DRAFT REPORT

Assessment of the Trophic Status of Several Lakes in the Harvey Area

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1. Introduction

The *Greater Harvey Improvement Association* (GHIA) and the New Brunswick Department of Environment and Local Government (DELG) are working on a multi-year project to investigate sustainable economic growth in the Harvey area without compromising environmental quality. Early on in the project, an inventory of the infrastructure and the important environmental, cultural and historic features was carried out. This information was documented in maps and databases and compiled in a map atlas.

The GHIA recognized that the lakes in the Harvey area and their prime water quality are key to the attraction of the area and its economic growth. Consequently, an assessment of these lakes with considerations of existing or potential future residential development on water quality was initiated. The following study was carried out by NATECH Environmental Services in partnership with DELG with support from the New Brunswick Environmental Trust Fund.

1.1 General Background Information

The study area encompasses an area of 1,300 km^2. The terrain is hilly with elevations ranging from 75 to 250 m. Land cover in the area includes forest with agricultural and residential use occurring along the major roads, rivers and lakes. Lakes of residential and recreational significance in the Greater Harvey Region include Yoho Lake, Lake George, Harvey and Second Harvey Lakes, Magaguadavic and Little Magaguadavic Lakes, Oromocto Lake and Little Kedron Lake (Figure 1-1). Lake characteristics for each lake studied are summarized in Table 3-1 (found in section 3.1). The lakes are in either into the St. John or the Magaguadavic River drainage.

River drainage.

Often, lakes near urban centres experience rapid and relatively uncontrolled residential development. As a result, nutrient loadings from septic systems, lawns, paved areas, ditches, gravel roads, etc. increase, leading to excessive growth of aquatic vegetation. This unsightly vegetational growth has adverse effects on fish habitat and the aesthetic and recreational value of the lakes. Eutrophication is nutrient enrichment causing excessive growth of aquatic vegetation. Typically, phosphorus is the nutrient that triggers eutrophication in fresh water. Mathematical modelling is a useful tool to determine the potential for eutrophication in lakes. For this report, several models were tested and the most appropriate model was selected to predict the eutrophication potential of the seven major lakes in the Harvey Area under increasing levels of development (this is found in methods as well, delete here, ??).

1.2 Water Quality and Eutrophication

Eutrophication can significantly degrade water quality which negatively impacts fish habitat. When algae and rooted aquatic vegetation die, they settle to the bottom of the lake. Decomposition of the dead vegetation may deplete oxygen, leading to odour generation and impacts on fish. A portion of the nutrients remains in the lake and along with additional nutrients imported from the watershed may contribute to further growth of vegetation. Human activities can accelerate eutrophication through construction site runoff, manure spreading, use of fertilizers, improper design and maintenance of septic systems, etc.

The nutrients that are required for algae growth are carbon, nitrogen, potassium and phosphorus. If a certain minimum of each of these nutrients is present in water and environmental conditions (e.g. sunlight and water temperature) are favourable, algae will grow. With the exception of phosphorus, most nutrients are available in abundance in lake water. Often phosphorus is the growth limiting nutrient. Increases in phosphorus can result in appreciable increases in the growth of aquatic vegetation. When algal populations increase a corresponding decline in water transparency will be observed.

Phosphorus enters a lake from precipitation, groundwater that seeped through soil formations containing phosphates or groundwater that has received septic system effluents and in runoff from land with agricultural or other human usage. Most all runoff from land contains phosphorus to some degree. Spring turnover in the lake causes phosphorus to be re-suspended and uniformly mixed throughout the water column. This, combined with the peak runoff from snow melt creates maximum lake phosphorus levels at that time.

Phosphorus is a significant eutrophication indicator. Spring phosphorus levels can be determined by three separate methods including:

1. Measurements of phosphorus concentration in spring lake water samples;
2. Calculations using the average Chlorophyll a concentration. A well established relationship exists between spring phosphorus concentrations and summer Chlorophyll a concentrations;
3. Calculations using measurements of transparency of water in the summer.

The correlation between Secci depth (a measure of light penetration in water) and Chlorophyll a concentrations is well established therefore, Secchi depth measurements provide an inexpensive way to estimate Chlorophyll a concentrations. With Chlorophyll *a* quantified, spring phosphorus levels are then calculated (Dillon and Rigler, 1974 and Panuska, 1994). Figure 1-2 shows the relationship between Chlorophyll a concentrations and Secchi depth. Secci depth is also affected by water colour, impacting the relationship

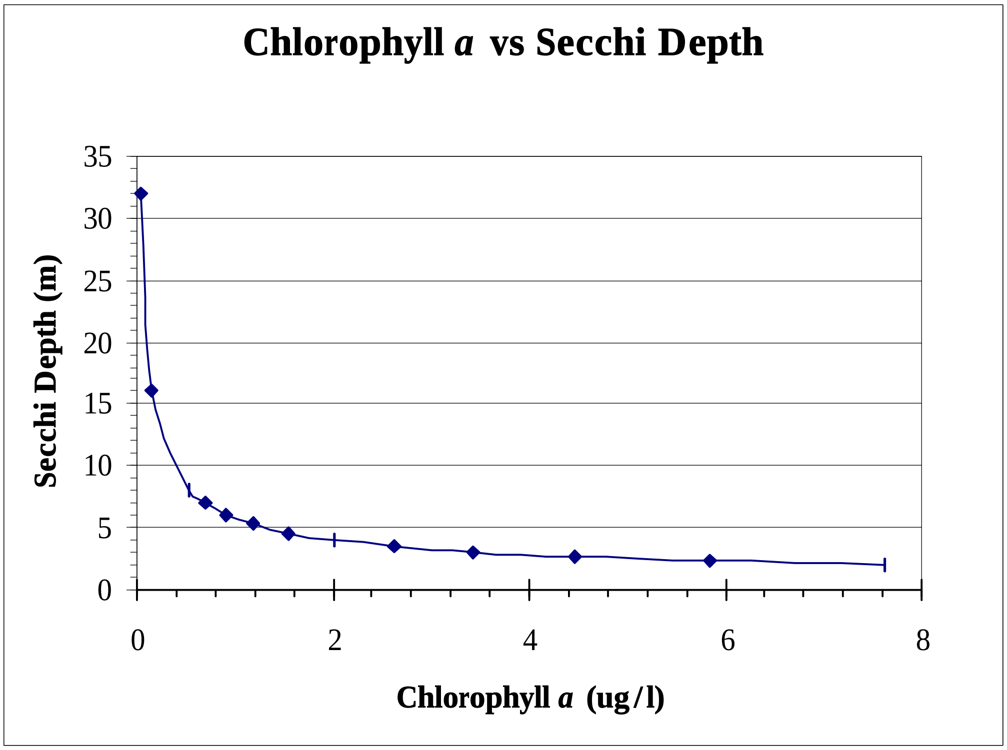

Figure 1-2 Relationship of Chlorophyll a to Secchi Depth (adapted from Panuska, 1994)

between Chlorophyll *a* and Secchi depth. Once Secchi depths and Chlorophyll a concentrations are obtained, the affect of colour on this relationship can be assessed on a lake by lake basis.

1.3 Trophic Status Index

The Trophic State Index (TSI), or Carleson Index, was developed to define the potential for algae growth in lakes. The trophic states for the index are defined using each doubling of algal biomass as the criterion for the division between each state (ie. each time the concentration of algal biomass doubles from some base value, a new trophic state is recognized). A simple approximation for algal biomass is obtained by measuring the depth of light penetration into the lake. The instrument used to measure light penetration is a Secchi disk and the measured depth is the Secchi Depth (SD). A Secchi Disk measures the water transparency by determining the maximum depth at which a black and white 25 cm (10 inch) diameter disk can be seen in water. The correlation between the TSI and the SD is described as:

$$TSI = 60 - (33.2 \times Log_{10} SD)$$

where SD is the Secchi Disk value. The Carleson Index has four trophic states; oligotrophic (nutrient poor), mesotrophic (moderate nutrient content), eutrophic (nutrient rich), and hypereutrophic (extremely nutrient rich); and the status of a lake can be determined from the secchi depth, chlorophyll-a concentrations, or total phosphorus. This Index is shown in Figure 1-2. The following describes each indices on the scale:

- TSI< 30 — Classical oligotrophy: clear water, oxygen throughout the year in hypolimnion (the deep, cold and relatively undisturbed part of the lake).
- TSI 30-40 — Deeper lakes still exhibit classical oligotrophy but some shallower lakes will become anoxic in the hypolimnion during the summer.
- TSI 40-50 — Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.

TSI 50-60 Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte (larger aquatic plants) problems evident, warm water fisheries only.

TSI 60-70 Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.

TSI 70-80 Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration.

TSI 80-90 Algal scums, summer fish kills, few macrophytes, dominance of rough fish.

1.4 Dillon-Rigler Lake Level Index

Dillon and Rigler (1975) assign lake classifications according to phosphorus concentrations in lake water (see figure 1-3). Classifications are as follows:

Level 1: 2mg/m^3; for lakes to be used primarily for body contact water recreation, and where it is desirable to maintain hypolimnetic concentrations of 5mg/L to preserve cold water fisheries. The lake will be extremely clear with a mean Secchi disc visibility of 5 m and will be very unproductive. (Note - Secchi disc visibility will be lower in brown water (dystrophic) lakes).

Level 2: 5mg/m^3;for lakes to be used for water recreation but where the preservation of cold water fisheries is not imperative. The lake will be moderately productive and correspondingly less clear, with a mean Secchi disc visibility of 2-5m.

Level 3: 10mg/m^3; for lakes where body contact recreation is of little importance, but emphasis is placed on fisheries. Hypolimnetic oxygen depletion will be common. Secchi disc depths will be low (1-2 m), and there is a danger of winter kill of fish in shallow lakes.

Level 4: 25mg/m^3; suitable only for warm water fisheries. Secchi disc depth <1.5 m, hypolimnetic oxygen depletion beginning early in summer, considerable danger of winter kill of fish except in deep lakes.

2. Methodology

The following tasks were carried out as part of this study:

- **Information Review:** A literature review was carried out on eutrophication and computer models suitable for predicting the trophic status of lakes as a result of human activities. Also obtained was information on lake bathymetry, land uses, drainage areas and documented water quality.

- **Water Quality Measurements:** Since historic data were found to be limited and older water sampling results were possibly inaccurate (J. Choate personal communication), a field sampling program was initiated. Samples were taken by DELG, NATECH and volunteers from Harvey Lake and Lake George during the spring and summer of 2000, see Figures 2-1 and 2-2 for sampling station locations. Samples were analysed at the Department of Environment and Local Government Laboratory for a number of parameters including: phosphorus, chlorophyll *a*, Escherichia coli and numerous other organic and inorganic parameters. The spring water samples were taken to establish the phosphorus concentrations in the lakes and the summer samples were important to quantify the summer chlorophyll *a* concentrations. Additionally, teachers and students from Harvey High School as well as volunteers from the community took Secchi disk measurements during the summer months.

- **Soil Sampling:** Since a significant contribution of nutrients is believed to originate from soil contaminated with effluent from septic systems, soil samples were taken and analysed for nutrients. Soil samples were procured from several properties adjacent to Harvey Lake. The samples were taken, using a soil auger, from developed and vacant lots. For developed lots, samples were taken at various depths adjacent to septic tile fields and at the shoreline on the same lot. On vacant lots, samples were taken at a central location on the lot and along the shoreline.

- **Application of Computer Models:** Eight eutrophication computer models were procured and set up for simulating lakes in the area. They are as follows:

  Walker, 1985
  Canfield-Bachmann, 1981, Natural Lake Model
  Reckhow, 1979, Natural Lake Model
  Reckhow, 1977, Oxic Lakes
  Walker, 1977, General Lake Model
  Vollenweider, 1975, General Lake Model
  Dillon and Rigler, 1975, Lake Model
  NTIS “Bathtub”, 1996 Model.

  As part of the model calibration, results from model predictions were compared with sampling results obtained during spring and summer 2000. Parameters within the model (such as export coefficients and unit loadings) were changed so that model predictions approximate the values observed in the water sample results. The models had to be calibrated to existing conditions in order for predictions to be made for future development/loading scenarios.

- **Interpretation of Findings:** As a result of the model comparison with sampling results then model calibration , the most suitable models for predictions of eutrophication based on a correlation between predicted phosphorus concentrations and water sampling results were selected. Those models, combined with a review of the monitoring results, were used to:

  1. Determine the trophic state of each lake using the Carleson Index
  2. Assess the development potential of each lake. This was accomplished by predicting the changes to phosphorus concentrations and trophic status if additional residential development occurred.

3. Prepare recommendations for action.

3. Results

3.1 Information Review

3.1.1 General Lake Characteristics

Lake characteristics data are required for input into the model. Table 3-1 contains many of the physical characteristics of the lakes in the Harvey area. This information was obtained from Service New Brunswick, the New Brunswick Department of Natural Resources and Energy and the New Brunswick Department of Environment and Local Government.

3.1.2 Historic Sampling Results

The information review determined that historic water quality information is limited. Data that did exist was, for the most part, both sporadic and quite dated. Upon reviewing the sampling data for several lakes, the phosphorus levels appear to have experienced a reduction over time. Two factors may have contributed to the decline. Firstly, analytical techniques have dramatically improved since the early samples were analysed. Therefore, the accuracy of sample results older than the mid to late eighties are suspect (Mr. J. Choate, NBDELG, personal communication). Typically, concentrations would have been overstated in older samples due to the higher detection limit of the time. Secondly, phosphorus levels in detergents have been reduced over time this would have relevance in lakes with high degrees of shoreline development. Table 3-2 summarizes the available water quality measurements for Harvey area lakes.

3.2 Year 2000 Analytical Results

3.2.1 Water Quality

Samples were taken on Harvey Lake and Lake George during late May and early June 2000. The phosphorus levels are usually at their greatest at spring turnover. Typically, spring turnover lasts from ice out (mid April) to the third week in May, when water temperatures rise above 4^{o}C. This spring turnover occurred earlier than in previous years (Mr. J. O'Keefe, NBDELG, personal communication) and consequently the water samples may have phosphorus levels slightly less than the actual peak values. Using the measured spring phosphorus levels, the summer Chlorophyll a concentrations were predicted. Selected sampling results from this year 2000 sampling sessions are shown in Table 3-3. A complete set of sampling results is found in Appendix A.

Table 3-3 Year 2000 Sampling Results, Harvey Lake and Lake George

Lake	Spring [P] (mg/m^3)	Summer [chl a] (mg/m^3)	Summer Secci Depth (m)	TSI	Trophic Status
Harvey Lake	6	1.978	3.76	42	Mesotrophic
Lake George	7.1	1.875	3.2	43	Mesotrophic

Based on measured spring phosphorus concentrations and summer chlorophyll a concentrations, a generic relationship between spring and summer water quality parameters was established. With this spring phosphorus and summer chlorophyll *a* relationship, in the event of the absence of one parameter the other can be calculated. The observed spring phosphorus concentrations at each sampling sation are listed in Table 3-4 for Harvey Lake and Table 3-5 for Lake George, values for surface, mid-depth and bottom are given for each station. The lake average spring phosphorus concentration, summer chlorophyll *a* concentrations and summer Secchi depths are listed in Table 3-6.

Table 3-4 Harvey Lake, Total Phosphorus (mg/m^3) June 4, 2001

Depth	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Surface	5	7	5	7	5	N/A
Mid-Depth	6	6	5	6	6	5
Bottom	5	7	6	8	7	5
Average	5.3	6.7	5.3	7.0	6.0	5.0

Table 3-5 Lake George, Total Phosphorus (mg/m^3) May 28, 2000

Depth	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Surface	5	7	6	7	6	9
Mid-Depth	6	21	7	5	5	7
Bottom	N/A	6	5	5	5	5
Average	5.5	11.3	6.0	5.7	5.3	5.0

Table 3-6 Spring Phosphorus Levels, Lake Average, All Sampling Stations

	Spring Measured		Model Predicted*		Chlorophyll A Predicted		Secci Depth Predicted	
Lake	[P] (mg/m^3)	TSI	[P] (mg/m^3)	TSI	[P] (mg/m^3)	TSI	[P] (mg/m^3)	TSI
Lake George	6.9	43	6.9	43	5	41	4.8	40
Harvey	6	42	6.1	42	4.4	40	7	43

**Dillon and Rigler (1975) is the model used to make these predictions.

As shown in Tables 3-4 and 3-5, water quality measurements indicate that the lakes are well mixed, both vertically and horizontally. Field measurements confirmed that the lakes were not stratified.

3.2.2 Phosphorus Contributions From Soil

Soil samples were taken from cottage lots and from a field near Harvey Lake on November 2nd and November 4th, 2000. Of the five lots, three had cottages and two were vacant. Samples were analyzed for phosphorus and other nutrients. The phosphorus results are presented in Table 3-7. The complete results are presented in Appendix B. A significant increase of phosphorus in soil can be observed near septic systems. Observed results indicate that vacant lots typically show levels below 10 mg/kg, near septic systems the levels often increase to above 40 mg/kg.

Table 3-7 Phosphorus Measurements From Soil Samples

Lot	Lot Status	Sample Id	Sample Location	Depth of Sample (m)	[P] mg/kg
1	Developed	CC1	Near Septic System	0 - 0.3	24
		CC2	Near Septic System	0.3 - 0.6	23
		CC3	Near Septic System	0.6 - 0.9	61
		CC4	At Shoreline	0 - 0.3	46
2	Vacant	AF1 (CC5)	150m from Septic System	0.3 - 0.6	8
3	Vacant	ECV1	Centre of Lot	0 - 0.6	4
		ECV2	Centre of Lot	0.3 - 0.6	7
		ECV3	Centre of Lot	0.6 - 0.9	1
		ECV4	At Shoreline	0.3	6
4	Vacant	JS1	Centre of Lot	0.3	17.9
		JS3	At Shoreline	0.3	5
5	Developed	JS2	At Shoreline	0.3	8
		JS4	Near Septic System	0.3	44
		JS5	Near Septic System	0.76	35
6	Developed	ECS1	Near Septic System	Surface	11
		ECS2	Near Septic System	0.3	5
		ECS4	At Shoreline	0.3	16

3.3 Available Phosphorus Models

A number of empirical mathematical models have been developed over the last two decades to predict lake eutrophication on the basis of phosphorus concentration. In this study three phosphorus modelling systems (containing nine different models) have been used, some of which have sub models that are specific to particular water bodies.

Dillon and Rigler (1975) has been incorporated into a spreadsheet based model of calculations which use physical lake characteristics, phosphorus loading coefficients and development densities. The model utilizes information that is readily available for the Harvey Area, based on the Phase I infrastructure mapping work. The output includes a theoretical phosphorus concentration and calculation of the maximum allowable phosphorus concentration for each lake. In the past, the Department of Environment has used this model to determine the carrying capacity of Yoho Lake.

The **Dillon and Rigler** model makes recommendations for development potential based on, among other things, phosphorus loading from cottages. The amount of loading from cottage development, precipitation and runoff water will in turn give an estimation of the spring phosphorus concentration.

The **Wisconsin Lake Model** is an umbrella for ten individual models. It requires a more detailed review of the simulated lake than Phosmod. The output is in spreadsheet format and provides a summary of the theoretical total phosphorus concentration in a lake. The Wisconsin Lake Model then compares the results to known values and determines the most appropriate model to use. This model also calculates the trophic state of the lake using the Carleson Index. Recommendations for development potential can be made by changing input variables (e.g. by increasing the number of houses within the watershed) to projected values.

The **Wisconsin Lake Model** bases its estimations of phosphorus concentrations on lake and watershed characteristics, as well as the input of various land use types and the number of dwellings. The model then calculates an estimated spring phosphorus concentration.

A third software package used in this study to quantify lake phosphorus concentrations is the US EPA developed, NTIS Simplified Procedure for Eutrophication and Prediction. **BATHTUB** is one of the component programs in the NTIS model. It is used to make phosphorus predictions by incorporating water quality data and watershed characteristics. This program also estimates concentrations of other water quality parameters, such as nitrogen. The **NTIS** model also uses lake characteristics, different land use types and loading factors to predict a spring phosphorus concentration.

3.4 Model Calibration

3.4.1 Phosmod

This model is easily calibrated by changing the unit loading from cottages, the phosphorus concentration in precipitation or the phosphorus export coefficient from land. Table 3-8 compares the observed water quality with the model predictions after calibration.

Table 3-8 Calibrated Model Results

	Observed Results		Calibrated Model Results		
Lake	[P] mg/m^3	TSI	[P] mg/m^3	TSI	Trophic Status
Harvey Lake	6	42	6.1	42	mesotrophic
Lake George	7.1	43	6.9	43	mesotrophic

3.4.2 Wisconsin

The Wisconsin Lake Model Spreadsheet (WLMS) contains ten separate models. WLMS has a variety of parameters and loading coefficients which may be altered to better reflect local site conditions. Many of the parameters come pre-set but are then modified according to region specific values. Similar to Dillon and Rigler, WLMS is calibrated by changing the unit loading from cottages, the phosphorus concentration in precipitation or the phosphorus export coefficient from land.

The Wisconsin Lake Model Spreadsheet's 10 subset models are not all applicable to lakes in the Harvey region. Certain models are unusable because either:

❏ the observed model predicted a result that differed greatly with the observed value; or

- the lake does not fall within the expected ranges expected for one or more of the criteria for which the model was developed (e.g. hydraulic retention time, areal phosphorus loading, flushing rate, inflow phosphorus concentration, areal water loading, mean depth, predicted in-lake phosphorus concentration).

Calibration of WLMS for use with area lakes proved ineffective. Changing the export coefficients for the various phosphorus loading constituents proved cumbersome and not regionally applicable for area lakes. Of the 10 models, invariably two or three of them would obtain a phosphorus loading prediction that matched or closely approximated observed values for Harvey Lake and Lake George. However, the subset WLMS models that predicted values which approximated observed values were not the same for Harvey Lake and Lake George. This made it impossible to determine model parameters that could be set to make phosphorus predictions for lakes throughout the Harvey region.

3.4.3 NTIS Model

The NTIS Bathtub model produced results that closely matched historic observed results. However, the model could not be calibrated to reflect the observed results for Harvey Lake and Lake George. Also, the model did not display a sensitivity to increased development and land use densities within the watershed. Since the model results could not be calibrated, this model was not used any further.

3.5 Application of Phosmod for Trophic Status Assessment

3.5.1 Existing Conditions

Observed and predicted phosphorus lake water concentrations can be used to assign a Trophic Status Index (TSI) value to lakes. Table 3-9 details the results of the observed lake phosphorus (a lake average for all sample stations), and model predicted spring lake water phosphorus concentrations. For Harvey Lake and Lake George, the Trophic Status has been assigned based on observed TSI values. Due to the likely inaccuracies of the historic data, for the remainder of the lakes, Trophic Status has been assigned according to the model calibrated TSI value.

Table 3-9 Calibrated Model Results

	Observed Results		Calibrated Model		
Lake	[P] mg/m^3	TSI	[P] mg/m^3	TSI	Trophic Status
Harvey Lake	6	42	6.1	42	mid mesotrophic
Lake George	7.1	43	6.9	43	mid mesotrophic
Magaguadavic[1]	3.2	37	8.3	45	mid mesotrophic
Little Magag.[1]	40	57	10.0	46	high mesotrophic
Oromocto[1]	20	51	3.0	37	low mesotrophic
Yoho	9.4	46	10.3	46	high mesotrophic
Little Kedron[1]	7	43	5.0	41	mid mesotrophic

Note [1] observed values are based on dated results and may no longer be accurate

TSI
37-41 Low Mesotrophic
42-45 Mid Mesotrophic
46-47 High Mesotrophic

48+ Near Eutrophic

Yoho Lake has the highest cottage density of all lakes in the area and the highest TSI. To date, measured and simulated water quality characterizes the lake as high-mesotrophic.

Dillon and Rigler (1975) discuss the response time of a lake to changes in phosphorus loadings. Lakes in Ontario for instance, may take 4 years or longer for 75% of the effects of a change in phosphorus loadings (both increases and decreases in phosphorus concentrations) to be reflected in a change to lake water phosphorus concentrations. This response time highlights the need for several consecutive years of sampling data to get the real picture of phosphorus concentrations in lakes.

3.5.2 Future Development Scenarios

All of the lakes in the Harvey area have some degree of development around their shoreline. Table 3-10 lists the current acreage around each of the lakes and the remaining undeveloped area within 300 m of the lake. The possible number of additional cottages has been calculated assuming 100% of the available shoreline area were developed and each dwelling was on a 1 acre (0.405 hectares) lot.

Table 3-10 Shoreline Development Characteristics

Lake	Total Shoreline Area (ha)	Developed Shoreline Area (ha)	Remaining Undeveloped Area (ha)	Current Number of Cottages	Possible Additional Cottages
Harvey	535	60	473	273	1128
George	414	62	354	253	875
Magaguadavic	1341	20	1321	100	3364
Little Magag.	377	5	372	14	921
Oromocto	1260	40	1220	201	3035
Yoho	264	24	240	120	713
Little Kedron	246	2	244	4	607

The impact of increased cottage densities on lake water phosphorus concentrations has was assessed under various growth scenarios. Table 3-11 shows the expected change in phosphorus concentration and Trophic Status Index (TSI) under increased development densities.

4. Conclusions and Recommendations

The year 2000 water quality measurements show Harvey Lake and Lake George have high oxygen levels, low phosphorus concentrations and low counts of coliform bacteria. These measurements indicate good water quality with little stress from human development.

Sampling data obtained during the year 2000 from Harvey Lake and Lake George were used calibrate the phosphorus prediction models. Of the nine available models, only Dillon and Rigler was found suitable for calibration to match observed values. Attempts to calibrate the Wisconsin Lake Models for use on lakes throughout the region were unsuccessful. The NTIS model did not allow for calibration.

The Dillon Riggler model was used to make spring lake water phosphorus predictions for other lakes in the Harvey area as well. The calibrated model puts all of the lakes in the mesotrophic water quality category. Since each successive trophic state represents a doubling of algal biomass, distinctions are made within the mesotrophic category. For instance, Oromocto and Little Kedron are at the lower end of the mesotrophic category. Harvey, Lake George and Magaguadavic are considered mid-mesotrophic. Little Magaguadavic and Yoho are at the high end of the mesotrophic category.

The lakes that were not tested in the year 2000 should be targeted for future sampling. Secci disk readings were found to provide useful information to estimate spring phosphorus concentrations, if phosphorus analyses were not feasible. Future measurements of spring phosphorus, summer chlorophyll *a* and summer Secchi depths should be used to verify the model predictions.

An assessment of the existing and future development densities was expressed as a percentage of the shoreline area that could potentially be developed. Lakes in the Harvey area responded with an increase in spring phosphorus concentrations to an increase in the number of cottages/residences on the lake.

Based on sampling and modelling results, Harvey Lake and Lake George would support moderate growth in the number of cottages on those lakes. Several successive years of observations should be taken to confirm the predicted phosphorus and year 2000 observed concentrations to ensure that year 2000 results were not anomalous. Additionally, as previously discussed with respect to the response time of a lake to changes in phosphorus loadings, recent increases in phosphorus loadings may not be reflected in recent sampling data. Several consecutive years of sampling results should be carried out to confirm recent measurements.

Sampling data as well as model predictions Yoho Lake as high-mesotrophic. Several successive years of phosphorus monitoring should be carried out on Yoho Lake to corroborate the calibrated model's findings and recent water sampling results.

Calibrated model predictions indicated that Oromocto Lake, Magaguadavic Lake, Little Kedron Lake would support some degree of lake shore development with little change to trophic status. Lake shore development on Little Magaguadavic lake should be closely monitored since model results suggest a high-mesotrophic status. Increases in phosphorus concentrations may result in a change in status to Eutrophic, an unacceptable water quality designation. Existing lake water quality should be confirmed with current lake water sampling data or at least Secchi disk measurements.

Year 2000 water quality testing did not intend to search for signs of localized eutrophication. If localized eutrophication was of concern to area residents, it would be assessed in the summer by performing water quality measurements in some of the coves with high cottage densities.

Soil sampling results suggest that developed lots have soil phosphorus concentrations that are significantly higher than in vacant lots. Further sampling of cottage lots could be used to assess the effectiveness of various septic systems at minimizing phosphorus contributions from cottages. Additionally, further sampling could be used to identify failing or faulty septic systems in localized lake areas suspected to have poor water quality. This would only be considered with public buy-in and participation of all parties involved (lake residents, lake associations, municipal government, Department of Health and Wellness and Department of Environment and Local Government).

Indices

6. References

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Appendix A Water Sample Results

Samples Taken During Spring and Summer 2000

Appendix B Soil Samples

Samples Taken November 2 and November 4, 2000