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Ref.: ESSC_OECD (8 pages)

To: **Environment & Sustainability Standing Committee (ESSC), HRM**
Cc'd Mayor Mike Savage, and CAO, Richard Butts
Cc'd John Sheppard PEng. (Director), and Dr. Tony Blouin, Environmental Services, Halifax Water
Also sent to Hon. Sterling Belliveau, Minister, NSE; Mr. Andrew Younger, Liberal Environment Critic; and Mr. Chuck Porter, PC Environment Critic

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

Date: February 21, 2013

Subject: OECD research with emphasis on lake management- Limnology: Part-3

Informally formulated. 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. Due to the significance of this topic, some details are provided here, most of them being from the OECD research of which Canada was a leader in its scientific talent. All our URLs below are case sensitive. We thank all the recipients of our submissions.

Detailed Preamble:-

This submission is intended primarily to raise awareness of the scientific consensus of the then leading Government scientists of the 18 wealthiest countries of the world, i.e., the OECD (Organization for Economic Co-Operation and Development). Kindly access our web page (http://lakes.chebucto.org/TPMODELS/OECD/oecd.html). From that web page, you can access several others that we developed on the said findings.

A Canadian scientist, Dr. Richard Vollenweider (deceased), was the Manager and headed the research.

The multiple volumes of the OECD research are accessible primarily from the Environment Canada library in Burlington, Ontario, and other libraries across Canada.

Our team's initial report on select HRM lakes (1991) was based on the OECD research and is widely available via two libraries of Dalhousie University. Dr. Joe Kerekes, a collaborator of Dr. Vollenweider, directed our methodology of the said 1991 report.

Dr. Joe Kerekes was a good acquaintance/past collaborator of Dr. Tony Blouin, formerly of HRM, now with Halifax Water.

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We completed (and continue as necessary) numerous scientific mini-reports as well as detailed spreadsheet analyses of approx. two thousand (2,000) lakes/ponds across 3 counties of Nova Scotia, mostly utilizing the OECD research as the `backbone'.

In that way, we were not only able to understand our lakes better but also were able to `forecast' issues even before they occurred, for e.g., the recent issues at Lakes Banook and MicMac (Dartmouth), with probabilities attached to it as in any scientific modeling.

☞

Over more than 2 whole decades, I had indeed sent detailed emails, cautioning in advance, potential issues at certain lakes to many officials at the HRM (and its former municipal units) as well as at the NS Environment Dept. since there is little use of crying after-the-fact, but little to no action ensued in most cases!

ASPECT #1: The OECD research:-

It is the outcome of several years' concerted effort by 18 member countries. The objectives were to establish, through international cooperation, a basis for eutrophication control of inland waters (lakes and reservoirs in particular), and to develop better guidelines for fixing nutrient load criteria compatible with water use objectives.

The OECD lakes ranged from "pond-size" lakes to the Great North American Lakes. The momentum initiated by the International Biological Programme in 1964 was maintained. The information available was broad enough to establish the general statistical behaviour of lakes with respect to nutrient load and trophic response. It should be noted, however, that subtropical (in USA) and Arctic lakes (including high Alpine) were poorly represented, and saline, closed basin lakes were not represented at all in the programme. The OECD study was also restricted mainly to lakes of the temperate zone.

ASPECT #2: Incorrect conclusions on trophic status may result if the all important probability distribution diagrams are not utilized:-

"What emerged from the assessment of all information available, however, led to the conclusion that there is no possibility of defining strict boundary values between trophic categories. Whilst the progression from oligo- to eutrophy is a gliding one- as has been stressed many times in literature- any one combination of trophic factors, in terms of trophic category allocation, can only be used in a probabilistic sense."

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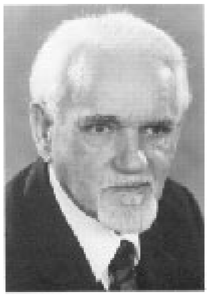
"Average conditions, expressed by "average nutrient concentrations", "average biomass values", "average transparency" do not necessarily express the degree of variability,



particularly with regard to peak levels, frequency of their occurrence, and their qualitative nature (type of phytoplankton). From the management viewpoint, such situations and their frequency are as important as average conditions."

For this reason, prediction uncertainties must be accounted for. Kindly listen to a 4-minute mp3 sound file (http://lakes.chebucto.org/TPMODELS/OECD/vollenweider.mp3) of Dr. Richard Vollenweider promoting the use of the OECD probability distribution diagrams in order to establish trophic states with a high confidence level. Kindly also access http://lakes.chebucto.org/PEOPLE/vollenwedier.html for a brief bio on Dr. Vollenweider.

See Appendix-E (page 8) to view the OECD probability distribution diagrams and a preliminary example from our first report (1991).

ASPECT #3: Predictions/Management (Sources: OECD, Ontario Ministry of Environment, and others):-

- 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 (total phosphorus) and Ch*a* (chlorophyll *a*), laboratory analysis are not perfect 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 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 models will still indicate the relative change in trophic state that would result from a given change in conditions.

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- The planning agency may pick any intermediate level of TP or Ch*a* from the predictive models should it so desire subsequent to intensive public consultations.

- In 2004, the CCME (Canadian Council of Ministers of the Environment) developed stringent requirements for setting phosphorus values as the lake management criteria (http://documents.ccme.ca/download/en/205/). Based on the predicted values, the agency could set the densities as follows:

  - In the case of areas served with on-site sewage disposal systems, a maximum number of allowable systems within 300 metres of lake shores could be ascertained. 300 metres is a compromise value and has withstood the test of time in Ontario, Nova Scotia, and elsewhere in North America.

  - In the case of areas served with sewered systems, controls could be placed on the amount of impervious areas as well as the agency could require total stormwater systems, for e.g., specially constructed (or engineered) wetlands together, not either/or, with a pre-detention basin. The latter will remove larger particles, and the wetland would act as a polishing device for removal/reduction of smaller particles as well as dissolved pollutants.

    - The stressors are not just total phosphorus alone, but are a whole range of post-development post-human-occupation derived stressors.

    - For an idea about potential stressors, kindly view two of our submissions to the community Councils:-
      - http://lakes.chebucto.org/HRM/SUBMISSIONS/2013/HWCC_Stressors_1.pdf, and
      - http://lakes.chebucto.org/HRM/SUBMISSIONS/2013/NWCC_stressors_2.pdf (this 1-page submission has the URL to view a half hour video that we produced featuring John Sheppard PEng when he was with the Halifax County, now a Director with Halifax Water; what John said then equally applies now as well.)

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<u>Appendix-A</u>: Ascertaining Phosphorus and/or Nitrogen limitation:-

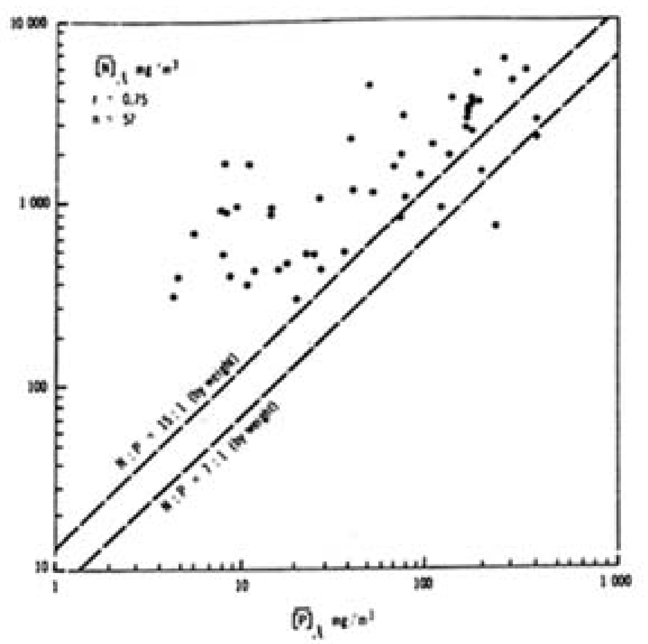
It should be noted:

- that relative to the phosphorus concentrations, the nitrogen/phosphorus ratio, on average, decreases from more than 100 on the oligotrophic side to less than 10 on the eutrophic side. This can be interpreted as a tendency for lakes to shift from phosphorus dependency to nitrogen dependency with increasing trophy;

- that specific lakes may deviate from this rule, independent of their trophic characteristics. Hypertrophic lakes, for example, may not be nutrient controlled at all but light-limited instead. Deep mixing and high water replenishment rates may also reduce the effect of nutritional conditions on production.

Generally, lakes are phosphorus limited with Total-N/Total-P ratios >15, and nitrogen limited for Total-N/Total-P ratios <7. For ratios of Total-N/Total-P between 15 and 7, either P or N or both P and N could be limiting.

The tendency for nitrogen and phosphorus to increase in parallel makes it difficult to determine the relative importance of the two factors in the eutrophication process. Accordingly, it is impossible to speculate solely on the basis of nutrient conditions found in a lake, which one of the two factors is limiting production. This question can only be resolved by careful analysis of all pertinent information.



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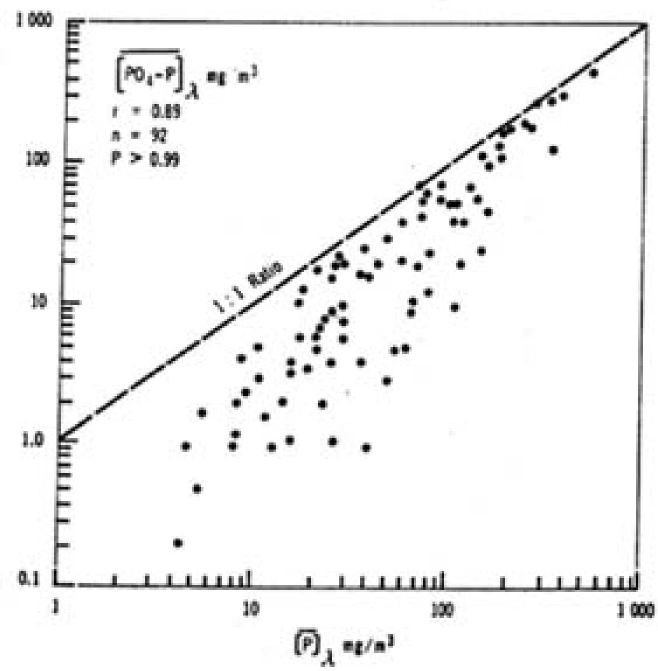
<u>Appendix-B</u>: Ortho-phosphate-P vs. Total-Phosphorus

In management terms, the OECD findings mean that the control of sources of nitrogen and phosphorus of high biological availability (dissolved mineral fractions) probably have a greater effect on the reversal of eutrophication than an unselective control, though equal in relative terms, of all sources.



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<u>Appendix-C</u>: Water Management-The preferred OECD Management Model:-

Another widely used predictive model is the OECD Management Model as inserted below. This model synthesizes the standard OECD equations for the relationships between average inflow phosphorus concentration $\overline{[P]}_j$, expected average lake concentration $\overline{[P]}_\lambda$ and expected average chlorophyll $\overline{[Chl]}$ concentration as a function of the average water residence time T(w). This diagram also gives approximate indications of the expected trophic category. As these categories are management oriented, they are slightly more stringently defined (i.e. approximately at the class midpoints) than are the categories used for diagnostic purposes. This provides a certain safety margin for the design of the loading objectives. The long term correlation equations are:

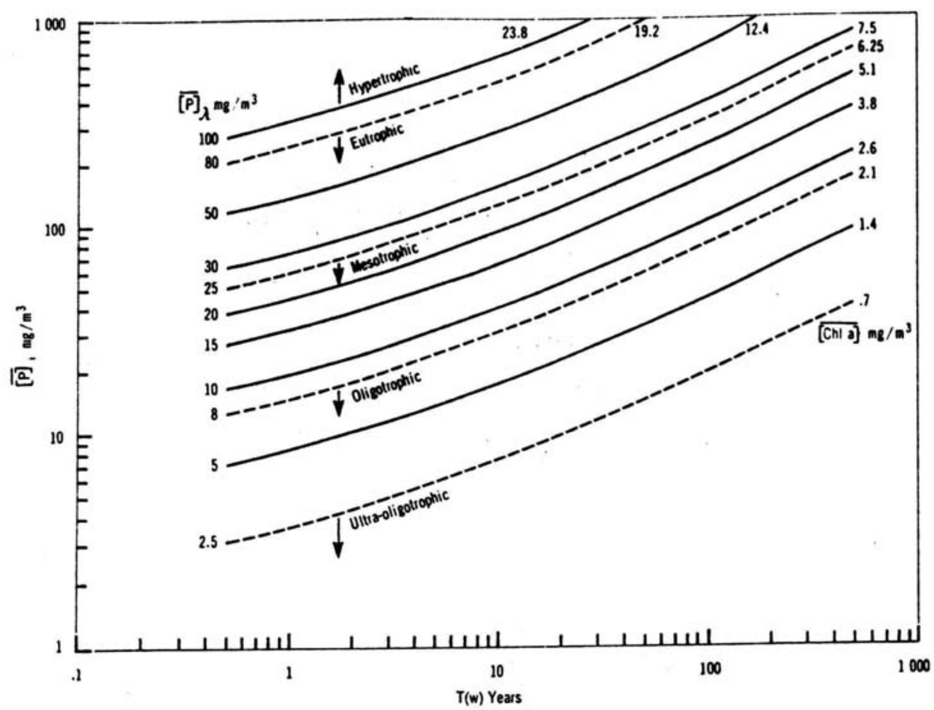
$$[\overline{P}]_\lambda = 1.55\left[[\overline{P}]_j\Big/\left(1+\sqrt{T(w)}\right)\right]^{.82},\ \overline{[Chl]} = 0.28[\overline{P}]_\lambda^{.96},\ \begin{bmatrix}\max\\ Chl\end{bmatrix} = 0.64[\overline{P}]_\lambda^{1.05}, \text{ and}$$

$$[\overline{N}]_\lambda = 5.34\left[[\overline{N}]_j\Big/\left(1+\sqrt{T(w)}\right)\right]^{.78}$$

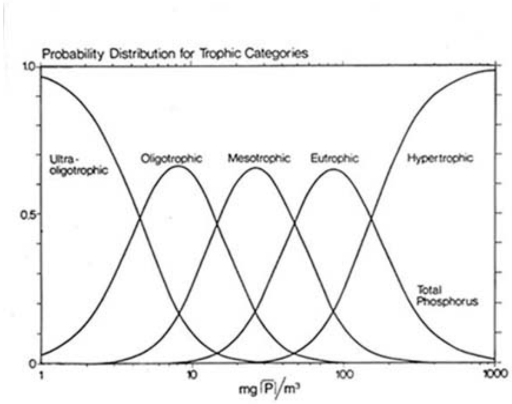
The corresponding approximate long term orthogonal regression equations are:

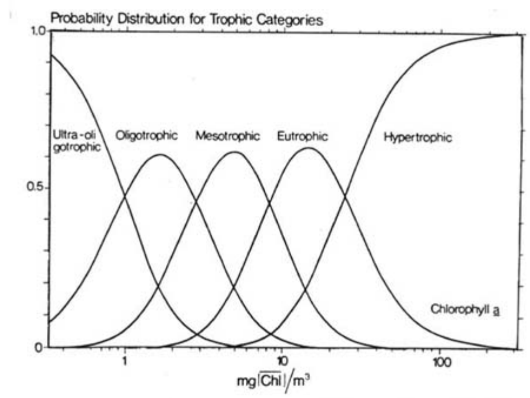
$$[\overline{P}]_\lambda = 1.22\left[[\overline{P}]_j\Big/\left(1+\sqrt{T(w)}\right)\right]^{.87},\ [\overline{Chl}] = 0.18[\overline{P}]_\lambda^{1.09},\ \begin{bmatrix}\max\\ Chl\end{bmatrix} = 0.42[\overline{P}]_\lambda^{1.17}, \text{ and}$$

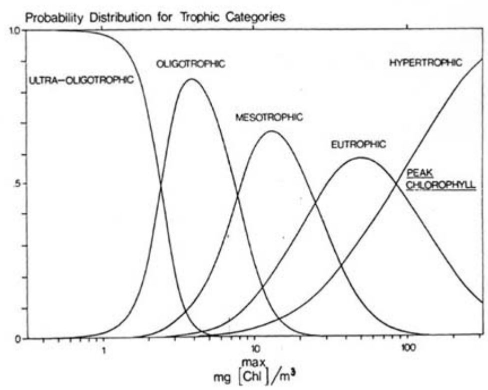
$$[\overline{N}]_\lambda = 3.25\left[[\overline{N}]_j\Big/\left(1+\sqrt{T(w)}\right)\right]^{.85}$$

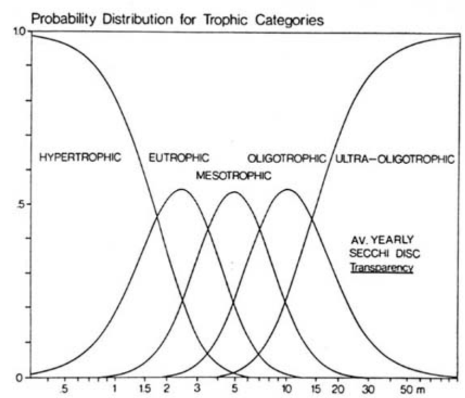


Appendix-D: The OECD's 4 probability distribution diagrams (average TP, average Ch*a*, peak Ch*a*, and average SD). Below is an example of the application for select HRM lakes (1991). We had not ascertained the probabilities based on peak chlorophyll*a* in 1991 since we did not have sufficient data to ascertain them. Our subsequent analyses, mostly in electronic format, did take those into account:-









Percentage Probability Classification of 1990 lake trophic states based on the "OECD" probability distribution curves. Classifications based on yearly averages for total phosphorus, chlorophyll a and Secchi disc readings. UO= Ultraoligotrophic, O= Oligotrophic, M= Mesotrophic, E= Eutrophic and HE= Hypereutrophic.

	Percentage Probability Classification														
	Based on Total Phosphorus					Based on Chlorophyll a					Based on Secchi Disc				
Lake	UO	O	M	E	HE	UO	O	M	E	HE	UO	O	M	E	HE
1 Albro	5%	55%	36%	4%	0%	51%	44%	5%	0%	0%	3%	34%	50%	11%	2%
2 Banook	14	66	18	2	0	59	38	3	0	0	0	12	50	35	3
3 Beaverbank	2	37	55	6	0	22	61	17	0	0	0	4	37	51	8
4 Bell	32	61	7	0	0	74	24	2	0	0	2	27	53	16	2
5 Bissett	0	17	65	18	0	0	14	62	24	0	0	0	4	38	58
6 Chocolate	35	60	5	0	0	93	7	0	0	0	32	54	14	0	0
7 First	4	46	46	4	0	0	19	63	18	0	0	0	13	52	35
8 Hubley Big	4	47	45	4	0	8	55	34	3	0	0	3	33	51	13
9 Kearney	22	65	13	0	0	93	7	0	0	0	2	31	51	13	3
10 Kinsac	4	46	46	4	0	8	55	34	3	0	0	8	45	40	7
11 Loon	22	65	13	0	0	82	18	0	0	0	-	-	-	-	-
12 Maynard	17	65	15	3	0	21	61	18	0	0	2	31	51	13	3
13 MicMac	4	47	45	4	0	5	50	42	3	0	2	19	53	24	2
14 Miller	22	65	13	0	0	63	34	3	0	0	0	8	45	40	7
15 Morris	4	46	46	4	0	22	61	17	0	0	0	3	33	51	13
16 Nicholson	14	66	18	2	0	34	56	10	0	0	-	-	-	-	-
17 Oathill	2	43	51	4	0	3	33	56	8	0	0	12	50	33	5
18 Papermill	19	65	14	2	0	22	61	17	0	0	0	8	45	40	7
19 Portuguese Cove	2	43	51	4	0	20	60	20	0	0	0	0	13	52	35
20 Rocky	17	65	15	3	0	59	38	3	0	0	6	44	44	6	0
21 Sandy	5	55	38	2	0	25	60	15	0	0	0	12	50	33	5
22 Second	5	55	36	4	0	20	60	20	0	0	2	19	53	24	2
23 Settle	0	20	65	15	0	0	11	58	29	2	0	0	4	38	58
24 Springfield	4	54	39	3	0	22	61	17	0	0	0	8	45	40	7
25 Third	35	60	5	0	0	20	60	20	0	0	0	12	50	35	3
26 Tucker	10	63	26	1	0	3	33	56	8	0	0	3	35	51	11