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To: Planning Advisory Committee
Attn.: Gail Foisey Esqrs., Secretary
Halifax County Municipality
From: S. M. Mandaville, Co-Ordinator
Date: 29 March 1995
Subject: Submission # 9501 to the Districts 14 & 17 MPS Review-- LAKE CARRYING CAPACITIES with special reference to allowable change in `productivity' of all lakes

Following is our written submission in point format as a successor to our very brief verbal presentation at the public meeting on 22nd March 1995:

[A] The municipality should **embrace the enlightened concept of setting `*Lake Carrying Capacities'* for all lakes in the plan area** with special emphasis on the following significant lakes; William, Thomas, Fletcher, Kinsac, Third, Three Mile, Rocky, Powder Mill, Soldier, Miller, Fish, and Shubenacadie Grand. We do not believe you can set the value for Charles at the present time as it is mostly within the bounds of the City of Dartmouth.

[B] **`*Lake Carrying Capacities*'** are based on the `desirable uses' of lakes by LAKE STAKEHOLDERS (beneficial lake users at large). These can be expressed either in the form of TP (Total Phosphorus) and/or Chlorophyll-a (Ch*a*) levels in µg/l, either as summer or ice-free or whole year concs. Appendix # 9501-I contains extracts from a handful of better known and widely quoted `*Lake Carrying Capacities*' concepts.

[C] In general you do not need existing data to set **`*Lake Carrying Capacities*'** except in the methodologies where you decide to set them based on a certain snapshot in time or an allowable percentage increase over the `background + direct aerial deposition' concs. If you choose the latter methodology of relational values, there is data available in the public domain on most of the Shubie headwater lakes, and we herewith undertake to supply them to you at no cost as we have summaries of all (both by our volunteers as well as by other investigators).

[D] <u>**Phase-2 of the Shubie studies**</u> d/May 1993 recommended on pg.-29 that the level of phosphorus in lakes Grand, Fletcher, Thomas, William, and Charles should not exceed 1990 loadings by the end of the ten year period.

It is quite probable that by year 2000 that target could be met since the aforementioned lakes have considerable assimilative capacity combined with the fact that development around upstream lakes is not proceeding at too fast a pace, in addition, depending upon the phosphorus retention factor of each upstream lake, the contributions will vary and beyond a certain order, the contribution will be negligible as it will be a combination of several phosphorus retention factors. <u>**In order to realistically achieve those values over the mid-term, you have to develop controls on the number of onsite systems within 300m of lakes to start with, thence within 300m of watercourses if these intercept groundwater.**</u>

[E] **<u>In areas served by onsite systems</u>**, it has been proven time and again that <u>even properly functioning systems</u> within 300 metres of watercourses do contribute phosphorus (varying amounts dependent upon soil type, soil complexes, age of the system, ...) over time. The logic for this is as follows:

> **<u>Septic system derived phosphorus</u>** is of concern where groundwaters discharge to nutrient limited surface waters. Because phosphorus is not completely consumed in the unsaturated zone of most conventional beds, the potential for phosphorus movement in groundwater to discharge sites exists. *Although phosphorus is attenuated in both calcareous and non-calcareous subsurface soils, phosphorus can migrate in environments especially where the contact between effluent and soil is limited due to macropore flow, rapid flow in preferential pathways, incorrect siting of the system with regard to local flow conditions including contrasts between hydraulic conductivity of tile bed material and native soil and sites with thin soils overlying fractured bedrock. In addition, phosphorus retention capacity may be affected by seasonally changing water tables, water flow and redox conditions which affect phosphate sorption and could persist even after current septic tile beds are decommissioned.*

[F] **<u>Predictive modelling</u>:**

i) Although predictive models are not perfect, neither are measurements. Actual biological conditions in a lake vary from year to year, as a result of climatic and other environmental variations. Field sampling and (in the case of TP and Ch*a*) laboratory analysis are not exact processes and involve a degree of error. For these reasons, when used as a basis for lake management decisions, measured data should represent the means of large numbers of samples over long periods of time; therefore the estimates generated by a well calibrated model based on current use and development conditions can be taken as representing the long term means around which measurements, if available, would vary. This is ofcourse an ideal world, and in the real world of large and complex lake systems, this claim of accuracy cannot be made in all cases. Even if there is a significant gap between the predicted and measured trophic state indicators for a particular lake, and some doubt surrounds the absolute value of the predicted indicators, the model will still indicate the relative change in trophic state that would result from a given change in conditions.

ii) To simplify the procedure, we have developed an **extensive spreadsheet model** (with approx. 130-140 columns on MS Excel software) of the entire Shubie headwaters system, and we herewith express our willingness to supply you a copy of same. The predictive model (for phosphorus loading) not only incorporates all of the Shubie studies to date (inclusive of the `70s) but updates them as Dillon et al of Dorset have fine-tuned the various regression relationships in their original Dillon-Rigler model which was utilized by Hart, Scott & Ogden during the late `70s on a handful of lakes. Our spreadsheet includes 50 lakes in the watershed, has background + aerial deposition values defined, recent TP loadings ascertained and compared with any recent reliable field values as well as the Future-Probable and the Future-Ultimate values were developed. We are also preparing a control spreadsheet with only a handful of columns (15±) which is interconnected with the aforementioned spreadsheet as well as with several others like runoff values, other watersheds, etc. This control spreadsheet can be used by you to obtain answers to ***`what if?'***. You could also vary the natural as well as the anthropogenic export coefficients and densities inclusive of any new STPs at ease in the control spreadsheet, and this would effectively vary the original inputs by us and thus result in new values. The export coefficients we utilized were locally derived and referenced in the various Shubie studies since the `70s as well as in certain published work by Dr. Waller and his students over the last several years. The flow chart of the Shubie headwaters covering several jurisdictions is depicted in Appendix 9501-IV.

[G] We further request that you **set firm standards for STP effluent discharging into lakes or into streams which flow into lakes, especially w.r.t. phosphorus concentrations.** This should apply to existing STPs as well, especially those with relatively large loads. We are particularly concerned with the Aerotech STP discharging into the Johnson brook and which in turn is an inflow to Soldier lake. This STP does not have phosphorus removal mechanisms. Properly functioning secondary STPs remove 0-20% of the TP. In addition, 80-95% of the TP in the STP effluent is in inorganic form which has high biological availability for algal growth and depending on total loading, the effects could be quite dramatic and pronounced especially during the summer months when minimal flushing takes place in most lakes.

There is a scientific methodology to ascertain such impacts and we direct you to a study conducted on Freshwater Lake in Cape Breton Island by Dr. Joseph Kerekes (1983) which is one of the best such publications (cf. Appendix 9501-II).

A P P E N D I X # 9 5 0 1 - I

LAKE CARRYING CAPACITIES

(1) For Ch*a*: In general, average ice-free Ch-a conc. up to about 2 µg/l indicate low algal densities and an unproductive or nutrient-poor lake (but of `good quality' per general terminology). Ice-free average concentrations below 1 µg/l indicate `high quality' per general terminology. Average conc. between 2 and
5 µg/l, although moderately high, are acceptable for swimming and other water contact recreation (`fair quality' per general terminology). However, lakes in this intermediate range can experience short term pulses of up to 10 µg/l to 12 µg/l in warm, calm periods in midsummer/fall, producing algal blooms. Average ice-free conc. exceeding 5 µg/l are high; at these levels, water quality for swimming and other water contact recreation frequently deteriorates, and aesthetic quality declines.

(2) Dillon and Rigler (1975) Based on long-range plans for the lake, decide what the ***maximum permissible average summer chlorophyll a concentration*** should be. The planning agency may pick any intermediate level should it so desire subsequent to intensive public consultations, and based on the said values, the planning agency sets the zoning regulations.

Level 1: Ch *a* = 2 mg/m^3

For lakes to be used primarily for body contact water recreation, where it is desirable to maintain hypolimnetic concentrations of oxygen in excess of 5 mg/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- the Secchi disc visibility may be lower in brown water [dystrophic] lakes).

Level 2: Ch *a* = 5 mg/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 2-5 m.

Level 3: Ch *a* = 10 mg/m^3

For lakes where body contact recreation is of little importance, but emphasis is placed on fisheries (bass, yellow perch,.......). 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: Ch *a* = 25 mg/m^3

Suitable only for warmwater fisheries. Secchi disc depth <1.5 m, hypolimnetic oxygen depletion beginning early in summer, considerable danger of winterkill of fish except in deep lakes.

(3) Reckhow and Simpson (1980) While this method is based on the aforementioned Dillon-Rigler model which is derived from a highly homogeneous set of lakes, the model includes a fairly wide range of lakes within the north temperate climatic zone (TP conc. whole yr= 0.004- 0.135 mg/L, TP loading= 0.07- 31.4 g/m^2-yr, and areal water loading= 0.75-187.0 m/yr). In addition, this model permits the quantification of prediction uncertainty, and it indicates to the user how valuable (certain) the information is that is provided by the model. The following TP values are the whole year averages.

TP < 0.010 mg/L

Suitable for water based recreation and propagation of cold water fisheries, such as trout. Very high clarity and aesthetically pleasing.

TP = 0.010-0.020 mg/L

Suitable for water based recreation but not for cold water fisheries. Clarity less than above.

TP = 0.020-0.050 mg/L

Limited total body contact suitability, based upon either loss of aesthetic properties or possible health hazards. Generally very productive for warmwater fisheries.

TP > 0.050 mg/L

A typical "old aged" lake in advanced succession. Some fisheries, but high levels of sedimentation and algae or macrophyte growth may be diminishing open water surface area.

(4) Ontario Ministry of the Environment Objectives and Guidelines (1991)

To avoid nuisance algae concentrations in lakes, total P should not exceed 20 µg/l.

To protect against aesthetic deterioration in lakes, total P should not exceed 10 µg/l.

To avoid excess plant growth in rivers & streams, total P should not exceed 30 µg/l.

(5) Hutchinson, Neary and Dillon (1991) The Trophic Status Model (TSM) of Ontario's Lakeshore Capacity Study is a refinement of the Dillon-Rigler (1975) model for predicting total phosphorus concentration and several trophic status indicators in lakes. ***Applying arbitrary guidelines will result in the loss of lakes of exceptionally high quality and the loss of a diversity of water quality***.

The model introduces the concept of a numerical objective (say, a 50% or 100% increase over background concentration), but the absolute change has to be specific for each lake. The background value represents phosphorus loading only from natural sources in the watershed and from precipitation inputs directly to the lake surface. For example, in a lake with a background concentration of 0.004 mg/L, 50% and 100% increases would result in 0.006 and 0.008 mg/L. Changes in Ch *a* and Secchi depth would be perceptible, but would produce minimal changes in aesthetic quality or hypolimnetic oxygen deficit compared with allowing the same lake to increase to 0.010 mg/L. In lakes with higher background concentrations (eg. 0.014 mg/L), 50 and 100% increases could produce aesthetic impairment or algal blooms where none existed before. In such a case a maximum of 0.020 mg/L could be imposed rather than 0.021 or 0.028 mg/L.

Indeed, there exists a proposal to implement such a methodology by the Ontario Ministry of the Environment & Energy though it is only in a draft form to date (cf. Appendix 9501-III).

A P P E N D I X # 9 5 0 1 - II

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