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Ref.:	Sandy_Lake_GlenArbour2013	(10 pages)
To:	**Chair & Members, North West Community Council, HRM**	
From:	S. M. Mandaville Post-Grad Dip., Professional Lake Manage. Chairman and Scientific Director	
Date:	September 19, 2013	
Subject:	SANDY LAKE, Glen Arbour:- Accelerated eutrophication based on the developer's data of 1996-99, and HRM's synoptic data of 2006-2011	

Please feel free to ask me any questions, and I will endeavour my level best to respond either via emails and/or in person at one of your meetings, if invited to do so. Written informally, hence may have typos.

General restoration aspects for consideration by the NWCC are suggested on page-4.

Mayor Peter Kelly's communication of April 17, 2001 addressed to the former Halifax Watershed Advisory Board is inserted on pages 9 and 10.

I have provided a synopsis of the relevant data from various known sources referenced appropriately on page-6.

Of specific interest are the TP (total phosphorus), the primary limiting nutrient, and Ch*a* (chlorophyll*a*) which is representative of the `algal production'.

HRM's TP data ranged 2-42 µg/l with a mean of means of 12.7 µg/l during the years 2006-2011. That is an unexpected and alarming range, and quite high compared with the pre-development value (1996) supplied by the developer of 4.3 µg/l.

HRM's Cha data ranged 0.56-7.68 µg/l during the years 2006 to 2011 with a mean of means of 3.01 µg/l. The pre-development value (1996) supplied by the developer was a low of 0.75 µg/l.

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Sandy Lake (Glen Arbour) underwent a remarkable accelerated eutrophication during the extremely short period of 1997-1999, a process which normally takes tens of thousands of years in an undisturbed state, if at all (see the model on page-8).

The lake has not recovered to the pre-development value (1996) per the pelagic parameters reported by HRM's synoptic data of 2006-2011.

The fact that the sampling events are limited per year may have some (scientific) weight but it should raise red flags to the dedicated parties. It was indeed the developer's consultant (CWRS, Dalhousie University) which designed their sampling frequency per the public hearing minutes of January, 1997 which I reference below:-

A brief history of the public hearing held by your community council on January 09, 1997:-

There was support from the general public in Hammonds Plains. But, the local environmental group, the Sackville River Watershed Advisory Committee (SARWAC), of which the Sackville Rivers Association (SRA) is an integral part of, was opposed to the development. Mr. Walter Regan, speaking as an individual, made an extensive impassioned plea in strong opposition as well. I had made a semi-scientific presentation on behalf of my scientific group (the SWCSMH), but it was not in opposition. I had forewarned on what may transpire if the HRM did not implement sound environmental controls (for more details, kindly access your approved minutes on the HRM's website with the URL of http://www.halifax.ca/commcoun/nwcc/nwcc1997/nw970109.pdf).

☞ As you can see from this submission, the HRM and the Province failed to protect the lake. Once a lake gets enriched, it is not easy to restore it to its natural state as any experience scientist in limnology may acquiesce.

I also include the predictive phosphorus modelling conducted by my team some years back (results updated in page-6, and the former pictorial model in page-8). The prime purpose of predictive modeling is to anticipate nutrient enrichment even before it occurs so that regulatory agencies can take the precautionary approach and protect the lake, hopefully in perpetuity. The enrichment has already occurred (see page-4 on suggested action by the NWCC).

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Environment Canada (2004) published a table which was derived from the 18-country OECD peer consensus (http://lakes.chebucto.org/DATA/PARAMETERS/TP/popup.html#modellingccme) which I reproduce below:-

Table 4.1 Trophic classifications of lakes, with their corresponding phosphorus and chlorophyll concentrations and transparency (Secchi depth) (sources: Wetzel 2001; Vollenweider and Kerekes 1982).

Trophic level	Total Phosphorus (μg·L⁻¹) Wetzel (2001)	Total Phosphorus (μg·L⁻¹) Vollenweider and Kerekes (1982)	Chlorophyll a (μg·L⁻¹) Vollenweider and Kerekes (1982) Mean	Chlorophyll a (μg·L⁻¹) Vollenweider and Kerekes (1982) Max	Secchi depth (m) Vollenweider and Kerekes (1982) Mean	Secchi depth (m) Vollenweider and Kerekes (1982) ~~Max~~ Min.
Ultra-oligotrophic	< 5	< 4	< 1	< 2.5	> 12	> 6
Oligo-mesotrophic	5-10	4-10	< 2.5	< 8	> 6	> 3
Meso-eutrophic	10-30	10-35	2.5-8	8-25	6-3	3-1.5
Eutrophic	30-100	35-100	8-25	27-75	3-1.5	1.5-0.7
Hypereutrophic	> 100	> 100	> 25	> 75	< 1.5	< 0.7

To further understand the relevance of Ch*a* values, kindly note that the Kings County of Nova Scotia set a maximum objective <u>Ch*a* values in the low range of 2.5 µg/l</u> for 18 lakes. I herewith insert a scan from their policy in my archives:-

Kings County adopted water quality objectives for 18 lakes in the county, through amendment of MPS and LUB. The maximum objective value of chlorophyll-a for most of these lakes is 2.5 µgm/L. Seven of the lakes' objectives were set below the level of 2.5. Based on predictive modelling, the estimated maximum number of dwellings that could be added to the contributing area without exceeding the threshold value was established. This number of dwellings was set as a limit for development in the LUB. Policy in the MPS enables application for a permit with a development having "near-zero impact" through site standards or performance standards. Primarily this condition is expected to be met with septic field fill with a 20 year phosphorus input retention and a requirement to replace the fill every 20 years. A condition in adopting these limits was implementation of an annual monitoring program for a minimum of six years. The sampling required was to be completed by volunteers.

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We have not studied the zoobenthos, i.e., the preferred indicator organisms within the sediments (or sometimes known as the `canary in the coal mines') there yet unlike select other metro lakes since we have numerous other scientific priorities right now.

Suggested deliberation for restoration by the NWCC:

(i) Restore the lake to its pre-development data of 1996 supplied by the developer as mean TP= 4.3 µg/l, and mean Ch*a*= 0.75 µg/l. Our (SWCSMH) modelled pre-cultural as well as the 1991 values were the same, i.e., TP=3.2 µg/l.

(ii) In comparison, HRM's data of 2006-2011 were:- for TP, mean of means=12.7 µg/l (alarming range of 2 - 42 µg/l). For Ch*a*, mean of means=3.01 µg/l (range of 0.56 - 7.68 µg/l). Reasons are unknown (Perhaps golf course fertlizers? Causes have to be investigated for confirmation).

(iii) Golf courses need fertilizers to maintain greenways. If the golf course is responsible for most of the phosphorus inputs to this lake, then HRM may consider installing a form of filter made of alum or lime (preferably lime). The filters have to be constructed around the golf course so that any surface waters and shallow groundwaters are filtered through prior to discharging into the lake. There is some documentation on similar filters used elsewhere in the western economies if one carries out an extensive survey of research. Re the costs, perhaps it could be shared by various parties and governments at all levels.

The following on lime treatment to reduce eutrophication is mostly from past published papers on lake restoration by Environment Canada scientists and their collaborators based mostly on their experience in the Canadian prairies. It was not about golf courses but filters have been used in some parts of the USA and Canada in other circumstances, hence it is worthwhile investigating. For further info, see our web page, http://lakes.chebucto.org/restocan.html

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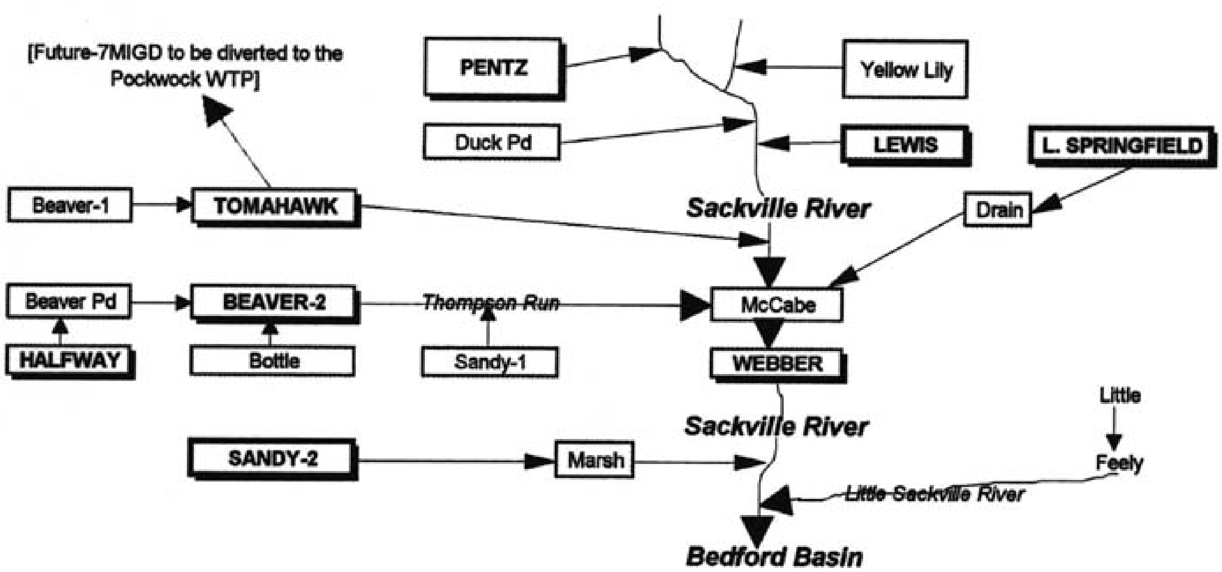
The traditional method for algal control is the application of copper sulfate or alum. But copper sulfate is toxic to nontarget organisms, and its use can upset the ecostructure of lakes. The long term adverse effect of alum in the natural environment is unknown.

Proper application of lime (specifically calcium hydroxide) reduces chlorophyll *a* levels.

Calcium hydroxide dissociates and forms calcium carbonate per
$Ca(OH)_2 + CO_2 \text{-->} CaCO_3 + H_2O$

These newly formed calcite crystals are small and present a relatively large surface area for adsorption. Associated with phosphate adsorption onto calcite is the molecular exchange of CO3-2 and PO4-3 on the surface of growing calcite crystals as follows:
$3CO_3 - 2(S) + 2PO_4 - 3(L) \leftrightarrow 3CO_3 - 2(L) + 2PO_4 - 3(S)$
where S and L denote calcite and aqueous phases, respectively.

The Sackville River flow chart developed by us
(Sandy, Glen Arbour is denoted as Sandy-1 below)



Data archives

Source of field data	Date(s) of sampling	#s of sampling events and type of sampling	TP (µg/l)		Cha (µg/l)	
		Deep stn.	mean	range	mean	range
SWCSMH's Predictive Modelling (also see graph on page 6)		Pre-cultural	3.2	-	-	-
		Based on 1991 land use stats	3.2	-	-	-
CWRS	Sept. & Dec., 1996	2#s (vol. wtd.)	4.3	3.8 – 4.7	0.75	0.41 – 1.09
CWRS	Feb.-Nov., 1997	4#s (vol. wtd.)	9.6	3.6 – 15.3	1.53	0.40 – 3.69
CWRS	Feb.-Nov., 1998	4#s (vol. wtd.)	15.0	9.7 – 21.3	6.54	0.75 – 15.7
CWRS	Apr.-Nov., 1999	3#s (vol. wtd.)	12.3	10.0 – 16.5	4.95	2.09 – 8.40
CWRS	Feb. & May, 2000	2#s (vol. wtd.)	10.80	9.6 – 12.0	3.09	2.26 – 3.91
JW	Oct. and Nov., 2001	2#s (surf.)	8.50	7 – 10	5.2	3.7 – 6.6
HRM	2006	2#s (1 m.)	5	2 – 8	2.44	0.56 – 4.32
HRM	2007	2#s (1 m.)	17	3 – 42	4.26	2.67 – 7.42
HRM	2008	3#s (1 m.)	21.3	15 – 32	3.56	0.36 – 7.68
HRM	2009	3#s (1 m.)	8.3	4 – 14	0.89	0.53 – 1.15
HRM	2010	3#s (1 m.)	9.0	5 – 14	3.00	2.26 – 3.75
HRM	2011	3#s (1 m.)	15.7	8 – 26	3.88	3.03 – 5.24

Acronyms & brief explanation on next page

Acronyms & brief explanation of the aforesaid table

vol.wtd.= volume weighted
surf.= surface samples
1 m.= 1 metre depth sampling

SWCSMH's predictive modelling- Computer modelling carried out by the Soil & Water Conservation Society of Metro Halifax
CWRS- Centre for Water Resources Studies, Dalhousie University (engaged by the developer, The Annapolis group, and supplied to the HRM as part of the development agreement)
JW- Jacques Whitford (engaged by HRM)
HRM- Halifax Regional Municipality (2006 to 2011; the Ch*a* values are means of the 2 methodologies reported)

Basic Morphometric and Hydrologic data
(computed by us from bathymetric maps supplied by the Provincial Fisheries Dept.)

- Shoreline length= 3.334 km
- Surface area= 35.7 ha
- watershed (headwater lake)= 152.3 ha
- In-lake TP retention= 0.70

- DL, Shoreline dev.= 1.6 ………… (DL is important because it reflects the potential for development of littoral communities which are usually of high biological productivity. Only a few lakes, such as Crater Lake in Oregon and a few kettle lakes approach the circular shape, i.e., DL = 1 (circular). DL is approx=2 in many subcircular and elliptical lakes. DL is large for lakes of flooded river valleys).

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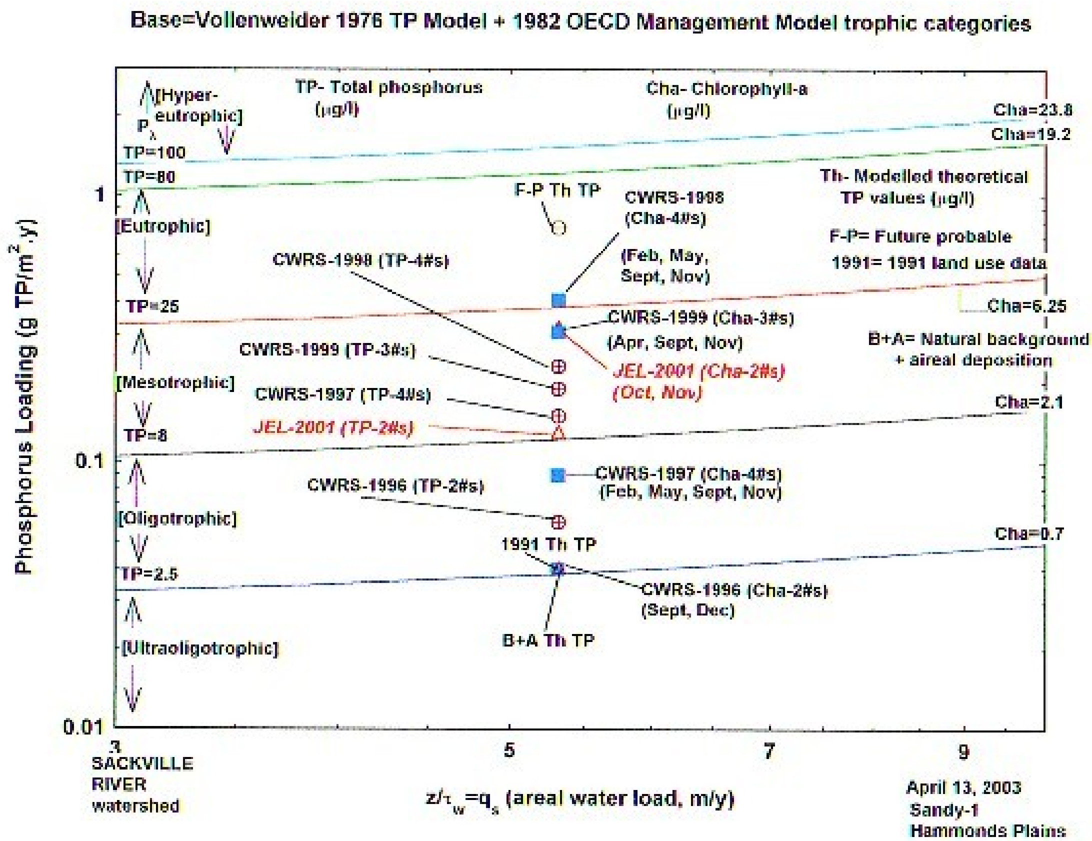
<u>Our predictive model utilizing the 18-country OECD (Organization for Economic Co-Operation and Development) peer consensus base models</u>



<u>Notes for the log-log graph above</u>:-

The X-axis is the areal water load. The Y-axis is the inflow TP concentration. The pelagic (i.e., open water) phosphorus concentrations are shown as curved lines with values of 2.5, 8, 25, 80, and 100 µg/l expressed as total phosphorus (TP) delineating the OECD management model categories of nutrient enrichment. We have not updated this figure with the HRM's data of 2006-2011 since the figure will be cluttered. There are other graphical programs available to plot extensive data but they are not convenient for the purpose of this submission.

B+A Th TP= Background+Aereal TP
1991 Th TP= TP Based on the 1991 land use stats
F-P Th TP= Future-Probable TP conc.

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Mayor Peter Kelly's communication to the Halifax Watershed Advisory Board (the info supplied by the board to the Mayor was partly from our written submissions as well as our extensive presentations using overheads. The Board was co-operative and quite concerned at the rapid eutrophication)

Halifax Regional Municipality

Peter J. Kelly
Mayor

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April 17, 2001

Dr. W.T. Stobo, Chair
Halifax/Halifax County Watershed Advisory Board
P.O. Box 1749
Halifax, NS B3J 3A5

Dear Dr. Stobo,

This letter is to update you on staff's efforts to respond to your letter of January 26, 2001 concerning water quality monitoring requirements set out in municipal development agreements. Staff from Planning and Development Services reviewed the issues you raised.

The first issue relates to the Glen Arbour development agreement, and your concerns about the potential decline in the water quality of Sandy Lake since the agreement was approved by Council. Staff has reviewed the Glen Arbour development agreement and the information submitted by the Board on the condition of Sandy Lake. The analysis submitted by the Board shows a significant deterioration of the water quality of Sandy Lake over the course of the water quality reports required in the agreement. Based on this information, municipal staff support additional testing to assess the current condition of the Lake and to determine what if any recovery has occurred. Staff is in the process of identifying resources to carry out further sampling, and is also following-up on several other issues related to the developer's responsibilities under the development agreement, and the role of other levels of government. Once a sampling program has been established for Sandy Lake, staff will respond directly to the Watershed Advisory Board with more information on how this matter is being handled.

The second issue relates to staff's expertise in water quality monitoring. As you know, the municipality has limited resources in this area. We expect through the municipality's Water Resources Management Study now underway to clarify the roles and responsibilities of the municipality in the area of water resource protection, and eventually this will enable us to identify appropriate resources. The municipality is also

(Mayor Kelly's communication continued from the previous page)

looking at improvements to our development agreement processes, which could lead to changes in how environmental protection measures are addressed. We have improved our process since Council approved the Glen Arbour agreement in 1997. For example, we now require analysis of water monitoring reports to be submitted along with the sampling data. The Board has helped the municipality in this regard by developing a consistent set of standards for water quality monitoring programs, which can now guide staff's negotiations of agreements where water quality is an issue. We hope over time to address your concerns as we continue to improve our processes.

Thank you for your interest in this issue. If you have any questions related to staff's review of the Glen Arbour agreement, please contact Kevin Warner Development Officer in the Central Region Development Office at 869-4389 or Jacqueline Hamilton, Planner at 490-4405.

Respectfully, I remain,

Peter J. Kelly, MBA
Mayor
/jc

c. Paul Dunphy, Director of Planning and Development Services
Roger Wells, Coordinator of Planning Applications
Austin French, Coordinator of Community Planning
Jacqueline Hamilton, Planner
Kevin Warner, Development Officer, Central Region
Bruce Colborne, Development Engineer, Central Region
Tony Blouin, Manager of Environmental Policy