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To: **Chair and Councillors, Harbour East Community Council, HRM**

From: S. M. Mandaville Post-Grad Dip., Professional Lake Manage.
Chairman and Scientific Director

Date: June 26, 2006 (Hand delivered same date to the Municipal Clerk)

Subject: **Russell Lake: Lake Carrying Capacity (LCC) based on the CCME (2004) Policy on Phosphorus (potential natural restoration)!**

Mr. Chair and member-councillors: We herewith salute you for your interest in this lengthy issue! There are two recommendations (I & II), and two scientific clarifications (1 & 2). One exhibit (A) is also included as legal/support documentation.

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Important preamble:

Mr. Chair and Councillors: If you accept HRM staff's threshold level for phosphorus of 15 µg/l, the potential impact may be an impediment to the long-term restoration of Russell Lake reverting back to its superb 'natural background phosphorus concentration'.

'Natural background' may imply the value that existed during the 1700s or earlier! This is not an impossible task as it may appear at first glance. It does not require expenditure for any new municipal programs as long as the HRM is willing to enforce state-of-the-art technologies on new developments rather than the age-old attitudes!

Russell Lake has already undergone an unexpected and surprising level of recovery in the limnetic phosphorus concentration based on the first ever paleolimnological study funded federally through the NSERC (the project acronym being T.E.A.M.)! We had notified your Community Council the summary results via our written submission dated November 01, 2005.

Back in February 2001, Mandaville was first approached for collaboration by the Ontario academia, who were also our formal associates, and we had suggested Russell Lake among select HRM urban indicator lakes for a detailed paleo study. Though the paleo study only hindcasted to pre-industrial, and not to pre-European settlement, or pre-cultural era primarily because of the Terms-of-Reference of the study which covered a broad spectrum across Nova Scotia and New Brunswick to impart a bird's eyeview!

The T.E.A.M.'s diatom-inferred phosphorus values for Russell Lake ranged between 16.3 and 29.9 µg/l approx., for the period 1995 to 2002, with the lowest value of 16.3 µg/l occurring in 2002 and the highest value around 1995. Around 1850, i.e., pre-industrial, the inferred TP value was reported as approx. 17.9 µg/l. Hence, the value in 2002 was slightly lower than even in 1850 which was totally unexpected but good news!

Left alone, just perhaps, further recovery may take place as a result of forces of nature and other scientific factors too extensive to do justice to in this submission!

Our values during the latter part of the aforesaid period were in the same range. Though a Dalhousie University intensive summer course comprising of undergrad as well as grad students reported both TP and Cha well within the oligotrophic range (we had been approached by them for some miscellaneous assistance)!

The Nova Scotia Environment Department's phosphorus data for the 1970s were in the range of 50-90 µg/l and the chlorophyll a values confirmed the trophic states implied by the phosphorus data for the most part except for the year-1975.

Recommendation-I: Lake Carrying Capacity (LCC) has to be set in total compliance with the national peer-consensus CCME (2004) Phosphorus Policy:

Based on the CCME (2004) Phosphorus Policy, our updated/upgraded predictive model yields an LCC for Russell Lake as 6.6 µg/l TP; it can be incremented to 7 (seven) µg/l which is somewhat higher than 50% over natural background value of 4.4 µg/l, the maximum as recommended by the CCME (and not 10 or 15 µg/l)!

Any significant deviation (15 µg/l) as recommended by the HRM per its report of May 26, 2006 would be self-defeating and counter productive. If HRM has pragmatic interest in the long term future of Russell Lake and its possible restoration in the direction of the 'pre-cultural state', then the only option is to follow the CCME policy.

Some historical reports in Nova Scotia as well as phytoplankton models also yield a range of 1-4 µg/l TP in clearwater lakes with chlorophyll a values generally lower than 1 (one) µg/l which result in the natural background trophic status as ultra-oligotrophy (and not even oligotrophy)!

The LCC's are not based on current or recent phosphorus values; they are set based on pre-cultural values, i.e., the values that would have existed prior to any human activity within the entire watershed.

It is however cautioned that direct aerial deposition of phosphorus on land is included in our computations but during the pre-cultural times there would have been little-to-zero deposition of TP.

The CCME document as well as its background literature clearly prefer the methodology of utilizing UNIT PHOSPHORUS EXPORT COEFFICIENTS where extant; they recommend other methodologies as a combination which we have implemented as well (but HRM never carried that out and neither did the proponent's consultants).

In Nova Scotia, unit TP-export coefficients have been developed over the years and upgraded not long back based on more extensive sampling, in generally undisturbed representative watersheds, all over the Province! They have been summarized in the following year-2003 report prepared for the Nova Scotia Dept. of Environment & Labour (NSEL) by select researchers at Dalhousie University, ourselves (SWCSMH), and Acadia University; the citation is (it is lodged at the NSEL Library for public use):

Scott, R., Hart, W., Mandaville, S., and Lowe, J. 2003. Selection of a Phosphorus Loading Model for Nova Scotia, Phase I. For: Nova Scotia Water Quality Objective and Model Development Steering Committee and Nova Scotia Dept. of Environment and Labour. 85p.

Scientific clarification-1: Possible significant misinterpretation of the undisturbed, pre-cultural trophic states of local clearwater lakes by HRM as well as by the consultants:

Both, HRM's staff as well as the consultant (Jacques Whitford) claimed in their reports that local lakes were at the upper end of 'oligotrophic' as the natural background status. But they based it only on a combination of questionable historical phosphorus data from not long ago (see also Exhibit-A).

That is not the scientific *modus operandi* to ascertain the trophic states; as example, refer to the latest world's leading textbook in Limnology by Wetzel (2001) as well as the international OECD (1982) literature which formed the primary basis in the Environment Canada (2004) background report.

The natural trophic states of most local lakes, especially the clearwater lakes, are **ULTRA-OLIGOTROPHY and not oligotrophy.**

Further, we are concerned with the Jacques Whitford report on Russell Lake modelling utilizing single event synoptic phosphorus sampling spearheaded by some Government agencies (generally referred to as the 'BIO data') when the Government authors themselves had strongly cautioned about their TP (total phosphorus) data.

Appendix-A has an insert of two scans from one of the BIO reports where they carried out scientific analyses and stats. Government scientists clearly caution the reader about significant shortcomings in their total phosphorus (TP) data as well as its poor sampling frequency! They place more emphasis on their chlorophyll *a* data.

Based on years 1991 and 2000 synoptic spring chlorophyll *a* data per the said BIO reports, the combined mean values for lakes, Topsail, Lamont, and Major are less than one (1) $\mu\text{g/l}$ (0.8 and 0.5 $\mu\text{g/l}$ respectively). These place the said nearby lakes in the ultra-oligotrophic category based on chlorophyll *a* values! The BIO

team did not carry out chlorophyll *a* analyses in 1980, hence the reliability of the phosphorus data is indeterminable (see also Appendix-A).

Similar conclusions were also made in select historical reports of the Province as well as of Environment Canada; they were further discussed at some informal scientific seminars over the years.

Further, the predictive models developed by Mandaville are continually under revision and/or upgrades to incorporate any latest scientific literature which receives international peer consensus. HRM never requested legal access to these models yet. But HRM could revise the ones that Mandaville submitted to them in extensive MS Excel format which incorporate several macro-regressions; a certain familiarity with advanced statistics will be required to fully understand and utilize any of Mandaville's predictive models since it appears staff misinterpreted Mandaville's model on Russell Lake!

Scientific clarification-2: Overview and caution on tracking incremental impacts of developments:

To reliably ascertain incremental inputs from new developments, outflows of major storm pipe outlets, in-situ devices (e.g., CDS, Stormceptor, Vortech), constructed wetlands outlets, have to be monitored regularly at the outlets from the developments, and pollutographs have to be developed.

Incremental impacts of new developments can rarely be tracked by inlake sampling unless the developments are of significant size.

This is primarily because of the competition between PHYTOPLANKTON, MACROPHYTES, and BACTERIA, though there could be a myriad of other factors as well (a discussion on this will be too lengthy here but our web pages in limnology address them which also include leading references).

Recommendation-II: If HRM is unwilling to abide by the national peer consensus standards which also take into account differences in natural background values all across our beloved Canada, then the Community Council could appoint an impartial judge to receive submissions and deliver a legal opinion:

Such a *modus operandi* is quite common, especially, throughout the progressive democracies, for e.x., the superb public hearings conducted during the 1990s when the Minister of the Nova Scotia Environment Dept. ordered a detailed investigation after the four Halifax area municipalities chose incineration as the methodology for disposal of metro garbage. As we are all aware now, the senior bureaucratic decision by the Metro Authority chaired by Mr. Mort Jackson was overturned by the honourable minister.

As a result, citizens throughout HRM have now been 'empowered' and are among the world's leaders in the 3-R's as claimed by several of you councillors at Regional Council (as viewed on Channel-10).

We fully realize that no official of HRM participated in the multi-year deliberations of Environment Canada as well as in independent public consultants by the CCME. On the other hand, some of our leading scientist-members were either consulted and/or their peer reviewed literature was indeed incorporated!

Appendix-A (cautions from the BIO-DFO report of 1993):

(cf. page-27 of the BIO report):

Total nitrogen and total phosphorous are plotted in Figures 18 and 19. On average, approximately one-half of the total nitrogen is nitrate while approximately one-quarter of the total phosphorous is phosphate. Surprisingly, there was a poor correlation ($r=-0.48$, $n=91$) between total phosphorous and chlorophyll, which suggests a problem with sample splitting or the analytical method for either chlorophyll or total phosphorus. Universally there is a strong positive correlation between these two variables (Vollenweider and Kerekes, 1981).

(Keizer, Gordon, Rowell, McCurdy, Borgal, Clair, Taylor, Ogden, and Hall, 1993)

(cf. page-39 of the BIO report):

Due to the high levels of colour in some Metro Area lakes (Fig. 21), trophic status estimates based on Secchi disk are not always reliable. Those based on total phosphorous (Fig. 19) are also judged to be unreliable because of some question over the accuracy of this data set. Therefore, estimates of trophic status in this report are based solely on the chlorophyll data (Fig. 20). Also, this assessment is limited and should be viewed with some reservation because it is based on a single early-spring measurement and not an average growing season value.

Based on the TSIs calculated from chlorophyll concentrations, Oathill, Bissett, and Settle Lakes can be categorized as eutrophic, First Lake as borderline between eutrophic and mesotrophic, Russell, Parr, and Morris Lakes as mesotrophic, and Third, Powder Mill, Frog Pond, Anderson, and Frenchman Lakes as borderline between mesotrophic and oligotrophic (Fig. 23). The remaining lakes can be classified as oligotrophic or ultraoligotrophic.

TSIs based on chlorophyll were calculated from mean annual concentrations determined from multiple samples collected from selected Metro Area lakes during 1990 (Soil and Water Conservation Society of Metro Halifax 1991). While the absolute values were generally lower, the highest values were found in the same four lakes (Oathill, Bissett, Settle, and First). Although not technically classified as eutrophic, Bissett and Settle Lakes were judged as showing eutrophic tendencies.

(Keizer, Gordon, Rowell, McCurdy, Borgal, Clair, Taylor, Ogden, and Hall, 1993)