Hutchinson
Environmental Sciences Ltd.

North Bay – Mattawa Conservation Authority

Callander Drinking Water Source Protection Technical Studies Update

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HESL Project Number: J100011

May 5, 2010

HESL

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May 5, 2010

Ms. Sue Miller
Manager Source Protection
North Bay-Mattawa Conservation Authority
15 Janey Ave.
North Bay, ON P1C 1N1

Dear Ms. Miller:

Re: J100011 – Callander Drinking Water Source Protection Technical Studies Update

Hutchinson Environmental Sciences Limited (HESL) is very pleased to present to the North Bay-Mattawa Conservation Authority this final report that provides updates to the technical studies previously completed by AECOM in their report entitled *Drinking Water Source Protection for the Municipality of Callander – Surface Water Vulnerability and Threats Evaluation* (May 15, 2009). Revisions to these technical studies were required to:

1. Meet the requirements of the MOE's Technical Rules that were amended November 16, 2009,
2. Account for the confirmed location of the drinking water intake, which was determined to be approximately 300 m from the estimated location used in the AECOM (2009) report, and
3. Address microcystin (toxin produced by cyanobacteria) as a drinking water issue following new direction provided by the MOE.

These revisions have resulted in changes to several key components of the technical input for the Assessment Report for Drinking Water Source Protection Planning under the *Clean Water Act* (2006), namely the delineation of the vulnerable areas (intake protection zones, IPZs) and transport pathways, the vulnerability scoring for the IPZs, the identification of drinking water issues and the evaluation of drinking water threats.

The following report consolidates all applicable information that was contained in the AECOM (2009) report and the results of new technical work completed by HESL. It therefore represents the final surface water vulnerability assessment for input to the Drinking Water Source Protection Assessment Report for the Callander municipal drinking water intake.

We thank the North Bay-Mattawa Conservation Authority for providing us with the opportunity to continue our work on this most challenging project and would be pleased to provide consulting services in support of future endeavours of the authority.

Sincerely,
HESL

T. KR

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TKR:tkr

Distribution List

Date	*Report distributed to:*
22 March 2010	Sue Miller, NBMCA
05 May 2010	Sue Miller, NBMCA

Revision Log

Date	*Revised by:*	*Comments/Revisions*
4 March 2010	TKR	Consolidation of AECOM (2009) draft report and HESL (February 20th, 2010) draft report, inclusion of issue contributing threats, mapping revisions
22 March 2010	TKR	Evaluation of agriculture-related activities as significant drinking water threats, evaluation of sewage holding tanks and fuel tanks on the Chief Commanda as drinking water threats
05 May 2010	TKR	Revised mapping and report edits based on NBMCA and TAC comments

Signatures

T. KR

Tammy Karst-Riddoch, Ph.D.
Senior Aquatic Scientist

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1. Introduction

As part of its strategy to protect Ontario's drinking water from source to tap, the Ontario government has released legislation under the *Clean Water Act* (2006) requiring the creation of source protection plans for all municipal drinking water sources. These plans identify potential risks to drinking water quality and supply, and provide strategies to reduce or eliminate these risks.

In January 2010, the North Bay-Mattawa Conservation Authority retained Hutchinson Environmental Sciences Ltd. (HESL) to update and finalize the drinking water source protection technical studies for the Municipality of Callander drinking water intake that were completed in draft form by AECOM (report dated May 15th, 2009). Revisions to the technical studies completed by HESL were presented to the Callander Bay Technical Advisory Committee at a meeting held February 26th, 2010 (minutes from the meeting are provided in Appendix A).

The following report represents the final consolidated technical works as input for the completion of an Assessment Report for the Municipality of Callander, a key part of the source protection planning process. The purpose of the Assessment Report is to identify and assess risks to the quality and quantity of municipal drinking water sources using a watershed-based approach. Technical information provided in the following report follows the rules set out in the Assessment Report: Technical Rules (December 12th, 2008) as amended November 16, 2009 under the *Clean Water Act* (2006) for the completion of an assessment report and includes the following:

- Intake characterization
- Intake protection zone (IPZ) delineations
- Vulnerability scoring for the IPZs
- Uncertainty analysis of the IPZ delineations and associated vulnerability scores
- Drinking water issues evaluation
- Threats identification
- Gap analysis and recommendations

2. Intake Characterization

2.1. Water Treatment Plant (WTP) and Intake Characteristics

The water treatment plant (WTP) for the Municipality of Callander is located on Part Lot 2, Concession 26 in the Township of North Himsworth (UTM 17 626356 E, 5119821 N)[1] (Figure 1). The plant is owned by the Municipality of Callander and is operated by the Ontario Clean Water Agency (OCWA). It is a Class 3 facility with a design capacity of 3,000 m^3/day (Amended Certificate of Approval 2214-5JASJC, February 7, 2003) and services a population of approximately 1,400 (according to the 2007 Monthly Data Process Report, OCWA). The plant was designed and constructed by Kenaiden

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[1] *UTM coordinates taken from the MOE Inspection Report, March 21, 2005*

Contracting Ltd. and R.V. Anderson Associates and came online in April 1995. Details of the design are described in the Design Summary (Kenaiden Contracting Limited, November 1994) and are further summarized by RAL Engineering Limited's Engineers' Report for Water Works prepared for the Township of North Himsworth (January, 2001) (Appendix B).

The surface water intake is a Type D intake as it is a surface water intake that draws water from and inland lake (Part VI.1, subrule 52). Water is drawn from Callander Bay of Lake Nipissing via the intake pipe, which extends approximately 1,000 m from the shoreline into the bay (46° 12' 50.0'' N; 79° 22' 23.5" W) and submerged at a depth of approximately 8 m as confirmed by Soderholm Maritime divers on October 15th, 2009 (Figure 1)[2].

The intake pipe is 400 mm in diameter and is fitted with an inner 40-mm diameter polyethylene tube and diffuser for possible future zebra mussel control. Treatment of the raw water includes filtration, coagulation, sedimentation and disinfection by chlorination. There is presently one Granulated Activated Carbon (GAC) gravity flow filter to treat for taste and odour problems caused by algae in Callander Bay. A second filter is scheduled for installation in the spring of 2010 subject to MOE approvals and OCWA scheduling of the work. Backwash from the wastewater is decanted to the storm sewer and sludge is pumped to the sanitary sewer.

Based on available flow data from 2001 to 2007, water demands average 400 m^3/day with a maximum demand of approximately 844 m^3/day that represents only 28% of the rated capacity for the plant (3,000 m^3/day) (Table 1). Daily flows vary over the course of the year with average peak demands in the summer months (Figure 2), but average daily flow rates appear to be increasing since 2001.

The response time to shut down the plant should a problem be identified is between 1 to 2 hours (John Hemingway, OCWA, pers. comm., August 2007). This is an estimate based on the approximate time for an operator to be notified and to travel to the plant if an emergency occurs outside of the hours of operation of the plant. If an emergency necessitating shut down occurs while personnel are present at the plant, the time to shut down is only a few minutes (OCWA, pers. comm., September 2007).

There is one elevated water storage tank (standpipe) (UTM 17 577823 E, 5135834 N) with a capacity of 2,272 m^3, providing water reserves for approximately 3 days at maximum daily flow demands or 6 days at average daily flow demands (calculations based on flow data for 2006).

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[2] *Actual confirmed coordinates of the intake location are approximately 300 m away from the reported location provided in the MOE Inspection Report, March 21, 2005 at UTM 17 625420 E, 5119225 N*

Table 1. Water Demands for the Callander WTP

Year	Average Daily Flow (m^3/day)	Maximum Daily Flow (m^3/day)	Maximum % of Rated Capacity
2001	352	810	27
2002	344	611	20
2003	376	720	24
2004	-	803	27
2005	-	-	-
2006	451	1024	34
2007[a]	476	1098	37
Mean	***400***	***844***	***28***

[a] values for January 1 to July 31, 2007

FIGURE 1
Location of the North Himsworth Water Treatment Plant Servicing Town of Callander

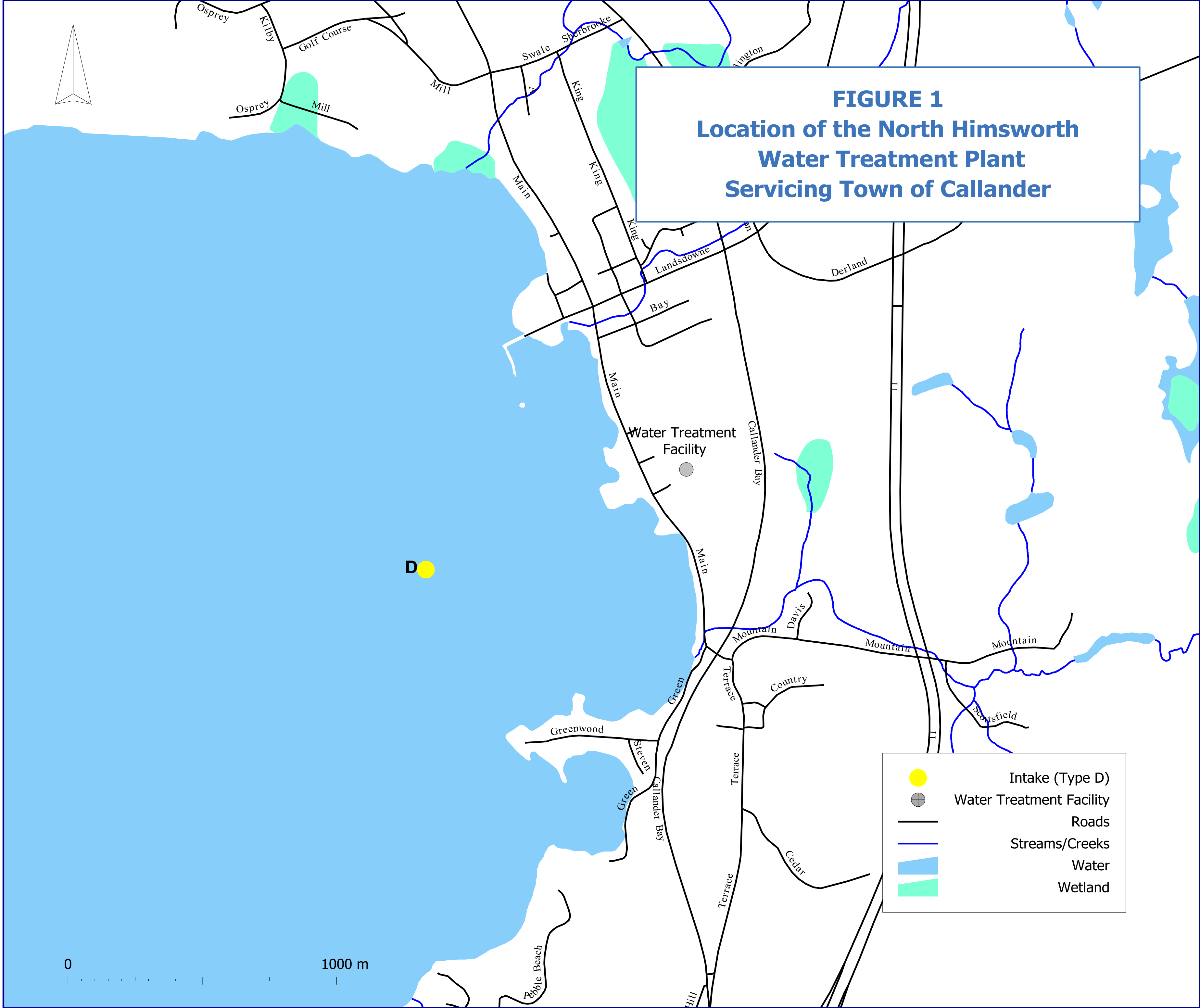
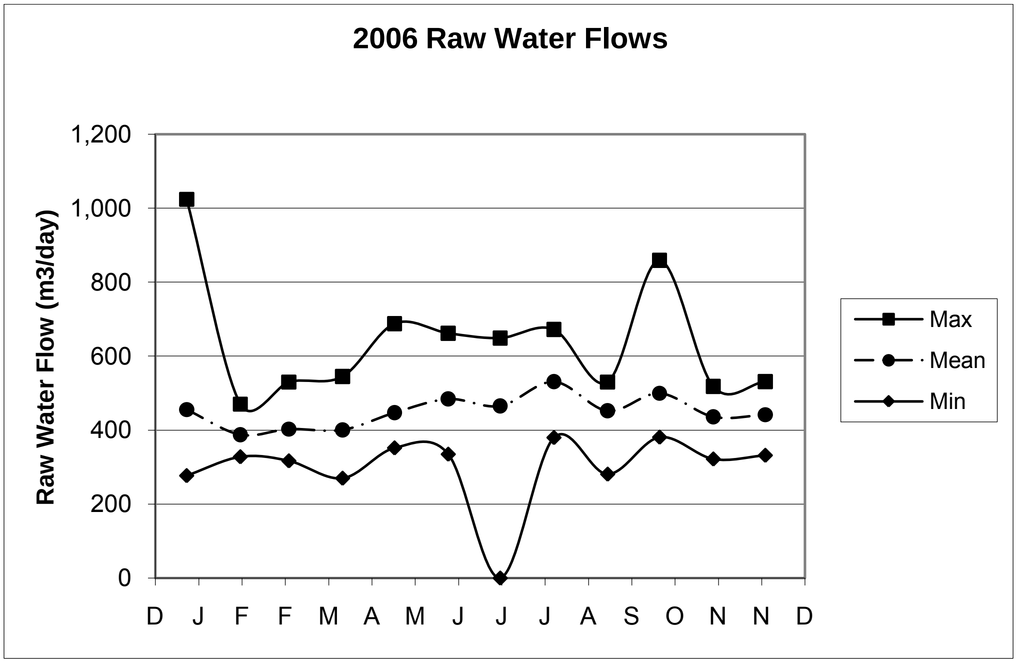


Figure 2. 2006 Monthly Raw Water Flows



2.2. Hydrodynamics/Hydrological Conditions

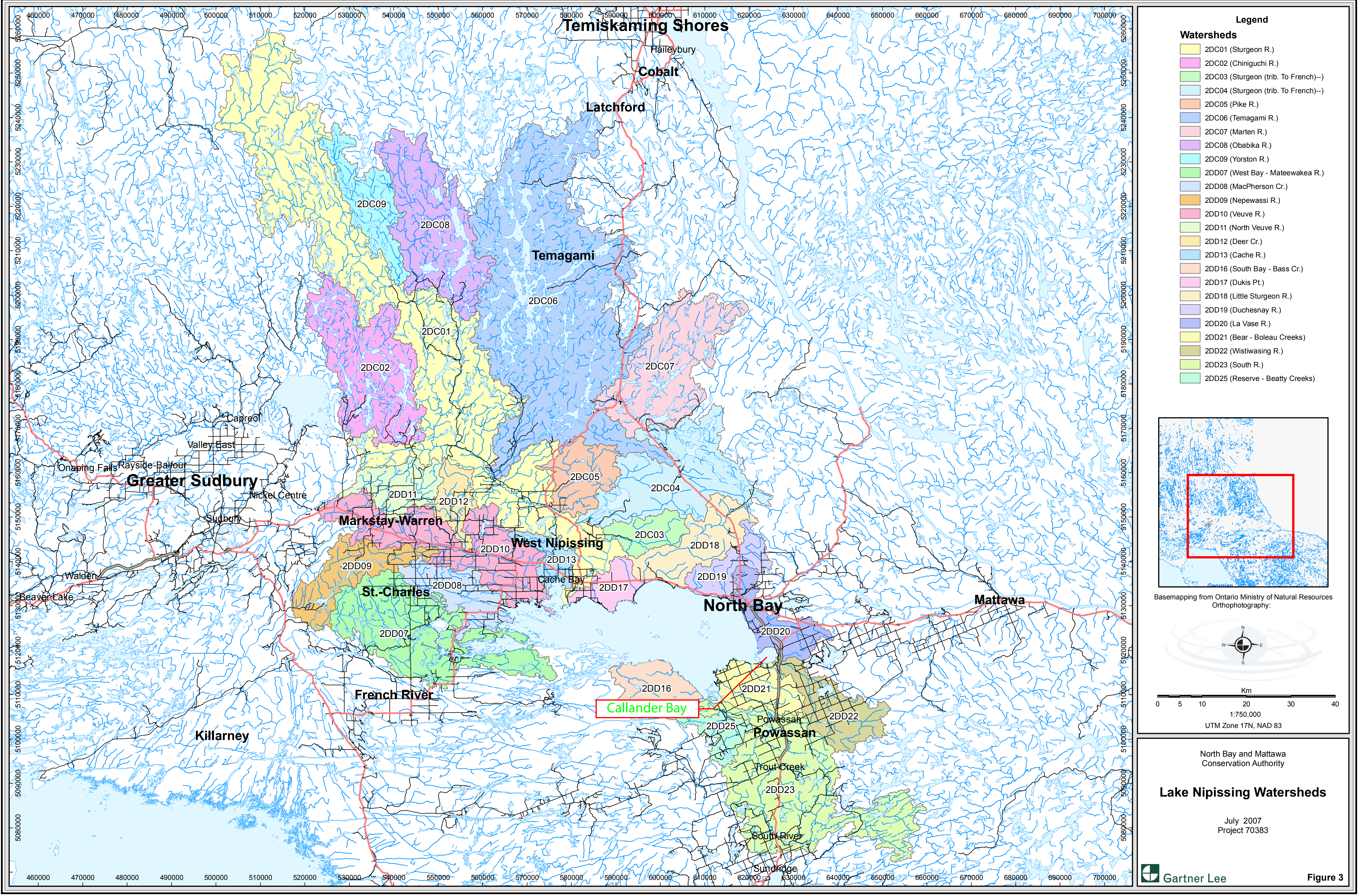
Lake Nipissing, the drinking water source for the Town of Callander, is the fourth largest lake in Ontario with a surface area of 874 km^2. The watershed area is large (12,047 km^2) with drainage from 26 Quaternary watersheds (Table 2; Figure 3).

Lake Nipissing is shallow, with water depths mostly less than 10 meters and exceeding 20 meters only near the outflow of the lake to the French River. Given the shallow nature of the lake and long fetch of approximately 60 km, the water column is easily mixed to the bottom by wind and wave action preventing thermal stratification. Thermal stratification has been observed, however, at a deep (40 m) sampling location near Campbell's Point located near the outflow to the French River based on a water quality survey by the MOE in 1990 (Neary and Clark, 1992).

Water levels in Lake Nipissing are controlled by three dams near the headwaters of the French River: the Big Chaudière Dam, Little Chaudière Dam and Portage Dam. The dams are owned and operated by the Government of Canada. In October, after Thanksgiving weekend, waters are released from the French River dams to lower lake levels by approximately 1.3 m (~1 cm/day until March 15) in order to accommodate spring runoff (Phil Hall, MNR North Bay, Pers. comm.). The summer operating level for Lake Nipissing is 195.75 m a.s.l., however water levels can fluctuate up to half a meter during the open water season due to precipitation patterns (PWGSC, 2007).

Table 2. Quaternary Watershed Areas of Lake Nipissing

Name	Watershed Quaternary	Area(km^2)
Bear – Bolder (Bear-Boleau) Creeks	02DD21	178
Cache R.	02DD13	93
Chiniguchi R.	02DC02	589
Deer Cr.	02DD12	116
Duchesnay R.	02DD19	140
Dukis Pt.	02DD17	101
La Vase R.	02DD20	184
Lake Nipissinq	02DD28	959
Little Sturgeon R.	02DD18	257
MacPherson Cr.	02DD08	212
Marten R.	02DC07	529
Nepewassi R.	02DD09	248
North Veuve R.	02DD11	184
Obabika R.	02DC08	574
Pike R.	02DC05	200
Reserve - Beatty Creeks	02DD25	103
South Bay - Bass Cr.	02DD16	185
South R.	02DD23	829
Sturgeon (trib. To French)--	02DC04	551
Sturgeon (trib. To French)--	02DC03	123
Sturgeon R.	02DC01	2,132
Temagami R.	02DC06	1,965
Veuve R.	02DD10	513
West Bay - Mateewakea R.	02DD07	596
Wistiwasing (Wasi) R.	02DD22	236
Yorston R.	02DC09	251
Total		1,2047



North Bay and Mattawa
Conservation Authority

Lake Nipissing Watersheds

July 2007
Project 70383

Gartner Lee

Figure 3

The drinking water intake is located in Callander Bay, a relatively isolated bay connected to the extreme east end of Lake Nipissing via three channels. These include the North (between the north shore and Grand Trunk Island), Centre (between Grand Trunk Island and Smith Island) and Main (between Smith Island and the south shore) channels. Only 3 of the 26 Lake Nipissing Quaternary watersheds drain to Callander Bay, including the Wistiwasing (Wasi) River watershed and portions of the La Vase River and Bear-Bolder (formerly the Bear-Boleau) Creeks watersheds (Figure 3).

There are six tributaries that drain to Callander Bay, including Windsor Creek that drains part of the Bear-Boulder Creeks watershed, the Wistiwasing River, and Burford Creek and 3 unnamed tributaries that drain portions of the La Vase River watershed.

A hydrological study performed in October 1993 determined that the dominant flow in the Main Channel connecting Callander Bay to Lake Nipissing is toward the main basin of the lake (Northland Engineering Limited 1993) (Table 3). These flows were observed to be greatest coincident with the lowering of Lake Nipissing water levels to accommodate spring runoff inputs, but also with a high wind event that occurred on October 21st. It is unlikely, however, that lowering of Lake Nipissing during the sampling interval of the study resulted in the elevated flows because water levels are only lowered by approximately 1 cm per month beginning in October. It is more likely that the high wind event, potentially in combination with a seiche[3] on Lake Nipissing, caused the high flow. Frequent, but minor flow reversals into Callander Bay via the Main Channel appear to occur as a result of seiche events on the main basin of the lake (Northland Engineering Limited 1993). These findings indicate that there is only limited mixing of waters from the main basin of Lake Nipissing with waters in Callander Bay. This conclusion is also supported by water quality characteristics of the bay that are distinct from those of the main lake (Neary and Clark, 1992; Section 2.3).

Table 3. Water Currents in Callander Bay, October 1993 (from Northland Engineering, 1993)

Parameter	Units	Main Channel	North Shore	East Shore
Latitude	N	46° 12’ 04”	46° 13’ 34”	46° 13’ 05”
Longitude	W	79° 25’ 00”	79° 23’ 18”	79° 22’ 17”
Resultant Current	cm/s	0.92	0.53	0.30
Resultant Current Direction	° from Magnetic North	276	337	221
Mean Current Speed	cm/s	2.52	2.35	2.02
Maximum Current	cm/s	20.0	15.4	14.9
Minimum Current	cm/s	1.5	0.5	1.1

Based on the observed currents in 1993 in Callander Bay (Table 3), the minimum time for water to move 1 km is approximately 1.4 to 1.9 hours at maximum current speeds and 11.0 to 13.8 hours at mean current speeds, respectively (assuming constant speed

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[3] *A seiche is a long standing wave that affects the motion of the entire water mass of a lake. Seiches are most commonly created by wind-induced tilting of the water surface. Wind pushes water to one end of the lake and as the wind stress is removed, the tilted water surface flows back. Once established, these waves have great momentum and continue to rock back and forth.*

and direction). We note that the delineation of Intake Protection Zone 2 (IPZ-2) must encompass a minimum 2-hour travel time for contaminants to reach the intake (see Section 3.2). As the current speeds observed in the main channel of Callander Bay reflect channelized flow from Callander Bay to the main basin of Lake Nipissing, the maximum current speeds observed at the North Shore more appropriately depict maximum speeds that would be generated within Callander Bay and are therefore more appropriate for calculating time-of-travel for the purposes of the IPZ-2 delineation. At the maximum current speed observed along the North Shore of Callander Bay of 0.154 m/s, water would travel 1.11 km in two hours.

Wind can affect wave patterns and currents on lakes, which in turn can influence water quality conditions and the movement of contaminants. Dominant winds in the Lake Nipissing region are from the southwest throughout most of the year with north winds prevailing in winter and early spring (February to April) based on meteorological data from the North Bay Airport (Table 4). Mean wind speeds are 13 km/h with maximum hourly speeds ranging from 51 to 72 km/h between 1971 and 2000. The maximum wind speed observed in October 1993 during the Callander Bay hydrological study (Northland Engineering, 1993) was 54 km/h, which is within the range of the 1971-2000 maximum hourly speeds. This suggests that the current speeds observed in the Northland Engineering (1993) study reflect the current speeds that can occur under maximum wind conditions in Callander Bay.

Table 4. Wind Pattern Normals (1971-2000) at the North Bay Airport (WMO Station 71731), Environment Canada

Month	Speed	Most Frequent Direction	Max. Hourly Speed	Max. Gust Speed	Direction of Max. Gust	Days with Winds >= 52 km/h	Days with Winds >= 63 km/h
	km/h		km/h	km/h			
Jan	13.6	SW	58	100	S	0.7	0.1
Feb	13.6	N	64	90	NE	0.4	0
Mar	14.8	N	**72**	89	E	0.7	0.2
Apr	14.8	N	59	97	SW	0.5	0.2
May	13.5	SW	64	93	W	0.3	0.1
Jun	12.2	SW	64	**115**	SW	0.1	0
Jul	11.5	SW	56	82	NW	0.3	0.1
Aug	10.7	SW	56	91	S	0	0
Sep	11.8	SW	51	89	S	0	0
Oct	13.1	SW	70	96	S	0.4	0.1
Nov	13.9	W	68	96	SW	0.5	0.2
Dec	13.2	E	59	85	SW	0.6	0.1
Year	13.1	SW			SW	4.6	1.1
Oct-93	13.8	SW	54				

There are no known hydrological studies related to wind and wave action for the main basin of Lake Nipissing. Given the long fetch[4] of the lake across an east-west axis and dominant winds from the southwest, seiche events are likely common in the main basin of the lake. This supports the observations of Northland Engineering for frequent flow

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[4] *Fetch distance over which wind can blow uninterrupted by land.*

reversals in the Main Channel that direct flow from the main lake basin into Callander Bay (Northland Engineering, 1993).

Of the six tributaries draining to Callander Bay, hydrological information is only available for the Wistiwasing River.

Water Quality Model

The 1993 Northland Engineering Study included the development of a water quality model (Rand two-dimensional model) for Callander Bay. The model used field observations (water currents, temperature and wind) for the month of October 1993 to characterize hydrodynamics as it relates to pollutant transport patterns in relation to the drinking water intake. The wind patterns (speed and direction) used in the model are within the ranges reported by Environment Canada's Canadian Climate Normals (1971-2000) (Table 4) and are therefore likely representative of average wind conditions experienced at Callander Bay. The purpose of the modelling was to consider potential impacts at the intake due to inputs from the Wasi River and discharges from the Callander Wastewater lagoons (Northland Engineering Limited, 1993). Results of the study indicated that:

- The dominant measured flow near the Main Channel is toward the main basin of Lake Nipissing, but frequent minor flow reversals into Callander Bay appear to occur as a result of seiche events on the lake;
- The strongest measured currents that occurred in the Main Channel were coincident with the lowering of Lake Nipissing water levels by ~1.0 to 1.5 m to accommodate spring runoff inputs (however, we note that the water levels are lowered gradually by 1-cm per day until March, and therefore not likely to have caused a significant flow event);
- Measured currents near the lagoon discharges are generally in an east-west direction along the shoreline with the resultant dominant flow northwest away from the location of the intake;
- The main direction of flow near the location of the intake is toward the southwest and the Main Channel;
- Easterly currents in Callander Bay during the October high speed event could transport lagoon discharge along the north shore toward the location of the intake;
- Discharge from the lagoons would have an impact on the bay with a peak bacteria density >80 FC counts/100 mL within 150 m from the discharge point and peak levels of approximately 35 FC counts/100 mL near the intake (based on an effluent level of 5,000 fecal coliform (FC) counts/100 mL and no bacterial decay); and
- When the model was adjusted to incorporate bacterial decay, no impact from lagoon discharges was predicted near the intake .

While the 1993 water quality model concluded that there would be no impact near the intake from lagoon discharges when bacterial decay is considered, this conclusion was based on an effluent level of 5,000 fecal coliform counts/100 mL. These bacterial levels, however, are likely an underestimate of those that could potentially enter Callander Bay from the lagoon discharge. In a 1988 study of bacterial concentrations in the lagoon effluent draining through the wetland into Callander Bay, fecal coliforms greatly exceeded this concentration near the point of discharge to the lake in February (fecal coliforms reached 70,000 counts/100 mL) (Lake, 1988). The sewage lagoon is normally discharged twice yearly (in May and October), but at that time, the lagoon was at capacity and raw sewage effluent was flowing through the wetland at the time of the February sampling. The 1988 study was performed prior to the expansion of the lagoon system when only one cell was operating with a capacity of 84,000 m^3. The present system includes two cells with a total capacity of 264,000 m^3. The total amount of bacteria discharged to Callander Bay therefore has also likely increased since 1988.

We also note that the present lagoon system is nearing capacity and that the sewage main nearly breached in 2006 because it is undersized to service the present population (Anthony Falconi, Public Works, pers. comm., May 15, 2007) and there is a risk of a breach that could result in inputs of raw sewage with high fecal coliform and *E. coli* counts like those observed in 1988 into the wetland and hence Callander Bay. The Municipality is presently undertaking an Environmental Assessment (EA) for improvements to the present sewage treatment system.

Concern: The 1993 water quality model is more than 15 years old. Bacterial levels used to model the influence of lagoon discharges near the intake are likely under-representative of actual levels, and hence underestimate the potential of bacterial contamination near the intake. We therefore recommend that a new water quality model would be useful to better reflect current conditions in Callander Bay.

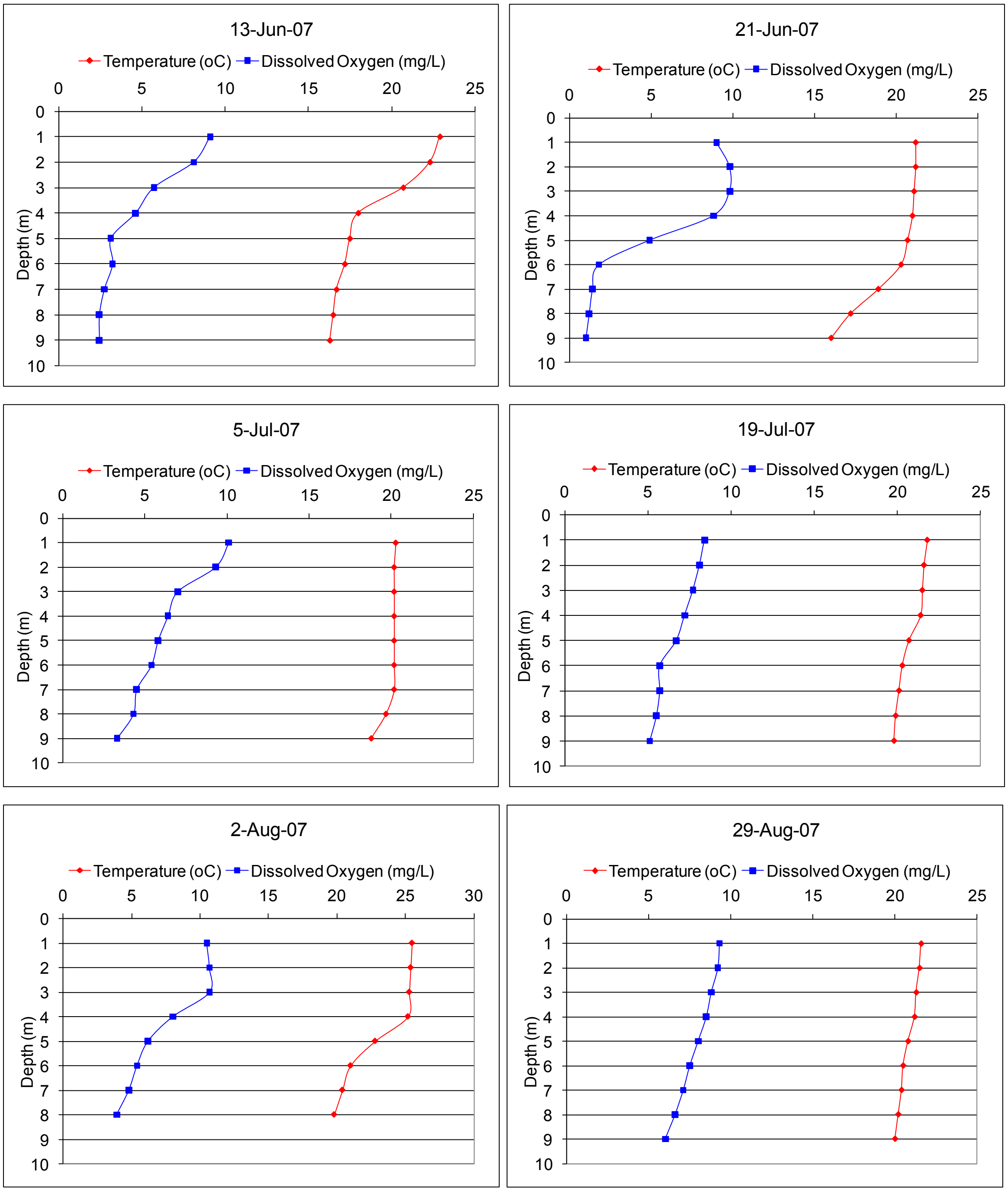
Callander Bay Stratification Patterns

As with the main lake basin, Callander Bay is shallow and the water column does not maintain thermal stratification over the summer months (only weakly stratifies). Therefore, the water column is easily mixed to the bottom by wind and wave action. This is illustrated by temperature and dissolved oxygen concentrations measured in the water of Callander Bay during the summer of 2007 as part of a water quality survey being conducted by the NBMCA (Figure 4).

On June 13th, patterns of temperature and dissolved oxygen concentrations indicated that the bay was weakly stratified with a uniform, warmer, less dense layer of surface waters to a depth of approximately 4 m. Below 4 m, temperature and dissolved oxygen concentrations decreased with depth to the bottom of the water column. A decline in oxygen occurs because oxygen is consumed by decomposition of organic matter and the weak stratification prevents mixing, which is needed to replenish oxygen deeper in the water column. The difference in temperature between the surface and bottom waters, however, was only 5ºC. The difference in density of water over this temperature range is relatively small, and so there is little resistance of the water column to mixing by wind. On July 5th, the temperature of the water was uniform throughout nearly the whole water column indicating that the bay had undergone vertical mixing. On August 2nd, the water column had weakly stratified again and on August 29th, had mixed.

Mixing of the water column effectively replenishes dissolved oxygen concentrations to the bottom waters of the bay. However, we note that during a period of temporary stratification (on June 21st) dissolved oxygen levels reached very low levels of 1 mg/L that approach anoxia (lack of oxygen) (Figure 4).

Figure 4. Temperature and Dissolved Oxygen Concentrations in Callander Bay, 2007 (data from NBMCA)



Anoxia in bottom waters has important implications for phosphorus cycling in Callander Bay. If periods of stratification are maintained for a sufficiently long period of time, there is a risk of complete oxygen depletion near the sediments. Phosphorus is normally bound in sediments under oxygenated conditions, but can be released into the water column under anoxic conditions. This process is called internal phosphorus loading. In lakes that maintain thermal stratification over the summer (i.e., only mix in late fall), phosphorus released by internal loading is confined to the deep cool dense layer of water (the hypolimnion) and remains mostly unavailable for uptake by algae until mixing of the water column in late fall. Callander Bay, however, mixes frequently over the summer months and so phosphorus in bottom waters from internal loading could be introduced into the surface waters at the height of the growing season, promoting aquatic plant growth.

Concern: Callander Bay is shallow and mixes frequently (i.e., polymictic) over the course of the open water season. Therefore, contaminants entering the surface waters can be readily transported to deep waters near the lake bottom and the location of the drinking water intake. We recommend that if a hydrological study is performed for Callander Bay, that this study assess vertical mixing patterns in addition to surface water currents to better understand contaminant movement toward the intake.

Concern: Sustained periods of thermal stratification pose a risk of internal phosphorus loading due to anoxia. Subsequent mixing during the height of the growing season can supply this phosphorus to overlying waters and promote growth of algae. We recommend continued monitoring of temperature and dissolved oxygen profiles over the ice-free season to better characterize stratification patterns and the extent of oxygen depletion in Callander Bay.

2.3. Source Water Quality Conditions

Lake Nipissing

The last known detailed water quality study for Lake Nipissing was conducted by the Ontario Ministry of the Environment between 1988 and 1990 (Neary and Clark, 1992). Overall, water quality parameters in Lake Nipissing were found to be typical for a large, shallow, moderately productive lake that supports a productive warmwater fishery. All measured parameters were within acceptable levels. Major conclusions from the study included:

1. Lake Nipissing has relatively high levels of calcium, contributing to a pH that is circumneutral to slightly alkaline and a relatively high acid neutralizing capacity. These features act to protect the lake from acidification, which is of concern due to lake's proximity to Sudbury, a major source of sulphur deposition that has resulted in widespread regional acidification of Ontario lakes.
2. Total phosphorus concentrations were indicative of mesotrophic conditions (moderately productive) and ranged between 10 and 15 μg/L in the spring. Exceptions were Callander Bay and Cache Bay, two relatively enclosed embayments that receive little mixing from the main basin of the lake, but also receive drainage from considerable agricultural areas. Total phosphorus concentrations were found to increase in the east end of the lake over the open

water season reaching maximum concentrations in November. This phosphorus enrichment was attributed to the decay of extensive beds of aquatic plants in eastern sections of the lake, including Callander Bay. Comparison of total phosphorus and chlorophyll a concentrations from a previous water quality study conducted from 1971-1974 suggested that no significant change in the trophic status of the lake had occurred over that 15-year time period.

3. There was clear evidence of road salt inputs in the east section of Lake Nipissing and Callander Bay based on concentrations of sodium (4.0-4.5 mg/L) and chloride (4.5-5.5 mg/L). However, these levels were well below those considered to have toxic effects on aquatic organisms.

Callander Bay

General water chemistry surveys have been conducted for Callander Bay by the MOE from 1998-1990 and again from 2003 to 2004, and the results of these are summarized in Table 5 and compared to applicable Ontario drinking water quality standards, objectives and guidelines[5]. Water quality data were also available for the Wastiwising (Wasi) River (2007) from MOE's Provincial Water Quality Monitoring Network (PWQMN) database and are included in Table 5 for comparison.

Based on available water quality surveys, lake water is circumneutral (pH = 7.4), has low alkalinity (18.4 mg/L), and is ionically dilute with a conductivity of 82.5 μS/cm. Callander Bay has slightly greater ionic strength than most Shield lakes, and hence higher pH and alkalinity likely due to the slightly thicker soils and glacial deposits in the catchment, but also the influence of large wetland areas in the catchment. In addition, the bay supports large aquatic plant communities that would contribute to the relatively higher pH and alkalinity. All measured parameters for Callander Bay are within applicable Ontario drinking water standards, objectives and guidelines, but aluminum and iron concentrations exceeded the guidelines in the Wasi River, a primary tributary to Callander Bay, in 2007 (Table 5). Aluminum concentrations are further discussed in Section 6.2 as they relate to potential drinking water issues for source protection planning.

In terms of trophic state conditions, Callander Bay is highly productive, or 'eutrophic' as indicated by its nutrient rich conditions and high chlorophyll *a* concentrations. In most Shield lakes, phosphorus limits production of aquatic plants including algae. Mean total phosphorus concentration in Callander Bay during the ice-free season is 0.022 mg/L (1988-2008), which exceeds the Provincial Water Quality Objective of 0.020 mg/L for the protection against nuisance aquatic plant growth, and likely contributes to the high algal production observed in the bay.

There are no apparent changes in total phosphorus concentrations in Callander Bay over the past 15-20 years, based on measured spring concentrations (Figure 5). Monitoring data prior to about 1990 may not be reliable due to analytical constraints, and therefore, long-term changes in phosphorus concentrations in Callander Bay prior to this time are uncertain based on measured data.

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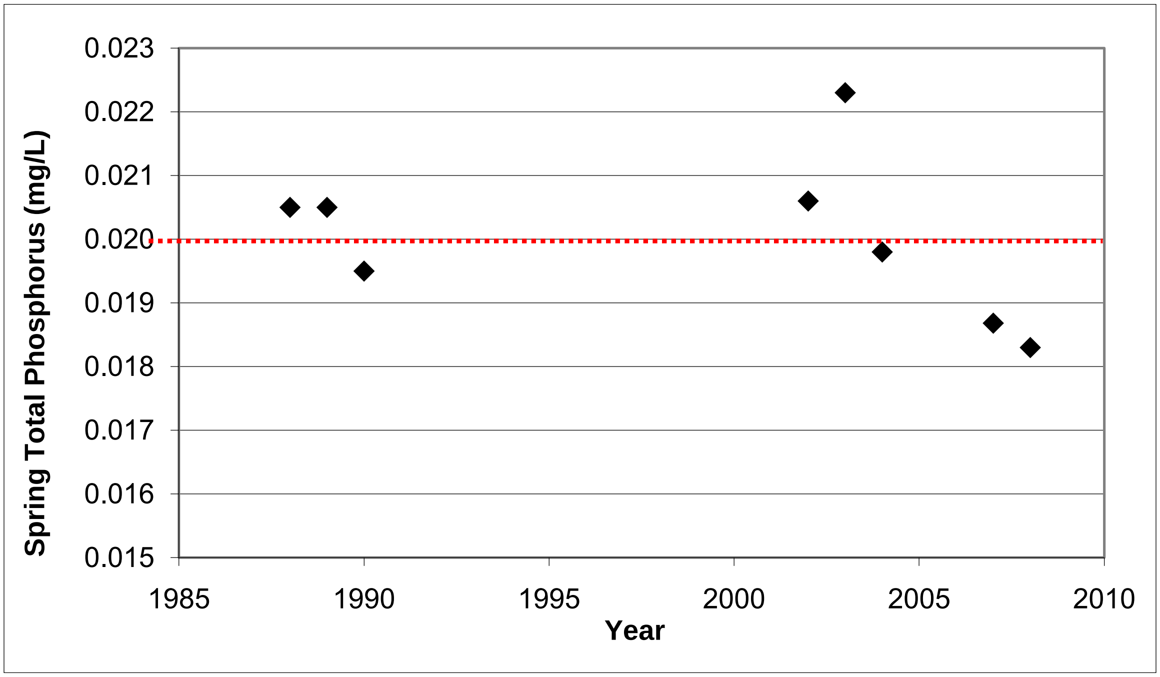
[5] *As per the Ontario Drinking Water Quality Standards (O.Reg. 169/03) and the TechnicalSupport Document for Ontario Drinking-water Quality Standards, Objectives and Guidelines (MOE, 2006)*

Table 5. Water Quality Conditions in Callander Bay (1988-2004) and Wasi River (2007)

Parameter	**Units**	**Callander Bay**			**Wasi River 2007 mean**	**CDWQ Guideline**
		1988-1990 mean	**2003-2004 mean**	**Overall mean**		
Alkalinity	mg/L	18.4	18.4	18.4	21.9	30-500^{og}
Aluminum	mg/L	0.078	0.052	0.055	**0.146**	0.1^{og}
Calcium	mg/L	7.4	7.2	7.3	6.1	n/a
Chlorophyll *a*	mg/L	11.3	4.0	10.9	nd	n/a
Chloride	mg/L	5.4	6.4	5.8	4.7	≤250^{ao}
Conductivity	µS/cm	82.2	82.9	82.5	70.1	n/a
Dissolved inorganic carbon	mg/L	4.6	5.0	4.8	9.2	n/a
Dissolved organic carbon	mg/L	6.0	6.4	6.2	10.2	n/a
Iron	mg/L	0.140	0.115	0.130	**0.581**	0.3^{ao}
Floride	mg/L	0.06	n/a	0.06	na	1.5
Potassium	mg/L	0.9	0.9	0.9	na	n/a
Magnesium	mg/L	2.4	2.2	2.3	2.3	n/a
Manganese	mg/L	0.027	0.015	0.021	0.02	0.05^{ao}
Sodium	mg/L	4.0	4.6	4.3	na	200^{ao}
Ammonia	mg/L	0.050	0.051	0.050	0.030	n/a
Nitrate+Nitrite	mg/L	0.032	0.109	0.063	0.057	n/a
Total Kjedahl nitrogen	mg/L	0.504	0.412	0.466	0.629	n/a
pH		7.4	7.3	7.4	7.5	6.5-8.5^{og}
Total phosphorus	mg/L	0.022	0.023	0.023	0.040	n/a
Silicate	mg/L	0.7	0.7	0.7	1.9	n/a
Sulphate	mg/L	9.4	7.0	8.4	ns	500^{ao}

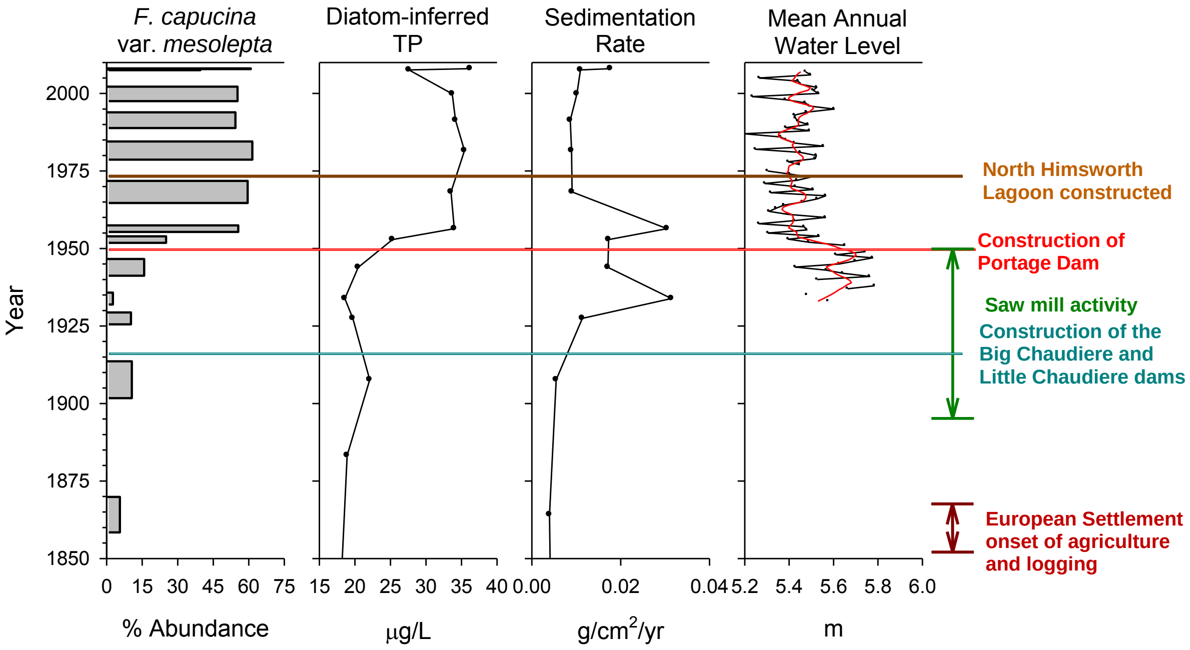
Notes: Bold values exceed applicable Ontario Drinking Water Quality Standards (O.Reg. 169/03), objectives or guidelines (MOE, 2006); ^{0g}is the operational objective for conventional water treatment plants, ^{ao} is an aesthetic objective, n/a = no applicable standard, guideline or objective, nd = no data available:

Figure 5. Mean Spring Total Phosphorus Concentrations in Callander Bay (1988-2008)



To determine long-term changes in phosphorus concentrations in Callander Bay, a paleolimnological study was completed by AECOM for the NBMCA (AECOM, 2009). This study reconstructed total phosphorus concentrations by analyzing fossil diatom assemblages preserved in a dated sediment core from the bay. Diatoms are a unicellular group of algae with cell walls that are composed of silica and preserve well in the sediments. They are abundant in most freshwater environments and are excellent indicators of environmental conditions because they have well defined ecological preferences. Total phosphorus concentrations were reconstructed by applying a model developed from Ontario lakes to the fossil diatom assemblages in Callander Bay to give a reliable record of changes that have occurred over the past ~400 years. Results from this study confirmed that total phosphorus concentrations have remained relatively stable in recent decades, but that a significant increase occurred coincident with the construction of the Portage Dam in 1949-1950 at the outlet of Lake Nipissing (Figure 6). Operation of the dam resulted in an overall decrease in water levels in Lake Nipissing, particularly during the spring melt period. The influence of this hydrological change may have resulted in a combination of physical changes to Callander Bay including an altered mixing regime, changes in flushing rates and mixing with waters in the main basin of Lake Nipissing, exposure of productive low lying areas, and expansion of the shallow littoral zone, all of which could contribute to increased phosphorus concentrations. While the exact mechanism of change cannot be determined without further study, it is apparent that phosphorous concentrations in Callander Bay were sensitive to this major hydrological change. Other factors related to post-war activities in the watershed may also have played a part in this significant ecological change in the state of Callander Bay at this time.

Figure 6. Paleoenvironmental summary of Callander Bay, Lake Nipissing (1850-2008).



As previously reported by the MOE (Neary and Clark, 1992), total phosphorus concentrations in Callander Bay increase over the course of the growing season (Figure 7). The MOE attributed increased phosphorus concentrations in the late fall (1988-1990) to decomposition of abundant aquatic plants. In addition to this mechanism, we suggest that earlier increased phosphorus concentrations (i.e., in late summer) may result from internal phosphorus loading due to anoxia and/or sediment resuspension. Evidence from temperature and dissolved oxygen profiles suggests that Callander Bay is prone to oxygen depletion in bottom waters under conditions of sustained periods of stratification, which could lead to internal phosphorus loading from the sediments. Subsequent mixing of the water column would effectively introduce this phosphorus into the surface waters thereby increasing phosphorus concentrations during the open-water season. In addition, strong mixing events to the bottom of Callander Bay can promote sediment resuspension, which could also increase total phosphorus concentrations. We note that bottom water samples were collected by the NBMCA and analyzed for total phosphorus concentration on July 17, 2007 (TP = 0.021 mg/L) and August 29, 2007 (TP = 0.029 mg/L). These values are much lower than would be expected if there were an internal load at the time of sampling. Unfortunately, temperature profiles from those dates indicated that the bay had only weakly stratified on July 17th, and had vertically mixed prior to August 29 (Figure 4). It is still possible however that internal load occurs during periods of prolonged stratification. Additional sampling of bottom water during periods of prolonged stratification would be required to confirm internal phosphorus loading in Callander Bay.

Phosphorus loads from the Wistiwasing (Wasi) River, the largest tributary to Callander Bay, may also contribute to the observed increase in phosphorus concentrations in Callander Bay over the ice-free season. Monitoring data collected by the NBMCA during 2007 and 2008 indicate phosphorus concentrations at the outlet of the Wasi River are highly variable and increase to levels that exceed the Provincial Water Quality Objective (PWQO) of 0.030 mg/L for rivers over the ice-free season (Figure 8). Notably, total phosphorus concentrations reached 0.154 mg/L on September 15, 2008 following a rain event.

Figure 7. Total Phosphorus Concentrations in Callander Bay during the Open Water Season

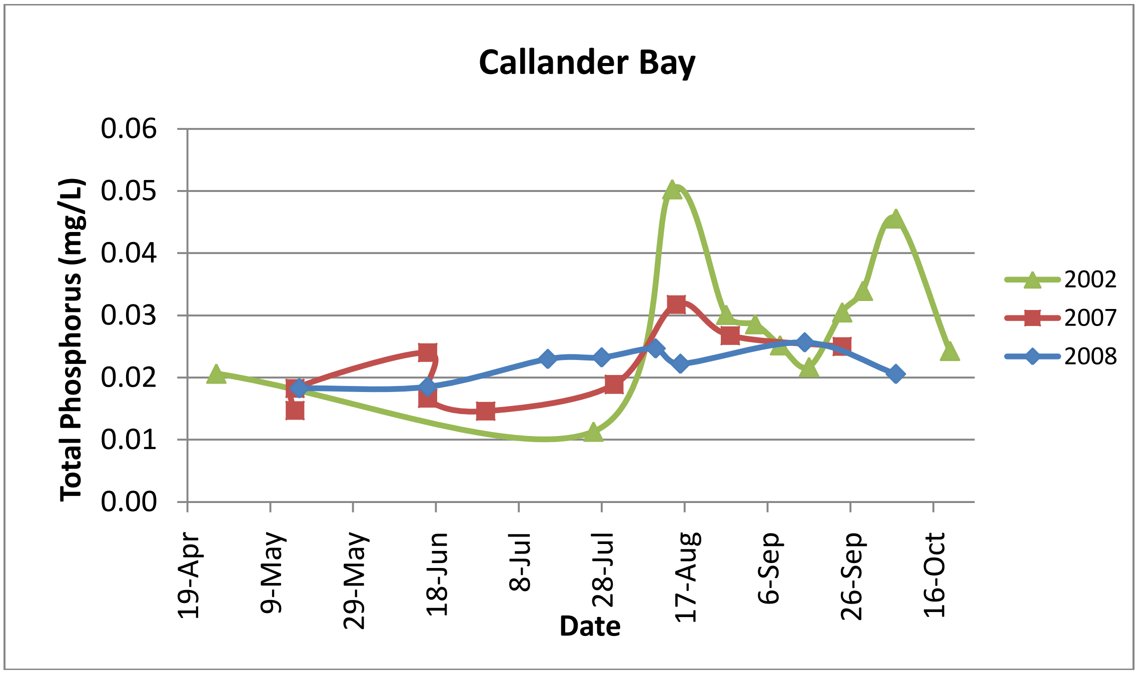
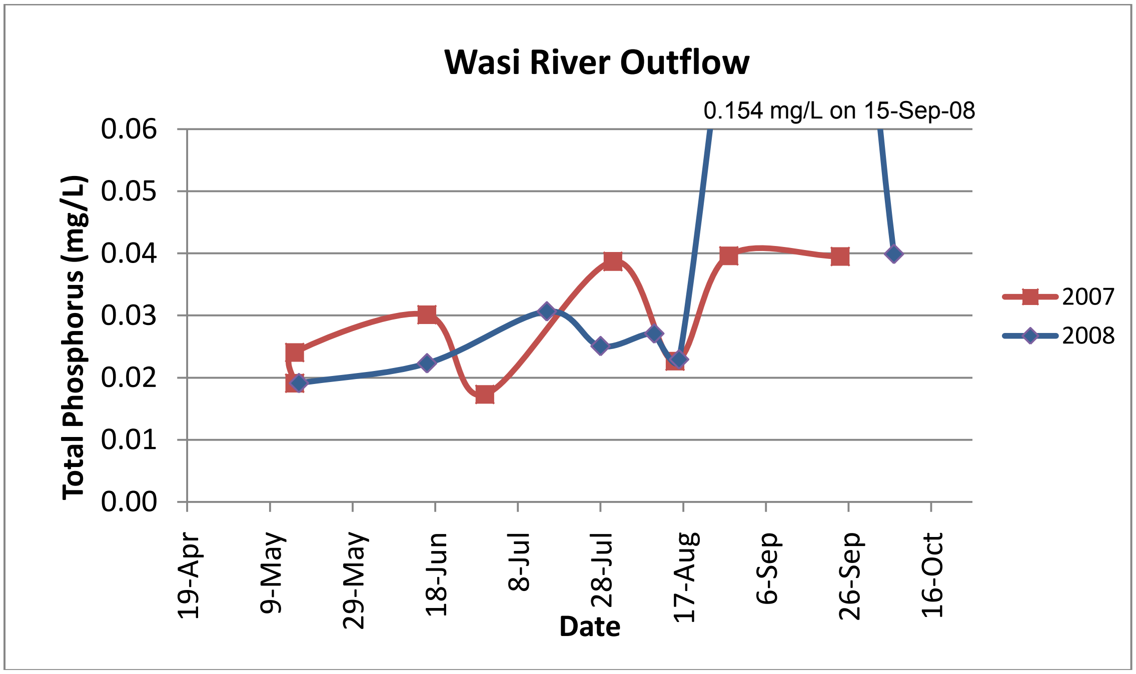


Figure 8. Total Phosphorus Concentrations at the Wasi River Outlet to Callander Bay during the Ice-Free Season



With respect to drinking water quality, there is no Ontario standard, objective or guideline for phosphorus because at the levels present in lake water, consumption of phosphorus poses no known human health risk. However, high algal productivity resulting from high phosphorus concentrations can impair the aesthetic quality of drinking water by reducing water clarity (increasing turbidity and colour) and by producing compounds that cause taste and odour problems (e.g., geosmin). In addition, certain types of bluegreen algae (cyanobacteria) can produce toxins, notably microcystin, that are potentially harmful to human health.

Concern: Phosphorus concentrations in Callander Bay exceed the PWQO of 0.020 mg/L for protection against nuisance aquatic plant growth in surface water bodies, and contribute to high algal productivity.

Concern: Total phosphorus concentrations in Callander Bay increase over the open water season, potentially from internal phosphorus loads due to anoxia and/or sediment resuspension.

Concern: Total phosphorus concentrations in the Wasi River exceed the PWQO of 0.030 mg/L for the protection against nuisance aquatic plant growth in rivers, and contribute to high algal productivity in Callander Bay.

Recommendation: We recommend that a phosphorus budget be developed for Callander Bay to identify the relative contribution of all sources of phosphorus to the bay, including internal loads from the sediments and loads from the Wasi River. This information would inform potential management plans to reduce or control phosphorus loads to Callander Bay.

Algal Productivity

Due to the concern about algal productivity in Callander Bay, the NBMCA conducted a water quality survey in 2007 to characterize algal (i.e., phytoplankton) community composition and biomass over the open water season. Overall, the phytoplankton biomass was high on all sampling occasions, but increased from 2,083 μg/L on June 21st to a maximum of 7,066 μg/L on August 16th. Species belonging to the Division Bacillariophyta, which include the diatoms (golden brown algae), dominated the phytoplankton community in June (Figure 9). Diatoms typically bloom in spring and fall and contribute to most of the primary production in many lakes. As the summer progressed, the phytoplankton assemblages became strongly dominated by cyanobacteria, commonly known as bluegreen algae, representing between 66% and 96% of the total algal biomass in Callander Bay. This increase in algal biomass largely contributes to the rapid decline in water clarity over the summer months as indicated by a decrease in Secchi depth observed in 2007 (Figure 10).

Concern: Algal productivity increases to very high levels over the summer months in Callander Bay impairing aesthetic water quality by increasing turbidity and colour, reducing water clarity and potentially affecting taste and odour of the water.

Figure 9. Phytoplankton Composition and Biomass in Callander Bay, Summer 2007

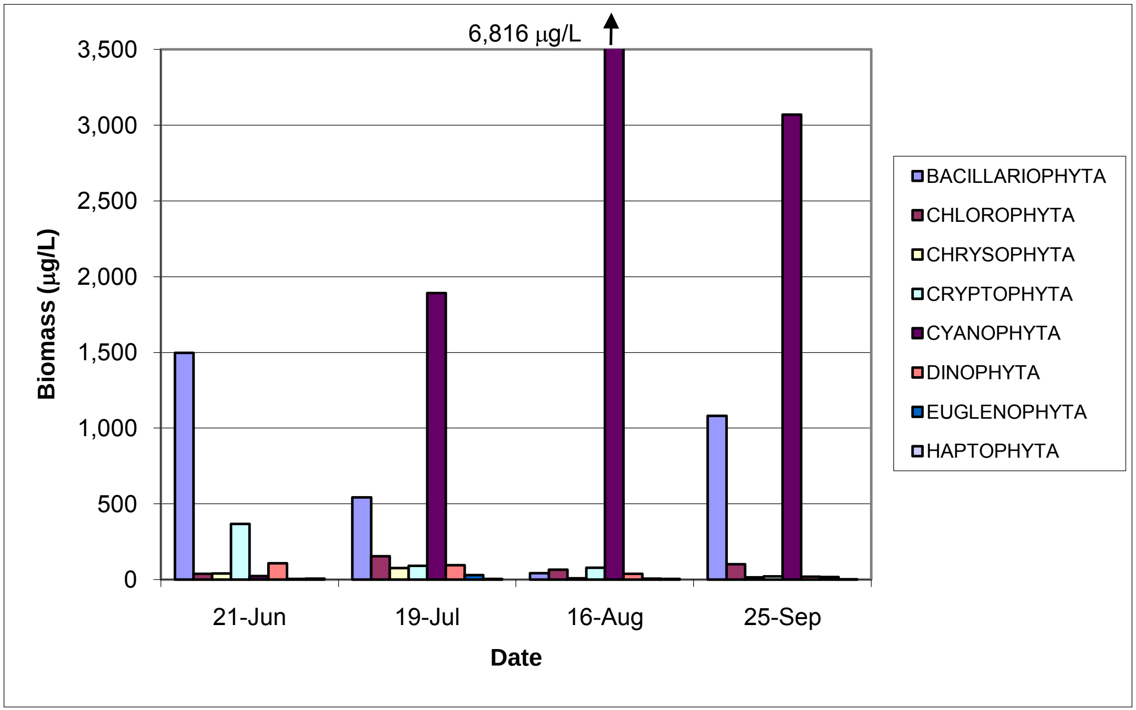
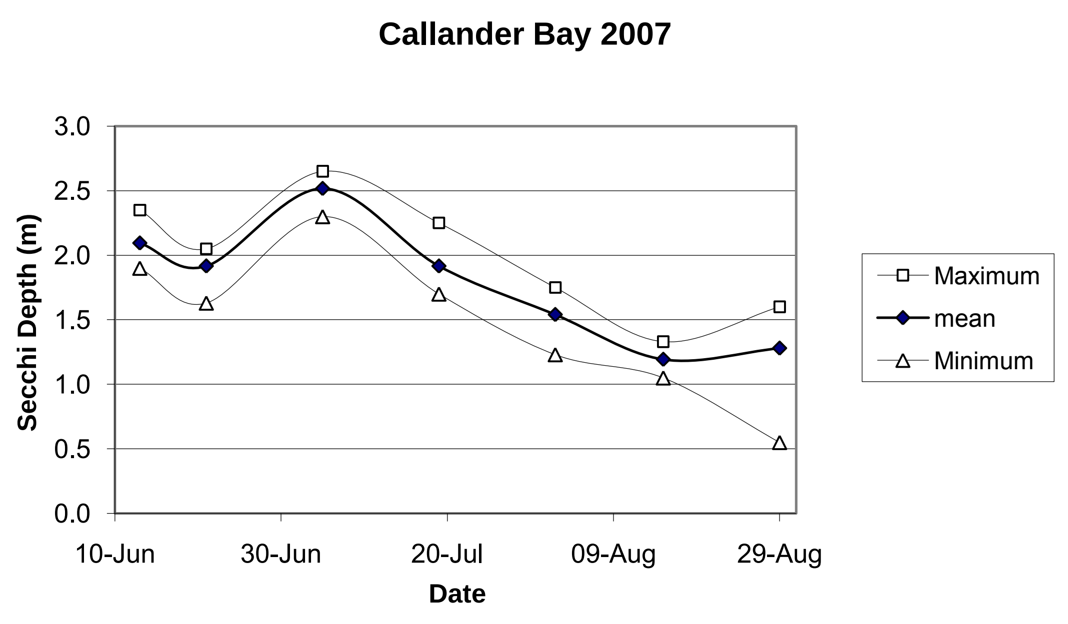


Figure 10. Secchi Depth in Callander Bay[1], Summer 2007



[1] *n=11 sites*

The bluegreen algal community in Callander Bay was dominated by filamentous, nitrogen-fixing genera belonging to the Order Nostocales including *Anabaena spp.* and *Aphanizomenon spp.* (Table 6). These species of bluegreen algae are commonly bloom forming and can produce ‘surface scums’ or ‘algal mats’ under certain conditions. They are known to be able to adjust their buoyancy and can float or sink depending on light conditions and nutrient supply, making them excellent competitors for these resources. In addition, they are capable of fixing atmospheric nitrogen in specialized cells called heterocysts, so they have a competitive advantage over other aquatic plants when usable nitrogen availability is low.

Species belonging to the Order Chroocales (i.e., *Microcystis spp.*, *Chroococcus spp.*, *Woronochinia naeglianum*) were also present in the algal assemblages, but with lower concentrations in comparison to species of the Nostocales (Table 6). These species are colonial, bloom-forming, and are not known to fix nitrogen.

Table 6. Potential Toxin Producing Bluegreen Algae in Callander Bay, 2007

Genera	Biomass (μg/L)				Potential Toxin Producer[1]
	21-Jun	19-Jul	16-Aug	25-Sep	
Anabaena	15.69	906.29	6,458.73	1,615.65	X
Aphanizomenon	2.54	825.62	194.00	237.46	X
Aphanocapsa		0.09	present		
Aphanothece		2.48	1.96	0.05	
Chroococcus	0.81	11.07	0.51		
Coelomoron		7.25	8.97	2.17	
Woronichinia	0.58	60.54	42.81	561.89	
Snowella	0.08	0.26			
Lyngbya	2.34	11.23	85.45	568.23	X
Merismopedia		0.34	0.19		
Microcystis	0.36	59.87	12.72	63.00	X
Planktothrix		5.49	0.42	20.86	X
Pseudanabaena		0.16	6.13	0.09	
Synechococcus	0.82	1.28	4.15		
Synechocystis	0.01	0.17			
Romeria				0.23	
Blue-green, unident.				0.66	
Total	**23.23**	**1,892.14**	**6,816.04**	**3,070.29**	
Total Potential Toxin Producers	**20.93**	**1,808.50**	**6,751.32**	**2,505.20**	
% Potential Toxin Producers	**90.10**	**95.58**	**99.05**	**81.59**	

[1] *Not produced by all species of the particular genus; Chorus and Bartram, 1999*

Many of the bluegreen algae identified in Callander Bay are known to produce toxins, and these represent a large proportion of the total bluegreen algal biomass in Callander Bay (Table 6). *Microcystis spp.* are almost always toxic, while species from other groups (e.g., *Anabaena spp.*) can have toxic and non-toxic strains. The toxicity of a strain depends on whether or not it contains the gene for toxin production, but also on environmental factors promoting expression of the gene. Environmental conditions leading to the dominance of toxic strains over non-toxic strains of bluegreen algae are, however, not well understood. Cyanobacterial toxins have only been analyzed in a single surface water sample from Callander Bay in late October 2009. Toxins were not detected at that time, but the sample was collected in the fall beyond the time of cyanobacteria bloom activity, which is typically greatest in late summer.

While there are toxin-producing cyanobacteria in Callander Bay, observed cyanobacteria biomass levels pose “relatively mild and/or low probabilities of adverse health effects” based on World Health Organization (WHO) guidelines (Chorus and Bartram, 1999). At a guideline level of 20,000 cyanobacterial cells/mL (corresponding to 10 µg/L of chlorophyll *a* under conditions of cyanobacterial dominance) potential adverse health effects can occur, not due to cyanotoxin toxicity, but due to the irritative or allergenic effects of other cyanobacterial compounds. Health outcomes due to microcystin are unlikely and providing information for visitors to bathing sites with this low-level risk is considered to be sufficient. Additionally, it is recommended that the authorities are informed in order to initiate further surveillance of the site (Chorus and Bartram, 1999). There are presently no known Canadian guidelines for bluegreen algal concentrations in surface water.

Concern: Toxin producing genera of bluegreen algae are abundant in Callander Bay, creating a risk of contamination by cyanotoxins in the raw drinking water supply. It should be noted, however, that granular activated carbon, which is used in the secondary treatment at the North Himsworth water treatment plant, is considered to be an effective method for treating bluegreen algal toxins (MOE, 2008).

Recommendation: We recommend that if a bluegreen algae bloom is suspected in Callander Bay, that the Ministry of the Environment be notified by calling the Spills Action Centre at 1-800-268-6060, as suggested by the Chief Drinking Water Inspector (MOE, 2008; see Appendix C).

The presence of cyanobacteria in Callander Bay and the potential production of cyanobacterial toxins are further discussed as they relate to drinking water in Section 6.4.

Bacteria

Fecal bacterial indicators (total coliform and *E. coli*) were measured in Callander Bay as part of the NBMCA’s water quality monitoring program in the summer of 2007 (Table 7). Bacterial levels were low at all sample locations with the exception the outlet of the Wistiwasing (Wasi) River (CB12), when on July 19th and September 25th, 2007 *E. coli* levels exceeded the PWQO of 100 CFU/100 mL for recreational body contact. We note that Site CB2, located at the outlet from Cranberry Creek where the sewage lagoons are discharged had low bacterial counts on the sampling dates. However, the sampling program was not conducted during times of discharge of the lagoons (spring discharge is from May 1st to June 15th and fall discharge is from October 31st to December 15th). Therefore, the bacterial levels reported here are not representative of those that potentially occur during periods of lagoon discharge.

Table 7. Total Coliform (TC), *E. Coli* (EC) and Background (BG) Bacteria Levels (CFU/100 mL) in Callander Bay, 2007

Site	Location	21-Jun-07			19-Jul-07			15-Aug-07			25-Sep-07		
		TC	EC	BG	TC	EC	BG	TC	EC	BG	TC	EC	BG
CB12	at Wasi R. outlet	26	11	OG	OG	**121**	OG	89	8	OG	OG	**130**	OG
CB1	nearshore at Osprey	23	4	OG	117	86	OG	24	1	OG	OG	7	OG
CB2	At outlet from Cranberry Cr. (STP)	6	2	OG	89	48	OG	8	0	OG	OG	1	OG
CB3	nearshore Steven Pl.	37	17	OG	131	93	OG	23	7	OG	OG	8	OG
CB4	nearshore Bay St.	79	8	OG	92	61	OG	660	20	OG	OG	28	OG

Notes: Bolded values exceed the PWQO for E. coli *of 100 CFU/100 mL for recreational body contact. However, the PWQO is based on a geometric mean of a minimum of 5 samples, and reported values are single samples. OG refers to samples that were over grown (>200 CFU/100 mL)*

The Health Unit monitored *E. coli* levels at Callander Beach and Callander Park between 1998 and 2001. *E. coli* levels were below the PWQO of 100 CFU/100 mL for recreational body contact on all sampling occasions with the exception of one date at Callander Beach (August 16, 2000) (Table 8). These results suggest that these areas are not significant sources of *E. coli* to Callander Bay, however, we note that recent monitoring data are not available.

Concern: The Wasi River is a source of fecal bacteria to Callander Bay.

Concern: Discharge from the sewage treatment lagoons is a likely source of pathogens to Callander Bay, however the NBMCA sampling program did not capture times of lagoon discharge.

Recommendation: Sampling for fecal bacterial indicators at the CB2 site during lagoon discharge times is recommended to determine potential bacterial contamination in Callander Bay from this source.

Table 8. Health Unit *E. Coli* Monitoring Results (1998-2001)

Date	Geometric Mean *E. coli* (CFU/100 mL)	
	Callander Beach	Callander Park
10-Jun-98	10	10
3-Jul-98	10	10
5-Aug-98	10	51
12-Jul-00	31	16
16-Aug-00	**157**	10
7-Sep-00	21	10
14-Jun-01	12	10
21-Jun-01	31	31
28-Jun-01	12	10
10-Jul-01	13	16
12-Jul-01	18	10
20-Jul-01	10	10
26-Jul-01	10	10
2-Aug-01	10	13
10-Aug-01	10	10
16-Aug-01	10	16

Note: Bold values exceed the Provincial Water Quality Objective (PWQO) of 100 cfu/100 mL.

2.4. Sediment Characterization

There are no known studies that characterize sediment quality in Callander Bay. In several areas of Callander Bay, there is substantial accumulation of sawmill debris. In addition, there are potentially deposits of contaminants in the sediments from historic sawmill activity, agricultural practices in the watershed, and urban drainage including lagoon discharges. Due to the shallow nature of the bay and its susceptibility to complete mixing, sediments are easily resuspended, potentially releasing nutrients and contaminants into the water column and influencing water quality near the intake. There is direct evidence for sediment resuspension from a sediment core collected from near the centre of Callander Bay in August, 2007. The sediments were highly organic and flocculant in the top 5 cm of the core, and sediment particles were suspended in the water of the core tube above the sediment-water interface.

Concern: Sediments in Callander Bay are highly flocculant and prone to resuspension, potentially contributing to turbidity and release of nutrients and contaminants near the drinking water intake.

Recommendation: Given potential contamination of sediments in Callander Bay and sediment resuspension into the water column, it is recommended that lake

sediments be analyzed for sediment quality parameters (i.e., total organic carbon, total phosphorus, total nitrogen, total metals, and contaminants (mercury, polycyclic aromatic hydrocarbons, BTEX chemicals and pesticides).

3. Delineation of Vulnerable Areas: Surface Water Intake Protection Zones (IPZs)

The vulnerable area for the Callander drinking water intake includes three intake protection zones (IPZs) following Part VI of the Rules for a Type D intake.

3.1. Intake Protection Zone 1 (IPZ-1)

Intake Protection Zone 1 (IPZ-1) is intended to provide a protective area around the intake that is most vulnerable to contamination. If a contaminant enters this area, it will have little or no dilution potential before reaching the intake.

In accordance with the Technical Rules, the IPZ-1 for Callander includes the surface area of Callander Bay within a 1-km radius of the drinking water intake crib (46° 12’ 50.0’’ N; 79° 22’ 23.5” W), and where this area abuts land[6], the area of land within 120 m of the shoreline measured from the high water mark of the bay where overland flow drains into the bay (Figure 11).

3.2. Intake Protection Zone 2 (IPZ-2)

Intake Protection Zone 2 (IPZ- 2) provides a secondary protective area that reflects the response time for the water treatment plant operator to respond to an emergency (i.e., time to shut down the intake).

IPZ-2 is defined by the Rules as the area within each surface water body or stormwater management works (e.g., stormwater ponds, storm sewers, ditches) that contributes water to the intake where the time of travel to the intake is the greater of:

- 2 hours, or
- the time that is sufficient to allow the operator of the water treatment plant to respond to a spill or other event that may affect water quality at the intake.

Where areas of surface water bodies abut land, the IPZ-2 only includes land area within 120 m of the shoreline (measured from the high water mark) where overland flow drains to the surface water body. This setback may be extended to include the area that contributes water within a 2-hour time-of-travel to the intake via a transport pathway that is natural or man-made. IPZ-2 does not include water or land area that lies within the IPZ-1.

A two-hour time of travel was estimated for Callander Bay using the maximum current speed of 0.154 m/s observed along the north shore of Callander Bay (Northland

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[6] *The 120-m setback extends perpendicular to the tangent of the 1-km radius circle where it intersects the shoreline.*

Engineering, 1993), as described in Section 2.2. At 0.154 m/s, water would travel 1.11 km in two hours.

The IPZ-2 (Figure 11) is composed of the following areas:

1. The surface area of Callander Bay within 1.11 km of the intake, which represents a two-hour time-of-travel to the intake, and where this area abuts land, the land area within 120 m of the shoreline measured from the high water mark of the bay where overland flow drains into the bay,
2. The area of the stormwater sewershed draining to Callander Bay that lies within 1.11 km of the intake (to approximate a two hour time-of-travel to the intake in accordance with Rule 65(2)). Time-of-travel in the sewershed is unknown, but is likely to be slower than that which occurs due to wind driven surface currents in Callander Bay (overland flows are generally slower than surface water currents). The 1.11-km distance to the intake is therefore a conservative estimate to approximate the necessary distance to encompass a two-hour time-of-travel to the intake from the sewershed area, and
3. The surface area of Burford Creek and unnamed Creek 323 that could contribute water to the intake within a two-hour time-of-travel and associated maximum 120-m setbacks on land.

There are no known available flow or modeling data to calculate flow velocities in Burford Creek or Creek 323. The IPZ-2 was therefore extended upstream of these creeks to capture a two-hour time-of-travel under the flow velocity for a 100-year flood event of 0.5 m/s that was determined for the nearby Wistiwasing River in the Wasi River Management Study (A. J. Robinson and Associates, Inc., 1986). Using this velocity, the IPZ-2 is extended 205 m upstream of Burford Creek and 130 m upstream of Creek 323 to encompass a two-hour time-of-travel to the intake. This extension of the IPZ-2 is considered to be very conservative as the Wistiwasing River is a large larger river with substantially greater flow velocities than that which would be observed in the smaller creeks. This extension of the IPZ-2 therefore may require modification in subsequent phases of Source Water Protection planning if measured velocities are obtained for Burford Creek and Creek 323.

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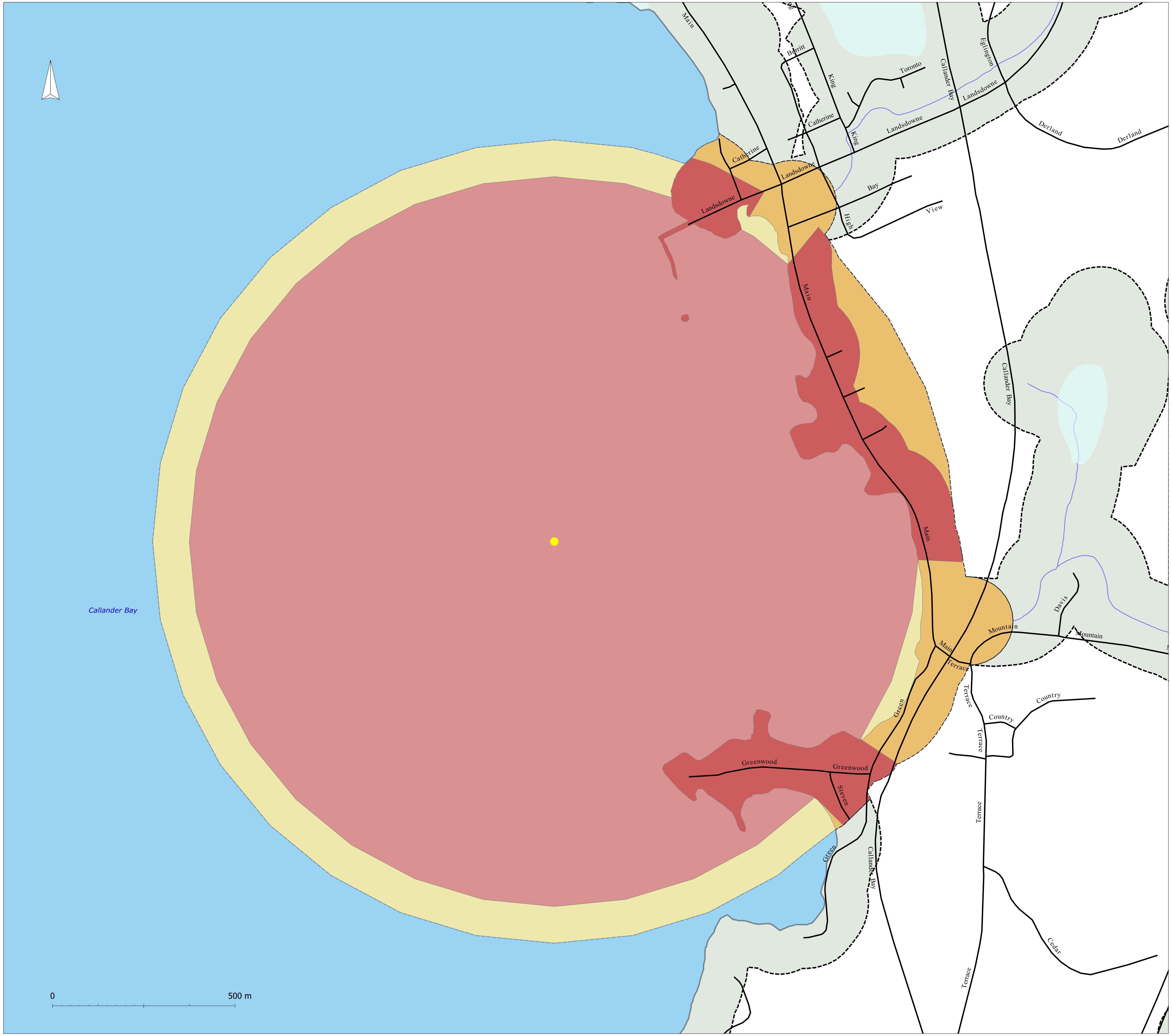

FIGURE 11
Municipality of Callander Intake Intake Protection Zone One, Two (IPZ 1,2)

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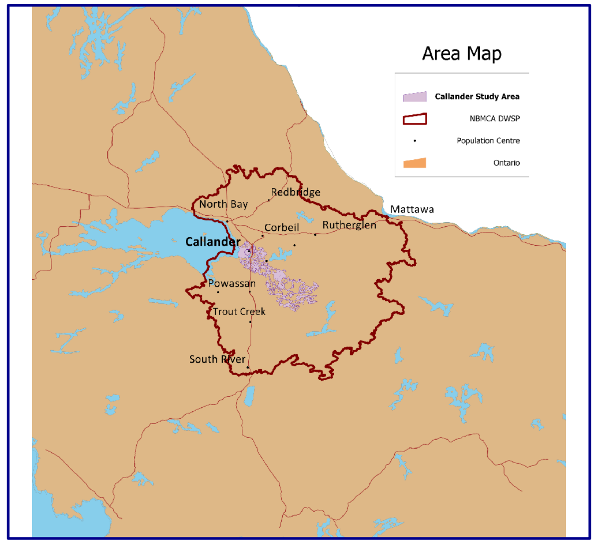

Streams/Rivers
Waterbody
Wetland
● Callander Bay Intake
Roads
Callander Bay IPZ
IPZ-1
IPZ-2
IPZ-3
IPZ-1- Water
IPZ-2- Water

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Map Projection: NAD83 UTM Zone 17N

3.3. Intake Protection Zone 3 (IPZ-3)

Intake Protection Zone 3 (IPZ-3) is meant to protect water quality against long term chronic exposure of contaminants that can impair the quality of the water as a source of drinking water.

The IPZ-3 includes the area of Callander Bay and the areas of each surface water body in its watershed that may contribute water to the intake, and where these areas abut land, a maximum 120-m setback along the abutted land where overland flow drains into the surface water body (Figure 12). The IPZ-3 was extended to include the portion of the Callander sewershed that drains to Callander Bay outside of the IPZ-2. The IPZ-3 does not include areas defined as IPZ-1 or IPZ-2. It should be noted that this delineation does not reflect the potential for contaminant transport under extreme events.

As the Callander intake is located in Lake Nipissing, Rule 68 requires that IPZ-3 be delineated to include the area within each surface water body through which, modelling or other methods demonstrate that contaminants released during an extreme event may be transported to the intake. This rule stems from the fact that Lake Nipissing and its watershed are extremely large such that more distant parts of the lake and surface water bodies in its watershed are unlikely to contribute contaminants to the intake under normal weather conditions. As described in Section 2.2, under normal weather conditions, the dominant flow is from Callander Bay toward the main basin of Lake Nipissing, away from the intake. Flow reversals can occur, however, potentially allowing the transport of contaminants released during an extreme event toward the intake.

At the outset of this project, the Source Protection Area (SPA) had not yet been defined, and it was initially thought that the SPA would only extend to the mouth of Callander Bay where it meets the main basin of Lake Nipissing. Under the *Act*, the IPZ-3 cannot extend beyond the boundary of the SPA (George Jacoub, Ministry of the Environment, Pers. Comm.). Modelling was therefore not considered to be required to delineate areas of Lake Nipissing and its watershed where contaminants released during an extreme event may be transported to the intake (these areas were thought to fall outside of the SPA). The final boundaries of the SPA that were designated in 2009, however, do in fact include portions of Lake Nipissing and its watershed. The Source Protection Committee should consider the need to re-evaluate the IPZ-3 delineation to account for extreme events as defined by Rule 68 in the SPA areas outside of Callander Bay.

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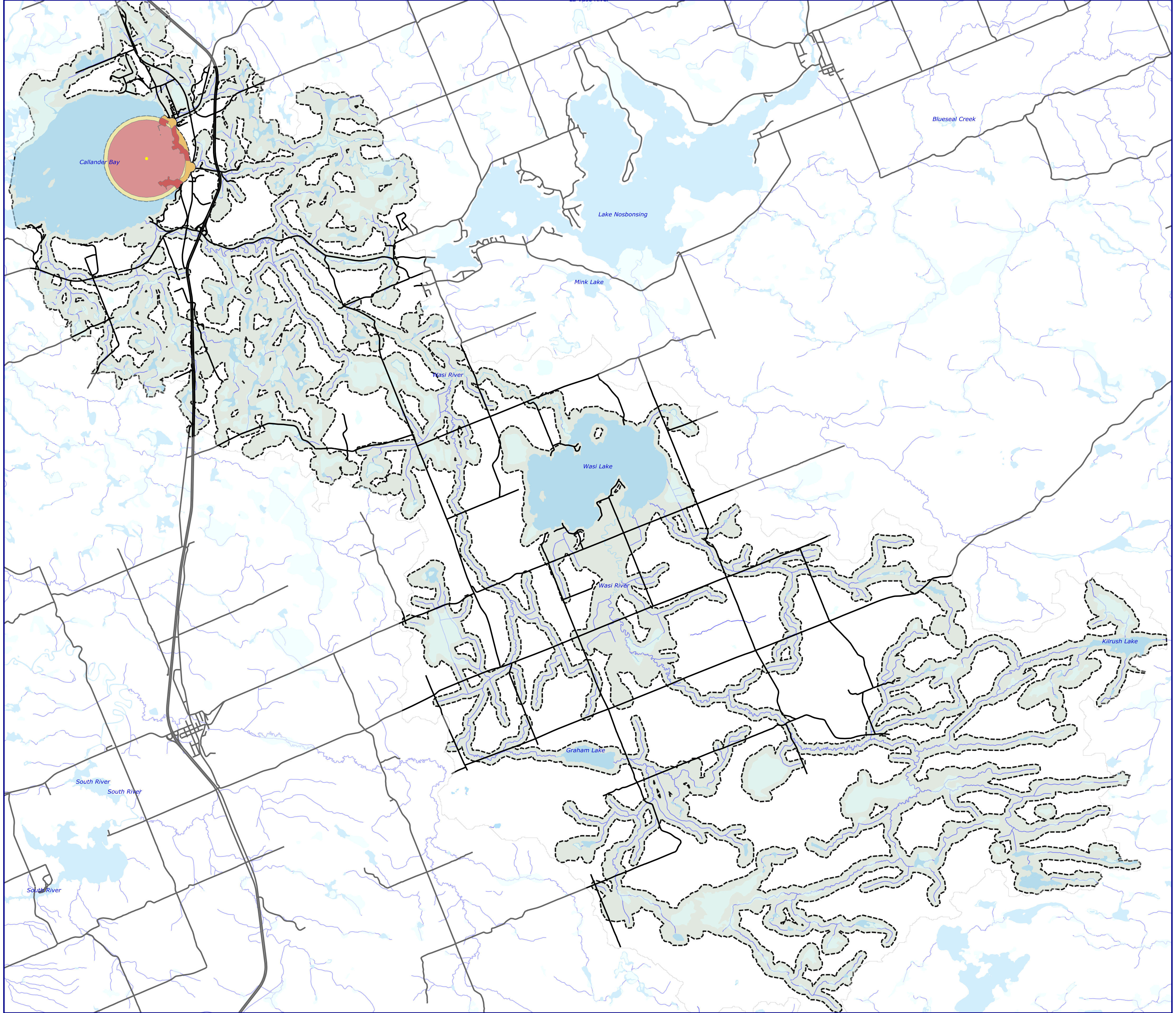

FIGURE 12
Municipality of Callander Intake Intake Protection Zone Three (IPZ 3)

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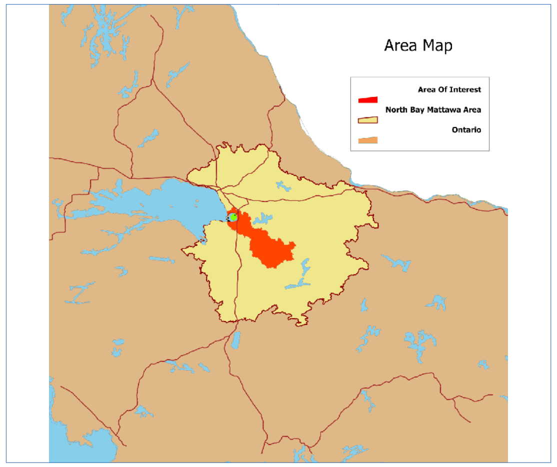

—	Streams/Rivers
▬	Water
▬	Wetland
●	Callander Bay Intake
—	Roads
	Callander Bay IPZ
▨	IPZ-3
▨	IPZ-2
▨	IPZ-1
▬	IPZ-1- Water
▬	IPZ-2- Water

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Map Projection: NAD83 UTM Zone 17N

4. Transport Pathways

Transport pathways are shortcuts through which contaminants can more easily travel to the drinking water source, thereby influencing vulnerability of the intake protection zones. There are two types of preferential pathways:

1. natural pathways (e.g., small channels or swales that are not sufficiently large to be mapped at a scale 1:50000, sand lenses, fractured rocks); and
2. constructed pathways (e.g., sewer discharge pipes, utility trenches, urban and rural drainage).

Transport pathways located in the IPZ-1 and IPZ-2 and portions of the IPZ-3 were identified during several site visits.

The setback areas of the IPZ-2 and IPZ-3 can be extended to include the area that contributes water through a transport pathway and are considered in the vulnerability scoring of those zones.

While several small natural transport pathways were identified during site visits, the drainage areas of these were mostly contained within the setback areas of the IPZs and therefore would not necessitate an extension of the IPZ-2. Natural pathways included two small creeks that drain the Callander Municipal yard.

Constructed preferential pathways include nine stormwater outfalls that drain urban lands from the Town of Callander to Callander Bay and one stormwater outfall draining to Unnamed Creek 323, which then drains to Callander Bay. As well, an additional pathway consists of a constructed ditch that captures drainage from areas between Terrace and Callander Bay Roads. The extent of the drainage area captured by this pathway was not able to be confirmed by HESL due to snow cover. Water is directed under Callander Bay Road via a culvert which then enters an infiltration ditch that runs along Green Road, then Greenwood Road (within IPZ-1),eventually discharging to Callander Bay on the south side of Burford Point. The locations of constructed transport pathways are illustrated in Figure 11. As the drainage areas of these pathways were encompassed by the IPZ-2, no extension of the IPZ-2 was required.

5. Intake Protection Zone (IPZ) Vulnerability Scores

Vulnerability scores (V) provide a comparative assessment of the likelihood that a contaminant originating within the intake protection zones could reach the Callander intake. Vulnerability scores are calculated by multiplying the Area Vulnerability Factor (Vfa) by the Source Vulnerability Factor (Vfs) (Rule 87). Guidance for calculating these vulnerability factors is provided in Part VIII.2 and Part VIII.3 of the Rules.

The Source Vulnerability factor (Vfs) is the same for all IPZs and is scored in consideration of:

1. the depth of the intake from the surface of the water,
2. the distance of the intake from land, and
3. the history of drinking water concerns relating to the intake.

Callander Bay is assigned a Vfs of 0.9 from a possible range of 0.8 to 1.0. The following characteristics contribute to the vulnerability of the source:

- the intake is located in relatively shallow water (~8-m deep) and Callander Bay is polymictic, mixing frequently over the open water season, thus allowing potential contaminants from surface waters to move to the depth of the intake during mixing events, and
- there have been past instances of drinking water concerns related to the intake including seven drinking water issues identified under Rule 114 (see Section 6).

The source vulnerability is moderated, however, because the intake is located relatively far from shore (the closest distance to land from the intake is ~0.7 km), and while drinking water issues exist, these are all primarily the result of natural causes.

Area Vulnerability factors (Vfa) were assigned to the IPZs in accordance with Rules 88-93. Vfa is a fixed value of 10 for the IPZ-1. For the IPZ-2 and IPZ-3, assignment of Vfa must consider the following aspects that influence vulnerability:

1. the percentage of area that is composed of land, where a greater land area reduces vulnerability,
2. land cover, soil type, permeability of the land and the slope of any setbacks,
3. hydrological and hydrogeological conditions in the area that contribute water to the area through transport pathways, and
4. in respect of the IPZ-3, the proximity of the area of the IPZ-3 to the intake.

A Vfa of 9 from a possible range of 7 to 9 was assigned for IPZ-2 because:

- most of the IPZ-2 is comprised of water, which facilitates the movement of potential contaminants,
- land area consists primarily of urban and residential lands with a high percentage of cleared area and impermeable surfaces (~15%) that create high runoff generation potential,
- the setback areas along the southwest shore of Callander Bay have steep slopes, enhancing water movement toward the bay, and
- there are several transport pathways that drain urban and residential lands facilitating the transport of potential contaminants to Callander Bay. These include the Green Road transport pathway, two stormwater outfalls that drain areas of the sewershed and two intermittent creeks that drain areas of the Municipal yard.

Rule 90 allows for different Vfa scores to be assigned to different areas within the IPZ-3, but these scores must be lower than those of the IPZ-2, and so must range between 1 and 8. The IPZ-3 was subdivided into 6 subzones, IPZ3a-f. For each subzone, the Vfa was calculated as the sum of individual scores (0, 1 or 2) assigned for each of the four aspects that are to be considered when assessing vulnerability. The breakdown of the Vfa scoring is provided in Table 9 and the rationale for the scoring is described, below.

IPZ-3a includes the surface area of Callander Bay associated 120-m setbacks on land. This subzone was assigned a Vfa of 7 because the area is comprised primarily of water, there are numerous transport pathways draining land areas (stormwater outlets, stormwater pond drainage, the inlet of the lagoon discharge channel) and the area lies in proximity to the intake. All of these characteristics increase the vulnerability of the area. Land cover of the setback area is variable with some cleared areas with low density residential/cottage development, moderate amounts of impermeable surface area where roads are present, and some greatly sloping areas, particularly along the east shoreline south of the low lift station pump house.

Subzones IPZ-3b-e were all assigned a Vfa of 5. These areas are considered less vulnerable than the IPZ-3a subzone as they are comprised of nearly equal portions of land and water, the setbacks on land have less impermeable surfaces (<2%) and cleared area, and the subzones are more distant from the intake.

Subzone IPZ-3f encompasses the surface area of Wasi Lake and upstream water bodies, and associated 120-m setbacks on land. This subzone was assigned a low Vfa of 3. As with IPZ-3b-e, IPZ-3f is comprised of nearly equal amounts of land and water. Much of the land area is cleared for agricultural use increasing the vulnerability of this subzone. There is little impermeable area in the subzone and slopes of the setback are low. Vulnerability of this zone is greatly reduced due to its distance from the intake. Transport pathways were not identified in this zone, but given the agricultural land use in the subzone, there are likely constructed pathways that could increase vulnerability.

Table 9. IPZ-3 Area Vulnerability Factors

Aspect	IPZ-3 Subzone Factor Scores		
	a	b-e	f
% land area	2	1	1
Land cover, soils, permeability, slope of setbacks	1	1	1
Transport pathways	2	2	1
Proximity to the intake	2	1	0
Total (Area Vulnerability Factor, Vfa)	7	5	3

The resulting vulnerability scores for the vulnerable area of the Callander intake are summarized in Table 10 and illustrated in Figure 13.

Table 10. Vulnerability Scores (Vs) for the Callander Vulnerable Areas

Area	Source Vulnerability Factor	Area Vulnerability Factor	Vulnerability Score
IPZ-1	0.9	10	9
IPZ-2	0.9	9	8.1
IPZ-3a	0.9	7	6.3
IPZ-3b,c,d,e	0.9	5	4.5
IPZ-3f	0.9	3	2.7

North Bay – Mattawa

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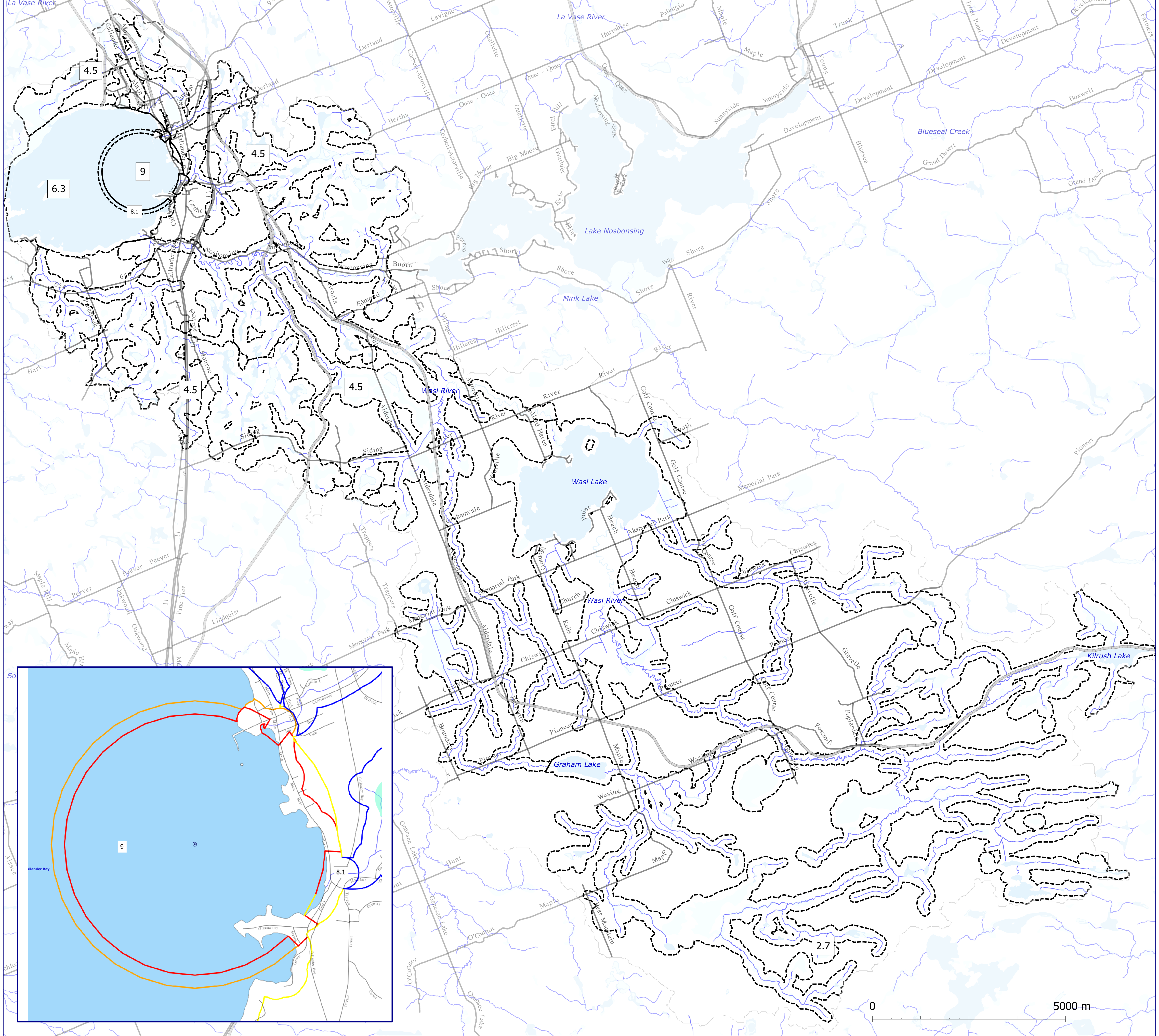
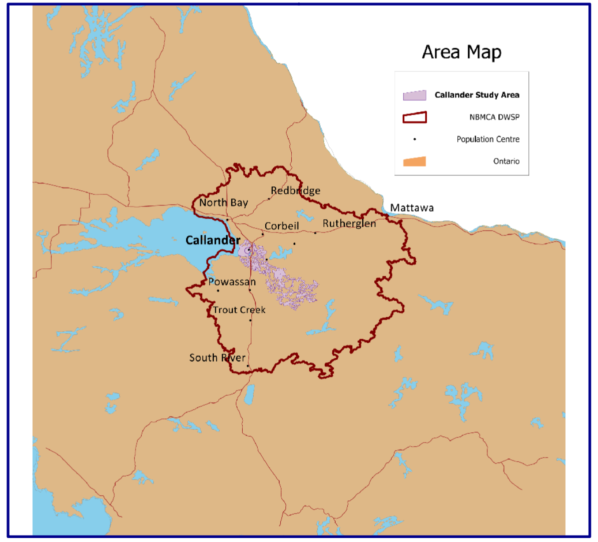
FIGURE 13
Municipality of Callander Intake Intake Protection Zone Vulnerability Scores

DRAFT





━	Streams/Creeks
🟦	Water
🟩	Wetland
━	Roads
	IPZ Vulnerability Areas
▭	Scored Area

Map produced by:
GIS/Data Specialist
North Bay-Mattawa Conservation Authority
15 Janey Avenue, North Bay ON P1C 1N1
(705) 475-5420

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Map Projection: NAD83 UTM Zone 17N

6. Uncertainty Analysis – Water Quality

Part I.4 of the Rules requires that an uncertainty rating of high or low be made with respect to the delineation of the surface water intake protection zones (Rule 13 (3)) and the assessment of vulnerability of the zones (Rule 13(4)) based on the consideration of factors set out in Rule 14, including:

1. The distribution, variability, quality and relevance of data used in the preparation of the assessment report.
2. The ability of the methods and models used to accurately reflect the flow processes in the hydrological system.
3. The quality assurance and quality control procedures applied.
4. The extent and level of calibration and validation achieved for models used or calculations or general assessments completed.
5. The accuracy to which the area vulnerability factor and the source vulnerability factor effectively assesses the relative vulnerability of the hydrological features.

In general, the distribution, variability, quality and relevance of the data were adequate to confidently delineate the IPZs and assign vulnerability scores. Geographical information available from the Ministry of Natural Resources provided the data necessary to identify water bodies and water courses to delineate watershed areas and to characterize setback areas for the vulnerability scoring. The position of the intake is accurate having been confirmed by divers.

A degree of uncertainty exists, for the delineation of the IPZ-2 due the lack of a current hydrodynamic model to estimate time-of-travel in Callander Bay and two creeks (Burford Creek and Creek 323). We have used measured current information from a study conducted in 1986 and based time-of-travel calculations on maximum observed velocities in October of that year assuming constant current direction toward the intake. This method of calculating time-of-travel is conservative based on the available data, but is unable to provide confident time-of-travel estimates under storm conditions (e.g., 20-year storm event. Despite this uncertainty, time-of-travel estimates derived using the 1986 data are consistent with time-of-travel estimates using general limnological principals for maximum surface water current speeds (i.e., for the City of North Bay intake), lending confidence to the calculations for the Callander intake.

Additional uncertainty exists for the delineation of the IPZ-2 as there are no known available flow or modelling data to calculate flow velocities in Burford Creek or Creek 323 at the time of the study. The IPZ-2 was extended upstream of these creeks to capture a two-hour time-of-travel under the flow velocity for a 100-year flood event of 0.5 m/s that was determined for the nearby Wistiwasing River in the Wasi River Management Study (A. J. Robinson and Associates, Inc., 1986). Using this velocity, the IPZ-2 is extended 205 m upstream of Burford Creek and 130 m upstream of Creek 323 to encompass a two-hour time-of-travel to the intake. This extension of the IPZ-2 is considered to be very conservative as the Wistiwasing River is a large larger river with substantially greater flow velocities than that which would be observed in the smaller creeks. The IPZ-2 therefore may require modification in subsequent phases of Source Water Protection planning if measured velocities are obtained for Burford Creek and

Creek 323. We note, however, that the creeks discharge to Callander Bay at distance to the intake, requiring that the IPZ-2 only be extended to include a time-of-travel of 4 and 6.8 minutes for Creek 323 and Burford Creek, respectively. Use of measured flow velocities for these creeks would result in minimal change to the delineation of less than 205 m for Burford Creek and 130 m for Creek 323. We note that flow data were collected from these creeks over the 2009 ice free season and could be used to assess the validity of the delineations. These data were not received by HESL until after production of this report.

A low level of uncertainty exists for the vulnerability scoring of the IPZ-3 as transport pathways were not identified by site investigations for this large area. Given the great distance of the IPZ-3 to the intake, however, the existence of transport pathways in this vulnerable area would not significantly influence the vulnerability scoring of this zone.

While there is some uncertainty in the IPZ-2 delineation and vulnerability scoring for IPZ-3, as described above, this uncertainty is considered to be low and additional data to reduce the uncertainty would not likely result in significant changes to the delineations or the vulnerability scores. In summary, an overall ‘low’ uncertainty is given to all of the IPZ delineations and the associated vulnerability scores.

7. Drinking Water Issues

Drinking water issues, as defined in Part XI.1 of the Rules relate to the presence of a ‘listed parameter’[7] in water at the intake if:

1. the parameter is present at a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water; or
2. there is an increasing trend of the parameter that would result in the deterioration of water quality for use as drinking water.

Drinking water issues can also relate to pathogens in water at a surface water intake that are not one of the ‘listed parameters’, but to be included requires that a microbial risk assessment be conducted with respect to that pathogen. For the Callander intake, no microbial risk assessment was undertaken for any pathogens. The only pathogens considered in this issues evaluation are total coliforms and *E. coli*, which are listed parameters.

The Rules do not specifically define ‘deterioration of the quality of water for use as a source of drinking water’, but the MOE has noted that evaluation of drinking water issues should relate to the ability of the treatment facility to treat the water (EBR Technical Consultation, June 2008). Moreover, insufficient data exist for raw and treated water from the WTP to evaluate trends, such that the potential degree of deterioration of water quality for use as a drinking water source cannot be determined at this time. In consideration of above, listed parameters were therefore identified as drinking water issues if a parameter has exceeded any of the applicable benchmarks: (Ontario Drinking Water Quality Standard (ODWQS), or MOE’s (2006) Aesthetic Objective (AO), or Operational Guideline (OG)).

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[7] *Parameters listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines.*

7.1. WTP Raw Water Quality Parameters

The following section describes parameters in raw water sampled at the Callander intake and assesses those parameters relative to applicable drinking water quality standards, objectives and guidelines (O.Reg. 169/03; MOE, 2006) based on all available raw water quality data received for evaluation prior to May 15, 2009.

Data Availability

The original Certificate of Approval (C of A) for the Callander WTP required that raw water be analyzed quarterly for general water quality parameters[8], on a weekly basis for *E. coli* and colour, and at least once per day for pH, colour, turbidity and temperature. The original C of A has been amended several times such that raw water quality sampling has changed. The Ministry of the Environment developed new rules that came into effect on August 26, 2000 with the implementation of the Drinking Water Protection Regulation for Larger Waterworks (O. Reg. 459/00). As of June 1, 2003, under the Safe Drinking Water Act, the Drinking-Water Systems Regulation (O. Reg. 170/03) came into effect superseding O. Reg. 459/00. These data are archived in the Drinking Water Information System (DWIS) that is maintained by the Drinking Water Management Division of the OMOE.

Since 2000, raw water from the Callander intake has been monitored for turbidity, colour, pH and iron, which are reported on a monthly basis. Monthly process reports for these parameters were available for 2000-2002, 2006 and 2007 (January to July) from OCWA and were reviewed for this study. Monthly process reports for 2003 to 2005 have been requested from OCWA and the OMOE Thunder Bay, and data from these missing reports will be included in our assessment of raw water quality if they are received prior to the final report deadline. The last known analysis of general raw water quality parameters for the Callander drinking water supply was conducted on March 28, 2001, and the results are provided in Table 9. Information pre-dating 2001 was obtained from an overview of the Engineers' Report for Water Works by RAL Engineering Limited (2001).

Drinking Water Information System (DWIS) data, which provides *E. coli* data for 2005 and 2006 and total coliform data for 2003 to 2004, were available for both raw and treated water. No other parameters for raw water were provided in the DWIS file that was made available by OCWA.

The analysis of raw water quality that follows is based on:

- a single sampling date (March 28, 2001)
- available Monthly Process Reports for colour, turbidity, pH and iron (for 2000-2002, 2006 and 2007 (January to July)
- DWIS data for *E. coli* (2005, 2006) and total coliform (2003-2004)

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[8] *Quarterly water quality parameters include alkalinity, hardness, calcium, sodium, iron, copper, lead, zinc, arsenic, aluminum, manganese, conductivity, chloride, sulphate, ammonia + ammonium (N), total Kjeldahl nitrogen, nitrite, nitrate, dissolved organic carbon, and phenols.*

Information pre-dating 2001 was obtained from the Engineers' Report for Water Works by RAL Engineering Limited (2001).

Recommendation: Only limited raw water quality monitoring data from the Callander Water Treatment Plant were made available despite several requests from OCWA and the MOE Thunder Bay District office. It is our understanding that the following information exists and should be reviewed to confidently assess raw water characteristics for the identification of drinking water issues for source protection:

- Monthly process reports (2003-2005) – turbidity, colour, pH, iron, *E. coli*
- Quarterly Reports (prior to 2000) – general raw water parameters
- Weekly Reports (prior to 2000) – *E. coli*, colour
- Daily Reports (prior to 2000) – pH, turbidity, temperature, colour
- any recent general raw water quality data (post March 28, 2001)

Concern: Lack of long-term raw water quality data precludes a confident assessment of general water quality conditions and identification of potential changes in raw water quality over time.

General raw water chemistry measured March 28th, 2001 entering the Callander WTP reflects the overall water quality characteristics in Callander Bay (Table 11). Waters were circumneutral (pH = 6.82), coloured (true colour = 5 TCU) and turbid (turbidity = 2.0 NTU) and had relatively high concentrations of dissolved organic carbon (DOC), organic nitrogen (total organic and total Kjeldahl) and suspended solids. All general water quality parameters on that sampling date were below the applicable Ontario Drinking Water Standards, Objectives and Guidelines (MOE 2006) with the exception of aluminum, colour, and organic nitrogen, which are discussed below.

Aluminum

The aluminum concentration of 0.216 mg/L exceeded the operational guideline of 0.1 mg/L (MOE, 2006) in raw water in March 2001 (Table 9). Aluminum is the most abundant metal on Earth, and is found naturally in soil, water and air. Because of the pervasiveness of aluminum in the natural environment, and its enhanced mobility and leaching from soils that are poorly buffered like those in the catchment of Lake Nipissing, it is not uncommon for aluminum concentrations to exceed the guidelines in raw water in this region. Similarly elevated aluminum concentrations occur in other locations in Lake Nipissing, although it should be noted that the concentration in the raw water sample in March 2001 was higher than any surface water measurement from Callander Bay (see Table 5). Snowmelt in early spring can release acidity to runoff waters, mobilizing aluminum that would otherwise be bound in the sediments. Therefore, the elevated aluminum concentration in the raw water sample may reflect a spring acidity pulse.

Issue: Aluminum levels during spring snowmelt have exceeded the Ontario Drinking Water-quality Operational Guideline in raw water at the Callander intake.

Colour

Colour may occur in natural waters for several reasons. It may be due to natural causes such as the presence of coloured organic substances originating from the decay of vegetation within the lake or its catchment, and/or from the presence of metals such as iron, manganese and copper, which are abundant in nature and are weathered from rock. Other sources of colour include industrial wastes, the most common of which are pulp and paper and textile wastes.

Table 11. General Raw Water Quality (March 28, 2001)

Parameter	Units	Value	Method Detection Limit (MDL)	CDWQ Guideline
Alkalinity (as $CaCO_3$)	mg/L	25.0	1	30-500^{og}
Aluminum	mg/L	**0.216**	0.025	0.1^{og}
Ammonia-N	mg/L	<0.05	0.05	
Arsenic	mg/L	<0.002	0.002	0.025^{I}
Barium	mg/L	0.024	0.001	1
Boron	mg/L	0.020	0.005	5^{I}
Cadmium	mg/L	<0.003	0.003	0.005
Chloride	mg/L	130	15	250^{ao}
Chromium	mg/L	<0.005	0.005	0.05
Colour	TCU	**5**	5	5^{ao}
Copper	mg/L	<0.003	0.003	1.0^{ao}
Dissolved organic carbon	mg/L	4.3	0.1	5^{ao}
Fluoride	mg/L	<1	1	1.5
Free Cyanide	mg/L	<0.02	0.02	0.2
Hardness (as $CaCO_3$)	mg/L	37.0	n/a	80-100^{og}
Iron	mg/L	0.208	0.005	0.3^{ao}
Lead	mg/L	<0.002	0.002	0.01
Manganese	mg/L	0.037	0.001	≤0.05^{ao}
Mercury	mg/L	<0.0001	0.0001	0.001
Nitrate	mg/L	<1	1	10
Nitrite	mg/L	<0.1	0.1	1
Nitrite+Nitrate	mg/L	0.0	n/a	10^{n}
Nitrilotriacetic Acid (NTA)	mg/L	<0.05	0.05	0.04
Organic Nitrogen	mg/L	**0.47**	0.15	0.15^{og}
pH		6.82	0.01	6.5 - 8.5^{og}
Selenium	mg/L	<0.002	0.002	0.01
Sodium	mg/L	6.58	0.06	200^{ao}
Sulfates	mg/L	21.0	5	500^{ao}
Total Dissolved Solids	mg/L	87.0	1	500^{ao}
Total Kjeldahl Nitrogen	mg/L	0.5	0.1	
Turbidity	NTU	2.0	0.1	5.0
Zinc	mg/L	<0.003	0.003	5.0^{ao}

Notes: *Values in bold exceed the applicable Ontario Drinking Water Quality Standards, Objective and Guidelines (MOE, 2006); ^{op}operational guideline for conventional water treatment plants; ^{I}interim maximum acceptable concentration (IMAC); ^{ao}aesthetic objective;* ^{n}where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen)

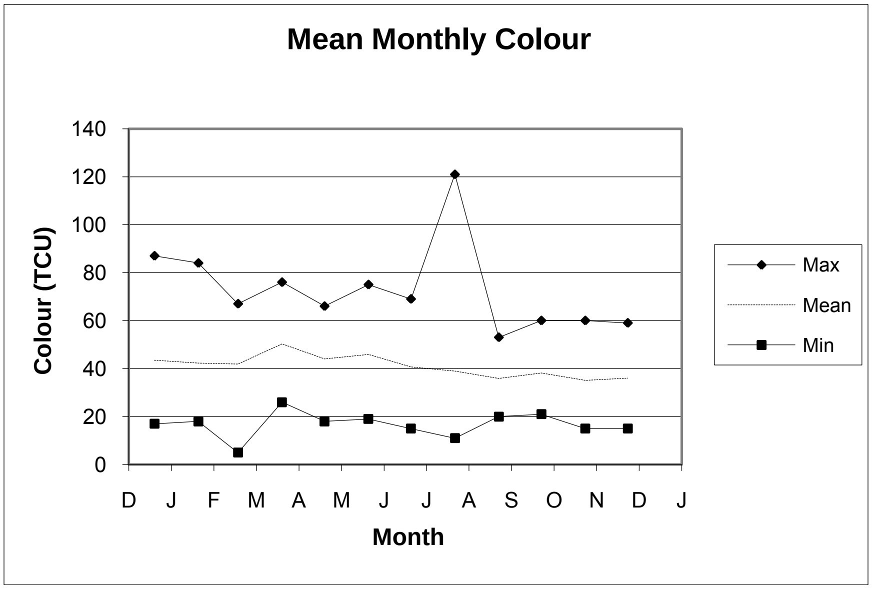
Colour is primarily an aesthetic quality of water, however the presence of colour in drinking water may be indirectly linked to a variety of health risks. True colour is the measure of colour in water from which particulate matter has been removed. The Ontario Drinking Water-quality Aesthetic Objective for colour is 5 true colour units (TCU)

(MOE, 2006). Raw water drawn from Callander Bay is highly coloured and exceeds these objectives based on available Monthly Process Reports (Figure 14). Mean monthly colour ranges from approximately 35 to 50 TCU. The highest recorded colour occurred in August of 2001.

The source of colour in Callander Bay is due primarily to elevated concentrations of dissolved organic substances and naturally occurring iron concentrations. Dissolved organic matter is not monitored in raw water, but dissolved organic carbon (DOC) concentrations measured in surface water of Callander Bay and the Wasi River are elevated (Table 5). Similarly, naturally occurring iron concentrations are relatively high in the surface waters of Callander Bay, but this is not uncommon for soft water lakes in the Canadian Shield. We note that high colour can also result from algal production. Callander Bay is eutrophic with high algal productivity that likely contributes to colour. Despite elevated colour measured in raw water, treatment processes at the Callander WTP effectively reduce colour in the treated water to values below the objectives.

Issue: Colour regularly exceeds the Ontario Drinking Water-quality aesthetic objective in raw water at the Callander intake. Colour is likely due to natural causes including a combination of high concentrations of dissolved organic matter and iron, but also high algal production.

Figure 14. Mean Monthly Colour in Raw Water Drawn from Callander Bay



Note: Data were obtained from Monthly Process Reports for 2000-2002, 2006-2007.

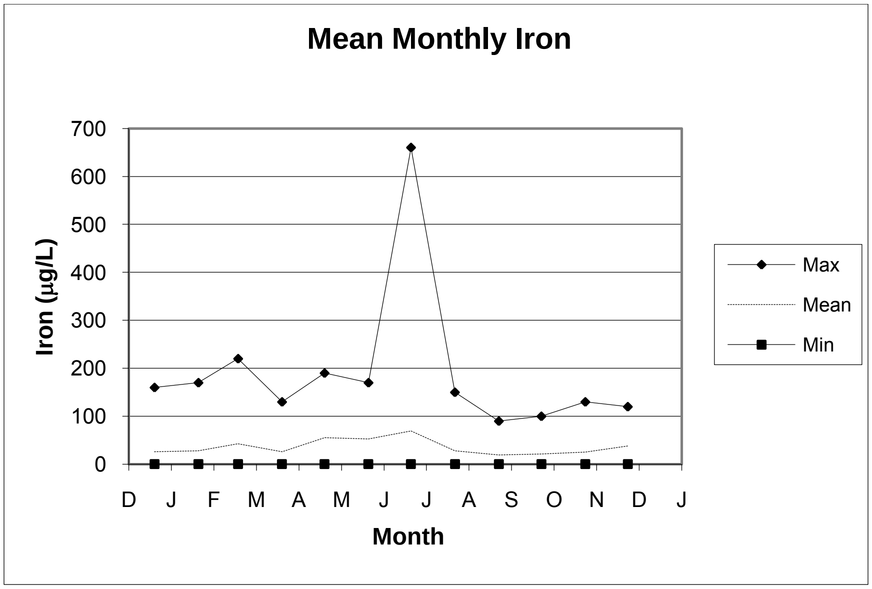
Iron

Iron in surface waters can originate from the weathering of rocks and minerals, acidic mine water drainage, landfill leachates, sewage effluents and iron-related industries. The concentrations of iron in Canadian surface waters are generally below 1.0 mg/L. While iron can have toxic effects at very high levels, there is no evidence to indicate that concentrations of iron commonly present in food or drinking water pose any hazard to human health (Health Canada, 2006). The aesthetic objective for iron in drinking water is 0.3 mg/L (MOE, 2006).

Mean monthly concentrations of iron in raw water from Callander Bay ranged between 0.26 and 0.70 mg/L based on available records (Figure 15). Over this time period, the objective was exceeded only in the month of July in 2002. Iron concentrations are reduced by treatment processes and have not exceeded the Ontario Drinking Water Standards (MOE 2006) in treated water (see Section 6.3).

Issue: Iron concentrations have exceeded the Ontario Drinking Water Aesthetic Objective in raw water. Iron in the raw water is likely from natural sources.

Figure 15. Mean Monthly Iron Concentrations in Raw Water Drawn from Callander Bay



Note: Data were obtained from Monthly Process Reports for 2000-2002, 2006-2007.

Turbidity

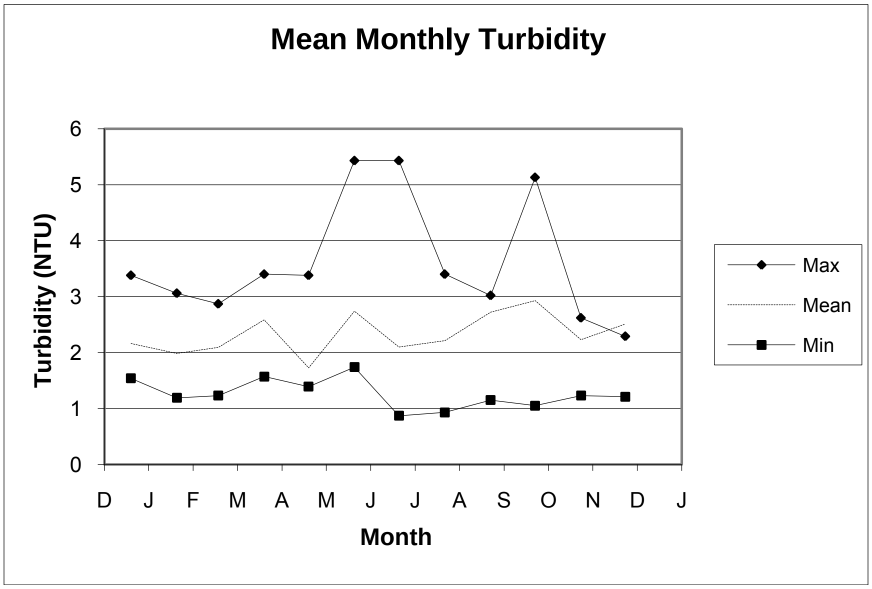
Turbidity is a measure of the 'cloudiness' of water and is caused by suspended particles in the water that cause light to scatter. Suspended particles in water can be clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity is measured as NTU (nephelolometric turbidity units), which is the measurement of the amount of light that passes through a sample of water. The maximum acceptable turbidity for drinking water is 5 NTU (MOE, 2006).

Elevated turbidity levels can interfere with the water treatment process (e.g., chlorination and UV disinfection), and also affect drinking water infrastructure (e.g., leading to pipe corrosion). Turbidity associated with suspended organic matter can lead to higher amounts of disinfection by-products that form in treated water, such as trihalomethanes. In addition, suspended particles that cause turbidity can include disease-causing organisms (e.g., *Giardia* cysts and *Cryptosporidium* oocysts) and may contain toxins such as heavy metals and biocides. Excessive turbidity may also be associated with unpleasant tastes and odours in the drinking water.

Turbidity is reported as monthly averages in the Monthly Process Reports. The average monthly turbidity of raw water from Callander Bay is relatively constant throughout the year ranging from 2.0 to 2.8 NTU. Maximum peaks in turbidity typically occur in the summer months (June and July), but also in October (Figure 16), and these have exceeded the aesthetic objective of 5 NTU (MOE, 2006). The primary cause of the turbidity peaks in raw water from Callander Bay is likely resuspension of sediments during strong wind events. Other potential causes of increased turbidity include high algal productivity and inputs of suspended particles via stormwater outlets and tributary discharges during rain events. PWQMN data from the Watiwising River (2007) indicate relatively high concentrations of total suspended solids (mean particulate residue = 6.71 mg/L), also likely contributing to turbidity in Callander Bay.
The Callander WTP effectively reduces turbidity by filtration to levels below the Ontario Drinking Water Aesthetic Objective of 5.0 NTU (see Section 6.3).

<u>Issue</u>: Turbidity in raw water has exceeded the Ontario Drinking Water Aesthetic Objective of 5 NTU.

Figure 16. Mean Monthly Turbidity in Raw Water Drawn from Callander Bay



Note: Data were obtained from Monthly Process Reports for 2000-2002, 2006-2007.

Organic Nitrogen

Organic nitrogen is the difference between Kjeldahl nitrogen and ammonia nitrogen. There are natural sources of organic nitrogen, but contamination from septic tanks, sewage effluent and agricultural runoff can also be a significant source. Amine groups are commonly found in organic nitrogen compounds, which can react with chlorine and reduce its disinfectant power. Taste and odour problems are commonly associated with elevated organic nitrogen concentrations in drinking water.

Organic nitrogen concentration in March 2001 was 0.47 mg/L, which exceeded the operational guideline of 0.15 mg/L (MOE, 2006). Elevated organic nitrogen in Callander Bay is most likely from natural sources and there is no evidence of significant contamination by septic systems (based on the septic system inspections performed by the NBMCA) or from the sewage lagoon discharges that would cause organic nitrogen concentrations to exceed the guidelines.

***Issue*: Organic nitrogen has exceeded the operational guideline of 0.15 mg/L in raw water at the Callander intake and is most likely caused by natural source of nitrogen.**

Bacteria

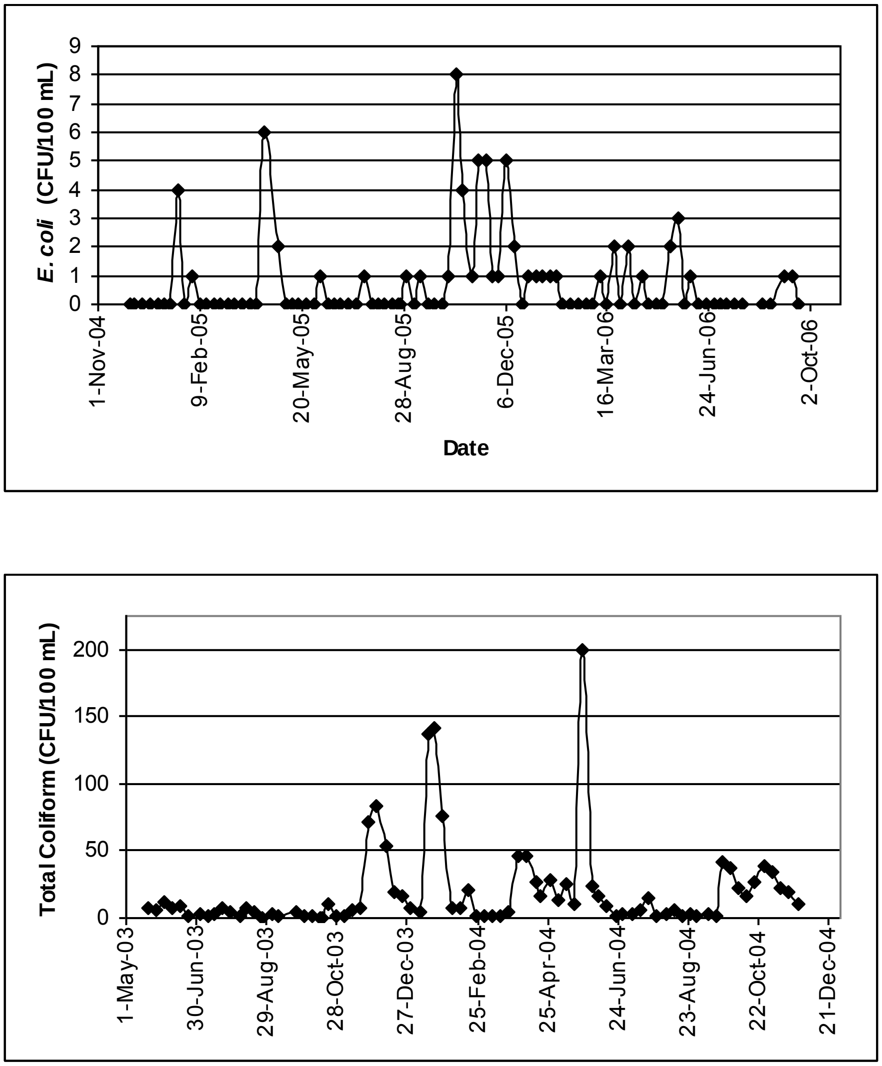
Only two years of data were available to characterize fecal bacterial indicators (total coliform (2003-2004) and *E. coli* (2005-2006)) in raw water from Callander Bay (Figure 17). Based on these data, bacterial levels are low throughout the year, but often exceed the ODWQS. Insufficient data exist to assess seasonal or annual trends. Treatment processes have effectively maintained *E. coli* and total coliform counts at 0 CFU/100 mL as per the ODWQS (MOE, 2006) (see Section 6.3).

Concern: Lack of data precludes confident assessment of fecal bacterial indicators in the raw water supply for Callander. Missing data should be obtained and reviewed to assess any potential trends in bacterial levels (e.g., relationship between the timing of lagoon discharges and bacteria levels at the intake, seasonal or yearly trends).

E. coli concentrations in raw water are typical for natural surface waters and are not indicative of contamination by human sources of sewage.

Issue*: E. coli *has exceeded the ODWQS in raw water at the Callander intake, most likely due to natural sources.

Figure 17. *E. coli* (top) and Total Coliform (bottom) in Raw Water Drawn from Callander Bay



7.2. WTP Treated Water Quality Parameters

The following treated water records were made available to Aecom for review:

1. Ministry of the Environment's annual Drinking Water System Inspection Reports (2003/04 and 2006/07),
2. Drinking Water Inspection System (DWIS) data (2003-2006), which contained treated water records for the point of entry and distribution system,
3. Quarterly Report for microbiological parameters and turbidity (September 30th, 2000) in Ral Engineering Ltd. (2001),
4. Quarterly Reports for chemical parameters (1999-2000) in RAL Engineering Ltd. (2001)

5. Performance Assessment Reports (1999, 2000; mean monthly turbidity, colour, trihalomethanes and bacteria) in RAL Engineering Ltd. (2001)

Based on the above reports and data, only two parameters have exceeded the applicable drinking water standards, objectives or guidelines. Turbidity exceeded the ODWQS on 6 occasions between June 1st, 2003 and February 11th, 2004 and lead exceeded the ODWQS on September 4, 2003.

***Issue*: Turbidity has exceeded the ODWQS in raw water at the Callander intake. Sources of turbidity are considered to be natural.**

Lead is not considered a drinking water issue as it only exceeded the ODWQS on a single occasion in September 2003, and was likely the result of a laboratory error as all other lead measurements were well below the standards.

7.3. Cyanobacterial Toxins

Section 2.3 provides a detailed description of the occurrence of toxin-producing cyanobacteria in Callander Bay. Water samples, however, have only been analyzed for algal toxins on a single occasion by the MOE and were not detected in the sample. This result is not unexpected, however, as the sample was collected in late October, and cyanobacteria blooms typically occur in late summer. Analysis of water samples for cyanotoxins should be conducted during cyanobacterial bloom events. Even so, toxin production is highly variable in space and time and is therefore often difficult to detect. As such, chemical analysis of cyanotoxins in water samples cannot be reliably used to assess the presence of microcystin without an extensive monitoring survey.

Under Rule 114, a chemical parameter can only be considered a drinking water issue if that parameter is present at a concentration that may result in the deterioration of quality of the water for use as a source of drinking water, or if there is a trend of increasing concentration of the parameter and a continuation of that trend would result in the deterioration of quality of the water for use as a source of drinking water. Measured concentrations of microcystin would therefore be required to evaluate this parameter as a drinking water issue under Rule 114.

With revisions to the Rules and approval by the Director, microcystin can now be identified as a drinking water issue based on the documented occurrence of a cyanobacteria bloom dominated by toxin-producing taxa, in accordance with the Rules. Specifically, this can be achieved under Rule 15.1, which states that:

> *Despite any provision of these rules, in preparing an assessment report a source protection committee may use an alternate method or approach for gathering information or for performing a task that departs from the method or approach prescribed in these rules if the following requirements are complied with:*
>
> *(1) The assessment report includes,*
>
> *a. a rationale for the departure; and,*
>
> *b. an explanation of how the method or approach used by the source protection committee to gather information or perform*

> *the task is equivalent to or better than the approach or method prescribed in these rules;*
>
> (2) *The Director has provided the source protection committee with written confirmation that he or she agrees to the departure and a copy of the confirmation is included in the assessment report."*

It is HESL's understanding that under Rule 15.1, the Director has approved the identification of microcystin LR as a drinking water issue under Rule 114 based on the occurrence of cyanobacterial blooms with the presence of species that can produce microcystin.

Microcystin LR is therefore considered to be a drinking water issue under Rule 114 for the Callander intake based on the following rationale:

1. Microcystin LR is a listed chemical parameter in Schedule 2 of the Ontario Drinking Water Quality Standards under the *Safe Drinking Water Act* (2002),
2. Microcystin LR has not been monitored in water at the surface water intake of the North Himsworth WTP, with the exception of one sample collected in October 2009, precluding the evaluation and identification of microcystin LR as a drinking water issue under Rule 114,
3. Significant cyanobacterial blooms dominated by toxin-producing taxa have been documented in Callander Bay (AECOM, 2009), providing sufficient evidence to list microcystin LR as a drinking water issue under Rule 114, as accepted by the Director.

7.4. List of Drinking Water Issues

Based on a detailed assessment of raw and treated water quality records from the Callander WTP and an evaluation of potential cyanotoxin production in Callander Bay, seven listed parameters have been identified as drinking water issues as per Rule 114 under clause 15(2)(f) of the *Clean Water Act* (2006) in accordance with Rule 115 (Table 12). With the exception of *E. coli*, these are also considered as drinking water issues in respect of drinking water systems not mentioned in clause 15(2)(e) of the Act that draw water from Callander Bay (Rule 114 (3)).

Table 12. List of Drinking Water Issues for the Municipality of Callander Drinking Water Supply

Issue	Water Source
Turbidity	Treated and Raw
Aluminum	Raw
Colour	Raw
Organic Nitrogen	Raw
E. coli	Raw
Microcystin	Raw (based on documented bloom activity dominated by toxin producing cyanobacteria taxa)

It should be noted that with the exception of turbidity, none of the listed drinking water issues exceeded applicable guidelines in treated water (note that microcystin has not been measured in treated water). This suggests that the Water Treatment Plant has effectively treated these parameters at the concentrations at which they occur in raw water. There are presently insufficient long-term data, however, to assess whether there is an increasing trend in any of these parameters that may affect the ability of the WTP to treat them. The determination of drinking water issues should consider treatment capabilities of the plant. In future years as these parameters continue to be monitored, if it is determined that there is no significant increase in concentrations that would affect treatment capability, then the Source Protection Committee may reassess these parameters as listed drinking water issues.

All of the drinking water issues with the exception of microcystin LR were considered to be primarily a result of natural causes, and further description of these issues under Rule 115 (identification of an issue contributing area and drinking water threats that contribute or may contribute to the issue) is not required as this rule only applies to drinking water issues that result or partially result from anthropogenic causes.

For microcystin, toxin-producing cyanobacteria are likely naturally occurring in Callander Bay, but anthropogenic sources of phosphorus to the bay are likely contributing to cyanobacterial production and the recent bloom activity (see Section 2.3). Identification of an issue contributing area and drinking water threats that contribute or may contribute to microcystin production are therefore required under Rule 115.

The issue contributing area includes the entire vulnerable area of the Callander intake (IPZs) because activities, conditions that result from past activities, and naturally occurring conditions in this area may all contribute to the phosphorus concentration in Callander Bay. It should be noted, however, there are likely abundant sources of phosphorus to Callander Bay in the watershed area outside of the IPZ such that the issue contributing area, as defined by the Rules, may not be appropriate. A phosphorus budget that determines the relative loads of phosphorus from different locations within the watershed and in the IPZs would help to ascertain whether the issue contributing area should be extended to include areas outside of the IPZs.

Drinking water threats that contribute or may contribute to phosphorus concentration in Callander Bay in accordance with Rules 118, 119 and 126 are described in Section 8.

8. Drinking Water Threats Evaluation

The threats evaluation involves the identification and assessment of threats that could cause contamination of raw water by a chemical or pathogen. Threats can include ‘activities’ or ‘conditions’ that occur within the Intake Protection Zones (IPZs). There are 19 activities that can be considered as threats with respect to drinking water as prescribed in the Clean Water Act (2006) O. Reg. 287/07 (General) in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) (Table 13). Conditions, as defined by Part XI.3 of the Rules, result from past activities and can include the presence of:

1. a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area,

2. a single mass of more than 100 L of one or more dense non-aqueous phase liquids (DNAPLs) in surface water in a surface water IPZ,
3. a contaminant in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area, if the contaminant is listed in, and its concentration exceeds the potable groundwater standard in, Table 2 of the Soil, Ground Water and Sediment Standards,
4. a contaminant is surface soil in a surface water IPZ if the contaminant is listed in, and its concentration exceeds the standard for industrial/commercial/community property in, Table 4 of the Soil, Ground Water and Sediment Standards, or
5. a contaminant in sediment if the contaminant is listed in, and its concentration exceeds the standard in, Table 1 of the Soil, Ground Water and Sediment Standards.

There are two major components to addressing drinking water threats to comply with the Rules. These involve:

1. the LISTING of activities that would be significant, moderate or low threats if they were conducted within the vulnerable areas, and
2. the ENUMERATION of significant threats (activities or conditions) that presently exist in the vulnerable areas.

There are two approaches to identifying threats; the *threats approach*, which is based on the vulnerability scores of the vulnerable areas and the *issues approach*, is based on activities or conditions that contribute to existing drinking water issues listed under Rule 114.

Table 13. Activities Prescribed to be Drinking Water Threats under the *Clean Water Act* (2006)

O. Reg. 287/07 par.	Activity
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act*.
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
3	The application of agricultural source material to land.
4	The storage of agricultural source material.
5	The management of agricultural source material.
6	The application of non-agricultural source material to land.
7	The handling and storage of non-agricultural source material.
8	The application of commercial fertilizer to land.
9	The handling and storage of commercial fertilizer.
10	The application of pesticide to land.
11	The handling and storage of pesticide.
12	The application of road salt.
13	The handling and storage of road salt.
14	The storage of snow.
15	The handling and storage of fuel.
16	The handling and storage of a dense non-aqueous phase liquid.
17	The handling and storage of an organic solvent.
18	The management of runoff that contains chemicals used in the de-icing of aircraft.
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard

Note: "agricultural source material", "application", "commercial fertilizer", "livestock", "non-agricultural source material" and "outdoor confinement area" have the same meanings as in O.Reg. 267/03 (General) of the Nutrient Management Act, *2002; "management" means, with respect to agricultural source material, the collection, handling, treatment, transportation or disposal of agricultural source material; "pesticide" has the same meaning as in the* Pesticides Act*; "sewage" has the same meaning as in the* Ontario Water Resources Act*, O. Reg. 385/08, s. 3.*

8.1. Listing Drinking Water Threats Related to Activities

Threats Approach

Part XI.4 of the Technical Rules describe the methods for identifying significant, moderate and low drinking water threats related to activities in the vulnerable area of a drinking water intake. A threat is deemed significant, moderate or low depending on a set of specific circumstances related to the activity, the vulnerable area in which the activity occurs or would occur, and the vulnerability score of the vulnerable area as specified in the Tables of Drinking Water Threats provided by the MOE. For example, in Table 14 below, the drinking water threat in Column 1 would be considered to be Significant if it was located in an area of the IPZ-1 with a vulnerability score of 9 under the circumstances set out in Column 2. The same threat would be considered to be Low in an area of an IPZ-2 with a vulnerability score of 5.1.

Table 14. Example from the MOE`s Tables of Drinking Water Threats

DRINKING WATER THREAT: Column 1	Ref. #	Under the following CIRCUMSTANCES: Column 2	Area within Vulnerable Area Column 3	Threat is Significant in Areas with a Vs of: Column 4	Threat is Moderate in Areas with a Vs of: Column 5	Threat is Low in Areas with a Vs of: Column 6
The application of agricultural source material to land	1	1. Agricultural source material is applied to land in any quantity. 2. The application may result in the presence of one or more pathogens in groundwater or surface water.	IPZ-1, IPZ-2, IPZ-3 & WHPA-E	8 - 10	6 - 7.2	4.2 - 5.6
			WHPA-A & WHPA-B	10	8	6

The Rules require that areas within vulnerable areas where activities that would be a significant, moderate or low drinking water threat be listed in the Assessment Report (that is, regardless of whether the activities presently exist in the vulnerable area).

Lists of significant, moderate and low drinking water threats related to chemicals and pathogens were compiled for each of the vulnerable areas of the Callander drinking water intake using a Ministry of the Environment, Microsoft Access database (Threats_LUT_v7.1.2) that allows the user to query threats based on vulnerability scores for vulnerable areas. Due to the large size of these data files, the lists of significant, moderate and low threats for the Callander vulnerable areas are provided in digital format in Appendix D, and the number of significant, moderate or low threats is provided in Table 15

Table 15. Numbers of Significant (S), Moderate (M) and Low (L) Threats Related to Activities in the Vulnerable Area of the Callander Intake

Vulnerable Area	Vulnerability Score	Chemical Threats			Pathogen Threats		
		S	M	L	S	M	L
IPZ-1	9	239	967	646	41	27	4
IPZ-2	8.1	14	834	898	40	13	19
IPZ-3a	6.3	n/a	40	1,282	n/a	40	28
IPZ-3b-e	4.5	n/a	n/a	239	n/a	n/a	41
IPZ-3f	2.7	n/a	n/a	n/a	n/a	n/a	n/a

Notes: n/a indicates that there are no theats

Issues Approach

In addition to the above noted threats related to activities, Rule 115 requires that threats be listed for those drinking water issues listed under Rule 114 that result from, or partially result from human activities. For microcytin, any activitiy that results in the input of phosphorus to Callander Bay is considered a threat as phosphorus contributes to the production of toxin-producing cyanobacteria. Moreover, these threats are considered significant threats regardless of the vulnerability scores of the vulnerable areas. The number of significant drinking threats related to activities that may contribute to phosphorus loading to Callander Bay and hence cyanobacteria biomass and the production microcystin and are provided in Table 16.

Table 16. Numbers of Significant Drinking Water Threats Related to Activities that may Contribute to Phosphorus Loading in Callander Bay

Activity	# of Significant Threats
The application of agricultural source material to land.	9
The application of commercial fertilizer to land.	9
The application of non-agricultural source material to land.	9
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	27
The establishment, operation or maintenance of a waste disposal site.	7
The handling and storage of commercial fertilizer.	8
The handling and storage of non-agricultural source material.	12
The storage of agricultural source material.	12
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	6
Total	99

8.2. Existing Significant, Moderate and Low Threats

Threats to drinking water within vulnerable areas for the Callander intake were identified primarily using a desktop research approach, which included review of data from the following sources of information:

- Occurence Reporting Information System (ORIS)
- National Pollutant Release Inventory (NPRI)
- Technical Standards & Safety Authority (TSSA) (data provided by the Ministry of the Environment)
- Hazardous Waste Information System (HWIS)
- Federal Contaminated Sites Inventory (FCSI)
- Lands Information Ontario (LIO) (e.g., land cover, permeability)
- North Himsworth Waste Water Treatment annual reports
- Discussions with the Technical Advisory Committee
- Mr. George Stivrins, Source Protection Committee, regarding the Chief Commanda

In addition, the presence of several threats was confirmed during field investigations (July, 2007; May 2008; February 2010) and by telephone inquiries to Mr. Anthony Falconi at the Municipality of Callander and numerous local businesses.

Activities – Threats Approach

Based on a review of the information sources listed above and several site investigations, 64 occurrences related to 6 activities prescribed to be drinking water threats in Paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of O.Reg.

287/07 (General) were confirmed to exist in the vulnerable area of the Callander drinking water intake (Table 17).

Each occurrence of an activity prescribed to be a drinking water threat was evaluated as significant, moderate or low based on the circumstances of that occurrence and using the Tables of Drinking Water Threats. Based on this evaluation, there are no existing significant drinking water threats in the vulnerable area of the Callander drinking water intake based on the threats approach. Several occurrences of the activities have circumstances that cause them to be moderate or low threats, and these are summarized in Table 17 and illustrated in Figure 18. No significant, moderate or low threats presently exist in subzones IPZ-3c-f.

Table 17. Existing Moderate (M) and Low (L) Threats in the Vulnerable Area of the Callander Drinking Water Intake (Vs refers to vulnerability score; numbers in brackets refer to the number of occurrences of the threat if greater than 1)

Activity Prescribed To be a Threat	IPZ-1	IPZ-2	IPZ-3a	IPZ-3b	Circumstance Reference #[a]
	Vs=9	Vs=8.1	Vs=6.3	Vs=4.5	
establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage			L (2)		278
			L (2)		279
			L (2)		281
			L (2)		284
			L (2)		285
			L (2)		286
			L (2)		289
	L	L			656
	L	L			657
	L				658
	L	L			660
	L	L			661
	L	L			662
	L	L			663
	L	L			664
	L	L			665
	L				666
	L	L			667
	L				668
	L	L			695
	L	L			696
	L	L			697
	L	L			698
	L	L			699
	L	L			700
	L	L	L		701
	M	L	L		702
	L	L	L		703
	M	L	L		704
	M	L	L		705
	M	L	L		706

Activity Prescribed To be a Threat	IPZ-1	IPZ-2	IPZ-3a	IPZ-3b	Circumstance Reference #[a]
	Vs=9	Vs=8.1	Vs=6.3	Vs=4.5	
handling and storage of a pesticide				L	73
application of road salt	M	M			92
	M	M			93
			L		90
			L		91
handling and storage of road salt		L			1435
		L			1436
handling and storage of fuel		L (2)			1364
		L (2)			1365
		L (2)			1366
		L (2)			1367
		L (2)			1368
		L (2)			152
		L (2)			153
		L (2)			154
		L (2)			155
		L (2)			156
	M (4)	L (2)			1349
	L (4)	L (2)			1350
	L (4)	L (2)			1351
	L (4)	L (2)			1352
	L (4)	L (2)			1353
	M (4)	L (2)			152
	L (4)	L (2)			153
	L (4)	L (2)			154
	L (4)	L (2)			155
	L (4)	L (2)			156
establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage			L (2)		1949
	M (67)	M (43)	L (67)		1956
	M	M	L		1958
				L	1959

Notes: [a]Circumstance Reference Numbers refer to those provided in Table 1 or Table 2 of the Tables of Drinking Water Threats.

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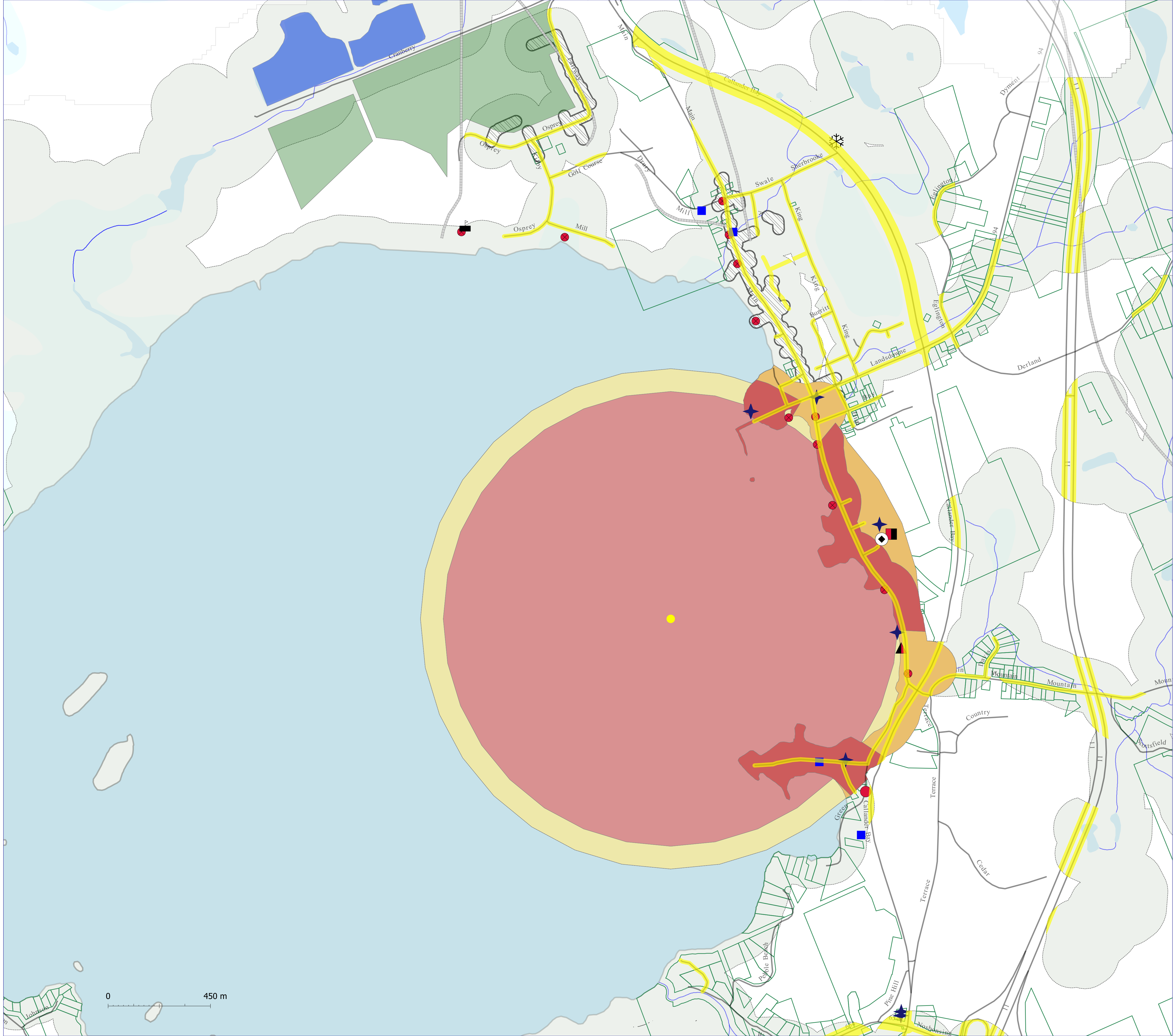
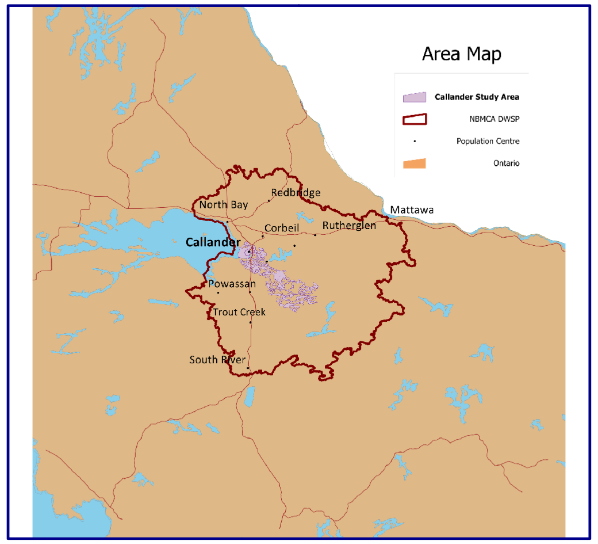
FIGURE 18
Municipality of Callander Intake Intake Protection Zone Threats and Issues Draft

DRAFT





—	Streams/Rivers
▬	Water
▬	Wetland
●	Callander Bay Intake
▨	Callander Storm Sewer
▬	Road Salt Application
▬	Golf Course
▭	Properties w/ Septic Systems
▬	Holding Ponds
▬	IPZ-1
▬	IPZ-2
▬	IPZ-1- Water
▬	IPZ 3
▬	IPZ-2- Water
◈	Salt Storage
■	Water Treatmeant Facility
❄	Snow Storage Area
✦	Fuel Storage
▬	Storm Water Pond
	Transport Pathways
●	Culvert
■	Drainage
▲	pumphouse
⊗	Storm Drain

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Map Projection: NAD83 UTM Zone 17N

Activities – Issues Approach

There are presently occurrences of 5 activities that are prescribed drinking water threats related to phosphorus in areas of the issue contributing area (equal to the vulnerable area of the Callander intake) for microcystin. As anthropogenic sources of phosphorus contribute to cyanobacteria production and hence microcystin production, these threats are considered to be significant drinking water threats regardless of the vulnerability of areas in the vulnerable area. The existing significant threats related to phosphorus and the number of occurrences of those threats are summarized in Table 18 and the locations of the threats are provided in Figure 19.

It should be noted that there is a great degree of uncertainty regarding threats related to agricultural practices. The Source Protection Committee is aware of several inconsistencies with the MPAC data and existing agricultural practices in the vulnerable area. Significant threats related to agriculture therefore are considered to be potential significant threats and site inspections are required to confirm their presence.

Conditions

There are presently no known conditions that exist in the vulnerable areas of the Callander intake.

Despite this, further evaluation of anthropogenic sources of phosphorus in sediments of Callander Bay is warranted as it relates phosphorus loading to the bay and its potential to contribute to microcystin-producing cyanobacteria. Phosphorus in lake sediments is not a listed parameter in Table 1 of the Soil, Ground Water and Sediments Standards and is therefore not considered a condition contributing to cyanobacteria biomass and the production of microcystin under the Rules. As described in Sections 2.3 and 2.4, however, phosphorus contained in sediments of Callander Bay may in fact contribute to internal phosphorus loading and this loading may represent a large portion of the total phosphorous load to the bay. If the results of a nutrient budget confirm that internal phosphorus loading is a significant component of the total phosphorus load to Callander Bay, then the source protection committee should consider requesting that sediments in Callander Bay be classified as a condition under Rule 15.1.

Table 18. Existing Significant Drinking Water Threats Related to Phosphorus and Contributing to the Drinking Water Issue, Microcystin

Prescribed Drinking Water Threat	Threat Subcategory	Quantity Circumstance	Chemical Circumstance	Ref #	# of Occur-rences
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Discharge of untreated stormwater from a stormwater retention pond	Where the drainage area is 1 to < 10 ha and the predominant land use is rural, agricultural, or low density residential.	A stormwater management facility designed to discharge stormwater to groundwater (through infiltration) or surface water	313	2 (IPZ-3a)
	Sewage treatment plant effluent discharges (includes lagoons)	Sewage Treatment Plants that discharge treated effluent >2,500 m3/d or < 17,500 m3/d on an annual average	A sewage treatment plant effluent discharge, and the discharge is not a bypass. Plant is subject to the OWRA and requires a CofA	853	1 (IPZ-3b)
	Sanitary sewers and related pipes	Sanitary sewer with a conveyance of >1,000 - 10,000 m3/d	All pipes that are moving human waste that are not part of plumbing (sanitary sewer trunks, mainlines, service connections)	667	2 (1 in IPZ-1, 1 in IPZ-2)
	Septic system	Septic system that is subject to the Building Code.	Sewage system that is defined in O.Reg. 350 under the Building Code Act (onsite septic system), except a holding tank, that may discharge to groundwater or surface water	699	See Table 19 for IPZ break-down
	Sewage holding tank	Septic System holding tank is subject to the OWRA	Sewage system (on site septic system) that requires or uses a holding tank as defined in O.Reg. 350 under the Building Code Act, that may discharge to groundwater or surface water	717	1 in IPZ-1
The application of agricultural source material to land.	Application Of Agricultural Source Material (ASM) To Land	Dependent upon % managed land and NU/acre of managed land	Land application of agricultural source material	2 4 6 8 10 12 14 16	90 in IPZ-3

Prescribed Drinking Water Threat	Threat Subcategory	Quantity Circumstance	Chemical Circumstance	Ref #	# of Occur-rences
				18	
The application of commercial fertilizer to land.	Application Of Commercial Fertilizer To Land	Dependent upon % managed land and NU/acre of managed land	Commercial fertilizer is applied to land and may result in a release to groundwater or surface water	24 26 28 30 32 34 36	28 in IPZ-3
The storage of agricultural source material.	Storage Of Agricultural Source Material (ASM)	Dependent upon the weight or volume of manure stored annually on a Farm Unit	Where agricultural source material is stored partially below grade in a structure that is a permanent nutrient storage facility as defined under the Nutrient Management Act (O.Reg 267)	1202 1204 1206 1208 1210 1212 1214 1216 1218 1220 1222 1224	90 possible in IPZ-3
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation (Grazing and pasturing)	Dependent upon NU/acre	The use of land as livestock grazing or pasturing land, where agricultural source material may be generated, and may result in a release to land or water	201 203 205	88 in IPZ-3
	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation (Yards or confinement)	Dependent upon NU generation per hectare	The use of land as an outdoor confinement area or a farm-animal yard, where agricultural source material may be generated, and may result in a release to land or water	206 209 211	90 possible in IPZ-3

Notes: Shaded cells indicate potential significant threats related to agricultural activities that require verification (by site investigations) as available MPAC data do not necessarily reflect existing conditions.

Table 19. Septic System in the Vulnerable Area of the Callander Intake

Vulnerable Area	# of Septic Systems
IPZ-1	67
IPZ-2	43
IPZ-3a	67
IPZ-3b	5
IPZ-3c	192
IPZ-3d	125
IPZ-3e	161
IPZ-3f	206

9. Summary of Information Gaps

Primary information gaps that create uncertainty in the evaluation of drinking water issues and threats noted in this study include:

1. Lack of sufficient long-term data to assess trends in parameters for the evaluation of drinking water issues.

The Municipality of Callander will now be participating in the MOE’s Drinking Water Surveillance Program (DWSP) (Pers. Comm., Jeff Celentano, CAO) and additional data collected under this program may be used, in time, to assess trends in parameters of concern. Once sufficient data become available, parameters that are presently listed as drinking water issues should be reassessed to determine if there is evidence of increasing trends that could affect the treatment capability of the plant. If not, the Source Protection Committee may consider their removal as drinking water issues.

2. Delineation of the Issue Contributing Area for threats related to phosphorus.

The Rules require that the delineation of the Issue Contributing Area include areas of the vulnerable area where threats related to the parameter of concern would contribute to a listed drinking water issue that is caused by, or partially caused by human sources. For the drinking water issue, microcystin, human sources of phosphorus can contribute to cyanobacteria blooms and hence potential production of microcystin. The Issue Contributing Area as defined by the Rules may not, however, be suitable for describing the area contributing human sources of phosphorus. That is, there may be human sources of phosphorus in areas beyond the vulnerable area that can significantly influence phosphorus concentrations in Callander Bay. A detailed phosphorus budget is required to assess human sources of phosphorus in the Callander Bay watershed and to evaluate the appropriateness of the Issue Contributing Area for phosphorus that has been delineated in accordance with the Rules.

3. Lack of recent information regarding agricultural activities in areas of the vulnerable area as they relate to significant drinking water threats contributing to phosphorus.

The MPAC data used to identify parcels with agricultural activities, and to calculate % managed land and nutrient units (NU) is out-dated and does not reflect current agricultural practices in areas of the vulnerable area for the Callander intake. Site specific investigations are therefore required to obtain the necessary data to evaluate drinking water threats related to agricultural activities.

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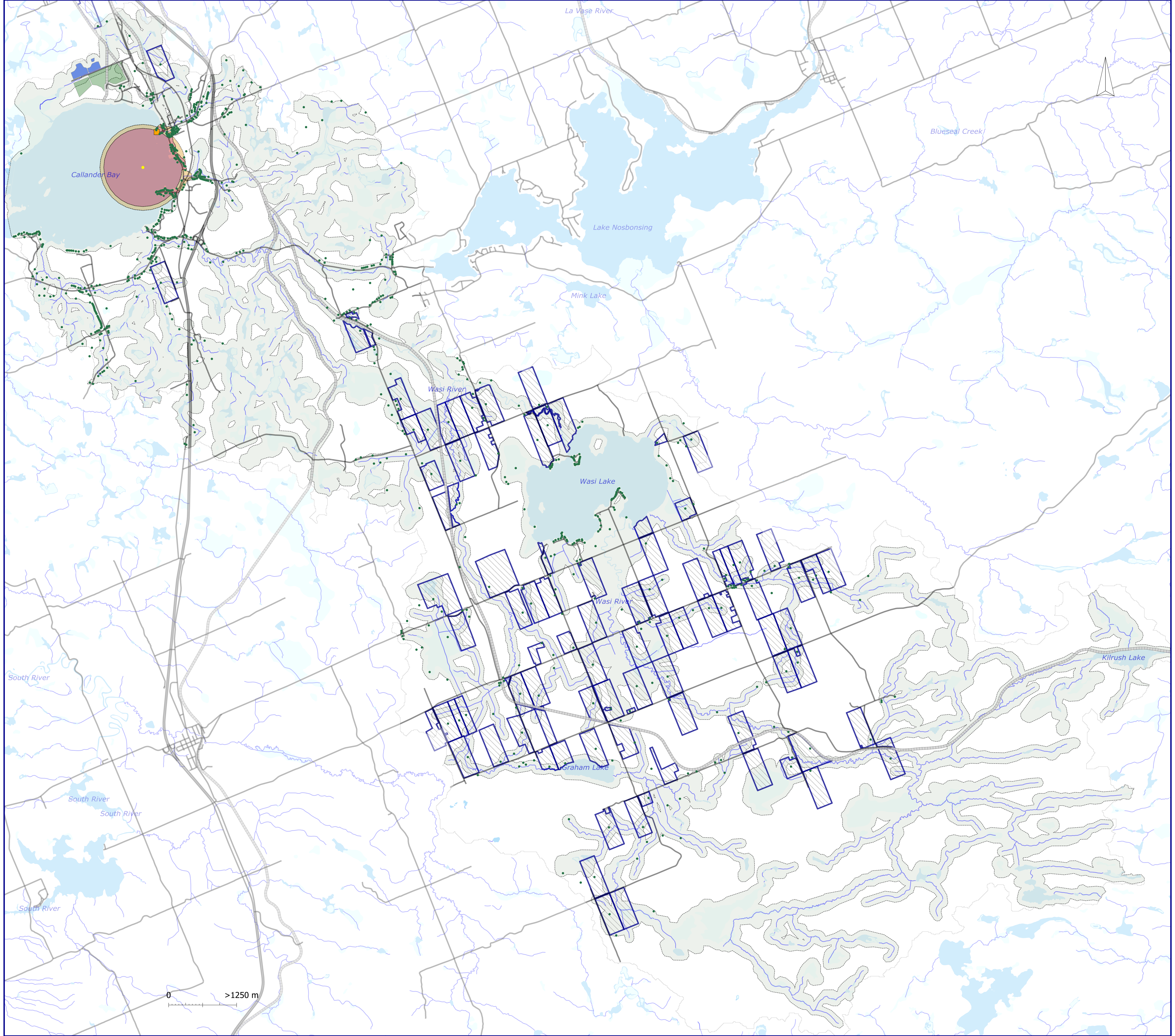
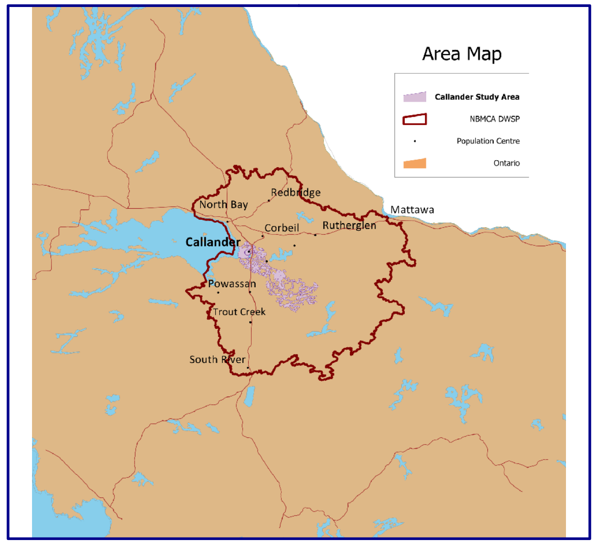


FIGURE 19
Significant Drinking Water Threats Contributing to Phosphorus in Callander Bay (Issues Approach)



- ■ Chief Commanda Sewage (Winter)
- ● Septic System (parcel centroids only)
- ▨ Potential Agri Landuse Threat
  *** see disclaimer
- — Streams/Rivers
- ▬ Water
- ▬ Wetland
- ● Callander Bay Intake

*** requires verification as available data are not current and do not necessarily reflect existing conditions.

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Appendix A

Minutes to Technical Advisory Committee Meeting, February 26, 2010

A JOINT MEETING OF THE CALLANDER BAY TECHNICAL & WATERSHED ADVISORY GROUPS
FEBRUARY 25, 2010, 1 PM AT THE NORTH BAY-MATTAWA C.A. BOARDROOM

Attendees:

Sue Miller (Chair)	NBMCA
Rob Pringle (Secretary)	NBMCA
Sue Buckle	NBMCA
Francis Gallo	NBMCA
Scott Higgins	NBMCA (arr 1:49)
Tammy Karst-Riddoch	Consultant: Hutchinson ESL
George Onley	NBMSPC
Heather Busch	Municipality of Callander (to 2:30)
Roger Acton	Sustainable Community Committee
Don Clysdale	Sustainable Community Committee (arr 1:49)
Barbara Groves	NBMSPC Chair (to 3:20)
Neil Gervais	MOE Liaison to SPC
Chuck Poltz	NBPSDHU Liaison to SPC (to 2:45)

Preliminary Comments:

Sue Miller, Project Manager for Source Water Protection at the NBMCA introduced the Consultant, Tammy Karst-Riddoch of Hutchinson Environmental Geosciences Ltd. Sue then asked the remainder of the group to provide self-introduction. Sue explained that the Callander Bay study has undergone several revisions since the report of May 2009 was presented. Identification of the actual, not planned, location of the intake took several months and required re-analysis of intake protection zones, vulnerability of the intake, and vulnerable area scores.

Updating the Callander Bay Technical Study:

Tammy provided a thorough description of the changes that were necessary to the report which had been prepared by Aecom Consulting for May 2009. Due to the technicality of transition between firms, Tammy had attempted to provide a stand-alone document which made updates but did not copy text directly from the Aecom report. Revisions to this format are likely to be made to make the report understandable.

A second major update to the Technical Study came in the form of identification of cyanobacterial (blue green algae) concentrations and the potential for creation and release of harmful microcystin lr. The Director approved the ability to list the potential for microcystin via presence of cyanobacteria as drinking water issue. Because of the measured and visible presence of cyanobacteria, the updated guidance allows for the issue to be counted for in our reports.

The committee sought clarification on some of the conditions which would create this drinking water issue. Barbara Groves was under the impression that the upstream blooms in Wasi Lake were contributing to the Callander Bay issue. Tammy explained that there is normally occurring levels of algal bacteria within all water bodies, but the several conditions must be met for a bloom to occur. The breakup of an upstream bloom would not survive intact to reform in a lower water body. The Source Protection Plan will be focusing on the anthropogenic contribution to water quality, and George Stivrins of the Source Protection Committee made it clear that it is those phosphorous (or other nutrient or chemical) sources that we will have the greatest control over to prevent water contamination. We don't want conditions to worsen.

As a result of the necessary modifications, and due to updates to the analysis framework of the threats identification, there was a higher yield of threats. In the threats approach analysis, 239 threats are potentially significant. If the activity was established in the given area, it would be identified as a significant threat to drinking water. The issues approach to drinking water threats identified 99 threats, most of which are a result of identifying the microcystin/cyanobacteria issues.

Further information on these issues is outlined in the presentation, which is being attached in .pdf format to this record.

Future work:

This study will require some consolidation with the Aecom report to provide clarity in the process; Tammy is discussing with various partners to decide how this will best be implemented. There is some follow-up research activity required, especially with regards to the cyanobacteria/microcystin issue and the contributing area for phosphorous.

The Sustainable Community Committee expressed interest in partnering with the Conservation Authority on some sampling programs they are forming to build a database of water information on and around Callander Bay.

Meeting Adjourned 3:33 PM.

Callander Drinking Water Source Protection

Technical Studies Update

Technical Advisory Committee Meeting

February 25th, 2010

Hutchinson
Environmental Sciences Ltd.

Technical Updates

Round 4!

Updates to the Callander DWSP technical studies were required to:

- Adhere to amended Technical Rules: Assessment Report (November 2009)
- Assess microcystin as a drinking water issue based on new guidance by the Director
- Account for the new confirmed location of the intake

Implications:

- vulnerable area, vulnerability scores, drinking water issues and threats

HESL

Intake Characterization

Intake – Type ‘D’

- in Callander Bay of Lake Nipissing
- depth of ~8 m
- ~ 1 km from shore

Water Treatment Plant

- capacity of 3,000 m^3/day
- mean daily water takings of 400 m^3 (maximum = 844 m^3/day)
- filtration, coagulation, sedimentation and disinfection by chlorination
- 1 to 2 hours shut down time

Water Storage

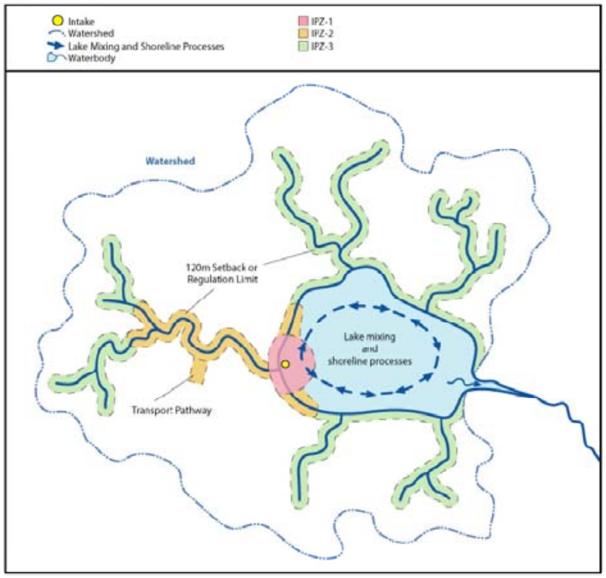
- 1 reservoir, 2,272 m^3 capacity
- ~6 days of supply at low demand, 3 days at maximum demand

HESL

Vulnerable Area

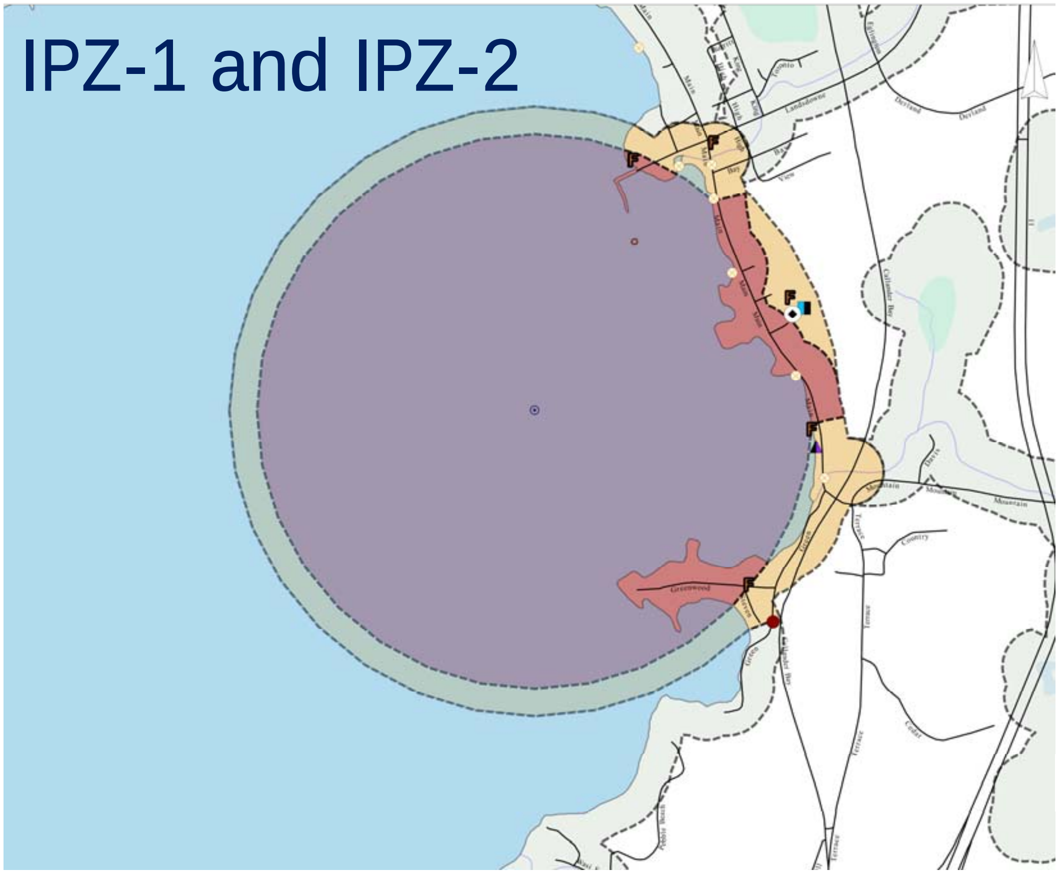
Intake Protection Zones (IPZs)

- IPZ-1 – area of surface water within a 1-km radius of the intake and 120-m setback where this area abuts land
- IPZ-2 – 2-hr time of travel, extended to include transport pathways
- IPZ-3 – area of surface waters that contribute water to the intake and 120-m setback where this area abuts land



HESL

IPZ-1 and IPZ-2



North Bay – Mattawa

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Vulnerable Area

(IPZ-1, IPZ-2 &IPZ-3)

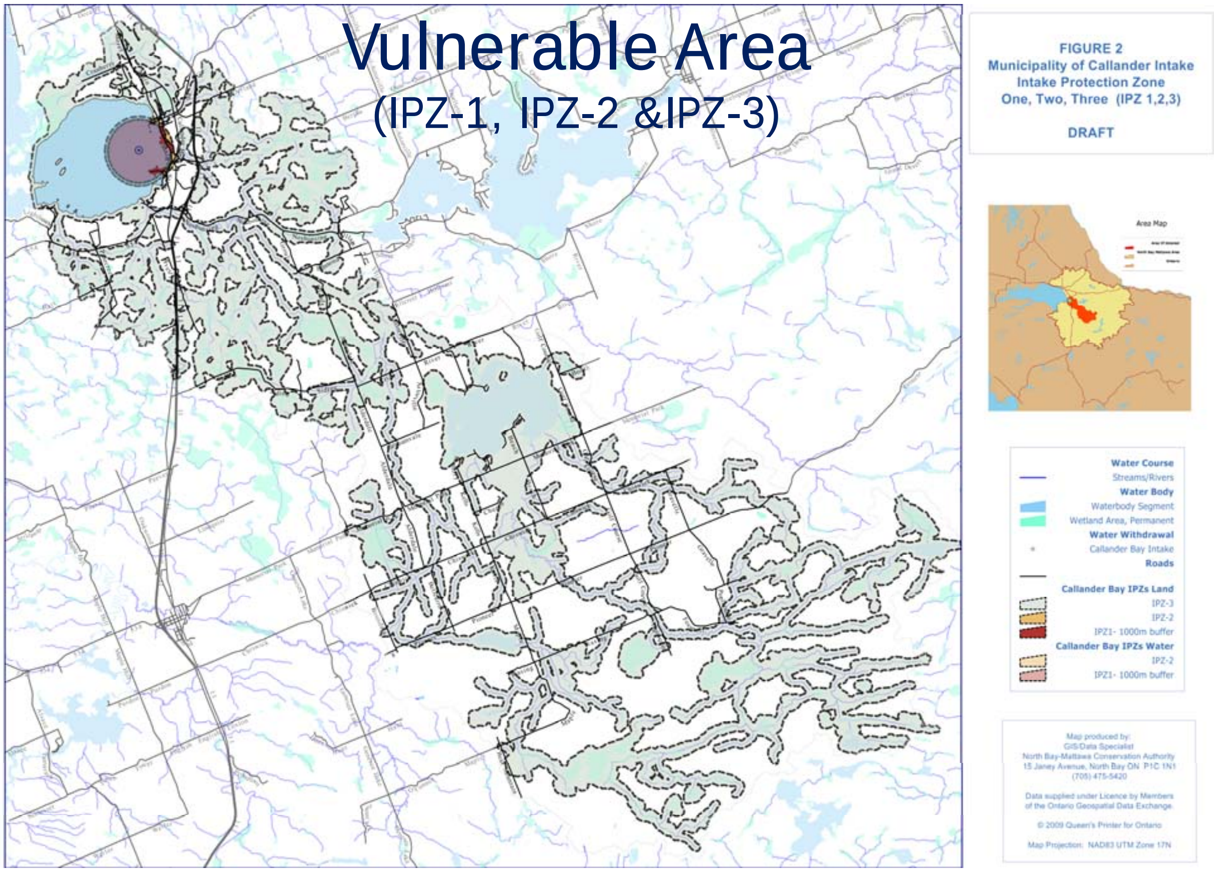


FIGURE 2
Municipality of Callander Intake Protection Zone One, Two, Three (IPZ 1,2,3)

DRAFT

Map produced by:
GIS/Data Specialist
North Bay-Mattawa Conservation Authority
15 Janey Avenue, North Bay ON P1C 1N1
(705) 474-5420

Data supplied under Licence by Members of the Ontario Geospatial Data Exchange

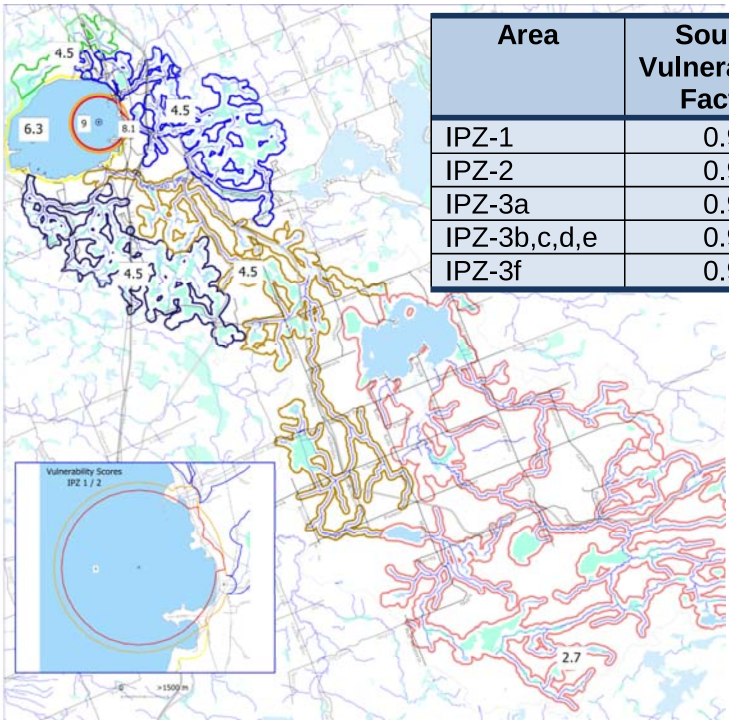
Map Projection: NAD83 UTM Zone 17N

Vulnerability (Vs) Scoring

Vs = source vulnerability X area vulnerability

- Source vulnerability
    - Depth of the intake
    - Distance of the intake from land
    - History of drinking water concerns
- Area Vulnerability
    - % land area
    - Soils, slope, land cover, permeability
    - Transport pathways
    - Distance from the intake (IPZ-3)

Vulnerability Scores



Area	Source Vulnerability Factor	Area Vulnerability Factor	Vulnerability Score
IPZ-1	0.9	10	9
IPZ-2	0.9	9	8.1
IPZ-3a	0.9	7	6.3
IPZ-3b,c,d,e	0.9	5	4.5
IPZ-3f	0.9	3	2.7

Drinking Water Issues

- Concentration of a chemical or pathogen in the drinking water source that has exceeded the DWQS, or that is trending upward such that it may exceed the DWQS (Rule 114)

Issue	Water Source
Turbidity	Treated and Raw
Aluminum	Raw
Colour	Raw
Organic Nitrogen	Raw
E. coli	Raw
Microcystin	Raw

- All identified issues are considered ‘natural’ except microcystin

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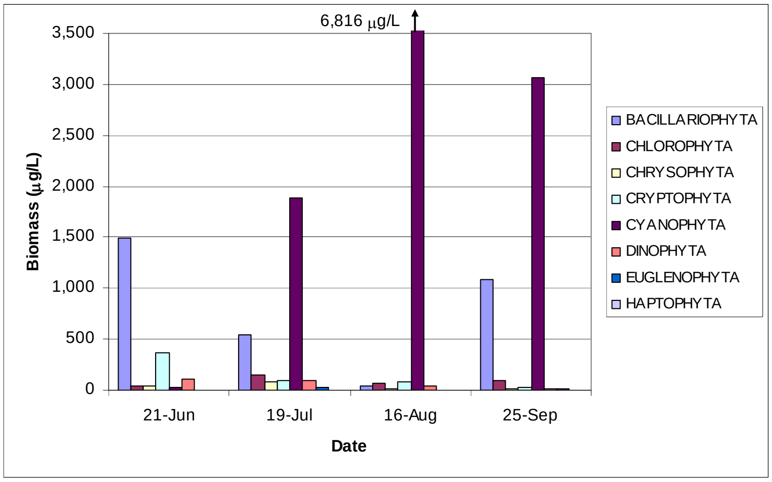
Cyanobacteria and Microcystin as a Drinking Water Issue



- Production of toxin is variable and difficult to monitor
- Risk of toxin production is related to the biomass of toxin producing cyanobacteria

Issue Rationale

- New MOE guidance
- There are documented blooms of cyanobacteria
- Blooms are dominated by toxin-producing taxa

Factors Controlling Cyanobacteria Production

Both natural and human causes:

- Light
- Water temperature
- Mixing patterns
- Nutrient concentrations
  - Phosphorus
  - Ratio of phosphorus to nitrogen

Sources of phosphorus

- Atmosphere
- Natural watershed
- Human sources
  - sewage, agriculture, detergents

Microcystin – Implications for Source Protection

- Microcystin listed as a drinking water issue (Rule 114)
- Human inputs of phosphorus contribute to cyanobacteria production, hence the risk of microcystin production

  Issue Contributing Area (Rule 115) = Vulnerable Area (IPZs)
- *Activities* in the vulnerable area that contribute phosphorus to Callander Bay are considered to be **significant** drinking water threats

Drinking Water Threats

- ***Activities*** or ***conditions*** that result in the degradation of water quality for use as a source of drinking water
- ***Conditions*** result from past activities
- Activities are prescribed under O. Reg. 287/07

Activities Prescribed as Drinking Water Threats (O. Reg. 287/07)

1. establishment, operation or maintenance of a waste disposal site
2. collection, storage, transmission, treatment or disposal of sewage
3. application of agricultural source material to land
4. storage of agricultural source material
5. management of agricultural source material
6. application of non-agricultural source material to land
7. handling and storage of non-agricultural source material
8. application of commercial fertilizer to land
9. handling and storage of commercial fertilizer
10. application of pesticide to land
11. handling and storage of pesticide
12. application of road salt
13. handling and storage of road salt
14. storage of snow
15. handling and storage of fuel
16. handling and storage of a dense non-aqueous phase liquid
17. handling and storage of an organic solvent
18. management of runoff that contains chemicals used in the de-icing of aircraft
19. livestock grazing or pasturing land, outdoor confinement area or farm-animal yard

Significant, Moderate and Low Threats

- Threats Approach
  - Depends on the vulnerability and circumstances surrounding the threat (activity)
- Issues Approach
  - Activities that contribute to a drinking water issue are Significant threats
- 2 tasks:
  - LIST significant, moderate and low threats whether they presently exist or not
  - ENUMERATE significant threats that presently exist

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of Significant, Moderate and Low Threats

- Based on the threats approach:

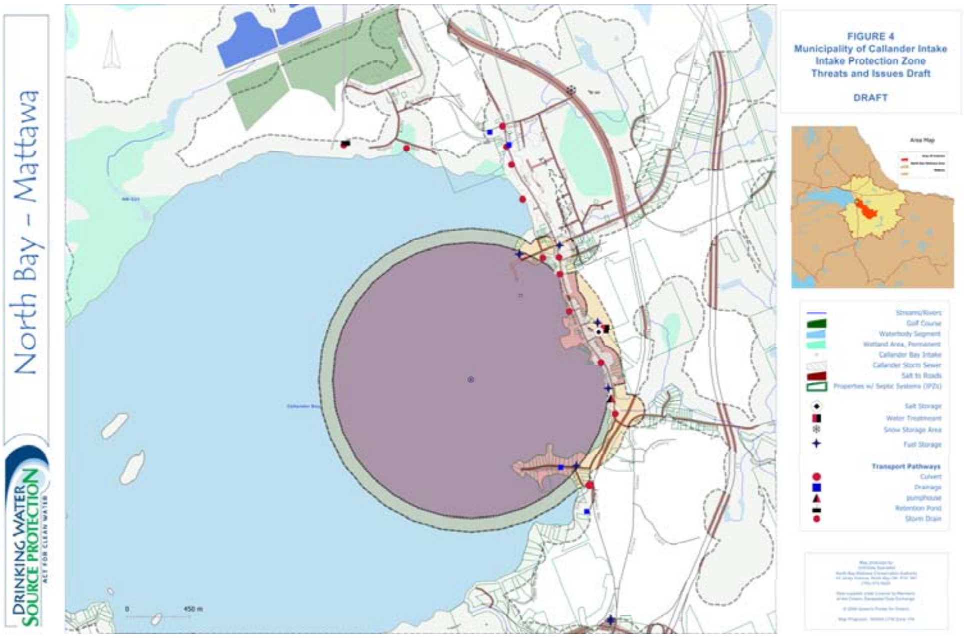
Vulnerable Area	**Vulnerability Score**	**Chemical Threats**			**Pathogen Threats**		
		S	**M**	**L**	**S**	**M**	**L**
IPZ-1	9	239	967	646	41	27	4
IPZ-2	8.1	14	834	898	40	13	19
IPZ-3a	6.3	n/a	40	1,282	n/a	40	28
IPZ-3b-e	4.5	n/a	n/a	239	n/a	n/a	41
IPZ-3f	2.7	n/a	n/a	n/a	n/a	n/a	n/a

- Based on the issues approach: 99 significant threats

Significant Threats - Phosphorus

Activity	# of Significant Threats
The application of agricultural source material to land.	9
The application of commercial fertilizer to land.	9
The application of non-agricultural source material to land.	9
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	27
The establishment, operation or maintenance of a waste disposal site.	7
The handling and storage of commercial fertilizer.	8
The handling and storage of non-agricultural source material.	12
The storage of agricultural source material.	12
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	6
Total	99

Existing Activities that are Drinking Water Threats



Appendix B

Design Summary for the North Himsworth Water Treatment Plant

DESIGN FEATURE	DETAIL	VALUE
Nominal Capacity	- maximum	- 3,000 m^3/d
Intake Structure	- type	- prefabricated
Intake Pipe	- length - 0 nominal - roughness allowed, C - ultimate capacity	- 1.0 km - 400 mm - 80 - 4,500 m^3/d
Zebra Mussel Control Line	- location - 0 nominal - use	- inside intake pipe - 40 mm - future
LLPS	- firm capacity ultimate - pumps – submersible - pump capacity installed - spare impeller capacity - screens – in series - screen mesh	- 3,070 m^3/d - 2 qty - 2,070 m^3/d - 3,070 m^3/d - 2 qty - 9 mm
FM	- LLPS to WTP – capacity - 0 nominal	- 3,070 m^3/d - 300 mm
Plant Gross Flow		- 3,070 m^3/d
Plant Net Flow		- 3,070 m^3/d
Raw Water		- Callander Bay
In-line Static Mixer	- diameter - length - elements	- 8” - 965 mm - three (3), PVC
Package WTP	- units - gross capacity each - manufacturer	- 2 qty - 1,535 m^3/d - Graver/Ecodyne
Flocculation Tank (per unit)	- type - speed - detention time at max flow	- mechanical - variable - 30 minutes
Sedimentation Tank (per unit)	- gross area – min - settler types - tube overflow rate - horiz projected area - sludge wasting	- 18.2 m^2 - tube - 1 m/h - 128 m^2 - auto, intermittent
Filters (per unit)	- filter area - filter rate – max. day flow type - bed agitation during backwash	- 10.05 m^2 - 6.4 m/h rapid, dual media, gravity, split - surface wash
Backwash Water Storage	- location - total storage volume	- above filters - 147 m^3
Clearwell (per unit)	- units - volume	- 2 qty - 231 m^3
Total Finished Water Storage Capacity	- system balancing (per PDR) - BW down time - safety factor (1% max day) - total	- 325 m^3 - 107 m^3 - 30 m^3 - 462 m^3
Backwash Holding/	- units	- 1 qty

DESIGN FEATURE	DETAIL	VALUE
Settling Tank	- volume - supernating - supernatant discharge to - sludge removal - max. vol waste sludge - BW volume (once/d) - waste sludge removal -net volume required for BW holding and waste sludge	- 147 m^3 - floating weir - storm sewer - pumps - 61 m^3/d - 107 m^3/d - semi-continuous - 115 m^3
Waste Sludge Pumps (submersible)	- units - firm capacity -discharge to	- 2 qty - 2.15 L/s - sanitary sewer
High Lift Pumps (vertical turbine)	- units - capacity – each - firm capacity	- 3 qty - 2,300 m^3/d - 4,600 m^3/d
Alkalinity Adjustment	- type - dosage – max - storage - feed pumps (corrosion control pump available as standby)	- sodium hydroxide - 10 mg/L - shipping containers - 1 qty
Coagulant	- type - dosage (max) - max flow (48% sol'n) - storage tanks) - volume/tank - feed pumps (1 standby)	- alum - 30 mg/L - 145 L/d - 2 qty - 15,000 L - 2 qty
Disinfection	- type - dosage – primary – max - post –max - shipping containers	- 12% sodium hypochlorite - 2 mg/L - 1mg/L - 3 qty
Corrosion Control	- type - dosage – max - storage - feed pumps (non-essential) chemical; no standby required	- sodium hydroxide - 10 mg/L - shipping containers - 1 qty

Appendix C

“Blue-Green Algae” - Excerpt from the Chief Drinking Water Inspector Report 2006-2007 (MOE, 2008)

Tapping in

Blue-Green Algae

Blue-green algae, or cyanobacteria, is a primitive, microscopic organism that has been living in fresh water lakes, bays and inlets for some two billion years. Known to most of us as “pond scum,” blue-green algae are not really plants, but are actually tiny bacteria that prefer living in shallow, slow-moving water. The algae often form large “blooms” in the late summer or early fall, and these blooms make the water look like thick pea soup, while giving it an unpleasant smell.

Cyanobacteria are naturally present in the environment, but human activities can make them even more prevalent. Storm water and agricultural runoff, effluent from waste management systems and faulty septic systems all add nutrients to surface water bodies, and that helps provide the algae with good conditions for blooming. It is important to be cautious when these blooms occur, because some forms of blue-green algae are known to cause health problems for both humans and animals.

Some forms of blue-green algae are harmless, but others produce harmful toxins, the most common of which are microcystins. Swimming in water that contains this toxin causes itchy, irritated eyes and skin, while drinking contaminated water can cause headaches, fever, diarrhea, abdominal pain, nausea and vomiting. Even more serious health problems can occur when large quantities are consumed.

Once they are present in the water, blue-green algae toxins can be difficult to remove. Special filtration systems and secondary treatment processes such as oxidation, granular activated carbon or membrane filters are effective at treating water contaminated with blue-green algae toxins, but these technologies are used mainly in large water treatment plants. Smaller systems with minimal or no water treatment are more vulnerable, and the water purification methods they rely on may not be effective on blue-green algae. For example, using herbicides, copper sulphate or other algaecides actually breaks open the algae cells and releases more toxins into the water. Boiling the water or treating it with chlorine can have the same effect, and water jug filtration systems are not effective at all.

The best approach to reducing the potential health threat from blue-green algae in our drinking water is prevention. By controlling or eliminating the additional nutrients that we put into Ontario’s surface water bodies, we can effectively reduce the number and severity of the large algae blooms that occur, and thus reduce the potential for microcystins and other contaminants in our water. The ministry has set the Ontario Drinking Water Quality Standard for microcystin-LR at 0.0015 mg/L, which is the equivalent of 1.5 parts per billion, because of its potential to harm human health.

The Ministry of the Environment has been studying blue-green algae and other emerging pathogens with technical and scientific specialists working in both the laboratory and in the field to monitor, track, assess and carry out research into algae-related drinking water issues. The ministry performs this fundamental research to better understand the factors that lead to algae blooms, and to help predict when they will be formed.

If you suspect a blue-green algae bloom, you should assume that toxins are present, and call the ministry’s Spills Action Centre at 1-800-268-6060. If you are not sure about the safety of water for drinking during an algae bloom, the ministry recommends that you use alternative water sources, such as bottled, carted or tanked water. **For more information on blue-green algae, contact the ministry’s Public Information Centre at 1-800-565-4923 or see Health Canada’s fact sheet at: www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/cyanobacter_e.html**

Appendix D

Lists of Significant, Moderate and Low Drinking Water Threats (digital)