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Memorandum

Date: **September 26, 2013**

To: **Kelly Krist, Director of Community Services, Seguin Township**

From: **Tammy Karst-Riddoch, Christine Geiger**

Re: **J100033 – 2013 Water Quality Monitoring Summary**

In 2013, Seguin Township completed the sixth year of sampling for its Water Quality Monitoring Program. This program collects total phosphorus (TP) concentration data and other pertinent lake information (e.g., Secchi depth, dissolved oxygen concentration, lake depth, dissolved organic carbon, etc.) in support of the water quality model developed by AECOM (2009) to predict phosphorus concentrations in Township lakes. Continued monitoring will also allow the Township to identify potential problems in lake water quality as they emerge.

The 2013 monitoring was conducted by summer students employed by Seguin Township. HESL staff did not provide an on-site training session prior to fieldwork as in previous years of the program, but provided ongoing technical guidance. In May and June, water samples were collected from 53 lakes for analysis of spring overturn TP concentration and in August and September, 49 of those lakes were revisited to measure dissolved oxygen and temperature profiles, Secchi depth and lake depth.

The major findings from the 2013 monitoring period are summarized below and recommendations are provided for future sampling.

1. Spring Total Phosphorus Sampling

Duplicate water samples from 53 lakes were analyzed for spring TP concentrations. We evaluated the analytical precision of the data (i.e., how well sample duplicates agreed). Contamination of samples can occur during sample collection or as a result of zooplankton biomass, which can produce elevated TP concentrations and 'bad splits' between field duplicates. Even with careful sampling, bad splits are common and occur for approximately 10% of sample submissions to DESC (pers. comm., Bev Clark). For the 2013 data, we flagged all sample pairs that differed by more than a) 40% from the minimum of the two values, and b) 4 μg/L, and removed the higher of the two values, assuming contamination, which is the approach currently used by the District Municipality of Muskoka. There was 1 bad split identified in the 2013 samples, representing 2% of the samples (Table 1). This percentage of bad splits represents good sampling practices as it is below the average for samples submitted to DESC. We recommend continued vigilance in following sampling protocol when collecting water samples to minimize the potential for sample contamination. We note that samples flagged as bad splits due to contamination should be reassessed by comparison with data from additional years of sampling as the monitoring program progresses.

Table 1. Bad Splits Between Duplicate Samples Collected by the Seguin Township Monitoring Program (ST) and the Lake Partner Program (LPP)

Year	# of Bad Splits (>40% and >4 µg/L difference between sample pairs)	Total # of Samples	% Bad Splits
2008 (ST)	3	25	12
2009 (ST)	7	37	19
2010 (ST)	6	36	17
2011 (ST)	11	47	23
2012 (ST)	4	50	8
2013 (ST)	1	53	2
LPP (02-10)	16	233	7

Note: The total number of samples exceeds the number of lakes sampled in 2011 because 4 lakes were sampled twice during spring 2011.

Outliers between years of data were identified using the Dixon's Q and Grubbs' outlier tests at a significance level of $\alpha = 0.05$. In total, 9 values were identified as outliers based on both tests and were removed from the dataset (Table 2). We note that these values should be reassessed as outliers each year as additional data are collected.

Table 2. TP values (2002-2013) in Seguin Township lakes identified as outliers in 2013.

Lake	Year	Outlier TP (µg/L)	Mean 2002-2013 TP (µg/L) (outlier excluded)
Cosh Lake	2008	21.0	7.22
Gilbank	2006	13.9	8.43
Joselin (Burnt) Lake	2002	10.6	5.04
Lane	2013	10.0	4.96
Little Whitefish Lake	2006	10.1	4.53
McDonald	2009	10.8	8.97
McNutt Lake	2008	16.5	8.69
Salmon Lake	2002	13.2	5.92
Sucker Lake	2008	8.4	5.20

Table 3 summarizes the 2013 total phosphorus concentration results and mean concentrations of data collected in previous years by both the Seguin Township monitoring program (2008-2013) and the Lake Partner Program (2002-2011). Combined, these two monitoring programs provide spring overturn total phosphorus data for 74 of the 128 lakes in Seguin Township that have a surface area of at least 10 ha. The LPP data for 2013 have not yet been posted, but these data should be reviewed and included in future revisions to the phosphorus model if applicable.

The MOE recommends a minimum of two years of spring overturn TP data to be 95% confident of being within 20% of the mean annual concentration of a lake. For Seguin Township lakes, 72 lakes now have at least two years of monitoring data, in comparison to 56 lakes in 2012, 47 lakes in 2011, 39 lakes in 2010, and only 28 lakes in 2009. With continued monitoring by the program, approximately half of the Seguin Township lakes will have at least 3 years of data by 2014 when a review of the 2009 water quality model and development capacity estimates of the lakes were recommended by Aecom (2009). These data will provide more reliable estimates of long term, steady-state total phosphorus concentration of the lakes for calibration and validation of the model, thereby providing more robust and confident assessment of shoreline development capacity.

Table 3. Mean Spring Total Phosphorus (TP) Concentrations in Seguin Township Lakes (n=74)

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2013 (µg/L)	# of Years Sampled (02-13)	Mean TP (02-13) (µg/L)
Armishaw Lake	1	6.50	4.35	3	5.23
Baby Lake	2	6.38		5	6.01
Back Lake	1	5.50	8.85	3	7.07
Black Water Lake	4	11.75	8.50	7	10.74
Blue Lake	3	4.93		5	4.48
Brennan Lake	0		10.20	2	10.63
Capton Lake	1	6.95	6.55	2	6.75
Clear Lake	6	3.12	4.20	10	3.33
Cosh Lake	0			3	7.22
Diamond Lake	1	13.84		4	10.17
Draper Lake	1	7.60		3	7.58
Dyson Lake	3	5.39	4.80	6	4.66
Fair Lake	1	8.25	8.00	2	8.13
Faris Lake	1	3.90		2	4.05
First Lake	1	7.10	5.20	3	6.49
Flaxman Lake	1	4.50		2	4.20
Forget Lake	1	7.06	5.15	4	5.63
Gilbank Lake	3	9.75		5	8.43
Haines Lake	1	4.90	12.40	3	7.92
Horseshoe Lake	8	7.23	6.68	12	7.36
Isabella Lake	8	9.38	9.50	12	9.70
Joselin (Burnt) Lake	7	5.08	4.40	9	5.04
Kight Lake	1	11.10	11.55	3	10.59
Kingshott Lake	0		14.75	3	11.18
Lane Lake	1	5.10		2	4.96

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2013 (µg/L)	# of Years Sampled (02-13)	Mean TP (02-13) (µg/L)
Lieback Lake	1	6.40	5.70	3	5.45
Linger Long (Napken) Lake	1	11.07	9.40	4	9.44
Little Lake Joe	0		5.75	3	4.48
Little Otter Lake	0		3.20	1	3.20
Little Seguin/Duck Lake	4	8.60	7.75	8	9.03
Little Whitefish Lake	3	4.63		6	4.53
Long Lake	2	9.67		3	8.51
Long Lake 1	1	4.82		2	4.32
Lower Fry Lake	0		9.45	4	13.90
Manitouwaba Lake	8	6.26		9	6.19
Maple Lake	5	12.56	7.70	9	11.10
Martin Lake	4	7.20	6.05	6	7.02
McDonald Lake	1	10.80		2	8.97
McGowan Lake	7	4.46		9	5.14
McKechine Lake	1	3.40		3	3.96
McLean Lake	1	8.40		3	7.45
McNutt Lake	4	8.97		6	8.69
Mirror Lake	1	5.00	8.70	3	6.99
Murdock Lake	1	13.45		2	12.68
Mutton Lake	0			3	10.73
Neville Lake	1	9.80	12.55	3	10.41
Oastler Lake	5	6.36	7.15	8	6.52
Otter Lake	8	6.41	7.25	12	6.12
Pender Lake	0		5.30	2	4.89
Portage Lake	1	7.77	5.25	5	5.91
Rankin Lake	8	8.57	8.55	11	8.32
Roberts Lake	3	7.25	6.80	5	6.87
Salmon Lake	7	6.05	5.00	9	5.92
Scime Lake	0			1	9.06
Scott Lake	1	7.09	12.25	4	7.44
Second Lake	1	13.75	7.45	3	10.81
Star Lake	8	9.46	9.30	12	9.60
Storm Lake	1	5.65	5.45	3	5.87
Sucker Lake	0		5.20	4	5.20

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2013 (µg/L)	# of Years Sampled (02-13)	Mean TP (02-13) (µg/L)
Sugar Lake	7	7.39	5.80	11	6.90
Ten Mile Lake	0		5.85	3	9.33
Third Lake	1	12.10	4.20	3	8.97
Three-Legged Lake	6	5.88	4.45	8	5.42
Tiffin Lake/Silver	1	6.14		4	6.55
Trout Lake	1	5.40	7.95	4	5.11
Tub Lake	1	7.85		2	6.95
Tucker Lake	1	9.15	8.75	4	7.98
Turtle Lake	5	8.56	7.95	9	8.02
Upper Fry Lake	6	14.03	17.45	10	15.33
Virtue Lake	2	10.38	9.50	5	8.66
Whitefish Lake	1	3.40	5.40	4	5.07
Windfall Lake	1	7.65	6.80	3	7.32
Yarrow Lake	0		10.55	2	8.86

Simple linear regression was used to determine whether TP concentrations were changing significantly over time (2002-2013) in any of the lakes. Only lakes with at least 5 years of data were analyzed. Only Upper Fry Lake displayed a significant positive trend in TP over time ($p<0.05$). This lake should continue to be monitored closely to verify the trend.

2. August Field Sampling

Many of the lakes in Seguin Township are shallow, with the potential to have internal phosphorus loading due to resuspension of phosphorus in the water column with wind mixing and increased rates of mineralization of organic matter, and/or have relatively high concentrations of dissolved organic carbon (tea-stained lakes), which were suspected as contributing to error in the 2009 model predictions. In addition, some lakes may be prone to anoxia (lack of oxygen) in the hypolimnion, which can also result in internal phosphorus loading and error in the model predictions. To identify these potential problems, dissolved oxygen and temperature profiles, lake depth, Secchi depth and water colour (qualitative) were monitored at 49 study lakes in August. These field data are summarized in Table 4.

Of the 49 lakes monitored in August 2012, 16 were shallow and mixed to the bottom at the sampling location (Table 4). These lakes should be evaluated for potential internal phosphorus loading due to wind mixing and resuspension of phosphorus into the water column in future revisions to the model. We note that data for Star Lake were missing from the data files provided to HESL.

Table 4. Summary of August 2012 Field Sampling Results

Lake Name	Depth (m)	Surface Water Temperature (˚C)	Dissolved Oxygen (1-m off bottom) (mg/L)	Potentially Anoxic Hypolimnion?[1]	Shallow Mixed Water Column?	Secchi Depth (m)	Water Colour
Back Lake	11	22.5	0.04	yes	yes	2.4	orange
Bright Lake	4.5	23.6	4.8			3.6	orange/green
Burr Lake	7	24.1	0.16		weakly stratified	3	yellow/orange
Capton Lake	24	22.4	0.07		yes	4.6	yellow
Clear Lake*	27	23.7	10.08		yes	8.3	clear/blue
Day Lake	7	23.9	0.06	yes	weakly stratified	0.85	orange
Doley Lake	4.5	23.9	4.08		weakly stratified	bottom	orange
Duck Lake	16	22.5	5.24		yes	3.5	tea/orange
Dyson Lake*	15	22.5	12.29		yes	5.8	blue/green
Fair Lake	4	21.7	7.47			3	orange
First Lake	3.5	25.2	9.71			bottom	clear/green
Forget Lake	17	23.9	6.19		yes	5	clear/green
Gilbank Lake	17	22.1	0.08	yes	yes	5.2	yellow/green
Haines Lake	14	22.3	5.29		yes	4.3	yellow/orange
Horseshoe I Lake	18	22.9	0.06	yes	yes	4.6	green
Horseshoe II Lake	21	23.1	0.07		yes	4.9	clear/green
Horseshoe III Lake	7.3	23.2	0.82			4.8	clear/green
Isabella Lake	15	22	1.37		yes	2.7	yellow/orange
Lane Lake	6.5	22.8	10.53			5.4	tea
Lieback Lake	16	22.9	0.11		yes	5	blue/green
Lioness Lake	8.9	21	0.07		weakly stratified	4.6	yellow
Little Otter Lake	5.3	24	8.01			3.6	green
Little Whitefish Lake	27	21.7	0.5		yes	5.7	blue/green
Long Lake	19	23.9	0.98		yes	4.7	yellow/green
Lower Fry Lake	9.5	22.1	0.08		weakly stratified	2.9	orange
McDonald Lake	2.5	18	6.35			bottom	yellow/orange
MacLeod Lake	3.2	19.1	5.56			1.4	red/brown

Lake Name	Depth (m)	Surface Water Temperature (˚C)	Dissolved Oxygen (1-m off bottom) (mg/L)	Potentially Anoxic Hypolimnion?[1]	Shallow Mixed Water Column?	Secchi Depth (m)	Water Colour
Manitouwaba Lake	9.1	23.3	4.9		weakly stratified	5.3	yellow
Maple Lake	14	22	0.1		yes	3.4	green
McKenchnie Lake	5.5	24.1	7.77			4.8	yellow/green
McNutt Lake	7.7	23.3	1.64		weakly stratified	4	yellow
Mirror Lake	4.2	24.4	7.52			3.8	yellow
Otter Lake*	43	23	0.16		yes	4.6	grey/blue
Pender Lake	11.5	21.2	0.11		yes	4.3	yellow/brown
Portage Lake	19	21	5.06		yes	4.5	clear/green
Rankin Lake	20	23.4	4.58		yes	5.1	blue/green
Roberts Lake	4.3	24.4	7.02			4.1	yellow/brown
Salmon Lake	10	23.8	2.49		weakly stratified	4.9	blue
Silver Lake	18	21.1	2.08		yes	4.1	yellowish
Soverign Lake	12	23.8	0.06	yes	yes	1.9	orange
Stata Lake	7	22	0.56			4.4	yellow/green
Sucker Lake*	17	22.7	4.2		yes	2.6	blue
Three-Legged Lake*	34	22.8	5.22		yes	5.4	blue
Turtle Lake	12	21.3	0.67		weakly stratified	4.2	tea
Unnamed Lake 1	5	23.4	3.43			3.2	yellow
Unnamed Lake 2	5.1	23.8	6.41			bottom	yellow/green
Virture Lake	3.2	23.8	7.87			bottom	yellow/green
Whitefish Lake	23	21.9	4.01		yes	5.9	blue

[1]mean hypolimnetic dissolved oxygen concentration <0.1 mg/L.

*dissolved oxygen profile is suspect.

The water of 27 lakes was noted as being tea-stained, “yellow”, “orange” or ‘brown’ with relatively shallow Secchi depths indicating that they likely have high DOC concentrations (Table 4). These lakes should be identified in revisions to the model to explain possible error in the model predictions.

Several of the lakes displayed low oxygen concentrations (<0.1 mg/L) within 1 m of the lake bottom, but only five of the lakes (Back, Day, Gilbank, Horseshoe I, and Sovereign lakes) were considered to potentially develop anoxic (no oxygen) hypolimnia as mean dissolved oxygen concentrations in the bottom waters of these lakes was <0.1 mg/L. Dissolved oxygen concentration in the hypolimnion of lakes

can continue to decline until fall overturn and so anoxia and internal phosphorus loading potentially occurs in these lakes. Potential internal phosphorus loading in these lakes should be considered in future revisions of the model.

3. Summary and Recommendations

- A total of 73 of 128 lakes (57%) in Seguin Township have measured spring total phosphorus concentration data and at the conclusion of the 2013 spring monitoring program, and 65 lakes have a minimum of 3 years of data. There are now a sufficient number of lakes with measured phosphorus data to confidently validate the water quality model.
- We recommend that the Sequin Township monitoring program continue to monitor spring total phosphorus concentration for the existing monitoring lakes (65 lakes) on a 2-year rotation (approximately half of the lakes each year). A list of suggested lakes for spring total phosphorus monitoring is provided in Appendix A.
- Due to the complex lake shape and bathymetry of Horseshoe Lake, we continue to recommend that spring total phosphorus sampling be conducted at 3 locations in the lake in 2013 to support the possibility of multi-basin modeling of this lake in future revisions to the model.
- Upper Fry Lake has displayed an increasing trend in phosphorus concentration since 2002. This lake should be included in the 2014 spring monitoring.
- August monitoring of dissolved oxygen, temperature, lake depth and Secchi depth has been completed for 68 lakes. These data have been useful to flag shallow lakes, high DOC lakes and lakes that potentially undergo anoxia for refinement of the model. We recommend that monitoring in 2014 focus on lakes that have not yet been monitored, lakes that have been flagged as potentially developing anoxia in the hypolimnion and lakes that are designated as Lake Trout Lakes by the Ministry of Natural Resources (Appendix A).
- If additional time or funding is available, we recommend that a subset of lakes be sampled for dissolved organic carbon or phosphorus concentration at the end of summer from the hypolimnion. HESL will work with Seguin Township to select the most appropriate lakes for additional sampling if this is possible. Collection of these additional parameters, where appropriate, is recommended over sampling additional lakes for spring total phosphorus.
- There may be additional phosphorus data from LPP which could be used for the 2014 update of the model, but these data should be reviewed (bad splits, outliers, timing of sample collection, etc.) for consistency with the Sequin monitoring data.
- The three basins making up Horseshoe Lake should be considered for separate monitoring for the update of the model

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