7.0 Powassan

7.1 Introduction and Summary of Findings

The Municipality of Powassan draws its municipal drinking water from two wells near Genesee Creek. There is a clay aquitard throughout much of the study area that provides significant protection to the aquifer from surface contaminants. There are no significant or moderate stresses to the quantity of water.

A Wellhead Protection Area (WHPA) divided into areas of varying vulnerability was identified for the municipal supply. The procedure used computer modelling to determine the length of time it would take a waterborne contaminant to reach the wellhead and then assessed the degree of protection provided by the soil from contaminants moving down from the surface.

The only potential issue identified for the Powassan groundwater supply is the presence of elevated sodium in the water, but this was determined to be due to natural sources within the aquifer.

There are two septic systems located on properties within 100 m of the wellhead which are automatically classified as posing significant pathogen threats. During the planning phase of the program, when policies are being developed to ensure the ongoing protection of the water supply, more specific circumstances including the effectiveness of the existing aquitard will be evaluated and considered.

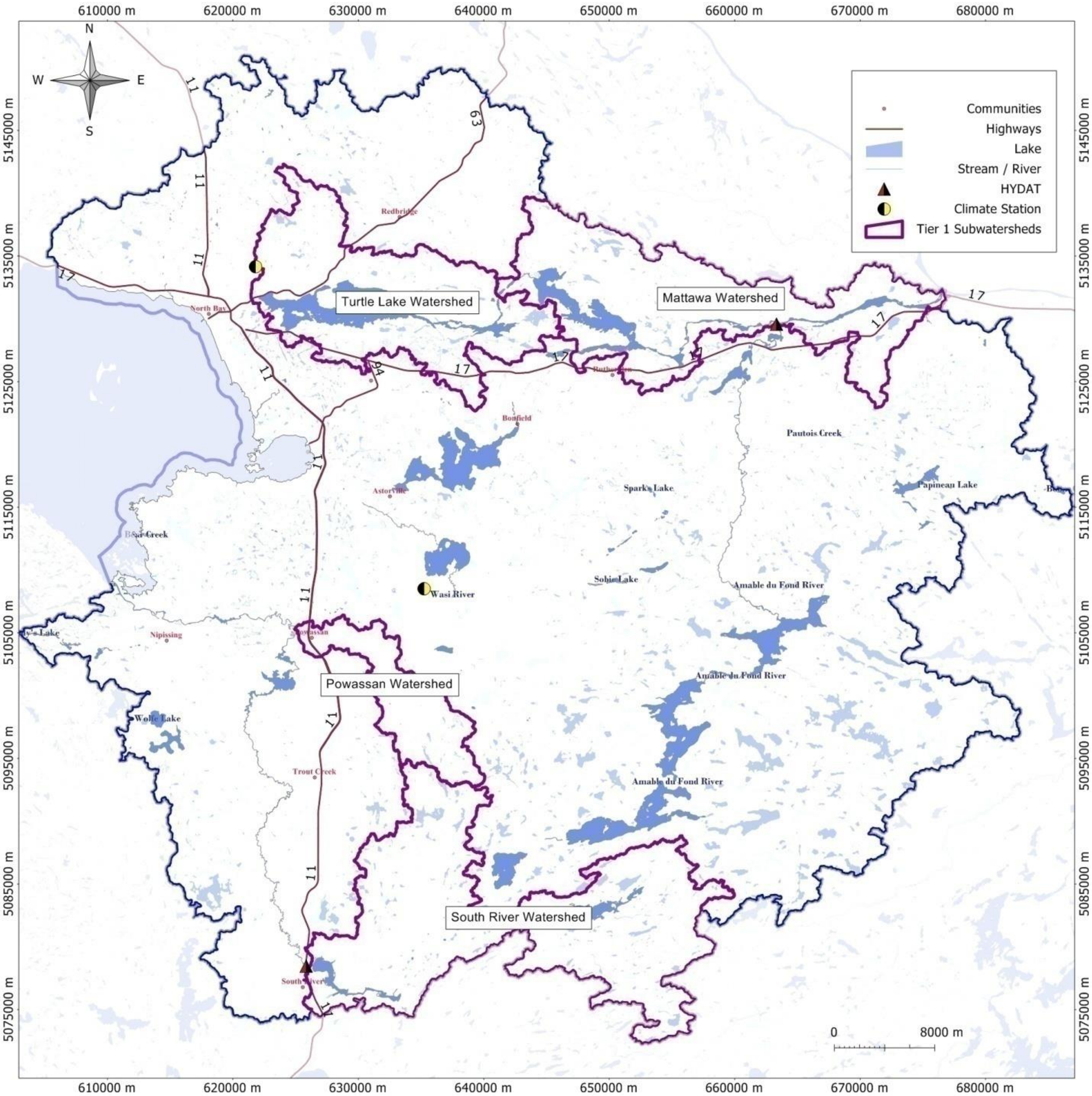
7.2 Water Budget and Water Quantity Stress Assessment

A water budget and water quantity stress assessment for each subwatershed is required by the *Clean Water Act (2006)* to determine whether the subwatershed will be able to meet current and future demands of all users.

General principles were explained earlier in Section 2.5 Conceptual Water Budget. The methodology specified in the Technical Rules Part III describes a tiered approach whereby all subwatersheds are subjected to a Tier One assessment and if stress is low during all months of the year, no further assessment is required. If stress levels are shown to be either moderate or significant, a more robust Tier Two assessment is completed and, similarly if that reveals moderate or significant stress, a Tier Three Local Risk Assessment must be undertaken. The information for this Section is based primarily on the Tier One Water Budget and Stress Assessment for the subwatersheds supplying the South River, Powassan and Mattawa Municipal Water Supplies (WESA, 2010). A Tier One Assessment for the remainder of the subwatersheds in the SP Area is presented in Section 2.6.

The portion of the South River Watershed that contributes to the groundwater intake for Powassan is approximately 70.1 km^2 and is depicted along with the contributing subwatersheds for the municipal supplies for the Town of Mattawa and the Village of South River in Figure 7-1.

Figure 7-1. Tier One Water Budget Subwatershed



Municipal drinking water for the Municipality of Powassan is provided by two overburden wells that tap into a gravel aquifer. The Municipality of Powassan experienced a population decline of 1.8%, between 2001 and 2006, but had experienced an equivalent increase during the previous period between 1996 and 2001, resulting in a stable population over those ten years. (NBMCA, 2007; Statistics Canada, 2007). In addition, the municipality does not anticipate a significant change in population or in pumping rates in the upcoming years (Waterloo Hydrogeologic, 2006). Therefore future water demand and land use change are expected to be minimal and have minimal impact on the subwatershed water budget parameters. As a result, additional assessment into future scenarios is not necessary.

Water budget elements include precipitation, actual evapotranspiration (AET), surplus, recharge and runoff. All are expressed in mm to make them comparable to precipitation figures. The resulting water budget for Powassan is shown below in Table 7-1.

While total annual surplus should theoretically equal stream flow (Gartner Lee Ltd., 2007b), there is no recent stream flow data within the Powassan municipal supply subwatershed. Data from gauge 02DD001 (South River at Powassan) ends in 1936 so is not necessarily representative of current flow conditions. Instead data from another gauge, Environment Canada/Water Survey of Canada gauge 02DD009 (South River at South River), was used to approximate conditions within the Powassan subwatershed.

Table 7-1. Estimated Water Budget Elements (Powassan)

Month	Precipitation (mm)	AET (mm)	Surplus (mm)	Recharge (mm)	Runoff (mm)
January	64.9	0.0	68.5	1.7	2.5
February	51.9	0.0	53.0	0.8	1.2
March	62.9	0.0	63.4	0.4	0.6
April	66.1	24.9	41.6	22.3	33.1
May	82.8	76.9	6.2	67.5	99.9
June	89.0	106.5	0.0	33.7	50.0
July	99.5	119.6	0.0	16.9	25.0
August	94.6	103.9	0.0	8.4	12.5
September	112.3	68.8	0.8	4.4	6.5
October	95.6	32.0	64.9	15.3	22.6
November	86.7	0.0	89.2	7.6	11.3
December	64.3	0.0	67.3	3.8	5.7
Total	**970.7**	**532.7**	**454.9**	**182.8**	**270.8**
Gartner Lee (2007)	936	539	430	173	257

Analysis of continuous stream flow data collected at this gauge yielded a total annual surplus of 435 mm. By comparison the total surplus predicted by the Thornthwaite-Mather soil moisture budget conducted by WESA on the Powassan subwatershed yielded a total annual surplus of 455 mm. Gartner Lee Ltd. (2007a) estimated the surplus in a comparable location to be 430 mm. The primary cause for the difference is that the precipitation predicted by the WESA GIS model was 34 mm greater than that predicted by Gartner Lee Ltd. (2007a). All water budget parameters estimated by WESA are within 6% of those estimated by Gartner Lee Ltd. (2007a). The close agreement between the results obtained by WESA and Gartner Lee Ltd. (2007a) provides a high level of confidence in the water balance.

The groundwater supply is the water available for a subwatershed’s groundwater users. The Powassan municipal supply subwatershed contains two such structures: Elliot Chute and Bingham Chute. Elliot Chute and Bingham Chute host small hydroelectric generating stations (Gartner Lee Ltd., 2007a). It is assumed that groundwater flow into the subwatershed is negligible as the Powassan municipal supply subwatershed is bounded by the South River Reservoir on the downstream side and flow divides on the upstream sides. Consequently, groundwater supply was estimated to equal recharge as determined using a soil moisture model described in the WESA report.

Annual recharge was estimated to be 183 mm, which results in an average monthly recharge of 15.2 mm. Considering the area of the subwatershed (70.1 km^2), the average groundwater supply is 0.406 m^3/s. Lateral groundwater flow was assumed to be negligible. Water reserve was set at 10% of the recharge.

Water use (demand) was calculated considering available datasets for the study area, and the results compiled on monthly and annual scales. Municipal and communal use was determined using the Environment Canada Municipal Water and Wastewater Survey (Environment Canada, 2004b) as well as the Permit To Take Water (PTTW) database (MOE, 2009a). There were no permitted communal water takings located in the Powassan subwatershed.

Water takings and returns were divided between deep groundwater, shallow groundwater, and surface water. The following assumptions were made:

- most private wells are completed in bedrock, while municipal wells are completed in the overburden (Waterloo Hydrogeologic, 2006), therefore, it was assumed that takings are from deep groundwater and shallow groundwater, respectively;
- municipal water consumed includes water from population with sewage haulage; and
- municipal system losses are returned to shallow groundwater through infiltration.

Gross takings for municipal/communal use are approximately164,219 m^3/yr. Of the gross municipal/communal takings, approximately 162,047 m^3/yr (99%) is consumed. The high percentage of consumption is due to the fact that municipal water is returned to a lagoon that discharges to Lake Nipissing via the South River downstream of the Powassan municipal watershed, and is therefore lost from the watershed (i.e consumed). Municipal and communal water takings make up approximately 68% of the total gross water takings in the subwatershed and 68% of the water consumed. Environment Canada (2004b) states that 99% of serviced residents are on municipal sewers and 0.8% are on septic. The remaining 0.2% was assumed to return to surface water.

Datasets included the following:

- municipal and communal use (as specified above);
- domestic use from private water supplies (based on Statistics Canada 2006);
- agricultural use (livestock and irrigation from Statistics Canada, 2007).

Domestic use was calculated based on the population of the Municipality of Powassan of 3,309 and an estimate that 46% of those were supplied by private wells (Statistics Canada, 2007) with a total gross water taking of 97,227 m^3/yr (consumptive factor 0.2 assuming rest of water returned via septic systems to shallow groundwater).

Reported gross water takings for agricultural purposes are entirely for livestock because crop irrigation data are suppressed to meet confidentiality requirements of the Statistics Act and assumed negligible. Water for livestock is assumed to be taken entirely from deep groundwater wells and returned to shallow groundwater by infiltration. Gross water takings are estimated at 75,760 m^3/yr. Total agricultural demand comprises approximately 32% of the total water takings and total consumption.

The water use results developed for each of the sectors were amalgamated to estimate the cumulative water use for each of the systems (surface water, shallow groundwater, and deep groundwater). Results from all sectors are summarized on an annual scale in Tables 7-2a, b and c and graphically on Figure 7-2.

Table 7-2a. Annual Water Use Results - Gross Takings (Powassan)

Gross Annual Takings (m³)						
Reservoir	Permitted Takings			Non-Permitted		TOTAL
	Municipal and Communal[a]	Industrial and Commercial[b]	Other Permitted	Private Domestic	Agricultural[c]	
Surface Water						0
Shallow Groundwater	164,219					164,219
Deep Groundwater				97,227	75,760	172,987
TOTAL	164,219	0	0	97,227	75,760	337,206

Table 7-2b. Annual Water Use Results - Consumption (Powassan)

Annual Consumed (m³)						
Reservoir	Permitted Takings			Non-Permitted		TOTAL
	Municipal and Communal	Industrial and Commercial	Other Permitted	Private Domestic	Agricultural	
Surface Water						0
Shallow Groundwater	162,047					162,047
Deep Groundwater				19,445	75,760	95,205
TOTAL	162,047	0	0	19,445	75,760	257,252

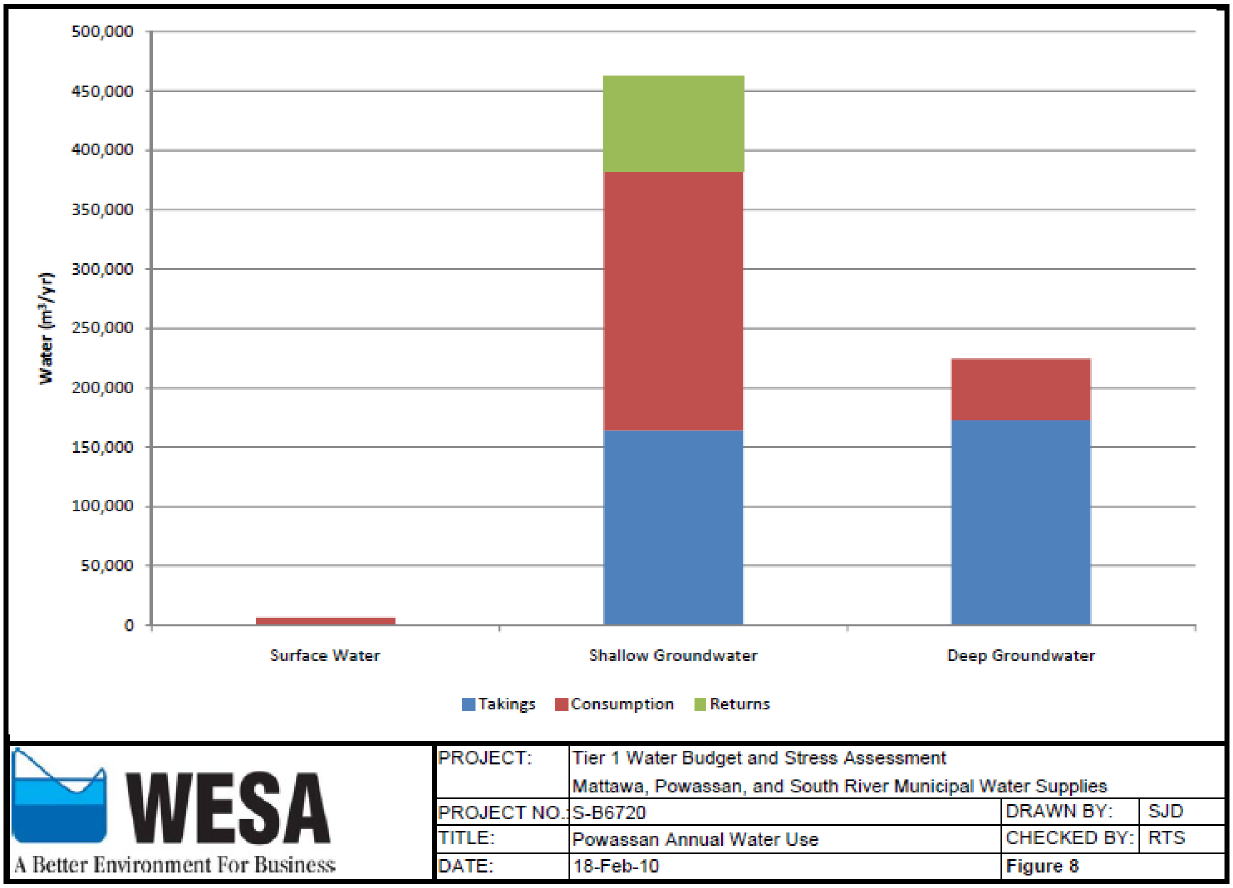
Table 7-2c. Annual Water Use Results - Returns (Powassan)

Annual Returned (m³)						
Reservoir	Permitted Takings			Non-Permitted		TOTAL
	Municipal and Communal[d]	Industrial and Commercial[b]	Other Permitted	Private Domestic[e]	Agricultural	
Surface Water						0
Shallow Groundwater	2,201			77,782		79,983
Deep Groundwater						0
TOTAL	2,201	0	0	77,782	0	79,983

Notes:
[a] Includes system losses, which are assumed to return to surface water
[b] Assume industrial and commercial water comes from shallow groundwater and returns to SW through sewer service
[c] Assume agricultural water comes from deep groundwater, since assuming source is same as private wells, and most private domestic wells are in deep bedrock
[d] Assume remaining 0.2% returns to surface water (99% on sewer and 0.8% on septic)
[e] Assume returns from private domestic wells discharges through septic systems to shallow groundwater

All of the gross annual water takings within the study area are from groundwater; 49% from shallow groundwater (municipal takings) and 51% from deep groundwater (private domestic and agricultural takings).

Figure 7-2. Annual Water Use (Powassan)



Of total water consumed, 63% comes from shallow groundwater and the remaining 37% from deep groundwater. Municipal water to serviced residents is 100% consumed with respect to the subwatershed of interest. Water not consumed through the "consumptive factor" is returned to a lagoon for treatment that discharges to Lake Nipissing, which is downstream of the Powassan municipal supply watershed; therefore it is considered lost to the watershed in question (i.e., consumed) All water that is not consumed is assumed to be returned to shallow groundwater through infiltration and septic systems; it is assumed that leakage from the municipal system returns to the shallow groundwater through infiltration. This is consistent with the mostly rural nature of the region. Table 7-3 compiles the net water takings for each of the systems. There is a net taking from groundwater of approximately 257,224 m^3/yr. Both the shallow and deep groundwater systems have more water taken than returned; 84,237 and 172,987 m^3/yr, respectively.

Table 7-3. Net Water Takings (Powassan)

Reservoir	Net Water Takings (m^3)
Surface Water	0
Shallow Groundwater	-84,236
Deep Groundwater	-172,987
TOTAL	-257,223

Note:
Positive values indicate that returns exceed takings

Monthly water use was nearly constant between months (differing only due to the number of days in each month) since there are no seasonal uses. Monthly takings from shallow groundwater range from 12,598 to 13,947 m^3, while takings from deep groundwater range from 13,270 to 14,692 m^3.

7.2.1 Groundwater Stress Assessment

Groundwater stress is determined by examining the ratio of water demand (water takings) to water supply, while considering in the reserve required to maintain ecosystem function (MOE, 2007). The percent water demand is compared to a stress threshold (Table 7-4) to determine the stress level.

Table 7-4. Groundwater Stress Thresholds Based on Annual and Monthly Percent Water Demand

Groundwater Quantity Stress Level Assignment	Average Annual (%) Water Demand	Maximum Monthly (%) Water Demand
Significant	≥ 25%	≥ 50%
Moderate	> 10% and < 25%	> 25% and < 50%
Low	≤ 10%	≤ 25%

The annual and maximum monthly percent groundwater demand for the Municipality of Powassan supply subwatershed are 2.23% and 2.27%, respectively. Table 7-5 below presents the monthly and annual demand, supply, and reserve values used to calculate the percent demand.

Table 7-5. Percent Groundwater Demand (Powassan)

Month	Consumption	Supply	Reserve	%Demand
January	*0.312*	*15.2*	*1.52*	*2.27*
February	0.282	15.2	1.52	2.05
March	*0.312*	*15.2*	*1.52*	*2.27*
April	0.302	15.2	1.52	2.20
May	*0.312*	*15.2*	*1.52*	*2.27*
June	0.302	15.2	1.52	2.20
July	*0.312*	*15.2*	*1.52*	*2.27*
August	*0.312*	*15.2*	*1.52*	*2.27*
September	0.302	15.2	1.52	2.20
October	*0.312*	*15.2*	*1.52*	*2.27*
November	0.302	15.2	1.52	2.20
December	*0.312*	*15.2*	*1.52*	*2.27*
Annual	3.67	183	18.3	2.23

A subwatershed is considered low stress if the average annual percent demand is between 0 and 10% and if the maximum monthly percent demand is between 0 and 25%. As a result, the Municipality of Powassan municipal supply subwatershed was considered low stress and did not require a Tier Two Water Budget.

7.2.2 Uncertainty

The limitations inherent to each dataset individually, combined with the discrepancies between datasets, all introduce various levels of uncertainty which are ultimately compounded into the results.

Because this study is conducted at the regional scale, results must be interpreted in their context and would require confirmation and refinement through further investigation at the local scale. Also, the various datasets used in the analysis are a ‘snapshot in time’, as population census is as of 2006, while municipal water use data is current as of 2004. Obtaining contemporary, more up to date data would reduce the error associated with the combination of datasets from varying dates;

Only water takings greater than 50,000 L/d are included in the Permit to Take Water (PTTW) database, while water use from smaller users is unknown. There were no PTTW records available for Powassan.

Other sources of uncertainty include how very little information is available for some sectors; for instance, there may be a number of smaller industrial and commercial users that are not accounted for. Water taking for livestock is exempt from the permitting requirements, regardless of the volume taken. Similarly, no information is available for recreational or ecological users.

Considering the significant sources of uncertainty, the uncertainty associated with the Tier

1 Water Budget and Stress Assessment is considered high. However, the percent demand for this system is well below the defined thresholds, and as such no additional work is likely required to address the uncertainty.

7.3 Groundwater System Characterization

The information contained in the following Sections assessing the water quality component of the vulnerability and threats to the Powassan system was taken primarily from the two 2009 Technical Assessment Reports on the Municipality of Powassan prepared by Waters Environmental Geosciences Ltd. (WEGL) entitled:

- Groundwater Vulnerability Analysis, and (2009c);
- Groundwater Risk Assessment (2009a) .

The Municipality of Powassan well field consists of two municipal wells, located on the north side of Highway 534 and west of the Highway 11 corridor, in Powassan (Figure 7-3). The well field is located on a gently sloping topography between Highway 534 and Genesee Creek, with both wells being located above the creek level. The UTM co-ordinates of the two municipal wells (in *NA*D83) are 625874 mE and 5104525 mN (Well No. 1) and 625890 mE and 5104590 mN (Well No. 2). The system services approximately 1,025 people (2006 census).

Figure 7-3. Powassan Study Area

Table 7-6 below summarizes the construction details of the wells. The sand and gravel soils are typical of the area.

Table 7-6. Specifications for the Two Powassan Municipal Wells

Well No.	1	2
Year drilled	1981	1983
Drilling Company	Crowley Groundwater Ltd. (Dundas)	Crowley Groundwater Ltd. (Dundas)
Depth Below Grade	23.2 m	18.6 m
Steel Casing - Diameter - Depth	160 mm (6 1/4 in) 19.3 m	305 mm (12 inch) 11.0 m
Stainless Steel Composite Screen	3.8 m screened interval 140 mm (5 1/2 inch) diameter screen with two 0.9 m long No. 10 slot screens over top of one 1.2 m long No. 50 slot screen	7.6 m screened interval 250 mm (10 inch) diameter composite screen with a 2.7 m long No. 30 slot screen atop 4.0 m of No. 40 slot screen over top 0.9 m of No. 35 screen
Gravel Packing	No indication of any	No indication of any
Static Water Level at Completion (Below grade)	5.9 m	0.4 m (approximately at elevation of nearby Genesse Creek)
Registration No.	Not Registered	
Formation encountered during drilling	Fine brown sand to a depth of 10.7 m; over brown layered silty clay and fine sand to a depth of 15.2 m; over coarse sand and gravel with occasional cobbles to completion depth of 24.1 m	Brown dirty sand to a depth of 3.4 m, over clay with streaks of sand to a depth of 10.4 m; over gravel and sand to a depth of 18.9 m (with a partially cemented layer from 12.3 m to 12.8 m); over clay, gravel and sand to completion depth of 22.0 m

Water consumption data were obtained from the Municipality, for the time period January 2003 to December 2008, and examined for overall trends. Although there is a degree of scatter in the plot (attributed to some seasonal effects coupled with well maintenance activities), there is no distinct trend in total water use over the period. The highest total consumption was for December 2008, averaging 613 m3/day (402 m3/day being taken from Well No. 1 and 211 m3/day from Well No. 2). Over the total time period for which the records were obtained, the average total daily consumption was 508 m3/day, with an average of 208 m3/day being taken from Well No. 1 and 300 m3/day being taken from Well No. 2.

These values are well below the maximum permitted pumping rate (both wells combined) of 1,313 m3/day (Permit to Take Water No. 82-P5292).For the present analysis, the allocated quantity of water to be used in the well head protection analysis was assumed to be equal to

508 m3/day which is the average for the period reviewed. The individual rates used in the capture zone assessment were set at 208 m3/day for Well No.1 and 300 m3 /day for Well No. 2. A review of available information indicated that there is no proposed expansion to the water distribution system.

Despite the close proximity of the wells to Genesee Creek, particularly Well No. 2, the Powassan well field has not been flagged as groundwater under the direct influence of surface water (GUDI), however a review of the initial pumping test data suggested that at higher pumping rates, the area of influence of the pumping wells may extend outwards far enough to capture a portion of surface water via recharge. A supplemental analysis was undertaken to investigate the specific pumping conditions which could lead to the conversion of the water supply from non-GUDI to GUDI (Groundwater Under Direct Influence) status. This information was identified as being of value to future watershed planning and, as well, would provide a sensitivity analysis of the model itself to future changes in groundwater withdrawals. Findings are discussed in Section 7.4.

The area is characterized by rolling hills and bedrock outcrops. Because the bedrock is fractured, it transmits water readily enough that the upper portions had to be included as part of the groundwater flow system beneath the well field in the model. Overburden (soil covered) areas exhibit soil layers of varying hydraulic conductivity (rate at which water can pass through soil) above the aquifer. In the areas of lower elevation the uppermost layer tended to be primarily clay which would impede the infiltration of water. However, this was not consistent over the study area. In the valley and floodplain of Genesee Creek, a layer of silty sand alluvium, which conducts water more readily, penetrates the clay layer offering a “window” for surface water recharge to the underlying sand and gravel till aquifer. The alluvium is still relatively fine grained and its hydraulic conductivity is low relative to the sand and gravel aquifer.

This means that there is a clay aquitard over much of the study area that provides significant protection to the aquifer from surface contaminants.

Using the VisualMODFLOW groundwater flow model, the amount of time needed for the water “particles” to travel through the aquifer to the well field can be determined, allowing the contributing areas to be defined by their respective travel times (or time of travel values). During the model calibration process, the soil properties and recharge values were adjusted manually until a close match of the water table surface and the water levels in the wells and creeks were obtained. Table 7-7 shows the final calibrated parameters used in the model.

Table 7-7. Powassan Model Parameters at Calibration

Zone	Material	$k_x = k_y$ (cm/sec)	k_z (cm/sec)	Recharge (mm/year)	S_s (1/m)	S_y	$n_{eff} = n_{tot}$
1	basal till	4×10^{-3}	4×10^{-4}	180	6×10^{-5}	0.24	0.35
2	bedrock	9×10^{-4}	9×10^{-4}	150	1×10^{-6}	0.04	0.10
3	alluvium	1×10^{-4}	1×10^{-5}	80	6×10^{-7}	0.18	0.25
4	clay	1×10^{-6}	1×10^{-7}	10	3×10^{-4}	0.05	0.45
5	sandy silt	9×10^{-5}	9×10^{-6}	80	1×10^{-4}	0.18	0.40
6	silty sand	3×10^{-4}	3×10^{-5}	110	1×10^{-4}	0.18	0.40

Zone	Material	$k_x = k_y$ (cm/sec)	k_z (cm/sec)	Recharge (mm/year)	S_s (1/m)	S_y	$n_{eff} = n_{tot}$
7	sand and gravel aquifer	3×10^{-2}	3×10^{-3}	na	6×10^{-5}	0.24	0.35

In Table 7-7 above, "na" indicates that there is no recharge value applicable to the sand and gravel aquifer because the unit is not in the uppermost layer (i.e. recharge only applies to the uppermost layer of the model). "k" refers to the hydraulic conductivities, with the subscripts indicating the direction in which the parameter is measured (corresponding to the x, y and z axes). "S_s" refers to the specific storage, "S_y" refers to the specific yield and "$n_{eff} = n_{tot}$" refers to the effective and total porosity (set equal to each other in this case). With the exception of the bedrock unit, an anisotropy ratio of 1:10 was used for the vertical to horizontal hydraulic conductivity values.

7.4 Delineation and Scoring of Vulnerable Areas

The procedure for delineating and scoring the vulnerable area of a Type One Drinking Water System under the *Clean Water Act (2006)*, is outlined in detail in Section 7.4.1. Identifying the vulnerable area is based largely on the time it takes water to travel in the aquifer to the wellhead.

7.4.1 Defining the Vulnerable Areas (Wellhead Protection Areas)

Four subzones of the wellhead protection area (WHPA) were identified; time of travel (TOT) was determined using computer based three-dimensional groundwater flow modelling:

- WHPA-A is the area within 100 m;
- WHPA-B extends beyond the 100 m zone to a line marking the 2-year TOT;
- WHPA-C extends from the WHPA -B limit out to the 5-year TOT;
- WHPA -D extends from the WHPA-C limit out to the 25-year TOT.

Several years previous, a regional groundwater study was conducted (Waterloo Hydrogeological, 2006) which also used computer modelling to delineate a wellhead protection area. The current study used a more recent version of the same software, local mapping and a substantial amount of additional data to create a revised model at a finer scale resulting in the delineation of vulnerable areas as shown in Figure 7-4a.

The shape of the Powassan wellhead protection area is due to the direction that the groundwater flows in the aquifer. Flow tends to run from the east and southeast toward the well. So the vulnerable area does not include lands to the west or north.

The municipal sewage treatment lagoons are located outside of the vulnerable area and discharge downstream of the wells.

A supplemental GUDI analysis was performed as part of the assessment. Wells that draw all or some of their water supply from a surface water body, and have less than 50 days time of travel from the surface water to the well intake, are classified as groundwater under the direct influence of surface water (or GUDI), and once classified require additional levels of water treatment before distribution to the public.

The Powassan well field has not been flagged as having any interaction with the nearby surface water feature (Genesee Creek), as was indicated in the First Engineers' Report (Totten Sims Hubicki Associates, 2001), and is considered to be a non-GUDI supply under the *Clean Water Act (2006)*. However, a review of the initial pumping test data suggested that at higher pumping rates, the area of influence of the pumping wells may extend outwards far enough to capture a portion of surface water via recharge. The purpose of this analysis was to determine if there are pumping conditions under which surface water could reach the well in less than 50 days.

Municipal Well No. 1, by this analysis, receives no surface water inputs from Genesee Creek at the allocated pumping rate. Municipal Well No. 2 does receive a portion of its intake from Genesee Creek under the allocated pumping rate, but the location of this surface water input is approximately 1 km east of the well field area, and the associated time of travel to the well is in the range of 30 to 40 years. A second scenario simulated the entire allocation being drawn from Well No. 2 which could be required during maintenance of the other well. The surface water recharge location and time of travel did not change.

An additional scenario was run simulating one well pumping at the maximum permitted rate which is two and a half times the normal rate. Under these conditions, some water infiltrates from a closer location but the time of travel is still on the order of 100 days and the well field remains non-GUDI. It should be noted that there is some uncertainty associated with any model, so caution is advised in interpretation of these findings at rates exceeding the allocated quantity.

7.4.2 Vulnerability Scoring

The other factor in determining the vulnerability score is how easily contaminants could travel through the soils and down to the aquifer (hydraulic conductivity). This depends on the nature and thickness of the soils between the surface and the aquifer.

The hydraulic conductivity of each type of soil can be described by its K-factor as shown in Section 3, Table 3-4.

The Intrinsic Susceptibility Index (ISI) is then calculated for each location within the vulnerable area considering the degree of protection provided by the type and thickness of various soil layers. Susceptibility of the aquifer at each location is then rated as high, medium or low (Fig. 7-4b). The mapping of the susceptibility (ISI) (Fig. 7-4b) shows the extent of the clay aquitard, described previously, which reduces the risk of contamination (ISI - Low). Beyond that the overburden consists of sandy silt above till; the susceptibility of that type of soil is rated as medium (ISI - Medium). There are a couple of gravel deposits fairly distant from the wells and the susceptibility in those areas is high.

The vulnerability score can be modified if there is concern that transport pathways within the WHPA may increase the vulnerability of the aquifer beyond that which was originally mapped. In two transport pathway locations along the highway corridor, two lens-shaped areas of higher susceptibility (8 and 10) are shown in Figure 7-4b. The ISI rating in these areas was increased due to the documented existence of several deep abandoned geotechnical boreholes drilled during highway construction. Review of the subsurface logs indicates that many of the drill holes penetrated lower permeability (clay) horizons, in which case it is likely that the boreholes would not have remained open for any length of time. Unfortunaltely, a clay unit was not always encountered, and it is considered possible that a constructed pathway from the surface to the aquifer may have been created within the identified geotechnical test areas. At the time of the completion of the technical study, there was no information available as to how the boreholes had been decommissioned (filled and capped) and the date of the drilling predates more recent policies relating to borehole abandonment and sealing in accordance with the requirements of O. Reg. 903 (water well regulation).

Technical Rule 83 provides the appropriate vulnerability scores based on the WHPA zone and the susceptibility of the aquifer at a particular location in the zone as shown below in Table 7-8. Once the WHPA and its subzones area have been delineated (Fig. 7-4a), and the susceptibility of the aquifer throughout that area has been determined (Fig. 7-4b), these two factors were combined to provide the vulnerability score for the Powassan WHPA (Fig. 7-4c and 7-5b).

Table 7-8. Vulnerability Scores (Vs) for the Powassan Vulnerable Area

Intrinsic Susceptibility Index	Vulnerability Scores within Wellhead Protection Area			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	4	2

Figure 7-4c (below) shows the resultant vulnerability scores for the entire vulnerable area once the WHPA zone and susceptibility factors are combined. An enlarged and detailed map of the modified vulnerable areas is provided in Figure 7-5 with reference to vulnerability scores shown on Figure 7-5b.

Figure 7-4a. Powassan Wellhead Protection Area

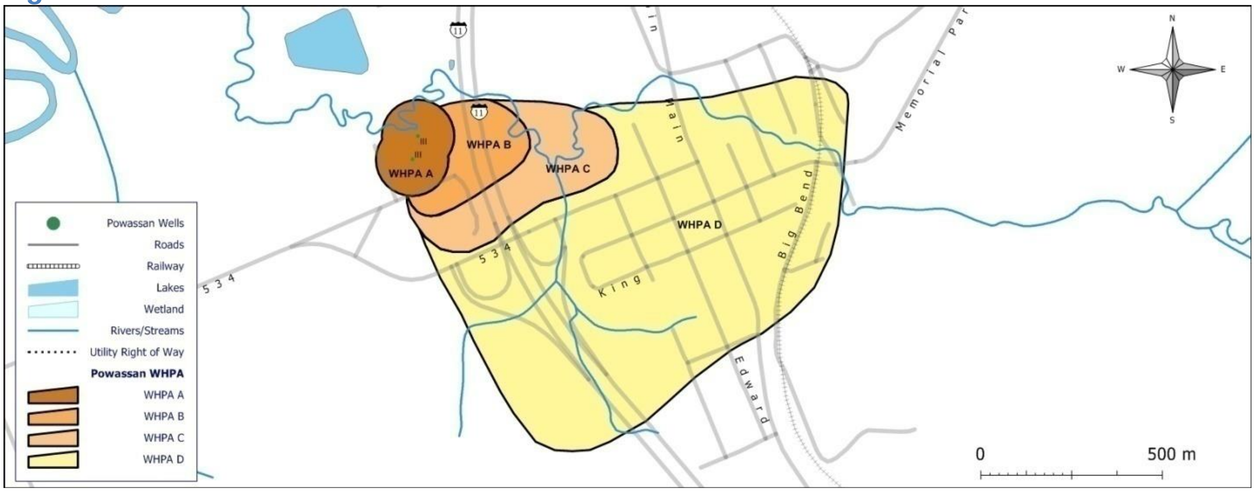


Figure 7-4b. Powassan Wellhead Protection Area - Intrinsic Susceptibility Index

Figure 7-4c. Powassan Wellhead Protection Area - Vulnerability Score

(7-4a.Vulnerability + 7-4b.Intrinsic Susceptibility = 7-4c. Vulnerability Score)

Figure 7-5a. Detailed Powassan Wellhead Protection Area

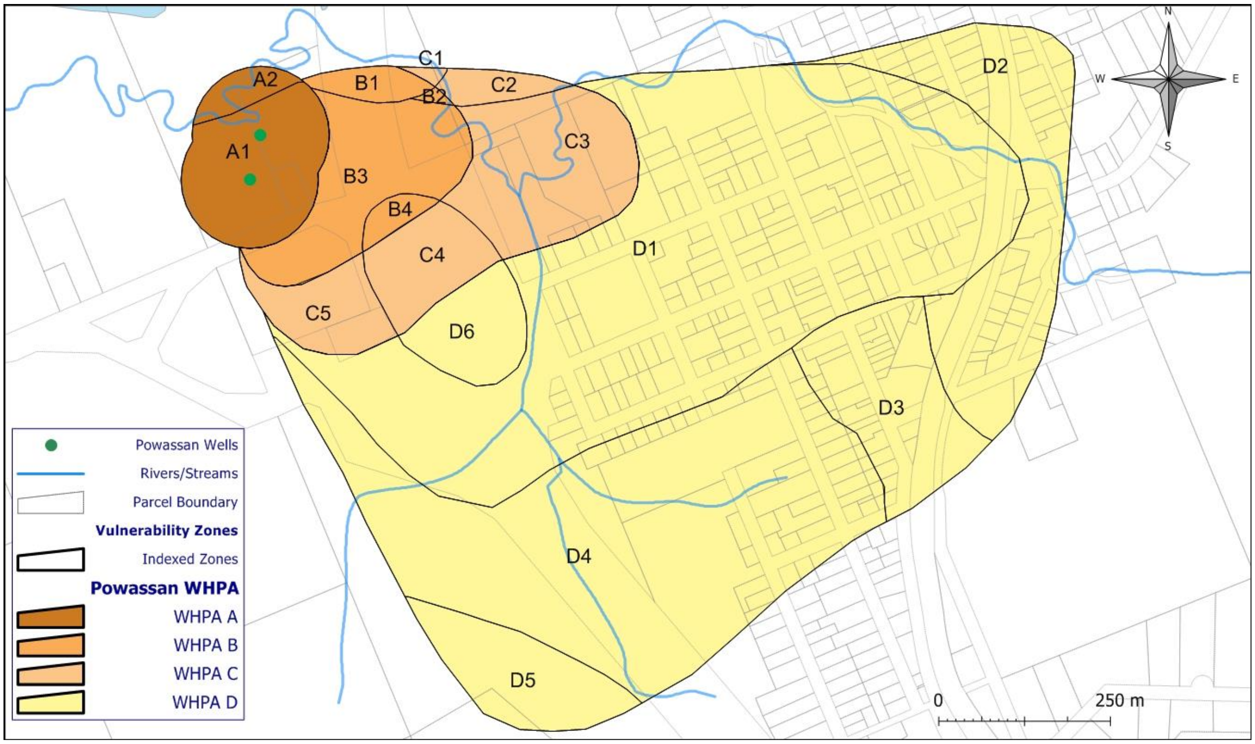
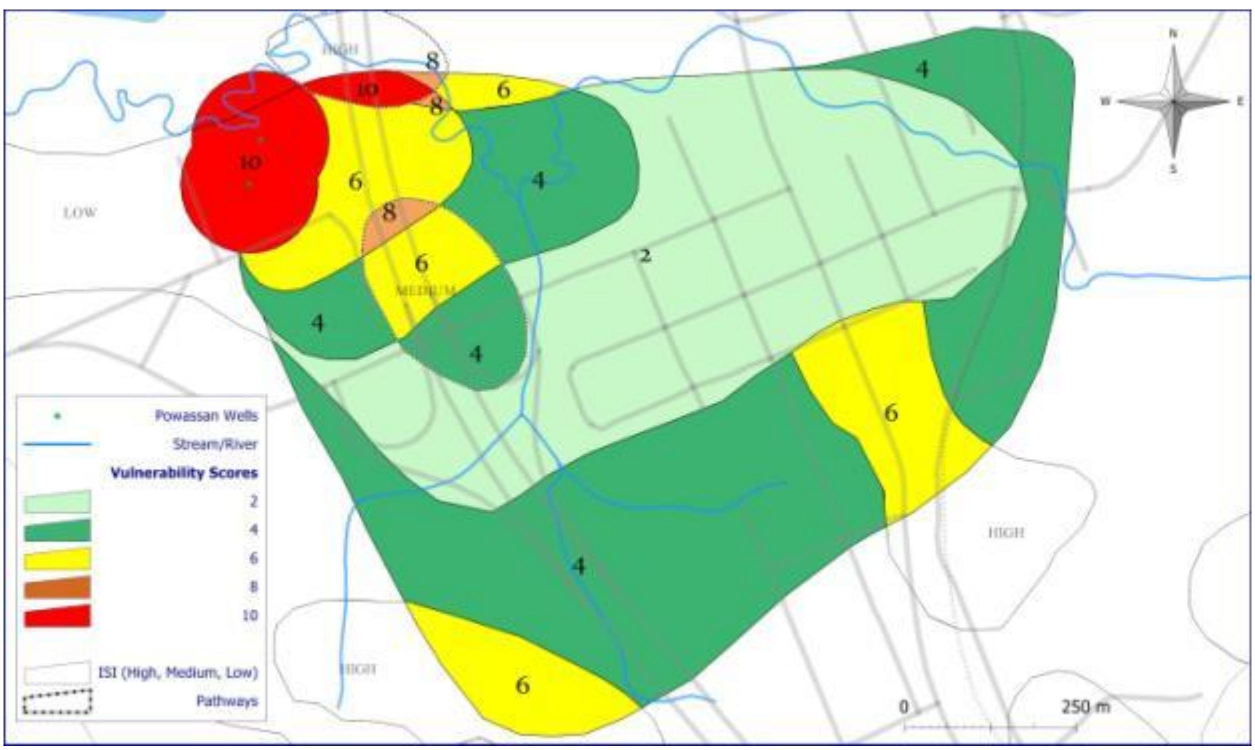


Figure 7-5b. Powassan Wellhead Protection Area Vulnerability Scores



7.4.3 Uncertainty Analysis

Delineation of the vulnerable areas within the WHPA will carry a degree of uncertainty, depending upon the quality of the data used in the assessment and the professional judgment skills of the analyst. The uncertainty of the vulnerability scoring of each area must be rated as either high or low (Table 7-9).

Table 7-9. Uncertainty Assessment - Powassan Groundwater Vulnerability Analysis

WHPA Zone	Vulnerable Area Designation	Intrinsic Vulnerability Category	Vulnerability Score	Uncertainty Factor	Explanation
A	A-1	low	10	low	fixed radius was applied, no hydrogeological interpretation required
	A-2	medium	10	low	fixed radius was applied, no hydrogeological interpretation required
B	B-1	high	10	high	status of abandoned geotechnical boreholes are unknown in this area
	B-2	medium	8	low	detailed modelling indicates stable capture zone close to the well head multiple scenario modelling indicates similar capture zone configuration
	B-3	low	6	low	detailed modelling indicates stable capture zone close to the well head multiple scenario modelling indicates similar capture zone configuration
	B-4	medium	8	high	status of abandoned geotechnical boreholes are unknown in this area
C	C-1	high	8	high	status of abandoned geotechnical boreholes are unknown in this area
	C-2	medium	6	low	detailed modelling indicates stable capture zone close to the well head multiple scenario modelling indicates similar capture zone configuration
	C-3	low	4	low	detailed modelling indicates stable capture zone close to the well head multiple scenario modelling indicates similar capture zone configuration

	C-4	medium	6	high	status of abandoned geotechnical boreholes are unknown in this area
	C-5	low	4	high	low density of subsurface information in this area
D	D-1	low	2	high	low density of subsurface information in the west half of this area multiple scenario modelling indicates variable capture zone configuration
	D-2	medium	4	high	low density of subsurface information in this area multiple scenario modelling indicates variable capture zone configuration
	D-3	high	6	low	sufficient density of subsurface information in this area
	D-4	medium	4	low	multiple scenario modelling indicates similar capture zone configuration
	D-5	high	6	high	low density of subsurface information in this area
	D-6	medium	4	high	status of abandoned geotechnical boreholes are unknown in this area

For the most part, there was adequate data available to achieve low uncertainty with respect to both the delineation of the WHPA and the assignment of susceptibility ratings using the ISI method. There is a small portion within each of WHPA-C and WHPA-D where there was less subsurface information available, so uncertainty has been rated as high for those areas. However, the delineation and scoring is consistent with adjacent areas. There are two other portions of WHPA-D where subsurface information is limited and the multiple scenarios showed some shifting of capture zone configuration.

However, it should be noted that the current results are consistent with the findings of the previous NBMCA Groundwater Study (Waterloo Hydrogeologic, 2006). As well, they are consistent with the accepted geological interpretation of the area. The increased susceptibility assigned to areas where technical boreholes had been drilled in the early 1980s prior to construction of the interchange and bridge on Hwy 11 is a conservative approach based on a lack of information available to confirm that appropriate decommissioning procedures were followed; it is the opinion of the consultant that that lack of information means the uncertainty for the susceptibility of the borehole area must be rated as high.

7.5 Issues Identification and Assessment

Discussions with the Ministry of the Environment identified that the only potential issue associated with the Powassan groundwater supply is the presence of elevated sodium in the water. Sodium levels for the time interval of 2003 to 2006 ranged from 27 mg/L to 31 mg/L (Ministry of the Environment, 2008/2009 Inspection Report for the Powassan Water Well

Supply). Under the current Ontario Drinking Water Quality Standards(ODWQS) (O.Reg 169/03; Amended 2006) sodium levels above 20 mg/L constitute a notification level. The local Medical Officer of Health must be notified so that the information may be passed onto local physicians. The focus of such a notification is to provide warning to persons on a sodium-restricted diet of the presence of sodium in the water supply. As indicated in the ODWQS, sodium is not toxic.

Further investigations compared incidents of road salt contamination to water chemistry data for the Powassan well field. The levels of sodium observed at the Powassan well field have been seen at other locations in the North Bay area, and are usually attributed to naturally occurring sodium levels in the bedrock formations of the region. Road salt impacted wells generally have a much higher concentration of sodium (and chloride) than has been reported for the Powassan well field. Therefore, the presence of the indicated sodium levels in the Powassan well supply is interpreted to be due to natural sources within the aquifer.

Public consultation identified a potential concern regarding historic use of the area adjacent to the wells for grazing livestock. However, available information suggests that this activity ceased in about 2000; further, in 2003 the Municipality adopted a by-law that restricts such land usage within 200 m of the wellhead. Given the passage of time and current land use restrictions, the risk of pathogens in the area due to former agricultural land use practices is not elevated.

Based on a review of these discussions and review of available data it was determined that were no issues associated with the Powassan groundwater supply.

7.6 Threats Identification and Assessment

Threats are defined as those activities or conditions that could cause contamination of drinking water by a chemical or pathogen within one of the Wellhead Protection Areas (WHPA). Activities must be assessed and reported whether or not they currently occur within the vulnerable areas. Ontario Regulation 287/07 Section 1.1 (1) under the *Clean Water Act (2006)* lists 19 activities that may result in threats to drinking water quality. (Two additional prescribed activities pose threats to quantity.) (Section 3, Table 3-4).

Conditions, as defined by Part XI.3 of the Technical Rules, refer to past activities that have produced contaminants that may result in significant drinking water threats and include the presence of:

- a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area;
- 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;
- 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;
- a contaminant in 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
- 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 Technical Rules. These involve:

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

Of the three approaches used to identify threats, this system involved the *threats approach*, which is based on listing the prescribed activities that are or would be drinking water threats within the vulnerable areas, and the *issues approach*, which is based on activities or conditions that contribute to existing drinking water issues listed under Rule 114. The third approach, the *events-based approach*, is based on modelling that demonstrates a chemical or pathogen release from an activity that could result in the deterioration of source drinking water. The *events-based approach* was not used in the identification of threats for the Municipality of Powassan.

7.6.1 Threats Approach

Part XI.4 of the Technical Rules describes 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:

1. the vulnerable area in which the activity occurs or would occur;
2. the vulnerability score of the vulnerable area;
3. a set of prescribed activities and corresponding circumstances that constitute a threat

The Technical Rules require activities that would be a significant, moderate or low drinking water threat within the vulnerable areas to be listed in the Assessment Report, *regardless of whether or not the activities presently exist in the vulnerable area.* For an activity to pose even a low threat, the vulnerability score of the area in which it occurs must be greater than or equal to 6 for a groundwater system.

Lists of significant, moderate and low drinking water threats related to chemicals and pathogens were compiled for each of the vulnerable areas of the Powassan drinking water intake based on the MOE Tables of Drinking Water Threats.

Existing activities were compared to the MOE Tables of Drinking Water Threats, where the prescribed activities that pose a threat were classified as significant, moderate or low based on their circumstances.

Threats Approach - Potential Activities & Circumstances

Based on the resulting vulnerability scores, the possible threat levels were identified for each of the vulnerable areas (Table 7-10). Due to the vulnerability scores within the WHPAs, only WHPA-A,B,and C may contain potential significant chemical threats and WHPA-A & B may contain significant pathogen threats (only WHPA-A and B for all wellheads in Ontario may contain pathogen threats). Refer to Figure 7-5b above for further support of the vulnerable areas where activities are significant, moderate or low.

Table 7-10. Areas Within Powassan Wellhead Protection Area Where Activities Are or Would be Significant, Moderate and Low Drinking Water Threats

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemicals	WHPA-A1, A2	10	✓	✓	✓
	WHPA-B1	10	✓	✓	✓
	WHPA-B2, B4	8	✓	✓	✓
	WHPA-B3	6		✓	✓
	WHPA-C1	8	✓	✓	✓
	WHPA-C2, C4	6		✓	✓
	WHPA-C3, C5	4			
	WHPA-D3, D5	6		✓	✓
	WHPA-D2, D4, D6	4			
	WHPA-D1	2			
Pathogens	WHPA-A1, A2	10	✓	✓	
	WHPA-B1	10	✓	✓	
	WHPA-B2, B4	8		✓	✓
	WHPA-B3	6			✓
	WHPA-C1	8			
	WHPA-C2, C4	6			
	WHPA-C3, C5	4			
	WHPA-D3, D5	6			
	WHPA-D2, D4, D6	4			
	WHPA-D1	2			

The circumstances under which these threats may be considered as significant, moderate or low are referenced in the MOE Provincial Table of Circumstances. These tables can be used to help the public determine where activities are or would be significant, moderate and low drinking water threats. A summary of the list of Provincial Tables relevent to each vulnerable area in Mattawa is provided in Table 7-11.

The Provincial Table headings listed within Table 7-12 (i.e. CW10S) represent one of 76 tables and are titled using a combination of acronyms explained in the chart below. The MOE Provincial Tables of Circumstances can be found at http://www.ene.gov.on.ca/environment/en/legislation/clean_water_act/STDPROD_081301.html

The table headings are acronym for a list of circumstances utilizing the following identifiers:

Acronym	Definition
C	Chemical
P	Pathogen
D	Dense Non-Aqueous Phase Liquid
W	Wellhead protection area
IPZ	Intake protection zone
IPZWE	IPZ and WHPA-E
(number)	Vulnerability score
A	Any vulnerability score

Acronym	Definition
S	Significant
M	Moderate
L	Low

For example: CW10S is a table of:

C - **C**hemical Threats in a
W- **W**ellhead Protection Area with a vulnerability score of
10 - **10,** categorized as a
S - **S**ignificant threat

Table 7-11. Summary of Tables of Circumstances Related to Threat Levels and Vulnerability Scores

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification and Provincial Table Reference Code		
			Significant	**Moderate**	**Low**
Chemical	WHPA-A, B1	**10**	CW10S	CW10M	CW10L
	WHPA-B2, B4, C-1	**8**	CW8S	CW8M	CW8L
	WHPA-B3, C2, C4, D3, D4, D6	**6**	NA	CW6M	CW6L
	WHPA-C3, C5, D2, D4, D6	**4**	NA	NA	NA
	WHPA-D1	**2**	NA	NA	NA
Dense Non-Aqueous Phase Liquids (DNAPLs)	WHPA-A,B,C	**Any**	DWAS	NA	NA
	WHPA-D	**6**	NA	DWHVASGRA6M	DWHVASGRA6L
Pathogen	WHPA-A, B1	**10**	PW10S	PW10M	NA
	WHPA-B2, B4, C-1	**8**	NA	PW8M	PW8L
	WHPA-B3, C2, C4, D3, D4, D6	**6**	NA	NA	PW6L
	WHPA-C3, C5, D2, D4, D6	**4**	NA	NA	NA
	WHPA-D1	**2**	NA	NA	NA

Note: The table references refer to the Provincial Table of Circumstances.

There are 18 prescribed activities that are or would be significant drinking water threats if they occurred in the Powassan Wellhead Protection Area. A breakdown of the prescribed activities and the number of circumstances under which those activities would be significant is provided in Table 9-4.

Table 7-12. Enumeration of Circumstances under which Prescribed Activities are or would be Significant Threats to the Powassan Municipal Groundwater System

Activities Prescribed to be Drinking Water Threats	# of Significant Threat Circumstances	
	Chemical	Pathogen
The application of agricultural source material to land.	5	1
The application of commercial fertilizer to land.	5	
The application of non-agricultural source material to land.	5	1
The application of pesticide to land.	11	
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	135	6
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	244	1
The handling and storage of a dense non-aqueous phase liquid.	28	
The handling and storage of an organic solvent.	20	
The handling and storage of commercial fertilizer.	1	
The handling and storage of fuel.	36	
The handling and storage of non-agricultural source material.	6	2
The handling and storage of pesticide.	13	
The handling and storage of road salt.	2	
The management of runoff that contains chemicals used in the de-icing of aircraft.	2	
The storage of agricultural source material.	6	3
The storage of snow.	38	
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.	2	2
Number of circumstances under which the threat is or would be significant	**561**	**16**

Threats Approach - Existing Significant, Moderate and Low Threats

The identification of specific groundwater quality threats in the Powassan vulnerable areas was based on inputs from several sources. The process included a local field survey of properties in the WHPA previously delineated by the NBMCA Groundwater Study (Waterloo Hydrogeologic, 2006), a search of publicly available databases through Ecolog ERIS, a review of the NBMCA database of *on-site* septic systems, and public consultation. The Threats of Drinking Water Tables were then used to rate the level of significance of each activity. [Drinking water threats as prescribed in Paragraphs 1 through 18 and paragraph 21 of subSection 1.1(1) of O.Reg. 287/07 (General)]

Based on a review of the above information, there are septic systems located on two properties that extend into the WHPA-A and are automatically classified as posing significant (S) pathogen threats. (Table 7-14)
The Powassan Threat Assessment report completed by WEGL (2009) identified the application of pesticides along the Highway 11 corridor as a significant threat in an area where the aquitard may have been compromised by previous technical borehole drilling. However, it was subsequently determined through consultation with Ministry of Transportation that MTO has not applied pesticides in that area in at least fifteen years, so the application of pesticides is not considered an existing activity.

Fuel storage at the wellhead for the standby generator was identified as a moderate threat.

Table 7-13. Existing Threats within Powassan Wellhead Protection Area

Activity Prescribed to be a Threat	WHPA-A	WHPA-B			WHPA-C		WHPA-D	Circumstance Reference #
	Vs=10	Vs=10	Vs=8	Vs=6	Vs=8	Vs=6	Vs=6	
The handling and storage of fuel.	M (2)			L (1)		L (1)	L (13)	1354
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	S (2)			M (1)				1956
					M (1)	L (1)	L (1)	663
The application of road salt.		M (1)	L (1)	L (1)		L (1)	L (1)	92 93

** Occurrences in columns with bold boxes represent one parcel with multiple circumstances*

7.6.2 Issues Approach to Threat Identification

There are no drinking water issues, in accordance with Rule 114 and 115 in the Powassan Wellhead Protection area.

7.6.3 Conditions

There are no known conditions that exist in the vulnerable areas of the Powassan drinking water intake.

7.6.4 Local Threat Considerations

The North Bay-Mattawa Source Protection Committee is concerned about the threat posed by the transportation of hazardous substances along highway and rail corridors within the Powassan Wellhead Protection Area (WHPA) which creates the potential for a spill to occur.

Although there is no prescribed threat activity related to the transportation of hazardous substances under the Clean Water Act, Technical Rule 119 allows Source Protection Committees to request that an activity be listed as a drinking water threat if:

1. The activity has been identified by the Source Protection Committee as an activity that may be a drinking water threat; and
2. The Director indicates that the chemical or pathogen hazard rating for the activity is greater than 4.

The Source Protection Committee submitted a formal request to the Ministry of Environment for the addition of transportation of hazardous substances as a non-prescribed (local) drinking water threat in the SP Area. This request was approved by the Director on February 8, 2011 (Appendix G). Included in the approval are the circumstances and hazard ratings for the activities considered.

Table 7.14 shows where significant, moderate and low threats relating to the transportation of hazardous substances are located in the Powassan WHPA. Both chemical and pathogen significant threats exist within Powassan WHPA-A and B1 (Figure 7-4a). The pathogen threat relates to the transportation of septage, for which a spill may result in the presence of pathogens in ground water. Significant chemical threats relate to the transportation of sulphuric acid or sodium hydroxide in quantities greater than 2,500 litres, for which a spill may decrease or increase, respectively, the pH of groundwater beyond acceptable limits.

Table 7-14. Areas within Powassan Wellhead Protection Area where Transportation of Hazardous Substances is Considered a Significant, Moderate or Low Drinking Water Threat

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemicals	WHPA-A1, A2	10	✓	✓	
	WHPA-B1	10	✓	✓	
	WHPA-B2, B4	8		✓	✓
	WHPA-B3	6			✓
	WHPA-C1	8		✓	✓
	WHPA-C2, C4	6			✓
	WHPA-C3, C5	4			
	WHPA-D3, D5	6			✓
	WHPA-D2, D4, D6	4			
	WHPA-D1	2			
Pathogens	WHPA-A1, A2	10	✓		
	WHPA-B1	10	✓		
	WHPA-B2, B4	8		✓	
	WHPA-B3	6			✓
	WHPA-C1	8		✓	
	WHPA-C2, C4	6			✓
	WHPA-C3, C5	4			

	WHPA-D3, D5	6			
	WHPA-D2, D4, D6	4			
	WHPA-D1	2			

7.7 Gap Analysis and Recommendations

The present analysis was based on the information available at the time of reporting. Due to on-going changes in land use in Powassan, some of the information obtained in the 2007 data collection phases may no longer be accurate, and therefore constitute a potential knowledge or data gap in the present interpretation. Since ongoing land use changes are a characteristic of most municipalities, the suggested improvement to the database will be through periodic review and updating of the drinking water threats.

The present analysis of groundwater quality issues was limited by a lack of detailed raw water chemistry results for the municipal wells. However, this lack of this information does not compromise the validity of the findings.

From a scientific viewpoint, additional supplemental analysis of the water chemistry would be of benefit in tracking any long-term trends in water quality, for those parameters not mandated by the Certificate of Approval for the water system. As a suggestion, it is recommended that a complete water quality scan of the raw water characteristics (major ion analysis, heavy metals analysis, nutrient indicators and general water chemistry parameters) be undertaken annually, complimenting the analysis required by the Certificate of Approval.

Uncertainty scores were assigned to the various vulnerable areas in this assessment, being flagged as either “high” or “low”. In many instances, high uncertainties were assigned because of a lack of detailed subsurface information. In the case of the municipally-serviced areas of Powassan, it is unlikely that any new deep well constructions will occur, and so the future subsurface information gathered in these areas may be limited to relatively shallow road work excavations and shallow geotechnical boreholes. In the interest of continuous improvement, as new subsurface data become available, it is recommended that they be periodically assessed against the current conceptual model of the local geological setting so that any anomalous information is corrected for future planning cycles.

Potential data gaps were identified where the Ecolog and Conservation Authority search areas did not sufficiently cover the newer WHPAs (2009). These gaps were unforeseen at the time of the initial data collection, and with the presently-defined WHPAs it is recommended that the search areas be re-visited to determine if any additional threats can be identified. It should be noted that the identified area of concern lies within the boundaries of a WHPA-D zone, and it is not possible to locate a “significant” threat in a WHPA-D zone (because of the scoring conventions presented in the Tables of Drinking Water Threats). However, for completeness, it is recommended that these areas be investigated and the table of existing threats revised (if appropriate).