A Summary of Results of the 1997-99 Kings County Volunteer Water Quality Monitoring Program*

Prepared for

Kings County Water Quality Monitoring Volunteers
and
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By

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Kings County Volunteer Water Quality Monitoring Program

1. Introduction

In early 1997 Kings County began a volunteer water quality monitoring program at a number of lakes located within the Gaspereau River watershed. This program was initiated in order to validate a lakeshore capacity model developed for this region by Horner and Associates, an Ontario based consulting firm. The model attempts to predict how lake water quality will be affected by changes in development within the watershed. A major objective of the monitoring program is to collect water quality data that can be used to validate the model. In addition to the data collected in 1993 by Horner and Associates used for development of the model, three years of data (1997-1999) have been collected to date.

2. Methods

Prior to the beginning of each year of the program, volunteers are trained in the procedures for recording data, making various water quality measurements and proper collection of water samples, at a workshop held at Acadia University. Sampling is carried out at monthly intervals between early May and late October of each year. The water samples collected at each site are delivered on the same day to a project coordinator having the responsibility of ensuring that samples are collected, packaged properly and sent by bus on the day of collection for analysis at the Environmental Chemistry Laboratory of the Queen Elizabeth II Health Science Centre in Halifax.

In addition to the water quality survey, during the period between mid-May and mid-June 1999 data was collected on surface and bottom water temperatures at six of the lakes being monitored. Vemco data loggers were installed from moored floats at depths of one meter below the surface and one meter above the bottom at locations in close proximity to the water quality sampling stations. The loggers were programmed to continually record temperature at intervals of one hour.

3. Results

All of the water quality data has been tabulated as an Access database. In addition to that collected by the volunteers during 1997-1999, the database also contains the data collected by Horner and Associates during 1993. A total of eleven sites have been monitored, but not all have been monitored during all years. One of these sites, Hardwood Lake, is located outside of the Gaspereau watershed and serves as a control site.

Interpretation of the results is largely restricted to consideration of the levels of total phosphorous concentration, chlorophyll *a* concentration and Secchi Disk depth. These three variables are the ones typically used to evaluate water quality with respect to the influence of

development within watersheds. Total phosphorus is the nutrient most commonly associated with *eutrophication*, a term used to describe the conditions associated with excessive algal growth in water bodies. Chlorophyll *a* is a measure of the amount of algae contained in the water and Secchi Disk depth is a measure of the transparency of the water body. The values of each of these parameters associated with varying levels of water quality are presented in Table 1.

Table 1. Water quality criteria.

Parameter	GOOD	MEDIUM	POOR
Total Phosphorus (μg/l)	< 10	10 – 20	> 20
Chlorophyll *a* (μg/l)	< 3.5	3.5 - 5.0	> 5.0
Secchi Depth (meters)	> 5	3 – 5	< 3

In general, total phosphorus levels in 1999 fall within the mid-medium water quality range while chlorophyll *a* values are mostly within the good water quality range (Figure 1). Secchi disk depths, however, are largely within the poor quality range but, as discussed in the 1998 report, this is likely due to the natural color of the lake water rather than high algal concentrations.

There appears to be a significant temporal trend in the yearly averages over the three year period in which the lakes have been monitored. In almost all cases total phosphorous levels appear to be increasing and are particularly high for 1999. Exceptions are Hardwood and Murphy. Hardwood has varied little between 1997-99 and Murphy has decreased since 1997. The fact that Hardwood, the control lake, has changed little suggests that the changes observed in the other lakes are not related to normal yearly variation in natural physical factors such as precipitation and temperature. Also noteworthy is the persistence in 1999 of the relatively large increase in total phosphorous previously noted at Lumsden Pond in 1998.

The yearly changes in chlorophyll *a* levels seem to bear little relationship to those of total phosphorous. In many instances chlorophyll *a* decreases when total phosphorous increases. Changes in Secchi Disk depth also shows little relationship to changes in total phosphorous or chlorophyll *a* concentrations. Figure 2 is a series of scatterplots showing the relationship between total phosphorous and chlorophyll *a* for each lake as well as all lakes combined. Figure 3 shows the same for the relationship between chlorophyll *a* and Secchi Disk depth. In general, these relationships are poor on both an individual lake basis and for all lakes combined.

Figure 4 shows the variation in total phosphorous, total nitrogen and the ratio between total nitrogen and total phosphorous. In general, total nitrogen appears to exhibit the same temporal trends as does total phosphorous. There is also a moderately good relationship between total phosphorous and total nitrogen for most lakes (Figure 5). The N:P ratios are mostly above 15 and clearly indicate that phosphorus is the limiting nutrient in these lakes (N:P ratios less than seven are assumed to indicate that nitrogen, as opposed to phosphorous, may be limiting). This is important to know because the lake capacity model assumes phosphorus to be the limiting factor.

4. Model Predictions vs Measured Values

Having monitored the lakes for three years, it is now appropriate to determine how well the lakeshore capacity model developed by Horner and Associates performs with respect to predicting the levels of total phosphorus and chlorophyll *a* and Secchi Disk depth. The model was run to produce predictions for each year in which monitoring was carried out using the development parameters appropriate to each year. Table 2 lists the average yearly measured and predicted values for each site, and Figures 6 and 7 present the difference between predicted and measured values as absolute values and percentages respectively.

Table 2. Yearly measured average values of selected water quality parameters and corresponding values predicted by the Horner and Associates model based on level of development within the watershed.

Site	Year	Measured Total P (µg /l)	Predicted Total P (µg /l)	Measured Chl a (µg/l)	Predicted Chl a (µg/l)	Measured Secchi Depth (meters)	Predicted Secchi Depth (meters)
Hardwood	1993	10.1	8.6	1.7	1.6	2.9	1.1
"	1997	12.8	8.6	1.7	1.6	3.1	1.5
"	1998	14.3	8.6	1.7	1.6	2.3	1.7
"	1999	13.7	8.6	1.7	1.6	2.1	0.3
George	1993	9.1	10.3	1.7	2.1	3.8	4.4
"	1997	8.7	10.6	1.4	2.2	4.0	4.2
"	1998	12.7	10.6	2.0	2.2	3.8	4.1
"	1999	13.0	10.6	1.5	2.2	4.0	3.3
Loon	1993	12.0	7.9	2.5	1.5	2.9	3.3
"	1997	10.6	8.1	2.5	1.5	2.8	4.1
"	1998	8.5	8.3	3.5	1.6	3.1	3.4
"	1999	15.3	8.3	2.2	1.6	3.5	2.9
Aylesford (M)	1993	10.1	8.5	3.0	1.6	3.2	2.8
"	1997	9.7	8.6	2.0	1.6	2.9	3.7
"	1998	14.2	8.6	2.3	1.6	3.0	4.0
"	1999	12.2	8.7	2.0	1.7	3.5	2.9
Aylesford (FC)	1993	9.0	8.5	3.0	1.6	3.1	-
"	1997	9.2	8.6	2.3	1.6	2.5	3.3
"	1998	15.2	8.6	2.6	1.6	3.0	3.6
"	1999	13.2	8.7	1.9	1.7	3.0	2.3
Murphy	1997	16.8	12.3	1.4	2.8	2.2	1.8
"	1998	10.7	12.4	1.4	2.8	2.5	3.1
"	1999	10.8	12.5	1.7	2.8	2.1	1.3
Gaspereau	1998	13.8	7.2	2.3	1.3	2.1	3.8
"	1999	15.2	7.2	2.0	1.3	2.1	2.2
Trout River	1997	13.2	8.4	1.8	1.6	1.9	1.1
Little River	1998	14.8	8.5	1.9	1.6	2.6	2.2
"	1999	13.7	8.5	1.7	1.6	2.6	1.0
Black River	1997	8.0	8.4	1.9	1.6	2.3	2.1
"	1998	11.7	8.4	2.2	1.6	2.1	2.7
"	1999	15.4	8.4	2.6	1.6	2.4	0.0
Lumsden	1997	9.0	10.2	4.4	2.1	2.0	2.6
"	1998	15.3	10.2	3.3	2.1	2.2	2.0
"	1999	15.3	11.0	2.4	2.3	1.8	0.8

In almost all cases the model underpredicts total phosphorous concentrations. The mean percentage error is -36 % with a range of 18 to - 111% (in their original report, Horner and Associates state that a difference of about ±20% between measured and predicted values is acceptable). The average percent error is -37%. The fact that the predictions are poor for Hardwood, the control lake, indicates that the problem is not solely related to the way the model estimates phosphorous loads as a result of lakeshore development.

The differences between measured and predicted values of chlorophyll *a* and Secchi Disk depths is also large. The mean percentage error for these parameters is -26 and -19%, but the ranges are 51 to -125% and 44 to -168 % respectively. This indicates that the regression equations used in the model to predict these values are in need of revision.

5. Lake Stratification

Complete temperature data records were collected successfully at all sites except Hardwood and Gaspereau. At Hardwood and Gaspereau the loggers became detached from their moorings and were recovered on 22 August and 21 November, respectively, floating within the shoreline of the lakes. It is not known exactly when these loggers became detached form their moorings.

The output of the temperature data loggers is presented in Figure 8. Surface and bottom water temperatures reached a maximum of about 25 and 20 °C respectively. There is little indication that any of the lakes exhibited significant thermal stratification. In most instances temperature differences between the surface and bottom never exceeded more than 5 °C and this was often periodically broken down. Based on this data, all of the lakes monitored for temperature can be considered *polymictic*, i.e., they become weakly stratified for short periods, seldom more than one month, but this stratification is easily and quickly broken during periods of moderate wind induced mixing. In addition, it is likely that for those lakes in which water is drawn form the hypolimnion for power generation, any colder bottom water present is removed preventing the development of any significant thermal stratification.

6. Conclusions

Based on the data collected to date, total phosphorous concentrations in most of the lakes appear to be increasing and are now in the mid-mesotrophic range,

The elevated levels of total phosphorus observed in 1998 at Lumsden Pond have persisted in 1999,

The model does poorly with respect to predicting total phosphorus, chlorophyll *a* and Secchi Disk depth and there is a need to better define the relationships used in the model to predict the water quality parameters,

None of the lakes monitored for temperature exhibited significant thermal stratification.

Figure 1. Mean values of total phosphorus, chlorophyll a and Secchi Disk depth at each lake for each year (error bars are one standard error of the mean).

Figure 2. Scatterplots of total phosphorous vs. chlorophyll *a* for each lake and all lakes combined.

Figure 3. Scatterplots of chlorophyll *a* vs. Secchi Disk depth for each lake and all lakes combined.

Figure 4. Mean values of total phosphorous, total nitrogen and their ratio at each lake for each year (error bars are one standard error of the mean).

Figure 5. Scatterplots of total phosphorous vs total nitrogen concentrations for each lake and all lakes combined.

Figure 6. Absolute differences between predicted and average measured values of total phosphorous, chlorophyll *a* and Secchi Disk depth at each site for each year.

Figure 7. Percent difference between predicted and average measured values of total phosphorous, chlorophyll *a* and Secchi Disk depth at each site for each year.

Figure 8. Seasonal temperature variation of surface and bottom waters for those lakes monitored with data loggers during 1999.