LAKE MANAGEMENT PLANNING DESBARATS LAKE

Prepared for:

Township of Johnson

January 2014

Michalski Nielsen
ASSOCIATES LIMITED
ENVIRONMENTAL PLANNING BIOPHYSICAL ANALYSIS
LAKE CAPACITY ASSESSMENT RESOURCE MANAGEMENT

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Michalski Nielsen
ASSOCIATES LIMITED

January 27, 2014

Ms. Ruth Kelso
Clerk Administrator
Township of Johnson
1 Johnson Drive, Box 160
Desbarats, Ontario
P0R 1E0

Re: Desbarats Lake; Our File 3013

Dear Ms. Kelso:

Enclosed please find our report entitled **LAKE MANAGEMENT PLANNING – DESBARATS LAKE** (January 2014).

Should you have any questions, or if further clarification is required, do not hesitate to call.

Yours truly,

MICHALSKI NIELSEN ASSOCIATES LIMITED
Per:

Gord Nielsen, M.Sc.
Ecologist
President

GN/be

Enc.

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1 INTRODUCTION

1.1 Overview of Desbarats Lake

Desbarats Lake is located in Johnson Township, north of the Community of Desbarats, 60 kilometres east of Sault St. Marie (**Figure 1**). Considerable background information on the lake can be found in two studies which have been completed or commissioned by The Central Algoma Freshwater Coalition (CAFC), with the financial support of The Township of Johnson: Characteristic Study for Assessing Water Quality of Desbarats Lake, Johnson Township, prepared by Lindsey Verdone of The Central Algoma Freshwater Coalition, March 2010; and Water Quality and Remediation Options for Desbarats lake, Johnson Township, prepared by Gertrud Nürnberg and Bruce LaZerte of Freshwater Research, May 2013. In brief, Desbarats Lake and its watershed can be characterized as follows:

- the lake is of moderate size, with a surface area of 4.0 km^2 (this number is based on our measurements, and is slightly larger than older measurements of 3.6 km^2);
- it is a shallow lake, with an average water depth of 6.7 m and a maximum water depth of 10.5 m;
- the lake is roughly oblong in shape, and oriented in a northwest to southeast direction. The slope of the lake, its orientation which exposes it to the prevailing northwesterly winds and its shallow depth all combine to make this lake quite prone to wind-induced mixing;
- most deeper lakes, and some shallower lakes with different morphological characteristics than Desbarats Lake, become temperature stratified during the summer months. In this regard, a well-developed warmer upper layer, known as the epilimnion, becomes separated from the colder, deeper waters, or hypolimnion, resulting in very different chemical and dissolved oxygen conditions between these areas. However, this is not the case with Desbarats Lake. Existing data shows that this lake can become weakly stratified over short periods of the summer, but that this condition does not typically persist;
- as a consequence of there being little to no stratification within Desbarats Lake, dissolved oxygen levels generally remain quite high throughout the entire water column of the lake, even during the mid to late summer period;
- Desbarats Lake supports a warmwater fishery, which includes northern pike, walleye, smallmouth bass and yellow perch. The report by Freshwater Research (2013) indicates that a fish kill was

Figure 1. Location Map

Project Name:	Desbarats Lake
Project Number:	3013
Date:	January 2014
Created By:	G.N.
Scale:	N.T.S.

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reported by a lake resident; interestingly, this fish kill is reported to have occurred in the late summer, not during the winter;

- presently, approximately 55 camps/cottages are situated around the shoreline of Desbarats Lake. This figure is based on my review of assessment mapping with the former Township Clerk in the fall of 2013. I note that this number of developed properties differs somewhat from that indicated in CAFC's 2010 background study, a number which is also referenced in Freshwater Research's 2013 study. However, my review of the Township's assessment mapping indicates an additional approximately 12 existing lots of record, which are undeveloped, bringing the total number of existing lots to 67, which more closely matches the number of lots referenced in the background studies;

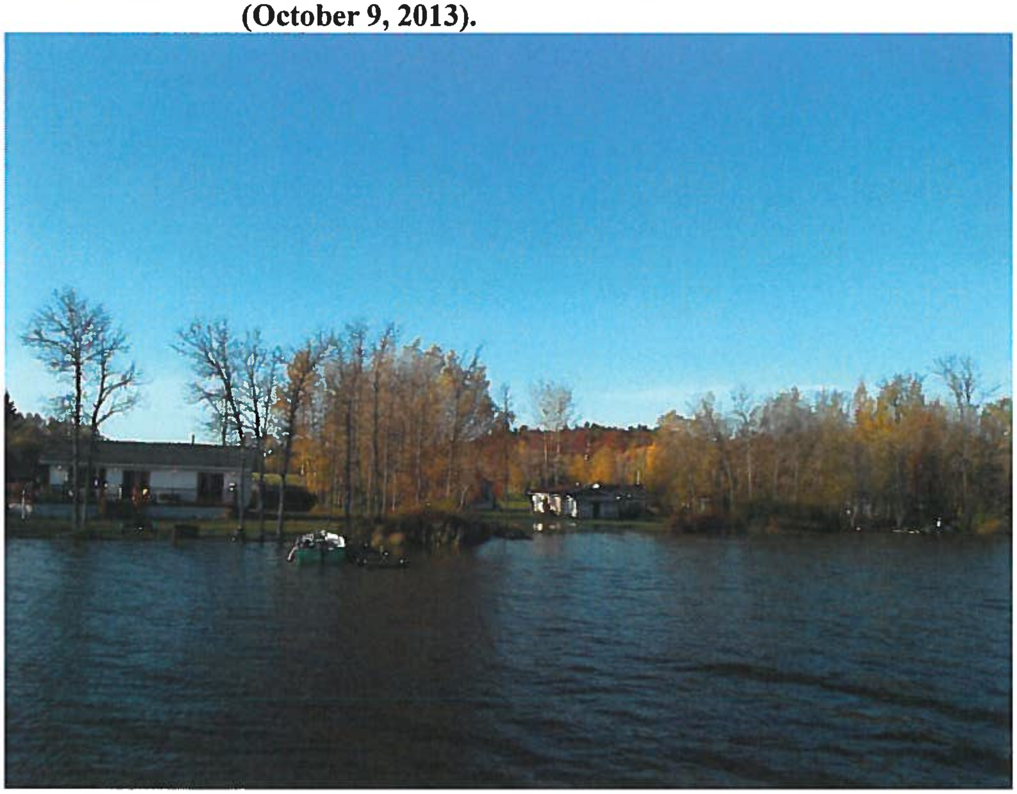
- the developed properties include one small youth camp (**Photograph 1**), approximately 10 cottages which are now utilized as year-round homes, approximately 10 cottages which are summer access only, and which are very small, and approximately 34 cottages which are, or which could be, occupied on an extended seasonal basis. **Photographs 2 – 6** provide typical views of the camps/cottages located around the shoreline of the lake. These are typically modest-sized dwellings, and many of them are situated on very small lots;

- many of the undeveloped lots are also very small in size, and may not meet present day requirements for the establishment of a sewage disposal system and/or have adequate room to site a cottage and septic system 30 m or more from the lake;

- records on the nature of sewage disposal systems associated with the approximately 55 developed lots are incomplete, given the older age of many of the cottages. It appears that several of the cottages are not serviced by sewage disposal systems which would meet present-day Ontario Building Code requirements;

- much of the shoreline of Desbarats Lake remains undeveloped, with a few privately owned properties having very considerable amounts of shoreline frontage. This is particularly true along the northeast shoreline. As shown in **Photographs 7 – 10**, the overall intensity of development on Desbarats Lake is quite modest, much of the shoreline is forested, and the overall impression is one of a relatively pristine cottage lake;

Photograph 1. **Existing, small youth camp on Desbarats Lake (October 9, 2013).**



Photograph 2. **Typical view of cottage development on Desbarats Lake (October 9, 2013).**

Photographs 3 and 4. **Typical views of cottage development on Desbarats Lake (October 9, 2013).**

Photographs 5 and 6. **Typical views of cottage development on Desbarats Lake (October 9, 2013).**

Photographs 7 and 8. **Views of undeveloped portions of Desbarats Lake (October 9, 2013).**

Photographs 9 and 10. **Views of undeveloped portions of Desbarats Lake (October 9, 2013).**

- the lake has an external watershed area of approximately 27 km^2 (this is based on my calculations, and is slightly larger than previous measurements of 23 km^2). As illustrated in **Figure 2**, this watershed includes some rural development, some agricultural lands (**Photographs 11** and **12**), forest (**Photographs 13** and **14**) and wetland (**Photographs 15** and **16**). Wetlands comprise a large portion (approximately 20% from our calculations) of this watershed, and include areas of swamp thicket, wet meadow and marsh;

- while there has been a recent resurgence in the amount of farming within the Desbarats area, agricultural lands make up quite a small percentage of this watershed (approximately 4%, from our calculations), and are best characterized as having a low intensity of use; this is not apt to change with the resumption of more farming activity. These lands are predominantly used for livestock pasturing, with some cropping for hay and corn;

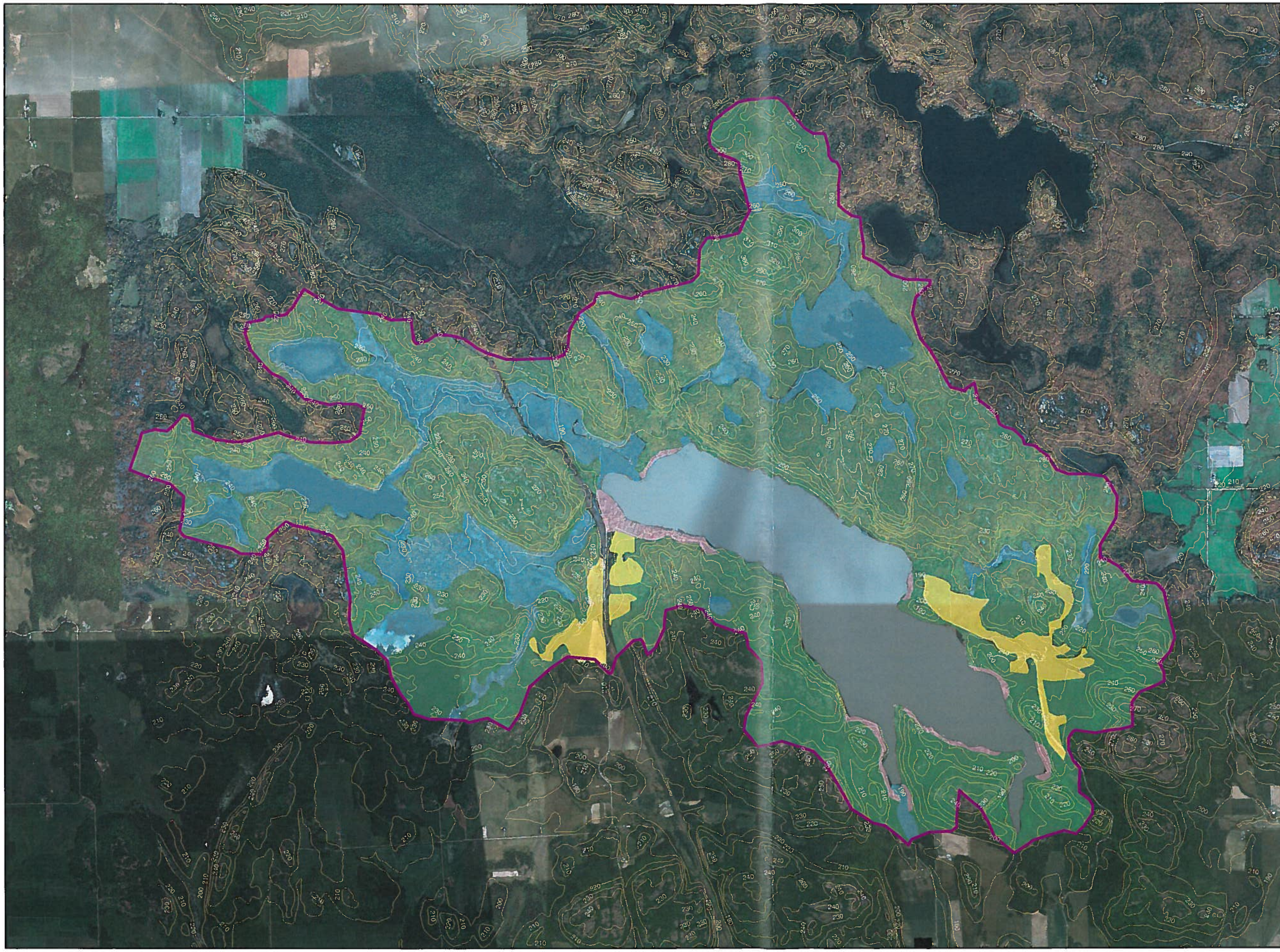
- it is my understanding that there has been some logging within forested lands within the lake's watershed in the past, however my observation of these forested areas (**Photographs 13** and **14**) indicates that such logging occurred decades earlier, and that forested lands are typically healthy and mid-mature to mature;

- wetlands are a predominant feature within this watershed, and are significantly influenced by beaver activity (**Photographs 17** and **18**). It is my understanding that there was beaver trapping in the past, that in recent years the amount of trapping has been very minimal, but that there has recently been some resumption in this activity (associated with the recent resurgence in farming within this area, some of the farmers also make a portion of their livelihood from trapping);

- as illustrated in **Photographs 19** and **20**, the failure of large beaver dams can be very catastrophic, with the rapid flushing of the ponds and outwash of soils being detrimental to Desbarats Lake;

- there are four watercourses which convey flows from the surrounding watershed to Desbarats Lake. Three of these enter as well defined channels (**Photographs 21** and **22**), whereas the fourth is very diffuse and marshy where it enters (**Photographs 23** and **24**). There are some additional smaller wetland areas along the shoreline which convey some localized runoff to the lake, with overland runoff and localized groundwater discharge also contributing to the water entering the lake;

Figure 2. Desbarats lake Watershed and Land Characterization



Legend

Watershed Boundary

Land Uses

- Farm
- Forest
- Lake
- Wetland/Shallow Lakes or Pond
- Shoreline Development

490 245 0 490 Meters

Map Source:

Project Name:	Desbarats Lake
Project Number:	3013
Date:	October 2013
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Scale:	1:35,000

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Photographs 11 and 12. Typical views of agricultural lands within Desbarats Lake watershed (October 9, 2013).

Photographs 13 and 14. **Typical views of forested lands within Desbarats Lake watershed (October 9, 2013).**

Photographs 15 and 16. Typical views of wetlands within Desbarats Lake watershed (October 9, 2013).

Photographs 17 and 18. Examples of beaver dams and their influence within the Desbarats Lake watershed (October 9, 2013).

Photographs 19 and 20. **Examples of the catastrophic failure of a beaver dam, with bottom photograph showing a road and culvert that were washed out following failure of dam (October 9, 2013).**

Photographs 21 and 22. Well-defined watercourses entering Desbarats Lake (October 9, 2013).

Photographs 23 and 24. Poorly defined watercourse entering Desbarats Lake (October 9, 2013).

- the lake drains out via the Desbarats (or Walker) River, which outlets to the North Channel of Lake Huron (**Photographs 25** and **26**);

- Desbarats Lake has high levels of nutrients, and the limited longer-term data that is available suggests this has been the case for a number of decades. Phosphorus, the nutrient controlling eutrophication within this lake, is the key parameter of concern from a lake enrichment perspective. Levels of phosphorus in the lake averaged 37 μg/L in sampling completed over 21 occasions between 2010 and 2012, with the mean lake concentration on each of those different sampling occasions ranging from 22 μg/L up to 52 μg/L. These data indicate the lake is "eutrophic", a term which is described by the Ministry of the Environment (2011) as meaning "rich in nutrients and highly productive. Eutrophic lakes are generally characterized by dense populations of aquatic plants and algae, reduced water clarity, and if thermally stratified, depletion or low levels of oxygen in the hypolimnion."; and

- as is characteristic of eutrophic lakes, Desbarats Lake does indeed have large amounts of algae seasonally, and typically poor water clarity (**Photographs 27** and **28**). Other nuisance aesthetic and ecological consequences of a lake being eutrophic can include algae blooms, decaying algae on the shoreline, odours, poor drinking water, and the potential for fish kills. Desbarats Lake has experienced summer and fall algae blooms, including several blooms of Cyanobacteria; the latter events can produce toxic compounds, making water unfit for human or animal consumption.

Lake eutrophication is both a natural phenomenon and one which can be influenced by human activities. The degree to which this is a natural phenomenon within Desbarats Lake, or one which is controllable, is an area of obvious interest and concern to both lake residents and the Township of Johnson. So too is the question of whether there are issues surrounding opportunities to prevent this situation from getting worse and/or to improve upon it.

1.2 Background On The Purpose Of This Report

In June of 2013, the Township of Johnson submitted a Request for Proposal, Lake Capacity Assessment, Desbarats Lake, a copy of which is included in **Appendix A**. This Terms of Reference was circulated to several known qualified consultants. Included with the terms of reference was an electronic copy of the Freshwater Research (2013) report, as background. The issuance of this Request for Proposal was based on the recognition that Desbarats Lake has water quality issues, and that the completion of a Lake

Photographs 25 and 26. Desbarats (Walker) River, at the lake outlet (October 9, 2013).

Photographs 27 and 28. Views showing poor water clarity within Desbarats Lake (October 9, 2013).

Capacity Assessment might be the logical next step in better understanding this issue. Further, it was to explore the role that municipal planning might play in preventing phosphorus levels from increasing within the lake.

On July 23, 2013, Michalski Nielsen Associates Limited responded to the Township of Johnson's Request for Proposal; a copy of our proposal is provided in **Appendix B**. However, that proposal noted that, while we were very interested in assisting the municipality in addressing water quality issues within Desbarats Lake, we were concerned that a traditional Lake Capacity Assessment would not provide meaningful assistance. The rationale for this was as follows:

- background data which we had reviewed at that time suggested that the lake exhibited quite dramatic within-year, as well as year-to-year changes in phosphorus concentrations;

- the influence of development activities on lake water quality tend to be very gradual but sustained. As new cottages are built, there is typically a corresponding increase in phosphorus, but this result is generally not dramatic, or sporadic;

- while it is true that land clearing associated with new cottage development or other land uses can temporarily increase suspended sediment/soil particulate concentrations in runoff, with a corresponding change in phosphorus concentrations, this does not produce dramatic changes in water quality unless it is very widespread;

- our initial review of land use activities around Desbarats Lake indicated quite a modest level of cottage activity and other anthropogenic land use activities, none of which were likely to have had a substantial influence on lake water quality (and which did not explain observed water quality fluctuations). Accordingly, we expressed the opinion that traditional measures which might be considered as part of a Lake Plan, such as improving riparian buffers, instituting a septic inspection and replacement program, etc., would have relatively small benefits on water quality, and would do relatively little to remedy existing water quality concerns;

- further, our review of the work completed by Freshwater Research (2013) lead us to agree with that report's conclusion that phosphorus remobilization from lake sediments did not appear that substantial, and could not explain fluctuations in water quality;

- our initial review of lake watershed conditions and the stream water quality data then available to us suggested that external loads of phosphorus from this watershed were having a major influence on lake water quality;

- it was our assessment that modeling would do a poor job in predicting phosphorus concentrations in Desbarats lake. In this regard, Ontario's Lakeshore Capacity Assessment Handbook (MOE et al. 2010) indicates three situations where the model does not work well, as follows: (1) shallow lakes; (2) tea-stained lakes; and (3) lakes with small surface areas. This lake has a mean depth of 6.7 m, slightly above the minimum recommended depth for the application of the model. It is larger than the minimum threshold size, albeit still quite small. Further, it has relatively high DOC concentrations, albeit these are lower than the maximum threshold recommended for model application. The combination of all three factors inherently makes this lake a very difficult one to model. When a model does not fit with the data, adjustments to the inputs then need to be made to make the model a better fit, but this reduces the overall reliability of the model's predictions;

- Desbarats Lake has a phosphorus concentration in excess of 20 µg/L, so modeling it would simply show it to be over capacity. Knowing this in advance defeats one of the major benefits of preparing such a model, which is typically undertaken to determine just how much additional shoreline development a lake can sustain. To this point, Ontario's Lakeshore Capacity Assessment Handbook states "a total phosphorus concentration of 20 µg/L will be used as the upper limit to protect against nuisance algal blooms. In situations where a lake is naturally above 20 µg/L (e.g., highly coloured, tea-stained lakes), regional MOE staff may use discretion to allow a limited amount of new development (e.g., <10 lots), provided the lake is not sensitive." This lake has had outbreaks of Cyanobacteria, which would indicate it is sensitive and that no new development should be permitted; and

- perhaps most importantly, the model will not have any value in better understanding, and developing potential solutions for, the root cause of water quality problems in Desbarats lake, which the data I had initially reviewed strongly suggested was the result of external watershed loadings.

In accordance with the above, I recommended a work program which I felt provided a practical, meaningful and cost-effective way to further understand, and assist in the remediation of, the known water quality issues in Desbarats Lake. This consisted of the following steps:

A. a background review, which included collecting and collating mapping information and other data on Desbarats Lake and its watershed;

B. a site assessment to obtain additional information on the lake and its watershed. This visit was to be conducted over a two day period in the late summer or early fall, and was to include a visual examination and notes on the magnitude and nature of shoreline development on Desbarats Lake (including the number of cottages), together with an inspection of upstream watershed areas, including wetlands and their outlets, agricultural and other land uses;

C. at the time of the site assessment, meeting with the municipality to look at the number of vacant lots of record on Desbarats Lake, and the existing policy framework influencing development activities both on Desbarats Lake and within its watershed;

D. at the same time, attending a meeting to be organized through the municipality, including local ratepayers and ratepayer groups, both to hear their concerns and to look towards opportunities to augment existing water quality data;

E. reviewing potential solutions to existing water quality issues with the municipality and ratepayers, together with the benefits and limitations of each. Through this process, seeking some consensus on next steps of this project;

F. contacting MNR and MOE staff, as may be appropriate based on the initial work, about potential solutions to phosphorus loading issues from the lake's watershed; and

G. following completion of the site inspection and meeting, preparation of a report providing insight on the issues and potential solutions for Desbarats Lake. This was to include recommendations relating to:

   - existing shoreline development;
   - other existing development within the watershed;
   - any new development on existing lots of record along the shoreline. In this regard, our office has been successful in developing strategies which provide for near-zero new phosphorus loads from new cottage developments, which typically involves governing the development of such lots through the Site Plan Control process, with specific

recommendations/restrictions on the location of the dwelling, the location of shoreline structures, the preservation of a shoreline buffer, and the use of techniques to provide long-term phosphorus attenuation as part of the sewage system design. These measures have been utilized on many lakes in Muskoka which are deemed over-threshold (at capacity) from a phosphorus perspective;

- potential measures to remediate against natural phosphorus loadings from the watershed, with options to be considered including an active beaver-management and beaver dam removal program within the watershed, reinforcement of existing beaver dams to increase their permanency, creation of additional permanent dams/berms to attenuate flows along channels downgradient of existing wetland areas, incorporation of phosphorus-reactive soils in channels downgradient of wetlands, and other measures which may arise based on field investigations; and

- providing a realistic impression of the extent to which water quality may be improved within Desbarats Lake, including discussion of climate issues which may continue to contribute to some of the problems being observed.

This would end this phase of investigation, although logical additional stages (beyond the scope of my retainer) may be to interpret and comment on any additional water quality data that could be collected by ratepayers per the recommendations of our report, and to assist in the implementation of any recommendations arising from our report.

The municipality did award this project to Michalski Nielsen Associates Limited in the late summer of 2013. Items A – E from our recommended work plan were completed as part of a lake inspection, watershed inspection and series of meetings I was involved in from October 8 – 11, 2013; this included an inspection of the lake and watershed with members of CAFC and culminated with a public open house, which provided an excellent opportunity to share information and ideas with a number of lake and watershed residents. Item F was completed subsequent to field inspections, and some additional sampling I felt was necessary and warranted based on those inspections. This report is intended to satisfy Item G, to provide insight on the issues and potential solutions for Desbarats Lake. Please note that this report is not a Lake Management Plan per se, as such plans are typically prepared by, and receive buy-in from, multi stake-holder interests, including lake residents, other property owners in the watershed, and the municipality. However, I believe it provides important insight which can be used by CAFC and other ratepayers in the preparation of a Lake Management Plan, and by the Township of Johnson towards measures which are within its control, and which are complimentary to those being implemented by CAFC and other ratepayers.

1.3 Organization of This Report

Section 2 of this report provides additional information on nutrient enrichment within Desbarats Lake. This includes an overview of how phosphorus gets into lakes, as this is fundamental to the understanding of how it can be controlled. While not being the aim of this report to reproduce the excellent information included in the two background studies already completed on Desbarats Lake, it provides further insight on existing lake water quality as well as on historical/long term trends. Further, it provides additional insight on the lake's watershed characteristics and their relationship to water quality. It also utilizes aspects of Ontario's Lakeshore Capacity Model to explore, in relative terms, just how much of an influence existing cottage development is having on Desbarats Lake. It explores the issue of high phosphorus loadings from the lakes' watershed, and seeks to provide some understanding of the complex reasons for this. It concludes with a summary of the issues facing Desbarats Lake, the opportunities to do something about these, and also the limitations in doing something about these.

Section 3 of this report explores lake management opportunities for Desbarats Lake. This includes some practical advice relating to things that can be done by property owners and/or ratepayer groups in relation to existing camps/cottages, things that can be done by the municipality with respect to future growth, best management practices which are of assistance in minimizing agricultural contributions to phosphorus loads, and things which might be able to be done to better manage other external loads, particularly those relating to wetlands and the large extent of beaver activity within such wetlands.

1.4 Acknowledgements

I would like to thank:

- the Township of Johnson for commissioning this study;
- Lennie Smith, formerly with the Township of Johnson, for taking the time to go through the municipal records with me, and

- the Central Algoma Freshwater Coalition (CAFC), and in particular Hugh Coverley, Edith Orr, Victoria Thomas and Tim Bruder, for taking the time to show me Desbarats Lake and its watershed. I am particularly grateful to Hugh Coverley, who additionally assisted me with sampling as a follow-up to my visit.

This report builds on the very excellent information contained in the two background studies completed by, or on behalf of, CAFC (CAFC 2010; Freshwater Research 2013).

2 NUTRIENT ENRICHMENT IN DESBARATS LAKE

2.1 Overview of How Phosphorus Enters Lake

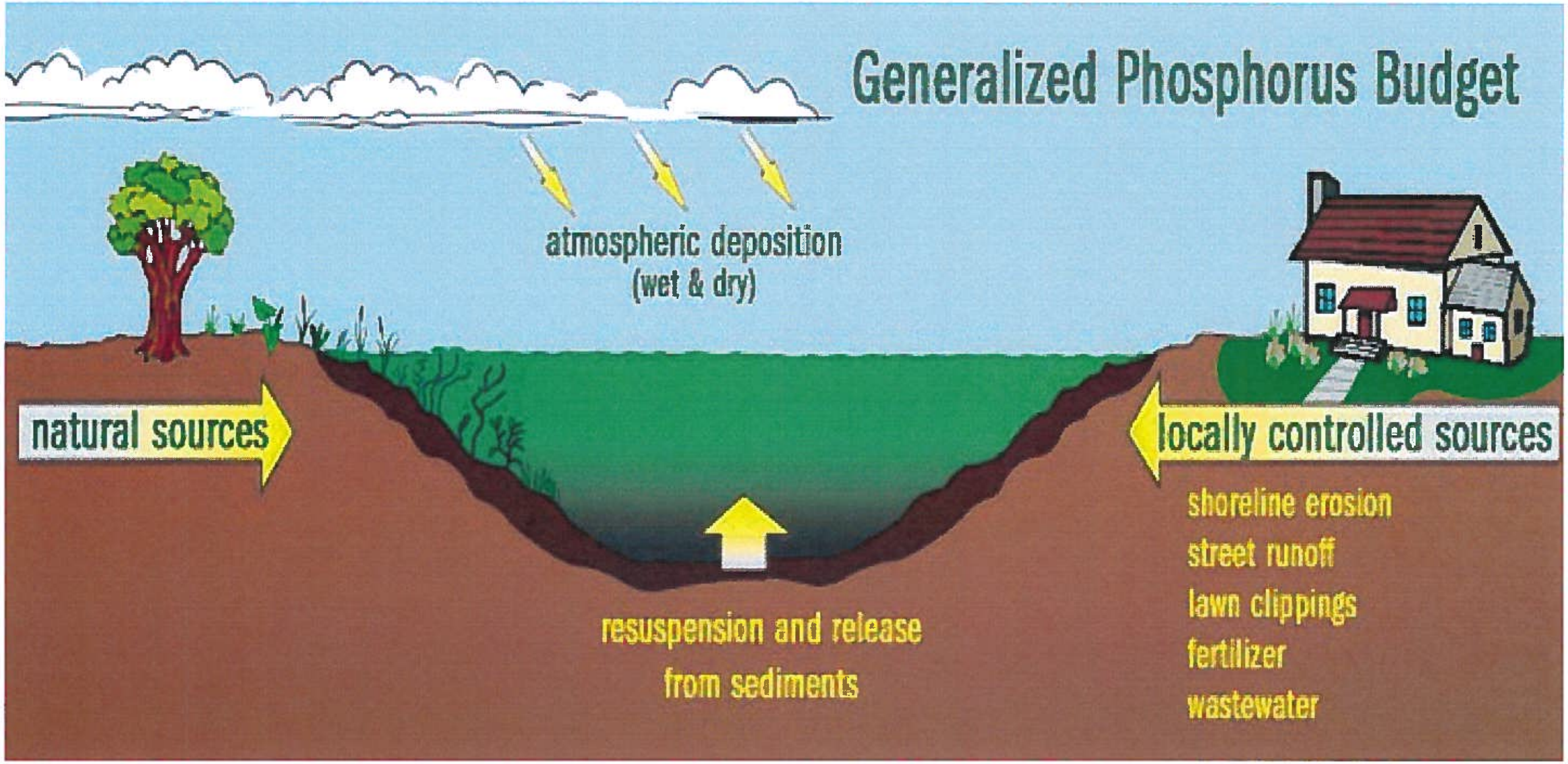
As previously noted, water quality issues in Desbarats Lake all relate to levels of the plant nutrient phosphorus. This naturally occurring element is necessary for the growth of plants and algae. While nitrogen and a number of other micro-nutrients are also required by such plants and algae, most lakes in Ontario are phosphorus limited, which means that it is the addition of phosphorus to the system alone that controls eutrophication; the work completed by Freshwater Research (2013) also indicated that the poor transparency of the lake often controls the amount of algae, with Cyanobacteria blooms linked to periods which followed an increase in light transparency.

Phosphorus is a non-metallic element which occurs in dissolved and particulate, organic and inorganic forms in water. In a chemically combined state (the elemental form is rare) it is virtually non-toxic to aquatic life. It is naturally occurring in soils, and is vital to the growth of any vegetation, including crops, lawns, forests, etc. Hence, its presence within inletting drainage and within the water of a lake is also completely natural. That being said, this element is also present in human and animal wastes, farm and industrial wastewater, and a variety of products, such as soaps and fertilizers that end up in sanitary or storm sewage or runoff.

Additionally, human activities result in increased levels of phosphorus in the airborne particles that settle or fall with precipitation onto lake surfaces. Other human actions, particularly the clearing of forests and vegetation, reduce the ability of the land around lakes to retain phosphorus, resulting in further increases in phosphorus discharges to water.

Figure 3 provides a simple overview of how phosphorus enters a lake. Natural sources include runoff from all lands, including areas of forest and wetlands. Wetlands have quite different characteristics than other elements of the landscape with respect to the timing of phosphorus release, an issue which is explored in more detail later in this report. So too is the issue of beaver influences on wetlands, which can both increase phosphorus export and result in periods of very high loadings during the catastrophic failure of beaver dams. Natural sources also include nutrients contained in wildlife wastes. While natural sources are typically not controllable, the influence of beaver activity within the watershed can be managed.

Atmospheric deposition is not controllable, except in situations where there are adjacent land use activities such as an aggregate operation, which are an ongoing source of dust.



Source: http://www.lakeaccess.org/lakedata/lawnfertilizer/p-diagram.htm

Figure 3. Generalized Phosphorus Cycle

Project Name:	Desbrats Lake
Project Number:	3013
Date:	27.01.2014
Created By:	GN/ KLF
Scale:	Note to Scale

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Sediment release of phosphorus is an issue on many lakes, particularly those which are deeper, have considerable amounts of organic sediment, and which release phosphorus during periods when oxygen levels at the water-sediment interface become very low. This issue was considered in the background report by Freshwater Research (2013), which concluded that such sediments are unlikely a major source of phosphorus to the lake. Regardless, this source is essentially uncontrollable.

As illustrated on **Figure 3**, locally controlled sources of phosphorus include those related to cottages or camps, such as septic systems, shoreline erosion, runoff from lawns and from fertilizer use. They also include agricultural activities within the watershed, including livestock contributions and runoff from agricultural fields. There are management opportunities associated with these various sources.

The most obvious effects of increased levels of phosphorus are more algae and weeds and less clear water. These changes are generally viewed as undesirable, although it should be emphasized that mature aquatic plants are part of a healthy, productive lake system. In coldwater lakes, increased levels of phosphorus can result in reduced habitat for coldwater fish species, however as Desbarats Lake supports a warmwater fishery, this is not of concern (in fact, in warmwater lakes, higher levels of nutrients are generally associated with a more productive fishery, albeit one that can be susceptible to fish kills over the winter). The effects of increased phosphorus loadings are generally not detectable from one year to the next, but if they are permitted to increase unabated, they can be noticed from one decade to the next, and can be very significant over a generation or a lifetime.

2.2 Present Lake Water Quality

CAFC collected a great deal of water quality information for both Desbarats Lake and its inletting watercourses in 2010 and 2011, with some additional data collected in 2012. This organization was very helpful in providing me with the raw data, with a summary of the results relating to phosphorus included in **Table 1**.

For each of the 22 sampling occasions during which inletting watercourses 1-3 were sampled, I have summarized that data, together with the mean phosphorus concentration in the lake (typically of between 7 and 9 samples, collected at different lake locations and depths), and the phosphorus concentration in the lake outlet.

These data show some variation in average lake phosphorus concentrations between years (39 µg/L in 2010; 35 µg/L in 2011; 30 µg/L in 2012), but demonstrate that eutrophic conditions exist in each year.

Table 1. Recent Phosphorus Data for Desbarats Lake.

Date	Inletting Streams			Stream Avg.	Lake Avg.	Outlet
	1	2	3			
May 20, 2010	41	42	36	40	38	39
June 2, 2010	36	29	28	31	32	30
June 14, 2010	110	48	40	66	38	35
June 28, 2010	51	38	60	50	-	41
July 14, 2010	35	42	41	39	40	33
July 27, 2010	33	32	44	36	36	34
Aug 11, 2010	65	40	16	40	38	34
Aug 23, 2010	33	28	23	28	30	29
Sept 7, 2010	94	49	52	65	39	45
Sept 21, 2010	78	47	44	56	41	38
Oct 5, 2010	43	40	39	41	42	38
Nov 3, 2010	52	51	28	44	44	58
Nov 16, 2010	88	35	17	47	52[1]	42
June 29, 2011	40	37	27	35	52[1]	-
July 18, 2011	68	36	44	49	34	28
Aug 8, 2011	39	35	34	36	37	30
Aug 29, 2011	35	28	33	32	36[1]	26
Oct 11, 2011	35	30	21	29	27	29
Oct 26, 2011	48	31	14	31	29	28
Nov 14, 2011	55	27	17	33	32	28
Aug 20, 2012	24	22	18	21	22	23
Sep 5, 2012	76	42	44	54	39	37
Mean (2010)	58	40	36	45	39	38
Mean (2011)	46	32	27	35	35	28
Mean (2012)	50	32	31	38	30	30
Mean (Overall)	54	37	33	41	37	35

[1] one lake sample much higher than remainder; may have contained stirred-up bottom sediments. In each case, removal of the outlier sample would bring value into same range, or lower than, average inlet stream value.

The overall average concentration over the three year period was 37 μg/L, well above a concentration of 20 μg/L which is considered an indication of vulnerability to nuisance algae conditions (MOE 1994), and 30 μg/L, which is indicative of eutrophic conditions.

The average phosphorus concentration from lake sampling on any single day (itself the mean of several samples collected at different locations and depths) showed some variation, ranging from a low of 22 μg/L (still above the threshold to produce nuisance algae conditions) to a high of 52 μg/L. This range in values, while considerable, is less than I might have anticipated based on earlier data collected for the lake, as reported in both the CAFC (2010) and Freshwater Research (2013) background studies.

Phosphorus concentrations during these recent years are at levels where one would anticipate periodic nuisance alga blooms, periods during which algae collects and decays along the shoreline, odour issues, and possible odour and taste issues associated with lake drinking water supplies.

The issue of Cyanobacteria outbreaks is of concern, with several blooms having occurred since at least the early 1990's, and perhaps even as early as the 1960's (Freshwater Research 2013; CAFC 2010). Cyanobacteria, also known as blue-green algae, are of concern because they **can** produce toxins (microcystins and anatoxins). Cyanobacteria blooms can give a lake a bluish-green "pea soup" appearance (MOE 2005). While many forms of Cyanobacteria are relatively harmless, some forms produce toxins which can be harmful to people and animals. Human health effects can include itching, irritated eyes and skin from body contact, and symptoms such as headaches, fever, diarrhea, abdominal pain, nausea and vomiting when ingested (MOE 2005). More serious complications can occur from repeated ingestion of water containing these toxins, or if the toxicity of a particular type of Cyanobacteria was particularly high (MNR 2004). However, it should be stressed that Cyanobacteria is a normal component of the algae of lakes, and that many forms of this algae do not produce toxins. To this end, testing has been undertaken by CAFC to determine if toxins were present during previous blooms of Cyanobacteria within Desbarats Lake. Based on my review of CAFC's 2010 background report, levels of such toxins were below the laboratory detection limits during algae blooms in 2007 and 2009. It is my understanding that such sampling has been ongoing, with no measureable amounts of toxins identified to date.

2.3 Insights into Long-term Water Quality Trends

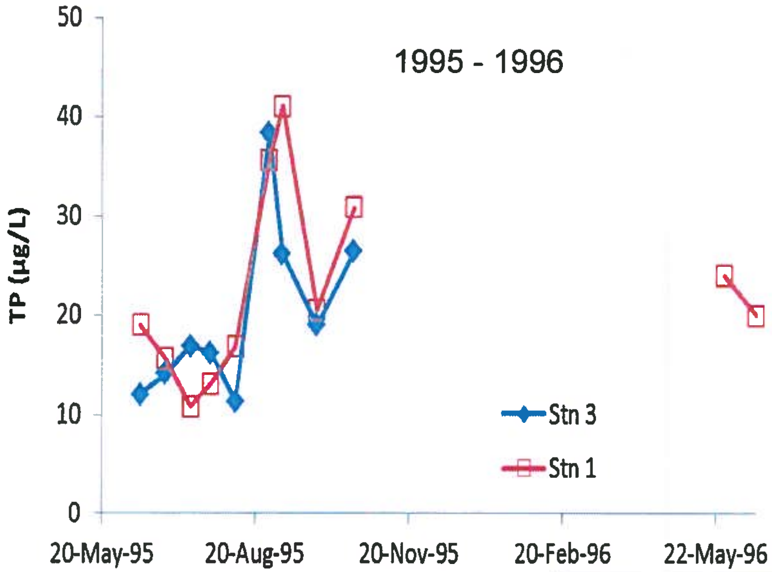
CAFC (2010) indicates that development on Desbarats Lake began in the 1960's, when the first cottages were built along the southernmost shoreline of the lake, and along the boat access subdivision in the north corner (cottages only accessible by boat). More cottages were built in the early 1980's, at the southern end of the lake and within the Puddingstone subdivision (CAFC 2010). More recently, land development has occurred within the eastern portion of the lake.

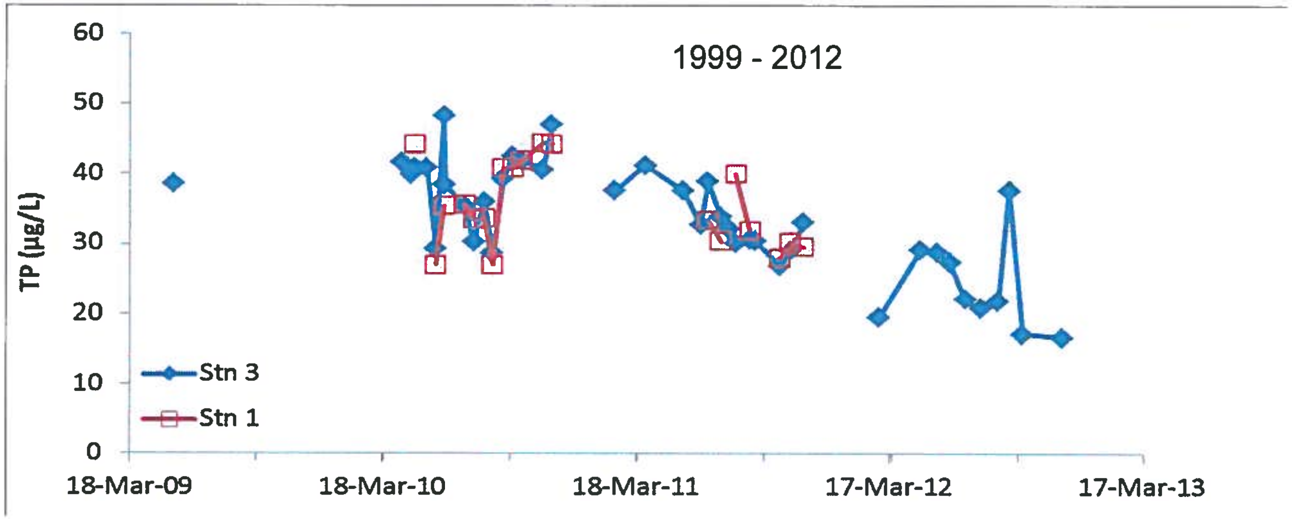
The CAFC (2010) report further indicates that the lake began to show warning signs of algal growth in 1968. The first recorded Cyanobacteria blooms were in 1994, and again in late 1995, and apparently have been a continuous problem every 2 to 5 years since.

There is a small amount of more historic water quality sampling from Desbarats Lake, dating back to 1995. Unfortunately, this data was limited to 1995 and 1996 periods, with no further sampling until 2009. **Figure 4** provides graphical data comparing that from the 1995-1996 period with that for the 2009-2012 period, as summarized in Freshwater Research's (2013) background document. The 1995 to 1996 data shows phosphorus levels of between approximately 10 µg/L and 40 µg/L, with the average concentration being well in excess of 20 µg/L. While this is somewhat lower than the average value observed between 2009 and 2012, it is not dramatically lower, particularly in comparison with the 2012 data reported by Freshwater Research (2013).

Some additional insight on long term water quality trends can be seen in the Secchi disk transparency data collected between 1995 and 2012. Those data were summarized graphically within Freshwater Research's (2013) report, and are included as **Figure 5** to this report. A Secchi disk is simply a disk with alternating white and black quadrants which is lowered into the water table to measure light transparency. The results shown in **Figure 5** show considerable year-to-year and within-year variations. While relatively high light transparencies were recorded over portions of 1995, and very low light transparencies were recorded in both 2010 and 2011, results in 1996 and 2012 were reasonably comparable, making it difficult to know if there are really any longer term trends.

Unfortunately, as is the case in most lakes, the long term data base is insufficient to really establish whether the water quality in Desbarats Lake has been declining over the years. However, that concerns regarding algae were apparently first recognized in 1968, during the period of initial cottage development on the lake, is suggestive that problems have occurred for many years, and may well have occurred, but





Source: Water Quality and Remediation of Desbarats Lake - Freshwater Research May 2013

Figure 4. Graphical Phosphorus Data from Desbarats Lake
From 1995 - 1996 and 2009 - 2013

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Scale:	Note to Scale

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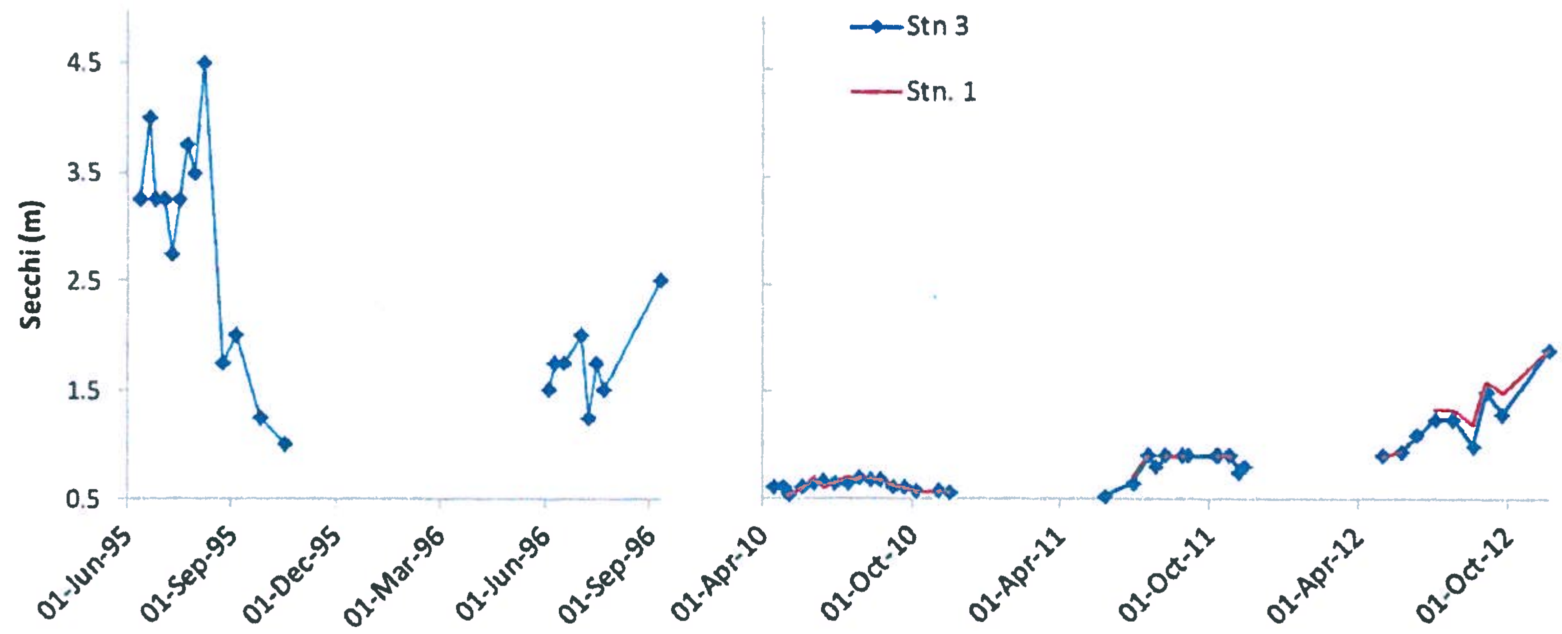

Source: Water Quality and Remediation of Desbarats Lake - Freshwater Research May 2013

Figure 5. Graphical Secchi Disk Data from Desbarats Lake
From 2010 - 2013

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Scale:	Note to Scale

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gone unnoticed, prior to there being any development. The additional analysis which is included in **Section 2.4 Shoreline Development, and its Relationship to Lake Water Quality**, strongly suggests that cottage development, while having some influence on lake water quality, is not a primary cause, with the additional information included in **Section 2.6 Lake Watershed Characteristics and their Relationship to Lake Water Quality**, pointing towards natural conditions within the watershed as the primary cause. Accordingly, it would appear that nutrient enrichment has long been an issue in Desbarats Lake, despite the lack of good long-term water quality information to firmly support this hypothesis.

A further issue affecting the interpretation of what little long-term data there is, or indeed of individual cottagers' recollection of past water quality issues, is that considerable year-to-year and within-year variations in phosphorus levels, light transparency, and incidents of algae blooms can be expected. That is because water quality from external sources can be greatly influenced by climate, as well as by the number and condition of beaver dams within the watershed. For example, during a drier season, a watershed that is substantially influenced by wetlands, such as that of Desbarats Lake, will attenuate much of the phosphorus in runoff within these wetlands. However, a large summer rain may result in significant flushing of wetlands, and even the catastrophic failure of beaver dams, resulting in a large pulse of phosphorus to the lake. Algal blooms are also very dependent on the vagaries of weather, as conditions need to be created where a species of algae can suddenly outcompete with other species; such conditions may occur in response to sudden temperature changes, an increase in water clarity, or a pulse of higher phosphorus concentrations entering the lake.

2.4 Shoreline Development and its Relationship to Lake Water Quality

My initial assessment of existing water quality data for Desbarats Lake, based on a review of the information in the two background studies (CAFC 2010; Freshwater Research 2012), was that while cottage development was a contributing factor to phosphorus loads in Desbarats Lake, it could not explain the poor water quality conditions in the lake. This hypothesis gained further credibility on my examination of the lake, and the relatively low intensity of shoreline development. Since that time, I have had the opportunity to validate my initial impressions in two different ways: first, I have looked at all of the detailed water quality results obtained by CAFC during the 2010-2012 period; secondly, I have used Ontario's Lakeshore Capacity Model to assess the potential contributions of cottage development to existing water quality. My comments in relation to both of these assessments are provided in the paragraphs following.

1. Review of Detailed Water Quality Data

The previously described data collected by CAFC and summarized in **Table 1** includes information for each of the three well-defined inletting watercourses, as well as for the lake outlet. Although there is no information on flows within the different inletting streams, which would permit a mass balance, a simple arithmetic mean of the phosphorus concentrations in these three streams provides a ballpark estimate of the average phosphorus concentration in inletting waters at any given time (see **Table 1** for the average stream value).

If there were significant contributions of phosphorus to the lake from shoreline development, or from internal loadings from sediment, one would anticipate that the concentration of phosphorus in both the lake and the lake outlet would be moderately higher than the average inletting concentration on a fairly frequent basis. In other words, the concentrations of phosphorus in inletting streams would not be able to fully explain phosphorus concentrations in the lake or lake outlet. However, this is not the case. As can be seen in **Table 1**, there were only three instances when average phosphorus concentrations in the lake were elevated by more than 2 µg/L above the average concentration in the inletting stream, but in each of these cases there was an anomalous sample from the lake, possibly the result of the sample containing stirred–up bottom sediments. There was only a single instance when phosphorus concentrations in the lake outlet exceeded the average concentration in the inletting streams by more than 2 µg/L. In the majority of circumstances, the average phosphorus concentration in the inletting streams was very close to or higher than the average concentration within the lake and within the lake outflow. In all three years, the mean value in the inletting streams was as high or higher than that for the lake or lake outlet. When the data is examined as a whole, inletting concentrations are 11% higher than those in the lake and 17% higher than those in the lake outlet.

This analysis is, admittedly, an oversimplification of how the lake behaves. In this regard, there is likely some dilution of phosphorus entering the lake from cleaner groundwater, and some loss of inletting phosphorus through sedimentation of both soil particles and organic matter. However it provides a good indication that neither cottage loadings nor internal loadings are a substantial cause of the eutrophic conditions seen in Desbarats Lake.

2. **Use of Lakeshore Capacity Model to Estimate Loadings From Cottages**

I have used the Lakeshore Capacity Model to determine just how much of the existing phosphorus concentration in Desbarats Lake can be explained by existing cottage development. After completing that exercise, I went one step further to look at the potential implications of development of the remaining existing lots of record on lake water quality.

In each case, this is a relatively straightforward exercise. The Lakeshore Capacity Model provides guidance on determining how much water will flow through Desbarats Lake on an annual basis, based on lake area, watershed area, annual precipitation quantity, the amount of runoff to the watershed that is lost to evapotranspiration, and the amount of direct precipitation to the lake that is lost to evaporation. In fact, this portion of the exercise has already been completed in the work completed by Freshwater Research (2013).

From that information:

Lake volume	=	$23.93 \times 10^6\ m^3$
Annual flushing rate	=	2.45 times per year
Annual flow through lake	=	$58.63 \times 10^6\ m^3/yr$

Note that there may be small changes to these values based on newer measurements of lake and watershed area, however as those differences are small, and as such changes would not substantially alter the subsequent analysis, we have used the values from the Freshwater Research (2013) report.

With that information in hand, we can then use the model to calculate existing and potential future phosphorus loadings from cottages. In this regard, the foundation of the Lakeshore Capacity Model is its ability to predict phosphorus from new development, based primarily on sewage contributions, but to a lesser extent also on the potential additional supply of phosphorus from runoff over developed cottage properties. For sewage, it does so by looking at typical occupancy rates of cottages and the average amount of phosphorus in sewage produced per capita year; each of these values have been validated from the Ministry of the Environment's ongoing research, and are updated from time to time. For overland runoff, it provides a standardized quantity of additional phosphorus expected in runoff from a developed lot, in relation to that from a forested environment.

The important coefficients from the Lakeshore Capacity Model which are key to the present assessment are as follows:

Cottage type	Usage rate (capita yrs/yr)
Seasonal	0.69
Extended seasonal	1.27
Permanent	2.56

Note: seasonal is employed where there is no winter road access.

P contribution from cottage septics:	0.66 kg P/capita/yr
Increased P contribution from runoff over a cottage lot:	0.04 kg P/lot
P contribution from youth camp:	0.125 kgP/camper/yr

Existing Contribution from Cottages:

The number of existing cottages needs to be determined, with background information and my own review summarized as follows:

- Freshwater Research (2013)suggests 65 cottages;
- CAFC (2010) also suggests 65 cottages, and describes majority as seasonal;
- discussions with lake residents suggest approximately 10 of the cottages are now permanent homes;
- my review of Township mapping, with the former Township Clerk, indicated 54 previously developed lots, one which is presently under development, and a total of 12 lots which have not been developed; many of these undeveloped lots are very small, and may not meet present day requirements for establishment of a sewage disposal system and/or have adequate room to site a cottage and septic system 30 m or more from the lake;
- 8 of the vacant lots are on Puddingstone Road; the other four are located along Desbarats Lake Road;
- my shoreline review of the lake suggests that 55 developed lots is quite accurate, with one of these developed as a small youth camp – approximately 20 campers maximum.

Based on the above, and making some assumptions on present usage of the approximately 55 lots which are developed, P contributions are calculated as follows:

Unit Type			
1. 1 Youth Camp	20 youths x 125 g P per year	=	2.50 kg P/yr
2. 10 permanently occupied cottages/homes Each contribute	2.56 capita yrs/yr x 0.66 kg P/capita/yr = 1.690 kg P/yr x 10 cottages	=	16.90 kg P/yr
3. 10 seasonal cottages (there are several cottages accessed off of Pollard Drive through small laneways; these have a very seasonal appearance) Each contribute	0.69 capita yrs/yr x 0.66 kg P/capita/yr = 0.455 kg P/yr x 10 cottages	=	4.55 kg P/yr
4. 34 extended seasonal cottages Each contribute	1.27 capita yrs/yr x 0.66 kg P/capita/yr = 0.838 kg P/yr x 34 cottages	=	28.49 kg P/yr

Plus, each of these 55 lots is deemed to contribute 0.04 kg P/yr from overland runoff, above what would constitute natural runoff from the landscape.

	55 x 0.04 kg P/yr	=	2.2 kg P/yr
Total P contributions from existing development		=	**54.64 kg P/yr**

The influence of this annual P load influence on water quality can be quite easily calculated, by dividing the annual load by the annual quantity of water moving through the lake, as follows:

$$\frac{54.64 \times 10^6 \text{ mg P/yr}}{58.63 \times 10^6 \text{ m}^3\text{/yr of flow through lake}}$$

= a contribution of 0.93 mg/m^3 or **0.93 µg/L P** over natural background (as additionally influenced by other land uses occurring through broader watershed).

Note that this modeled contribution from existing cottages of 0.93 µg/L to lake phosphorus concentrations accounts for only 2.5% of the existing phosphorus concentration in the lake (based on the 2010 to 2012 average value of 37 µg/L). This is based on 100% of P from sewage disposal systems getting into the lake, plus a small overland runoff contribution from each developed cottage lot. It does not account for additional P getting into the lake from land clearing/disturbance during cottage development, but there was no evidence of substantial concerns in relation to this. While it is possible that I have missed a small number of existing cottage lots in performing these calculations, this would have only very minor influence on the analysis.

Potential Contribution of New Cottages

While modeling of the additional potential influence of developing the existing cottage lots on the lake is more pertinent to the information included in Section 3 of this report, I provide this analysis in the paragraphs below, as it is easier to follow in the context of the calculations above.

I will examine a worst case scenario, where all 12 existing lots of record are deemed appropriate for development. Of these 12 lots, I will assume six are developed into permanently occupied cottages and six are developed into extended seasonal cottages **without** any phosphorus abatement measures. In accordance with that scenario, additional phosphorus contributions would be calculated as follows:

6 new permanently occupied cottages/homes

6 x 1.690 kg P/yr	=	10.14 kg P/yr

6 extended seasonal cottages

6 x 0.838 kg P/yr	=	5.03 kg P/yr

Plus, each of these 12 new lots would be calculated to contribute an additional 0.04 kg P/yr from overland runoff over what would constitute natural runoff from the landscape

12 x 0.04 kg P/yr	=	0.48 kg P/yr
Total Potential new P Contributions (without any P abatement)	=	**15.65 kg P/yr**

How would this maximum potential new P load influence water quality on an annualized basis?:

$\frac{15.65 \times 10^6 \text{ mg P/yr}}{58.63 \times 10^6 \text{ m}^3\text{/yr of flow through lake}}$

= an additional potential contribution of 0.27 mg/m^3 or **0.27 µg/L P** over existing conditions.

In this scenario, all new and existing cottage development around the lake would contribute a maximum of 0.93 µg/L + 0.27 µg/L

= **1.2 µg/L P** over natural background (as additionally influenced by other land uses occurring through broader watershed). This would have very little influence on existing water quality conditions.

Keep in mind that this analysis is based on a scenario where all 12 lots are developed, with six of these as permanent homes, a situation which is not likely realistic. Further, it does not include any phosphorus abatement, which, as further detailed in **Section 3.3**, is being recommended for new lot development. **Regardless, such a development scenario would only increase those P contributions specifically associated with cottage development on this lake by 29%, and would only increase the existing P concentration in Desbarats Lake by less than 1%.** Accordingly, in my opinion, development of existing lots of record, particularly if this is undertaken with appropriate best management practices, together with the implementation of phosphorus abatement measures for new sewage disposal systems, poses very little risk to lake water quality.

Summary Comments on Additional Lake Water Quality Assessment Work

This additional work has been very useful in demonstrating that cottage development on Desbarats Lake is minimally responsible for existing water quality conditions, and that the development of additional lots of record poses very little risk. However, cottage development does remain a source of nutrients, and it is not the purpose of this assessment to dismiss the importance of ensuring that the development of any existing lots of record is undertaken with considerable care, or to suggest the municipality and other stakeholders should not be looking for opportunities to improve the relationship of existing cottage development to water quality whenever it receives an application for major redevelopment.

2.5 Lake Sediments, and their Relationship to Water Quality

As previously noted, the work conducted by Freshwater Research (2013) included an examination of the potential for internal phosphorus loads to Desbarats Lake. This can occur in two different ways; first, through wave or wind induced mixing of bottom sediments, although a majority of the phosphorus in such sediments may not be available for uptake by algae; and second, through the release of phosphorus which is bonded to sediment soil particles, which can occur during periods of low oxygen levels (typically, phosphorus adsorbed to iron hydroxide are released as a consequence of redox changes during periods of extended hypoxia at the water-sediment interface). Freshwater Research (2013) recognizes in their report that determining the amount of phosphorus release from sediments can be very difficult to determine. However, important to assessing this potential, the morphological characteristics of Desbarats Lake, in combination with a series of dissolved oxygen profiles that were obtained over the growing season, indicate that this lake does not normally undergo periods of sustained hypoxia at the water-sediment interface. Further, testing of bottom sediments from the lake was undertaken by Freshwater Research (2013), and showed relatively low levels of both organic material and phosphorus (organic content of 8-12%; total phosphorus of less than 0.7 mg/g dry weight, and phosphorus that was associated with iron hydroxide of less than 0.1 mg/g). Drs. Nürenburg and Lazerte of Freshwater Research noted that the composition of these sediments were more consistent with fast flushed reservoirs than for typical tea-stained lakes, and hypothesized that this could be due to persistent bottom scouring within this relatively fast flushed lake. While this work does not indicate that there is no internal phosphorus loading, it does strongly indicate that this is not a major source of phosphorus to the lake (once again, the very high levels of phosphorus in inletting streams corroborates that this must be the case). However, there is the potential (i.e., during a particularly dry, hot summer, and when winds are very light) for more extended periods of hypoxia to occur at the water-sediment interface, during when internal loadings of phosphorus may be somewhat more of a factor.

2.6 Atmospheric Deposition, and its Relationship to Lake Water Quality

As illustrated in **Figure 3**, atmospheric deposition is a contributing source of phosphorus to lakes. The Lakeshore Capacity Model uses a value of 16.7 $mg/m^2/yr$ for atmospheric deposition, which has been calculated as the 17-year mean for three meterological stations in Ontario (Puttnam *et al* 2006). This value is equivalent to 0.167 kg/ha/yr. Unless there were significant local sources of persistent dust, which there are not, this is a reasonable value to use in estimating the influence of atmospheric deposition on phosphorus loads and concentrations in Desbarats Lake.

The value for atmospheric deposition considers precipitation which falls directly on the lake surface, not that which falls over the remainder of the watershed. While there is indeed atmospheric deposition of phosphorus over the remainder of the watershed, much of this is attenuated where it falls and its influence is otherwise considered in determining that portion of phosphorus load which enters a lake from overland runoff/groundwater/watershed contributions.

With a lake area of 3.99 km^2, or 399 ha, the annual load of phosphorus from atmospheric deposition is calculated as:

0.167 kgP/ha/yr x 399 ha = 66.6 kgP/yr

This load is not insignificant, and in fact is slightly higher than that calculated from all existing cottages development on the lake.

The influence of this annual P load on water quality can be easily calculated, by dividing the annual load by the annual quantity of water moving through the lake, as follows:

$$\frac{66.6 \times 10^6 \text{ mg P/yr}}{58.63 \times 10^6 \text{ m}^3\text{/yr of flow through lake}}$$

= a contribution of 1.14 mg/ m^3 or 1.14 μg/L P over other contributions.

Based on an overall mean phosphorus concentration in Desbarats Lake of 37 μg/L from sampling conducted between 2010 and 2012, atmospheric deposition is calculated to be responsible for 3.1% of phosphorus in the lake. While not insignificant, this does not substantially explain the lake's phosphorus levels.

2.7 Lake Watershed Characteristics, and their Relationship to Lake Water Quality

If lake water quality cannot be substantially explained by adjacent shoreline development, internal loadings from sediments, or atmospheric deposition, then it can only be explained by watershed contributions. As a brief recap, approximately 2.5% of phosphorus contributions to Desbarats Lake can be explained by existing shoreline development, whereas 3.1% can be explained by atmospheric deposition. Internal loadings cannot be calculated, but are considered to be low based on the work of Freshwater Research (2013). That leaves 94.4% (minus the assumed minor contribution of sediment re-suspension and/or phosphorus release under anoxic conditions) which must come from the watershed. This equates to 34.9 μg/L of the average 37 μg/L phosphorus concentration within the lake. As an annual load, it represents:

$34.9 \text{ mgP/m}^3 \times 58.63 \times 10^6 \text{ m}^3\text{/yr}$ of flow through the lake

$= \quad 2{,}048 \times 10^6 \text{ mgP/yr}$

$= \quad 2{,}048 \text{ kgP/yr}$

Based on an external watershed area of approximately 26.9 km^2 (2,690 ha), the average amount of phosphorus that is being exported from the watershed on an annual basis (not discounting for whatever contributions relate to internal load) are:

$$\frac{2048 \text{ kg P/yr}}{2{,}690 \text{ ha}} = 0.761 \text{ kg/ha/yr}$$

This value, is very, very high, but proof of it is borne out by the very high average concentrations in phosphorus within the three inletting streams to the lake. The question is why are these watershed contributions so high, which is also a question which arises on review of both of the earlier background studies on Desbarats Lake (CAFC 2010, Freshwater Research 2013).

To put the watershed export values of approximately 0.761 kg/ha/yr into context, we have looked at other export values which have been calculated, and which have been used in other modeling applications, for other jurisdictions. In this regard, requirements under the *Lake Simcoe Protection Act* relating to new development have resulted in the calculation of phosphorus export coefficients specific to that watershed, and comparison of those calculated values with export values determined in other jurisdictions. Average export coefficients for the Lake Simcoe Watershed are included in a recently developed phosphorus budget tool (Hutchinson Environmental Services *et al* 2012, with values derived from Burger 2010). These are provided as follows:

Land use type	Phosphorus Export (kg/ha/yr)
Forest	0.075
Wetland	0.064
Pasture	0.147
Cropland	0.341
Low intensity residential	0.095
High intensity residential	0.525

How is it then that the average phosphorus export value (0.76 kg/ha/yr) from a relatively pristine watershed is substantially higher than export values typically associated with forests and wetlands, or pasture and cropland, or for that matter even high intensity residential uses? This is something of a paradox, and while outside of the scope of my intended work plan, it is something I have put a considerable amount of effort towards trying to better understand. Watershed observations are unambiguous in demonstrating very modest and non-intensive agricultural uses, no recent land clearing or forestry activities, and no other human related sources. Further, the watershed sampling conducted between 2010 and 2012 (**Table 1**) demonstrates that, while inletting stream 1 has the highest average phosphorus concentration, contributions from the other tributaries are also very considerable, indicating that this is more a systemic watershed issue, not one which can be attributed to just portions of the watershed.

To explore this issue further, I had Mr. Hugh Crawley, a local resident and member of CAFC, collect three soil samples from the Inletting Stream 1 subwatershed for me, in accordance with instructions I provided him. I chose to sample Inletting Stream 1 because this subwatershed has the highest average contribution of phosphorus (see **Table 1**; 2010-2012 mean value of 54 µg/L, versus 37 µg/L for Inletting Stream 2 and 33 µg/L for Inletting Stream 3). The first two soil samples were collected from areas immediately within the floodplain, within areas which are routinely subject to beaver-flooding and seasonally elevated water levels. The third came from a woodland area adjacent to the stream. I then collected a fourth reference sample from the Lake Muskoka watershed, from the floodplain of a similarly sized stream. These samples were submitted to a laboratory for two types of testing: (1) measurement of total phosphorus in the soil; and (2) a leaching test, whereby soil was agitated in distilled water for one hour, with the leachate then filtered through a very fine filter, then sampled for phosphorus. The second part of this methodology, involving the measurement of phosphorus in a filtered sample, is the same protocol as used to measure orthophosphorus in water; as in the case of sampling for that parameter in water samples, 100% of the soluble phosphorus remaining upon filtration is deemed to be orthophosphorus[1].

Results of this testing are provided in **Table 2**, and are very surprising. I had anticipated that these soils might contain very large amounts of phosphorus, perhaps owing to the presence of phosphate minerals in the subwatershed, but that is not the case. To the contrary, the total amount of phosphorus was reasonably low in comparison with the reference sample I obtained from the Lake Muskoka watershed, as well as with published literature values. However, the proportion of the phosphorus appearing as soluble reactive phosphorus (orthophosphorus) in these samples was extremely high, being between 17.2% and 57.8% of total phosphorus, in comparison to only 0.5% within the Lake Muskoka watershed sample, and similarly typically low percentages reported in the literature.

On receipt of these results, I anticipated mineralization of these soils must be quite unique, and in particular the amounts of aluminum and iron in the soils must be low. In this regard, phosphorus in soils generally forms tight bonds with calcium under alkaline conditions, and with aluminum and iron under acidic conditions. The binding of phosphorus to these minerals generally results in the majority of phosphorus that is present being tightly bound in soils and insoluble; it is neither readily available for plant uptake or easily leached from soils into watercourses and lakes. I therefore asked the lab to conduct some additional testing of these soils, to determine the amount of calcium, iron, aluminum and manganese, as well as to determine soil pH.

Results of this additional testing are provided in **Table 2**, and are equally surprising. Calcium concentrations are reasonably high, typically about twice those in the Lake Muskoka watershed reference samples. Iron and aluminum concentrations are very high, averaging 3.7 times and 5.6 times those in the Lake Muskoka watershed reference sample, which are quite high in themselves. This only adds to the mystery; how can soils which one would expect to be able to very tightly bind phosphorus not be able to do so? This question is one for which I do not have a definitive answer, and which would require much more soil research.

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1 In accordance with the **US EPA Monitoring and Assessment Protocols – 5.6 Phosphorus** (2012), "the term 'orthophosphate' is a chemistry-based term that refers to the phosphate molecule all by itself. 'Reactive phosphorus' is a corresponding method-based term that describes what you are actually measuring when you perform the test for orthophosphate. Because the lab procedure isn't quite perfect, you get mostly orthophosphate but you also get a small fraction of some other forms."

Table 2. Phosphorus Concentrations in Soils and Soil Leachate.

Sample location	Sample description	Total phosphorus (mg/kg)[1]	Orthophosphorus leached from sample (mg/kg)[1]	Proportion of Phosphorus as leachable Orthophosphorus	Calcium (mg/kg)[1]	Iron (mg/kg)[1]	Aluminum (mg/kg)[1]	Manganese (mg/kg)[1]	pH
Desbarats Lake 1	Inletting Stream 1 subwatershed – floodplain	315	182	57.8%	7,800	34,400	30,800	464	6.84
Desbarats Lake 2	Inletting Stream 1 subwatershed – floodplain	330	60	18.2%	8,200	38,800	35,200	548	6.48
Desbarats Lake 3	Inletting Stream 1 subwatershed – adjacent to floodplain	406	70	17.2%	6,500	33,000	24,200	904	6.13
Lake Muskoka 1	Floodplain of similarly sized stream	509	2.6	0.5%	3,800	9,600	5,400	144	4.99

[1] reported concentrations, including those for the leachate tests, are based on dry weight of soil.

I did consult with limnology, soil geochemistry and surface water specialist colleagues (Michael Michalski of Michalski Nielsen Associates Limited, Dr. Will Robertson, University of Waterloo, Ted Belayneh, Myron Zurawsky and Victor Castro, Ministry of the Environment), and conducted limited additional research, and on that basis can offer the following additional comments on this matter:

- the pH of soil samples from the Desbarats Lake watershed were only slightly acidic, with the two samples from locations that were most influenced by beaver flooding being closest to neutral. This is in sharp contrast to the soils from the Lake Muskoka watershed, which are quite characteristic of soils from much of the Precambrian Shield in being very acidic. The soils literature I have reviewed points towards there being a very strong relationship between soil pH and the complexation of phosphorus with other minerals. **Figure 6** illustrates this phenomenon. This graphic shows that in more acidic soils, phosphorus creates very strong complexes with aluminum, and with increasing acidity, iron, and that at a basic pH, it forms moderately strong complexes with calcium. Between a pH of approximately 6.1 and 7.2, the complexation of phosphorus with iron, aluminum and calcium all appear quite weak, with particularly weak complexation with any minerals between a pH of approximately 6.5 and 6.9. While this graphic oversimplifies a great deal of complex geochemistry, it is very noteworthy that the Desbarats Lake 1 sample, in which 57.8% of the phosphorus was determined to be leachable orthophosphorus, had a pH of 6.84, precisely within the range where this graphic would suggest particularly weak complexation, and that the other two samples, in which the percentage of phosphorus as leachable orthophosphorus ranged from 17.2% to 18.2%, had pH values in which complexation would be anticipated to be quite weak;

- on the basis of the above, and on the limited soil sampling conducted within the Desbarats Lake watershed, it appears that soils are naturally very vulnerable to releasing phosphorus in a form that is readily available as a nutrient to algae within Desbarats Lake;

- Dr. Will Robertson cautioned me that there is a potential for reducing conditions to be created during sample transit and storage, if the soils in that sample are wet; under such reducing conditions, some of the phosphorus which is complexed may break its bonds with and/or adsorption to soil minerals. Accordingly, the percentage of phosphorus in these soils being measured as orthophosphorus may be artificially high based on sampling methodology. This cannot be discounted, as the soils that were collected were somewhat damp (although not what I would consider wet), and were in transport for a few days before being analyzed by the

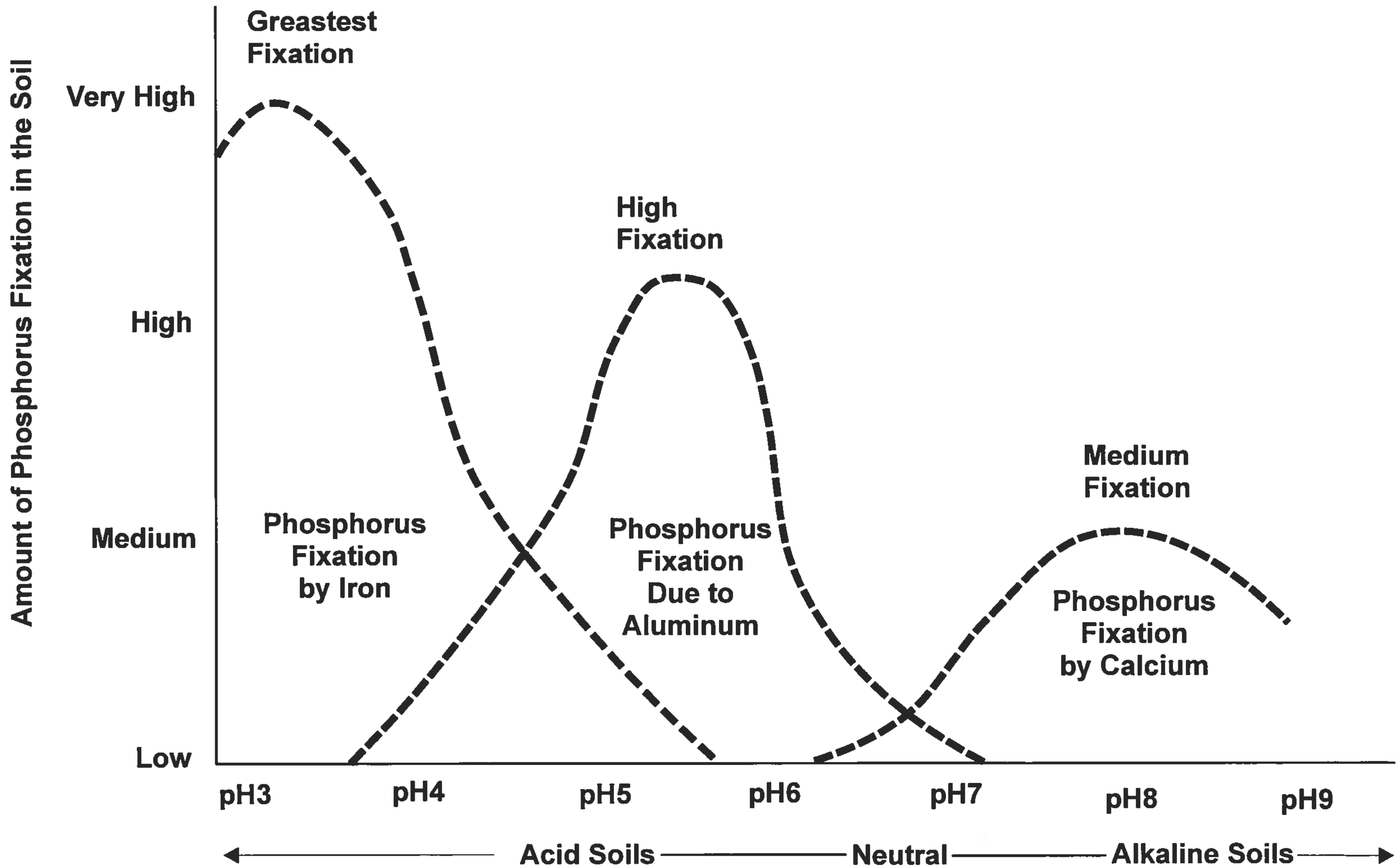

Figure 6. Phosphorus availability across pH ranges.
(Havlin et al. 1999, as cited in Department of United States Department of Agriculutre)

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laboratory. However, so too was the sample collected within the Lake Muskoka watershed. This potential technical issue in sampling is one which highlights another phenomenon occurring in the Desbarats Lake watershed, which is the extent of wetland habitat, including that influenced by beaver activity, and the role that the associated flooding has in creating reducing conditions in soils;

- wetlands are a dominant part of the Desbarats Lake watershed. From a phosphorus management perspective, naturally occurring wetlands are generally advantageous. These are highly productive environments; during the late spring and summer, they allow for abundant plant and algae growth, providing for temporary storage of phosphorus. Most naturally occurring wetlands which are situated along watercourses act as sediment traps for water flowing into them, by encouraging sedimentation (as water slows down, soil particles carried in suspension can settle out), and by filtering flows through often dense vegetation. Accordingly, these help to hold phosphorus during the growing season, and prevent such phosphorus from entering Desbarats Lake where it would otherwise fuel the growth of algae;

- there are some limitations to the phosphorus storage function of naturally occurring wetlands. First, wetlands release the majority of stored phosphorus as plant material decays in the late fall, winter and early spring; however the timing of this release is still of benefit to Desbarats Lake, as the relatively rapid flushing rate of this lake ensures most of that phosphorus has moved through the lake before warming water temperatures in the early summer are more conducive to abundant algae growth. Second, wetlands can create a reducing environment, and as a consequence their underlying soils can be vulnerable to phosphorus release; however, wetlands which have been in place for thousands of years as relatively static features in the environment are not apt to have much phosphorus which can still be leached from their underlying soils. Thirdly, large summer rain events can have some influence on the export of phosphorus from wetlands, particularly that portion of phosphorus associated with suspended solids which have been detained through settlement or filtration;

- wetlands which have been created and/or modified by beaver activity are entirely different with respect to their role in phosphorus management from those which I have referred to as naturally occurring wetlands above (I realize this distinction is somewhat artificial, as beaver activity is indeed a natural component of such landscapes). Firstly, the activity of beavers results in the flooding of lands, often of quite considerable acreage, which were once dry. That process affects the geochemistry of soils, including through the possible creation of reducing conditions which promote the release of phosphorus. As the earlier described soil chemistry information for the Desbarats Lake watershed shows, the large pool of readily available phosphorus in soils (whether this requires reducing conditions or not) is very vulnerable to release when soils which were not flooded become subject to more sustained periods of flooding. Secondly, while beaver ponds can, like other wetlands, promote sedimentation and the temporary storage of phosphorus, they are much more vulnerable than naturally occurring wetlands to the release of this phosphorus during large runoff events. This is particularly true when there is a catastrophic failure of a beaver dam during a large spring, summer or fall rain, as has quite routinely occurred within this watershed (as the earlier referenced **Photographs 19** and **20** illustrate). On watersheds with many beaver dams, the failure of one dam often has a "domino effect", with a number of downstream dams failing as a large pulse of water moves down a watercourse following the original failure of a dam;

- while there remains many unanswered questions about soil geochemistry within the Desbarats Lake watershed, and its inherent vulnerability to allowing phosphorus to be released into the watercourses draining to this lake, the information strongly suggest that beaver activity plays a substantial role in this process. As beaver dams become larger, and as more and more land becomes flooded by consequence (and these beaver dams become increasingly vulnerable to catastrophic failure), the problem becomes magnified. In my review of the soil chemistry data with Dr. Will Robertson, a geochemist with the University of Waterloo, he noted that beaver dams appear to be a substantial factor influencing the release of phosphorus from soils within other lake watersheds experiencing some similar problems to Desbarats Lake. While the soil conditions of the Desbarats Lake watershed are not within anyone's control, and the same can be said about naturally occurring wetlands, beaver activity is controllable, at least to a substantial extent.

3 LAKE MANAGEMENT OPPORTUNITIES FOR DESBARATS LAKE

3.1 A Summary of Issues, Opportunities and Limitations

The review in this report of water and soil chemistry information from Desbarats Lake and its watershed shows this issue of phosphorus enrichment to be one of considerable complexity, one for which we don't have all of the answers (and even with considerable more research, would still have many unanswered questions). However, the following are reasonable conclusions on the basis of the information we do have:

- Desbarats Lake is a highly enriched eutrophic lake, which is vulnerable to poor water clarity, algae blooms, and also the aesthetic and nuisance issues associated with such eutrophic conditions;

- existing development on the shoreline of Desbarats Lake is a factor influencing phosphorus concentrations, but is not a substantial reason for it;

- agricultural activities within the watershed play a very minor role in influencing phosphorus levels, and there are no concerns that a resumption of more agricultural activities will substantially change this;

- there is no evidence of recent forestry activities, or other human-influenced conditions, within the lake's watershed which may be negatively impacting water quality;

- the limited soil chemistry information obtained within the lake watershed points to a very considerable vulnerability to natural phosphorus release from soils, and provides a better understanding that water quality conditions within Desbarats Lake are substantially a naturally occurring condition; and

- the extensive amount of beaver activity within the watershed appears to play a role, and perhaps a very major role, in the release of phosphorus from the Desbarats Lake watershed and, by association, on the water quality conditions within that lake.

In accordance with the above, and as at least partially corroborated by the information contained in the earlier background reports on Desbarats Lake (Freshwater Research 2013; CAFC 2010), Desbarats Lake has likely always been a nutrient-enriched lake. It stands to reason that this would not have been that apparent to anyone prior to initial cottage development on this lake in the 1960's. It also stands to reason, and is borne out by the limited long-term sampling, that water quality conditions can be quite different from one year to the next. Possible reasons for this include:

- weather conditions from one year to the next can have substantial influences on phosphorus release from the watershed. This includes whether there are relatively dry or wet conditions from late spring through early fall, the period during which the lake is most susceptible to phosphorus inputs. Differences in the number, intensity and timing of rain events during this period from one year to the next will have a substantial influence on water quality conditions. So too will air temperatures, with prolonged hot conditions generally creating better conditions for the growth of algae. However sudden changes in temperature from one week to the next can also create the perfect opportunity for algae blooms;

- natural cycles in beaver activity can have a major influence on phosphorus release from soils. Beaver activity is far from static, with beaver ponds coming and going, and the landscapes they have influenced changing quite substantially from one year to the next, and certainly from one decade to the next. The more beaver-flooded lands, the more opportunity for water, which eventually flows to Desbarats Lake, to be in prolonged contact with soils (regardless of whether the release of phosphorus is mediated by redox conditions). The size and age of beaver dams, and whether these are still being actively managed by beaver, is also a factor, with larger, older and poorly managed/unmanaged dams being particularly vulnerable to failure. Changes in the extent of beaver dams within the watershed, in combination with weather differences, can make the lake much more vulnerable to water quality issues in certain years; and

- the extent of trapping activity within the watershed will have a major influence on the extent of beaver-flooded lands, and by association can have a substantial influence on phosphorus release. There is information which suggests that trapping was once quite active within the Desbarats Lake watershed, that this activity then declined (or stopped altogether), and that it has only very recently resumed. If beaver activity and the extent of lands which are being flooded by new or larger dams is increasing, it stands to reason (based on earlier discussions of soil chemistry) that the watershed becomes more vulnerable to the release of phosphorus. This may at least partially explain differences in water chemistry data collected in the 1995 and 1996 period versus that collected in 2010 and beyond.

It is very important to realize that many lakes are naturally eutrophic, and that such lakes do have many very positive attributes. Concerns were expressed by some Desbarats Lake residents during the Public Open House that was held on October 10, 2013 that their lake is "polluted". This is an understandable concern, as a great many lakes in Ontario have become eutrophic as a consequence of improperly planned land use activities, including excessive shoreline development, and would properly be characterized as having been polluted. However, the overwhelming evidence for Desbarats Lake is that eutrophication is a naturally occurring phenomenon, only minimally influenced by shoreline development and other human activities within the watershed. The presence of high levels of phosphorus is not associated with the presence of other "pollutants" which can be associated with human activities within the watershed, including high levels of bacteria, or high levels of metals or organic contaminants. It remains a beautiful, substantially pristine lake, despite the aesthetic and nuisance conditions which the large supply of phosphorus does cause from time to time. One substantial benefit of eutrophic lakes is that they can support a very productive fishery, as algae and plants are at the base of the food chain which supports fish. While there are potential toxicity issues associated with Cyanobacteria blooms, this has not been encountered during testing of previous blooms within this lake. Accordingly, the residents of Desbarats Lake should take some comfort in knowing that their lake is not polluted, it has many good aesthetic qualities, and it will be one of the most productive lakes in this area for fishing.

From a lake management perspective, there are limitations to what can be done to improve water quality in Desbarats Lake. However, it is my opinion that those limitations are not appropriate justification to do nothing. There are things which lake residents can do, with the support of the municipality and broader community, to both protect the status quo and achieve some water quality improvements. Further, there are things which they can do to minimize the potential for rapid changes in water quality, which can be one of the driving forces behind algae blooms. This includes ensuring there is no new lot creation on this lake, taking very careful precautions in the development of any existing lots of record, looking at major redevelopment applications as an opportunity to improve the status quo, seeking out opportunities to improve the relationship of existing cottage development to the lake, and ensuring agricultural activities within the watershed are minimizing the potential for adverse impacts. Of likely greatest consequence to water quality conditions in the lake, and to the maintenance of more consistent water quality conditions, is the management of beaver activities within the watershed. On a related matter, managing beaver dams at the outlet of the lake, to help prevent flooding of the lands along the lake shoreline, should provide considerable benefit. On an individual basis, most of these measures (with the probable exception of better beaver management) will have very little influence on lake water quality. However, their cumulative benefit in improving water quality conditions could be considerable. Additional thoughts and advice in relation to these opportunities are provided in the pursuant sections.

On a less positive note, climate changes may exacerbate water quality issues in Desbarats Lake, and may already be a contributing factor to some of the water quality issues being experienced. While there is considerable ongoing public discourse surrounding climate change, there is evidence that there has been changes over the last couple of decades, which include:

- longer, warmer summers; and
- more frequent large storm events, particularly during the summer period.

Further, there is evidence that this pattern of change will continue.

While care must be taken in looking at climate data over relatively short periods of time, and assuming ongoing patterns on this basis, neither of the above-noted changes are beneficial from a Desbarats Lake water quality perspective. Longer, warmer summers mean warmer lake temperatures and conditions which are better suited for algae blooms; areas such as the north shore of Lake Huron, located within the northern temperate region, may be more vulnerable to changes in the number of growing degree days and its corresponding impact on lake temperatures than areas to either the south or north. More frequent large storm events create more opportunities for wetland flushing, for the leaching of phosphorus from flooded lands, and for the catastrophic failure of beaver dams; Desbarats Lake is particularly vulnerable to such occurrences during the late spring, summer and early fall period.

3.2 Community Involvement

Desbarats Lake is fortunate to have a group of landowners who are passionate about their lake, and have been actively involved in initiatives such as the Ministry of the Environment's Lake Partner Program. Further, it is fortunate to have a well-established, active and sophisticated lake association, the Central Algoma Freshwater Coalition. That lake association has already commissioned two very good and comprehensive studies to assess water quality conditions in Desbarats Lake, and remains actively involved in lake monitoring. This association has the advantage of representing the ratepayers and interests of a number of different lakes within this area, which provides both a higher level of membership support and a broader perspective. This organization has been instrumental in bringing together other watershed stakeholders, including the municipality and the farming community. This is very helpful, as it is my strong opinion that successful lake management really requires a community, working together, to bring about change.

Too often when it comes to lake management activities, there is finger pointing towards who is to blame. For example, those with older cottages may point to newer cottage development as the culprit, whereas those with newer cottages may point to older septic systems, or inadequate sewage treatment systems, associated with older cottage development as the root cause. Cottagers may collectively point at other landowners within the watershed, including the agricultural community or persons who have harvested timber from their property, as the problem. Cottagers may also point to the municipality for not being sufficiently proactive. The reality is, none of this finger pointing is at all helpful in resolving lake water quality issues. Further, if nothing else, this report adds to all of the other information collected as part of two very good background studies (Freshwater Research 2013; CAFC 2010) in demonstrating that **no individual, group of individuals or stakeholder group is responsible for the high phosphorus levels in Desbarats Lake**. It is hoped that the considerable community-wide interest that has already been shown in the water quality of Desbarats Lake will translate into ongoing opportunities for collaboration in effecting change.

As earlier noted, it is not the intention of the present document to serve as a comprehensive Lake Management Plan, however it is hoped that the sections which follow provide information which is useful in allowing CAFC and other stakeholder interests to develop such a plan. Further, it provides information for various stakeholders, including the municipality, on the role they can play in protecting existing water quality, and promoting its improvement.

Finally, on the matter of a Lake Management Plan, I think it helpful to look at such a plan as a living document. That is to say, it is one which should be continuously added to as initiatives are tried and implemented, and as the success of such measures can be evaluated through ongoing collection of water quality information. It should not be viewed as an onerous exercise to complete, and does not necessarily even require preparation of a detailed, stand-along report. What is important is that lake management opportunities not be delayed until a formal Lake Management Plan is in place. To this end, the recommendations which I have included in this report can be explored further by CAFC, the municipality and other stakeholders. It is very critical that CAFC and lake residents continue to collect abundant water quality information from the lake and its inletting streams; I would recommend that phosphorus data be collected at least once monthly, and twice monthly if possible, over the growing season, from the three lake inlets already being sampled, the lake itself, and the lake outlet. Without necessarily completing a stand-alone Lake Management Plan, these water quality results, together with a timeline of phosphorus management measures which have been implemented and an assessment of their success, can be collated into an ongoing annual "lake report card".

3.3 Future Shoreline Development

There are two separate aspects relating to future shoreline development. First is the creation of **new lots,** and second is the development of **existing lots of record**. These are fundamentally different issues, and as such are discussed separately below.

It is my understanding that **the municipality does not allow any new lot creation on Desbarats Lake**. This is fully appropriate, and should continue to be the position that is upheld/reinforced in any updates to the Official Plan. As already noted in **Section 1** of this report, if a full Lake Capacity Study were completed for Desbarats Lake, it would illustrate that no new lots should be created, as the data is unambiguous in showing lake phosphorus concentrations exceed 20 μg/L, and as the lake has a demonstrated sensitivity to any increase in phosphorus.

Existing lots of record are different, in that once such lots have been created, the owners generally have certain development rights (unless these lots are too small to be safely developed). My review of the Township's mapping indicated there are presently 12 undeveloped existing lots of record on Desbarats Lake. If such lots are of sufficient size to address Building Code and local Health Unit requirements for a Class 4 sewage disposal system (consisting of a treatment system [typically a septic tank] and leaching bed), and if both the dwelling and leaching bed can be established a minimum 30 m back from the lake, the Township of Johnson excepts that these lots can be developed, subject to certain additional precautions. From my perspective, this approach is both a reasonable and defensible one. Further, as was demonstrated through calculations included in **Section 2.4**, it has very limited potential to adversely impact lake water quality, particularly when measures are taken to address potential phosphorus loads. In this regard, my analysis, which assumed a worst case scenario in which all 12 of the existing lots of record met the criteria to allow development, and which assumed no precautions were in place to control phosphorus, showed these additional lots would only increase lake phosphorus concentrations by 0.27 μg/L, or 1%, over existing conditions. The reality is that not all of these 12 lots, a number of which are long-established lots of very small size, will meet the municipality's requirements for development. Further, there are a number of precautions which can and should be taken in the development of these lots in order to minimize any potential increase in phosphorus loads to the lake. In this regard, I understand that the municipality already requires any such lots to be developed under a Site Plan control process, and look at their development potential and limitations on a lot-by-lot basis. This is very helpful. To reinforce and possibly build on what the municipality is already doing on such lots, Michalski Nielsen Associates Limited recommends that:

- **development on any of the 12 existing lots of record be subject to Site Plan Control;**
- **a site-specific analysis be completed by a qualified professional (planner, ecologist or engineer), experienced in the matter of lot development in sensitive lake settings, to prepare a plan and report for the site, which is to include:**

  Existing Conditions

  - **the lot size, including frontage, depth and area;**
  - **location of public and private access roads;**
  - **location of significant features on or immediately adjacent to lot, including such features as wetlands and streams;**
  - **additionally, the location of any seasonal depressions and gullies;**
  - **area of slope between 0 to 9%, 10% to 25% and over 25%;**
  - **a general description and mapping of site vegetation characteristics;**
  - **soils information, to include soil depths from a minimum of 20 hand-augered samples collected within the area of the proposed sewage disposal system and downgradient of it along its flow path to the lake, as well as soil profiles, from a minimum two locations and to a depth of 1 m, showing depths and physical attributes (type, texture, colour) of each soil horizon.**

  Recommended Building/Septic Envelopes

  - **location of proposed dwelling, septic system, outbuildings, dock, paths, amenity area, driveway and parking;**
  - **identification of a minimum 25 m shoreline buffer (which is to be kept in a substantially natural state), and of any uses that are intended within that zone (all of which must be of very limited scale);**

  Analysis

  - **determination of whether the site has suitable locations, which are more than 30 m back from the lake and more than 15 m from any defined wetland, drainage courses or drainage swales outletting to the lake, in areas of moderate slope, for both a septic system and building;**
  - **demonstration that driveway access, parking and an amenity area can be accommodated while maintaining a minimum 25 m shoreline buffer;**

- **demonstration that there is good access from the dwelling down to a suitable dock location at the waterfront, and that this and any other activities proposed on the property are compatible with the maintenance of a minimum 25 m shoreline buffer;**
- **demonstration that measures have been taken to minimize the extent of vegetation removal;**
- **identification of whether there are opportunities to improve upon the function of the shoreline buffer, through planting of areas of existing disturbance;**
- **details of construction best management practices to be implemented to protect against sedimentation and erosion during construction (at a minimum, to include the proper installation and maintenance of sediment fencing downgradient of any areas of site disturbance);**
- **details on measures being taken to control post-development site runoff during storm events, including through grading and the use of soak-away pits for roof leaders to promote the infiltration of site runoff;**
- **details on septic system design, including any requirements to import soils in the construction of the leaching bed and mantle, and any measures being implemented to promote long term phosphorus removal;**

Monitoring

- **a commitment to monitor and report on the success of these measures during construction, and one year following substantial completion, and to correct any deficiencies.**

It is noted that this level of site specific analysis is quite consistent with the requirements of the District Municipality of Muskoka Official Plan for Water Quality Impact Assessments of existing lots of record, on lakes deemed to be either or both high sensitivity or overthreshold (high sensitivity lakes being those very susceptible to water quality impacts and overthreshold lakes being those where existing development has already substantially impacted water quality). The process is intended to ensure development has a "near zero" impact on phosphorus contributions to the lake, and has been followed with success on many development applications on lakes in Muskoka; and

- **consideration be given to the use of specialized approaches for sewage treatment and disposal, using systems having a demonstrated high efficiency in permanently removing phosphorus**.

With respect to the consideration for specialized approaches to sewage treatment systems, Michalski Nielsen Associates Limited is aware of three possible solutions, all of which have been demonstrated to be successful elsewhere, although we do have reservations about the use of the first of these approaches in the present circumstance. These are as follows:

1) **Use of soils with a demonstrated ability to effectively eliminate phosphorus**. This is an approach which has received the support of the District Municipality of Muskoka. It involves the use of existing or imported soils of specific qualities which meet a minimum threshold for phosphorus adsorption capacity (based on their ability to complex all of the phosphorus that would be produced through the sewage system over the life of the leaching bed). However, the effectiveness of this system is based on the very stable complexes, or permanent mineralization, of phosphorus with certain minerals, and in particular iron and aluminum, in acidic soils common to the Canadian Shield. The testing of soils within the Desbarats lake watershed indicates that these soils are near neutral, and that iron and aluminum do not create stable complexes with phosphorus. While it would be possible to import acidic soils with the correct properties for phosphorus complexation, a concern is that the pH of any imported soils would gradually shift to a more neutral one, mimicing the existing soils in this area, and that phosphorus may not be held in these soils for the long term.

2) **Use of Waterloo EC-P Phosphorus Removal System**. There has been very promising work by the makers of the Waterloo Biofilter in the development of a phosphorus removal system for use as part of individual household Class 4 sewage systems. This system involves the use of an iron electrode in a septic tank. Through an electrolytic process, iron from this electrode binds with phosphorus to create stable iron-phosphate minerals, such as vivianite and strengnite. These minerals, which have very low solubilites in both aerobic and anoxic environments, are removed by biological/physical filtration in a downstream synthetic biological filter and or sand filter. Considerable field testing of the efficiencies of these systems has already been completed, generally demonstrating a phosphorus removal efficiency in excess of 90%. Information on this system and initial test results are provided in **Appendix C**. This system holds a very considerable amount of promise for use on Ontario lakes where phosphorus is of concern, including Desbarats Lake.

3) **Use of Ecoflow DpEC Phosphorus Removal System**. There is a competing, and in many ways similar, phosphorus removal system for use as part of individual household Class 4 sewage systems being developed by Premier Tech Aqua, based in Quebec and maker of the Ecoflow wastewater treatment system. Their system uses an aluminum electrode within the treatment unit to create complexes with phosphorus, which precipitate within the septic tank as sludge. Considerable testing of this system has also been undertaken, demonstrating a phosphorus

removal efficiency of well over 90%. This treatment unit has been certified as a phosphorus removal system in Quebec. Information on it (a presentation provided to us by the manufacturer, which contains some typographic errors) is included in **Appendix D**. Like the Waterloo EC-P system, this holds a very considerable amount of promise for use on Ontario Lakes where phosphorus is of concern, including Desbarats Lake.

3.4 Major Redevelopment

Whenever there is an application for major redevelopment on an existing, developed cottage lot, there is an opportunity for the municipality to implement some of the same tools described in **Section 3.3** for development on a vacant existing lot of record. For example, if there is an application to tear down an existing cottage and rebuild a new, larger cottage in its place, the municipality should try to ensure that measures are taken to reduce phosphorus loads over those which are occurring at present. This process must recognize the history of use of the property in determining which of the measures described in **Section 3.3** are appropriate to such redevelopment, on a case-by-case basis. For example, if the existing dwelling is 15 m from the lake, it may be difficult to move it back another 15 m, but may be possible to move it back an additional 5 m, in concert with efforts to re-establish a more naturalized shoreline. Matters which the municipality should consider in reviewing and approving major redevelopment should include:

- ensuring that there is a Class 4 sewage disposal system, not a privy;
- reviewing the age and condition of the existing sewage disposal system, with a determination of whether this still has a number of years of good service, or whether it should be replaced. This review should also ensure the leaching bed and mantle are above the water table and the high water elevation of the lake;
- where this is to be a replacement of the sewage disposal system, having the new system located 30 m from the lake, or otherwise as far from the lake as is practical. Further, there should be exploration of whether it is feasible to install a system with phosphorus removal capabilities (which may be warranted, for example, if there is a conversion to a full time home, particularly in situations where it is not possible to establish a leaching bed at least 30 m back from the lake);
- where there is to be replacement of a dwelling, having the new dwelling located 30 m from the lake, or otherwise as far from the lake as is possible; and

- seeking out opportunities to restore a vegetated buffer to a minimum 25 m from the lake, or otherwise as far back from the lake as is practical.

3.5 Existing Shoreline Development

Where landowners are not proposing any major redevelopment, there are no municipal tools that I am aware of that would require them to improve the relationship of their existing development to the lake. Further, it must be recognized that a heavy-handed approach by the municipality in such circumstances could put undue financial burdens upon the owner. For example, some of the very small camps/cottages on the lake appear to be serviced by privys and, while it would be beneficial if these were all replaced with modern Class 4 sewage treatment systems, potentially even with those incorporating phosphorus removal technologies, the cost of such sewage disposal systems would be difficult for the long-standing (and often-times retiree) owners of such modest camps to be able to afford.

A reasonable approach to take with existing shoreline development is for CAFC to provide information to existing landowners on the various things they might be able to do to improve the relationship of their property to water quality, and to seek assistance where required for landowners to make such improvements. Examples of measures which can be implemented on existing shoreline lots, wherever feasible, include:

- restoring a vegetated shoreline buffer along mown or disturbed areas of shoreline. Note that even a few metres of trees, shrubby vegetation and tall grasses along disturbed portions of a shoreline is better than none at all;

- "no maintenance management" of shoreline areas, meaning to move away from the regular mowing and maintenance of areas in proximity to the shoreline;

- careful attention to the repair of any areas of ongoing soil erosion; and

- regular septic inspection, with replacement of failing or inadequate systems wherever this can be achieved.

3.6 Agricultural Activities

As noted in **Section 1.1**, agricultural land uses comprise a very small proportion of the Desbarats lake watershed (approximately 4%). Agricultural land uses are best characterized as being of low intensity, consisting of livestock pasturing, with some cropping for hay and corn. With the resumption of more farming activity in this area, both the amount of land being farmed and the intensity of agricultural uses are expected to only minimally change. Accordingly, there is little concern that present agricultural uses are having much of an impact on water quality, or that this is apt to change in the future. Nevertheless, the soils in this watershed have been shown to be very vulnerable to exporting phosphorus into Desbarats lake, and it is therefore worthwhile to make sure land tilling and livestock grazing practices are carried out with as much sensitivity to the issue of soil erosion as possible. I understand that the Township of Johnson and Ontario Ministry of Agriculture and Food require a nutrient management plan for new farming operations, including one for the farm which is situated in the Desbarats Lake watershed on which there has been a recent resumption of farming activity. In concert with the requirements of such a management plan, Michalski Nielsen Associates Limited suggests the following matters be considered in the management of farm properties:

- increasing stream buffers, to include 15 m of naturalized unpastured/untilled land wherever this can be achieved;
- use of conservation tilling practices for crop production (which I believe is already being practiced within this watershed);
- the use of livestock fencing to keep cattle away from streams; and
- keeping livestock out of fields which are prone to being seasonally wet during those wet periods.

Recognizing that farming within this area is a difficult venture at best, CAFC and other ratepayers should look for opportunities to assist farmers with the implementation of such measures, including by seeking funding opportunities for such work.

3.7 Beaver Dam Management

It is my belief that better management of beaver activity within the Desbarats Lake watershed likely affords the greatest opportunities for water quality improvements, including more stable water quality conditions. Beaver are a natural part of this landscape, and always will be, therefore it is not a reasonable objective to eliminate beaver dams from the watershed. A more practical strategy is to ensure such activities are kept in check, including by reducing the liabilities associated with very large and/or poorly-maintained, dams. There are a variety of strategies which can be employed in the management of beavers, including:

- having an active trapping program, to keep the beaver population in control;
- installing "beaver bafflers" or similar devices to reduce the level of flooding behind beaver dams (these devices allow water to flow through beaver dams in a manner that is undetectable, and therefore which cannot be counteracted, by beavers. By reducing the height of water behind the dam, the extent of flooding is reduced, as are liabilities associated with a potential breach; and
- occasionally breaching beaver dams to reduce pond levels and the extent of flooded lands.

Managing beaver within this watershed has a number of complexities, including the remoteness of many of the ponds and dams, the location of many of these ponds and dams on privately owned lands (and/or within a separate municipality), potential competing interests of stakeholders, and possible regulatory issues. That there has been a recent renewal in trapping activity within this watershed is very helpful. Further to this, Michalski Nielsen Associates Limited recommends:

- **CAFC organize a working group, to consist of representatives of that organization, shoreline residents, a representative of the Ministry of Natural Resources, and local trappers, to develop a strategy to better manage beaver activity within this watershed;**
- **the key objectives of that strategy will be to minimize the amount of flooded land within the watershed, and to reduce liabilities associated with very large and/or poorly-maintained dams;**
- **it is likely that all three of the above-referenced techniques (trapping, the use of "beaver bafflers" and occasionally breaching dams of particular vulnerability) will form part of such a strategy;** and
- **the control of beaver activity within this watershed is a long-term initiative, and its benefits to lake water quality may not be immediately evident, but may become more evident over a few years. It is important that CAFC correlate the progress in better managing beaver activity within this watershed with ongoing water quality data for the inletting streams and the lake itself, over a period of a number of years, to best gauge the success of these measures.**

3.8 Lake Water Level Control

When I inspected Desbarats Lake and its watershed in October, 2013, water levels in the lake were very high, but receding. There were two dams within the outlet area of the lake, with very fast flows through an apparent break in one dam suggesting it had very recently been breached (and that this breach was responsible for the declining lake level).

Water levels will naturally rise in Desbarats Lake during periods such as the spring freshet, which will result in some flooding of lowlying areas around the lake, including some of the lawns and possibly even foundations of existing cottages. This is natural and unavoidable. However, the maintenance of artificially high water levels over more extended periods, because of the presence of beaver dams at the lake outlet, is both avoidable and harmful to the lake. Maintaining an artificially high lake level is harmful in a variety of ways, including:

- lands become flooded; as has been previously discussed, the prolonged flooding of soils which are not normally wet will liberate phosphorus from these soils, with soils in the Desbarats Lake watershed appearing particularly vulnerable to this. Any phosphorus which is leached from soils adjacent to the lake have a direct conduit to the lake, with no opportunity for attenuation;

- this flooding may extend back into the mantle and leaching beds of Class 4 sewage systems, or into or immediately adjacent to areas of privys, on some of these cottage lots. This has the potential to mobilize very considerable amounts of phosphorus; and

- any increase in lake volume caused by an artificially high lake level increases the retention time of water in the lake (i.e., it results in a lower flushing rate). In a shallow lake such as Desbarats Lake, a change in water levels of only 0.3 m can have a measureable influence on retention time with the lake more vulnerable to the impacts of any increase in phosphorus concentration (including that described in the previous two bullets) the longer water is held in the lake (a high flushing rate decreases vulnerability; a low flushing rate increases vulnerability).

Accordingly, Michalski Nielsen Associates Limited recommends that:

- **CAFC and lake residents monitor beaver activity around the lake outlet;**
- **if beaver dams are being created which could flood the lake, there be an active effort to remove the beaver and/or dams. The Ministry of Natural Resources should be**

consulted as part of this process, and local trappers should be enlisted as required; and

- **under no circumstance should a beaver dam be allowed to develop which artificially raises water levels within the lake.**

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APPENDIX A – TOWNSHIP OF JOHNSON REQUEST FOR PROPOSAL

The Corporation of the Township of Johnson

Request for Proposal

Lake Capacity Assessment – Desbarats Lake

The Township of Johnson is accepting Request for Proposals (RFP) for conducting a Lake Capacity Assessment for Desbarats Lake.

RFP packages may be picked up at the Municipal Office, 1 Johnson Street, Desbarats, Ontario between the hours of 9:00 am and 4:30 pm local time, Monday to Wednesday and Friday from the Clerk's Office.

RFP submissions will be accepted at the Municipal Office in Desbarats, 1 Johnson Drive, Ontario, P0R 1E0 until 3:00 pm Local Time, Friday, July 26, 2013. Submissions must be sealed in an envelope and clearly labeled as to the contents as follows:

"Request for Proposal – Lake Capacity Assessment Desbarats Lake"

And addressed to:

Ruth Kelso
Clerk Administrator
Township of Johnson
1Johnson Drive, Box 160
DESBARATS ON P0R 1E0

The lowest and/or any RFP are not necessarily accepted. The Township of Johnson reserves the right to accept/reject, cancel/re-advertise any RFP.

REGISTRATION FORM

Addendums to bid documents will be forwarded to all registered bidders upon completion of this form in order to guarantee notification and receipt of addendums (if any). Those who do not complete a *Registration Form* are responsible for obtaining all addendums associated with this project. The Township of Johnson shall not be responsible for misinformed bidders who neglect to complete this form.

Addendums become part of the bid document and shall be submitted along with the originally distributed bid document.

Please return the completed form **in person, by email to 'ruth.kelso@bellnet.ca' or by fax to 705 782-6780.**

Project Name	
Closing Date	
Company Name	
Principle Contact	
Address	
Address (Line 2)	
City and Province	
Postal Code	
Telephone with area code	
Facsimile	
Email address	
Date	

GENERAL INSTRUCTIONS

1. All bid documents must be submitted in accordance to the location, date, time, and manner specified in the Tender/RFP/Quotation Call/bid document.

2. All **bid documents** and **corresponding addendums** must be submitted in a **sealed envelope**, and clearly marked as to its contents in ink or typed form, or by a pre-supplied label by the Township of Johnson.

3. As submissions are received, they are time and date stamped by the Clerk's office at the Municipal Office to ensure compliance with the closing date and time.

4. **Faxed or emailed bid documents will not be accepted.**

5. Late submissions shall not be accepted and will be returned unopened to the proponent at the time of submission and if not possible, shortly thereafter by regular mail.

6. Openings are a public process and will be held in the Council Chambers, Municipal Office at the time of closing or shortly thereafter, and on the date specified in the Tender/RFP/Quotation Call/bid document.

7. For tenders, the name of the bidder and the total amount will be read aloud and duly recorded. For RFPs and quotations, the name of the bidder will be read aloud and recorded, but not the total amount.

8. All persons in attendance are required to sign an *Attendance Form.*

9. Following the opening, the completed *Unofficial Results Form* and accompanying bid documents will be given to the Clerk for evaluation.

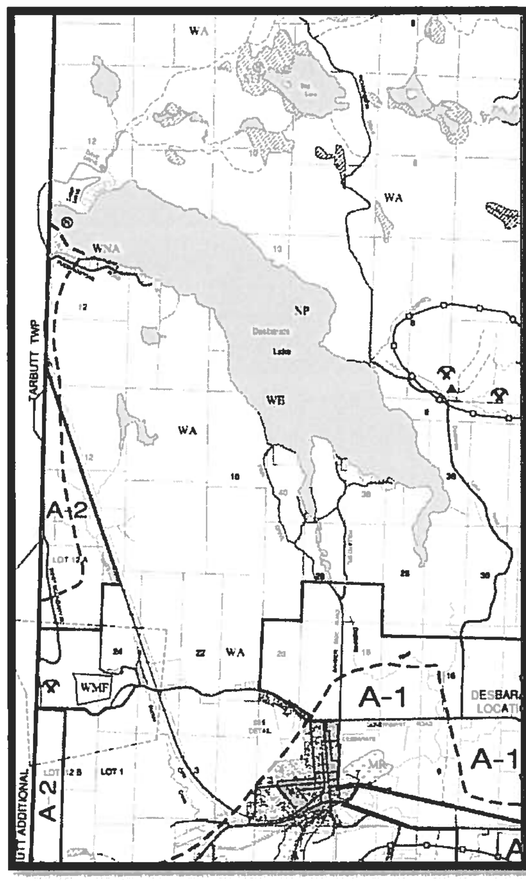
The lowest and/or any RFP are not necessarily accepted. The Township of Johnson reserves the right to accept/reject, cancel/re-advertise any RFP.

PART A – THE PROJECT

1. INVITATION

The Township of Johnson is issuing a Request for Proposal (RFP) to interested parties for conducting a Lake Capacity Assessment for Desbarats Lake. The intent of the RFP is to award the work to a consultant, based on the evaluation of the relevant information from respondents with proven track records and management expertise in similar undertakings.

2. INTRODUCTION AND BACKGROUND



The Township of Johnson is a rural township municipality (population 750 - 2011) characterized by its agricultural base, a small hamlet, an archipelago along the Lake Huron Shoreline and a number of inland lakes. The larger lakes are host to a mix of land uses typical of Northern Ontario municipalities. The shorelines of these lakes have been developed for both seasonal and permanent (year-round) residential uses and recreational vehicles on vacant lots of record. Development has persisted for a number of decades. Shoreline development is typically serviced with on-site individual sewage disposal systems; however the age, type and condition of the systems are not documented. The municipality is experiencing pressures for waterfront residential development which have precipitated concerns for water quality on inland lakes as well as the relationship of permanent and seasonal development along the Lake Huron shoreline and outlying islands to wetlands and other shoreline amenities. The sensitivity of inland lakes to despoliation through overdevelopment will necessitate a stringent approach by requiring water quality analysis as a pre-requisite to further development.

The Central Algoma Freshwater Coalition has produced a study report entitled: *Water Quality and Remediation Options for Desbarats Lake, Johnson Township*, (Baysville: May 24 2013) which provides detailed water quality and other information and is to be considered in conjunction with this RFP.

The Township of Johnson has an approved Official Plan and an approved Zoning By-law. The Official Plan sets out a policy framework for guiding growth and development in the municipality and more particularly, to govern development on lakes and water bodies. Relevant policies to the RFP are as follows:

"**Section 2.8.11 – Development Criteria**: Where development is proposed with private sewage systems on water bodies, approval of the development will be subject to a Lake Development Capacity Calculation. The public body having jurisdiction will assess the effects of the proposal on Desbarats Lake, Caribou Lake, Diamond Lake, Gordon Lake and Round Lake respectively and development will be limited to that level which results in no change to the trophic category of the lake.

Section 2.13 – Lake Management Plans: Lake Management Plans (LMPs) are an essential planning tool to effective environmental stewardship of lakes and rivers in the Township. Council recognizes the need to develop LMPs for all lakes experiencing development pressures. It is also recognized that there are a number of stakeholders who have a role to play i.e. property owners, cottage/lake associations, environmental partnerships, agencies and the Township. A cooperative and coordinated approach is necessary in developing and implementing LMPs. Technical data and information is important, but so is the process in preparing an LMP as well as public education. The public must understand the importance of lake management planning and build protection and conservation practices into their daily living. The Lake Management planning area should include the watershed for the subject water body or all lands within 300 m [984 ft] of the shoreline.

Lake Management Plans will include a number of components including:

- **A lake capacity assessment to determine the carrying capacity for existing and new development and the opportunities to improve or enhance water quality**;
- An inventory of existing and proposed development by type, characteristics of sewage and water services;
- A shoreline capability assessment to determine lands which are suitable for development given such features as slope, vegetation cover, depth of overburden, the presence sensitive natural heritage features and areas;

- A resource inventory of water quality, vegetation, fish and wildlife habitat, geology;
- resource inventory phosphorus and oxygen levels;
- land tenure (existing seasonal and permanent land uses, existing approved but vacant lots, development proposals);
- shoreline and recreational capability (slopes, soil types, access);
- water quality enhancement measures;
- An assessment of fish habitat;
- The nature of public access to and use of the lake for aquatic and boating activities;
- Road access to shoreline development;
- Flood plain management;
- Shoreline management principles that provide for appropriate development setbacks and the retention/conservation or restoration of natural features;
- Septic tank re-inspection;
- Criteria for controlling seasonal to permanent conversions and commercial to residential conversions;
- Implementation and monitoring; and
- Public education

Lake management plans will be prepared as a partnership initiative with stakeholder groups with preference being placed on lakes experiencing development pressures. It is the intent of Council to explore funding options for the preparation of Lake Management Plans.

Lakes at Capacity and Lake Trout Lakes

Where lakes are determined to be at capacity, the creation of new lots, by either consent or plan of subdivision, that are within 300 m [984 ft] of the highwater mark of these lakes, or their tributaries, shall be prohibited except where the lake capacity for development is assessed with the Lakeshore Capacity Model as outlined in the Ministry of the Environment Lakeshore Capacity Assessment Handbook.

Section 2.15 - Lots of Record: Except for lots which are subject to flooding, lots of record which are vacant may generally be used for building purposes provided they front on a publicly maintained road and can be adequately serviced satisfactory to servicing standards of the Ministry of Environment and Energy and/or its designate. An absolute minimum lot size may be established in the zoning by-law for lots of record.

Section 2.20 - Public Service Facilities and Infrastructure:

Subsection 2 (c) Individual On-Site Systems: Lands throughout the Rural Policy Area may be serviced by individual on-site (private) sewage disposal systems. Planning applications for new development shall be supported by a terrain analysis or an assimilation capacity study satisfactory to meeting the approval requirements of the applicable legislation, e.g.:

i. Where the total effluent discharged by a sewage system is 10,000 litres/day/lot (2,200 gallons/day/lot) or less, and the system will be entirely within the bounds of the lot, the approvals will be governed by the Building Code Act;

ii. Where the total effluent discharged by a sewage system is greater than 10,000 litres/day/lot (2,200 gallons/day/lot), the approval authority will be the Ministry of the Environment. The associated hydrogeological study and terrain analysis shall demonstrate soil suitability, sufficient area for effluent treatment and site suitability for the disposal system;

iii. A water supply assessment report may be required for proposals using a groundwater source (i.e. well); to demonstrate that there is an adequate supply (quantity and quality) and that there will be no interference from sewage disposal or draw down of the water table. (Reference should be made in this regard to the Ministry of the Environment's Guideline D-5-4, Technical Guideline for Individual On-Site Sewage Systems.) Consideration shall be given to the cumulative impact of development on the available water supply. A water budget for users may be required in this regard; and

iv. Provided site conditions are suitable for the long-term provision of such services and sufficient reserve sewage system capacity for hauled sewage is available. The determination of sufficient reserve sewage system capacity for individual on-site sewage services shall include treatment capacity for hauled sewage from private communal sewage services and individual on-site sewage services. It is the intent of the Council to investigate the options for the determination of treatment capacity from private services in the implementation of this policy;

b) Applications for lot creation on privately owned and operated individual or communal systems generating more than 4,500 litres of effluent per day as a result of the development shall require the submission of a servicing options report and a hydrogeological report;

c) Well construction standards will be required to meet Ontario Regulation 903 for lands serviced with an on-site (private) water supply (i.e., well);

Section 2.24 - Shoreline Alterations and Docking Facilities: The construction of any dock, wharf, boat house, pier, retaining wall or other structure or works along the shorelines of inland lakes or Lake Huron shall be subject to prior approval by the Ministry of Natural Resources.

It is the intent of Council to require the establishment and/or retention of a natural vegetation buffer on lands within 15 m [49.2 ft] of the shoreline of a lake or a tributary. In situations where the natural vegetation buffer will be reduced to accommodate the expansion of an existing building, the replanting of an area equivalent or greater than the area required for the expansion, will be required.

The policies of this section shall apply to shoreline structures abutting any lake or water body:

1. With the exception of docks and (wet) boat houses, all shoreline structures shall be constructed within the confines of the property boundaries of a lot;
2. Shoreline structures including single storey boat houses, boat ports and float plane hangars shall be limited to a maximum width as regulated by the zoning by-law;
3. Construction of a second storey addition for any shoreline structure shall not be permitted;
4. Interior finishing or occupancy of any portion of a boat house or boat port for use or occupancy as a dwelling shall not be permitted;
5. Saunas or steam baths shall not be serviced by a pressurized water system. (See also setback requirements below);
6. Floating structures, cribs and docks (of less than 15 m^2 [161.5 ft^2]) in area shall be subject to municipal review and review by MNR while

structures exceeding this area shall require permits from the appropriate regulatory authority;

7. The type of docks shall generally be limited to floating, cantilevered or post dock construction. Other types of docks may be permitted where it is demonstrated that they will not have a negative impact on fish habitat. Docks shall be built of non-toxic building materials. The size of docks may be regulated by the zoning by-law and in no case shall limit or restrict safe navigation. The shoreline below the high water mark shall not be permanently altered through the construction of shoreline structures except to accommodate the placement or use of docks as approved by the authority having jurisdiction;

8. No shoreline structure which will destroy fish habitat shall be permitted;

9. Other shoreline structures may include a gazebo, utility or storage shed, deck or viewing area subject to the standards set out above (with the exception of size); and

10. Shoreline structures shall be permitted in a front yard subject to meeting appropriate zoning standards (i.e., the minimum setback for structures other that boat houses and docks, shall be 30 m [98.4 ft]).

Section 5.28 - Seasonal residential development along the shoreline of inland lakes (Diamond, Desbarats, Gordon, Caribou and Round only) may only be permitted where it is clearly demonstrated that such development does not have a negative impact on the water quality or the capacity of the lake to sustain such development."

Section 2.13 bold script above is considered the enabling policy for preparing lake capacity assessments. Desbarats Lake is considered to be a priority given water quality concerns such as blue-green algae blooms. The intent of the lake capacity is to assess the current water quality of the lake and to ascertain whether it has reached its development or carrying capacity. The outcome of the study may also assist the Township and property owners around the lake in preparing a lake stewardship plan or lake management plan that would provide controls and/or guidelines intended at recovering the health of the lake. The other policies set out above are intended to give the consultants an indication of the policy framework within which development could take place. Policy 5.28 is clear to the extent that the Township does not support development that has a negative impact on water quality.

3. PROPOSED WORK PROGRAM

The Ministry of the Environment Lakeshore Capacity Model is a planning tool designed to enable users to assess the lakeshore capacity of a specific lake. The model may be used for lakes on the Precambrian Shield to determine the amount of development — whether seasonal, permanent, resort or point source that each lake in a watershed could accommodate. The model calculates the total phosphorus (TP) concentration of a lake by calculating what the TP concentration would have been without shoreline development (the predevelopment concentration) and adding this amount to the current estimated TP contribution from shoreline development. The model can also be used to determine how changes in the upper watershed will influence the quality of water in downstream lakes. The user can compare the model results with the provincial water quality objectives for total phosphorus. The user can then determine the amount of development that could occur while still enabling these objectives to be met. The model translates water quality objectives (as µg/L phosphorus) into total allowable phosphorus load. The total allowable phosphorus load can either be expressed in kilograms or as the number of allowable cottages, permanent residences or resort units.

The Township of Johnson requires a qualified professional to undertake a lake capacity assessment of Desbarats Lake to determine its potential for additional development, if any or alternatively, to determine measures and best management practices that may be applied to improve the health of the lake. The consultant must also create an inventory of all existing sewage disposal systems in use on the lake.

The consultant shall use the **Lakeshore Capacity Assessment Handbook (MOE), (May 2010)** as the basis for conducting the Lake Capacity Assessment.

The work program for the Lake Capacity Assessment shall address the following matters.

1. Identify and prepare map to show the watershed area for Desbarats Lake including any upstream lakes and their watersheds;
2. Calculate the lake area and the area of the watershed;
3. Create an inventory using excel spreadsheet that identifies the development status of properties on Desbarats Lake including:
    a) The number of cottages
    b) The number of permanent (year-round) dwellings
    c) The number of recreational vehicles on vacant lots of record
    d) The number and type of resorts
    e) Any other existing land uses i.e. agricultural operations, mineral aggregate operations
    f) The number and size of vacant lots of record and land holdings
    g) Number and types of individual on-site sewage disposal systems
    h) Number and types of water supply systems;

4. Prepare a land use map to illustrate the land use inventory. The boundaries of the map or study area shall include all lands within 300 m of the shoreline of Desbarats Lake;
5. Provide a description of the shoreline with respect to:
    a) Usage rate of shoreline properties
    b) Vegetative cover of the critical riparian area (i.e. first 30 m inward)
    c) Characteristics of slope and soil overburden
    d) Characteristics of soils for effluent attenuation
    e) Fish habitat
    f) Identification of significant development constraints;
6. Categorize the hypolimnion as anoxic or oxic, and trophic status of the lake;
7. Determine/calculate observed or measured Total Phosphorus (TP) as a basis for comparing modeled estimates with measured values;
8. Determine lake mean depth [volume ÷ area];
9. Calculate lake capacity limits for new development, if any, including a comparison of the model results with actual measured data for water quality (this will need to be data collected as part of the lake partner program (MOE), or other suitable water quality monitoring program), and in the case where the lake does not model accurately give an explanation as to why and recommendation on how to proceed. All measurements shall be given in a format that will permit comparison particularly with respect to future measurements. If the lake is determined to be at capacity, the study shall indicate:
    a) Recommended restrictions/controls for redevelopment or expansions to existing uses
    b) Requirements for a monitoring program
    c) Mitigation measures focused on how to improve water quality through such measures as BMPs for maintenance and operation of septic tanks, water conservation, shoreline vegetation, phosphorus abatement
10. Impacts of development in the upstream watershed area on Desbarats Lake, if any and land use controls or restrictions that should apply.

The study will use available data such as the Lake Partners program and the data and information set out in the *Water Quality and Remediation Options for Desbarats Lake, Johnson Township*, (Baysville: May 24 2013) report. If the existing collected data is insufficient, the consultant will recommend a testing program.

The Township will assist the consultant in providing property information from the assessment roll on land use; however, the consultant is expected to confirm the land use information where necessary through field inspections. The consultant may use surveys or other acceptable means to collect information on sewage disposal systems.

4. PROGRAM DELIVERABLES

The consultant shall conduct the lake capacity assessment study using qualified professionals. The study shall include the following deliverables:

a) A start-up meeting with Council to discuss and confirm the details of the work program, timelines, reporting and contract requirements.
b) A public information centre (PIC) designed to advise the public of the scope of the study and the opportunities for input. The PIC may be piggy-backed to the start-up meeting as a cost saving.
c) A draft report setting out the results of the research and data collection, the state-of-the-lake and lake capacity assessment, and recommendations for monitoring and water quality conservation and improvement measures.
d) A public meeting to present the draft report and to engage the public on conservation and improvement measures, BMPs etc.
e) A final report in a Microsoft Word format. The consultant shall provide five (5) hard copies and one digital copy of the final report. All intellectual property collected during the course of the study shall become the intellectual property of the municipality and shall be submitted to the municipality at the conclusion of the study.
f) All presentation materials
g) A public meeting notice acceptable to the Clerk Administrator for advertising in the local newspaper.

5. CONTENTS OF PROPOSAL

The consultant shall provide **six (6) copies of the proposal**. The proposal shall set out the following:

a) A statement that indicates that the proponent understands the required work assignment and the needs of the Municipality with respect to the undertaking.
b) The details of the proposed work program.
c) A flow diagram or equivalent setting out the proposed tasks, timelines for the program and key milestones (i.e. meetings, report presentation)
d) A costing chart setting out a breakdown of the costs related to the various tasks. The project cost shall identify the time allocation and professional fees for each member of the consultant team, disbursements (i.e. travel, printing) and HST. Where the proponent proposes to use a sub-consultant
e) A description of what is expected of the municipality in terms of resources and inputs
f) Demonstration of an ability to be creative and innovative
g) Previous experience completing studies of a similar nature. The consultant should feel free to provide an example of a study completed using the Lakeshore Capacity Assessment Handbook
h) Three references for studies of approximately the same magnitude that have been successfully completed including names, telephone and email addresses.

i) Any value-added component which is deemed to improve the study program.
j) A completed and signed copy of Schedule 'A'.
k) Joint submissions are accepted; however only the lead consultant is required to complete Schedule 'A'. All sub-contractors must be identified in the proposal and shall provide three references separate from (h) above.

The proposal shall not exceed ten (10) pages in length excluding Schedule 'A', CVs, corporate profiles and the timeline and costing chart.

PART B – THE EVALUATION

1. PROPOSAL SUBMISSION

The Township of Johnson will receive proposals for the project until 3:00 pm Local Time (E.S.T.) on Friday, July 26, 2013. Proposals received after the proposal submission deadline, as recorded by the Clerk's Office shall NOT be considered. Proponents are solely responsible for ensuring proposals are delivered as required. Delays caused by any delivery service, including Canada Post, will not be grounds for an extension of the Proposal Submission deadline. Faxed or electronic transmissions or other forms of unsealed proposals will not be considered.

2. QUESTIONS AND ANSWERS

Questions from proponents concerning this RFP can be forwarded in writing or by email to Glenn Tunnock, MPA, RRPP at the address below.

In the event that a question(s) results in refinements to the RFP, a copy of the amended RFP will be directed to those Proponents that have completed the registration process. A decision to extend or vary the proposal submission date may be made at the sole discretion of the Clerk-Administrator.

Any inquiries related to the proposal submission process or technical questions regarding this proposal shall be sent by email directed to:

Glenn Tunnock, MPA, RPP
Tunnock Consulting Ltd.
247 Hearst Street
NORTH BAY ON P1B 8Z2
Email: gtunnock@tunnockconsulting.ca

Any addendum arising from questions raised will be distributed to all registrants.

The last date for submitting a question(s) shall be July 15, 2013.

3. EVALUATION

The Clerk-Administrator will prepare a recommendation report to Council with respect to the approval of the successful proponent.

It is the Municipality's intent to employ consultants on the basis of their demonstrated competence and expertise, their ability to complete work efficiently and effectively, their past record in performing similar work to ensure acceptable performance and completion of the assignment and the cost of their services. Municipal staff will check the responses against the mandatory criteria.

The award of the contract will not be solely based on price, but will consider the overall value to the municipality. All proposals will be evaluated using an evaluation matrix on the basis of experience, proposed work plan, timeframe for completion and fees. Council may conduct interviews before making a final decision.

Compliance with the proposal requirements and items to be addressed include:
General (5%)

a. The correct number of copies are provided
b. Reference information as stipulated is provided
c. Examples of comparable projects of size or scope are provided
d. All required signatures acknowledgements and documents have been provided

Work Program (30%)

- Satisfies the scope of work
- Demonstrates understanding of the scope of work
- Effective and efficient project design, including a brief description of the proposed method of accomplishing the assignment including a work plan and flow chart (GANT)
- Additional recommended tasks, if necessary

Qualifications and Skill of Consultant (Team) (30%)

- Appropriate professional designations
- Demonstrated expertise in conducting lake capacity assessments
- Appropriate qualifications of any subcontracted consultants
- Satisfactory references (Municipality reserves rights to conduct reference checks)
- Statement that consultant (team) does not have a conflict of interest
- Any value-added items are identified and associated costs are included

Quality of Approach and Timing (15%)

- High quality form and style of submission
- Logical project team structure with sufficient hours devoted by senior team leader
- Innovation in meeting RFP requirements
- Timing tailored to requirements for water quality testing and to completing assignment expeditiously

Budget (25%)

- Breakdown of all costs are clearly and properly itemized and unit costs and time allocations shown for each staff member
- Disbursements itemized and clearly shown separately from professional fees
- Any/all additional costs are clearly and properly itemized
- Any additional value-added items are identified and associated costs are included

Schedule "A"

REQUEST FOR PROPOSALS FOR A

FULL COST OF SERVICES AND RECOMMENDATIONS FOR THE ESTABLISHMENT OF BUILDING PERMIT FEES REPORT

FORM OF PROPOSAL

Total cost: **$**________________

Harmonized Sales Tax: **$**__________________

TOTAL AMOUNT: $__________________

Schedule of hourly rates for extras and additional services.

____

Submitted to: The Corporation of the Township of Johnsom.

NAME OF COMPANY:

____

ADDRESS:

____

POSTALCODE_____________

NAME OF SIGNING OFFICER:____

TITLE: ____

AUTHORIZED SIGNATURE: ____

TELEPHONE: ________________________ **FAX:** ___________________________

EMAIL ADDRESS: ____

H.S.T. REGISTRATION NO.:__________________________________

Person signing must be authorized to sign on behalf of the company/Individual represented, and to bind the Company/Individual to statements made in response to this Proposal.

THE LOWEST OR ANY PROPOSAL OR ANY PART OF ANY PROPOSAL NOT NECESSARILY ACCEPTED.

APPENDIX B – MICHALSKI NIELSEN ASSOCIATES LIMITED'S RESPONSE TO THE REQUEST FOR PROPOSAL

Michalski Nielsen
ASSOCIATES LIMITED

July 23, 2013

Ms. Ruth Kelso
Clerk Administrator
Township of Johnson
1 Johnson Drive, Box 160
Desbarats, Ontario
P0R 1E0

Re: Request for Proposal – Lake Capacity Assessment Desbarats Lake

Dear Ms. Kelso:

I have read with great interest the Terms of Reference for this study and the accompanying report prepared by Dr. Gertrud Nurnberg. Michael Michalski and I have spent considerable time in looking at the data that is included in Dr. Nurnberg's report, and while we are very interested in assisting your municipality in addressing the water quality issue within Desbarats Lake, we have significant concerns that a traditional Lake Capacity Assessment will not provide meaningful assistance. I recognize that such a significant departure from the Terms of Reference carries a risk that our proposal will not receive further consideration, but I do hope you will read on to understand why I feel so strongly about this, and what I am suggesting as a more meaningful alternative to the approach suggested in the RFP.

The report prepared by Dr. Nurnberg paints a very interesting portrait of Desbarats Lake. The lake exhibits very dramatic within-year and year-to-year changes in phosphorus concentration, which is far from a normal situation. Phosphorus concentrations range from a low of approximately 10 μg/L to a high of approximately 50 μg/L, a five-fold difference. Four-fold differences are seen within individual years. By contrast, in the vast majority of Ontario's lakes, phosphorus concentrations would typically vary by less than 50% through the course of individual years, or from year-to-year. This lake is phosphorus-controlled, so it is these fluctuations in phosphorus concentration which give rise to dramatic changes in overall lake water quality, aesthetics and nuisance algae conditions, as well as potentially dangerous cyanobacteria blooms. The report's conclusion that Desbarats Lake is not at equilibrium is very true.

When a lake responds to changes in development activity, the response tends to be a very gradual but sustained one. If new cottages are built, there is typically a corresponding increase in phosphorus resulting from these changes in land use, but this response is generally not dramatic, nor is it sporadic. It is true that land clearing associated with new cottage development or other land uses can temporarily increase suspended sediment/soil particulate contradictions, with a corresponding impact on phosphorus concentrations, but unless such changes are very widespread they do not produce dramatic changes in phosphorus concentrations.

Our review of land use activities around Desbarats Lake indicates quite a modest level of cottage activity, or other anthropogenic land use activities, none of which are likely to have a substantial influence on lake water quality (and which don't explain the larger water quality fluctuations). While that is not to say that traditional measures which might be considered in a Lake Plan, such as improving riparian buffers, instituting a septic inspection and replacement program, etc. would not have any benefits in water quality, but it is our strong opinion that these benefits would be relatively small, and would do very little to remedy existing water quality concerns.

Our review of Dr. Nurnberg's information and commentary on lake sediments leads us to agree with her conclusion that phosphorus remobilization from lake sediments does not appear that substantial, and cannot explain fluctuations in water quality.

Our review of lake watershed conditions, including the predominance of wetlands within the watershed, the albeit somewhat limited data on phosphorus contributions from this watershed, and the known and anecdotal correlations between beaver dam failure and periods of high phosphorus levels in Desbarats Lake, leads us to conclude that it is the external load of phosphorus that is predominantly responsible for the massive fluctuations in water quality in this lake, the resultant aesthetics and nuisance issues this creates, and the cyanobacteria blooms this also creates. The relatively small surface area and shallow nature of Desbarats Lake exacerbates this issue, making it much more responsive to rapid increases in phosphorus supply from the watershed.

With all of this in mind, our basic concerns with the completion of a traditional Lake Capacity Assessment are as follows:

1. The model would do a poor job in predicting existing phosphorus concentrations in Desbarats Lake, and has no capability of predicting the fluctuations in conditions. When a model does not fit with the data, adjustments in the inputs need to be made to make the model a better fit, but this reduces the overall reliability of model predictions. Ontario's Lakeshore Capacity Assessment Handbook indicates three situations where the model does not work well, as follows (1) shallow lakes, (2) tea-stained lakes, and (3) lakes with small surface areas. This lake has a mean depth of 6.7 m, slightly above the minimum recommended depth for application of the model. It is larger than the minimum threshold size, although still quite small. Further, it has relatively high DOC concentrations, albeit these are lower than the maximum threshold recommended for model application. Our sense is that it is the combination of such factors (i.e., all three tending towards poor model application) which reduces the reliability of the model.

2. Because the majority of lake water quality measurements indicate Desbarats Lake has a phosphorus concentration in excess of 20 μg/L, any modeling excess would indicate it is already over capacity. Knowing this is in advance of modeling defeats one of the major benefits of preparing such a predictive model (which is typically undertaken to determine just how much additional shoreline development a lake can sustain).

   The model specifically states "a total phosphorus concentration of 20 μg/L will be used as the upper limit to protect against nuisance algal blooms. In situations where a lake is naturally above 20 μg/L (e.g., highly coloured, tea-stained lakes), regional MOE staff may use discretion to allow a limited amount of new development (e.g., < 10 lots), provided the lake is not sensitive". This lake has had outbreaks of cyanobacteria which would indicate it is sensitive and that no new development is permitted; and

3. Perhaps most importantly, the model will not have any value in better understanding, and developing potential solutions for, the root causes of water quality problems in Desbarats Lake, which the data strongly suggest is the result of external watershed loading.

Our Intended Work Program

In accordance with the previous discussion, we suggest our work program include the following;

A. background review, which includes collecting and collating mapping information on Desbarats Lake and its watershed. This will include measurements of the lake area and watershed area;

B. a site assessment to obtain additional information on the lake and its watershed. This visit will be conducted over a two day period in the late summer or early fall, and will include a visual examination and notes on the magnitude and nature of shoreline development on Desbarats Lake (including the number of cottages), together with our inspection of upstream watershed areas, including wetlands and their outlets, agricultural and other land uses;

C. at the time of the site assessment, meeting with the municipality to look at the number of vacant lots of record on Desbarats Lake, and the existing policy framework influencing development activities both on Desbarats Lake and within its watershed;

D. at the same time, attending a meeting to be organized through the municipality, including local ratepayers and ratepayer groups, both to hear their concerns and to look towards opportunities to augment existing water quality data;

E. reviewing potential solutions to existing water quality issues with the municipality and ratepayers, together with the benefits and limitations of each. Through this process, seeking some consensus on next steps of this project;

F. contacting MNR and MOE staff about potential solutions to phosphorus loading issues from the lake's watershed, to determine preliminary feasibility and buy-in to potential corrective actions;

G. following completion of the site inspection and meeting, preparation of a report providing insight on the issues and potential solutions for Desbarats Lake. This will include recommendations relating to:

- existing shoreline development;
- additional existing development within the watershed;
- any new development on existing lots of record along the shoreline. In this regard, our office has been successful in developing strategies which provide for near-zero new phosphorus loads from new cottage developments, which typically involves governing the development of such lots through the Site Plan Control process, with specific recommendations/restrictions on the location of the dwelling, the location of shoreline structures, the preservation of a shoreline buffer, and the use of techniques to provide long-term phosphorus attenuation as part of the sewage system design. These measures have been utilized on many lakes in Muskoka which are deemed over-threshold (at capacity) from a phosphorus perspective. We have also been involved in the resolution of shoreline development issues on other at capacity lakes, including MOE approval for shoreline development on three at-capacity lake trout lakes (Lake Manitou, Redhorse Lake and Limerick Lake);
- potential measures to remediate against natural phosphorus loadings from the watershed, with options to be considered including an active beaver-management and beaver dam removal program within the watershed, reinforcement of existing beaver dams to increase their permanency, creation of additional permanent dams/berms to attenuate flows along channels downgradient of existing wetland areas, incorporation of phosphorus-reactive soils in channels downgradient of wetland, and other measures which may arise based on field investigations; and
- providing a realistic impression of the extent to which water quality may be improved within Desbarats Lake, including discussion of climate issues which may continue to contribute to some of the problems being observed.

This would end this phase of investigation, although logical additional stages may be to interpret and comment on any additional water quality data that can be collected by ratepayers per the recommendations of our report, and to assist in the implementation of any recommendations arising from our report.

This work program is intended to provide practical, meaningful and cost-effective input to best assist in the remediation of issues in Desbarats Lake.

Our Timeline

Dependent on the timing of the municipality, an approximate realistic time frame for the completion of the above steps is as follows:

Task	Time Frame
A.	August 1 – September 15, 2013
B.	August 20 – October 15, 2013
C.	August 20 – October 15, 2013
D.	August 20 – October 15, 2013
E.	September 15 – November 30, 2013
F.	September 15 – November 30, 2013
G.	November 15 – January 30, 2014

We are certainly prepared to review these timelines with the municipality to best suit its schedule.

Our Costs

Costs for the above tasks are as follows:

Task	Hourly Involvement*			Total Fees	Disbursements	Total
	GN @ $130	MM @ $160	Support @ $70 average			
A.	8	2	4	$1,640	–	$1,640
B.	24	–	–	$3,120	$700	$3,820
C.	6	–	–	$780	–	$780
D.	6	–	–	$780	–	$780
E.	8	4	2	$1,820	–	$1,820
F.	6	2	2	$1,240	–	$1,240
G.	12	4	8	$2,760	$300	$3,060

Task	Hourly Involvement*			Total Fees	Disbursements	Total
	GN @ $130	MM @ $160	Support @ $70 average			
Total≠						$13,140

* GN = Gord Nielsen

MM = Michael Michalski

Support = GIS technician, graphics, word processing, etc.

≠ Total costs are exclusive of H.S.T.

Our Team and its Experience

This work will be led by **Gord Nielsen**, M.Sc., Aquatic Biologist and President of Michalski Nielsen Associates Limited. Gord has 24 years of experience as an environmental consultant in Ontario, with the majority of that experience relating to the assessment of development related impacts on the natural environment, including water quality. Much of the focus of Gord's work is on limnology (lake-related) issues. His work has included numerous lake assessment studies, focusing on strategies to mitigate development impacts, and in particular those relating to phosphorus loadings. It has also included many additional studies involving modeling of phosphorus loads associated with various types of land use change, and development of strategies to ensure a net-neutral or better phosphorus load. This work has included extensive work with municipalities, the Ministry of the Environment, and various Conservation Authorities. It has also included working with ratepayer groups on lake management issues.

Michael Michalski will serve as a senior advisor to Gord. Michael is a limnologist who began his career, which now spans 45 years, with the Ministry of the Environment (then the Ontario Water Resources Commission), before becoming an environmental consultant. Michael's entire career has been dedicated to the resolution of lake-related issues. He was instrumental in the development of Ontario's first lake capacity model, has studied phosphorus impacts on lakes extensively, and has been a pioneer in the development of phosphorus mitigation strategies for lakes.

Gord and Michael have worked collaboratively for 20 years, providing a very experienced and effective team to assist the Township of Johnson with this issue. CV's for each are appended, together with a brief description of Michalski Nielsen Associates Limited.

References

We include a brief list of references who you may contact regarding our work on lake capacity, phosphorus modeling and phosphorus mitigation issues. In each instance, these references will be familiar with our work on many related projects, including those of somewhat smaller, similar, and much larger projects.

Mr. Victor Castro, Technical Support Section Eastern Region Ministry of the Environment (613) 540-6862 Victor.Castro@ontario.ca	• over many years, our office has worked with Mr. Castro and other members of his team on a wide variety of projects to resolve concerns relating to phosphorus loads on at-capacity or sensitive lakes.
Mr. Ted Belayneh, Group Leader, Surface Water-Water Resources Unit, Central Region Office Ministry of the Environment Ted.Belayneh@ontario.ca (416) 326-3472	• similarly, our office has worked with Mr. Belayneh and his team on a wide variety of projects involving phosphorus modeling and phosphorus mitigation strategies to reduce phosphorus loads and improve water quality.
Mr. Bob List, President List Planning Consultants (and former Director of Planning for the District of Muskoka) (705) 645-7360 list@cogeco.ca	• our office has worked with List Planning on many dozens of projects involving mitigation of phosphorus impacts on lake development projects.
Mr. David Pink, Director of Planning Township of Muskoka Lakes (705) 765-3156 dpink@muskokalakes.ca	• Our office has completed numerous Site Evaluation Reports to guide development on lakes within the Township of Muskoka Lakes which are deemed sensitive from a phosphorus perspective. The recommendations of such reports have been incorporated into many Site Plans.

* * * * *

In closing, we do hope you will consider this proposal, and that we have the opportunity to work with the Township of Johnson and the ratepayers of Desbarats Lake.

Yours truly,

MICHALSKI NIELSEN ASSOCIATES LIMITED
Per:

Gord Nielsen, M.Sc.
Aquatic Biologist
President

APPENDIX C – BACKGROUND INFORMATION ON WATERLOO BIOFILTER'S WATERLOO EC-P PHOSPHORUS REMOVAL SYSTEM

MIMICKING NATURE TO REMOVE PHOSPHORUS IN SEPTIC LEACH FIELDS

by

Craig Jowett, Yanqing Xu, Glenn Pembleton, Christopher James & Christopher Jowett

Waterloo Biofilter Systems, Rockwood ON Canada

Abstract

Iron-rich 'B-horizon' soil is formed naturally by precipitation of oxides of iron leached from the overlying 'A-horizon' soil. Reactive phosphorus dissolved in septic tank effluent passing through B-horizon soil adsorbs onto and binds chemically to surfaces of iron oxides and hydroxides. These Fe-P mixtures transform into stable iron-phosphate minerals such as vivianite and strengite, which have very low solubilities in aerobic and anoxic environments. Total phosphorus (TP) is thus removed from the hydrologic cycle, out of groundwater and adjacent surface water bodies.

In cases where soil, sand, or synthetic filtration media are used to treat septic tank effluent, but which have low to no iron content, iron can be added to the system to function as an iron-rich B-horizon soil. A novel method of mimicking iron-rich B-horizon soil formation has been developed since 2010 to remove TP in domestic leach fields that are otherwise poor in iron and therefore otherwise poor in phosphorus attenuation and removal.

Iron is dissolved into sewage at a controlled rate that is dependent on hydraulic flow, expected concentration of TP, and targeted TP effluent limit. Additional reactive iron may be added to achieve higher percent removals or to deal with higher-than-expected influent TP concentrations. The technology is abiotic and temperature independent and has no effect on pH in the system. The majority of Fe-P particulates formed are removed by biological-physical filtration in the downstream sand filter, synthetic biological filter, or soil leach field component, and are not sequestered and concentrated in the septic tank.

As well as theory and prototype testing, this paper documents actual field studies where the limits and performance of the technology have been tested:

Generic Recirculating Sand Filter;

- TP = 1.1 mg/L at lesser iron dissolution rate (82% removal) and
- TP = 0.51 mg/L at greater iron dissolution (92% removal) in the first study, and
- TP = 0.58 mg/L (91% removal) in a second study.

Conventional Soil Leach Field;

- TP = 0.11 mg/L after 12" of sandy loam soil (98% removal),
- TP = 0.05 mg/L after 24" of sandy loam soil (99% removal), and
- TP = 0.02 mg/L after 36" of sandy loam soil (>99% removal).

Residential Waterloo Biofilter;

- TP = 0.61 mg/L (96% removal).

Public School Waterloo;

- TP = 0.56 mg/L (92% removal).

Energy consumption is not significant, measured at MASSTC as 0.45 kW-hr per day for a residential size leach field. The Fe-P unit was retrofitted easily into systems not otherwise configured for TP removal, and this flexibility has significant advantages for broad use of the system in existing conventional soil leach fields in P-sensitive areas.

Introduction

Where attenuation of the nutrient total phosphorus (TP) in decentralized septic systems is required, such as around fresh water lakes and rivers, ocean reefs, and potable water source protection zones, receiving soils must be iron-rich, preferably with high aluminum and calcium contents, to adsorb and mineralize phosphorus from the wastewater (e.g., Brandes 1975; Anderson et al. 1989; Robertson et al. 1989; Barber 2002).

In certain jurisdictions in Ontario, natural B-horizon soils rich in iron are mined and brought in as imported soil fill below septic leach fields to carry out this function. As well as having to be extracted and transported long distances, the weak link in this method is that TP and Fe are separated in space; TP is in the sewage whereas Fe is in the soil. In order to precipitate insoluble minerals and remove TP from the groundwater, the Fe and TP must get close to each other to react and precipitate. There is no guarantee that phosphorus will be thoroughly removed, though, as channel-ways can form in more permeable parts of the leach field, possibly overloading the adsorptive capacity of the soil. Phosphorus will therefore by-pass much of the iron-rich soil and discharge to water bodies.

Other methods to remove TP include adding alum to the septic tank (Brandes 1976) to form a flocculent and physically separate TP from the sewage. Alternatively, sewage is passed through iron-rich slag and other reactive or adsorptive materials: many of these efforts are detailed in Hutchinson & Jowett (1997) and Heufelder & Mroczka (2006). Many adsorptive materials have a limited life span and require frequent replacement. Slag effluent is so caustic at pH = 10 – 12 that the leach field soil soon becomes plugged with calcium carbonate cements. Final replacement and disposal of the used slag or other used media is problematic.

A new technique has been developed where iron is dissolved into the sewage itself to react with the TP in the sewage. The advantage of this method is that both the TP and the Fe have already chemically bonded in fine particulate form before they enter the soil leach field. They migrate together to the filtration component and all they need to do is precipitate onto soil or sand surfaces, or onto synthetic filtration media like foam.

This paper details field research carried out since 2010 at field sites where the limits and performance of the technology have been tested, including truck stop, residential, school, and MASSTC (Buzzards Bay) test facility sand and soil filters. In all cases, the Fe-P unit was retrofitted easily into an existing system that was otherwise not configured for TP removal: this adaptability has significant advantages for broad use of the system in existing leach fields in P-sensitive areas. It can also be installed in new systems or to replace chemical dosing methods in existing systems.

Forming 'B-Horizon' Soil

B-horizon soil is formed when degrading iron silicates release Fe^{2+} ions into solution in the upper A-horizon soil, aided by decomposing organic matter (Figure 1, Table 1). The dissolved iron percolates downwards, and precipitates, primarily as oxidized ferric iron oxides and hydroxides, in the underlying B-horizon soil. Reactive phosphorus dissolved in water passing through the B-horizon soil binds chemically to iron oxides to ultimately form iron-phosphate minerals, and these reactions can be very quick (e.g., Schulte & Kelling 1996; Barber 2002). Because Fe-P minerals have very low solubility constants under both aerobic and anoxic conditions (Hansen & Poulsen 1999; Barber 2002), phosphorus below septic system leach fields is thus removed from the hydrologic cycle and kept out of groundwater and adjacent surface water bodies (e.g., Robertson 1995).

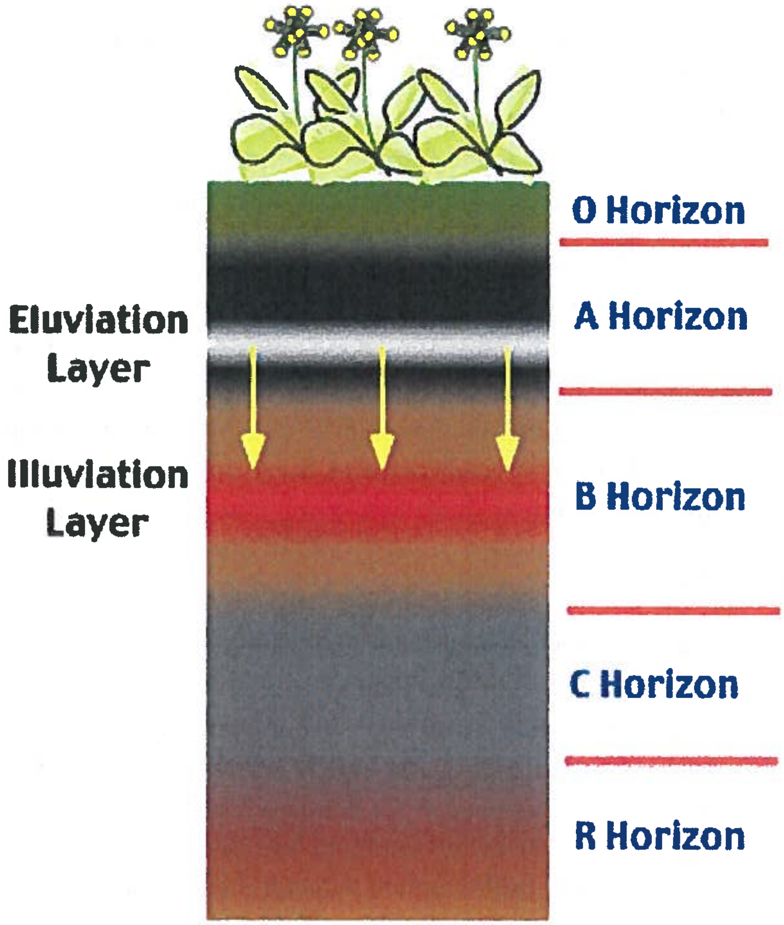


Figure 1. Schematic of soil horizons, showing dissolution of soluble components such as Fe^{2+} ions from the organic-rich A-Horizon soil to accumulate beneath to form an iron-rich B-Horizon soil (www.physicalgeography.net).

The general chemical processes of B-horizon soil formation are depicted in Table 1. Soil organics in A-horizon soil degrade to form CO_2 and thus carbonic acid ($H_2CO_3 = H^+ + HCO_3^-$), whose protons (H^+) help degrade Fe-rich silicate minerals, releasing ferrous ions (Fe^{2+}) into solution. In the more oxidizing B-horizon soil, ferrous ion is generally oxidized to ferric ion (Fe^{3+}), which is more readily precipitated as the characteristically coloured yellow, red, and brown hydroxides.

Stable, insoluble Fe-P minerals form in both aerobic and anoxic conditions, as e.g., strengite $FePO_4 \cdot 2H_2O$ in oxidizing, ferric Fe^{3+} conditions, and as vivianite $Fe_3(PO_4)_2 \cdot 8H_2O$ in reducing, ferrous Fe^{2+} conditions. Strengite has a solubility product constant $K_{sp} \approx 10^{-22}$ and vivianite has $K_{sp} \approx 10^{-36}$. These K_{sp} values are very low (compare to e.g., calcium carbonate with $K_{sp} \approx 10^{-9}$), indicating high stability of these Fe-P minerals once they precipitate (see Schulte & Kelling 1996; Barber 2002).

Table 1. General chemical processes in forming iron-rich B-horizon soil. Note that iron-phosphate minerals occur in both oxidizing (ferric Fe^{3+}) and reducing (ferrous Fe^{2+}) conditions.

Soil organics decomposition

$CH_2O + O_2 \rightarrow CO_2 + H_2O$

Generate protons or acidity

$CO_2 + H_2O \rightarrow H^+ + HCO_3^-$

Decomposition of iron-rich silicates (biotite, pyroxene, etc.)

$SiO_2\text{-}Fe^{2+} + 2H^+ \rightarrow Fe^{2+} + 2HO\text{-}Si$

Oxidation ferrous to ferric iron

$Fe^{2+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+ + e^-$

Reduction ferric to ferrous iron

$FeOOH + e^- + 3H^+ \rightarrow Fe^{2+} + 2H_2O$

Reduced Fe^{2+} species are more soluble & mobile

- *Ferrous Fe^{2+} iron leaches from topsoil leaving whitish layer with no iron*
- *Ferric Fe^{3+} iron precipitates below in B horizon*

Ferric minerals:

Goethite α-FeOOH – yellowish brown
Hematite α-Fe_2O_3 – bright red
Lepidocrocite γ-FeOOH – bright orange
Maghemite γ-Fe_2O_3 – red to brown
Ferrihydrite $5Fe_2O_3 \cdot 9H_2O$ – reddish brown
Strengite $FePO_4 \cdot 2H_2O$

Ferrous minerals:

Siderite $FeCO_3$
Vivianite $Fe_3(PO_4)_2 \cdot 8H_2O$
Pyrite FeS_2

Mimicking B-Horizon Soil Formation

A method of mimicking iron-rich B-horizon soil formation has been developed since 2010 to remove TP in domestic leach fields and filtration treatment systems. It is intended to be used with soil, sand, etc. that are poor in iron and therefore poor in phosphorus attenuation and removal.

Iron is dissolved into sewage at a controlled rate dependent on the hydraulic flow, expected concentration of TP, and targeted TP effluent limit. Reactive iron can be increased to achieve higher percent removals or to deal with higher-than-expected influent TP concentrations, or decreased if lower-than-expected influent TP is encountered. The technology is abiotic and therefore temperature independent, is largely independent of water characteristics, and has no effect on pH of the sewage or final effluent.

The iron phosphate minerals can be contained in part as septic tank solids, but the majority of Fe-P particulates are removed by biological-physical filtration in the downstream biological filters or soil leach field component.

Bench-scale testing was carried out at an Ontario truck stop to develop and optimize prototypes. Flow rates, dissolution rates, materials, and configurations were examined, resulting in the actual systems to be field-tested.

Predicting TP Removal

Several configurations of the technology were tested at an Ontario truck stop where abundant Waterloo Biofilter effluent was available. The technologies removed dissolved TP from a few cubic metres of Waterloo effluent each day, and discharged the Fe-P rich effluent to the septic tank to be re-delivered to the Waterloo. As Fe-P minerals precipitated in the Waterloo, its effluent became weaker in TP with time, from the initial TP $\approx$ 19 mg/L and to TP $\approx$ 12 mg/L near the end of the testing (Figure 2), even though only a small percentage of the total flow was being treated.

Knowing the details of the whole sewage treatment system at this facility introduced an opportunity to test another theory: that of predicting TP removal using standard laws of physics and chemistry, as outlined in Xu (2010). If the test analytical data conform to calculation using known physics and chemistry theory, the technology gains greater confidence and more general acceptance. The simulation uses actual hydraulic flow rates of influent sewage, of re-used water (this facility uses Waterloo effluent for toilets & urinals), and of water passing through the experimental systems. These data are combined with concentrations of TP in the three water types, and by using physical relationships of Fe-P chemical bonding the TP concentration in the Waterloo effluent is calculated and compared to the actual laboratory analyses (Figure 2).

In Figure 2 the energy input (solid red line) increases from the starting date of September 27 2010 to Day 112, and TP in Waterloo effluent (black dots) is thereby depleted at a rate conforming to that predicted by theory (solid purple line). This conformity confirms that known physical-chemical theory does apply, that the technology is designed and operated appropriately, and that the mass of TP removed can be predicted to a large degree.

After Day 112, the energy input (solid red line) is decreased and the predicted concentration of TP (solid purple line) increases as expected along with the actual concentration (black dots) until the end at March 7 2011. (The fluctuations seen in the solid purple line around Day 112 are due to anomalously low flows followed by a 7-fold increase in sewage volume from the facility.)

After the experiments were discontinued and energy to the system shut off on March 7 2011, the TP in the Waterloo effluent had returned to normal values of 18 – 20 mg/L by July – August 2011. The simulated theory predicted these concentrations as well, based on the flow rates and zero energy input to the TP removal system.

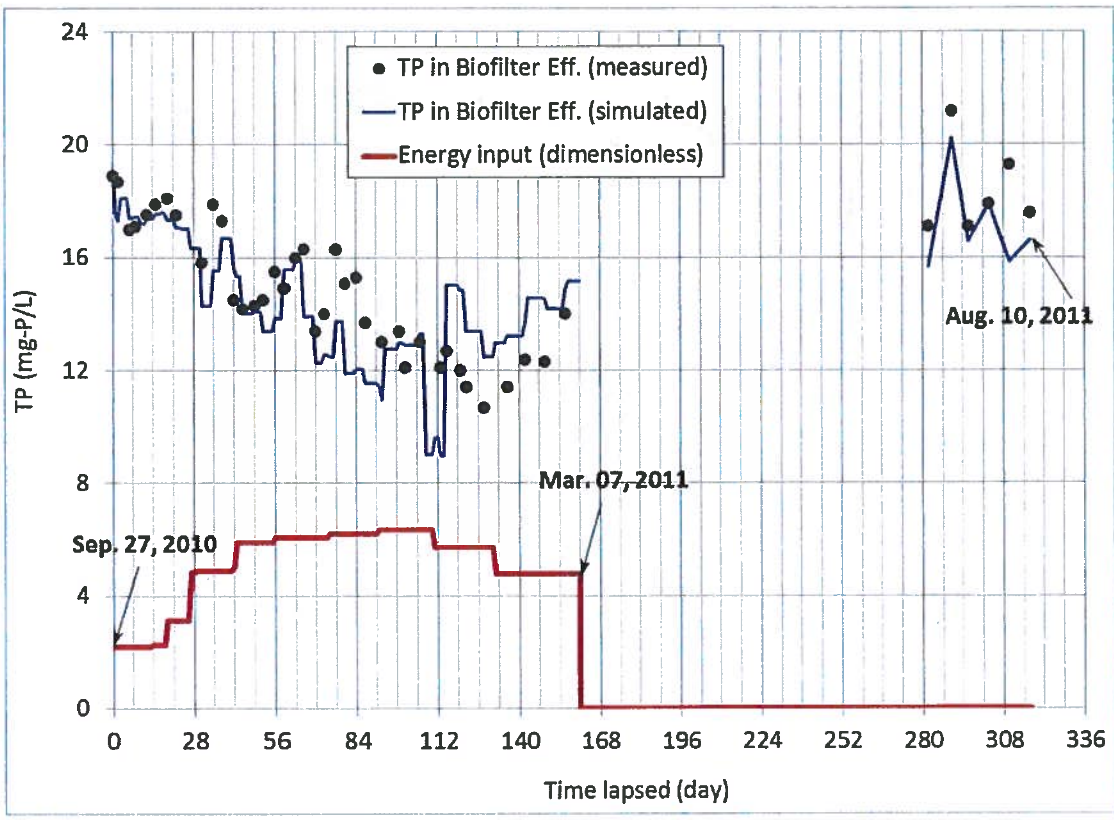


Figure 2. Theory of predictability of TP removal applied during bench-scale testing at truck stop.

ETI Recirculating Sand Filter

In a generic recirculating sand (pea gravel) filter at the MASSTC in MA (Figure 3), TP at ~6 mg/L in the prior RSF effluent is taken down to ~1 mg/L and then to ~0.5 mg/L after installation of the unit for Study 1. Red iron oxides coating the pea gravel are readily visible (Figure 4). After the unit was removed at Day 180, there was a residual 'grace period' effect over several months when additional TP was removed, presumably due to surplus Fe having accumulated in the sand filter.

In Study 3, phosphorus was successfully removed to average TP = 0.5 mg/L concentrations in the coarse sand within 4 weeks of start-up (92% removal), with average total Fe = 0.3 mg/L, lower than the influent sewage value of 1.1 mg/L.

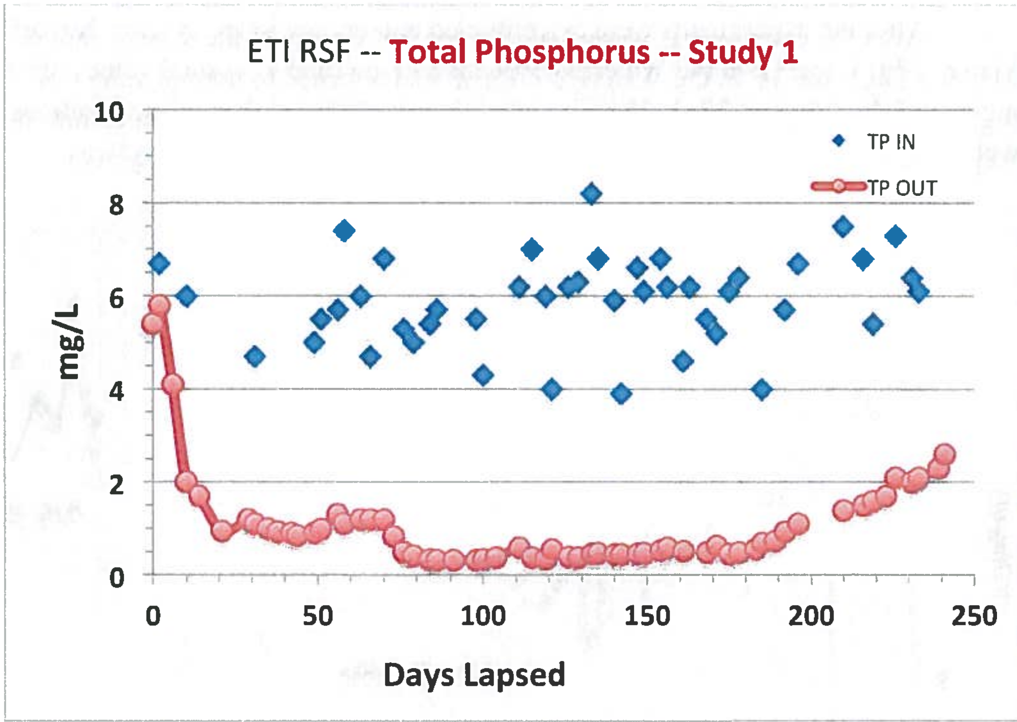


Figure 3. Study 1 TP removal in ETI re-circulating sand filter testing at Buzzards Bay test facility, MA.

Figure 4. Iron oxide scale coating on distribution pipes and on upper pea gravel in the ETI recirculating sand filter.

Residence with Waterloo Biofilter

Figure 5 demonstrates removal of TP at an Ontario residence with high-strength sewage due to water conservation measures in the house. Levels were lowered from ~18 mg/L TP in the sewage, to 2 – 8 mg/L in the septic tank, and to 0.5 – 1.0 mg/L in the Waterloo Biofilter effluent. TP in Waterloo effluent averages TP = 0.61 mg/L (~96% removal). As an experiment, iron dissolution was increased by 35%, which caused much Fe and some TP to pass through the system. After the unit was removed at Day 250, there was a residual effect of continued P removal, with septic tank effluent climbing back to its original levels, but with Waterloo effluent still below 1 – 2 mg/L.

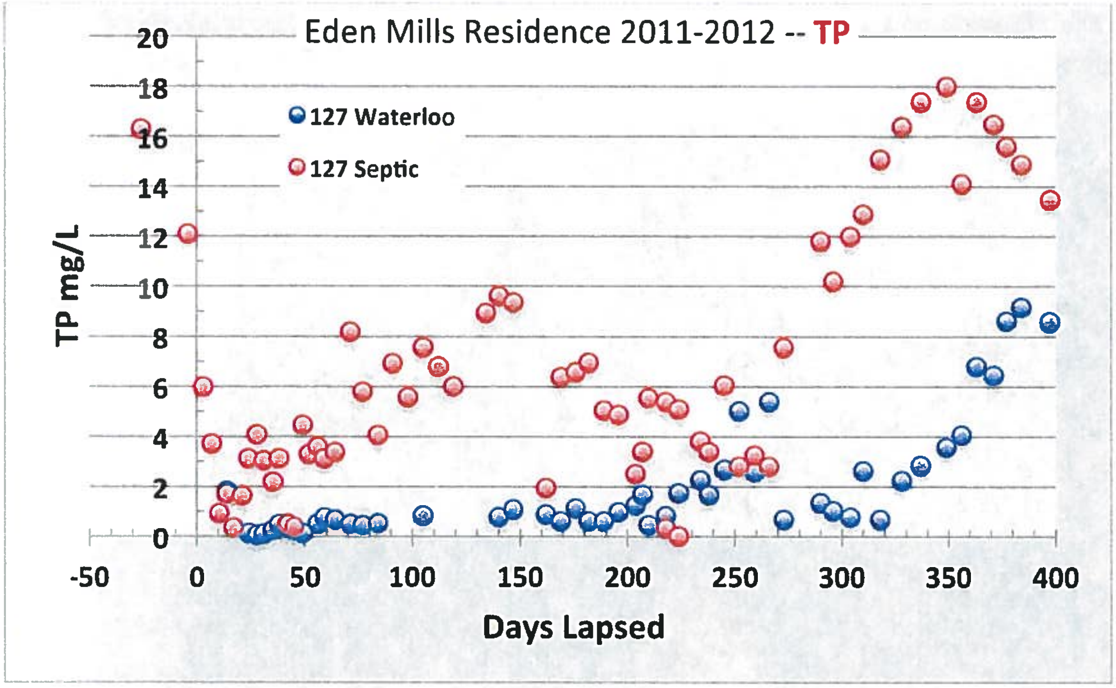


Figure 5. Removal of TP from high-strength residential sewage in Ontario.

School with Waterloo Biofilter

At an Ontario school normally in the TP = 4 – 15 mg/L range, TP is being lowered to 0.1 – 1.0 mg/L in the Waterloo Biofilter effluent as Fe-P minerals precipitate in the filtration medium (Figure 6). The average effluent is TP = 0.56 mg/L or 92% removal between raw sewage and final effluent. Total iron averages 0.41 mg/L in the effluent compared to 0.64 mg/L in the sewage, and pH averages 7.2, no change from the sewage average of 7.2. This commercial unit is also low maintenance with two cleanings in 7 months. Around Day 560, the unit disconnected by accident and the TP rose in the effluent as seen in Figure 6, after which the unit was repaired and put back into service.

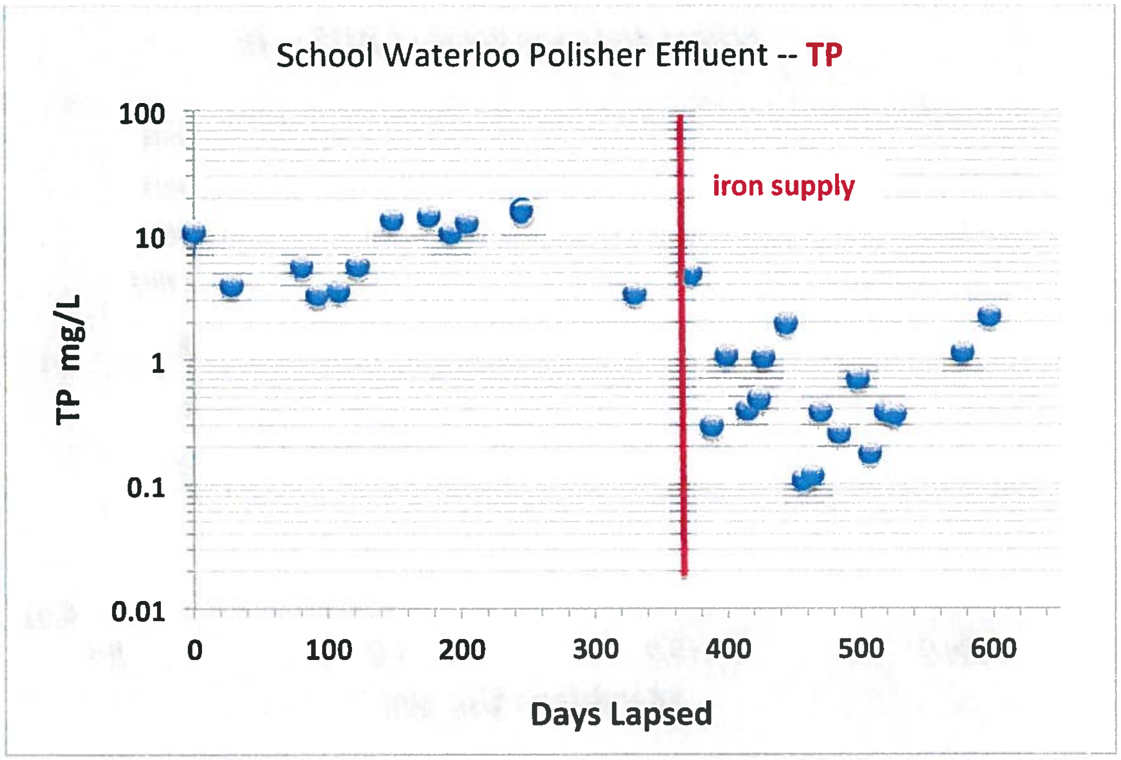


Figure 6. Ontario school with retrofitted unit installed at Day 365.

Final Waterloo Polisher effluents were filtered through membranes of pore sizes 8 µm, 2.5 µm, 0.7 µm, 0.45 µm, and 0.2 µm, and the permeate analysed for TP and total Fe (Figures 7a,b). The '100 µm' value is used for convenience as the actual unfiltered Biofilter effluent. The permeate analyses give a rough estimate of the non-particulate portion of TP that passes through the membranes.

For the Waterloo effluents (i.e., '100 µm') clustered around 0.3 mg/L TP (Figure 7a) the permeate values decrease quickly to ~0.04 mg/L TP indicating that most of the phosphorus (87%) is in particulates sized >8 µm, since there is only ~0.04 mg/L TP in the non-particulate permeate. The January 16 final effluent has a lower, 0.16 mg/L TP initial value and does not change substantially in the filtered permeate. Only about 17% of the TP is in particulates sized >8 µm, and the remainder is as non-particulates in the permeate.

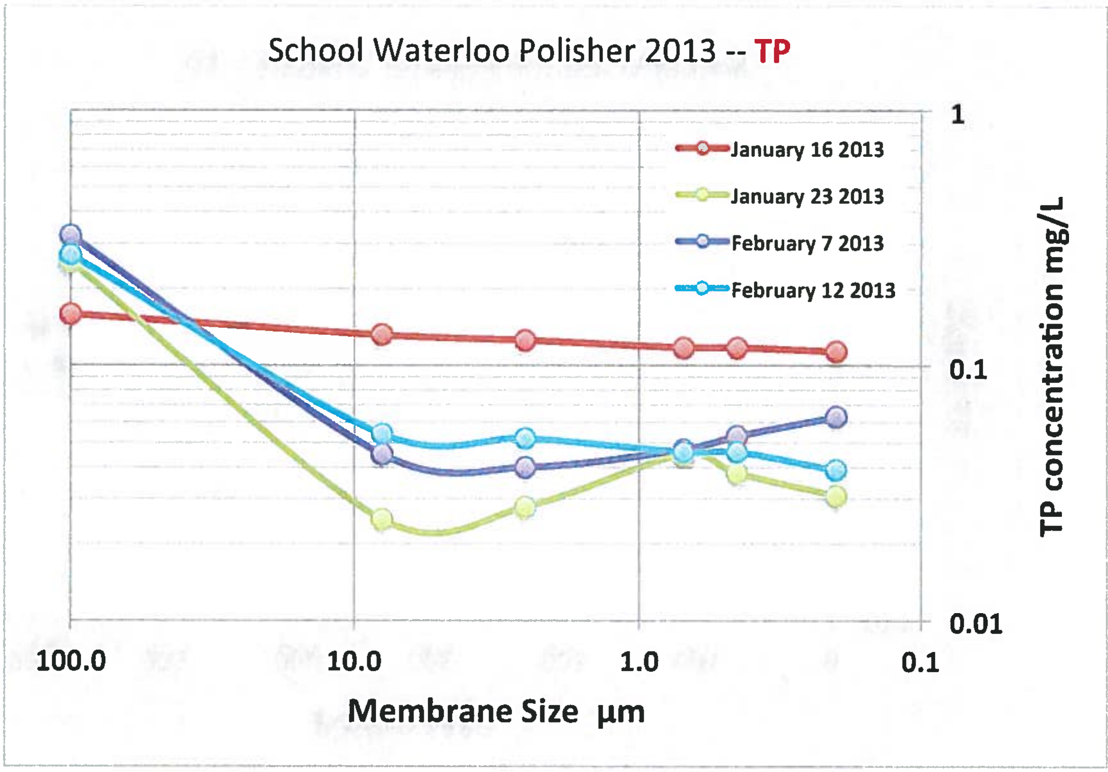


Figure 7a. Analyses of membrane permeate for particle size distribution of TP in final effluent.

Total iron in the membrane permeates shows a more regular pattern with most of the iron in particulates sized >8 µm (Figure 7b). Three of the samples at 75 – 80% of the total iron being in particulate form >8 µm, whereas the February 7 sample has the highest values and flattest curve, with only 61% of its iron in particulates sized >8 µm.

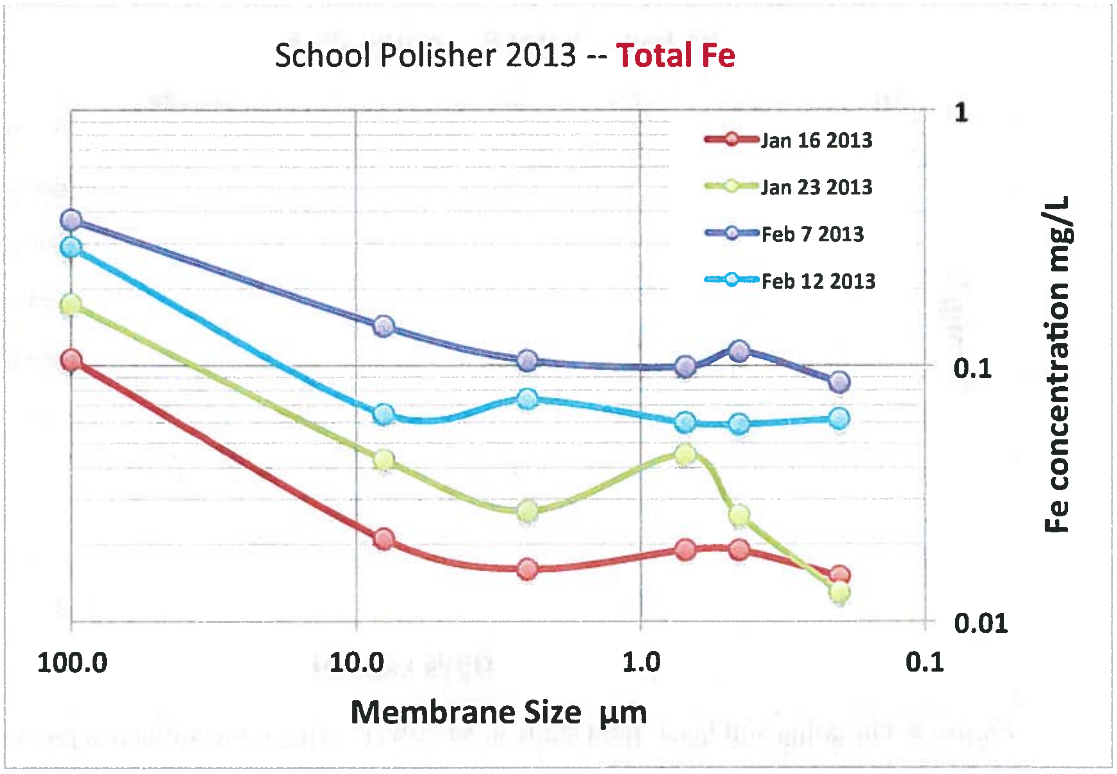


Figure 7b. Analyses of membrane permeate for particle size distribution of total Fe in final effluent.

Soil Leach Field with Septic Tank

To understand how a standard soil leach field would behave with the technology, a unit was retrofitted into an existing septic tank at MASSTC and pan lysimeters were installed at 300, 600, and 900 mm (12", 24", 36") depths within a sandy loam soil leach field. The 300 mm vertical separation is used for highly treated effluent in some jurisdictions, and the 900 mm depth is a common vertical separation to groundwater for septic tank effluent. Figure 8 shows the results of the on-going study.

TP of 6 – 10 mg/L in the sewage is being lowered to 0.5 – 0.05 mg/L with time at 300 mm depth (12") in the soil leach field and to 0.03 – 0.01 mg/L with time at 900 mm depth (36").

The soil leach field filters and precipitates out Fe-P particulates, and the septic water passing through averages 0.15 mg/L TP, 0.05 mg/L TP, and 0.02 mg/L TP with increasing depth of soil. These reflect very high percentage removals of 97.9%, 99.2%, and 99.6% respectively.

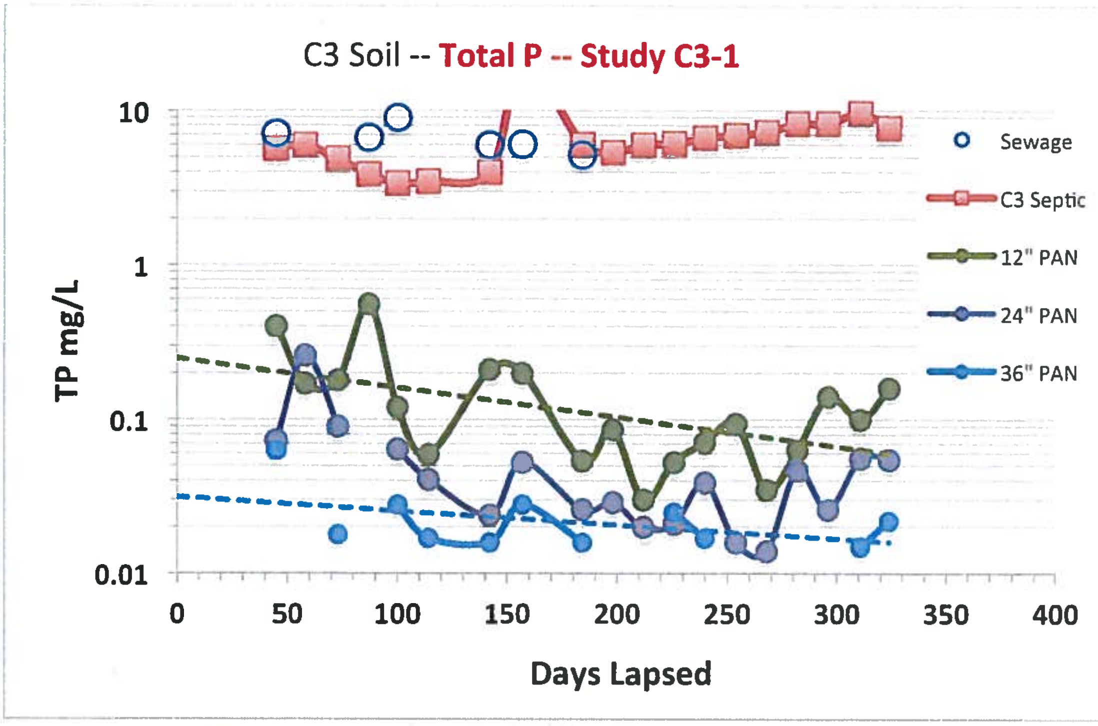


Figure 8. On-going soil leach field study at MASSTC using conventional septic tank with unit discharging to soil leach field made of 60% C33 sand and 40% sandy silt loam.

For a benchmark comparison, similar leach field tests had been carried out at MASSTC in the 24-month Environmental Technology Verification program of 1999 – 2001. The ETV soil filter used coarser C33 sand and no TP-removal system was installed. Pan lysimeter samples under the leach field revealed that only 19 – 26% TP was removed, a value likely typical in conventional residential leach fields without TP removal technology. The present study as depicted in Figure 8 reinforces the idea that otherwise poorly performing soil filters can be made into dynamic TP-removal systems simply by mimicking the function of iron rich B-horizon soils.

Conclusions

A new technology to remove TP from sewage by mimicking the formation and function of iron-rich B-horizon soil has been successfully tested at a variety of field sites and conditions. The unit is designed to remove TP by forming insoluble Fe-P mineral precipitates in a filtration component following pre-treatment like a septic tank. The following characteristics are demonstrated: low energy consumption, temperature independence, no effect on pH, and no disposal issues as with concentrated sludge or slag. Retrofitting the unit into existing conventional septic systems means that all residences close to P-sensitive water bodies can improve the TP removal from their sewage.

References

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APPENDIX D – BACKGROUND INFORMATION ON PREMIER TECH AQUA'S ECOFLOW DpEC PHOSPHORUS REMOVAL SYSTEM

Certified Phosphorus Removal Solution with no Chemical Handling for Dingle Dwellings

Mrs. Marie-Christine Bélanger
Technological Development Director
Premier Tech Aqua

February 2013

PREMIER TECH
AQUA

Content

- Context
- Summary of the Can/BNQ standard
- System tested
- DpEC System description
- Certification results
- Currently under certification
- System maintenance

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Context

- Since 2006 Quebec regulation requires treatment systems to be certified under the BNQ 3680-910
- March 2007: upon the demand of some Canadian provinces a steering committee was constituted to develop a new national certification standard for onsite wastewater treatment systems
- May 2009: the new CAN/BNQ 3680-600 standard was approved and published
- November 2012: MAH issued the new Building Code in which the Canadian standard has been adopted and requires treatment units to be certified under the CAN/BNQ 3680-600 by January 1st, 2017
- The CAN/BNQ certification protocol is actually the most stringent of the industry

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Summary of the CAN/BNQ standard

- 12 months to validate the system performance all year-round (4 seasons)
- Plant hardiness zone 3 or 4
- 2 periods of 6 months (Annexe A et Annexe B)
- Raw sewage temperature (3 options)
  - Uncontrolled
  - Minimum of 10 °C
  - Minimum of 16 °C (homes)

BNQ testing facilities in Lac St-Charles/Quebec

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Summary of the CAN/BNQ standard

Annexe A (first 6 months)

- Same testing conditions as NSF standard 40
- 26 weeks with
  - 18,5 weeks at Q design
  - 7,5 weeks with stress conditions

- Flow regime at Q design:
  - 35% of Q from 6h00 to 9h00
  - 25% of Q from 11h00 to 2 PM
  - 40% of Q from 5PM to 8 PM

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Summary of the CAN/BNQ standard

Annexe A (first 6 months)

- Flow regime 7 days/week
- Sampling days 5 days/week
- 4 stress periods
  - Stress « laundry day »: 1 week (3 days)
  - Stress « working parents »: 1 week
  - Stress « power outage »: 2 days
  - Stress « vacation »: 8 days

- Each of the stress test period is separated by a week under normal operating conditions

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Summary of the CAN/BNQ standard

Annexe A (first 6 months)

- Performance evaluation criteria
  - 30 days mean: 6 must meet compliance criteria for which the technology is tested
  - 7 days mean: 26 must meet 1,5 time the compliance criteria for which the technology is tested

Annexe B (second 6 months)

- Minimum of 30 sampling days during this 6-month period
- 1 sampling day/week except during the 13^{e} and 26^{e} week during which sampling is performed on 3 consecutive days

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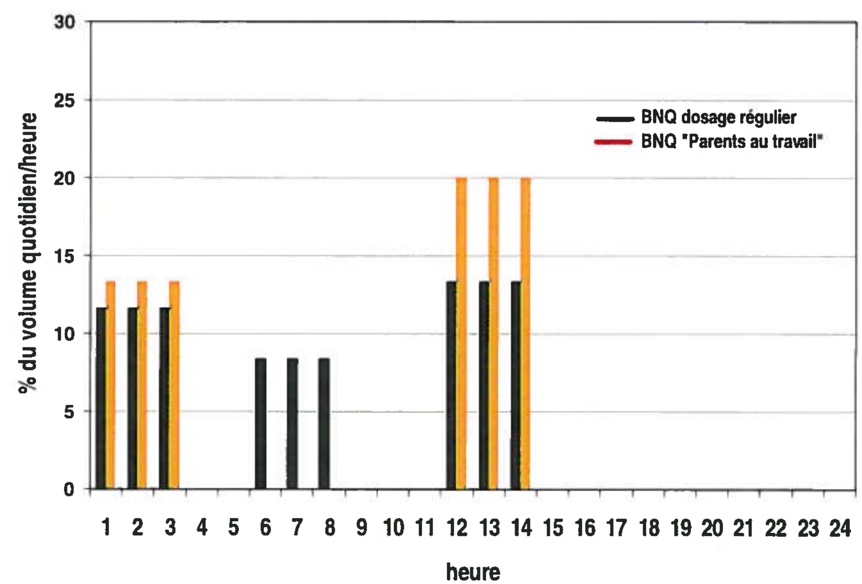
Summary of the CAN/BNQ standard

Annexe B (second 6 months)

- Flow regime: Only working parents

DAY	TIME PERIOD	Daily flow capacity
Monday to Friday	6h - 9h	40% daily flow
	17h - 20h	60% daily flow
Saturday & Sunday	6h - 9h	35% daily flow
	11h - 14h	25% daily flow
	17h - 20h	40% daily flow



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Summary of the CAN/BNQ standard

Treatment classes

Treatment classes	Basic level (B)*	
	TSS	$CBOD_5$
B-I	100	150
B-II	30	25
B-III	15	15
B-IV	10	10

* In mg/L

Treatment classes	Disinfection (D) UFC/100 mL	Phosphore (P) mg/L	Nitrogen (N)
	FC ou E. Coli*	P total	N total
D-I	50 000		
D-II	200		
D-III	ND (median < 10)		
P-I		1,0	
P-II		0,3	
N-I			50%
N-II			75%

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DpEC Self-Cleaning • Phosphorus Removal Unit

BNQ
Bureau de normalisation du Québec

Le BNQ est membre du Système national de normes (SNN)

CERTIFICAT DE CONFORMITÉ

Date d'expiration : 2014-10-31

N° du certificat : 1338
N° de la norme : CAN/BNQ 3680-600/2009-05-01
N° du protocole de certification : BNQ 3680-900/2009-05-15

Le Bureau de normalisation du Québec, ayant reconnu la conformité des systèmes de traitement autonomes des eaux usées résidentielles :

- DpEC (classes B-I et P-I)
- DpEC + Biofiltre Ecoflo (classes B-IV, P-II et D-I)
- DpEC + Biofiltre Ecoflo + lampe UV (classes B-IV, P-II et D-III)

(voir l'annexe au certificat pour une description complète des modèles à utiliser)

ainsi que l'aptitude du détenteur à fabriquer ces produits conformément aux exigences de la norme et du protocole de certification, délivre le présent certificat à :

PREMIER TECH TECHNOLOGIES LIMITÉE
(PREMIER TECH AQUA)

1, av. Premier, Rivière-du-Loup (Québec) G5R 6C1

Le présent certificat est délivré selon les règles précisées dans le document BNQ 9902-001. En foi de quoi, ont signé à Québec, le 11 octobre 2012.

Directeur du BNQ

Responsable de programme
Certification

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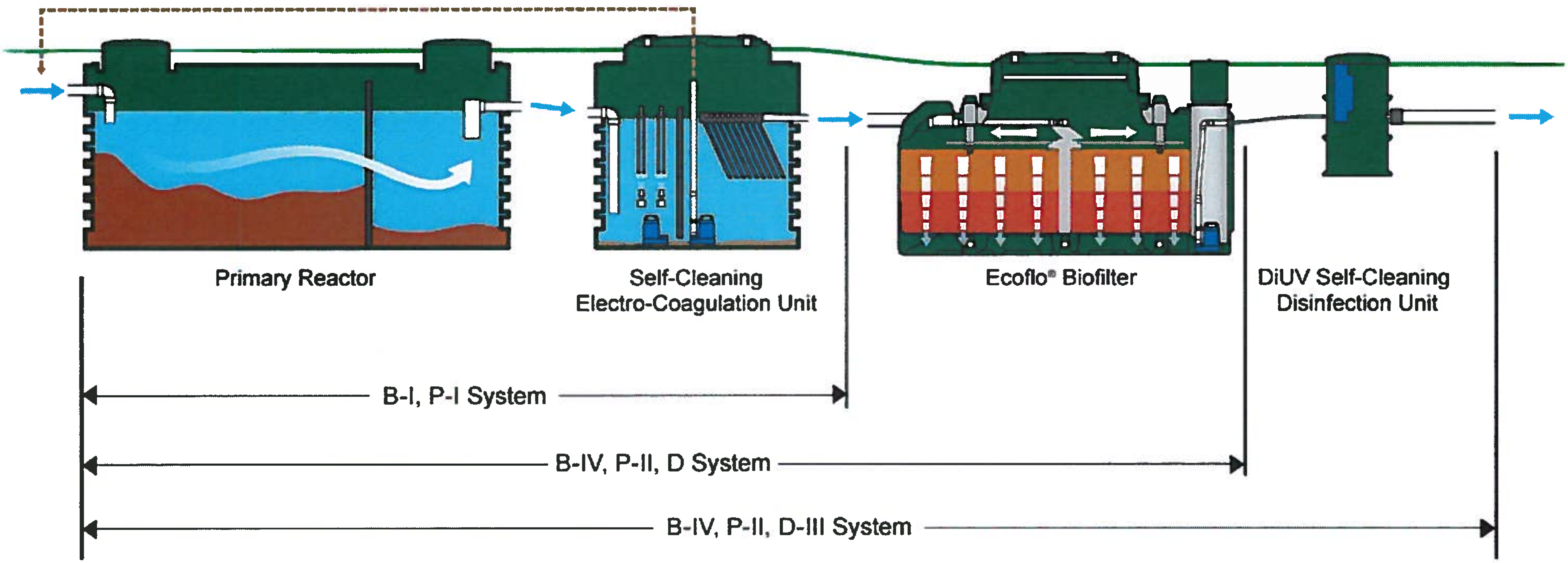
System tested



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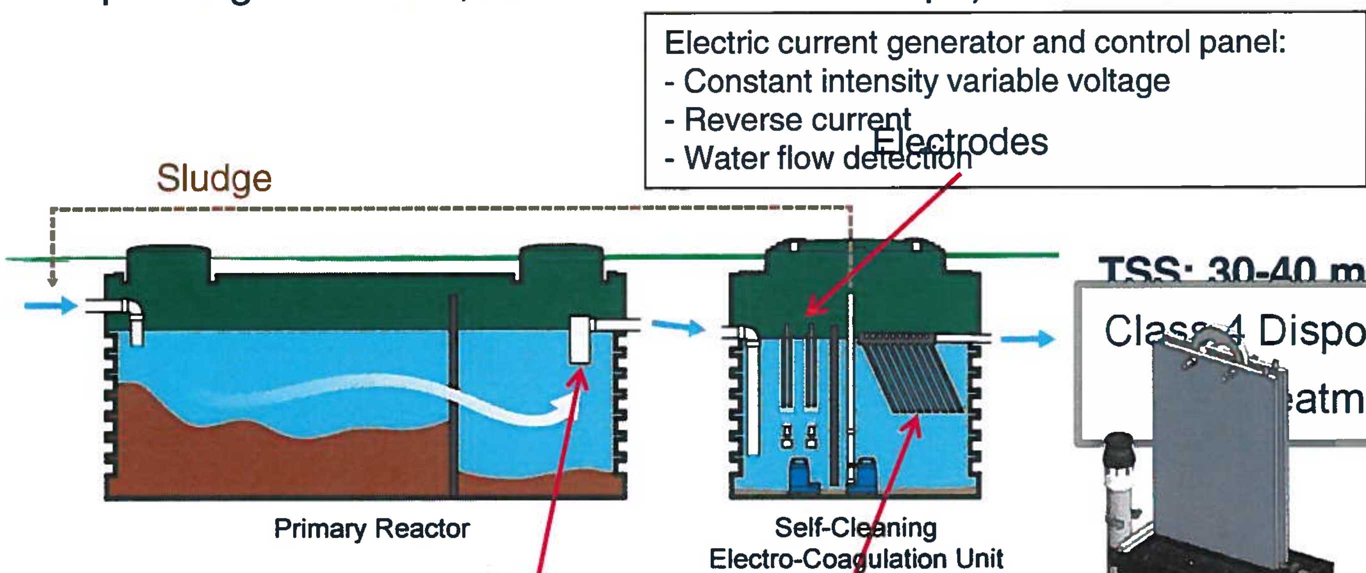
System description

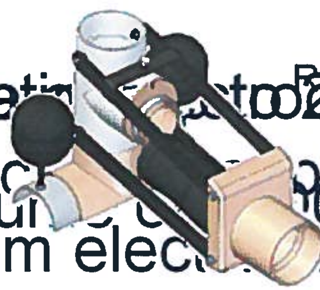
- Phosphorus removal unit using electrocoagulation
  (Patent pending in Canada, United States and Europe)



TSS: 30-40 mg/l

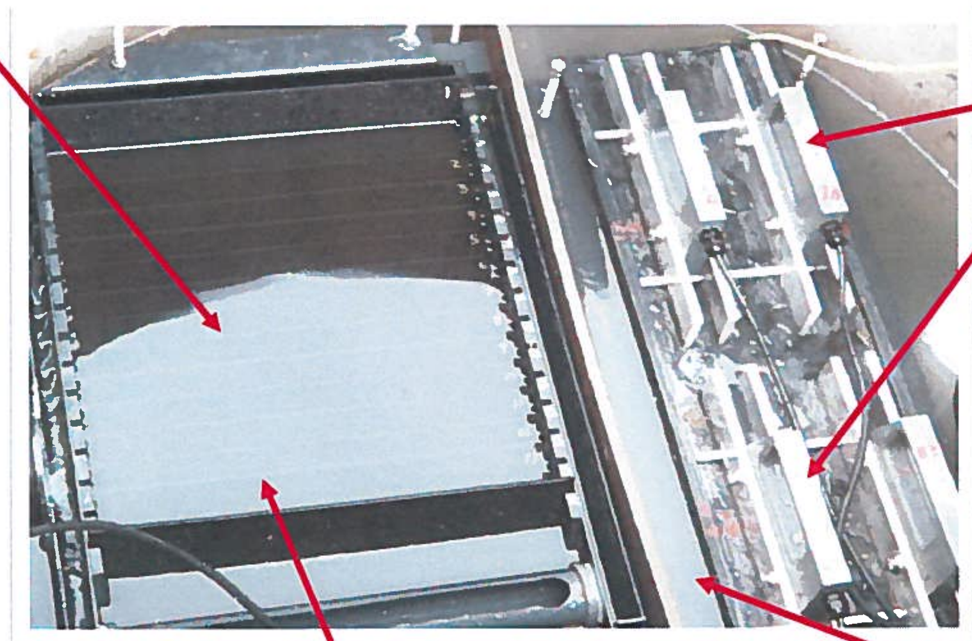
Class 4 Disposal Systems
...atment units

- Unit ... electrocoagula... electric c... plied bet... aluminum elec...es
- Unit volu... 0 liters, ... s... nk



PREMIER TECH AQUA

System description



System caracteristics

- Easy to operate – does not require any specific intervention
- No stocking and handling of chemical products
- None or limited impacts on pH
- Less sludge production (75% less than conventional chemical addition)
- Continuous self-cleaning of the electrodes (preventing passivation/ coating)
- Separation of the flocs (solids) by lamellar decantation
- Operates on-demand only

PREMIER TECH AQUA

Certification results

- CAN/BNQ results : Primary Reactor performance combined to EC Unit

Parameters	APR	ECE[1]	Removal
TSS (mg/L)	231 ± 65	**33 ± 23**	86 %
$CBOD_5$ (mg/L)	188 ± 63	**53 ± 23**	72 %
P total (mg/L)	5,1 ± 1,7	**0,4 ± 0,4**	92 %
FC (log)	6.4 (2 272 815)	**4.8 (62 773)**	1.6
pH	8,0	**8,2**	s. o.
n	159	**159**	s. o.

[1] ECE : Electrocoagulation Unit Effluent

PREMIER TECH AQUA

Certification results

- CAN/BNQ results : Primary Reactor performance combined to EC Unit and Ecoflo Biofilter

Parameters	APR	BFE[1]	Removal
TSS (mg/L)	231 ± 65	**2 ± 2**	99,5 %
$CBOD_5$ (mg/L)	188 ± 63	**2 ± 0,1**	98,6 %
P total (mg/L)	5,1 ± 1,7	**0,1 ± 0,1**	99 %
FC (log)	6.4 (2 272 815)	**2.3 (224)**	4.1
pH	8,0	**7,5**	s. o.
n	159	**159**	s. o.

[1] BFE : Ecoflo Biofilter Effluent

PREMIER TECH AQUA

Certification results

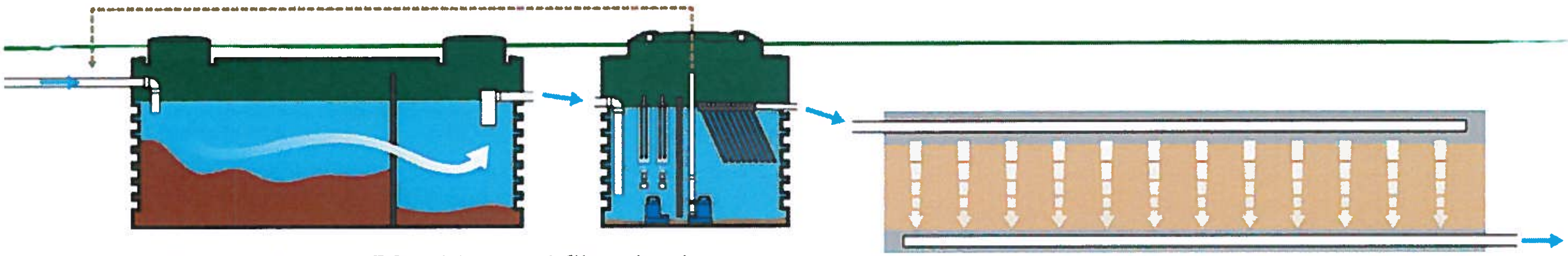
- CAN/BNQ results : Primary Reactor performance combined to EC Unit, Ecoflo Biofilter and DiUV Self-Cleaning

Parameters	APR	BFE[1]	Removal
TSS (mg/L)	231 ± 65	**2 ± 2**	99,5 %
$CBOD_5$ (mg/L)	188 ± 63	**2 ± 0,1**	98,6 %
P total (mg/L)	5,1 ± 1,7	**0,1 ± 0,1**	99 %
FC (log)	6.4 (2 272 815)	**<0.3 (<2)**	> 6
pH	8,0	**7,5**	s. o.
n	159	**159**	s. o.

[1] BFE : Ecoflo Biofilter Effluent

PREMIER TECH AQUA

Currently under certification



Self-Cleaning DpEC with sand filter bed

Objectives: BIV, PII, DIII system

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Comparative preliminary results

- PTA Experimental Plateform (over 12 months of testing):
  - DpEC+ Ecoflo
  - DpEC + Sand Filter Bed

Parameters	APR	BFE[1]	SFBE[2]	Removal
TSS (mg/L)	199 ± 64	**3 ± 2**	**2 ± 1**	98-99 %
$CBOD_5$ (mg/L)	207 ± 53	**1 ± 1**	**2 ± 2**	99 %
P total (mg/L)	9,7 ± 2	**0,1 ± 0,1**	**0,1 ± 0,1**	99 %
FC (log)	5,8	**2,4**	**0,3**	5,5
pH	7,2	**7,2**	**7,4**	s. o.
n	43	**43**	**43**	s. o.

[1] BFE : Ecoflo Biofilter Effluent

[2] SFBE : Sand Filter Bed Effluent at a design rate of 50 $L/m^2.d$

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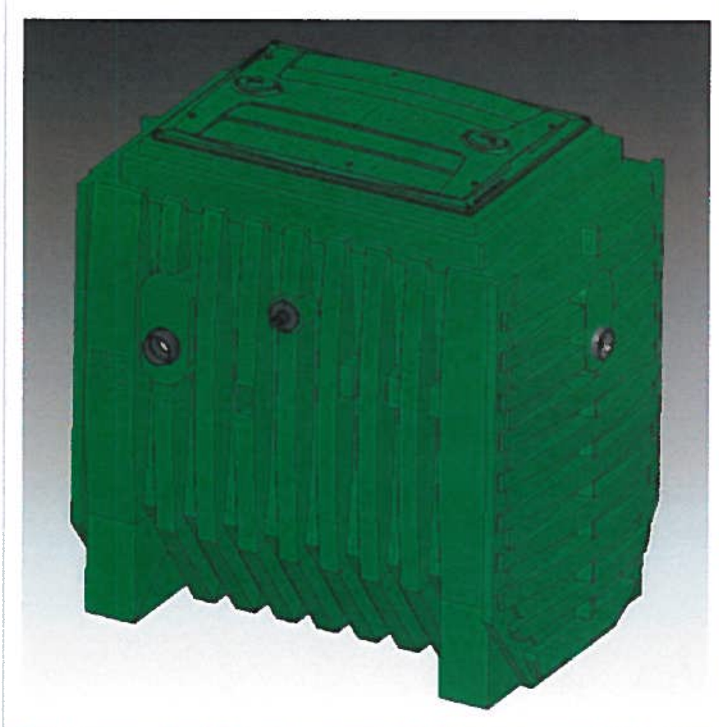
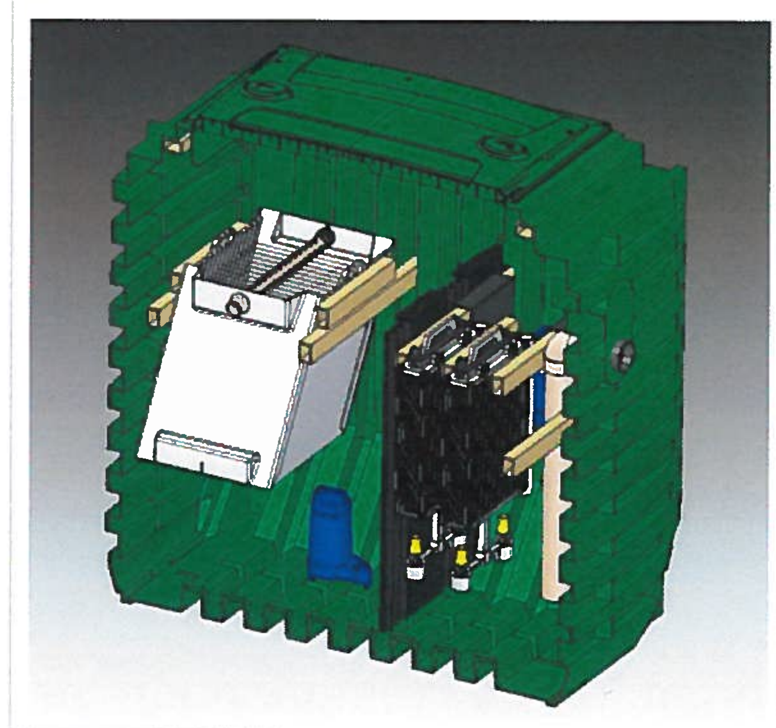
EC unit





Monthly Fees Associated with the System

Electricity and replacement of electrodes

$20 to $30 / month (3,650 hours)

$12 to $15 / month

<$10 / month

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System maintenance

- Inspection visits (per local regulation)
- Electrodes replacement frequency: