Chapter 6

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6 Surface Water Sources

Introduction

This chapter provides information on surface-water based municipal drinking water systems in the Mississippi Valley Source Protection Area (MVSPA). Information on the general process of determining Intake Protection Zones (IPZs) for all municipal surface water intakes in the Mississippi-Rideau Source Protection Region (MRSPR) is provided, followed by discussion on how the Carleton Place and the two City of Ottawa IPZs were delineated. Significant threats, issues, and conditions are discussed where applicable for each intake.

Information is included in the MVSPA Assessment Report on the two City of Ottawa drinking water intakes, Britannia and Lemieux Island and their IPZs, even though the intakes are located in the Rideau Valley Source Protection Area (RVSPA). This is due to the large area covered by the IPZs for these Ottawa River intakes. The IPZs extend to include the MVSPA, as the MVSPA is a sub-basin of the Ottawa River upstream of the intakes. Theoretically, water (and its contaminants) that enters anywhere in the Mississippi River will pass the Ottawa intakes locations.

There is one municipal surface water drinking water intake in the MVSPA, as seen in Figure 6-4. It is located in smaller inland waters, supplying the Town of Carleton Place. Figure 6-5 shows all intake protection zones in the Region with a vulnerability score of 8-10.

It should be noted that the estimated number of users may vary slightly from those found in the 2008 MRSPR Watershed Characterization report and Table 2-16, as more current information is included here.

Municipal Water Supply Location	Estimated Number of Users
Carleton Place	9,400
Total	9,400

Table 6-i. Surface Water Drinking Water Systems in the MVSPA.

Three main IPZs have been delineated for each of the municipal intakes. The IPZ studies for Carleton Place in the MVSPA, as well as the two RVSPA drinking water systems in Perth and Smiths Falls were completed together and are referred to as Type C: Inland Rivers Intake Protection Zone studies.

A number of lower or single tier municipalities have IPZs located within their boundaries. Table 6-4 lists which municipalities within the MRSPR have IPZs and shows the associated drinking water intake.

A discussion is included in Section 6.2 regarding the fact that this is the first time, unlike groundwater studies, for surface water studies to be completed in Ontario. With little experience and few "lessons learned" to draw from, the Technical Rules for surface water studies did not prescribe how to carry out vulnerability scoring for Intake Protection Zones. Rather, the Technical Rules requires locally developed methodologies to be used.

Summary of Key Findings

Following is a summary of Vulnerability Scores assigned to the Carleton Place and two Ottawa municipal surface water intake IPZs.

Intake Protection Zone (TOT = Time of Travel)		***Vulnerability Scores (V)***		
		Carleton Place	**Britannia**	***Lemieux Island***
IPZ-1		10	9	*9*
IPZ-2		9	8.1	*8.1*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	8	7.2	*7.2*
	Sub-zone 2 (6 to 10 hour TOT)	7	6.3	*6.3*
	Sub-zone 3 (10 to 14 hour TOT)	6	5.4	*5.4*
	Sub-zone 4 (14 to 18 hour TOT)	5	4.5	*4.5*
	Sub-zone 5 (>18 hour TOT)	*4*	*3.6*	*3.6*

Table 6-ii. Summary of Vulnerability Scores for IPZs Occurring in the MVSPA.

No issues or conditions have been identified at any municipal surface water drinking water intakes in the MRSPR. A summary of key results is in Table 6-1.

There were 20 potentially significant surface water drinking water threats identified in MVSPA in the Carleton Place IPZ. Table 6-2 is a summary of potentially significant threats to municipal surface water drinking water systems in the MVSPA.

Technical Studies

Five background technical studies were completed for the surface water drinking water sources chapter. The following table summarizes "who did what", including a peer review, if applicable. Further information about peer review is provided following the table.

Study & Completion Date	Lead Consultant	Peer Review
Inland Rivers (Carleton Place, Perth, Smiths Falls) Surface Water Vulnerability Study, 2010	J.F. Sabourin and Associates Inc., and Water and Earth Science Associates	Baird & Associates Ltd.
Ottawa River Surface Water Vulnerability Study, 2010	Baird & Associates Ltd.	J.F. Sabourin and Associates Inc.
Managed Lands and Livestock Density, 2010	Dillon Consulting	not peer reviewed
Impervious Surfaces, 2010	Mississippi-Rideau SPR Staff	not peer reviewed
Drinking Water Threats and Issues, 2010	*Dillon Consulting*	not peer reviewed

Table 6-iii. Surface Water Sources – Technical Reports.

Peer Review

An independent consultant was retained to undertake a peer review of each IPZ study. The objectives of the IPZ study peer review were as follows:

- To ensure consistency with the expectations of the MOE Technical Guidance modules, which have since been replaced by the Technical Rules
- To validate the approach for development of surface water vulnerability studies
- To ensure scientifically defensible surface water vulnerability studies.

Table 6-iii lists the names of consultants who undertook the peer review for each study. Each technical study contains a peer review record.

This chapter is a summary of the MRSPA surface water studies' processes and results. For further information on the work completed in the MRSPR related to surface water sources, see the related technical report(s). Further information on threats and issues processes may be found in Chapter 4. Information on data gaps may be found in Chapter 8. A list of all Assessment Report technical reports and data source information may be found in Appendix A-1.

6.1 Intake Protection Zones

This section provides information on IPZs; how they are classified, delineated, and scored for vulnerability within the MRSPR.

6.1.1 What is an Intake Protection Zone?

An IPZ is the land and water area that contributes water to a municipal surface water intake. Within this area it is important to monitor or regulate drinking water threats. IPZ studies aim to provide an understanding of local surface water flow conditions and potential sources of contamination surrounding one or more intakes that supplies a municipal drinking water system.

6.1.2 Classification of Intakes

The Technical Rules require classification of each municipal surface water intake into one of the following four categories:

- **Type A** intakes are located in a Great Lake;
- **Type B** intakes are located in a Great Lake Connecting Channel or River (such as the St. Lawrence River);

- **Type C** intakes are located in a smaller river where neither the direction nor flow rate at the intake is affected by a water impoundment structure (e.g. a dam); and
- **Type D** intakes are anything not classified as a Type A, B or C intake. Type D intakes are typically located in smaller inland lakes.

The classification of an intake determines how the related IPZs are developed and assessed. There is one municipal surface-water based drinking water systems in the MVSPA, as seen in the following table.

Municipal Drinking Water System	Source Water	Intake Classification
Carleton Place	Mississippi River	Type C

Table 6-iv. MRSPR Surface Water Intake Classification.

The IPZ studies for Carleton Place, together with Perth and Smiths Falls drinking water systems in the RVSPA, were completed together and are referred to as Type C: Inland Rivers Intake Protection Zone studies. Information relevant to the Carleton Place system is presented in Section 6.3 and the study results are presented in Sections 6.4. Information for the Perth and Smiths Falls systems can be found in the RVSPA Assessment Report.

The IPZ studies for Britannia and Lemieux Island (Ottawa) drinking water systems were completed together, and are referred to as Type C: Ottawa River Intake Protection Zone Studies. Information related to the Ottawa systems is presented in Section 6.5 and the individual study results are presented in Sections 6.6 and 6.7. This information is included in this MVSPA Assessment Report even though the intakes are located in the RVSPA, as the IPZs for these intakes include all of the MVSPA.

Although all municipal surface water intakes in the MRSPR are classified as Type C systems, the Technical Rules have different requirements for the delineation of IPZ-3s for the inland river intakes and Ottawa River intakes.

6.1.3 Delineation of Intake Protection Zones

An IPZ is made up of three separate zones: IPZ-1, IPZ-2, and IPZ-3. These areas are adjacent to one another, but do not overlap. The zones consist of both water areas and land areas which have the potential to contribute contamination to a municipal surface water intake. A general description of how the three IPZs are delineated follows below.

The delineation of the Type C: Inland Rivers IPZs in the MRSPR is presented in Section 6.3.1 for the Carleton Place municipal surface water intake. The delineation of the Type C: Ottawa River IPZs is presented in Section 6.6.1. This section provides information on the two municipal surface water intakes for the City of Ottawa located at Britannia and Lemieux Island.

IPZ-1

The IPZ-1 represents the most vulnerable area immediately surrounding the municipal surface water intake. The size and shape of the IPZ-1 is set by the Technical Rules but may be modified to reflect local conditions. If the IPZ-1 delineation includes land, it may only extend onto the land by 120 m from the high water mark or the Conservation Authority Regulation Limit (often referred to as the generic regulations line), whichever is greater. The general IPZ-1 requirements for each type of intake are shown in the following table.

Intake Type	Location	General Area Shape	Area Dimensions for IPZ-1
A	Great Lakes	Circle	One kilometre radius
B	Connecting Channels	Semi-Circle/Rectangle	One kilometre radius upstream of intake, rectangle two kilometres long and 100 m wide downstream
C*	Rivers	1) Circle, or 2) Semi-Circle/Rectangle	1) One kilometre radius, or 2) 200 m radius upstream of intake, rectangle 400 m long and ten m wide downstream
D	Other	Circle	One kilometre radius

Table 6-v. IPZ-1 General Features.

*MRSPR Municipal Surface Water Intake Type

IPZ-2

In-river

The in-river portion of IPZ-2 is based on a specified Time of Travel (ToT) within the river. This is the period required for surface water to travel to the intake. Under the Technical Rules, the required ToT must be equal to or less than the time that is sufficient to allow operators to shut down the water treatment plant in the event of a spill, or 2 hours, whichever is greater.

On-land

The on-land portion of IPZ-2 adjacent to the river is based on a setback of 120 m from the high water mark or the Generic Regulation limit as maintained by the Mississippi Valley and Rideau Valley Conservation Authorities, whichever is greater.

The Technical Rules also require that all storm sewers that may contribute water to the intake within the 2 hour ToT or the water treatment shut down time (if the shut down time is greater than 2 hours) be included in IPZ-2.

IPZ-3

The IPZ-3 is an area where contaminants, if released, could be transported to the municipal surface water intake. For municipal surface water intakes located on inland rivers other than the Ottawa River, the standard approach is to setback all rivers, streams, and lakes upstream of the intake by 120 m, or the Generic Regulation limit, whichever is greater.

The Technical Rules prescribe a different approach for municipal surface water intakes on the Ottawa River, called the event-based approach (EBA). The EBA outlines three optional approaches for undertaking IPZ3 delineation;

1. the Contaminant Transport Approach;
2. the Boundary Approach; or
3. a Combined Approach.

In this study, Option 2, the Boundary Approach, was applied. The Technical Rules state that this approach can be used if there are no activities of concern upstream of the intake.

Inclusion of Transport Pathways in IPZ Delineation

A Transport Pathway (TP) is anything that provides a direct route for contaminants to enter surface water. These are human-made or natural features such as drainage ditches, tile drains, roadways, or creeks and streams. Since these pathways can drain water from a larger area than the river's main channel alone, the intake protection zones must be expanded to include them.

Transport pathways are considered once a preliminary IPZ delineation has been completed. The IPZ-2 and/or IPZ-3 is expanded to include the transport pathways. In the case of the inland river municipal surface water intakes, a 120 m setback on both sides of the transport pathway was used to define the transport pathway area since not all information on conditions was known.

6.1.4 Vulnerability Scoring

Once the IPZs are delineated, the next step is to assess how susceptible the surface water in these zones is to contamination. This is done in order to identify areas where extra care is needed to protect the water supply.

The Technical Rules set out a process for assessing the vulnerability for each intake protection zone. The final Vulnerability Score is based on the following equation:

V = B x C

Where:

V is the Vulnerability Score

B is the Area Vulnerability Factor

C is the Source Vulnerability Factor

These factors, and how their values were calculated, are described below.

Determining the Area Vulnerability Factor (B)

The first step in the evaluation of surface water vulnerability is to determine the Area Vulnerability Factor (B) for each intake protection zone. The Area Vulnerability Factor must be a whole number (no decimal points), and the possible values range from 1 to 10, with 10 being the highest vulnerability.

IPZ-1

The Area Vulnerability Factor for IPZ-1 is always 10, as stipulated in the Technical Rules, since this zone is closest to the intake and encompasses the area of water and land to which the water intake is most vulnerable. It is assumed that if contaminants were released within IPZ-1 they would not be diluted or filtered before reaching the drinking water intake.

IPZ-2

The Technical Rules require that the Area Vulnerability Factor for IPZ-2 be 7, 8, or 9. One score must be assigned to the whole zone and the following factors must be taken into consideration:

- **Percentage of area of IPZ-2 that is land.** This factor reflects the assumption that as the percentage of land within an IPZ increases, the potential risk increases for a spill to occur that may impact water quality at the water intake.
- **The land cover, soil type, permeability of the land and the slope of the land.** This factor reflects the potential for overland water to flow into the zone. Whether vegetation is present, as well as the type of vegetation, affects how much of the water is overland water flow and how much of it soaks into the ground. Permeable soils allow for more infiltration. Slopes increase the percentage of overland flow compared to the amount of infiltration.
- **The hydrological and hydrogeological conditions where transport pathways are located.** This factor reflects the extent of the transport pathways including sewer systems that may exist in the zone and their influence on water (and potential contaminant) movement from land to rivers which are the source of water intakes.

IPZ-3

The Area Vulnerability Factor for IPZ-3 is based on proximity to the municipal surface water intake as well as the three factors considered for IPZ-2, shown above. Unlike IPZ-2, the Area Vulnerability Factor for IPZ-3 may differ by location throughout the area. As discussed is Sections 6.3.2 and 6.6.2, five sub-zones were identified for vulnerability scoring purposes in each IPZ-3. According to the Technical Rules, no value in the IPZ-3 may be a higher value than the value assigned to IPZ-2.

Determining the Source Vulnerability Factor (C)

The second step is to assess the Source Vulnerability Factor (C). This is an assessment of the location of the municipal surface water intake and how vulnerable it is to the impact of contaminants. The Source Vulnerability Factor is assigned to each intake in accordance with the following table from the Technical Rules.

Intake Type	Location	Source Vulnerability Factor (C)
A	Great Lakes	0.5 to 0.7
B	Connecting Channels	0.7 to 0.9
C*	Rivers	0.9 or 1
D	Other	0.8 to 1

Table 6-vi. Source Vulnerability Factor Ranges for Surface Water Intakes.

* Intake Type for all MRSPR Municipal Surface Water Intakes

In the MRSPR where there are only Type C intakes, a factor of 1 corresponds to a higher vulnerability and 0.9 indicates relatively less vulnerability.

The Source Vulnerability Factor (C) is based on:

- the depth of the intake below the water surface - the deeper the intake, the lower the vulnerability;
- the distance of the intake from land - the further away from shore, the lower the vulnerability; and
- the number of recorded drinking water quality issues at the intake, if any.

Calculating IPZ Vulnerability Scores

Once the Area (B) and Source (C) Vulnerability Factors have been finalized, the final step is to complete the calculation of the final Vulnerability Scores, according to the prescribed equation.

The following table summarizes the possible Area Vulnerability Factors (B), Source Vulnerability Factors (C) and Vulnerability Scores (V) for Type C intakes.

	Possible Area Vulnerability Factors (B)			Possible Source Vulnerabilit y Factors (C)	Possible Vulnerability Scores (V) [B x C = V] Expressed to a max. of one decimal point, depending on the value of C		
Zone	IPZ-1	IPZ-2	IPZ-3		IPZ-1	IPZ-2	IPZ-3

	Possible Area Vulnerability Factors (B)			**Possible Source Vulnerability Factors (C)**	**Possible Vulnerability Scores (V)** **[B x C = V]** **Expressed to a max. of one decimal point, depending on the value of C**		
Possible Values	10	7 to 9	1 to 9	0.9 or 1	9 or 10	6.3 to 9	0.9 to 9

Table 6-vii. Ranges of Possible Vulnerability Factors and Scores for Surface Water IPZs.

6.2 First Time for Surface Water Studies

Professionals have been carrying out groundwater studies since the late 1990s, providing experience and established best practices for the MOE to draw from for its development of the Technical Rules governing groundwater studies. The result is a fully prescribed approach for how to derive Vulnerability Scores for the Wellhead Protection Areas, discussed in Chapter 5, and a consistent approach has been applied across the province.

In contrast, surface water Intake Protection Zone studies are being undertaken for the first time in Ontario. With little experience and few “lessons learned” to draw from, the Technical Rules for surface water studies did not prescribe how to carry out vulnerability scoring for Intake Protection Zones. Rather, the Technical Rules requires locally developed methodologies to be used.

Local Approach Developed for Surface Water Vulnerability Scores

As outlined in Section 6.1.4, the Technical Rules prescribe that surface water Vulnerability Scores (V) be equal to the product of an Area Vulnerability Factor (B) and a Source Vulnerability Factor (C), where V = B x C. However, the Technical Rules do not provide explicit details on how to calculate B and C. Instead, they identify various matters to be considered.

Per the Technical Rules, the Area Vulnerability Factor (B) is to be based upon the following variables:

- the percentage of area of IPZ-2 or IPZ-3 that is land;

- the land cover, soil type, permeability of the land and the slope of the land;
- the hydrological and hydrogeological conditions where transport pathways are located; and
- the proximity of the area of the IPZ-3 to the intake.

And, the Source Vulnerability Factor (C) must be based upon the following variables:

- the depth of the intake below the water surface;
- the distance of the intake from land; and
- the history of water quality concerns at the intake.

In addition to the above, the Technical Rules specify the following:

- the Area Vulnerability Factor for IPZ-1 must be 10;
- the Area Vulnerability Factor for IPZ-2 is not less than 7 and not more than 9;
- the Area Vulnerability Factors for IPZ-3 are not less than 1 and not more than 9;
- the Area Vulnerability Factor for IPZ-3 shall not be greater than the Area Vulnerability Factor assigned to IPZ-2; and
- the Source Vulnerability Factor shall be 0.9 or 1 for the municipal surface water intakes located in the Mississippi-Rideau Source Protection Region.

The Technical Rules therefore requires each Source Protection Area to develop its own approach to determine Vulnerability Scores for Intake Protection Zones. This means that unlike Wellhead Protection Area studies, a consistent approach has not been applied across the province. The Committee considers the surface water Vulnerability Scores for the five surface water intakes in the MRSPR, derived by the method described in the next sections, as a reasonable first time assessment. Vulnerability Scores can be adjusted in an updated Assessment Report if an improved methodology becomes available. As the following table shows, the Vulnerability Scores determined for the IPZs in the MRSPR are in most instances at or close to the highest possible values permissible in the Technical Rules. Those Vulnerability Scores that are not the highest possible reflect the specific characteristics of that particular river and intake.

	Zone	**IPZ-1**	**IPZ-2**	***IPZ-3***
	Possible Vulnerability Scores Values	9 or 10	6.3 to 9	*0.9 to 9*
	Vulnerability Scores Values Results			
Intake Protection Zones	Carleton Place	10	9	*4-8*
	Perth	10	9	*4-8*
	Smiths Falls	10	8	*4-8*
	Britannia	9	8.1	*3.6-7.2*
	Lemieux Island	*9*	*8.1*	3.6-7.2

Table 6-viii. Summary of Possible and Final Vulnerability Scores for Intake Protection Zones in the MRSPR.

6.3 Type C: Inland River Intake Protection Zones in the Mississippi-Rideau Source Protection Region

This section provides information on inland river municipal intake protection zones.

6.3.1 Delineation of Type C: Inland Rivers Intake Protection Zones

The following describes the process which was undertaken to complete the IPZ delineation for the MVSPA municipal surface water intake for Carleton Place, as well as the RVSPA municipal surface water intakes in Perth, and Smiths Falls.

Collection and assembly of data and information

Local hydrology, water quality, and climate data was collected from federal, provincial, and municipal governments as well as other sources. Information collected includes the generic regulation limit lines for the study area, as maintained by the Rideau Valley and Mississippi Valley Conservation Authorities. Generic regulation areas identify land which could be unsafe for development due to naturally occurring processes associated with flooding, erosion, dynamic beaches, or unstable soil or bedrock.

The characteristics of the municipal surface water intakes and identification of surrounding land uses were determined through site visits, discussions with municipal staff and the review of available records and reports. Current and high-quality digital aerial photography and elevation data is an integral part of the analysis of Carleton Place, Perth and Smiths Falls. This data was acquired by the Mississippi-Rideau Source Protection Region in 2006.

Delineation of IPZ-1

As discussed in Section 6.1.3, the IPZ-1 surrounds the municipal surface water intake. The Technical Rules outline how to create IPZ-1. For Type C intakes, IPZ-1 can be created using a;

- one km radius (centred on the intake); or
- 200 m radius (centred on the intake) upstream of intake, plus a rectangle 400 m long and 10 m wide downstream of the intake.

The first method is more appropriate for intakes located in large surface water features such as lakes, where there is little or no flow. The second of the two methods listed above was selected for the three inland municipal water intakes in the MRSPR because, unlike a lake, the rivers have a continuous downstream flow.

Wherever the IPZ-1 intersects the shore, it was expanded to a setback of 120 m from the high water mark or the Conservation Authority generic regulation limit, whichever is greater.

Development of a computer model

Aforementioned datasets were used to develop a general understanding of the local surface water system. Using the geometry from cross-sections at various points along each river, along with water flow data from a stream flow gauge, the HEC-RAS computer model was chosen to determine how quickly water flows towards the three intakes.

HEC-RAS models how water flows through natural rivers and channels. This modeling software is publicly available and has been peer reviewed. The model was used to determine the velocity with which water (at the various points) travels towards the intake in the river. This information was used to determine the IPZ-2 ToT.

Delineation of IPZ-2

As discussed in Section 6.1.3, the IPZ-2 is based in part on the distance upstream from the intake that represents how far a contaminant in the water travels in a minimum of two hours.

Under the Technical Rules, the required ToT must be equal to or less than the time that is sufficient to allow operators to shut down the water treatment plant (WTP) in the event of a spill. The approximate shut down time for all MRSPR inland municipal water intakes ranges from five to 15 minutes after detection or notification, so the ToT was set to the minimum two hour limit. The following table shows the approximate shut down time for the Carleton Place inland municipal water intake after detection or notification.

Municipal Surface Water System	***Approximate Shut Down Time as Reported by Municipality***
Carleton Place	*5 minutes*

Table 6-ix. Approximate Shut Down Time for the Carleton Place Inland Water Treatment Plant.

In-river

The HEC-RAS model defined the upstream limits of IPZ-2 using the two hour ToT, as prescribed by the Technical Rules. The equivalent of each river's bankfull velocity was also required and this was represented by using the 2-year return period flow, which is considered to be representative of bankfull conditions.

The bankfull flow rate for the Mississippi River follows. The upstream limits of the IPZ-2s were extended to take into account wind effects on the ToT in the river. Appendix 6-1 provides the data and methodology used to determine the wind effects.

Intake	**Source Water**	***Bankfull flow (m^3/s)***
Carleton Place	*Mississippi River*	*144*

Table 6-x. MVSPA Inland Rivers Bankfull Velocity.

On-land

The next step involved determining the upstream limits of the storm sewer systems. No storm sewer outlets were identified upstream of the Carleton Place intake.

Calculations were done to determine the distance up the storm sewer to be included in the IPZ-2. Storm sewers where the sum of the ToT in the river and the ToT in the storm sewer are less than or equal to two hours are included, with the delineation being at the two hour ToT.

The IPZ-2 limits were extended to take into account the wind effects on the ToT in the river and main tributaries. In keeping with a conservative approach, only positive wind impacts were considered rather than wind drag. The parameters that were considered in the analysis of the wind-induced currents include;

- average wind conditions such as speed, direction, duration, and elevation; and
- the relationship between the wind velocity and surface currents (depth of influence and velocity profile).

The average wind-induced surface water velocity was combined with the average main channel flow velocity to determine the average water velocity over the depth of the water column.

The ToT within the sewers is not affected by the wind, but the ToT in the downstream river is reduced when the wind's influence is factored in. This results in the IPZ-2 two hour ToT extending further into the sewer systems than if wind is not a factor.

To complete the delineation, the outer boundaries of the zone, along the edges of the river, needed to be set. According to the Technical Rules, the outer boundary of the IPZ-2 on-land area along the river includes a setback of 120 m from the high water mark, or the generic regulation limits line (as developed and maintained by MVC and RVCA), whichever is greater.

Delineation of IPZ-3

IPZ-3

The IPZ-3 is an area where contaminants, if released, could be transported to the municipal surface water intake. For municipal surface water intakes located on inland rivers other than the Ottawa River, the standard approach is to buffer all rivers, streams, and lakes upstream of the intake by 120 m, or the Generic Regulation limit, whichever is greater.

Inclusion of Transport Pathways

The final step in the IPZ delineation process was to expand the preliminary IPZ-2 and IPZ-3 zones where transport pathways are present. Transport pathways are natural or anthropogenic features such as natural tributaries, roadways and ditches. The ToT up the transport pathways was determined by either a ToT formula or by the drainage divides. When the ToT formula was used, the distance up the transport pathways was calculated so the sum of the ToT in the river to the intake, and the ToT in the transport pathway, was equal to two hours.

Except for the specific areas noted below, the available data did not permit the inclusion of transport pathways in IPZ-3. The areas where transport pathways were included are as follows:

- mapped wetlands within the watershed that are contiguous to the IPZ-3 water courses along with a 120 m setback around the wetlands;
- IPZ-3 areas close to the intakes;
- Perth IPZ-2 transport pathway and storm sewer systems in the IPZ-3 for Smiths Falls (RVSPA); and
- draining network for the OMYA site in the IPZ-3 for Perth (RVSPA).

6.3.2 Vulnerability Scoring of Type C: Inland Rivers Intake Protection Zones

As presented in Section 6.1.4, the area Vulnerability Score is based on the following equation:

V = B x C,

Where;

V is the Vulnerability Score

B is the Area Vulnerability Factor

C is the Source Vulnerability Factor

The Technical Rules identify the possible IPZ Area Vulnerability Factor (B) values.

- **IPZ-1** is always 10
- **IPZ-2** may be 7, 8, or 9, same score throughout
- **IPZ-3** 1 to 9, must not be higher than IPZ-2, score varies but is always a whole number.

For Type C intake, the Source Vulnerability Factor (C), can be either 0.9 or 1. The Source Vulnerability Factor is the same for IPZ-1, IPZ-2 and IPZ-3.

The methodologies used to determine the Area Vulnerability Factor for IPZ-2 and IPZ-3 follow. This is followed by the methodology used to determine Source Vulnerability Factor.

Determination of Area Vulnerability Factor (B) for IPZ-2

At each of the three intakes, the Area Vulnerability Factor (B) for IPZ-2 was established based on a numerical approach involving a weighted combination of the factors in the Technical Rules requirements:

- **Percentage of area of IPZ-2 that is land***.* This factor reflects the assumption that as the percentage of land within an IPZ increases, the potential risk increases for a spill to occur that may impact water quality at the water intake.
- **The land cover, soil type, permeability of the land and the slope of the land*.*** This factor reflects the potential for overland water flow into the zone. Vegetation presence, as well as the type of vegetation, will affect the percentage of overland water flow which occurs and how much of the water infiltrates the ground. Permeable soils allow for increased infiltration. Slopes increase the percentage of overland flow compared to the amount of infiltration.
- **The hydrological and hydrogeological conditions where transport pathways are located***.* This factor reflects the extent of the transport pathways and sewer systems that may exist in the zone and their influence on water (and potential contaminant) movement from land to rivers which are the source of water intakes.

As discussed, according to the Technical Rules the Area Vulnerability Factor (B) may be a 7, 8 or 9. For each of the three factors shown above, circumstances were identified where, when combined and weighted, the Area Vulnerability Factor (B) would be set at the minimum value of 7. This also was done to identify circumstances where there would be the maximum value of 9. From that, a number of different circumstances were identified to quantify a range in the vulnerability experienced locally in the study region.

Using a scenario where the channel is relatively wide compared to the land setback for that location, it was estimated that the minimum percentage of IPZ-2 land area would be 10%. This was set as the assumed minimum value of 7. Then, scenarios were identified to determine an approximate maximum value which would represent an Area Vulnerability Factor ($B_{\%LA}$) of 9. This would occur in a situation such as where the channel would be relatively narrow compared to the amount of land included in the setback. The maximum percentage of IPZ-2 land area was then set as 90% which became the assumed maximum value.

Similarly, scenarios related to the land characteristics were used to determine the curve number (CN) (discussion follows in #2 of Determination of Area Vulnerability Factor for IPZ-3), and slope, both of which help determine runoff potential on the lands adjacent to the river ($B_{CN,Slope}$). From this, the minimum and maximum assumptions were determined for the curve number and slope.

Finally, scenarios on the extent or density of transport pathways were developed to determine the minimum and maximum numbers for the ratio of the total length of transport pathways over the length of the main channel in the IPZ-2 (B_{TP}).

All of these "assumptions" were reached by considering the physical characteristics of the waterway, the adjacent land, and transport pathways, combined with professional judgement.

Each of the three factors was then given an assumed weight, again based on consideration of the area and professional judgement, with the total weights summing to 100%. The assumed minimum and maximum Vulnerability Factor values for each of the three factors, as well as the assumed weighting factors used at each of the three water intakes, follows.

Three factors used for Area Vulnerability Factor (B)	**Symbol**	**Assumed Minimum Value (B = 7)**	**Assumed Maximum Value (B = 9)**	**Assumed Weighting**
Percentage of Area Composed of Land	$B_{\%LA}$	10 %	90%	30%
Runoff Potential based on land cover/soil type/permeability (CN) and slope	$B_{CN,Slope}$	CN =36, Slope = 0.25%	CN =95, Slope = 2%	30%

Three factors used for Area Vulnerability Factor (B)	Symbol	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Assumed Weighting
Transport Pathways (total length / main channel length)	B_{TP}	0	9	40%

Table 6-xi. Components of Area Vulnerability Factor and Assumed Weighting for Inland Rivers in the MRSPR.

In the final step, the actual or calculated value for each specific IPZ-2 was then converted, by interpolation, between the minimum and maximum values of the Area Vulnerability Factor (B) where B=7 and B=9. For example, an actual land area for IPZ-2 of 72% would result in a converted B value of $B_{\%LA}$=8.55.

Appendix 6-2 provides additional details on the Vulnerability Scoring methodology for the Type C: Inland Rivers Intake Protection Zones.

Determination of Area Vulnerability Factor (B) for IPZ-3

The Technical Rules require that the following be considered when determining Area Vulnerability Factors (B) within IPZ-3:

- percentage of the area IPZ-3 that is composed of land;
- land cover, soil type, permeability of the land and the slope of any setbacks;
- hydrological and hydrogeological conditions of the area where the transport pathway is located; and
- proximity of the area of the IPZ-3 to the intake.

The Technical Rules allow for more than one Area Vulnerability Factor (B) to be assigned within IPZ-3, based on differences in the characteristics noted above including distance from the intake. According to the Technical Rules, no Area Vulnerability Factor in IPZ-3 can be higher than the Area Vulnerability Factor assigned to IPZ-2.

Following discussions with MOE technical staff, the consultants and surface water municipalities it was decided that ToT would be the best way to define areas/sub-zones within the IPZ-3 that would receive different Area Vulnerability Factors. ToT is simply the time it takes for runoff to reach the municipal intake.

This means that proximity to the intake was the major consideration in determining Area Vulnerability Factors. In addition, determining ToT takes into account land cover, soil type, permeability of the land, slope and hydrological conditions of the area where the transport pathways are located – all of which are considerations listed above.

The ToT was determined for water flow both in-river and on-land, as follows:

In-River

ToT in the main channel was determined using:

- river velocities estimated by numerical models, and/or
- an event based approach as outlined in MOE guidance which uses existing flow records from the source river's flow gauges.

Choosing which method to use was determined by what models and/or data were available for each intake. Velocities of the 1:2 year return period flows were used for the calculations in the main river channel. Determining ToT this way takes into consideration the hydrological conditions of the main channel.

For Carleton Place, Perth, and Smiths Falls, because there was no numerical model of the inland rivers available, the ToT for up to 18 hours from the intake was determined by the event based approach. Data which was recorded at the Ferguson Falls and Appleton gauges was used, along with interpolation between the IPZ-2 upper boundary and the Ferguson Falls gauge. The interpolated distances were adjusted to account for variances in the channel width.

On-Land

ToT in the tributaries and transport pathways was determined using the following key steps:

1. **Delineation of Sub-Watersheds**

The watersheds within IPZ-3 were delineated into sub-watersheds using the ArcGIS Hydro data model (Arc Hydro) and the provincial 10 m DEM.

2. **Review of Sub-Watershed Delineation**

The derived sub-watersheds were then reviewed to ensure there was no conflict with other available data. The sub-watersheds which could not be delineated by the model were done manually using the existing data.

3. **Determination of Watershed Characteristics**

The primary inputs to the time of concentration formula discussed below are, slope, curve number (CN), and travel path length. The curve number is based on the area's hydrologic soil group and land use, and it reflects the propensity of an area to generating surface runoff. Using existing GIS datasets, slope and average CN values were calculated for each sub-watershed.

4. **Calculate Time of Travel in the Subwatersheds**

The time required for flow within the subwatershed tributaries to reach the subwatershed outlet was determined using a well known hydrologic equation called the SCS lag time of concentration formula. The time of concentration formula takes into consideration the subwatershed’s land cover, soil type and land surface permeability and tributary slope conditions.

5. **Calculate the Total Time of Travel to Intake**

To get the total ToT to the intake, the ToT for a watershed is added to the ToT in the river.

Assignment of Area Vulnerability Factors

Once ToT was determined in IPZ-3, Area Vulnerability Factors needed to be assigned. It was decided that all IPZ-3’s would have a starting Area Vulnerability Factor of 8 which was equal to or less than any of the IPZ-2 Area Vulnerability Factors. Choosing 8 as the starting value is in keeping with the trend set by MOE’s Technical Rules. The Technical Rules dictate an Area Vulnerability Factor of 10 for IPZ-1 and an Area Vulnerability Factor of 9, 8 or 7 for IPZ-2 (based on the local characteristics). The Rules therefore dictate a drop of at least one factor from IPZ-1 to IPZ-2 (10 to 9).

It was then decided that within IPZ-3, the Area Vulnerability Factor would drop by one every four hour ToT interval. Four hour intervals were chosen as double the protection of IPZ-2. The Technical Rules dictate that IPZ-2 must be a two hour ToT interval and this is viewed as a critical protection zone. As such it was decided to double this interval and apply it within IPZ-3 to determine where the Area Vulnerability Factor would be reduced by one (e.g. 2 hours to 6 hours would have a factor of 8; 6 hours to 10 hours would have a factor of 7, etc.).

The Area Vulnerability Factor becomes lower the farther away from the intake you get. It was decided that four would be the lowest Area Vulnerability Factor. This means that at the 18 hour ToT point, an Area Vulnerability Factor of four is assigned to the remaining IPZ-3.

Determination of Source Vulnerability Factor (C)

At each of the three inland river intakes, the Source Vulnerability Factor (C) was established based on a review of the following factors;

- the depth of the intake below the water surface (the deeper the intake, the lower the vulnerability);
- the distance of the intake from land (the further away from shore, the lower the vulnerability); and
- the number of recorded drinking water quality issues at the intake, if any, based on required water quality monitoring and a voluntary drinking water surveillance program.

The available information was considered adequate to assign the Source Vulnerability Factor (C) a score of 0.9 (lower vulnerability) or 1 (higher vulnerability).

6.3.3 Managed Lands and Livestock Density

The percentage of managed lands and nutrient units are indicators of the degree of agricultural activity and other land management activities. In some cases the storage and application of pesticides, fertilizers, and other agricultural materials associated with agricultural activities may result in pathogen and chemical contamination of drinking water sources.

MRSPR studies on managed lands and livestock density have been completed in accordance with the MOE Technical Guidance Bulletin entitled "Proposed Methodology for Calculating Percentage of Managed Land and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers" issued December 2009.

MOE lists a number of definitions for agricultural operations which fall under the Farm Unit. A summary of definitions follows and more information may be found at;
http://www.ene.gov.on.ca/en/water/cleanwater/cwdocs/tbmanagedLandsAndLivestock.pdf.

Key Definitions

1. **Managed lands** are lands to which fertilizers and/or nutrient units are, or may be, applied. Managed lands can be broken into two subsets: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed lands includes golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer).

2. **Nutrient Units** (NU) are used to measure how much manure an animal produces annually. MOE has categorized different types of livestock. It uses beef cattle as a base (conversion factor of 1 or NU=1) and compares the number of animals in other species which would be required to produce an equal annual amount of manure. From this, nutrient units for livestock of any category can be calculated.
3. **Livestock density** is defined as the number of nutrient units over a given area and is generally measured in nutrient units per hectare (NU/ha) or nutrient units per acre (NU/ac). The Technical Rules require NU/ac be used here.
4. A **farm unit** is the area where nutrients generated must be at least the size of the property deed, the generating facility, or all land receiving nutrients. It should include all facilities on other deeds owned by the same person if the nutrients generated there are used on the land of the first deed, and can consist of separate farm units if nutrients are applied to different land bases. The size of a farm unit depends on whether or not the unit generates nutrients. If the farm unit does not generate nutrients, it must be at least the size a single field where nutrients are applied.

The Province defined thresholds, as shown in the following table, based on the area of managed lands in a vulnerable area to determine the risk of over-application of nutrients causing contamination of drinking water sources.

Land Use	**Risk**
<40% of vulnerable area is managed lands	Low potential
40-80% of vulnerable area is managed lands	Moderate potential
>80% of vulnerable area is managed lands	High potential

Table 6-xii. Risk Thresholds.

MOE also defines thresholds based on livestock density in order to evaluate the risk of over-application of agriculturally sourced materials as shown in the previous table:

- if livestock density in the vulnerable area is less than 0.5 NU/acre, the area is considered to have a low potential for nutrient application exceeding crop requirements,
- if livestock density in the vulnerable areas is over 0.5 but less than 1.0 NU/acre, the area is considered to have a moderate potential for nutrient application exceeding crop requirements, and
- if livestock density in the vulnerable areas is over 1.0 NU/acre, the area is considered to have a high potential for nutrient application exceeding crop requirements.

Method used for Calculating Percentage of Managed Lands for IPZ-1 and IPZ-2

The areas of agricultural and non-agricultural lands were determined using land assessment and Municipal Property Assessment Corporation property classifications. The areas were confirmed through analysis of satellite imagery.

The percentage of managed lands within IPZ-1 and IPZ-2 was calculated by summing the total area of managed lands (both agricultural and non-agricultural) and dividing the result by the total land area.

Method used for Calculating Managed Lands for IPZ-3

The land area was determined using Landsat imagery of the study areas to identify vegetation types. Wooded areas were identified and removed from these calculations as, for the purpose of the study, it is assumed that these areas would not be used for grazing and nutrients would not be applied in these areas.

The percentage of managed lands within the IPZ-3 was calculated by summing the total area of managed lands (both agricultural and non-agricultural) and dividing the result by the total land area of the IPZ-3.

Method for Calculating Livestock Density

Livestock Density is measured in Nutrient Units per acre (NU/ac) to estimate the generation, storage and application of nutrients from agricultural source material (ASM) in an area. The NU represents amount of manure and biosolids used to fertilize a Farm Unit either produced by animals on the farm or brought from the outside. A farm unit is a single field, the land base that generates nutrients or the land base that receives nutrients.

The calculation of livestock density within the intake protection areas was based on the calculation of Nutrient Units per acre (NU/ac) of agricultural managed lands. Two values for livestock density were calculated. The first value is the Land Application of Nutrients, which represents the nutrient units applied to crops or turf, and was computed for IPZ-1, IPZ-2 and IPZ-3. The second value reported is for livestock density associated with grazing or pasturing, and was computed for IPZ-1 and IPZ-2. This value was calculated using the estimated number of livestock in each farm unit or pasture area. The following method describes the calculation of each of these values.

Method used for Calculating Livestock Density in IPZ-1 and IPZ-2

The following steps were used to determine Livestock Density in IPZ-1 and IPZ-2.

1. Determine the number of animals on a farm unit and estimate how many of each type of animals (e.g. poultry – broiler, cattle - cow, or swine - sows) are present. Estimates of the number of animals on a farm were carried out based on building design and size.
2. Convert the number of each type of animals to nutrient units using nutrient unit conversion tables supplied by MOE.
3. Determine the area of managed lands that are within the intake protection zone. For the purposes of estimating the NUs required for the estimation of livestock density in a farm unit, where a portion of a farm unit falls within a vulnerable area, the NUs generated on the entire parcel of land should be factored into the calculations rather than the NUs generated within the portion of land that falls within a vulnerable area.
4. Determine the area of land used for pasturing or grazing associated with each farm unit.
5. Calculate the livestock density for the application of nutrients to land by dividing the total number of nutrient units by the area of managed lands that are within a vulnerable area.
6. Calculate the livestock density for pasturing/grazing by dividing the total number of nutrient units by the area available for pasturing/grazing for each farm unit.

Method for Calculating Livestock Density in IPZ-3

The calculation of livestock density within IPZ-3 is based on the calculation of nutrient units per acre (NU/ac) of agricultural managed lands, as shown for IPZ-1 and IPZ-2.

Livestock density for the region was initially calculated in 2003 using 1996 Agriculture Canada data, which was the newest available at the time. The data areas were based on clusters of consolidated subdivision enumeration area boundaries. Twenty-two enumeration areas fell within the MRSPR.

In 2009, livestock density was again calculated for the region with the objective of updating information and determining whether livestock density in the MRSPR was changing. Data areas for the latter period were determined using Agriculture Canada's 2006 Soil Landscapes of Canada boundaries. Thirty-three soil landscape areas were identified in the MRSPR.

The two data bases were not identical so were adjusted to the same scale to facilitate comparison and provide the opportunity to determine whether there were changes in regional livestock density between 1996 and 2006.

6.3.4 Impervious Surfaces

Impervious surfaces are primarily constructed surfaces such as roads and parking lots that are covered by impenetrable materials such as asphalt, concrete and stone. These materials are a barrier to groundwater infiltration. Impervious surfaces also generate more runoff during melt or storm events.

Road salt applied to roads and walkways for winter maintenance may enter surface water or groundwater and is included in the list of Prescribed Drinking Water Threats, shown in Table 4-1. Impervious surface area calculations are required to determine if road salt application in the vulnerable areas could be a drinking water threat.

Method for Calculating the Percentage of Impervious Surfaces

The Southern Ontario Land Resource Information System (SOLRIS) was the primary data source used to identify impervious surfaces. SOLRIS is a landscape-level inventory of natural, rural, and urban areas. For the areas without SOLRIS coverage, a combination of the Ontario Road Network (ORN), Ministry of Natural Resources (MNR) built-up areas and some digitized areas were used (e.g. village boundaries).

Using GIS software, a 1000m x 1000m grid was created to cover the MRSPR. With permission from the MOE, the grid was then shifted so that one of the grid cell intersections overlapped the centroid (centre of mass) of the MRSPR. The use of one grid over the entire MRSPR was to eliminate grid overlap between the Mississippi and Rideau Source Protection Areas. The data sources listed above were then combined into one layer, impervious surfaces. For each grid cell, the amount of impervious surface area is divided by the area of the cell to determine the percentage of impervious surfaces. Appendix 5-1 provides information on the modifications.

6.4 Carleton Place Water Supply

The Mississippi River is 170 km in length, drains an area of approximately 3,750 km^2 and has an average annual flow rate of 40 m^3/s. Upstream of Carleton Place, the Mississippi River flows through a series of lakes (Crotch, Dalhousie, and Mississippi Lakes). It then flows past Carleton Place and Almonte, then turns north, where it flows into the Ottawa River. The Mississippi River is a regulated river, and seasonal operating ranges for reaches in the river are defined in the Mississippi River Water Management Plan.

The Carleton Place Water Treatment Plant (WTP) provides treated drinking water to the Town of Carleton Place for approximately 9,400 people each day. Figure 6-1a shows the town boundaries of Carleton Place and the location of the municipal surface water intake.

The Carleton Place WTP intake crib is located in the Mississippi River, approximately 48 m from shore and at 2.2 m below low flow water levels. Figure 6-1b is a map showing the local setting of the Carleton Place WTP and municipal surface water intake.

The natural water quality in the Mississippi River is characterized as having a high organic carbon content, which results in elevated colour levels. In general, the natural, or raw water exhibits relatively low turbidity levels (although elevated turbidity levels in the raw water have been measured on occasion). The natural water quality is generally soft, with hardness levels within the Ontario Drinking Water Standards, Objectives and Guidelines (ODWSOG) Operational Guideline range. Regular water quality testing is carried out by the Ontario Clean Water Agency, on behalf of the Town of Carleton Place, in both the untreated and treated water and the results are compared with the ODWSOG. *E. coli* and total coliforms are sometimes detected in the untreated source water samples at levels above the ODWSOG, which is typical for untreated surface water, and are removed during treatment. A review of available untreated water quality results indicates that turbidity, colour and Dissolved Organic Carbon (DOC) exceed the ODWSOG aesthetic objectives.

Water from the Mississippi River is treated at the WTP by first pretreating and screening to remove solids. It is then mixed with a coagulant which binds with remaining solids. The coagulant forms into sticky particles (called 'floc'), which attract and trap suspended particles before settling out of the water in large settling tanks. The 'floc' collects at the bottom of each settling tank, while the clear water flows into collection troughs at the top. The clear water is then filtered through layers of sand and anthracite and is disinfected. Fluoride is added as the last step before it is distributed. The treated water quality is consistently compliant with the Ontario Drinking Water Standards.

6.4.1 Delineation of the Carleton Place Intake Protection Zones

The steps undertaken to complete the IPZ delineation for Carleton Place are presented in Section 6.3.1. The results of the delineation process are discussed below.

Figure 6-1c shows the various components that make up Carleton Place's IPZ-1 and IPZ-2. These components include:

- the default IPZ-1 shape which is a semi-circle (200 m radius) upstream of the intake, plus a rectangle 400 m long and 10 m wide downstream of the intake;
- the in-river IPZ-2 limit, with and without the wind extension;
- the anthropogenic transport pathways, including a 120 m setback;
- a 120 m setback on watercourses; and
- the Mississippi Valley Conservation Generic Regulation Limit line.

As noted in Section 6.3.1, no storm sewer outlets were identified upstream of the Carleton Place intake.

Figure 6-1d shows the complete delineation for the Carleton Place IPZ-1 and IPZ-2. IPZ-1 covers an area of approximately 0.10 km^2, and IPZ-2 is approximately 3.9 km^2. Figure 6-1d also shows a portion of the Carleton Place IPZ-3 which is adjacent to IPZ-2. The full Carleton Place IPZ-3 is shown in Figure 6-1e. The IPZ-3 is approximately 1,551 km^2 and includes the 120 m on-land setbacks. The total area covered by IPZs for the Carleton Place municipal surface water intake is approximately 1,555 km^2.

Municipalities which are located within the Carleton Place IPZs are shown in Table 6-4.

Uncertainty

The level of uncertainly associated with the delineation of the Carleton Place Intake Protection Zones is as follows;

- IPZ-1 delineation is assigned a low uncertainty. Factors considered in the uncertainty analysis included: subjectivity of the criteria that define the extent of the zone; accuracy in the determination of the intake location; accuracy in the determination of the shoreline; and in-river verification of current conditions, with all factors having a low uncertainty;
- IPZ-2 delineation has a high uncertainty due to the limitations of the numerical model, mapping and field data, especially for transport pathways; and
- IPZ-3 delineation is assigned a high uncertainty due to the limited mapping and field data available, especially for transport pathways.

Further details regarding the uncertainty assessment are provided in Appendix 6-3.

6.4.2 Vulnerability Scoring – Carleton Place Intake Protection Zones

The approach used to complete the vulnerability scoring, including the Area Vulnerability Factor (B) and the Source Vulnerability Factor (C), for the Carleton Place IPZs is presented in Section 6.3.2. The specific vulnerability scoring inputs and results are discussed below.

Area Vulnerability Factor – IPZ-1

The IPZ-1 Area Vulnerability Factor for the Carleton Place intake is 10 as defined in the Technical Rules.

Area Vulnerability Factor – IPZ-2

The Area Vulnerability Factor for the IPZ-2 may range from 7 to 9. The following table summarizes the specific information, including assumed minimum and maximum values for Area Vulnerability Factor (B) that were used in the analysis to quantify each criteria. For more information on the assumed values, see Section 6.3.2.

Parameter	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Calculated value for Carleton Place IPZ-2 (based on local data)
Percentage of Area Composed of Land	10 %	90%	72%
Runoff Potential based on land cover/soil type/permeability (CN) and slope	CN =36, Slope = 0.25%	CN =95, Slope = 2%	CN =83, Slope = 1.42%
Transport Pathways (total length / main channel length)	0	9	14.86 km/2.12 km = 7.0

Table 6-xiii. Summary of Specific Information used to determine Carleton Place IPZ-2 A(B).

All three calculated values fall well into the higher half of the ranges between the assumed minimum values and the assumed maximum values. The final area vulnerability scoring falls in the higher half (above 8 which is the midpoint) of the predetermined 7-9 range for B and close to the ¾ point in the range. This is used as a general assessment of results to ensure validity.

The following table summarizes the derivation of the IPZ-2 Area Vulnerability Factor (B) for the Carleton Place IPZ-2. It includes the converted area vulnerability values between assumed minimum value (B=7) and assumed maximum value (B=9) for each of the three parameters, as well as the assumed weighting. The factor is then rounded to a whole number.

The final Area Vulnerability Factor for the Carleton Place IPZ-2 is 9

Parameter	**Calculated value for Carleton Place IPZ-2 (based on local data)**	**Converted B values for Carleton Place IPZ-2 between assumed minimum value (B=7) and assumed maximum value (B=9)**		
		$B_{\%LA}$	$B_{CN, Slope}$	B_{TP}
Percentage of Area Composed of Land	72%	8.55		
Runoff Potential based on land cover/soil type/permeability (CN) and slope	CN =83, Slope = 1.42%		8.88	
Transport Pathways (total length / main channel length)	14.86 km/2.12 km = 7.0			8.56
Assumed Weighting		30 %	30%	40%
Weighted Area Vulnerability Factor (B)	**8.65**			
Assigned Area Vulnerability Factor (B)	**9**			

Table 6-xiv. Summary of Scoring for Carleton Place IPZ-2 Area Vulnerability Factor (B).

Area Vulnerability Factor – IPZ-3

The Area Vulnerability Factors for the Carleton Place IPZ-3 sub-zones range from 8 (adjacent to IPZ-2) to 4. The following table shows the vulnerability factors as broken down into the four hour ToT increments. The methodology for determining the Area Vulnerability Factor for IPZ-3 can be found in Section 6.3.2.

Intake **Protection Zone** (TOT = Time of Travel)		***Area Vulnerability Factor (B) for Carleton Place***
IPZ-1		*10*
IPZ-2		*9*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	*8*
	Sub-zone 2 (6 to 10 hour TOT)	*7*
	Sub-zone 3 (10 to 14 hour TOT)	*6*
	Sub-zone 4 (14 to 18 hour TOT)	*5*
	Sub-zone 5 (>18 hour TOT)	*4*

Table 6-xv. Carleton Place IPZ-3 Area Vulnerability Factors.

Source Vulnerability Factor

As indicated in Section 6.1.4, the Source Vulnerability Factor for Type C intakes, can be either 0.9 or 1. Although there have been no reported water quality incidences and there are no hydraulic structures in close proximity upstream of the intake, the Source Vulnerability Factor was assessed to be 1 for Carleton Place due to the following:

- shallow depth of water intake, 2.2 m below surface at low water level; and
- moderate distance of the intake from shore, 48 m.

Final Vulnerability Scoring for Carleton Place Intake Protection Zones

As presented above, the Carleton Place Source Vulnerability Factor (C) was assessed to be 1. Thus, the final Vulnerability Scores (V) for each of the zones are the same as the Area Vulnerability Factors (B). Carleton Place's IPZ-1 has a final Vulnerability Score of 10; IPZ-2 has a score of 9. Figure 6-1f shows the final vulnerability scoring for IPZ-1 and IPZ-2 and the first part of IPZ-3 and Figure 6-1g shows the final vulnerability scoring for the full extent of all the IPZ's. Following are the summarized results.

	Area Vulnerability Factor (B) *Expressed as a whole number*			**Source Vulnerability Factor (C)**	***Vulnerability Score (V)*** *Expressed to one decimal point or as whole number depending on the value of C*		
Zone	**IPZ-1**	**IPZ-2**	**IPZ-3**		**IPZ-1**	**IPZ-2**	***IPZ-3***
Possible Values	*10*	*7 to 9*	*1 to 9*	*0.9 or 1*	*9 or 10*	*6.3 to 9*	*0.9 to 9*
Carleton Place Scores	***10***	***9***	***4 to 8***	***1***	***10***	***9***	***4 to 8***

Table 6-xvi. Summary of Carleton Place IPZ Vulnerability Scoring Results.

Uncertainty

The Technical Rules require uncertainty to be categorized as low or high. Uncertainty levels for vulnerability scoring of the Carleton Place IPZs are identified in the following discussion.

The Source Vulnerability Factor uncertainty is low for Carleton Place intake. The factors considered to determine this value were the intake locations and water quality records.

The Area Vulnerability Factor uncertainty is low for Carleton Place IPZ-1, and high for IPZ-2 and IPZ-3.

- Factors which were considered for IPZ-1 were the Technical Rules and the appropriateness of the IPZ-1 boundary;
- Factors considered for IPZ-2 were: slope; CN value; the length of transport pathways; and the length of the main channel in the IPZ-2; and

- Factors considered for IPZ-3 were: time of recorded peak flows, land use, soils, slope, channel information and ToT methods.

Final Uncertainty

The overall level of uncertainty is determined through combining the level of uncertainty for delineation, discussed in Section 6.4.1, and for vulnerability scoring, discussed above. Based on the level of uncertainty for the delineation and vulnerability scoring, the overall uncertainty ratings for Carleton Place IPZs are:

- IPZ-1 – Low uncertainty
- IPZ-2 – High uncertainty
- IPZ-3 – High uncertainty

Further details regarding the uncertainty assessment are provided in Appendix 6-2.

6.4.3 Managed Lands and Livestock Density – Carleton Place Intake Protection Zones

Percent managed land and livestock density calculations were carried out according to the methods outlined in Section 6.3.3. Figure 6-1h shows the managed lands and the livestock density in the IPZ's. The percent managed lands and average livestock densities for each zone are listed in Table 6-5. Also shown in the table is the risk threshold for the over application of nutrients to land and the risk threshold for the over application of ASM to land.

6.4.4 Impervious Surfaces – Carleton Place Intake Protection Zones

Impervious surfaces are primarily constructed surfaces such as roads and parking lots that are covered by impenetrable materials such as asphalt, concrete and stone. These materials are a barrier to groundwater infiltration. Impervious surfaces also generate more runoff during melt or storm events.

The method for calculating impervious surfaces is described in Section 6.3.4. Figure 6-1i shows the impervious surfaces for Carleton Place. In the Carleton Place IPZs the percentage of land which has impervious surfaces ranges from 0-75%.

6.4.5 Water Quality Threat Assessment – Carleton Place Intake Protection Zones

Water quality threats are existing conditions (e.g. contaminated sediment, soil or surface water) or existing or future land use activities that could contaminate a drinking water supply. A land use inventory was completed in 2008 for IPZ-1 and IPZ-2, and in 2010 for IPZ-3 areas that have a Vulnerability Score of 8.

It should be noted that a single land use activity can fall into multiple threat categories. For example, a crop farm may have fuel storage, may apply commercial fertilizer to land, and apply agricultural source material to land. Each of these activities is a separate threat category in the provincial table (see Section 4.3), and so therefore each is treated as a separate threat.

A land use activity and associated threats that occur where the Vulnerability Score is high may result in a determination that it is a significant threat. In many cases, the specific circumstances that apply to a threat category are unknown. Using the same example, a crop farm may have fuel storage, but the volume of fuel stored is unknown. Unless additional information was available, it was assumed that enough material was stored for that activity to be a significant threat.

A total of 20 potentially significant drinking water threats were identified in the Carleton Place IPZs. The list of identified potentially significant drinking water threats is provided in Table 6-6. The term “Poly” in the table refers to a polygon, or an area that may contain multiple threats. For example, a polygon may be a farm field, representing a single potential threat, or a residential area with an unknown number of septic systems, each which may be a potential threat. The term “Point” in the table refers to a point source. Figure 6-1j shows the areas containing potential significant threats in red, green and pink. The size of the area where significant threats may be present is approximately 7.9 km^2. See Section 4.4.3 for information on the full list of significant, moderate, and low threats.

Transportation Corridors

A number of transportation corridors, including major road arteries, exist within the Carleton Place IPZ. These corridors are not considered an activity under Clean Water Act definitions and, therefore, do not fall within the prescribed list of threats (see Section 4.3). However, there is potential for the transportation of dangerous and/or hazardous goods along these corridors and the potential for a spill to occur. Transportation corridors will be considered in the development of the Source Protection Plan to ensure the protection of groundwater sources from potential accidental spills. Transportation corridors (e.g. roads, railway lines) located within IPZ-1 and IPZ-2 can be seen in Figure 6-1d.

6.4.6 Issues and Conditions – Carleton Place Intake Protection Zones

As discussed in Chapter 4, issues are documented cases of water quality contamination approaching or exceeding acceptable provincial levels.

No issues were identified for the Carleton Place WTP. However, a number of parameters that exceed the Ontario Drinking Water Standards and Operational Guidelines are noted below. For the Mississippi River raw water, the following parameters exceed the Ontario Drinking Water Standards and Operational Guidelines:

- aesthetic objectives for turbidity, colour, and DOC; and
- health-related criteria for *E. coli* and total coliforms.

None of the above parameters are considered to be issues as they are known to be naturally occurring and do not represent a problem for the water treatment plant operator. The presence of *E. coli* and total coliforms is not unusual in surface water sources and they are easily removed during the treatment processes.

A condition is a situation where past activities resulted in a drinking water threat in accordance with the criteria found in the Technical Rules. Based on the criteria, there are no confirmed conditions in the Carleton Place IPZs. However, there were two spills noted in the Drinking Water Threats and Issues Technical Report.

6.5 Type C: Ottawa River Intake Protection Zones in the Mississippi-Rideau Source Protection Region

This section provides information on the two municipal surface water intakes in the Ottawa River which supply the City of Ottawa, Britannia and Lemieux Island. The intakes are both in the RVSPA, but the IPZs include the MVSPA.

6.5.1 Delineation of Type C: Ottawa River Intake Protection Zones

The following steps were undertaken to complete the intake protection zone delineation for the municipal intakes at Britannia and Lemieux Island.

Collection and assembly of data and information

Local hydrology and climate data was collected from federal, provincial, and municipal governments as well as other sources. This included the generic regulation limit lines for the study area, as maintained by the Rideau Valley and Mississippi Valley Conservation Authorities. Areas within the generic regulation limit identify lands that could be unsafe for development due to naturally occurring processes associated with flooding, erosion, dynamic beaches or unstable soil or bedrock.

The characteristics of the surface water intakes and surrounding land uses were determined through site visits, discussions with municipal staff, and review of available records and reports. In the summer of 2007, a hydrographic survey was conducted to map the riverbed topography from the Deschênes Rapids to the Chaudière Dam. Current measurements were also carried out to develop a better understanding of the river flow conditions around the intakes.

Delineation of IPZ-1

As discussed in Section 6.1.3, the IPZ-1 is directly adjacent to the surface water intake. The Technical Rules outline how to create IPZ-1. For Type C intakes, IPZ-1 can be created using a;

- one kilometre radius (centred on the intake) or
- 200 m radius (centered on the intake) upstream of intake, plus a rectangle 400 m long and ten m wide downstream of the intake.

The first method is more appropriate for intakes located in large surface water features such as lakes, where there is little or no flow. The second of the two methods listed above was selected for the Ottawa River municipal water intakes in the MRSPR because, unlike a lake, the river has a continuous downstream flow.

The Technical Rules also state that the dimensions of IPZ-1 may be modified to suite "local hydrodynamic conditions". For both the Britannia and Lemieux Island water intakes, IPZ-1 was modified from a semi-circle to a complete circle with a radius of 200 m. This was done to allow for the potential influence of winds on surface currents in the vicinity of the intakes; and the following other two reasons:

- the Britannia WPP is situated immediately downstream of the Deschenes Rapids in a region not representative of a typical intake structure in a river. The hydrodynamic conditions in this region are complex; the intake is located in close proximity to the rapids where the flow is turbulent, characterized by eddy currents. The intake also sits along the south side of the main river channel in close proximity to an embayment characterized by eddy currents.

- Although not related to river hydrodynamics, the other key component that was considered for the Lemieux Island WPP was the close proximity of a railway bridge (approximately 70m downriver) to the intake. The concern (and reasoning for making IPZ-1 a circle) is related to one of the fundamental assumptions regarding IPZ-1, that a spill within this zone would not dilute before impacting the intake. The train bridge is situated close enough to the intake that if a derailment occurred, this could potentially have a direct impact on the intake.

Where IPZ-1 intersected the shore, it was expanded to a setback of 120 m from the high water mark or the Conservation Authority generic regulation limit, whichever was greater.

Although the MRSPR does not extend across the provincial border, which essentially runs down the centre of the Ottawa River, slightly less than half of the Lemieux Island IPZ-1 falls in the Quebec side of the Ottawa River.

Development of computer models

A computer model was used to determine the flow rates upstream of the municipal water intake. The datasets collected were used to develop a general understanding of the local surface water system. Then, an appropriate surface water computer model was chosen to suit the conditions being modelled.

For both the Britannia and Lemieux Island intakes, the MIKE21 model was used to refine the river's bathymetry (the picture of the terrain of the river bed), and then another model, MISED, was used to delineate the in-river portion of IPZ-2. MISED is a three-dimensional numerical model that has the ability to handle the accelerated current speeds that occur in rapids. The MISED model was calibrated against measured current data collected in August 2007, and then utilized to determine the current patterns in the river and around the intakes.

Delineation of IPZ-2

As discussed in Section 6.1.3, the IPZ-2 was based, in part, on the distance upstream from the intake that represents how long a contaminant in the water takes to travel a minimum of two hours.

Under the provincial Technical Rules, the required ToT must be equal to or less than the time that is sufficient to allow operators to shut down the water treatment plant in the event of a spill. Since the Britannia and Lemieux Island plants both take less than 30 minutes to shut down after detection or notification, the ToT was set to the minimum 2 hour limit.

In-river

The MISED model defined the outer limits of IPZ-2 using the two hour ToT, as defined by the Technical Rules. The equivalent of the river's bankfull velocity was also required and this was represented by using the two year return period flow, which is considered to be representative of bankfull conditions.

The bankfull flow for the Ottawa River is 3,100 m^3/s. The outer limits of IPZ-2 were also extended to take into account wind effects on the ToT in the river. Additional modeling was carried out at low flow conditions to investigate the potential effluent discharged from a large area of stormwater catchments located to the south of the Lemieux intake. The results of the additional modeling helped define the limits of IPZ-2 south of the Lemieux Island intake.

On-land

For both Britannia and Lemieux Island, the inland portion of IPZ-2 is governed by storm sewer systems. To include the drainage areas of these systems, the distances inland were calculated using established hydraulic formulations based on flows through the sewer pipe network. It was assumed that all sewer pipes were flowing half-full. For nearby tributaries, the distance upstream was also calculated using an established hydrological formula.

According to the Technical Rules, the outer boundary of IPZ-2 is a setback of 120 m from the high water mark, or the generic regulation limits line (as developed and maintained by the RVCA), whichever is greater.

Québec and the Ottawa IPZ-2 Delineation

Although the MRSPR does not extend across the provincial border, which essentially runs down the centre of the Ottawa River, sufficient information was obtained from the Ville de Gatineau that permitted a preliminary assessment of the delineation of IPZ-2 into Quebec. The preliminary IPZ-2 shown for Quebec is for information purposes only.

Delineation of IPZ-3

For intakes located on the Ottawa River, the Technical Rules and the associated Technical Bulletin: Delineation of IPZ-3 using the Event Based Approach (MOE, 2009), prescribe an Event-Based Approach (EBA) for the delineation of IPZ-3. The EBA results in the delineation of an IPZ-3 which includes the areas beyond IPZ-1 and IPZ-2 that could contribute contaminants to the intake if a spill occurred during an extreme weather event.

The EBA allows for the use of one of three methods to delineate IPZ-3:

1. Contaminant Transport Approach;
2. Boundary Approach; or
3. A Combined Approach (Option 1 and 2).

The selection of an appropriate methodology depends on whether or not there are activities of concern upstream of the intakes. A review of existing activities upstream of the intakes did not identify any activities of concern. Thus, the Boundary Approach was used for the delineation of IPZ-3 for the Britannia and Lemieux Island intakes.

The Boundary Approach requires that a ToT be determined, based on the response of the system to flood events, with the assumption that any contaminant released within this ToT will reach the intake. The first step was therefore to determine the “extreme event”, and then to establish the farthest points within the watershed where a contaminant released during the “extreme event” could reach the intake. The “extreme event” for the Ottawa River watershed and key contributing tributaries, including the Mississippi and Carp river systems, were defined as a flow event that has a 100-year return period.

In the Technical Bulletin, an “extreme event” can be defined as wind storm event or 100 year flood event. Due to the size of the Ottawa Basin, a 100 year flood event is most likely to occur during spring freshet, when the snowpack in the Basin is melting and running off into watercourses, and is often combined with rain. Based on a review of available flow monitoring data for the Ottawa, Mississippi and Carp rivers, the most significant flows are associated with the spring freshet.

Duration of the high flows is also a factor and the duration of the mean freshet is significant for all three rivers. On the Ottawa River, the mean freshet has a duration of approximately 60 days, based on a lower threshold of 60% of the peak flow. Similarly, the Carp and Mississippi rivers have durations of approximately 28 days and 44 days, respectively, and the peak flows can be sustained over several days.

The maximum annual flows were used in the extreme value analysis in order to determine the 100 year event. The results showed that the Ottawa River has a projected 100-year return period freshet flow of 5300 m^3/s. On the Mississippi and Carp river systems, the 100 year flows were determined to be 264 m^3/s and 93 m^3/s, respectively.

Once the "extreme events" flows were determined, travel times were calculated, using 100-year storm flow data. There was insufficient information available to determine the ToT through the entire Mississippi watershed, which extends over 130 km inland from the Ottawa River, and contains numerous lakes and tributaries. Using numerical model (HEC-II) results and flow gauge data, travel times for the 100 year freshet event were estimated for the Mississippi River up to Ferguson Falls, a distance inland of approximately 67.5 km. A similar analysis was undertaken for the Carp River using HEC-II model results. The purpose of this analysis was to determine if it is reasonable to delineate IPZ-3 as the section of the watershed extending to the boundary of the source protection region.

The ToT from Lemieux Island intake to the upstream extent of the Carp watershed is approximately two days, and the travel time from Lemieux Island intake to Ferguson Falls on the Mississippi River is approximately 3.8 days. Ferguson Falls is situated approximately halfway up the Mississippi watershed. The river and tributary channels continue upstream from Ferguson Falls for approximately 30 km before reaching other lakes where current velocities would tend to decrease. While data limitations precluded analysis beyond Ferguson Falls, the conveyance through this 30 km section would most likely result in relatively fast ToT upstream.

The overall conclusion from this analysis was that the ToT up the Ottawa, Carp and Mississippi River systems is likely less than the duration of flows in an extreme flood event, which would likely occur during spring freshet and therefore have a significant duration, and that it is reasonable that IPZ-3 be delineated to the limits of the Mississippi-Rideau Source Protection Region. In order to complete the IPZ-3 delineation, a setback of 120 m was applied to all water bodies.

Inclusion of Transport Pathways

The final step in the IPZ delineation process was to expand the preliminary IPZ-2 and IPZ-3 zones where transport pathways are present. Transport pathways are natural or anthropogenic features such as natural tributaries, roadways and ditches. The ToT up the transport pathways was determined by either a ToT formula. The distance up the transport pathways was calculated so the sum of the ToT in the river and the ToT in the transport pathway was equal to two hours.

Except for the known municipal storm sewer networks, the available data did not permit the inclusion of transport pathways in IPZ-3.

6.5.2 Vulnerability Scoring of Type C: Ottawa River Intake Protection Zones

As presented in Section 6.1.4, the Vulnerability Score is based on the following equation:

V = B x C, where:

V is the Vulnerability Score

B is the Area Vulnerability Factor

C is the Source Vulnerability Factor

The Technical Rules identify the possible IPZ area Vulnerability Score (B) values.

- **IPZ-1** is always 10;
- **IPZ-2** may be 7, 8, or 9, same score throughout; and
- **IPZ-3** 1 to 9, must not be higher than IPZ-2, score varies.

For a Type C intake, the Source Vulnerability Factor, C can be either 0.9 or 1. The Source Vulnerability Factor is the same for IPZ-1, IPZ-2 and IPZ-3.

The methodologies used to determine B for IPZ-2 and IPZ-3 are presented below. This is followed by the methodology used to determine C.

Determination of Area Vulnerability Factor (B) for IPZ-2

Similar to the three inland intakes, at each of the Ottawa River intakes the Area Vulnerability Factor (B) for IPZ-2 was established based on a numerical approach involving a weighted combination of the factors required to be considered in the Technical Rules:

- Percentage of area of IPZ-2 that is land. This factor reflects the assumption that as the percentage of land within an IPZ increases, the potential risk increases for a spill to occur that may impact water quality at the water intake.
- The land cover, soil type, permeability of the land and the slope of the land. This factor reflects the potential for overland water flow into the zone. Vegetation presence, as well as the type of vegetation, will affect the percentage of overland water flow which occurs and how much of the water infiltrates the ground. Permeable soils allow for increased infiltration. Slopes increase the percentage of overland flow compared to the amount of infiltration.
- The hydrological and hydrogeological conditions where transport pathways are located. This factor reflects the extent of the transport pathways and sewer systems that may exist in the zone and their influence on water (and potential contaminant) movement from land to rivers which are the source of water intakes.

The following four parameters were developed to account for the three factors listed previously:

- Percentage of area composed of land;
- Type of land use;
- % imperviousness of the land; and
- Extent of transport pathways.

Four parameters used for Area Vulnerability Factor (B)	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Assumed Weighting
Percentage of Area Composed of Land	10 %	90%	33.3%
Type of Land Use	- Natural land cover was scored as 7 - Agricultural, open space was scored as 8 - Mainly developed land was scored as 9		16.65%
% Imperviousness of the Land	0%	80%	16.65%
Extent of Transport Pathways	Transport pathways were classified on the basis of the percentage of the preliminary IPZ-2 land area that is drained by storm sewer systems. - <10% of the land area was scored as 7 - 10 to 50% of the land area was scored as 8 - >50% of the land area was scored as 9		33.3%

Table 6-xvii. Determination of Area Vulnerability Factor for Ottawa River Municipal Surface Water Intakes.

Appendix 6-4 provides additional details in the vulnerability scoring methodology for Type C: Ottawa River Intake Protection Zones. The preliminary IPZ-2 for Quebec was not taken into account for the IPZ-2 Area Vulnerability Factor calculations.

Determination of Area Vulnerability Factor (B) for IPZ-3

The Technical Rules require that the following be considered when determining Area Vulnerability Factors (B) within IPZ-3:

- percentage of the area IPZ-3 that is composed of land;
- land cover, soil type, permeability of the land and the slope of any setbacks;
- hydrological and hydrogeological conditions of the area where the transport pathway is located; and
- proximity of the area of the IPZ-3 to the intake.

The Technical Rules allow for more than one Area Vulnerability Factor (B) to be assigned within IPZ-3, based on differences in the characteristics noted above including distance from the intake. According to the Technical Rules, no Area Vulnerability Factor in IPZ-3 can be higher than the Area Vulnerability Factor assigned to IPZ-2.

Following discussions with MOE technical staff, the consultants and surface water municipalities it was decided that ToT would be the best way to define areas/sub-zones within the IPZ-3 that would receive different Area Vulnerability Factors. ToT is simply the time it takes for runoff to reach the municipal intake. This means that proximity to the intake was the major consideration in determining Area Vulnerability Factors. However, determining ToT takes into account land cover, soil type, permeability of the land, slope of any setbacks and hydrological conditions of the area where the transport pathways are located – all of which are considerations listed above.

The ToT was determined for water flow both in-river and on-land, as follows;

In-River

ToT in the main channel was determined using:

- river velocities estimated by numerical models, and/or
- an event based approach as outlined in MOE guidance which uses existing flow records from the source river’s flow gauges.

Choosing which method to use was determined by what models and/or data were available for each intake. Velocities of the 1:2 year return period flows were used for the calculations in the main river channel. Determining ToT this way takes into consideration the hydrological conditions of the main channel. The specific methods used for the Ottawa River intakes are as follows:

- Travel times on the Ottawa, Mississippi and Carp river systems were determined for the 2 year river flow condition up to the 48 hour mark.
- On the Ottawa River, travel times were extrapolated from the three-dimensional model results.
- For the Mississippi and Carp rivers, travel time estimates were determined from HEC-II model results that were provided by the Mississippi Valley Conservation Authority.

On-Land

ToT in the tributaries and transport pathways were determined using the following key steps:

1. Delineation of Sub-Watersheds

The watersheds within IPZ-3 were delineated into sub-watersheds using the ArcGIS Hydro data model (Arc Hydro) and the provincial 10 m DEM.

2. Review of Sub-Watershed Delineation

The derived sub-watersheds were then reviewed to ensure there was no conflict with other available data. The sub-watersheds which could not be delineated by the model were done manually using the existing data.

3. Determination of Watershed Characteristics

The primary inputs to the time of concentration formula are, slope, curve number (CN), and watershed flow length. The curve number is based on the area's hydrologic soil group and land use, and it reflects the propensity of an area to generating surface runoff. Using existing GIS datasets, average slope and CN values were calculated for each sub-watershed. The length is defined as the longest hydraulic path in the watershed, and this distance was calculated during the delineation of the sub-watersheds.

4. Calculate Time of Travel for each Subwatershed

The time of concentration in the sub-watersheds was determined by one of two calculations. For ‘headwater’ sub-watersheds (those that had no channel flowing in from upstream), the SCS lag formula presented in the *EBA Technical Bulletin*

(MOE, 2009) was used. For channelized subwatershed, the Manning equation was used to determine flow velocities.

5. **Calculate Total Time of Travel to Intake**

To get the total ToT to the intake, the travel time for a watershed is added to the travel time in the river.

Assignment of Area Vulnerability Factors

Once ToT was determined in IPZ-3, Area Vulnerability Factors needed to be assigned. It was decided that all IPZ-3's would have a starting Area Vulnerability Factor of 8 which was equal to or less than any of the IPZ- 2 Area Vulnerability Factors. Choosing 8 as the starting value is in keeping with the trend set by MOE's Technical Rules. The Technical Rules dictate an Area Vulnerability Factor of 10 for IPZ-1 and an Area Vulnerability Factor of 9, 8 or 7 for IPZ-2 (based on the local characteristics). The Rules therefore dictate a drop of at least one factor from IPZ-1 to IPZ-2 (10 to 9).

It was then decided that within IPZ-3, the Area Vulnerability Factor would drop by one every four hour ToT interval. Four hour intervals were chosen as double the protection of IPZ-2. The Technical Rules dictate that IPZ-2 must be a two hour ToT interval and this is viewed as a critical protection zone. As such it was decided to double this interval and apply it within IPZ-3 to determine where the Area Vulnerability Factor would be reduced by one (e.g. 2 hours to 6 hours would have a factor of 8; 6 hours to 10 hours would have a factor of 7, etc.).

The Area Vulnerability Factor becomes lower the farther away from the intake you get. It was decided that four would be the lowest Area Vulnerability Factor. This means that at the 18 hour ToT point, an Area Vulnerability Factor of four is assigned to the remaining IPZ-3.

Determination of Source Vulnerability Factor (C)

At each of the Ottawa River intakes, the Source Vulnerability Factor (C) was established based on a numerical approach involving a weighted combination of the following factors:

- the depth of the intake below the water surface (the deeper the intake, the lower the vulnerability);
- the distance of the intake from land (the further away from shore, the lower the vulnerability); and

- the number of recorded drinking water quality issues at the intake, if any, based on required water quality monitoring and a voluntary drinking water surveillance program.

Each factor was assigned an equal weighting. The following assumptions were made in order to quantify the range of possible intake designs that might be encountered in practice.

Low Vulnerability

A deep water intake represents a low vulnerability scenario. Based on the provincial boundary line and the bathymetric features of the river within the study domain, an intake representing the lowest bracket of vulnerability would be located in water depths of less than 15 m, and up to 1,000 m offshore.

High Vulnerability

An example of a high vulnerability within the Source Protection Region might be a shallow intake located adjacent or close to the shore in a small river. Such an intake might have a depth of 2 m.

Factors used for Source Vulnerability Factor (C)	Assumed Minimum Value (C = 0.9)	Assumed Maximum Value (C = 1)	Assumed Weighting
Depth of Intake	15 metres	2 metres	33.3%
Distance of the Intake from land	1,000 metres	0 metres	33.3%
Historical Water Quality Issues	A value of 0.9 was assumed if there were no water quality concerns at Intake	A value of 1 was assumed if persistent or chronic water quality concerns were present at Intake	33.3%

Table 6-xviii. Source Vulnerability Weighting for Ottawa River Surface Water Intakes.

The assumed minimum and maximum Source Vulnerability Factor (C) values for each of the three factors as well as the assumed weighting factors used at each of the three intakes is presented below. The Technical Rules do not specify how weighting is to be determined so weighting was distributed equally for the Ottawa River municipal surface water intakes.

Source Vulnerability (C) Determination

The actual or calculated value for each of the factors (e.g., depth of intake = 7 ms) was converted between the minimum and maximum allowable values of C=0.9 and C=1. Results for the Britannia municipal surface water intake are shown in Section 6.6.2 and for the Lemieux Island municipal surface water intake in Section 6.7.2.

6.6 Ottawa Water Supply – Britannia

The Ottawa River is 1,130 km in length, drains an area of approximately 146,000 km^2 in both Ontario (35%) and Quebec (65%), and has an average annual flow rate of 1,200 m^3/s (near Britannia). The river originates northwest of Ottawa east of the Dozois Reservoir in Quebec. It then flows west into Lake Timiskaming and southeast before it discharges into the St. Lawrence River west of Montreal, Quebec. Over most of its length, the river forms the inter-provincial boundary between Ontario and Quebec.

The Britannia WTP is one of two water treatment plants in the City of Ottawa, Ontario on the Ottawa River. The Britannia and Lemieux Island WTPs provide treated drinking water to the City of Ottawa for approximately 814,000 people each day. The Britannia municipal surface water intake is located approximately 300 m from shore and seven m below the water surface in the Ottawa River. Figure 6-2a shows the location of the municipal surface water intake.

As shown on Figure 6-2b, the Britannia WTP is situated along a section of the river that extends from the Chaudière Dam upstream to Lac Deschênes. This segment of the river is unique and hydraulically complex due to the presence of several sets of rapids, a number of islands, and the Chaudière Dam. These physical features make this section of the river non-navigable for most watercraft, although canoes and kayaks are often seen in this reach. Large cribs made of wood and rock are remnants of the logging industry and were used to anchor large log booms. These permanent mooring stations are scattered throughout this part of the river, some sitting only inches below the water surface making navigation very hazardous, even for small boats.

The natural water quality in the Ottawa River is characterized as soft water with a low alkalinity. Regular water quality testing is carried out by the City of Ottawa in both the untreated and treated water and the results are compared with the Ontario Drinking Water Standards (ODWS). Hardness is below the ODWS – Operational Guidelines range. *E. coli* is present in some of the untreated source water samples, which is common for surface water, and can be removed during treatment. A review of available untreated water quality results indicates that turbidity, colour and DOC exceed the ODWS aesthetic objectives and alkalinity also exceeds the ODWS – operational guidelines.

Raw water from the Ottawa River is treated at the Britannia WTP by screening the water at the intake to remove larger debris and then mixing the water with a coagulant which binds with suspended particles within the water. The coagulant forms into sticky particles (called 'floc'), which attract and trap suspended particles before settling at the bottom of large settling tanks. The clear water from the top of the tank is then filtered through layers of anthracite, sand, and gravel. The filtered water is then disinfected, sodium hydroxide is added to adjust for pH (as well as to help reduce pipe corrosion), and fluoride is added before the water is ready for distribution. The treated water quality is consistently compliant with the Ontario Drinking Water Standards.

A tritium spill into the Ottawa River at the Chalk River nuclear laboratory in 1988 reached the City of Ottawa in approximately 16 days. Peak concentrations in the water were approximately 420 Bq/L which was below the ODWS maximum acceptable concentration of 7000 Bq/L. However, the allowable levels are currently being reviewed by the Ontario Drinking Water Advisory Council. It is possible that the allowable levels will be significantly reduced in the future. If a similar spill should occur, the peak concentrations in the water could be above the new standard. The City of Ottawa has indicated that untreated water is tested at least weekly for tritium and concentrations are usually below the laboratory detection limit of 5.0 Bq/L.

6.6.1 Delineation of Britannia Intake Protection Zones

The steps undertaken to complete the intake protection zone delineation for Britannia are presented in Section 6.5.1. The results of the delineation process are discussed below.

Figure 6-2c shows the various components that make up Britannia's IPZ-1 and IPZ-2. The components include:

- the default IPZ-1 shape which is a semi-circle (200 m radius) upstream of the intake, plus a rectangle 400 m long and 10 m wide downstream of the intake;
- the in-river IPZ-2 limit based on reverse particle tracking;

- the anthropogenic transport pathways (storm sewersheds) including a 120 m setback; and
- the Mississippi Valley/Rideau Valley Conservation Generic Regulation Limit line.

Figure 6-2d shows the complete delineation for the Britannia IPZ-1 and IPZ-2. IPZ-1 is approximately 0.13 km^2, and IPZ-2 is approximately 31.3 km^2. Figure 6-4e shows the Britannia IPZ-1 and IPZ-2, including the Quebec side of the Ottawa River. The first part of the Britannia IPZ-3, closest to the intake, within the MRSPR is shown in Figure 6-2f and the full extent of the Britannia IPZ-3 is shown on Figure 6-2g. The total area of the IPZ-3 within the MRSPR is 2,603 $km^{2.}$ The total area covered by IPZs for the Britannia municipal surface water intake is approximately 2,634 km^2. Figure 6-2h illustrates the location of the AECL Chalk River nuclear facility, approximately 180 km upstream of the Ottawa intakes.

Municipalities which are located within the Britannia IPZs are shown in Table 6-4.

Uncertainty

The level of uncertainly associated with the delineation of the Britannia IPZs is summarized below.

- Within the provincial regulation limits, the IPZ-1 and IPZ-2 delineation has been assigned a low uncertainty. Preliminary information was made available for the IPZ-2 delineation in Quebec but detailed work has not been completed.
- The IPZ-3 delineation, limited to Ontario, is assigned a high uncertainty due to the lack of information/data available to accurately determine the ToT through the entire Mississippi watershed.

Further details regarding the uncertainty assessment are provided in Appendix 6-5.

6.6.2 Vulnerability Scoring – Britannia Intake Protection Zones

The approach used to complete the vulnerability scoring, including the Area Vulnerability Factor (B) and the Source Vulnerability Factor (C), for the Britannia intake protection zones is presented in Section 6.7.2. The specific vulnerability scoring inputs and results are discussed below.

Area Vulnerability Factor – IPZ-1

The IPZ-1 Area Vulnerability Factor for the Britannia intake is 10 as predetermined by the Technical Rules.

Area Vulnerability Factor – IPZ-2

The Area Vulnerability Factor for IPZ-2 ranges from 7 to 9.

The following table summarizes the specific information, including assumed minimum and maximum values for Area Vulnerability Factor (B) that were used in the analysis to quantify each criterion.

Parameters used for Area Vulnerability Factor (B)	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Calculated Value for Britannia IPZ-2 (based on local data)
Percentage of Area Composed of Land	10 %	90%	73%
Type of Land Use	- Natural land cover was scored as 7 - Agricultural, open space was scored as 8 - Mainly developed land was scored as 9		Developed =9
% Imperviousness of the Land	0%	80%	34%
Extent of Transport Pathways	Transport pathways were classified on the basis of the percentage of the IPZ-2 land area that is drained by storm sewer systems. - <10% of the land area was scored as 7 - 10 to 50% of the land area was scored as 8 - >50% of the land area was scored as 9		>50%

Table 6-xix. Summary of Specific Information used to determine Britannia IPZ-2 Area Vulnerability Factor (B).

The estimated minimum and maximum values for percentage of area composed of land is discussed in Section 6.3.2 and found under assumed minimum and maximum values, while the measured values for Britannia are shown in the last column of the previous table. Similarly, the estimated range of minimum and maximum percentage of Imperviousness of the Land is found in the assumed minimum and maximum value columns, with the calculated value in the last column.

Parameter	**Calculated value for Britannia IPZ 2 (based on local data)**	*Converted B values for Britannia IPZ-2 between assumed minimum value (B=7) and assumed maximum value (B=9)*			
		$B_{\%LA}$	B_{land}	B_{Imp}	B_{TP}
Percentage Land Area ($B_{\%LA}$)	73%	8.6			
Type of Land Use (B_{land})	Developed		9.0		
% Imperviousness (B_{imp})	34%			7.9	
Percentage of Land Area Drained by Storm Sewer (B_{TP})	>50%				*9.0*
Assumed Weighting Factor		1/3	1/6	1/6	*1/3*

Parameter	Calculated value for Britannia IPZ 2 (based on local data)	*Converted B values for Britannia IPZ-2 between assumed minimum value (B=7) and assumed maximum value (B=9)*			
		$B_{\%LA}$	B_{land}	B_{Imp}	B_{TP}
Weighted Factor	***8.66***				
Selected Area Factor	***9***				

Table 6-xx. Summary of Scoring for Britannia IPZ-2 Area Vulnerability Factor (B).

The table summarizes the derivation of the IPZ-2 Area Vulnerability Factor (B) for the Britannia IPZ-2. It includes the converted area vulnerability values between assumed minimum value (B=7) and assumed maximum value (B=9) for each of the four parameters, as well as the assumed weighting. The final Area Vulnerability Factor for the Britannia IPZ-2 is 9.

Area Vulnerability Factor – IPZ-3

The Area Vulnerability Factors for IPZ-3 sub-zones range from 8 (adjacent to IPZ-2) to 4. The methodology for determining the Area Vulnerability Factor for IPZ-3 can be found in Section 6.3.2.

Intake Protection Zone **(TOT = Time of Travel)**		***Area Vulnerability Factor (B) for Britannia***
IPZ-1		*10*
IPZ-2		*9*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	*8*

Intake Protection Zone (TOT = Time of Travel)		***Area Vulnerability Factor (B) for Britannia***
	Sub-zone 2 (6 to 10 hour TOT)	*7*
	Sub-zone 3 (10 to 14 hour TOT)	*6*
	Sub-zone 4 (14 to 18 hour TOT)	*5*
	Sub-zone 5 (>18 hour TOT)	*4*

Table 6-xxi. Britannia IPZ-3 Area Vulnerability Factors.

Source Vulnerability Factor

The approach used to complete the Source Vulnerability Factor for the Britannia intake protection zones is presented in Section 6.5.2. The specific vulnerability scoring inputs and results are discussed below.

The table below summarizes the specific information, including assumed minimum and maximum values for Area Vulnerability Factor (B) that were used in the analysis to quantify each criteria.

Three Factors used for Source Vulnerability Factor (C)	Assumed Minimum Value (C = 0.9)	Assumed Maximum Value (C = 1)	Calculated value for Britannia (based on local data)
Depth of Intake (C_{depth})	15 metres	2 metres	7 metres

Three Factors used for Source Vulnerability Factor (C)	**Assumed Minimum Value (C = 0.9)**	**Assumed Maximum Value (C = 1)**	**Calculated value for Britannia (based on local data)**
Distance of the Intake from land ($\mathbf{C}_{Dist}$)	1,000 metres	0 metres	300 metres
Historical Water Quality Issues ($\mathbf{C}_{DWI}$)	A value of 0.9 was assumed if there were no water quality concerns at Intake	A value of 1 was assumed if persistent or chronic water quality concerns were present at Intake	none

Table 6-xxii. Summary of Specific Information used to determine Britannia Source Vulnerability Factor (C).

The following table summarizes the derivation of the Britannia Source Vulnerability Factor (C). It includes the converted source vulnerability values between assumed minimum value (C=0.9) and assumed maximum value (C=1) for each of the three parameters, as well as the assumed weighting. The final Source Vulnerability Factor for the Britannia intakes is 0.9.

Parameter	**Calculated value for Britannia (based on local data)**	*Converted B values for Britannia between assumed minimum value (C=0.9) and assumed maximum value (C=1)*		
		(C_{depth})	(C_{Dist})	(C_{DWI})
Depth of Intake ($\mathbf{C}_{depth}$)	7 metres	0.96		
Distance of the Intake	300 metres		0.97	

Parameter	**Calculated value for Britannia (based on local data)**	*Converted B values for Britannia between assumed minimum value (C=0.9) and assumed maximum value (C=1)*		
		(C_{depth})	(C_{Dist})	*(C_{DWI})*
from land (**C**$_{Dist}$)				
Historical Water Quality Issues (**C**$_{DWI}$)	none			*0.9*
Assumed Weighting Factor		1/3	1/3	*1/3*
Weighted Factor	***0.943***			
Selected Source Factor	***0.9***			

Table 6-xxiii. Summary of Scoring for Britannia Source Vulnerability Factor (C).

Final Vulnerability Scoring for Britannia IPZs

As presented above, the Britannia Source Vulnerability Factor (C) was assessed to be 0.9. Thus, the final Vulnerability Scores (V) for each of the zones is less than the Area Vulnerability Factors (B).

As shown in the following table, Britannia's IPZ-1 has a final Vulnerability Score of 9 and IPZ-2 a score of 8.1. The IPZ-3 final Vulnerability Scores range from 7.2 to 3.6.

Intake Protection Zone **(TOT = Time of Travel)**		**Area Vulnerability Factor (B) for Britannia**	***Final Vulnerability Score (V) for Britannia***
IPZ-1		10	*9*
IPZ-2		9	*8.1*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	8	*7.2*
	Sub-zone 2 (6 to 10 hour TOT)	7	*6.3*
	Sub-zone 3 (10 to 14 hour TOT)	6	*5.4*
	Sub-zone 4 (14 to 18 hour TOT)	5	*4.5*
	Sub-zone 5 *(>18 hour TOT)*	*4*	*3.6*

Table 6-xxiv. Britannia IPZ Vulnerability Scoring.

Figure 6-2i shows the final vulnerability scoring for IPZ-1 and IPZ-2 and the first part of the Britannia IPZ-3 and Figure 6-2j shows the final vulnerability scoring for the full extent of all the Britannia IPZ's. The final Vulnerability Scores are also summarized below.

	Area Vulnerability Factor (B) *Expressed as a whole number*			**Source Vulnerability Factor (C)**	***Vulnerability Score (V)*** *Expressed to one decimal point or as whole number depending on the value of C*		
Zone	IPZ-1	IPZ-2	IPZ-3		IPZ-1	IPZ-2	*IPZ-3*
Possible Values	*10*	*7 to 9*	*1 to 9*	*0.9 or 1*	*9 or 10*	*6.3 to 9*	*0.9 to 9*
Britannia Scores	*10*	*9*	*4 to 8*	*0.9*	*9*	*8.1*	*3.6 to 7.2*

Table 6-xxv. Summary of Britannia IPZ Vulnerability Scoring Results.

Uncertainty

The Technical Rules require uncertainty to be categorized as low or high. Uncertainty levels for vulnerability scoring of the Britannia IPZs are identified in the following discussion.

The Source Vulnerability Factor uncertainty is low for Britannia intake. The Area Vulnerability Factor uncertainty is low for Britannia IPZ-1 and IPZ-2, and high for IPZ-3. Factors which were considered in the uncertainly analysis were the good physical characteristics of the intake, the good water quality data and the overall lack of good watershed data used in the IPZ-3 vulnerability scoring approach. It is noted that no vulnerability scoring was completed on the Quebec side of the Ottawa River.

Final Uncertainty

The overall level of uncertainty is determined through combining the level of uncertainty for delineation scoring, discussed in Section 6.6.1, and for vulnerability scoring, discussed above. Based on the level of uncertainty for the delineation and vulnerability scoring, the overall uncertainty ratings for Britannia IPZs are:

- IPZ-1 – Low uncertainty
- IPZ-2 – Low uncertainty
- IPZ-3 – High uncertainty

Further details regarding the uncertainty assessment are provided in Appendix 6-4.

6.6.3 Managed Lands and Livestock Density – Britannia Intake Protection Zones

Percent managed land and livestock density calculations were carried out according to the methods outlined in Section 6.3.3. Figure 6-2k shows the managed lands and the livestock density in the IPZ's. The percent managed lands and average livestock densities for each zone are listed in Table 6-7. Also shown in the table is the risk threshold for the over application of nutrients to land and the risk threshold for the over application of ASM to land.

6.6.4 Impervious Surfaces – Britannia Intake Protection Zones

The method for calculating impervious surfaces is described in Section 6.3.4. Figure 6-2l shows the impervious surfaces within the Britannia IPZs. The percentage of impervious surfaces within the Britannia IPZs range from 0-98.3%.

6.6.5 Water Quality Threat Assessment – Britannia Intake Protection Zones

Water quality threats are existing conditions (e.g. contaminated sediment, soil or surface water) or existing or future land use activities that could contaminate a drinking water supply. A land use inventory was completed in 2010 within the MRSPR IPZs but not in Quebec.

It should be noted that a single land use activity could fall into multiple threat categories. For example, a crop farm may have storage of fuel, may apply commercial fertilizer to land, and apply agricultural source material to land. Each of these activities is a separate threat category in the provincial table, and so each is therefore a separate threat.

A land use activity and associated threats that occur where the Vulnerability Score is high may result in determining it to be a significant threat. In many cases, the specific circumstances that apply to a threat category are unknown. Using the same example, a crop farm may have fuel storage, but the volume of fuel stored is unknown. Unless additional information was available, it was assumed that enough material was stored for that activity to be a significant threat.

A total of six potentially significant drinking water threats, areas where the Vulnerability Score is 8 or greater, were identified in the Britannia IPZ-1 and IPZ-2. The list of identified potential significant drinking water threats is provided in

Table 6-8. The term “Poly” in the table refers to a polygon, or an area that may contain multiple threats. For example, a polygon may be a farm field, representing a single potential threat, or a residential area with an unknown number of septic systems, each which may be a potential threat. The term “Point” in the table refers to a point source. Figure 6-2m shows the areas containing potential significant threats in red and green. The size of the area where significant threats may be present is approximately 31.5 km^2. See Section 4.4.3 for information on the full list of significant, moderate, and low threats.

Transportation Corridors

A number of transportation corridors, including major road arteries, exist within the Britannia IPZ. These corridors are not considered an activity under Clean Water Act definitions and, therefore, do not fall within the prescribed list of threats (see Section 4.3). However, there is potential for the transportation of dangerous and/or hazardous goods along these corridors and the potential for a spill to occur. Transportation corridors will be considered in the development of the Source Protection Plan to ensure the protection of groundwater sources from potential accidental spills. Transportation corridors (e.g. roads, railway lines) located within IPZ-1 and IPZ-2 can be seen in Figure 6-2d.

6.6.6 Issues and Conditions – Britannia Intake Protection Zones

As discussed in Chapter 4, issues are documented cases of water quality contamination approaching or exceeding acceptable provincial levels. A condition is a situation where past activities resulted in a drinking water threat. No issues or conditions were identified for the Britannia WTP. However, a number of parameters that exceed the Ontario Drinking Water Standards and Operational Guidelines are noted below, including tritium which is identified as parameter that could potentially impact the Ottawa water supply.

For the Ottawa River raw water, there are numerous parameters that exceed the Ontario Drinking Water Standards and Operational Guidelines. The exceeding parameters include:

- aesthetic objectives of turbidity, colour, DOC and iron
- alkalinity, hardness and aluminum which are operational objectives
- health-related criteria for E. coli and total coliforms

None of the above parameters are considered to be issues as they are known to be naturally occurring and do not represent a problem for the water treatment plant operator. *E. coli* and total coliforms presence is usual in surface water sources and they are easily removed during the treatment processes.

The one parameter identified that could potentially impact the Ottawa water supply is tritium. The current maximum allowable concentration for tritium in the Ontario Drinking Water Standards is 7,000 Bq/L. In May 2009, the Ontario Drinking Water Advisory Council recommended that the guideline be revised to 20 Bq/L, applied as a running annual average. Chalk River Laboratories, the site of nuclear technology research and development, is located approximately 180 km upstream of the drinking water intakes.

In December 1988, a spill of heavy water containing tritium entered the Ottawa River. Personnel at the Britannia WPP were notified of the incident, and began monitoring raw water for tritium. Concentrations peaked at approximately 440 Bq/L, never exceeding the 7,000 Bq/L guideline set in the Ontario Drinking Water Standards. Increased tritium levels were observed from approximately Day 16 after the spill until Day 38 after the spill, with the peak occurring at Day 21.

The City of Ottawa currently tests raw water for tritium at least weekly and the concentrations are usually below the detection limit of 5.0 Bq/L. Between the year 2000 and August 2009, the highest (partial) annual average tritium concentration measured in the raw water at the Britannia WTP was 7.0 Bq/L (January to August 2009), with a maximum measured concentration of 22.8 Bq/L. While the annual average concentrations in recent years have been well below the current and proposed guidelines, an upstream heavy water release (similar to the 1988 incident) might have the potential to result in an annual average tritium concentration above the proposed guideline level.

Based on this information, tritium is currently not considered a drinking water issue in accordance with the Technical Rules. However tritium is considered to represent a potential concern that should continue to be tracked. It should be noted that municipal water treatment plants do not have the capacity to remove tritium from source water.

It is recommended that a reassessment of this parameter be carried out as part of a future Assessment Report update when and if the current tritium standard is revised.

6.7 Ottawa Water Supply – Lemieux Island

The Lemieux Island Water Treatment Plant (WTP) is located in Ottawa, Ontario on the Ottawa River, as shown in Figure 6-2a. The Lemieux Island and Britannia WTPs provide treated drinking water to the City of Ottawa for approximately 814,000 people each day. For more background information on the Ottawa River source water supply, see Section 6.5.

The Lemieux Island WTP intake is located approximately 450 m from the mainland and 11 m from the shore of Lemieux Island, and 6 m below the water.

6.7.1 Delineation of Lemieux Island Intake Protection Zones

The steps undertaken to complete the intake protection zone delineation for Lemieux Island are presented in Section 6.5.1. Discussion on the results of the delineation process follow.

Figure 6-3a shows the various components that make up Lemieux Island's IPZ-1 and IPZ-2. The components include:

- the default IPZ-1 shape which is a semi-circle (200 m radius) upstream of the intake, plus a rectangle 400 m long and 10 m wide downstream of the intake;
- the in-river IPZ-2 limit based on reverse particle tracking;
- the anthropogenic transport pathways (storm sewersheds), including a 120 m setback; and
- the Rideau Valley Conservation Generic Regulation Limit line.

Figure 6-3b shows the complete delineation for the Lemieux Island IPZ-1 and IPZ-2. IPZ-1 is approximately 0.07 km^2 (Ontario portion) and IPZ-2 is approximately 13 km^2. Figure 6-3c shows the Lemieux Island IPZ-1 and IPZ-2, including the Quebec side of the Ottawa River. The first part of the Lemieux Island IPZ-3, closest to the intake and within the MRSPR is shown on Figure 6-3d and the full extent of the Lemieux Island IPZ-3 is shown on Figure 6-3e. The total area of the IPZ-3 within the MRSPR is approximately 2,644 km^2. The total area covered by IPZs within the MRSPR for the Lemieux Island municipal surface water intake is approximately 2,657 km^2. Figure 6-3f illustrates the location of the AECL Chalk River nuclear facility, approximately 180 km upstream of the Ottawa intakes.

Municipalities which are located within the Lemieux Island IPZs are shown in Table 6-4.

Uncertainty

The level of uncertainly associated with the delineation of the Lemieux Island Intake Protection Zones is summarized below.

- Within the provincial regulation limits, the IPZ-1 and IPZ-2 delineation has been assigned a low uncertainty. Preliminary information was made available for the IPZ-2 delineation in Quebec but detailed work has not been completed.

- The IPZ-3 delineation, limited to Ontario, is assigned a high uncertainty due to the lack of information/data available to accurately determine the ToT through the entire Mississippi watershed.

Further details regarding the uncertainty assessment are provided in Appendix 6-4.

6.7.2 Vulnerability Scoring – Lemieux Island Intake Protection Zones

The approach used to complete the vulnerability scoring, including the Area Vulnerability Factor (B) and the Source Vulnerability Factor (C), for the Lemieux Island intake protection zones is presented in Section 6.5.2. The specific vulnerability scoring inputs and results are discussed below.

Area Vulnerability Factor – IPZ-1

The IPZ-1 Area Vulnerability Factor for the Lemieux Island intake is 10 as predetermined by the Technical Rules.

Area Vulnerability Factor – IPZ-2

The Area Vulnerability Factor for IPZ-2 ranges from 7 to 9.

The table summarizes the specific information, including assumed minimum and maximum values for Area Vulnerability Factor (B) that were used in the analysis to quantify each criteria.

Four parameters used for Area Vulnerability Factor (B)	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Calculated value for Lemieux Island IPZ-2 (based on local data)
Percentage of Area Composed of Land	10 %	90%	55%
Type of Land Use	- Natural land cover was scored as 7		Developed

Four parameters used for Area Vulnerability Factor (B)	Assumed Minimum Value (B = 7)	Assumed Maximum Value (B = 9)	Calculated value for Lemieux Island IPZ-2 (based on local data)
	- Agricultural, open space was scored as 8 - Mainly developed land was scored as 9		
% Imperviousness of the Land	0%	80%	42%
Extent of Transport Pathways	Transport pathways were classified on the basis of the percentage of the IPZ-2 land area that is drained by storm sewer systems. - <10% of the land area was scored as 7 - 10 to 50% of the land area was scored as 8 - >50% of the land area was scored as 9		>50%

Table 6-xxvi. Summary of Specific Information used to determine Lemieux Island IPZ-2 Area Vulnerability Factor (B).

The following table summarizes the derivation of the IPZ-2 Area Vulnerability Factor (B) for the Lemieux Island IPZ-2. It includes the converted area vulnerability values between assumed minimum value (B=7) and assumed maximum value (B=9) for each of the four parameters, as well as the assumed weighting.

The final Area Vulnerability Factor for the Lemieux Island IPZ-2 is 9.

Parameter	**Calculated value for Lemieux Island IPZ-2 (based on local data)**	*Converted B values for Lemieux Island IPZ-2 between assumed minimum value (B=7) and assumed maximum value (B=9)*			
		$B_{\%LA}$	B_{land}	B_{Imp}	*B_{TP}*
Percentage Land Area ($B_{\%LA}$)	55%	8.1			
Type of Land Use (B_{land})	Developed		9.0		
% Imperviousness (B_{imp})	42%			8.1	
Percentage of Land Area Drained by Storm Sewer (B_{TP})	>50%				*9.0*
Assumed Weighting Factor		1/3	1/6	1/6	*1/3*
Weighted Factor	***8.55***				
Selected Area Factor	***9***				

Table 6-xxvii. Summary of Scoring for Lemieux Island IPZ-2 Area Vulnerability Factor (B).

Area Vulnerability Factor – IPZ-3

The Area Vulnerability Factors for IPZ-3 sub-zones range from 7.2 (adjacent to IPZ-2) to 3.6. The methodology for determining the Area Vulnerability Factor for IPZ-3 can be found in Section 6.3.2.

Intake Protection Zone **(TOT = Time of Travel)**		***Area Vulnerability Factor (B) for Lemieux Island***
IPZ-1		*10*
IPZ-2		*9*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	*8*
	Sub-zone 2 (6 to 10 hour TOT)	*7*
	Sub-zone 3 (10 to 14 hour TOT)	*6*
	Sub-zone 4 (14 to 18 hour TOT)	*5*
	Sub-zone 5 *(>18 hour TOT)*	*4*

Table 6-xxviii. Lemieux Island ToT and Area Vulnerability Factor.

Source Vulnerability Factor

The approach used to complete the Source Vulnerability Factor for the Lemieux Island intake protection zones is presented in Section 6.5.2. The specific vulnerability scoring inputs and results follow.

The following table summarizes the specific information, including assumed minimum and maximum values, for Area Vulnerability Factor (B) that were used in the analysis to quantify each criteria.

Three Factors used for Source Vulnerability Factor (C)	Assumed Minimum Value (C = 0.9)	Assumed Maximum Value (C = 1)	Calculated value for Lemieux Island (based on local data)
Depth of Intake (C_{depth})	15 metres	2 metres	6 metres
Distance of the Intake from land (C_{Dist})	1000 metres	0 metres	450 metres
Historical Water Quality Issues (C_{DWI})	A value of 0.9 was assumed if there were no water quality concerns at Intake	A value of 1 was assumed if persistent or chronic water quality concerns were present at Intake	none

Table 6-xxix. Summary of Specific Information used to determine the Source Vulnerability Factor (C).

The following table summarizes the derivation of the Lemieux Island Source Vulnerability Factor (C). It includes the converted source vulnerability values between assumed minimum value (C=0.9) and assumed maximum value (C=1) for each of the three parameters, as well as the assumed weighting.

The final Source Vulnerability Factor for the Lemieux Island intakes is 0.9.

Parameter	**Calculated value for Lemieux Island (based on local data)**	*Converted B values for Lemieux Island between assumed minimum value (C=0.9) and assumed maximum value (C=1)*		
		(C_{depth})	(C_{Dist})	*(C_{DWI})*
Depth of Intake ($\mathbf{C}_{depth}$)	6 metres	0.97		
Distance of the Intake from land ($\mathbf{C}_{Dist}$)	450 metres		0.96	
Historical Water Quality Issues ($\mathbf{C}_{DWI}$)	none			*0.9*
Assumed Weighting Factor		1/3	1/3	*1/3*
Weighted Factor	***0.943***			
Selected Area Factor	***0.9***			

Table 6-xxx. Summary of Scoring for Lemieux Island Source Vulnerability Factor (C).

Final Vulnerability Scoring for Lemieux Island IPZs

As presented above, the Lemieux Island Source Vulnerability Factor (C) was assessed to be 0.9. Thus, the final Vulnerability Scores (V) for each of the zones is less than the Area Vulnerability Factors (B).

As shown in the following table, Lemieux Island's IPZ-1 has a final Vulnerability Score of 9 and the IPZ-2 a score of 8.1. The IPZ-3 final Vulnerability Scores range from 7.2 to 3.6.

Intake Protection Zone (TOT = Time of Travel)		**Area Vulnerability Factor (B) for Lemieux Island**	***Final Vulnerability Score (V) for Lemieux Island***
IPZ-1		10	*9*
IPZ-2		9	*8.1*
IPZ-3	Sub-zone 1 (2 to 6 hour TOT)	8	*7.2*
	Sub-zone 2 (6 to 10 hour TOT)	7	*6.3*
	Sub-zone 3 (10 to 14 hour TOT)	6	*5.4*
	Sub-zone 4 (14 to 18 hour TOT)	5	*4.5*
	Sub-zone 5 (>18 hour TOT)	*4*	*3.6*

Table 6-xxxi. Lemieux Island IPZ Vulnerability Scoring.

Figure 6-3g shows the final vulnerability scoring for IPZ-1 and IPZ-2 and the first part of IPZ-3 and Figure 6-3h shows the final vulnerability scoring for the full extent of all the IPZ's. The final Vulnerability Scores are also summarized below.

	Area Vulnerability Factor (B) *Expressed as a whole number*			**Source Vulnerability Factor (C)**	***Vulnerability Score (V)*** *Expressed to one decimal point or as whole number depending on the value of C*		
Zone	**IPZ-1**	**IPZ-2**	**IPZ-3**		**IPZ-1**	**IPZ-2**	***IPZ-3***
Possible Values	*10*	*7 to 9*	*1 to 9*	*0.9 or 1*	*9 or 10*	*6.3 to 9*	*0.9 to 9*
Lemieux Island Scores	***10***	***9***	***4-8***	***0.9***	***9***	***8.1***	***3.6 to 7.2***

Table 6-xxxii. Summary of Lemieux Island IPZ Vulnerability Scoring Results.

Uncertainty

The Technical Rules require uncertainty to be categorized as low or high. Uncertainty levels for vulnerability scoring of the Lemieux Island IPZs are identified in the following discussion.

The Source Vulnerability Factor uncertainty is low for the Lemieux Island intake. The Area Vulnerability Factor uncertainty is low for Lemieux Island IPZ-1 and IPZ-2, and high for IPZ-3. Factors which were considered in the uncertainly analysis were the good physical characteristics of the intake, the good water quality data and the overall lack of good watershed data used in the IPZ-3 vulnerability scoring approach. It is noted that no vulnerability scoring was completed on the Quebec side of the Ottawa River.

Final Uncertainty

The overall level of uncertainty is determined through combining the level of uncertainty for delineation scoring, discussed in Section 6.7.1, and for vulnerability scoring, discussed above. Based on the level of uncertainty for the delineation and vulnerability scoring, the overall uncertainty ratings for Lemieux Island IPZs are:

- IPZ-1 – Low uncertainty
- IPZ-2 – Low uncertainty
- IPZ-3 – High uncertainty

Further details regarding the uncertainty assessment are provided in Appendix 6-4.

6.7.3 Managed Lands and Livestock Density – Lemieux Island Intake Protection Zones

Percent managed land and livestock density calculations were carried out according to the methods outlined in Section 6.3.3. Figure 6-3i shows the managed lands and the livestock density in the IPZ's. The percent managed lands and average livestock densities for each zone are listed in Table 6-7. Also shown in the table is the risk threshold for the over application of nutrients to land and the risk threshold for the over application of ASM to land.

6.7.4 Impervious Surfaces – Lemieux Island Intake Protection Zones

The method for calculating impervious surfaces is described in Section 6.3.4. Figure 6-3j shows the impervious surfaces for Lemieux Island. The percentage of impervious surfaces within the Britannia IPZs range from 0-98.3%.

6.7.5 Water Quality Threat Assessment – Lemieux Island Intake Protection Zones

Water quality threats are existing conditions (e.g. contaminated sediment, soil or surface water) or existing or future land use activities that could contaminate a drinking water supply. A land use inventory was completed in 2010 within the MRSPR IPZs but not in Quebec.

It should be noted that a single land use activity could fall into multiple threat categories. For example, a crop farm may have fuel storage, may apply commercial fertilizer to land, and apply agricultural source material to land. Each of these activities is a separate threat category in the provincial table, and so each is therefore a separate threat.

Land use activities and associated threats that occur where the Vulnerability Score is high may result in determining it to be a significant threat. In many cases, the specific circumstances that apply to a threat category are unknown. Using the same example, a crop farm may store fuel, but the volume of fuel stored is unknown. Unless additional information was available, it was assumed that enough material was stored for that activity to be a significant threat.

No potentially significant drinking water threats, areas where the Vulnerability Score is 8 or greater, were identified in the Lemieux Island IPZs. Even though no potentially significant threats were identified for the Lemieux Island IPZs, Figure 6-3k shows the areas in red and green where potential significant threats would be found if they existed. The size of the area where significant threats may be present is approximately 13 km^2. Please see Section 4.4.3 for information on the full list of significant, moderate, and low threats.

Transportation Corridors

A number of transportation corridors, including major road arteries, exist within the Lemieux Island IPZ. These corridors are not considered an activity under Clean Water Act definitions and, therefore, do not fall within the prescribed list of threats (see Section 4.3). However, there is potential for the transportation of dangerous and/or hazardous goods along these corridors and the potential for a spill to occur. Transportation corridors will thus be considered in the development of the Source Protection Plan to ensure the protection of groundwater sources from potential accidental spills. Transportation corridors (e.g. roads, railway lines) located within IPZ-1 and IPZ-2 can be seen in Figure 6-3b.

6.7.6 Issues and Conditions – Lemieux Island Intake Protection Zones

As discussed in Chapter 4, issues are documented cases of water quality contamination approaching or exceeding acceptable provincial levels. A condition is a situation where past activities resulted in a drinking water threat. No issues or conditions were identified for the Lemieux Island WTP. However, a number of parameters that exceed the Ontario Drinking Water Standards and Operational Guidelines are noted below, including tritium which is identified as parameter that could potentially impact the Ottawa water supply.

For the Ottawa River raw water, there are numerous parameters that exceed the Ontario Drinking Water Standards and Operational Guidelines. The exceeding parameters include:

- aesthetic objectives of turbidity, colour, DOC and iron;
- alkalinity, hardness and aluminum which are operational objectives; and
- health-related criteria for E. coli and total coliforms.

None of the above parameters are considered to be issues as they are known to be naturally occurring and do not represent a problem for the water treatment plant operator. *E. coli* and total coliforms presence is usual in surface water sources and they are easily removed during the treatment processes.

One parameter was identified which could potentially impact the Ottawa water supply: tritium. Tritium is currently not considered a drinking water issue in accordance with the Technical Rules. However, tritium is considered to represent a potential concern that should continue to be tracked. It is recommended that a re-assessment of this parameter be carried out when and if the current tritium standard is revised. See Section 6.6.6 for more details.

6.8 Summary of Significant Threats to Intake Protection Zones

There is one MVSPA municipal surface water drinking water system in Carleton Place which has a total 20 potentially significant threats.

The results, in further detail, may be found in Table 6-2.

Figure 6-4 shows all IPZs within the MRSPR. Figure 6-5 shows all IPZs within the MRSPR with vulnerability scores of 8 to 10. For further information on the IPZs within the RVSPA, shown in Figure 6-5, see the RVSPA Assessment Report.

6.9 References

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