160	12	27.9	1420	11.6	120	325.00	14.1	37.8	576	15.6	20.2	1420
Lead (Pb)	ug/L	0.20	<0.20	0.28	0.29	<0.20	<0.20	<0.20	<0.20	0.22	<0.20	<0.20	0.25	<0.20	<0.20	<0.20	<0.20
Lithium (Li)	ug/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Manganese (Mn)	ug/L	1.0	<1.0	2.8	537	<1.0	2.3	489	<1.0	57.8	552.00	<1.0	2.1	558	<1.0	<1.0	726
Molybdenum (Mo)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel (Ni)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silicon (Si)	ug/L	100	2140	2740	4180	1980	2600	3890	1930	2740	3580	1980	2520	3900	1960	2030	4010
Silver (Ag)	ug/L	0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Strontium (Sr)	ug/L	1.0	55.1	47.2	48.8	53.1	46.7	47.6	54.6	45.8	52.70	53.4	47.8	47.1	56.5	56.4	52.3
Thallium (Tl)	ug/L	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Tungsten (W)	ug/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Uranium (U)	ug/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Vanadium (V)	ug/L	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Zinc (Zn)	ug/L	5.0	<5.0	15	6.6	<5.0	<5.0	<5.0	<5.0	6.9	<5.0	<5.0	15.2	5.4	<5.0	<5.0	<5.0
Zirconium (Zr)	ug/L	0.50	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (Ca)	mg/L	0.05	18.6	16.7	17.2	16.6	15.4	15.7	17.2	15.5	15.60	16.6	15.7	15.3	17.8	18	17.1
Magnesium (Mg)	mg/L	0.05	1.92	1.7	1.67	1.86	1.69	1.57	1.81	1.61	1.82	1.88	1.73	1.67	1.89	1.86	1.71
Potassium (K)	mg/L	0.050	1.93	0.31	0.364	0.34	0.289	0.312	0.325	0.282	0.34	0.346	0.29	0.32	0.36	0.324	0.358
Sodium (Na)	mg/L	0.05	1.94	7.73	7.38	8.42	7.39	7.05	7.81	7.14	7.86	8.35	7.61	7.29	8.4	8.19	7.54
Sulphur (S)	mg/L	3.0	1.95	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

2.10 Chlorophyll a

Chlorophyll a measures the pigments of algae in the lake water and is an indicator of the biological productivity of the lake. The 2017 data below show that Enos Lake is a productive lake (mesotrophic to mildly eutrophic) with a mean annual chlorophyll a concentration of 10.5 mg/L for 2017. The general classification for trophic position is that chlorophyll concentrations between 2 and 7 mg/L would be considered mesotrophic, a mean concentration of 10.5 is more typical of a eutrophic lake. The summer concentrations when the lake is stratified show surprisingly high chlorophyll a concentration in the deep water – higher than in the surface waters and may indicate a deep water phytoplankton layer as has been noted with previous sampling.

Table 2.13 Chlorophyll a

Sampling Date			02-Mar-17			02-Jun-17			14-Sep-17			20-Nov-17		
Site			SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Depth			1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m
	Units	RDL												
Chlorophyll a	ug/L	0.50	11.4	13.5	10.8	3.76	14.2	11.5	4.88	8.16	28.3	7.07	6.16	6.85
mean for date					11.9			9.82			13.78			6.693
annual mean														10.55

The PGL (2016) report summarized previous chlorophyll data and their table 2-6 is provided below. They note that the data showed considerable variation range from 0.17 to 19.8 mg/L but they felt 4-5 mg/l was typical. Average for all samples in table 2-6 is 6.3 mg/L.

Table 2-6. Baseline data for Chlorophyll a (surface samples only; based on data from AquaTerra, 2014 and MOE raw data)

Date	Chlorophyll a concentration (µg/L)		
	SWMP-04	SWMP-03[a]	SWMP-01
11-Mar-09	NM	11.3	NM
04-Apr-09	18.5	18.1	19.8
11-Nov-09	0.1	0.17	0.17
03-May-10	8.5	5.5	7
20-Dec-10	1.44	7.14	5.42
16-Feb-11	NM	9.5	NM
09-May-11	4.21	5.36	2.05
14-Nov-11	7.75	10.2	10
15-Feb-12	NM	7.03	NM
27-Aug-12	1.83	1.08	0.468
01-Mar-13	10.2	4.25	10.8
03-Dec-13	1.67	5.02	3.27

[a]Also includes samples from MOE taken in 2009, 2011, and 2012, in a very nearby location.

2.11 Hardness

Hardness is a measure of relative mineral content of water, of which calcium and magnesium are the main components. Hardness is import in assessing the relative toxicity of metals to aquatic organisms. Waters with values exceeding 120 mg/L are considered hard, while values below 60 mg/L are considered soft. The average of all samples in 2017 was 41 mg/L so the water would be considered moderately soft.

A summary table of the hardness values obtained in 2017 are provided below.

Table 2.14 Hardness

Sampling Date			02-Mar-17			08-Mar-17			13-Mar-17			15-Mar-17			Mar-23-17		
Site			SWMP-03			SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Depth		MDL	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m
Calculated Parameters																	
Total Hardne	mg/L	0.5	49.1	44.8	43.2	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Inorganics																	
Dissolved Ha	mg/L	0.5	41.9	42.2	42.1	46.6	46.5	44.3	43.5	43.8	42.7	44	44	43	42.3	43	43
mean																	41
Sampling Date			24-Aug-07			29-Aug-17			05-Sep-17			11-Sep-17			14-Sep-17		
Site			SWMP-03			SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Depth		MDL	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m
Calculated Parameters																	
T Hardness ((	mg/L	0.5	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Misc. Inorganics																	
Dissolved Ha	mg/L	0.5	54.3	48.7	49.8	49.2	45.5	45.7	50.5	45.4	46.5	49	46.4	45	52.2	53	50
mean																	46

2.12 Phosphorus

Phosphorus is the most important nutrient for the lake and an indicator of the productivity of the lake. Excessively high phosphorus can result in algal blooms and poor water quality. The water quality target for Enos Lake is 12 µg/L (presumably Total Phosphorus annual average?) and this target would not have been met in 2017. Annual average was 19 µg/L. Another typical evaluation would be TP at spring overturn (which would be 12.4 mg/L) and in this case the target would have been slightly exceeded. There is a surprisingly high concentration of OP in the June sampling – unusual.

Phosphorus concentration, along with chlorophyll and Secchi depth are the standard measures by which to assess trophic status. Total concentrations (measured at spring overturn for lakes with water residence times of greater than one year, or annual means for lakes with short water residence times (<1 year) if less than 10 µg/L are considered oligotrophic, 10-30 µg/L mesotrophic and greater than 30 to be eutrophic. By this classification, Enos Lake would be considered mesotrophic (moderately biologically productive).

Table 2.15 Ortho and Total Phosphorus

Sampling Date			02-Mar-17			02-Jun-17			20-Nov-17			20-Nov-17		
Site			SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Depth		MDL	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m
Orthophosphate	µg/L	1	7	6.5	6.3	15	15	11	3.2	4.9	1.1	0.00	0.00	10
Total Phosphorus	µg/L	2	12	12.9	12.3	41.9	21.8	38.9	11.8	14.5	33	10	10	20
OP 2017 mean														7.2
TP 2017 mean														19

The PGL 2016 report includes a summary table of phosphorus (their Table 2-5 shown below). Mean values for the three sites averages 10.8 mg/L over the four years sampling – significantly lower than the 2017 data but some indication that concentrations may be increasing?

Table 2-5. Summary of baseline Phosphorus concentrations (surface water samples; based on data from AquaTerra, 2014)

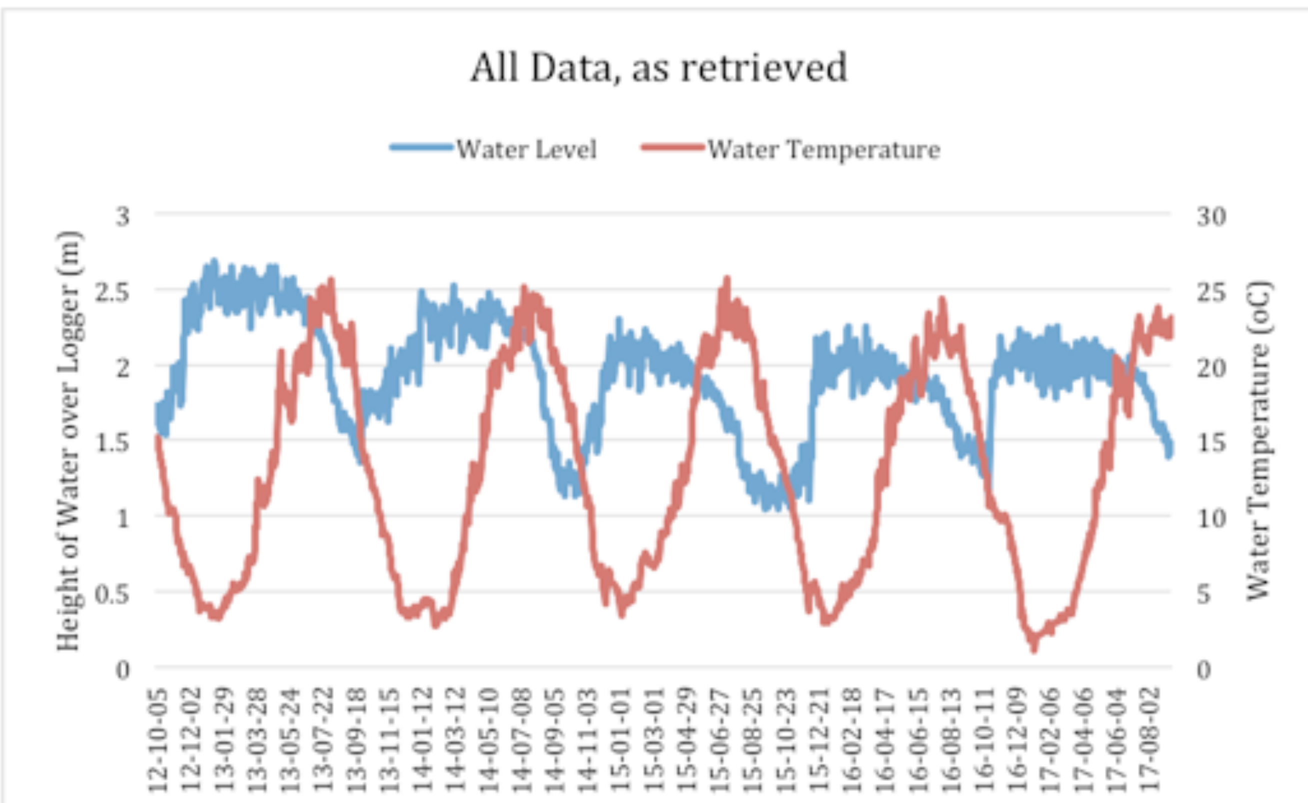
Date	Phosphorus Concentration (µg/L)		
	SWMP-04	SWMP-03	SWMP-01
03-May-10	8	8	9
20-Dec-10	12.2	12.1	13.3
09-May-11	10.8	10.6	11.6
14-Nov-11	10.2	12.2	11.7
27-Aug-12	6.5	6.6	8.2
01-Mar-13	12.8	11.7	12.7
03-Dec-13	11.7	14.1	12
Mean value	***10.31***	***10.76***	***11.21***
Standard deviation	***2.30***	***2.61***	***1.90***

3.0 Discussion

Although watershed development (roads, forest harvesting, soil disturbance, construction does provide some potential risk for deterioration in water quality and changes in the ecology of the lake, there are two other threats that must be taken into account. The first is climate change that will be difficult to adapt to. With warming conditions, water temperatures in the lake will likely be higher, biological productivity will likely increase, stratification times will be longer with more severe oxygen depletion in the hypolimnion. Higher temperatures also will affect evaporation rates that will change the water balance and water residence times.

Data for lake level and surface water temperature have been collected from 2012 to present and water level may show a trend – but no statistical analysis was done to evaluate this – but should be done when more data are available.

Enos Lake water level and temperature 2012-2017



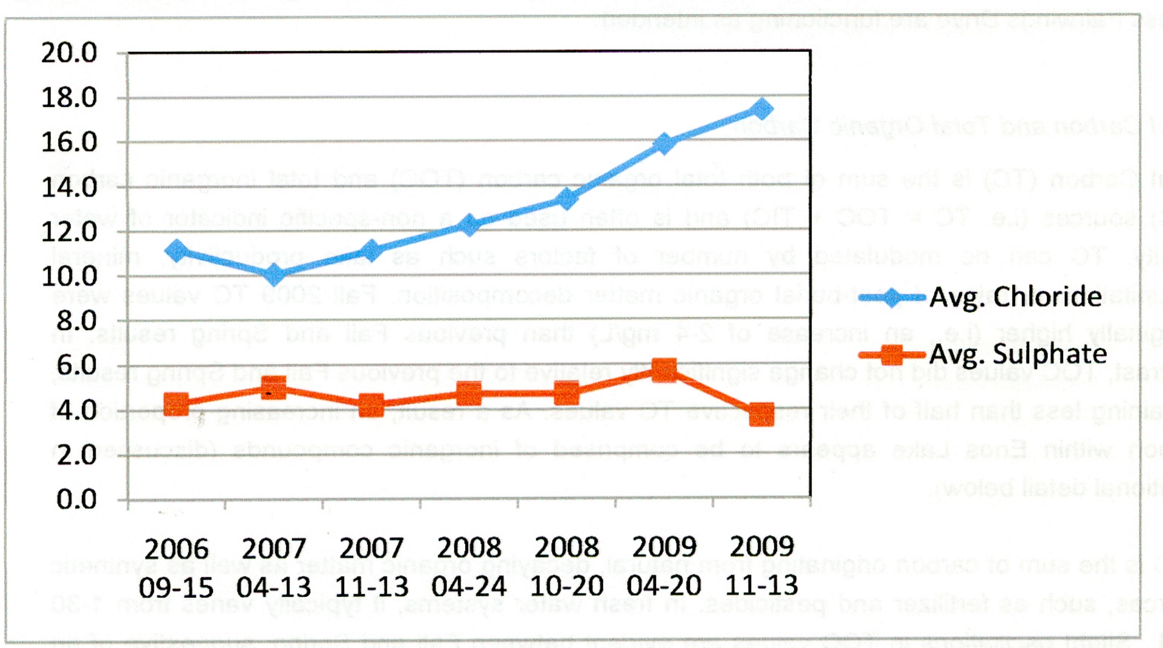
A high risk to the lake is introduction of new species. Previous reports have noted that introduction of trout to the lake would be a serious problem. Introduction of bass (or perch) would be an even more serious possibility. Fish introductions would likely have a disastrous effect on the stickleback population but also on the overall ecology with negative changes to phytoplankton and zooplankton and benthic invertebrates and subsequent changes in water clarity and potential algal blooms since the lake is moderately productive at present but not far from becoming eutrophic given the high phosphorus concentrations noted in 2017 and other indicators of productivity (phosphorus, chlorophyll, Secchi and hypolimnetic oxygen depletion).

4.0 Monitoring Program Recommendations

A separate program deals with water quantity – hydrology and stormwater (KWL 2013). A water budget would be an essential component of water quantity – as it bears on the water quality and response of lake water quality. An obvious need is to determine the volume of Enos Lake and the inflow and outflow volumes. Only a very basic bathymetric map exists (although reference is made in the VIU 2007 report that MoE had completed a bathymetric map) but it might be used to provide an initial estimate of the lake volume and a hypsographic table (volumes by individual depth strata). Lake volume in association with estimates of water inflow and outflow volume is need to calculate water residence time of the lake water which is essential in assessing expected response time to any ecosystem changes. Enos Lake is not really a lake, it is a reservoir. The bathymetry with the extensive littoral area, presumably flooded and added to the lake surface area when the lake was dammed is evidence of its pre-inundation bathymetry. It is this littoral area (and potentially water quality) that would be affected by lake water level drawdowns.

An interesting table in the Aquaterra (2009b) report (their Figure 2) shows an apparent trend in chloride. The report also noted increases in many other ions and metals relative to prior samples but the chloride concentration change is particularly striking but no data since 2009 seem to be available to confirm this trend?

Figure 2 from Aquaterra (2009b) report



It would be desirable to maintain a web accessible data base that posts all the reports and data related to environmental and water quality. A scan of the “Blue Binder” currently held by the Friends of Enos Lake would be an excellent start.

Appropriate signage and an educational program outlining the risks of introduction of invasive species (especially fish) would be appropriate.

5.0 Acknowledgements

Peter Law, Ross Peterson and Sandy Foxall provided a tour of the watershed and lake on 23 October. Peter Law and Ross Peterson also provided reports and data and a helpful review of the draft manuscript.

This document has been prepared as a contract for BCCF. The conclusions, data, opinions, or any other information contained in this document represent best professional judgment based on the information available at the time of its completion and as appropriate for the terms of reference for the work. The report was prepared after a field trip to Enos Lake and a tour of the major features of the watershed and one day of billed professional time to read the appropriate background reports and materials and write this document.

Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by a professional scientist.

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